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D-2.1 DEVELOPMENT OF THE CASE STUDIES

Digital transformation - Case studies for aviation safety standards – Data Science Applications (DATAPP)

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SUMMARY

Problem area

Data stays at foundation of decision-making, accelerating the digital transformation across industry. Strong data systems and new technology have been embraced in aviation with significant changes to the traditional working processes, business models, standards and regulations. In this context, EASA faces new challenges on what the required changes in safety standards and regulations are needed in response to the introduction of innovative solutions and processes. Anticipating what is to come in the industry in the field of data science applications is key to make sure safety levels are maintained without slowing innovation down.

The objective of this project is to identify and assess relevant changes to the existing aviation safety standards to support the deployment of the digital solutions under three case studies:

- Case Study 3: Flight training data for EBT/CBTA (Evidence-Based Training / Competence-Based Training and Assessment).
- Case Study 4: Digital fuel management.
- Case Study 5: Flight data models for safety.

The project aims to provide a comprehensive evaluation of benefits, constraints, standardisation and deployment issues, including the recommendations for adjusting safety regulations and related standards, and how new digital technologies could contribute to addressing the identified issues.

Description of work

This report represents deliverable “D-2.1 Development of the case studies” of “Digital Transformation – Case Studies for Aviation Safety Standards” project (EASA.2022.HVP.01- Horizon Europe Project). It describes the investigations made for each of the three (3) case studies, from detailing the existing limitations in the current working processes to proposing a set of solution packages and evaluating their impact.

Results and Application

The investigation performed to reach the objectives of the project is presented throughout this document. It provides details of working processes and exiting limitations within each of the Case Studies, structured on use cases and related activities. The main input for the results presented throughout this document comes from the 34 interviews held with aircraft operators, software providers, national aviation authorities, European organisations and aircraft manufacturers. This wide range of perspectives and individual situations seen during the interview gives reliability to the analysis, while bringing complexity at the time of concluding the message.

This document provides a set of proposed solutions driven by the limitations identified during the use case analysis with the objective of helping advance aviation through digital transformation. To ease the future development and potential adoption of the solutions, these have been grouped in packages. The proposed solution packages consist of safety promotion for awareness and dissemination of relevant information and best-practices, regulatory initiatives for new or amended regulatory/ guidance material and innovation & technology to support the integration and development of new technologies and concepts. They are evaluated by estimating their impact in terms of safety, economic, social, environment, changes to current process, maturity level, existing blocking points and a view of proportionality.

CONTENTS

ABBREVIATIONS

ACRONYM	DESCRIPTION
ACARS	Aircraft Communication Addressing and Reporting System
AMC	Acceptable Means of Compliance
AOC	Air Operator Certificate
ATO	Approved Training Organisations
AU	Airspace Users
CAT	Commercial Air Transport
CBTA	Competency-Based Training and Assessment
CS	Case Study
D4S	Data4Safety
EAA	European Aviation Authorities
EAFDM	European Authorities Flight Data Monitoring forum
EASA	European Union Aviation Safety Agency
EBT	Evidence-Based Training
ECA	European Cockpit Association
EOFDM	European Operators Flight Data Monitoring forum
FDAU	Flight Data Acquisition Unit
FDM	Flight Data Monitoring / Management
FDX	Flight Data Exchange
FSF	Flight Safety Foundation
GM	Guidance Material
IATA	International Air Transport Association
IFALPA	International Federation of Air Line Pilots' Associations
KPI	Key Performance Indicator
LFL	Logical Frame Layout
LOSA	Line Operations Safety Audit
MRO	Maintenance, Repair and Overhaul
NAA	National Aviation Authority
NOTAM	Notice To Airmen
OEM	Original Equipment Manufacturer
QAR	Quick Access Recorder
SMS	Safety Management System
SPI	Safety Performance Indicators
SRM	Safety Risk Assessment
UC	Use Case

Executive summary

The digital transformation initiated few years ago and evolves at a very quick pace, difficult to keep the pace with especially in terms of standards and regulatory framework. This research aims to assess the challenges faced by the industry when embracing new technologies and processes with the objective of proposing solutions strategies to these challenges. These will be then translated into proposals for changes to the existing aviation safety standards to support the usage of flight training data for EBT/CBTA, digital fuel management and flight data models for safety.

These three topics are structured in a Case Study each and broken down into use cases to allow a detailed analysis and a comprehensive view of the current working processes. The desk research complemented in the first part of the project has been complemented by direct input from the industry through stakeholder consultation. The present document reflects the aggregated feedback collected from 34 bilateral interviews with different stakeholder types, three webinars, three online questionnaires and three interactive workshops.

EBT and fuel schemes are new in terms of regulatory framework, being translated into a recurrent need for guidance material and best practice examples to foster their implementation. The stakeholder consultation has shown operators with high data analysis skills and advanced implementations, but on overall there is still a low maturity and lack of resources to embrace the EBT or fuel scheme. Flight data is much more advanced as it has been used for decades, with-mandatory usage for Flight Data Monitoring programmes in EASA Member States since 2008.However, the detailed analysis has allowed identifying stakeholders' challenges to which this project proposed a set of solutions.

Each of the Case studies is summed up in the sub-sections below, providing an overview of the analysis done and the key messages captured and transmitted by the industry through the stakeholder consultation completed under the scope of the project.

Case Study 3: Flight training data for EBT/CBTA

The aviation industry continually strives to enhance safety and efficiency in pilot training. Evidence-Based Training (EBT) programmes have emerged strongly with the aim of achieving these objectives, however several key limitations hinder their optimal implementation. EBT involves a shift in the approach to pilot training, the first steps for implementation were taken in 2015 at regulatory level and operators have been progressively aligning to it since 2017. EBT is evolving since it is a relatively new concept with few operators in EBT Baseline, but mature operators have acquired relevant experience and several more are on the way. In that regard, EBT must continue to be promoted as it is the future of training, with the aim to be extended to other licenses.

This document covers various areas and activities in the context of the EBT programmes. Each area is carefully examined, explaining the current process and activities, and identifying their specific limitations for finally proposing detailed solutions. These areas are framed into three different Use Cases:

- **Use Case 3.1 - Use of flight crew training and instructor data to drive EBT programmes:** The aim of the Use Case is to provide details on how training data is collected and used in the EBT programme. It includes the activities regarding the conduction of the training and the assessments of pilots for generating and collecting the training data, the analysis of such data to identify training needs and potential programme improvements, the assessment of the instructor concordance and the provision of relevant training data to the safety department.
- **Use Case 3.2 - Syllabus customisation and scenario contextualisation using operational data:** The objective of this Use Case is to provide details on how EBT programmes are customised and tailored to be adapted to the operators' needs. It covers the identification of the relevant operational data sources for the customisation of the programmes, the collaboration with the safety department and the customisation of the programmes and contextualisation of scenarios.

- **Use Case 3.3 - Authorities support and role within EBT programmes:** The last Use Case addresses the role of the authority in EBT programmes and their current challenges. The main areas in that case are the assessment and approval of the programme by the authorities and the conduction of the oversight of the EBT programmes.

Considering the above points, **potential solutions are provided across various domains**, including the areas of the cooperation with safety departments, the evaluation of pilots, the Instructor Concordance Assurance Programme (ICAP), and the link and communication with authorities, which constitute the key ones.

The initial focus of the proposed solutions is on enhancing collaboration between the safety and training departments for effective programme customisation. EBT programmes, initially designed based on provided reference training topics, are then customised using airline's operational data, the training data collected through the programmes, and industry-wide external data to address the operator and trainee needs.

In the context of this customisation, the collaboration between the training and the safety department is essential. **The cooperation between these two departments faces limitations** as there is an absence of a defined governance framework. To address this, **proposed solutions include developing best practices** specifying data sources to be shared, recommending cross-departmental initiatives, providing guidance on documentation creation, promoting training initiatives for inter-departmental familiarisation, and highlighting the importance of cross-profile personnel. With the provision of these guidelines, operators would have a reference and recommendations to **establish a good cooperation between departments**. This would also enhance their capacity to **customise programmes in an effective manner through the safety department's input.** Additionally, this would address the **need to share more than serious occurrences**, since the provision of these best practices would encourage to **exploiting and jointly discussing relevant safety data with an enhanced level of collaboration and integration between safety and training**.

The fact that governance is needed to share data in an effective way between safety and training also means that these departments need to communicate in a common language. **There is no common taxonomy between training and safety departments**. In most operators, the lack of this common taxonomy leads to an exchange of safety data that is not performed in the most efficient way. To address that, the **proposed solution involves the development of best practices to standardise the taxonomy between Flight Data Monitoring (FDM) methods and EBT competencies.** This includes **mapping FDM events to EBT competencies**, facilitating efficient data sharing between departments. By implementing that mapping, operators could **smooth the sharing of data between the safety and the training departments**. Furthermore, the training department would be able to easily identify which training topics should be introduced into the programmes to mitigate the risks shared by safety.

Once the EBT programme has been designed and customised, it is possible to proceed with the **conduction of the training, evaluating the pilots and gathering the key training data.** The defined pilot's competencies are assessed by means of a grading system and through the observable behaviours defined for each of the competencies. Such conduction of the trainings and the associated assessments is a **key step in the EBT programmes since it allows the instructors to generate and collect grading metrics** that will subsequently enable an analysis of training needs to be conducted in a data-driven manner.

One of the key limitations for this specific area is the lack of clarity on the assessment method. The current methodology for performing the assessment and the grading is standard but open to interpretation by each operator. This fact conditions the assessment, as it becomes a subjective approach that can affect the quality of the output training data. For solving that, the **proposed solution involves the provision of Guidance Material on how to satisfy the established Observable Behaviours.** And it is also vital to define in a clearer way how the assessment of pilots should be performed through the provision of **guidelines for the standard application of the grading system and the assessment method and techniques**, as it would contribute to avoid confusion among operators.

Also in that context, **another important limitation is the high workload of the instructors and the limited time for debriefing**. Instructors are in charge of observing, recording and taking notes of everything that happens during the session to, subsequently, classify the pilot's behaviours to determine a grade. That means that they have to deal with many things at the same time. To address this limitation regarding the workload, **more importance should be given to the debriefing**, perhaps even setting a reserved time slot to be able to discuss what has occurred and to end up assigning the grades with the sufficient time.

Since the **implementation of digital tools to support instructors in the process of assigning a grade** to the competencies could also be useful, guidelines should be developed defining the requirements to be met by this software. The proposed solution suggests developing guidance material capturing the **desirable capabilities for such tools.** In addition, it is especially important to underline and capture the potential **risks related to the use of this kind of tools**, with the objective of **preventing the excessive automation** of certain processes which is another limitation.

And finally, the **last limitation in this area is the lack of a programme difficulty metric.** Introducing a metric for the programme's difficulty could be a valuable step for assessing and communicating the level of challenge or complexity associated with the programme, and **it would allow to contextualise the pass-fail percentages, the grading data, and the concordance of the instructors.** In addition, the aim of this metric would be to explain the potential discrepancies between the grades given by one instructor and another or the grades of a certain population of pilots.

Being a key pillar, **ICAP is possibly the area that stakeholders find the most challenging**, and perhaps the hardest to implement. Operators must ensure that data generated and collected by the instructors is reliable, and therefore, measures must be taken to enhance the standardisation and concordance of the instructors. In the context of EBT, instructors must be monitored in their assessment in terms of accuracy and homogeneity. This is done through the **ICAP** that **measures concordance through the agreement**, which reflects if instructors provide similar assessments; and the **alignment**, which reflects if instructors are aligned with company standards.

In that context, additional best-practices are needed to define **suitable and standardised metrics and methodologies to assess the agreement and the alignment through statistical methods**, as the regulation does not clarify how the ICAP should work. In that way, operators would have a solid basis for ensuring the reliability of their instructors' data.

Assessing the alignment is very challenging. As discussed with some mature operators, they usually organise exercises or workshops based on reference videos, also known as "Golden Standards". These exercises serve as benchmarks for evaluating i**nstructor performance and alignment with the established standards of the airline**. However, it is true that not all operators are able to create them, given the significant costs in terms of resources and time that they entail. For that reason, one of the proposed solutions consists in the **creation and provision of "Golden Standards" as reference videos to be used by any operator.** These reference materials could be developed by the authorities or even by leveraging on industry's stakeholders' collaborations. In that way, any operator seeking to implement an EBT programme could at least have generic reference videos to start assessing their instructors' alignment.

In addition to clear guidance regarding the ICAP, **operators need a tool to support the analysis of instructors' data**, which allows them to intuitively draw conclusions in the form of potential improvements and mitigating measures that can be introduced into their programmes. In that direction, the proposed solution to address that limitation is the **implementation of a tool that allows the operators to manage the ICAP related data**. One approach could be to provide recommendations for operators to develop their own tools, giving references on how to collect data, which metrics to use or which statistical methods and algorithms should be used. And as a complementary approach, the authority or a third-party could develop a tool that can be used by any operator, building upon a pre-defined template in which operators could provide concordance related data on a periodic basis to perform analysis.

Another limitation in the area of the instructor concordance is that although there are mature operators who perform normalisation of instructors' data to fairly compare the assessments, there are **no indications on** how this should be done. In that regard, the proposed solution is developing **Guidance Material to enable operators to implement normalisation methods**, defining the level of metrics and the normalisation methods to be used.

And finally, the last key limitation regarding ICAP is the **potential appearance of forced concordance**. That risk comes from the fact that instructors may assign certain grades just to avoid falling outside of the concordance and from the use of pre-filled templates when conducting the assessments, which should be discouraged. **In addition to clearly defining how assessments should be performed, a framework of indicators or metrics should be defined** and introduced to assess whether there is a forced concordance, aiming to prevent it.

The last key area covers the link with the authority and its role in the context of the EBT. The relationship and **communication between operators and authorities should be strengthened**, as the external operational data such as regulator and industry wide data should be provided for customising the programmes. In addition, such communication should be bidirectional as operators are required to provide indicators and metrics of their programmes to the authority on a regular basis or during the audits conducted by the authority.

EBT implementation has been mainly driven by the operators and, authorities have limited resources to keep the pace with the development and are not able to provide data for EBT customisation, what finally **translates into the operators mainly relying on their own data for the identification of training needs**. The proposed solution suggests the **publication of industry best practices to encourage effective data sharing from authorities to operators**, covering the data sources, frequency, and methods to be considered. Also in that respect, and as an additional solution for that limitation, the **creation of collaborative data-driven mechanisms among authorities and operators should be incentivised.** This type of programme could potentially provide data for the operators’ programmes at national or European level, enabling a better customisation of the programmes, even filling data gaps that may be present in some operators’ data.

In the opposite direction, sharing metrics from the operator to the authority is a way for the authorities to check the correct implementation and functioning of EBT programmes, but it is not clear what metrics should be shared and in which way. The proposed solution is the publication of **Guidance Material defining a recommended framework of KPIs for oversight of EBT programmes by Authorities**, supporting the continuous evaluation of their effectiveness. This would facilitate the authority's monitoring work and would provide visibility on the programmes. It would also serve to **provide more transparency and allow benchmarking** at national level, which is another identified limitation in the context of sharing data with the authority.

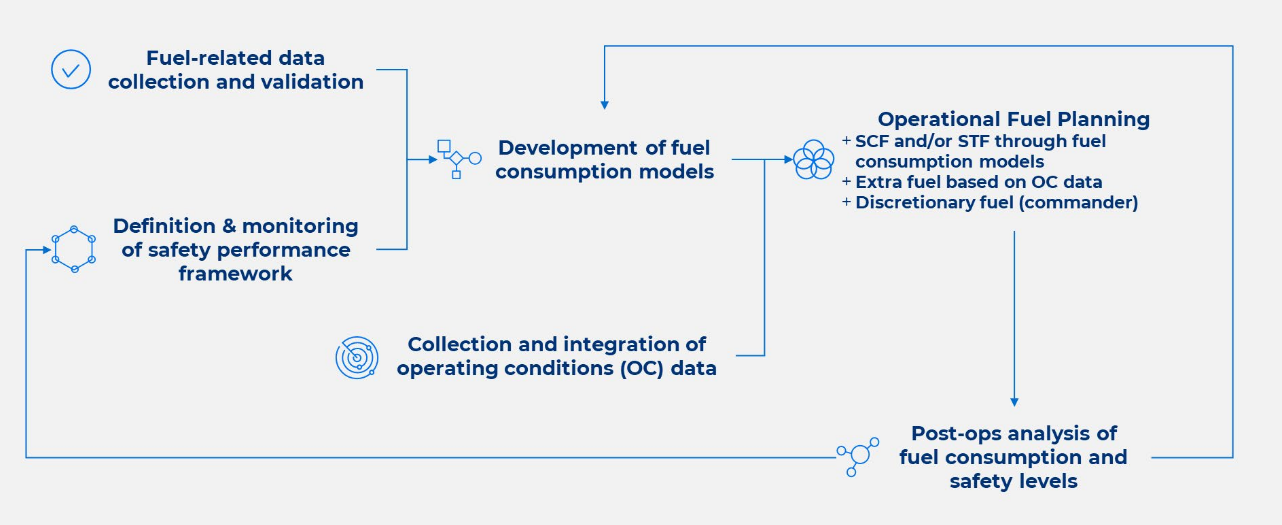
To address the current authorities’ limited capacity to exploit the data coming from the authorities having scattered data sources and the lack of staff, resources and expertise regarding EBT and IT or data analysis, a potential solution would be **supporting the definition of specific trainings for the enhancement of the authorities’ data analysis capabilities**.

In terms of the actual role of the authority in the EBT context, it is currently to ensure that the programme has been correctly implemented and to perform the oversight of the programmes. This role could be evolved and give the authority the possibility of ensuring the consistency of the programme once implemented. Mature operators note potential shifts in grading curves as instructors and pilots develop competencies, leading to over or downgrading. The proposed solution for that involves developing **industry best practices for standardised metrics to monitor the consistency of the EBT programmes over time.** The established framework or set of metrics would allow monitoring the evolution of the gradings and the concordance over time, and the flow between good and bad gradings and vice versa. **This approach empowers authorities to ensure ongoing programme consistency among operators.**

Case Study 4: Digital fuel management

The latest EASA’s regulatory package on fuel policy updated in 2022 introduces different levels of performance-based variations, named fuel/energy schemes. It offers operators a range **of frameworks to manage their fuel with greater flexibility** at expenses of adopting **new digital and analytical capabilities**. These soft rules are set to favour digitalisation, but despite the growing interest in its implementation they have also resulted in a lack of definition of certain aspects that hinder the seamless adoption, integration, and management of the most advanced schemes, as well as the digital solutions on which they should be leveraged.

The analysis performed for the development of this case study has allowed identifying the **steps in the fuel management process where data plays a significant role**. The process begins with the collection and processing of aircraft-specific fuel data, then operators integrate safety considerations into fuel policies and procedure to be able to develop fuel consumption models and integrate them into operational fuel planning. The latter also considers operations conditions data to be able to adapt the real needs. Upon flight completion, advanced analytics techniques are applied to the post-ops analysis of fuel consumption data to identify trends, patterns, and areas for fuel usage improvement.



Having the whole process view has allowed performing a deeper investigation on how fuel data is used and integrated into operators' performance, both from efficiency and safety perspectives. This has leaded to focusing on three use cases where each step has been analysed to identify limitations towards proposing a set of solutions to leverage both the implementation of fuel schemes and the adoption of digital tools:

- **Use Case 4.1: Leveraging aircraft-specific fuel data for fuel performance-based schemes** that identifies relevant fuel data derived from different origin sources and explores best-practices regarding its use, processing, and management to implement performance-based schemes.
- **Use Case 4.2: Characterising the safety performance indicators for fuel schemes** which includes their definition, calculation process and potential thresholds; and defines potential procedures for monitoring and reporting fuel consumption and for re-assessment of established SPIs.
- **Use Case 4.3: Using operating conditions data to support performance-based fuel schemes** whose objective is to perform the mapping of key data sources related to operating conditions required by regulation, perform their basic characterisation, and define best practices for their implementation within fuel schemes to facilitate regulatory compliance to CAT operators.

As the fuel management process begins with the collection and processing of aircraft-specific fuel data, the first challenge appears when operators need to decide which data source to use, as they need to navigate the existing trade-offs between sources, namely Aircraft Communication Addressing and Reporting System (ACARS) and Quick Access Recorder (QAR) that provides flight data. On one hand, ACARS only allows to collect a limited set of fuel parameters at specific points of the flight but in real-time. Operators may lack all necessary data points to justify certain fuel reductions. On the other hand, flight data offers a wider range of parameters with increased granularity, but with limitations in terms of **availability and control of data**. In front of this issue, it is proposed to develop guidance material or even applicable means of compliance (GM/AMC) for the **minimum requirements and selection criteria of fuel-related data sources** in terms of granularity of fuel-related data, availability and mechanisms for seamless collaboration between departments.

On top of the operators' challenges related to the data sources, they encounter difficulties in defining the **list of parameters to be recorded for the Basic Fuel Scheme with Variations or Individual Fuel Schemes**. Operators and authorities are left with the responsibility of identifying additional parameters to supplement the existing set for the Basic scheme, ensuring they offer the necessary level of detail to support safe reductions. As some operators are more advanced, sharing best practices for the definition of a comprehensive fuel data framework is recommended. The two key components of the framework should be a **standardised list of fuel-related parameters to be recorded and scheme-specific data requirements**, specifying the additional parameters necessary for the Basic Fuel Scheme with Variations or Individual Fuel Schemes.

While operators typically perform data quality assessments, they lack clear guidelines to establish **minimum accuracy requirements for fuel parameters and to ensure data consistency**. This is the case of duplicated parameters coming from different sources, namely ACARS and flight data, and the frequent cases of manual data collection that can introduce the errors in the process. The recommendation here lies on **GM/AMC for data validation** to define the minimum accuracy requirements, thresholds, methodologies for data consistency, how to assess the reliability of parameters and specific procedures for manual data collection, data entry, and quality control to minimise errors.

Fuel data collection, validation and analysis allow operators to **develop and apply data analytics techniques on fuel consumption**. It facilitates the creation of statistical or predictive models that provide insights into fuel usage for overall flights to plan fuel allocation more efficiently. The development of these models not only enable the identification of opportunities for reducing fuel amounts when deemed safe, but also help operators detect potential situations where fuel consumption trends deviate, and additional fuel needs to be added.

The stakeholder consultation showed that many operators already have **statistical models developed** and have been implementing them for a long time, but the amount of **data and methods diverge widely among them due to the lack of detail in the current regulation**. While EASA's guidance material provides some generic guidelines for reducing contingency or taxi fuels through statistical models, the fuel consumption modelling suffers from lack of standardised models for reductions, difficulty in defining the statistically relevant set of data, difficulty in capitalising the knowledge of fuel predictions and also an absence of model validation before deployment into daily operations.

The proposed solutions in the context of the development and implementation of fuel consumption models include mainly guidance material and best practice example from the community. A **standardised framework for fuel consumption models** could bring clarity on the methods to be applied, the methodologies for generalising statistical models, the application on different aircraft/ operational scenarios and which could be the limits of model generalisation for each operational context. The current standards requiring a minimum of two years of operational data should be further developed to establish **criteria for assessing the adequacy of data for statistical analysis** while considering operational variations, provide recommendations on effective data sampling techniques and guidance on how to revalidate datasets over time. As operators face difficulties in accessing pseudocode and algorithm details, which limits their understanding on the calculations performed, there is a need for **transparency in algorithm details provided by software providers**. This could be avoided through the provision of algorithms documentation and ensuring traceability of the indicators calculated. The access to the algorithm details would also support the authorities, facilitating the oversight with the transparency on the calculation process. As mentioned, the fuel consumption models have been implemented for a long time in some cases. However, these are usually deployed without going through validation or testing phases. This is acceptable as current models are statistical, but it will become crucial if models evolve to machine learning.

Despite improving flight efficiency and reducing environmental impact, fuel initiatives can be implemented only when ensuring the safety levels. The imperative activity here is the **establishment of a safety performance framework that encompasses a series of strategic actions**, defining a robust safety baseline for any proposed fuel scheme. There is a need for a detailed framework to define and implement Safety Performance Indicators for all fuel schemes, not only for the individual one. This should include a **minimum list of SPIs, critical parameters, thresholds and clear differentiation between metrics for fuel efficiency and safety events**. The definition of a standardised framework should be complemented by the reporting structure and process towards the authority. The detection of safety deviations is crucial to assess the stability of the fuel reductions and should be done in a proactive manner. These should be supported by the definition of precursor events, safety margins, monitoring of operating conditions and analysis of Annual Safety Reports consequential events. In terms of reporting, the frequency and format of the reporting towards authorities should also be addressed. As fuel initiatives imply changes to the daily operations, while maintaining safety levels, they require a close collaboration with safety department to ensure risks are identified in a timely manner. **Safety data with potential link to the fuel initiatives should be accessible by both fuel and safety departments**. Data availability should be complemented by **communication channels and protocols for monitoring safety performance indicators** related to fuel initiatives.

A fundamental aspect of the flexibility provided by fuel schemes to gain and establish control over operational data and monitor is to ensure that safety levels are sufficient and remain constant. This data-driven approach involves the **collection of operating conditions data, integration with other data layers like fuel-related data and safety indicators, and their use throughout the fuel planning process**. The intrinsic limitations of the operational data collection and usage are similar to those of the fuel data. These include low reliability of data, lack of consistency along the data fuel management process and the governance of the data sources.

Standardised data formats and protocols are needed to ensure consistency and compatibility among operating data sources. This would include the recommended criteria to evaluate the **reliability, accuracy, and completeness of the data** collected and also a set of **quality assessment methods** that could be adopted by the operators. In addition, the access to the operating conditions data should be maintained at all stages of the process (planning, in-flight replanning and post-ops). Therefore, the relevant data should be synchronised and updated in real time for in-flight fuel planning and management. Looking at on ground processes, the manual monitoring of numerous data sources for multiple flights can be highly challenging and resource-intensive for dispatch personnel. The **use of advanced technological solutions** should be incentivised, such as automated monitoring tools and data analytics platforms. Even if the tools and systems may provide some data, but pilots may still encounter **gaps in the availability of updated critical information**, such as real-time weather updates, unexpected delays, or specific runway configurations. Therefore, **communication protocols and channels** should be established between **dispatch and fuel management**, but also between **dispatch and flight crew**. Another significant challenge encountered in the collection of operating conditions data is ensuring its consistency not only at different stages of the process but also across operations. The optimal solution for this issue would be a **centralised platform that would consolidate information and provide the reference data to work with**. This might be feasible, but with significant effort and limiting the market opportunities exiting today for data providers. What does seem feasible is a **metadata centre where all available sources are defined together** with the detailed description of what data they provide, how and when. Even if there would not be a unique owner of the data, it is ensured that everybody knows what is available and where.

Finally, upon flight completion, advanced analytics techniques are applied to the post-ops analysis of fuel consumption data. The identified trends, patterns and areas for fuel usage improvement are considered in future fuel planning, closing the loop in the fuel data usage.

Case Study 5: Flight data models for safety

Case Study 5 Flight data models for safety has been developed in a different context than the other two case studies. Flight data has been used for decades and has allowed maturity in terms of analysis, while developments in digital fuel management and EBT/CBTA are more recent and have had less penetration across the industry. Responding to this difference, this case study presents some particularities:

- It focuses on common organisational or otherwise process-related issues which reduce the efficiency and effectiveness of the whole industry and cannot be resolved by individual efforts, instead requiring industry-wide agreements. Some of these are generally not discussed publicly given their sensitive nature but have been covered here to ensure a comprehensive picture of the industry is made.
- It contains extended descriptions of the process activities, as the specificity of limitations and solutions requires a significant degree of contextualisation. These descriptions represent a generalised version of the actual processes followed, as there is a high level of variability in technologies and methods.

The description, limitations and solutions in this case study are structured through two different use cases:

- **Use Case 5.1: Identification, decoding and processing of flight data for an FDM programme** focuses on the process by which flight data is made ready for usage, articulated by the example of an FDM programme. This process heavily relies on technology and is, to some degree, common across all uses of flight data, including the collection of flight data within the aircraft, its transmission to a computer server on the ground, its decoding from a binary format into human-interpretable engineering values, and its further processing for any specific usage (exemplified with the computation of FDM events).
- **Use Case 5.2: Usage of flight data for FDM and other safety-relevant activities** encompasses the actual application of flight data and derivate products to address a safety need. Such applications are considered from the perspective of the FDM programme (given its relevance and maturity in the flight data domain) and that of other safety-relevant activities (ranging from training to large data-exchange programmes). Transversal to both, the implementation of data access policies is also covered to reflect its key role in enabling and shaping the usage of flight data.

These use cases are developed in length with information presented following a uniform structure. A summary of the key points of each of the Use Cases is presented here, including the limitations identified and the solutions proposed.

Use Case 5.1: Identification, decoding and processing of flight data for an FDM programme

The first area in Use Case 5.1 refers to the **collection of flight data** within the aircraft, a necessary step to enable its longer-term storage and usage within an analysis tool. This area is characterised by a very automated process that heavily relies on technology, particularly the Quick Access Recorder (QAR), Direct Access Recorder (DAR), and Data Frame Layout (DFL). As such, **most of the limitations encountered are related to the continued usage of obsolete or old technology**, ranging from lack of recording capacity to issues with the customisation of the data being collected, and including specific limitations faced by operators of smaller aircraft whose access to technology solutions is limited.

Solutions to the continued usage of old technology are not directly proposed, as they can be directly resolved with new equipment. Nevertheless, the **consequences are mitigated**, with some of **the solutions proposed are focused on minimising the need for operators to customise what data they collect** by having the manufacturer define and implement Data Frame Layouts that are useful to many operators, as well as by **stablishing a standard for Data Frame Layout documentation** and content. Additionally, it addresses the limitations on access to technology by including a proposal to research and develop alternative technologies.

Following the collection of data, the second area covers **its transmission to a computer server**, from where it can be accessed later for analysis. In this case, however, the level of automation is variable, with either fully automatic or fully manual transmission. Both present their **limitations**, namely **on the cost of transmission** for the former, **and on** the cost and **delays** faced by the latter. Additionally, the risk of data loss due to data corruption or issues with the transmission can impact both modes, though the manual transfer is higher risk.

In this area, **the main solution proposed is the implementation of minimum data recovery requirements on operators**, to ensure they take the appropriate steps and adopt the necessary equipment to comply. Technological solutions to most of the limitations faced in data transmission already exist, thus being a matter of incentivising or mandating operators to integrate them if reasonable in terms of cost and complexity.

The third area of Use Case 5.1 relates to the **decoding of flight data into engineering values**. Flight data is originally recorded within the aircraft in a binary format to compress it and use less aircraft on-board memory, but it then must be decoded into interpretable engineering units to conduct any data analysis. While the decoding step itself can be automated without much problem, **limitations are very relevant in the preparation of the decoding**. This is a result of a lack of technical modernisation due to how the activity is organised, with software vendors preparing a decoding file in a very manual process using paper documentation produced by manufacturers, which is very inefficient and expensive. In addition**, limitations are also identified in** the amount of **computational resources necessary for decoding**, on the **Intellectual Property Rights (IPR)** applicable to flight data, to documentation, and to decoding files, and on the **knowledge of the operator** over this process of flight data decoding.

The main solution to the issue of producing decoding files is to generalise the usage of electronic documentation, readily usable in an open format that all software vendors can use, and achieved by requiring manufacturers to produce this electronic documentation. **As for the rest of limitations, solutions range from the requirement for minimum data analysis capabilities** (and associated computational resources), to **developing guidelines on IPR** in the context of FDM, and **requirements for the operator to maintain knowledge and documentation** on flight data and Data Frame Layouts.

Finally, the fourth area addresses the **implementation of FDM events and algorithms**, used to automatically process the decoded flight data and extract and summary relevant information. These events and algorithms are characterised by the need to be adapted for the specific concerns and Standard Operating Procedures of the operator, while adapting to the possibilities enabled by the data. In this context, the **main limitations include the lack of standardisation** of events and algorithms, the **loss of control by operators on the definition** of the events they use, the **lack of tools for regulators** to address these issues, and both the technical and organisational **limitations to the fusion of flight data** with other relevant data sources.

As for the **solutions proposed**, they are as varied as the limitations. They include the **development of industry-agreed definitions** within collaborative data-exchange programmes to address standardisation and the loss of control in the definition by operators, providing better tools for regulators (e.g., **minimum mandatory list of risk areas to monitor**, participation in definition of industry-agreed events), and **defining best practices and data repositories for flight data fusion** with other data sources.

Use Case 5.2: Usage of flight data for FDM and other safety-relevant activities

The first area of Use Case 5.2 refers to the **analysis of FDM events and the definition of mitigation measures to for the safety risks identified**. As the "classical" usage of flight data, the analysis of FDM events is performed through an initial validation of the event, and assessment of its severity and risk, and an understanding of the causes and factors. Afterwards, the information is integrated into the Safety Risk Management (SRM) process, where safety issues are assessed, and measures to mitigate them defined, implemented and monitored. This whole process presents **limitations on three main parts**: the **interoperability of FDM analysis software**, the **integration of FDM into the SRM process**, and the **variability in knowledge of operators and FDM analysts**.

To address the topic of interoperability, a **solution proposed is the implementation of minimum FDM software capabilities requirements**, to ensure that either tools are complete analytics suites without need for interoperability, or operators can demonstrate that their tools are integrated. On integration of FDM into the SRM process, proposed solutions include the **development of technical standards and industry best-practices**. Finally, variability of knowledge could be addressed through a **certification process for FDM analysts**.

The second area of this Use Case covers the **implementation of data access policies** by both operators and software vendors, be it in FDM programmes (and associated software), or for other activities using flight data. These policies restrict information access to authorised persons and prevent unjustified disclosures of crew identity. Among the limitations identified, the **lack of modernisation of data access policies** impacts software vendors through the **complexity of complying** and operators by **limiting the usage of the data for other activities** not currently contemplated.

As for the **solutions proposed**, they focus on the **development of modern best-practices on data access policies**, adapted for both flight data usage in FDM programmes and in other safety-relevant activities. The overall objective is to inform operators and flight crews on potential models that are being used in other organisations to manage their data access policies while maintaining their freedom to select the best mode for their own specificities and level of trust.

Finally, the third area addresses the **usage of flight data for other safety-relevant activities**, both performed internally by the operator (e.g., crew training, continuing airworthiness) or externally by other industry stakeholders (e.g., equipment design refinement, safety investigation). **Limitations** to these activities stem from their diversity and the preponderance of FDM. They include the **lack of adaptation of flight data and processes** to suit other activities, **the role of the FDM team**, the **duplication of decoding activities** or the **lack of common definitions**.

A varies set of **solutions** is proposed to address the different limitations. They **include some of the solutions already applicable in other areas** (e.g., certifications for FDM analysist in order to facilitate access to flight data knowledge and better manage the role of the FDM team), and new ones including the **development of cross-domain data formats** and of **best-practices on flight data governance and concept mapping**.

1. Introduction

1.1 Scope of the document

This report represents deliverable "D-2.1 Development of the case studies" of "Digital Transformation – Case Studies for Aviation Safety Standards" project (EASA.2022.HVP.01- Horizon Europe Project). This document describes the investigations made for each of the three (3) case studies, from detailing the existing limitations in the current working processes to proposing a set of solution packages and evaluating their impact.

This document is complemented by "D-2.2 Report on the stakeholder workshops, incl. presentations, briefings and feed-back collected", also delivered by DATAPP project. While D2.1 presents the complete development of the 3 case studies under the scope of the project, D2.2 describes the preparation, content and results of the webinars and workshops organised as part of the investigation for the project. The feedback collected through these means has been used as input to the development of the cases studies presented in D2.1.

The present document is structured as follows:

- Section 1 as an introduction presenting the scope of the document and the use cases selected to develop each of the case studies under the scope of the project.
- Section 2 presents the steps taken to develop the case studies, making emphasis on the stakeholder consultation as the main input for the analysis.
- Section 3 presents the analysis of the use cases defined under Case Study 3 "flight data for EBT", which includes details on the working process activities, identified limitations, proposed solutions and the evaluation of their impact.
- Section 4 presents the analysis of the use cases defined under Case Study 4 "Digital fuel management" and follows the same structure as section 3 described above.
- Section 5 presents the analysis of the use cases defined under Case Study 5 "flight data models for safety" and follows the same structure as section 3 described above.
- Section 6 summarises the results of the investigation made to develop each of the use cases, indicating the main elements for the deployment of the proposed solutions to address the limitations identified in the analysis.

1.2 Use Cases selection

The definition of use cases within each of the case studies under the scope of the project has been based on the identification of core processes related to the case study that allow addressing the main challenges identified through the desk research. These use cases have evolved and have been adjusted in line with the feedback received through the stakeholder consultation process. The final list of use cases for each of the cases studies is presented in the table below together with the objectives.

Table 1-1 List of Use Cases for each Case Study

ID	Name	Objective
Case Study 3: Flight training data for EBT/CBTA		
UC3.1	**Use of flight crew training and instructor data to drive EBT programmes**	Understand the limitations that operators face and propose solutions for managing the training data for benchmarking and training needs identification and for standardisation of the way in which instructors assign grades, ensuring data reliability.
UC3.2	**Syllabus customisation and scenario contextualisation using operational data**	Identify the constraints faced by operators when using operational data to customise EBT programmes and contextualise training scenarios to develop pilot competencies to ensure safe and efficient operations. In addition, propose digital solutions to address these constraints, and define their potential impact.
UC3.3	**Authorities support and role within EBT programmes**	Comprehend the current position of the authorities within the EBT implementation from its design and implementation towards its continuous improvement. Identify processes to be reinforced and strengthen the collaboration with the operators.
Case Study 4: Digital fuel management		
UC4.1	**Leveraging aircraft-specific fuel data for fuel performance-based schemes**	Identify relevant fuel data derived from different origin sources (fuel consumption monitoring systems, ACARS…) and explore best-practices regarding its use, processing, and management to implement performance-based schemes.
UC4.2	**Characterising the safety performance indicators for fuel schemes**	Characterise safety performance indicators, including their definition, calculation process and potential thresholds; and define potential procedures for monitoring and reporting fuel consumption and for re-assessment of established SPIs
UC4.3	**Using operating conditions data to support performance-based fuel schemes**	Perform the mapping of key data sources related to operating conditions required by regulation, perform their basic characterisation, and define best practices for their implementation within fuel schemes to facilitate regulatory compliance to CAT operators.
Case Study 5: Flight data models for safety		
UC5.1	**Identification, decoding and processing of flight data for an FDM programme**	Understand the limitations that operators encounter for flight data use within their FDM programmes and propose digital solutions that can help them succeed.

ID	Name	Objective
UC5.2	**Usage of flight data for FDM and other safety-relevant activities**	Detail and analyse the processes related with the usage of flight data, on one hand, for the validation and analysis of FDM events and, on the other hand, for other safety-relevant activities. It also looks at the data access policies and how these are implemented by the operator.

The use cases presented in Table 1-1 are an update of the those defined in "D1.2 Case study work plan, including analysis methods". The case studies' investigation has driven the adjustment of the focus and scope of the analysed elements, resulting in modifications to the initial list of use cases.

Use Case 3.3 has evolved from the initial "*Use Case 3.3 Data-driven approach to support the derivation of training topics for CBTA programmes*" due to the feedback collected during the bilateral meetings with authorities and operators. When investigating the context of EBT implementation with the authorities, several limitations were identified and lack of collaboration with the operators, mainly driven by the low maturity of the EBT programme at European level. The objective of the use case has been changed to investigate more on the current concerns of the authorities and to strengthen their role in the context of EBT.

Case Study 5 has also adapted the use cases to the real concerns of the industry based on the interviews held during the consultation process. The following changes have been applied to the initial use cases defined:

- Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme: This new chapter focuses on the more technical elements of flight data use and substitutes the previous *Use Case 5.1 Identification, decoding and processing of flight data for a new fleet* by expanding the scope to that of the entire FDM programme, not focusing only on new fleets. This change in scope results from the interest in exhaustively capturing all limitations that the industry faces in a coherent package, whereas the previous scope would present gaps or include content equally applicable to both scopes. Additionally, the topic of fusion of contextual data has been included in this use case, while it was previously covered in *Use Case 5.3 Combination of flight data with other safety-relevant data sources*.
- Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities: This new chapter focuses on the different uses of flight data and substitutes two previous use cases:
    - It includes most topics previously covered in *Use Case 5.3 Combination of flight data with other safety-relevant data sources*, excluding the technical elements of the fusion of contextual data but adding the role and implementation of data access policies.
    - It integrates the previous *Use Case 5.2 Onboarding of operator flight data to an industry-wide exchange programme* as part of the third activity of the new Use Case 5.2. The decision to remove it as an independent use case stems from the commonality in limitations between this topic and those identified for other safety-relevant uses.

2. Investigation performed

This section details the methodology followed to develop the case studies that are presented throughout the document. The research relies on the stakeholder consultation, the feedback received being the main input for the case studies development.

The research has followed the work plan defined in the previous phase of the project, published in "D1.2 Case study work plan, including analysis methods" with slight modifications driven by the investigation itself to adapt to the results obtained during the process.

2.1 Stakeholder consultation

DATAPP research relies mainly on information and feedback received through the stakeholder consultation process. Figure 2-1 below presents the involvement of the stakeholders within the development process.

Figure 2-1 Stakeholder involvement in the use case development

Bilateral interviews to understand:
- Current processes and data flow
- Limitations on the use of data

Technical webinar to share initial results and refine the current working process and existing limitations

Open stakeholder consultation through questionnaires to identify most recurrent limitations and suitable digital solutions

Hybrid technical workshop to validate results and conclude on the impact assessment

Participation to EASA webinars and working groups to gather insights of the current developments and challenges

Project deliverables review to ensure content is aligned with reality

1. Bilateral interviews

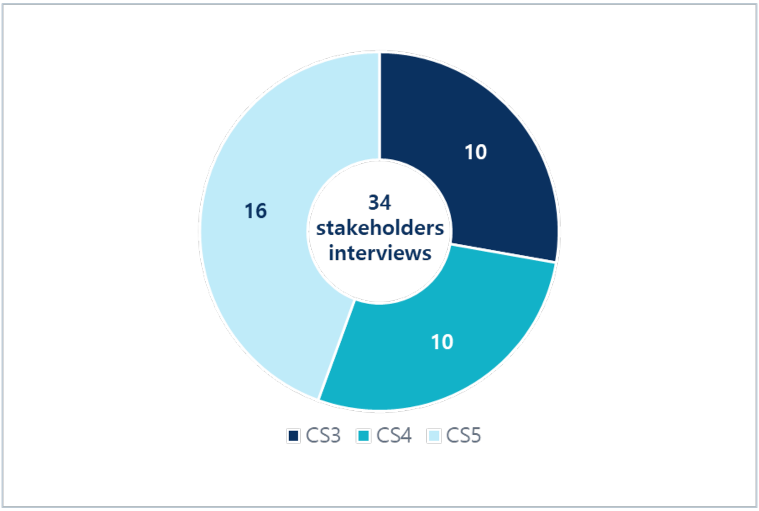
Up to 34 individual interviews have been conducted with representative stakeholders from different operational environments and business natures that provide broad perspective on the processes under each case study. The stakeholders presented in Figure 2-2 have contributed to this phase of the project, their input representing the main input for the case studies development.

Figure 2-2 Stakeholders interviewed for the scope of the project

Each interview consisted in a semi-structured meeting, supported by a set of topics to be addressed, to allow new ideas to be brought up during the interview following the different lines of thought of the discussion with the interviewee. The topics have been selected based on the stakeholder type and driven by the desk research completed in the first task of the project, to provide more insights into the existing limitations in terms of data usage and digital tools available.

Stakeholder engagement has been challenging due to the limited availability, summer period being highly demanding for operators, and due to the high number of missing replies. This has led to the extension of the interview period and an adjustment in the project plan to organise a higher number of interviews and broaden the feedback received. Around 50 stakeholders were invited to the consultation process, which materialised in 34 meetings throughout a period of 4 months. Figure 2-2 below provides an overview of the number of interviews held for each of the case studies.

➨ **Figure 2-3** Number of interviews per case study



The recurrent themes identified among stakeholders, as well as the conclusions drawn from the various individual interviews are reflected throughout the document, being the main input for the case studies development.

2. First webinars concluding on existing limitations

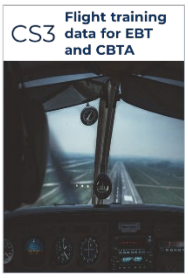
The investigation started with the desk research and has been enriched with the bilateral interviews leaded to a set of initial limitations and allowed the team to have insight into the activities linked to the use cases defined. The main findings were shared with the community through 3 webinars, presented in Figure 2-4 below.

The webinars main objectives were to:

- Present the initial limitations and problems encountered by stakeholders in the processes related to each case study and the use of the data.
- Ensure alignment between the feedback captured through the interviews performed and the wider community.
- Launch a questionnaire to capture validation on the presented preliminary conclusions and propose solutions to existing constraints to enhance the use of data science.

The webinars were held remotely, making use of Webex platform and **slido**. The duration of each session was of one (1) hour where the consultant explained the status of the context of each case study together with the main limitation identified through the bilateral interviews held at the time of organising the webinar. The last fifteen 15 minutes of the sessions were dedicated to the questions and answers where the consultant captured feedback from the attendees and clarified their concerns.

Figure 2-4 First webinars description

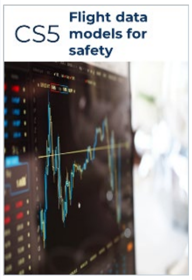


Current barriers and challenges for the implementation and enhancement of EBT/CBTA programmes - 26th July 12:00 – 13:00

Evidence Based Training (EBT) changes the training paradigm, and it is still maturing at European level. Operators are attracted by the effectiveness of this new programme, but its implementation is still new and requires additional resources and effort. Data is at the very heart of EBT programmes, its usage presents a set of challenges in terms of data identification, fusion, reliability, and processes definition.

Unveiling key challenges in current operations for fuel management - 28th July 12:00 – 13:00

The transition to digital fuel management allows operators for more flexibility and enable the application of specific fuel schemes, serving as a basis for defining and implementing new data-driven decision processes. Digitalisation is becoming a powerful proxy for fuel optimisation, but there are still development points and missing gaps in both regulations and digital capabilities.

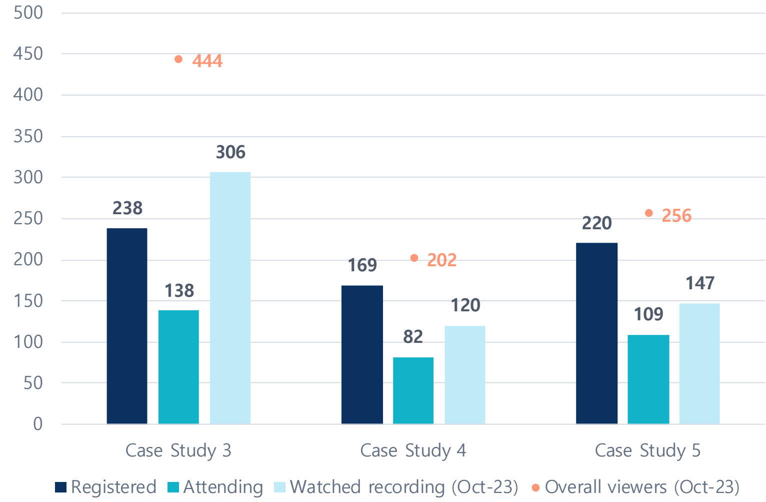


Overcoming limitations and unleashing the potential of Flight Data - 31st July 12:00 – 13:00

Risk management driven by safety intelligence relies on flight data, a unique source of information on the state of the aircraft and its components, on the interactions of the pilot and of the interactions of the aircraft with its surroundings. Challenges are still to be addressed to unlock the potential of flight data usage for proactive risk management.

The webinars had high number of registrations reflecting the dissemination efforts made. The people that really connected to watch the webinar live dropped 42%, 51% and 50% for each session respectively. Despite this drop, the attendance was as expected and fruitful discussions were held, which helped refine the message and the results of the research at that stage. In terms of further dissemination, the three webinars were recorded and uploaded on the DATAPP website so that they could be visualised online even after the event. This has allowed multiple reproductions of the webinars to interested parties who could not make it to the direct event. If we sum both attendees of the webinar and the reproductions afterward, we can conclude that we reached in all cases a wider audience than even the initially registered ones.

Figure 2-5 Webinars registration, attendance and watchers of the recording summary



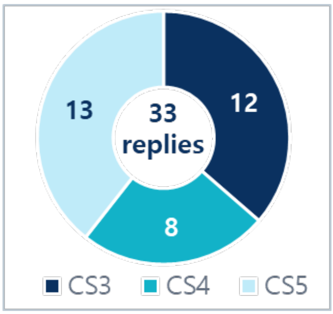
The webinar and the presentation of the main limitations identified in the current working processes related to the use cases under study represented the suitable context to launch the investigation on the potential digital solutions. This has been done through a questionnaire announced during each of the webinar sessions, described under point 3 below.

The development of the use cases defined for each case study has been further consolidated based on the comments received during the webinars and the Q&A sessions.

3. Open questionnaire for initial limitations and digital solutions

The objective of the data collection through the questionnaire launched during the webinars was to validate the initial limitations identified by the consultant and to guide the investigation on the potential solutions to solve these limitations. For this purpose, a dedicated questionnaire to each Case Study was launched. These remained open until the day of delivery of the present document (31st October 2023). The tool used for the development of the questionnaires is *EUSurvey - Welcome (europa.eu)*. The questions together with the design of the questionnaires will be included in D2.2-"Report on the stakeholder workshops, incl. presentations, briefings and feed-back collected" delivered in the context of DATAPP research project.

Figure 2-6 Questionnaire replies



The dissemination through the projects' website and LinkedIn posts translates into 33 replies, as presented in Figure 2-6. The feedback received validated the main limitations identified, showing a similar understanding of the weak points within each case study. In addition, the received answers indicated the direction of the definition of solutions, which were considered when proposing each one of the solutions in this document. The is a clear need for guidance and sharing of best practice to better understand how to analyse data, which metrics to use and how to build the governance around it in each of the case studies.

The feedback received through the questionnaires has leaded to additional interviews, for those including the contact details in the questionnaire. These have been used by the consultant to continue the discussions and take the opportunity of refining the investigation with additional feedback.

4. Technical workshop for validating the results and impact assessment

A hybrid workshop was held on 14-15th November where the research results on the development of the case studies were presented to the stakeholders with the aim of validating the proposed solutions and the evaluated impact. The workshop was performed in three sessions, each one dedicated to the cases study and structured as follows:

- 60 minutes where the consultant presented the limitation and proposed solutions, fostering the interaction with the audience through online surveys to weigh impact of the proposed solutions. The common structure of this part includes:
    - Brief introduction from the EASA's Technical Lead
    - Presentation of the Case study and Use Cases
    - Current status and stakeholder participation to DATAPP project
    - Identified limitations and proposed solutions broken down in specific areas, each one including a dedicated survey and Q&A session using slido platform
    - Next steps
- 30 minutes for an invited panellist to present the best practice case of their organisation.

The best practice case in each session will be presented by a representative from the industry, shown in Figure 2-7 below.

Figure 2-7 Workshop sessions and panellists

CS3 Session	CS4 Session	CS5 Session
- 14th November 10:00 - 11:30 - Panellist: A. Grammaticas (EasyJet)	- 14th November 14:00 - 15:30 - Panellists: Thomas Borer & Georg Wilckens (Lufthansa Group)	- 15th November 10:00 - 11:30 - Panellist: Leopold Sartorius (ATR)

The workshop was organised in a hybrid format, being open to the industry for registration and with invites sent to the targeted stakeholders (interviewed people, participants to the webinar held in July and those expressing interest in the project).

5. Participation to webinars and EASA working groups

The case studies development has also been nurtured through the consultant's participation in meetings and webinars organised by EASA. The consultant has participated to the meetings organised by the following working groups on each of the three topics under the scope of the project:

- Safety Promotion Task (SPT) 0012 Promotion of the new European provisions on pilot training;
- Safety Promotion Task (SPT) 0097 Promotion of the new European provisions on fuel /energy planning and management;
- European Operators Flight Data Monitoring (EOFDM) Working Group C Integration of the FDM programme into operator's processes".

The attendance to these working sessions has helped the consultant to understand development rolling in parallel to this research project and to ensure the results make sense in the current context.

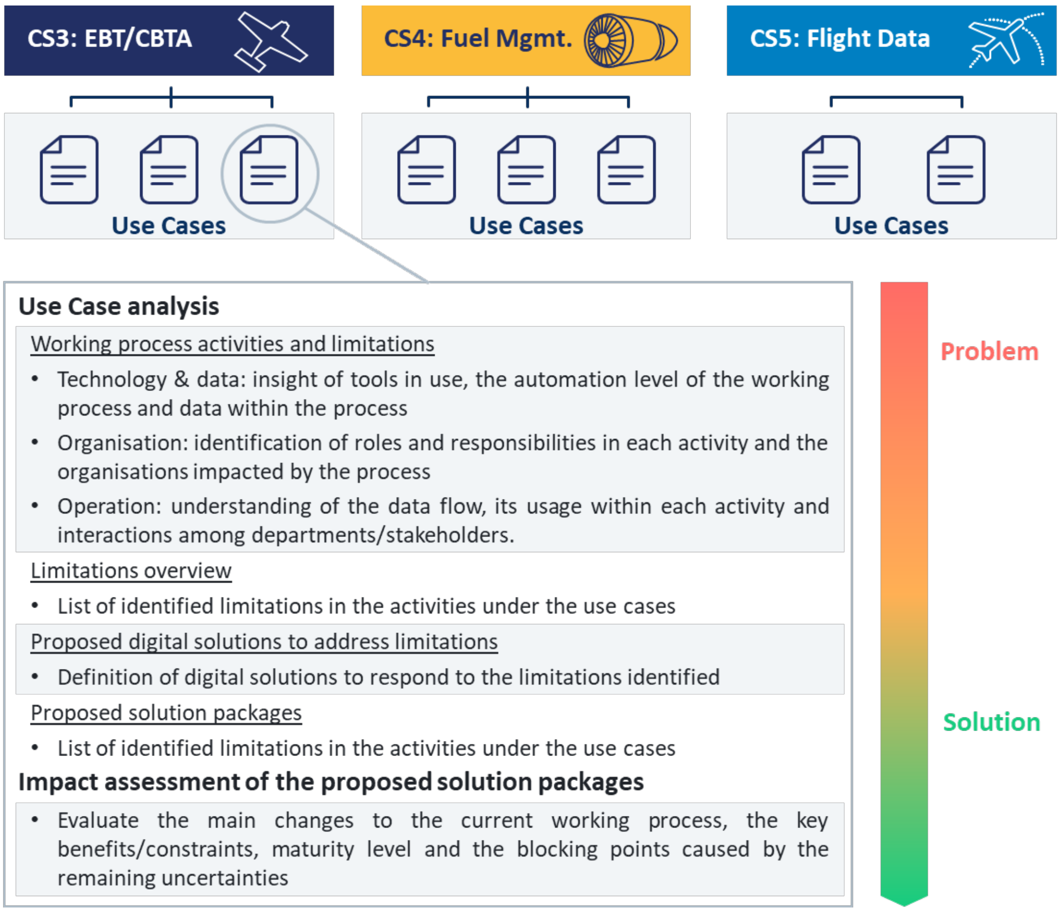
6. Project deliverable review

The documentation elaborated in the context of the project follows the consultant's internal quality review and EASA's review, following the deliverable acceptance procedure defined at project management level. This document has been reviewed by EASA's experts during the development to ensure alignment with the deliverable's expectations.

2.2 Case study development

As the Case Studies are broken into use cases, the development follows their structure. The analysis starts with the description of the activities in the working process where limitations are identified. Solutions and actions are proposed for the identified limitations, which are grouped into packages whose impact is evaluated. The key elements of the development are presented in Figure 2-8 below.

Figure 2-8 Use Case methodology and structure



2.2.1 Use Case analysis

This section describes the steps taken to analyse each of the use cases defined for the Case Study development. The methodology has been driven by the investigation itself, adapting the process to the feedback received and insisting on the significant issues. The structure presented here has been followed to organise the Use Case's sections throughout the document.

2.2.1.1 Working process activities and limitations

Use cases are structured around the data flow in the working processes, which serve to establish the framework under which limitations faced by the stakeholders have been identified. Each of the use cases under study is broken down in specific activities that reflect the main steps followed by the data and that represent the focus of this research study. These activities are described in the following three dimensions, providing a comprehensive understanding of the current situation:

- **Technology & data**: insight of tools in use, the automation level of the working process and data used and generated within the process.

- **Organisation**: identification of roles and responsibilities of the stakeholders involved in each activity and the interactions among departments/stakeholders, as well as the organisations impacted by the outcome of the process.
- **Operation**: understanding the steps and the process followed for each activity, as well as the data flow and its usage within the different activities.

The investigation performed to understand each of the use cases is based on the information received through the stakeholder consultation process described in section 2.1, mainly from the bilateral interviews with representative stakeholders. The study has allowed identifying a set of limitations when analysing the activities, being described under each description dimension. The limitations captured are of technical nature (e.g., difficulty of usage, data format, lack of standards, knowledge gap), organisational (e.g., existence of data silos, lack of manpower of qualified personnel in terms of digital transformation, need to hire for emerging jobs or profiles, development of in-house capabilities, prioritizations of other tasks, data governance), legal (e.g., data protection), economic (e.g., cost of processing or storage, cost of changing the current process), etc.

2.2.1.2 Limitations overview

The development of the case studies structured on use cases that are analysed from the technologic & data, organisation and operational perspectives has allowed going deep into the details and obtain a long list of limitations. This section part of the use case development gathers all identifies limitations and provides an overview of the activities under each use case and the associated limitations.

2.2.1.3 Proposed digital solutions to address limitations

To respond to the identified limitations on the usage of flight data, several solutions and actions are identified. This proposal reflects the existing or potentially viable solutions, with information collected from the solutions and digital capabilities already presented in deliverable D-1.1 of the project, from interviews, questionnaires and workshops performed during the stakeholder consultation process, and from additional desk research work by the consultant.

This section under the Use Case analysis defines each solution through a general description, the intended effects and how it addresses the identified limitation.

2.2.1.4 Proposed solution packages

The proposal of solutions has been driven by the limitations identified during the use case analysis. As the investigation goes deep into the details of the process and the activities, the list of solutions in extensive and they are highly interrelated. Therefore, the individual solutions are grouped into packages selecting those solutions that are related, dependent and that should be deployed together. The solution packages are further described through:

- The list of individual solutions included.
- Involved stakeholders for the definition/production/implementation of the solution and their role in the context of the solution.
- Data-related enablers requirements for the definition/production/implementation of the solution and the owner or potential provider of the data.

To ease their future development and potential adoption, **and as a proposal based on the current maturity of the proposed solutions**, the solution packages have been grouped into three categories:

- Safety promotion that could evolve into Safety Promotion Tasks (SPTs) as they involve training, awareness and dissemination of relevant information and best-practices.
- Regulatory initiatives that could lead to future Rulemaking Tasks (RMTs), proposing new or amended regulatory material (acceptable means of compliance), guidance material (GM) and implementation support activities.

- Innovation & Technology that might be translated into Research Actions (RES) to support the integration and development of new technologies and concepts.

These solution packages, together with their impact assessment, will serve as the input to Task 3 of the project, where key actions to be taken by safety regulators, service and solution providers to streamline the deployment of digital applications will be identified.

2.2.2 Impact assessment of proposed solution packages

The analysis of each use case goes from the description of the activities involved and the current limitations to the proposal of solutions grouped into packages. This is complemented by the impact assessment where the proposed solution packages are evaluated from different perspectives. The purpose is to identify the strengths, weaknesses and remaining uncertainties of the application of the solutions, structured along the categories shown in Table 2-1 together with their corresponding assessment criteria. The applied scores for each of the defined criteria is the same for all Case Studies, but adapted to the context of each topic.

Table 2-1 Impact assessment criteria

Category	Assessment criteria description
Safety	• Contribution to enhancing safety in aviation operations (e.g., improved pilot competencies, enhanced decision-making abilities, and better handling of challenging situations) • Consider the impact on reducing safety incidents, accidents and associated risks
Environmental	• Analyse the environmental benefits, particularly in terms of fuel efficiency, emissions reduction and environmental footprint • Consider the impact on environmental sustainability and compliance with emissions regulations
Social	• Evaluate effects on employment conditions • Promote high-quality jobs and professional development opportunities • Support training environment that promotes inclusivity, diversity, and equal opportunities for all participants • Assess potential reductions on the staff's workload • Facilitate mobility
Economic	• Assess the economic benefits in terms of cost savings and efficiency gains • Consider potential return on investment • Evaluate the potential for reduced operational costs, training savings, and improved resource allocation • Ensure cost-effectiveness & "level playing field" • Identify additional investment needs and higher resource demand
Proportionality	• Ensure proportionality by evaluating if it applies to small and medium or big-sized operators (e.g., General Aviation, Business Aviation)
Maturity level	• Evaluate the stage at which the proposed solution is present across the industry in terms of incipient initiatives or measures, products, research or equivalent ideas • Consider if the topics addressed by the proposed solutions are significantly mature or not

3. Development of Case Study 3: Flight training data for EBT/CBTA

3.1 Use Case 3.1: Use of flight crew training and instructor data to drive EBT programmes

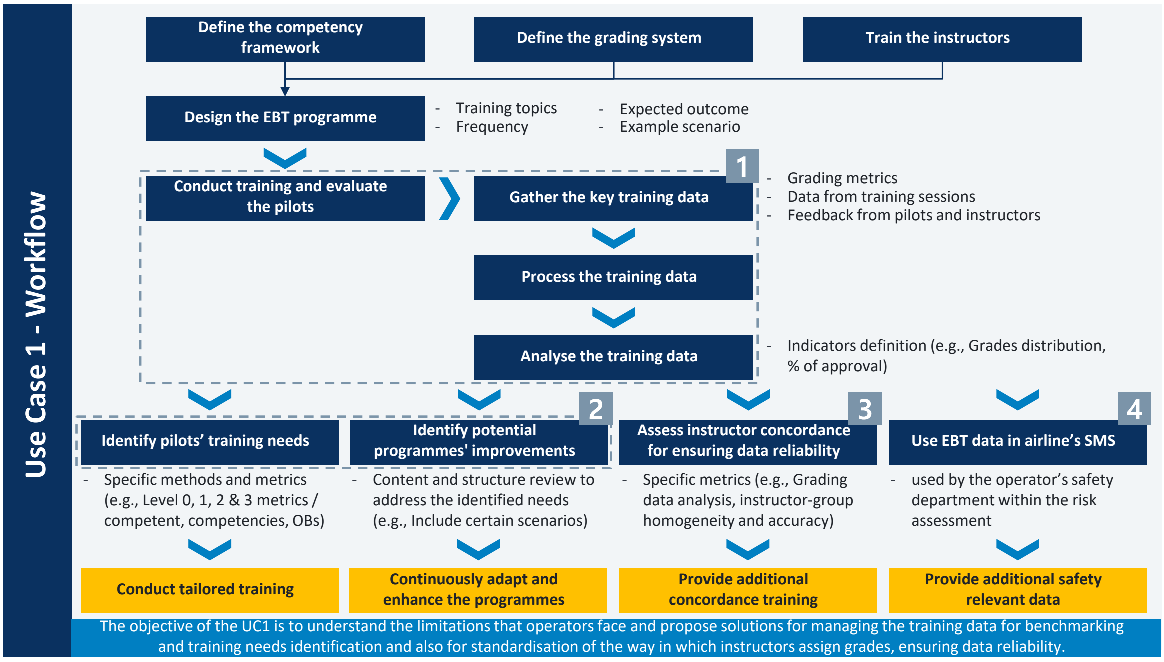
UC3.1 aims to provide details on how training data is collected and used within the EBT programme, understand the limitations that involved stakeholders face to propose solutions and evaluate their impact. Data stays at the heart of EBT programme from its definition to its implementation and continuous improvement. The programme relies on the competency framework recommended by EASA regulation (AMC1 ORO.FC.231(b)), and that is contained in the IATA document “Competency Assessment and Evaluation for Pilots, Instructors and Evaluators”, and on a grading system adapted to the understanding of the operator (AMC1 ORO.FC.231(d)(1) & AMC4 ORO.FC.231 (d)(1)).

The internal EBT data layer provides evidence of individual and group performance: gradings of the pilots, feedback from EBT instructors/evaluators and pilots, as well as training session data. These data sources are gathered, processed and analysed mainly for the following usage:

- Identify pilot’s training needs at group and even individual level, allowing for the provision of customised training and for programmes to be continuously adapted.
- Identify potential programme improvements, for instance, if a competency is identified as being deficient among operators or pilots, subsequent EBT programmes should strengthen this competency.
- Assess instructors concordance and ensure data reliability
- Identify potential risks and provide data to operators’ SMS

The overall EBT internal data workflow is presented in Figure 3-1 below. The development of the use case has been focused on the core activities indicated by the dotted line in Figure 3-1 and summarised in Figure 3-2.

Figure 3-1 EBT internal data workflow



To simplify the description of the activities, these have been grouped into four (4) key activities presented in Figure 3-2, corresponding to the numbers in the workflow presented in Figure 3-1 above. These activities described in depth in the subsequent sections of this document.

Figure 3-2 UC3.1 key activities

3.1.1 Working process activities and limitations

This section provides the description of the core data related activities for UC3.1 and the related limitations identified through the stakeholder consultation.

3.1.1.1 Conduct training, evaluate the pilots and gather the key training data

EBT is characterised by the development and assessment of a set of 9 competencies through which a pilot would be able to manage both usual or expected situations as well as potentially dangerous and unforeseen situations in flight. The pilot's competencies are assessed by means of a grading system and the observable behaviours defined for each of the competencies, thus being a process that should be as objective as possible and that should reflect the pilots' performance. The trainings and the associated assessments are a key step in EBT programmes since they allow the instructors/evaluators to generate and collect grading metrics that will subsequently enable an analysis of training needs to be conducted in a data-driven manner. Instructors/evaluators must follow a defined methodology to assign a grade to each of the competencies that the pilot must demonstrate during training and evaluation, and for this purpose the instructors/evaluators observe and take notes trying to identify and classify the pilot's behaviours.

3.1.1.1.1 Technology & Data

Some operators use third-party tools during the evaluation and training phases to assess and record behaviours and competencies in a de-identified manner, even allowing them to indicate whether a repetition of the manoeuvre or an additional clarification was required. This kind of tool is mainly used to collect and store data and allows operators to extract the percentage of repetition in case they consider it useful. Additionally, these tools enable the extraction of data at the end of the module to further analyse it, mainly using dedicated operator in-house tools. There exist a range of solutions such as tablet forms that can assist instructors/evaluators in the recording of annotations and in the entry of a grade for the competencies in the system.

The data collected from the evaluations and trainings are mainly the grading metrics which, together with simulator data from training sessions and feedback from pilots and instructors/evaluators, are considered an essential pillar of EBT programmes since they serve to identify training needs and potential improvements to be introduced into the programmes, allowing to customise the programmes considering the operator's needs.

Regarding grading metrics, these can be collected at the following levels:

- **Level 0 grading metrics (competent metrics):** data metrics providing the information whether the pilot is competent or not;
- **Level 1 grading metrics (competency metrics):** quantifiable data from the grading system — numeric grade of the competencies (e.g., 1 to 5);
- **Level 2 grading metrics (observable behaviour metrics):** The instructors/evaluators record predetermined OBs during the session;
- **Level 3 grading metrics (other metrics):** the instructors/evaluators may record other predetermined data (e.g., data based on specific tasks, actions, questions, etc.).

Limitations

- **UC3.1-TEC.1 – Risk of automating assessment**: Grading cannot be automatically or mathematically assigned. There is a risk coming from digital solution providers who try to implement it, for example, by automating the OBs recognition. This is driven by the complex role of the instructor of evaluating human behaviour, which cannot be directly transformed into a grade. There is a need for solutions to support instructors/evaluators in the decision-making process, keeping in mind that the decision maker is always the instructor, who is the one that has the knowledge and skill.
- **UC3.1-TEC.2 – Additional metrics for programme effectiveness**: EBT programme is new and few operators are mature enough to be able to demonstrate how well the programme works. Most operators are focusing on implementing the programme without looking at its continuous improvement, which usually comes after at a later stage. Since its definition, the programme effectiveness should be considered to be able to adjust the programme in a dynamic way. Some operators track the percentage of repetition of some manoeuvres during the training phase. This metric is used to adjust the training programme to ensure the competencies of the pilots are developed. The evolution in time of this type of metric will indicate the effectiveness of the EBT programme.
- **UC3.1-TEC.3 – Forced assessment by pre-filled templates**: Operators should be discouraged from using pre-filled templates when performing the grading, as this can be a contributing factor to forced concordance. Instructors/evaluators might be tempted to not change a pre-filled template due to lack of time or being uncertain on the grade to assign.
- **UC3.1-TEC.4 – Lack of a support tool for pilots' assessment**: Currently, instructors/evaluators do not have any tool to support them in the decision-making. On the software level it would be very beneficial to somehow implement something that helps to integrate the "how many" and "how often" so that the instructor can better understand how to come up to a grade, always without neglecting that the instructor is the main responsible of performing the decision-making.
- **UC3.1-TEC.5 – Programme difficulty metric**: There is no metric or reference to measure the difficulty of the module of the programme to contextualise the pass-fail percentages, the grading data, and the concordance of the instructors. The grading is associated with the difficulty of the programme, but there are no established KPIs on the difficulty. If this type of metric was available, the factor of the difficulty of the programme could be considered when analysing the data collected aiming to find the training needs of the pilots. It is possible that discrepancies may appear between the grades given by one instructor and another, or with the grades of a certain population of pilots, and some possible causes are the difference in the difficulty of the modules or programmes and the experience of the pilots undertaking the training. In malfunction clustering, the five malfunctions' characteristics are scored from 1 to 5 points following the DELPHI methodology, so each malfunction can have a maximum score of 25 points, which could be translated into a KPI to evaluate the difficulty of the programme with data. In that case, the operators decide which malfunctions are included in a particular phase or in the programme by defining a threshold. A similar scoring system could be established for the programme's training topics and scenarios, resulting in a metric for the difficulty.

3.1.1.1.2 Organisation

The responsibility for the execution of the training programmes and the assessment of the pilots relies directly on the instructors/evaluators, who observe and record everything that happens in the training sessions to determine a grade for the competencies, thus allowing training data to be generated and gathered. The operator is, however, responsible for the provision of training for instructors/evaluators with the objective of ensuring that assessments are carried out properly and that standardisation of the assessments, as well as the collection of data, is achieved. In addition, concordance must be assured, which is an even more challenging aspect. Finally, the operator's training department is responsible for the collection and storage of the data generated during the trainings, in most cases third-party tools are used for this purpose.

Limitations

- **UC3.1-ORG.1 - Instructors' high workload**: Instructors/evaluators have to deal with many things at the same time so there is a need for methods to reduce their workload in conducting the assessment of the competencies during the training sessions. This excessive workload may lead to the instructor not being able to observe everything that is taking place, and therefore the data generated may not reflect in an accurate or realistic manner what is actually happening in the training sessions. Despite this, the responsibility for undertaking the grading and the decision making should always rely on the instructor, and the aim should be to assist the instructor but without taking the risk of automating certain procedures.
- **UC3.1-ORG.2 – Prioritisation of observable behaviours**: Some operators were setting fewer OBs making it easier to comply or not comply with a competency, and this is not the proper manner to proceed. In addition, it would be beneficial if they were not modified, mainly for standardisation reasons among different operators and with a view to potential data sharing in the future.
- **UC3.1-ORG.3 – Limited access to data**: Usually, only the EBT Manager and the training manager have access to the data. After de-identification, training data should be shared and explained to pilots to ensure transparency and confidence into the programme.
- **UC3.1-ORG.4 – Training data misuse**: Data leakage is a potential problem, but misuse of the instructor's power is a big problem. Being able to justify the deviation of gradings to one point or another is very important and can only be corrected with training. There has to be a syndicate, an organisation representing the pilots, or a mechanism to audit the data usage, to control and monitor if the trainees are treated fairly and to ensure that they are not left defenceless and that the use of the data is justified.

3.1.1.1.3 Operations

To conduct the assessment of pilots with respect to the demonstration of proper performance and the defined competencies and Observable Behaviours, the instructors/evaluators are recommended to use the ORCA methodology. This methodology is explained in AMC3 ORO.FC.231(d)(1), where the following is stated:

"Grading the performance of flight crew members during an EBT module should include the following steps:

- *Observe performance (behaviours) during the simulator session.*
- *Record details of effective and ineffective performance (behaviours) observed during the simulator session ('record' in this context refers to instructors taking notes).*
- *Classify observations against the OBs and allocate the OBs to each competency (or competencies), using amongst others the facilitation technique.*
- *Assess and evaluate (grade): assess the performance by determining the root cause(s) according to the competency framework. Low performance would normally indicate the area of performance to be remediated in subsequent phases or modules. Evaluate (grade) the performance by determining a grade for each competency using a methodology defined by the operator."*

Thus, the training data is generated and can be used to perform analysis and determine the additional training needs of pilots and may trigger the provision of remedial training or tailored training.

Limitations

- **UC3.1-OPS.1 – Lack of clarity on the assessment method**: The current methodology for performing the assessment and the grading is standard but open to interpretation by each operator and its condition. The nature of training assessment is subjective, more guidance and standardisation on how to assess could ensure the alignment and quality of the training data.
- **UC3.1-OPS.2 – Limited time for debriefing**: Debriefing is currently given insufficient importance, as it is limited in time and quantity, and this, together with the high workload of the instructors, conditions

and hinders the collection of data. The importance of debriefing must be emphasised, and the instructor must be given sufficient time to process everything that has happened in the session and to enter the data into the system.

3.1.1.2 Analysis of the training data to identify pilots' training needs and potential programme improvements

In the context of EBT programmes, a large amount of data is generated and collected. This means that the implementation of EBT programmes requires time and effort, as well as specialised staff and tools to assist in certain processes. For that reason, digital solutions or tools are needed as a support in several areas of EBT programmes. Based on all the collected and stored training data, operators shall perform analyses to identify pilots' training needs at both group and individual level and translate these needs into tailored training to ensure that pilots develop an acceptable level of proficiency in all competencies and meet the minimum performance level defined by the operator. Similarly, the conclusions drawn from the analyses can be used to incorporate improvements into the EBT programmes on a continuous basis, aiming to maximise the development of competencies and strengthen those areas in which data indicates that pilots experience more difficulties.

3.1.1.2.1 Technology & Data

Once the training sessions have been conducted and the training data has been gathered, operators need to analyse the data to identify areas that need further strengthening, often using tools that have been developed in-house. This kind of tools allow displaying and analysing pilots' data in an aggregated way, enabling the comparison of pilots with the rest of the population thus facilitating the detection of the improvement points.

Nowadays, especially for operators with more experience and resources, a lot of data is analysed both on an individual basis to include personalised training and on an aggregated level on a de-identified basis. Even monitoring of specific manoeuvres or parameters is carried out, tracking their evolution to check that they are being trained effectively, and establishing minimum percentages to consider a training as effective and to declare it as satisfied.

The data used as basis for identifying particular training needs of the pilots are the grading metrics, mainly the grades of the different competencies (e.g., grades in a 1 to 5 scale), which allow to identify which competencies present the most problems when it comes to demonstrating a good performance. All those competencies in which it is detected that the pilot has not reached the minimum acceptable level established by the company will require additional reinforcement in the form of remedial or tailored training for the pilot with the aim of ensuring that the trainee develops an adequate level of proficiency in all competencies to guarantee safe and efficient operations.

In the cases where operators have the capacity to introduce additional metrics such as the percentage of repetition or the need for further clarification, these are also used to determine whether additional training is required or not, or even to undertake concrete measures to mitigate the associated risks identified through establishing concrete thresholds.

Limitations

- **UC3.1-TEC.6 – Need for data collection and analysis tools**: While it is true that third-party tools are often used for data collection, which imply a cost for the operators, even mature operators expose that they use their own in-house developed tools in areas such as pilot data analysis or instructor concordance assessment, which is resource and time demanding. This makes it difficult, or even impossible, to achieve the appropriate levels of quality and detail in the analysis that are performed, especially for operators with less maturity and resources. Also in that regard, some of the more mature operators indicate that they use their own in-house tools because they get better results and have more advanced tools than what they find in the market.
- **UC3.1-TEC.7 – Need for clustering analysis tools**: Currently, even in operators with experience and maturity in EBT, work is being done to reinforce competencies at the level of the entire pilot population,

but it would be interesting to be able to easily differentiate between specific pilots' populations or parameters, something that currently requires a lot of resources. This is an area where digital solutions could also potentially support operators.

- **UC3.1-TEC.8 – Methodologies to identify training needs**: There are no standard or established metrics or indicators to be extracted from the data collected, and therefore each operator must interpret how to perform the relevant analysis to identify training needs. In addition, if a framework of indicators is to be established, a large training sample is necessary for it to be useful.

3.1.1.2.2 Organisation

The training analysis team, under the guidance of the EBT Manager, is responsible for conducting comprehensive analyses of the collected training data and grading metrics, and operational feedback to identify key areas for improvement and development within the EBT Programmes. This team collaborates closely with various stakeholders, including instructors/evaluators, training personnel, and operational staff, to gather relevant data and insights as an input for the training needs assessment process. By conducting data-driven analyses, the EBT Manager and the training analysis team can effectively identify and prioritise critical training needs, develop tailored training strategies and implement targeted interventions with the aim of improving overall competencies development and performance outcomes within the EBT Programmes.

Limitations

- No specific limitations have been identified in this dimension.

3.1.1.2.3 Operations

Based on the data generated and collected by the instructors/evaluators after conducting the training sessions, an analysis of the data is performed with the aim of identifying training needs of the pilots and areas of improvement for the programmes. Based on the insights obtained from these analyses, it is possible to provide customised and tailored training to the pilots, and to adopt measures to introduce improvements into the programmes. Thus, the operators seek to address the needs encountered and, therefore, to improve the development of pilots' competencies, which will enable them to achieve a higher level of performance and to cope with any kind of situation they may face.

Limitations

- No specific limitations have been identified in this dimension.

3.1.1.3 Assessment of the instructor concordance for ensuring data reliability

Operators must ensure that data generated and collected by the instructors is reliable, and therefore, measures must be taken to enhance the standardisation and concordance of the instructors. Such concordance can be achieved by providing standardisation training to the instructors and by analysing the data using appropriate methods and metrics with the aim of finding instructor trends and behaviours, thus identifying lack of concordance as the lack of agreement among instructors in the evaluation. In that way, areas for improvement and training needs are identified, which derive into additional concordance training that allows ensuring concordance by aligning instructors' criteria to the company's golden standard.

Instructors must be monitored in their assessment in the context of EBT in terms of accuracy and homogeneity. This is done through the Instructor Concordance Assurance Programme (ICAP) that measures concordance through two dimensions:

- **Agreement:** reflects if instructors provide similar assessments;
- **Alignment:** reflects if instructors are aligned with company standards.

In that regard, the key to the success of the ICAP is that the organisation must have confidence in the validity of an evaluator's assessment, meaning that with any pilot, on any day, with any scenario, it is assured as far as possible that the assessment will be accurate.

3.1.1.3.1 Technology & Data

ICAP design is very complex, in fact it is the area that operators consider to be the most complex, as the regulation does not clarify how it should be done. What the regulation does stipulate is that as a minimum it should include, at least, a grading data analysis to identify potential elements of the EBT programme that are not working as expected (e.g., instructors not grading properly, competency found difficult to grade, etc.); and grading guidance to help the instructor in the duty of grading. For this purpose, operators need support and tools to be able to achieve the following:

- Define and employ suitable metrics and methodologies to evaluate concordance through statistical methods, measuring both individual and group metrics;
- Perform corresponding analysis of consolidated grading data to ascertain whether EBT programme's components are working effectively;
- Identify the root cause and potential actions for enhancing the programme and the instructors' standardisation (e.g., provide additional concordance training in specific cases where sufficient standardisation is not observed on the gathered data) through corrective training derived from the identified needs.

At present, some operators have defined and introduced metrics and indicators to assess the agreement and the alignment of the instructors. From the EASA side, a set of incipient metrics have been proposed in the EBT Manual (e.g., Cohen's kappa, Scott's pi and the related Fleiss' kappa, inter-rater correlation, concordance correlation coefficient, and intra-class correlation) that could be studied in depth, but mature operators are currently relying on other types of analysis.

In addition, as each instructor evaluates different people, some mature operators perform an extraction of the grading data from people that an instructor has evaluated and compare it to all the other gradings assigned by instructors who have evaluated the same people, thus normalising the instructors' data. This process is performed to standardise and contextualise the gradings that each instructor sets, so that they can be compared with what happened with the rest of the instructors. In this way, it is also possible to detect how representative are the possible deviations in the behaviours of the pilots and the instructors' gradings.

Limitations

- **UC3.1-TEC.9 – Lack of consensus on metrics to be used for ICAP:** The regulation does not specify which metrics should be used for ICAP. Although EASA has proposed incipient metrics in the EBT Manual, additional guidance is needed that could come from mature operators, who currently use other types of metrics and analysis.
- **UC3.1-TEC.10 – ICAP implementation is resource demanding**: Although some operators are implementing metrics or indicators to assess the concordance of their instructors, this requires data analytics background and an investment in terms of time and effort, something that not all operators can afford at the moment.
- **UC3.1-TEC.11 – Need for support to manage the data:** A digital solution is needed to ensure standardisation through statistical methods, looking at the dispersion of data within a data set like some operators are doing. This is a point where external support is needed to manage the data, either by a tool or by the regulator. There are even software providers interested in developing specific products for the concordance assurance.
- **UC3.1-TEC.12 – Risk of forced concordance**: Grading should be carried out on the basis of what is observed during the session, and a grade should not be assigned wondering whether or not it is going to be within or outside of the concordance. Also in this regard, there is a possibility that some operators

are using pre-filled assessment templates, which may lead to the instructors maintaining the grades that are already set and not a grade derived from their observations. In that regard, a framework of indicators or metrics should be introduced to assess whether there is a forced concordance, aiming to prevent instructors from entering gradings trying to avoid falling out of the concordance.

- **UC3.1-TEC.13 – Absence of guidance for normalisation of instructors data:** Although there are mature operators who perform normalisation of instructors' data to be able to compare evaluations, there are no clear regulations or guidelines explaining how this should be done.

3.1.1.3.2 Organisation

The responsibility for analysing instructor concordance data within the EBT programmes primarily lies with the EBT Manager, supported by a dedicated team proficient in data analytics. This team conducts a rigorous evaluation of instructor concordance, using methodologies and data-driven insights to assess the level of agreement and alignment among instructors. Based on the results and the conclusions drawn from these analyses, the implementation of the of targeted interventions and strategies to enhance instructor concordance and optimise the overall effectiveness of the EBT programmes is enabled. In this regard, the provision of customised concordance training and guidance material for instructors is fostered, contributing to the improvement of the instructors' performance in terms of concordance.

Limitations

- No specific limitations have been identified in this dimension.

3.1.1.3.3 Operations

Besides the pertinent data analysis, the provision of specific training and guidance material for instructors is needed to enhance concordance. Currently, the more mature operators are implementing initiatives, mainly workshops or sessions with specific exercises conducted on a regular basis, with the aim of reinforcing concordance with a special focus on the alignment. A set of reference videos known as the "Golden Standards" are used to show how instructors should perform the assessments based on real examples of manoeuvres or specific situations. These “Golden Standards” should be ideally created by an experienced training standards team and their accuracy is paramount because these materials serve as a reference point for evaluating and determining the proficiency of instructors in the context of the ICAP. In this way, the aim is to analyse whether the instructors are aligned with the standard set by the company, and to take corrective or mitigating actions accordingly to ensure that all instructors maintain a proper level of alignment and concordance. In this periodic studies and exercises, there are operators that group the instructors who are identified as being out of concordance with those who do evaluate correctly, so that a constructive discussion is created leading to improvements. Considering the results obtained in these sessions or exercises, it is possible to extract information that can be used as an input for future sessions and for the creation of future reference videos, this being an iterative process through which the objective is to continuously improve concordance.

Limitations

- **UC3.1-OPS.3 – Limited guidance on ICAP implementation**: It is very complex to achieve the ICAP and the regulation does not clarify how it should be done, the operators should be provided with support and guidance to implement it.
- **UC3.1-OPS.4 – Challenge on detecting and assessing the alignment of instructors:** The difficulty resides in ensuring the alignment and in defining suitable metrics to identify it. There is a need for guidance on which data could be used and how. EBT assessment and training data could be used, but guidance on normalisation and metrics should be provided.
- **UC3.1-OPS.5 – Complexity of golden standard definition:** Some operators use reference videos as “Golden Standards” for the different EBT modules, where concordance is analysed through different manoeuvres and that show how instructors should proceed, but it is resource intensive to create them. All operators implementing EBT must be able to ensure that their instructors are assessing in the appropriate manner and that they adhere to the criteria or standard set by the company. This is vital

for alignment but requires maturity and a lot of resources. There is a need for reference material for EBT implementation for operators with limited resources.

- **UC3.1-OPS.6 – Need for further guidance for instructors:** There is not a clear explanation on how to satisfy the different OBs of the competencies. It should be clearly stated which OBs should be considered and used, what their importance is and provide instructors with guidance that helps them to identify when the established OBs should be considered as satisfied. Otherwise, operators and instructors may have their own criteria or interpretation, which may be wrong, and that would condition the subsequent gradings.
- **UC3.1-OPS.7 – Lack of sharing of improvements implemented by operators in the concordance assessment:** There is currently no established framework by which operators share developments and improvements in the area of assessing instructor concordance, which, combined with the fact that there is no clear consensus on how to assess instructor concordance, limits the continuous increase in the maturity of this area.

3.1.1.4 Closing the loop with the usage of EBT data in airlines' SMS

The information coming from the safety department is a very important input for the definition and customisation of the EBT programmes, but it is also important that the information that the training department extracts from the conduction of the trainings can somehow get back to the safety department. In this way, the loop between the safety and training departments can be closed, relying on a good relationship and interaction between the safety and training departments. By closing the loop, the training department can use safety data as an essential source for the customisation of programmes, highlighting the importance of certain topics or scenarios that help mitigating the risks encountered in operations, and the safety department can benefit from data from training sessions that allows them to detect potential threats before they occur. Moreover, in the latter case where safety receives information from training, it is possible to collect information from a different perspective and from a different environment to that of real operations, allowing for the study of occurrences and hazards that do not appear in a normal environment.

For this purpose, it is important to emphasise the importance of using a common language or taxonomy between the training and safety departments which facilitates the exchange of information. In addition, another fundamental aspect is the provision of specific training to enable both departments to become more familiar with each other's processes and working methods (e.g., training safety personnel in the concept of pilot competencies).

3.1.1.4.1 Technology & Data

The data that can be extracted from the training programmes and that can be useful for the safety department is the data that can be obtained from the simulator. Some of the more mature EBT operators are already starting to transfer occurrences from the simulator to SMS. They try to detect certain behaviours and trends in the simulator that safety cannot detect in normal operations, and these are transferred to the safety department and discussed together as proactive safety. Then, they try to introduce mitigating measures through additional training to avoid incipient threats.

Limitations

- **UC3.1-TEC.14 – Actual differences between simulator and real operations:** Very different rates are obtained in the simulator compared to real operations, so it should not be compared for certain types of manoeuvres. This is mainly because pilots go to the simulator knowing that they are facing a test and they are more aware and conscious.
- **UC3.1-TEC.15 – Training data usually not transferred to safety:** The authorities state that, in some operators, the loop with safety is not closed since no information from the training department is provided to the safety department.

3.1.1.4.2 Organisation

To reach the point where the loop between the safety and training departments is closed and both departments can benefit from each other's information for their activities, it is vital to encourage a close and fluid collaboration. In this case, when it comes to the sharing of data from training to safety, the training department is responsible for ensuring that this data is shared in a de-identified way and in a manner that can be beneficial for the detection of potential hazards that are being observed in training and that may not be observed in actual operations.

Limitations

- **UC3.1-ORG.5 – Lack of bidirectional communication between safety and training:** The bidirectional relationship and communication with safety should be enhanced, following the steps of the most mature operators. In some cases, even if there is a good integration between the two departments in terms of programme customisation through the sharing of safety data, no training data is returned to safety to close the loop.
- **UC3.1-ORG.6 – Need for further maturity in EBT programmes:** In some operators the training data is not shared with the safety department because of the maturity of the project and the lack of evident results.

3.1.1.4.3 Operations

The most experienced operators are beginning to introduce incipient measures for sharing training data, mainly from the simulator, with the safety department. In this way, they seek to detect specific behaviours and trends in the simulator which safety can then consider in its analysis, as they are not normally detectable in real operations. This data sharing takes place through meetings between the two departments, where the data is jointly discussed on a proactive safety approach. In this way, measures such as additional training can be derived to mitigate these emerging risks, even before they appear.

Limitations

- There is a need for establishing a common taxonomy between the training and safety departments to smooth the exchange of data. Furthermore, both training and safety departments should be provided with specific trainings to become more familiar with the processes of the other department. As these limitations are discussed below in sections ***3.2.1.1.1*** & ***3.2.1.1.2***, where the relationship between the two departments is discussed, further details are provided in these sections.

3.1.2 Limitations overview

As highlighted throughout the description of the different activities encompassed in the Use Case 3.1, the collection and use of training data in EBT programmes presents a number of challenges and limitations that are manifested across different operational dimensions. This section presents a consolidated overview of all identified challenges, systematically classified into the three (3) key categories (Technology and Data, Organisation and Operations), and grouped according to their corresponding process activity.

➡ **Table 3-1** Overview of limitations identified for Use Case 3.1

Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**
Conduct training, evaluate the pilots and gather the key training data	• UC3.1-TEC.1 – Risk of automating assessment • UC3.1-TEC.2 – Additional metrics for programme effectiveness • UC3.1-TEC.3 – Forced assessment by pre-filled templates • UC3.1-TEC.4 – Lack of a support tool for pilots' assessment • UC3.1-TEC.5 – Programme difficulty metric	• UC3.1-ORG.1 - Instructors' high workload • UC3.1-ORG.2 – Prioritisation of observable behaviours • UC3.1-ORG.3 – Limited access to data • UC3.1-ORG.4 – Training data misuse	• UC3.1-OPS.1 – Lack of clarity on the assessment method • UC3.1-OPS.2 – Limited time for debriefing
Analysis of the training data to identify pilots' training needs and potential programme improvements	• UC3.1-TEC.6 – Need for data collection and analysis tools • UC3.1-TEC.7 – Need for clustering analysis tools • UC3.1-TEC.8 – Methodologies to identify training needs		
Assessment of the instructor concordance for ensuring data reliability	• UC3.1-TEC.9 – Lack of consensus on metrics to be used for ICAP • UC3.1-TEC.10 – ICAP implementation is resource demanding • UC3.1-TEC.11 – Need for support to manage the data • UC3.1-TEC.12 – Risk of forced concordance • UC3.1-TEC.13 – Absence of guidance for normalisation of the instructors data		• UC3.1-OPS.3 – Limited guidance on ICAP implementation • UC3.1-OPS.4 – Challenge on detecting and assessing the alignment of instructors • UC3.1-OPS.5 – Complexity of golden standard definition • UC3.1-OPS.6 – Need for further guidance for instructors • UC3.1-OPS.7 – Lack of sharing of improvements implemented by operators in the concordance assessment

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Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**
Closing the loop with the usage of EBT data in airlines' SMS	• UC3.1-TEC.14 – Actual differences between simulator and real operations • UC3.1-TEC.15 – Training data usually not transferred to safety	• UC3.1-ORG.5 – Lack of bidirectional communication between safety and training • UC3.1-ORG.6 – Need for further maturity in EBT programmes	

3.1.3 Proposed digital solutions to address limitations

To address the various limitations previously identified and described throughout the sections dedicated to each of the activities of the Use Case 3.1, a set of solutions have been proposed, which are presented and described in the following table:

➡ **Table 3-2** Proposed solutions identified for Use Case 3.1

Use Case 3.1: Use of flight crew training and instructor data to drive EBT programmes		
Limitation	**Solution**	**Description**
UC3.1-TEC.1 – Risk of automating assessment	**UC3.1-SOL.1** - Regulatory requirements / Guidance Material explicitly capturing the potential risks related to the use of software or services supporting EBT evaluations	Develop guidelines that underline which practices should be avoided in the case of having software that assists instructors in the process of conducting assessments. The guidelines should provide details on the limitations of specific software such as: • EBT's philosophical pillars: Highlight the philosophical aspects of EBT (e.g., the responsibility for the decision-making should always rely on the instructor) by which certain practices should be avoided when developing tools to support instructors, especially for digital solution providers so that they have clear limits in this regard. • Risk of automating certain processes: Tools to support instructors can be helpful in reducing their workload, but special caution should be taken with the automation of certain processes (e.g., automatic Observable Behaviours recognition).
UC3.1-TEC.2 – Additional metrics for programme effectiveness	**UC3.1-SOL.2** - Publication and promotion of best-practices for additional metrics for the EBT programmes	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices regarding the introduction of additional specific metrics for identifying training needs. Some operators track specific metrics such as the percentage of repetition of some manoeuvres during the trainings, which can be used as an indicator for identifying training needs. In that regard, the development and provision of best-practices and recommendations in terms of metrics that could potentially be useful for identifying training needs of the trainees should be considered. Some key aspects to be included in such recommendations are: • Specific metrics to be tracked and registered (e.g., percentage of repetition of manoeuvres not correctly performed, additional clarifications needed…) • Method for tracking the defined metrics (e.g., instructor indicates the number of repetitions during the assessment) • Frequency at which the metrics should be recorded

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Limitation	**Solution**	**Description**
		• Example of specific manoeuvres or events to which the recording of the metrics could apply • Practical examples of analysis that can be performed with an specific metric • Tools or functionalities that can be useful for tracking the metric, and also for performing the related analysis (e.g., software that allows to introduce or register the percentage of repetition)
UC3.1-TEC.3 – Forced assessment by pre-filled templates	**UC3.1-SOL.3** - Publication and promotion of best-practices for avoiding the appearance of forced concordance	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices providing recommendations on using and following the guidance material explained in the **"UC3.1-SOL.6 - Regulatory requirements / Guidance Material for standard application of grading system and assessment method and techniques"** as a reference in terms of how to perform the assessments through the use of the grading system, as well as clarifying the process to be followed by the instructors to arrive at a grade for the competencies. In that regard, instructors having a clear reference on how to assess and on the principles of EBT can contribute to assessing in the proper way and avoiding that the instructors assign grades trying to stay within the concordance, thus preventing the appearance of a forced concordance. In addition, and as part of these recommendations, it should also be stressed that the use of pre-filled templates is not recommended as it may lead to the appearance of forced concordance.
	UC3.1-SOL.4 – Promoting learning initiatives where forced concordance is addressed	Operators should include and highlight the aspect of the potential appearance of forced concordance in the learning initiatives (e.g., trainings, workshops, dissemination material) that they conduct and provide on a regular basis to their instructors.
UC3.1-TEC.4 – Lack of a support tool for pilots' assessment	**UC3.1-SOL.5** - Regulatory requirements / Guidance Material explicitly capturing desirable capabilities for EBT software or services supporting EBT evaluations	In the scenario in which digital tools to support instructors in the process of assigning a grade to the competencies of the trainees are introduced, guidelines should be developed defining the requirements to be met by the software to be implemented, mainly regarding the following areas: • Data gathering: What type of data are collected and how • Assessment automation: What level of automation can be achieved, always considering that the instructor is the decision-maker and that certain processes should not be automated • Quality Assurance: Regularly ensure that the outputs of the software used are reliable and actually support the instructor • Alignment with standards: Ensure that any process performed by the software is aligned with the standards set by the regulation • Data privacy: Ensure that the "just culture" policies are met, and that data collected and processed is de-identified and that it is not used in a punitive manner
	UC3.1-SOL.6 - Regulatory requirements / Guidance Material for standard application of grading system and assessment method and techniques	It is essential to define in a clearer way how the assessment of pilots should be performed through the provision of guidelines, as it has been observed that, due to the fact that it remains open to interpretation, it leads to confusion among operators. In that regard, EASA has taken actions through the working group SPT.0012 where amendments are being proposed to the EBT manual since this is an area that generates a lot of discussion and clarity is needed on how to proceed. In that context, discussions have been held on Observable Behaviours, VENN and ORCA methodology, and the VENN grading table in AMC4 ORO.FC.231 has been modified as part of the amendments of the EBT Manual. Following this line of discussion, guidelines should be provided to operators allowing them to use these as a reference and thus ensuring that assessments are conducted in an efficient manner and

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Limitation	**Solution**	**Description**
		on the basis of agreed standards. The guidance material should specify which methodologies and techniques are relevant and recommended for conducting pilots' assessments (e.g., VENN methodology and ORCA process), and that have been effectively implemented by the most mature operators, clearly presenting a step-by-step approach to be followed and some practical examples that allow for a clear understanding of the process and for regulatory compliance on the operators end.
UC3.1-TEC.5 – Programme difficulty metric	**UC3.1-SOL.7** - Definition and introduction of a metric for programme difficulty	Introducing a metric for the programme's difficulty is a valuable step for assessing and communicating the level of challenge or complexity associated with the programme, and it allows to contextualise the pass-fail percentages, the grading data, and the concordance of the instructors. Some key aspects should be considered for this metric: • Criteria: It is necessary to establish the criteria by which the difficulty of the program is selected (e.g., difficulty of the training topics introduced in the program, difficulty of the scenarios introduced in the program, malfunctions introduced in the program...). • Stakeholder input: It must be defined who is the responsible for assigning the difficulty of the program (e.g., starting from a reference established by the authority for all operators, each operator is responsible for assigning a level of difficulty within an agreed and delimited frame of reference, a consultation with EBT experts is carried out to define the difficulties according to a generic criterion...). • Weighting Factors: Establish weighting factors that allow defining a single score for the difficulty in case several criteria are considered (e.g., scenarios included, pilot experience, malfunctions introduced...). • Scoring system: A scoring system or scale should be defined to quantify the level of difficulty. A numerical scale (e.g., 1 to 10) or descriptive categories (e.g., low, medium, high) could be used. • Testing: Since any scenario included in the programs must be previously tested, it could also be used to assign a difficulty according to what is seen in the validations. • Training: Train instructors and staff on how to use and interpret the difficulty metric to better support trainees. • Continuous review: Periodically review the metric's effectiveness and adjust it as needed based on data and feedback. • Documentation: In addition, the used methodology must be defined and documented. As an example, in the context of malfunction clustering the five malfunctions' characteristics are scored from 1 to 5 points following the DELPHI methodology, so each malfunction can have a maximum score of 25 points, which could be translated into a KPI to evaluate the difficulty of the programme with data. In that case, the operators decide which malfunctions are included in a particular phase or in the programme by defining a threshold. A similar scoring system could be established for the programme's training topics and scenarios, resulting in a metric for the difficulty.
UC3.1-TEC.6 – Need for data collection and analysis tools	**UC3.1-SOL.8** - Regulatory requirements / Guidance Material explicitly capturing desirable capabilities for data analysis supporting solutions to identify training needs and programme improvements	Since the use of digital solutions and data analysis tools is increasingly growing in the context of EBT programmes, and because they are necessary to perform the appropriate analyses to identify training needs and programme improvements, materials should be developed defining the requirements to be met by the software to be implemented, mainly regarding the following areas: • Data usage: What type of data are used for the analysis and at which level (e.g., Level 0, Level 1, Level 2 or Level 3 grading metrics) • Quality Assurance: Regularly ensure that the outputs of the software used are reliable and actually support the trainees' needs identification

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Limitation	**Solution**	**Description**
		• Alignment with standards: Ensure that any process performed by the software is aligned with the standards set by the regulation • Data privacy: Ensure that the “just culture” policies are met, and that the data used and analysed is de-identified and that it is not used in a punitive manner
	UC3.1-SOL.9 – Development and use of a generic data analysis tool for EBT programme	Encourage the development and implementation of a generic data analysis tool that allows the input of data from any operator in a de-identified way, and that integrates a series of basic analyses that enables the extraction of insights from the data as well as the identification of training needs and improvements for the programmes. Through the use of this tool, it would be possible for any operator implementing an EBT programme, regardless of their resources and experience, to have access to a solution that offers a minimum of the analytical capabilities necessary to take advantage of their own data generated within their programmes. For this purpose, work could be performed for the development of a data entry template with the aim of having the most standardised data input as possible to be able to conduct the defined analyses in a simple way, even being able to compare data among operators in a de-identified and aggregated way for identifying areas for improvement of the programmes.
UC3.1-TEC.7 – Need for clustering analysis tools	**UC3.1-SOL.10 –** Development of best-practices for the conduction of clustering analysis for training data	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices regarding the conduction of clustering analysis for training data to identify specific training needs for different trainees populations or even specific parameters. Guidelines and recommendations on the following topics should be provided: • Relevant data to be considered for the analysis • Selection of relevant variables or parameters to perform the clustering (e.g., pilots’ populations, country…) • Clustering and aggregation techniques or algorithms to be used • De-identification techniques to be applied • Types of analysis to be conducted for the clustered data • Potential analysis tools to be introduced
UC3.1-TEC.8 – Methodologies to identify training needs	**UC3.1-SOL.11 –** Development of best-practices for training needs identification	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices regarding the metrics, methodologies and techniques to be used for the training needs identification. Guidelines should cover: • Definition of a standardised framework or set of metrics and indicators to use as a reference for the training needs identification • Data to be considered for the calculation of the established metrics or indicators, including the required level of detail • Performed analysis: Types of analysis and techniques to be considered and performed for the identification of training needs and programme improvements (e.g., individual trainees data analysis, analysis of aggregated data, benchmarking among trainees) • De-identification techniques to be applied
UC3.1-TEC.9 – Lack of consensus on metrics to be used for ICAP	**UC3.1-SOL.12** - Publication and promotion of best-practices for standardised metrics and methods to assess agreement and alignment	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices that allow operators to have solid references in terms of standardised metrics and methods to assess instructor-group assessment homogeneity (agreement) and accuracy (alignment). The developed guidance should:

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Limitation	**Solution**	**Description**
		• Identify and propose essential standardised metrics and methods for assessing assessment homogeneity and accuracy. In that regard, more weight or relevance could potentially be given to the incipient metrics proposed by EASA in the EBT Manual (e.g., Cohen's kappa, Scott's pi and the related Fleiss' kappa, inter-rater correlation, concordance correlation coefficient, and intra-class correlation). Additionally, methods such as the Bland-Altman plot or Krippendorff's alpha statistical test could be used. • Develop practical guidelines that provide step-by-step instructions for implementing the recommended metrics and methods, including examples and case studies where applicable. • Develop a dissemination plan to promote the best practices widely within the industry community. This may include publishing in certain authorities' channels, hosting webinars, and presenting at conferences.
UC3.1-TEC.10 – ICAP implementation is resource demanding	**UC3.1-SOL.13** – Development and use of a generic tool for concordance analysis	A potential solution would be that the authority or a third-party develops a tool that can be used by any operator, building upon a pre-defined template in which operators could provide concordance related data on a periodic basis to their authorities. In this way the process would be more standardised and any operator, both mature and new operators implementing EBT programmes, could have access to a tool where they could perform analysis of their data in the context of instructor concordance, either on an individual basis or potentially comparing with other operators (e.g., dashboard with built-in analysis and data visualisation features recommended to identify concordance needs). In a scenario where shared tools or data sharing solutions are used by operators, additional consideration should be given to measures to enforce data de-identification and access to information to respect "just culture" policies and allow benchmarking between operators on a de-identified basis.
UC3.1-TEC.11 – Need for support to manage the data	**UC3.1-SOL.14** - Publication and promotion of best-practices for concordance-related data management	Best practices regarding the methodology and the processes applied in the management of the instructors concordance related data by mature operators should be developed and published aiming to facilitate the implementation of EBT by as much operators as possible. In this way, any operator seeking to implement an EBT programme could proceed on the basis of reference guidelines and recommendations, knowing that these constitute an industry-proven approach.
	UC3.1-SOL.15 – Implementation of a tool that allows the operators to manage the ICAP related data	In addition to clear guidance regarding the ICAP, operators need a tool developed to support them in conducting data analysis of the instructors' data, which allows them to intuitively draw conclusions in the form of potential improvements and mitigating measures that can be introduced into their programmes. In the case of a scenario where operators are expected to develop their own tools, recommendations should be provided on: • How to collect and store the data to be used in the context of the ICAP • What data or metrics to be collected, calculated and used for performing the proper analysis • Granularity of data and periodicity of the data collection and conduction of the assessments of the concordance • Data validation procedures to maintain data accuracy and quality • Statistical methods, algorithms, and models that will be used for data analysis • Develop data governance policies and procedures to manage and analyse data responsibly and ethically As a complementary approach, solution "**UC3.1-SOL.13 – Development and use of a generic tool for concordance analysis**" could be considered.

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Limitation	**Solution**	**Description**
UC3.1-TEC.12 – Risk of forced concordance	**UC3.1-SOL.16** – Definition and introduction of a framework of indicators and data management considerations to assess the appearance of forced concordance	In addition to clearly defining how assessments should be carried out by the instructors, providing guidance materials that allow them to know how to proceed in any given case, other means should be introduced to check that no forced concordance is appearing. In that regard, a framework of indicators or metrics should be defined and introduced to assess whether there is a forced concordance, aiming to prevent instructors from entering gradings trying to avoid falling out of the concordance. For this purpose, various aspects should be considered: • Define which metrics could be used to detect if there is a potential forced concordance from an instructor's data (e.g., Cohen's Kappa, Fleiss' Kappa, or Intraclass Correlation Coefficient (ICC)…) • Examine the distribution of scores given by instructors. Forced concordance may be indicated by an unusually high concentration of scores at specific levels (e.g., majority of assignments receiving a grading of 3) • Examine the assessment trends of individual instructors over time, identifying instructors who consistently provide similar gradings looking at their historical patterns • Study trainees' performance trends across multiple assessments, identifying if the gradings consistently align with certain instructors • As a further measure, potentially review the comments and feedback provided by instructors, identifying if they are very similar or generic • Provide training for instructors, with specific mention of the potential impact of forced concordance and how to avoid it • Encourage operators to share data on the concordance with the authority, also demonstrating that there is a monitoring of the potential appearance of a forced concordance Therefore, it would be possible to implement methods to validate that there is not a forced concordance while ensuring that a proper monitoring of the instructors' concordance is performed.
UC3.1-TEC.13 – Absence of guidance for normalisation of the instructors	**UC3.1-SOL.17** – Development of guidance material for normalisation of instructors' data	To address the lack of guidelines on the normalisation of instructors' data, further efforts should be focused on developing guidance material to enable operators to implement normalisation methods to ensure that they analyse data in a consistent and fair manner. This guidance material shall provide comprehensive guidelines regarding the following: • Data to be used for normalisation purposes, defining at which level (e.g., Level 0, 1, 2 or 3 metrics) or with which granularity of data the operators need to work to perform the normalisation • Normalisation methods to be used (e.g., Z-Score normalisation, percentile ranks, equating…). Some mature operators are applying their own normalisation methods or procedures aiming to analyse the data. What has been observed in experienced operators is that they extract the assessments of all of an instructor's trainees and compare them to those of other instructors who have evaluated the same trainees. That process enables the standardisation and contextualisation of the assessments, making them comparable and considering the instructors differences. By doing so, the operator can identify the extent to which potential discrepancies in the conduction of pilots and instructors' evaluations are representative. • Examples of how to perform the normalisation process and how to detect potential outliers, indicating potential mitigating measures for the instructors identified as those that present specific training needs

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Use Case 3.1: Use of flight crew training and instructor data to drive EBT programmes		
Limitation	**Solution**	**Description**
		• Process to handle the data in a de-identified form, with the objective of performing analysis at both individual and aggregated level without compromising data privacy
UC3.1-TEC.14 – Actual differences between simulator and real operations	**UC3.1-SOL.18** – Research on the efficient usage of simulator data within the safety department	While there may be differences between simulator data and real operational data, simulator data can still provide valuable insights for the safety department for enhancing safety practices. For that reason, the research on the efficient usage of simulator data within the safety department, considering methods to reduce the impact of the discrepancies between the rates obtained in the simulator and the ones obtained in real operations should be considered. The research should focus on: • Specific data or metrics extracted from the simulators that may be relevant for the safety department, and therefore should be shared by the training department • Methodology to analyse the simulator data to extract valuable insights for the safety team, considering that there are differences when compared to regular operations • Comparing the outcomes of simulator-based training with real-world operational performance to analyse the discrepancies and identify areas where the simulator may not adequately replicate real operational conditions • Conduct an in-depth analysis to identify the specific areas where differences between simulator data and operational flight data are most notable, investigating the root causes of these differences and developing specific strategies to address them • Collaborate with simulator software providers to continuously introduce improvements towards replicating the reality of operations, including the possibility of introducing data collection and analysis tools similar to those used for normal operations
UC3.1-TEC.15 – Training data usually not transferred to safety	**UC3.1-SOL.19 –** Development of best-practices for sharing data from the training to the safety department	Some of the most experienced operators have real interest and, indeed, are starting to close the loop with the safety department by providing them with training data. Even though these incipient initiatives are being developed and conducted, there is a need for detailed guidelines providing recommendations on how to perform this process in an efficient manner, which could potentially lead to enhancing safety and even detecting trends or possible events that appear in training but that cannot be detected by the safety department. Such guidelines should provide recommendations on: • Protocols and mechanisms for the seamless transfer of training data from the training department to the safety department, ensuring that both departments understand their roles and responsibilities in this process. • Format and structure of training data to facilitate and potentially standardise its integration with safety data. • Potential initiatives to promote the collaboration between the training and safety departments (e.g., create cross-functional teams or that meet regularly to discuss how to transfer the data, perform analysis together and jointly discuss the data and the results) • Implementation of robust data privacy and security measures to protect sensitive data and to facilitate the sharing of such data, ensuring compliance with relevant data protection regulations. • Definition of responsibilities among the involved staff, indicating who is responsible for collecting, managing, and sharing training data with the safety department • Tools to be used for performing the proper analysis of the shared data, allowing the safety department to easily extract insights from training data

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Use Case 3.1: Use of flight crew training and instructor data to drive EBT programmes		
Limitation	**Solution**	**Description**
		• Performing monitoring of safety enhancements and conducting initiatives such as scheduling regular data review meetings between the training and safety departments to discuss findings, trends, and potential safety issues identified through training data analysis • Relevant trainings for both training and safety departments regarding the sharing of training data and its integration with the safety information
UC3.1-ORG.1 - Instructors' high workload		Solution **"UC3.1-SOL.6 - Regulatory requirements / Guidance Material for standard application of grading system and assessment method and techniques"** applies.
	UC3.1-SOL.20 - Regulatory requirements / Guidance Material explicitly highlighting the importance of the debriefing	Highlight that during the sessions the instructor should observe and take notes of what happens, so that later, during the debriefing, the collected data can be discussed and the observed behaviours can be classified, to finally assign a grade to the competences. To this end, more importance should be given to the debriefing, since it has been observed that it is very limited in time, perhaps even setting a reserved time slot to be able to discuss what has occurred and to end up assigning the grades with the sufficient time and in accordance with the importance that it has.
		Solution **"UC3.1-SOL.5 - Regulatory requirements / Guidance Material explicitly capturing desirable capabilities for EBT software or services supporting EBT evaluations"** applies.
	UC3.1-SOL.21 - Publication of best-practices for instructor training and learning materials provision	The publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices for the instructor training conduction and the provision of specific learning material could be considered as an additional step to reducing the instructors' workload. In that regard, the objective may be to ensure that the instructors' have a clear understanding on how to proceed while their confidence is enhanced by means of detailed materials to which they can access for having a reference. The key components of these guidelines should include: • Provision of detailed materials with explanations on how to satisfy the Observable Behaviours, as explained in solution **"UC3.1-SOL.22 - Publication of Guidance Material on how to satisfy the established Observable Behaviours"** • Provision of detailed explanations and step-by-step exercises regarding the assessment methodology and techniques (VENN methodology, ORCA process…) • Provision of reference material to allow instructors to better identify how to proceed in certain situations or scenarios they may encounter, including practical and guided examples (e.g., the reference videos or "Golden Standards" that are used in the area of the instructors' concordance to assess the instructors' alignment) • Recommendations for conducting specific trainings for instructors, underlining the importance of prioritising the key tasks to be completed
UC3.1-ORG.2 – Prioritisation of observable behaviours	**UC3.1-SOL.22** - Publication of Guidance Material on how to satisfy the established Observable Behaviours	As explained in the solution **"UC3.1-SOL.21 - Publication of best-practices for instructor training and learning materials provision"**, it is of utmost importance to clearly define which Observable Behaviours should be used and how to satisfy them. Besides helping the instructors, this will also contribute to operators having a reference criterion in this aspect, in favour of standardisation, which in its absence may represent a future problem for a hypothetical data sharing framework.

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Use Case 3.1: Use of flight crew training and instructor data to drive EBT programmes

Limitation	Solution	Description
UC3.1-ORG.3 – Limited access to data	**UC3.1-SOL.23** - Publication of best-practices for sharing data with pilots	The publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices for the sharing of data with the pilots should be considered. The aim of the development of such guidelines should be to encourage the operators to enhance their transparency towards pilots, and to provide them with opportunities to learn from their own data.
UC3.1-ORG.4 – Training data misuse	**UC3.1-SOL.24** - Publication of best-practices for preventing training data misuse	The publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices for preventing training data and instructor's power misuse should be considered to enable operators to have a reference and to ensure that the use of the data is justified. Best-practices should be provided considering that by implementing some measures, operators can create a training environment that prioritises ethical conduct, data privacy, and transparency reducing the risk of training data and instructor power misuse. Some measures on which recommendations should be provided are: • Developing a code of conduct and ethics for both instructors and trainees • Emphasising the importance of fair assessment, non-discrimination, and unbiased evaluation of trainees performance • Performing monitoring and oversight on a regular basis, ensuring that the data usage is as expected • Developing a mechanism that allows the trainees or the instructors to report any incidence related to the data misuse, while promoting a feedback process by which they can provide insights on the sessions • Promote transparency and ensure that the pilots are aware and understand how their data is used • Potential formation of a committee or syndicate who is responsible for ensuring that pilots rights are respected and that there is no data misuse, intervening if there is any discrepancy • Define the consequences in the case of any training data misuse or abuse of power
UC3.1-ORG.5 – Lack of bidirectional communication between safety and training		Solution **"UC3.1-SOL.19 – Development of best-practices for sharing data from the training to the safety department"** applies.
UC3.1-OPS.1 – Lack of clarity on the assessment method		Solution **"UC3.1-SOL.6 - Regulatory requirements / Guidance Material for standard application of grading system and assessment method and techniques"** applies.
		Solution **"UC3.1-SOL.21 - Publication of best-practices for instructor training and learning materials provision"** applies.
UC3.1-OPS.2 – Limited time for debriefing		Solution **"UC3.1-SOL.20 - Regulatory requirements / Guidance Material explicitly highlighting the importance of the debriefing"** applies.
UC3.1-OPS.3 – Limited guidance on ICAP implementation	**UC3.1-SOL.25** - Publication and promotion of best-practices for implementation and continuous improvement of ICAP	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices that allow easing the implementation and continuous improvement of the Instructor Concordance Assurance Programme (ICAP) of the operators. Developing comprehensive guidance and best practices for the ICAP will help ensure that the programme is well-structured, transparent, and effective in improving instructor concordance. In that regard, the developed guidelines should: • Clearly establish the objectives of the Instructor Concordance Assurance Programme (ICAP).

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Use Case 3.1: Use of flight crew training and instructor data to drive EBT programmes		
Limitation	**Solution**	**Description**
		• Explain which data collected in the training sessions should be considered to assess instructors' concordance, and at which level should the analyses be performed (e.g., analyse the Level 1 metrics, Level 2 metrics, Level 3 metrics, Level 4 metrics…). • Establish a baseline methodology that can be used by operators to begin analysing the collected data in terms of the concordance of the instructors. Recommendations should be provided on how to analyse the data and on the tools to be employed, in accordance with what has been observed from the most experienced operators on the basis of which the current regulations have been built and developed. Operators can gradually become more sophisticated in their analysis and tools as they gain experience, but they need these guidelines and recommendations to begin to focus their approach towards analysing the data and finding improvements for concordance. • Detail the training requirements for instructors participating in the ICAP as explained in the solution **"UC3.1-SOL.21 - Publication of best-practices for instructor training and learning materials provision"** • Include indications and recommendations on the trainings to be provided to the staff responsible for conducting the instructor concordance related analyses, based on the know-how of the stakeholders with more experience in EBT, especially the most mature operators who have a deeper knowledge of what type of trainings are effective in terms of evaluating and enhancing the instructors' concordance. • Define a mechanism to assess the concordance evolution over time, preventing from the appearance of overgrading or undergrading. Develop a dissemination plan to promote the best practices widely within the industry community. This may include publishing in certain authorities' channels, hosting webinars, and presenting at conferences.
UC3.1-OPS.4 – Challenge on detecting and assessing the alignment of instructors	**UC3.1-SOL.26** - Publication of best-practices for methods to assess instructors' alignment	Besides the need for the definition of specific metrics for assessing the instructors' concordance, there is a need to create guidelines providing recommendations on how to assess the instructors' alignment. For that reason, the publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices for standardised methods to assess instructors' alignment should be conducted. As discussed with some mature operators, they usually organise exercises or workshops based on reference video, also known as "Golden Standards", that serve as benchmarks for evaluating instructor performance and alignment with the established standards of the airline. These videos are considered exemplary and are used as a reference point for assessing and ensuring consistency among instructors, and instructors and trainees can also use them as training materials to understand the expected level of performance and behaviour. In that regard, authorities should develop materials such as best-practices and recommendations on: • Methods to assess the alignment of instructors, including the creation and usage of reference materials such as videos (e.g., Golden Standards) • Creation of these reference materials for the operators' instructors

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Use Case 3.1: Use of flight crew training and instructor data to drive EBT programmes		
Limitation	**Solution**	**Description**
		• Effective implementation of the methods and reference materials (e.g., use them in workshops or exercises on instructors group level for subsequent alignment-related analysis…) • Regularity with which such exercises or initiatives should be conducted • Tools and data that should be used for the creation of this kind of reference material and for the conduction of the initiatives in which they will be used • Types of analysis that can be performed based on that reference material
UC3.1-OPS.5 – Complexity of golden standard definition	**UC3.1-SOL.27** – Creation and provision of "Golden Standards" as reference videos to be used by any operator	While it is important to provide operators with guidelines on how to create their own reference materials and how they should be used, it would be interesting that reference materials were created and provided (e.g., reference videos or "Golden Standards"…) so that any operator has the possibility to use them. As operators gradually gain experience and increasingly customise their programmes, they should be able to develop their own reference materials to assess the alignment of the instructors. However, it is true that not all operators are able to create them, given the significant costs in terms of resources and time that they entail. For that reason, a series of reference videos could be produced for generic modules based on the reference programmes (e.g., reference training topics and scenarios) that are provided by the regulator in the form of tables. These materials could be developed by the authorities or even by leveraging on industry's stakeholders' collaborations (e.g., operators jointly developing these materials). In that way, any operator seeking to implement an EBT programme could at least have generic reference videos to start assessing their instructors' alignment.
UC3.1-OPS.6 – Need for further guidance for instructors		Solution **"UC3.1-SOL.22 - Publication of Guidance Material on how to satisfy the established Observable Behaviours"** applies.
UC3.1-OPS.7 – Lack of sharing of improvements implemented by operators in the concordance assessment	**UC3.1-SOL.28** – Establishment of a governance framework of recurrent concordance meetings among operators to share best practices	With the aim of being able to share the progress achieved by the operators in the area of instructor concordance, the area of the programmes where the greatest difficulties are encountered, it would be appropriate to establish a framework of regular meetings between experts from the most experienced operators. For this purpose, the following should be considered: • Identification of the key stakeholders to be involved in the regular meetings • Definition of the frequency, duration and modality for the meetings • Main topics to be discussed within the meetings • Conduction of practical exercises or case studies • Creation of documents reflecting what it is discussed in the meetings • Potential share of the advances observed with the rest of the industries' stakeholders These meetings would focus on improving the way in which operators assess the concordance of their instructors but could gradually be extrapolated to other areas of the programmes.

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3.1.4 Proposed solution packages

The potential digital solutions proposed in Section 3.1.3 have been strategically grouped into package solutions, drawing upon their commonalities and distinctive natures within the context of EBT programmes. The first category, encompassed within 'Safety promotion'. pertains to topics that are yet to find comprehensive industry-wide guidance and thus demand the initiation of industry-defined standards and development of industry best-practices. The second category, 'Regulatory initiatives' involving Guidance Material or Acceptable Means of Compliance, represents topics that have reached a level of maturity suitable for integration into formal regulations. Lastly, the third category, 'Innovation & Technology', centres on topics that may not be easily confined to regulatory frameworks but support the adoption and integration of digital solutions and capabilities. This categorisation enables a more focused approach to addressing the multifaceted challenges faced in EBT Programmes, ensuring that each package solution is tailored to its unique context and readiness for implementation.

Table 3-3 Solution package to address limitations of Use Case 3.1

<table>
<tr><th colspan="4">Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes</th></tr>
<tr><th>Solution package</th><th>Solutions included</th><th>Involved stakeholders
(Definition, production, or implementation of the solution)</th><th>Data-related enablers</th></tr>
<tr><td colspan="4">Solution package - Safety Promotion</td></tr>
<tr><td>UC3.1-PS.1 – Safety Promotion regarding the conduction of the programmes, assessments and data gathering</td><td>• UC3.1-SOL.2 - Publication and promotion of best-practices for additional metrics for the EBT programmes
• UC3.1-SOL.3 - Publication and promotion of best-practices for avoiding the appearance of forced concordance
• UC3.1-SOL.7 - Definition and introduction of a metric for programme difficulty</td><td rowspan="2">Aviation industry bodies and associations:
• Facilitate the definition of best practices by bringing together experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data analysts and data scientists to bring their expertise to the development of data analysis methods focused on the training needs identification, EBT experts to provide their experience to the definition of assessment methods)
• Collaborate with operators and regulatory authorities to ensure alignment with industry standards
• Promote for the adoption of best practices across the aviation industry
• Establishing mechanisms for monitoring the implementation of best practices within the industry and gather feedback from stakeholders
Regulatory authorities:
• Review the development of best-practices and ensure that they align with regulatory standards and requirements
• Promote for the adoption of best practices across the aviation industry</td><td>• Criteria and methodology used for the conduction of pilots' assessments and the related data collection
• Criteria for defining programme's difficulty, if used
• Additional metrics to be gathered for the programmes (e.g., percentage of repetition)
• Details on current processes used to approve and audit data-related processes (e.g., training data collection)</td></tr>
<tr><td>UC3.1-PS.2 – Safety Promotion regarding the analysis of gathered training data</td><td>• UC3.1-SOL.11 – Development of best-practices for training needs identification
• UC3.1-SOL.24 - Publication of best-practices for preventing training data misuse</td><td>• Data and parameters considered for the analyses focusing on the training needs identification
• List of metrics currently used for training needs identification
• Methodology and techniques applied for training needs identification
• De-identification techniques used for analysing training data respecting "just culture" policies</td></tr>
</table>

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Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
		• Assess the feasibility of publishing the best-practices as GM or AMC **Operators:** • Adopt and implement the best-practices in their processes and day-to-day operations • Collaborate with industry bodies and regulatory authorities in the development and refinement of best practices • Train their personnel in the application of best practices **Providers:** • Implement and adhere to the best-practices • Collaborate with operators to ensure that the provided data solutions align with best practices	• Information on the algorithms and pseudocodes employed for analysing and validating training data • Information on data fusing algorithms or methodologies • Details on current processes used to approve and audit data-related processes (e.g., training data analyses for training needs identification)
UC3.1-PS.3 – Safety Promotion regarding the sharing of the training data within the operator	• **UC3.1-SOL.18** – Research on the efficient usage of simulator data within the safety department • **UC3.1-SOL.19** – Development of best-practices for sharing data from the training to the safety department • **UC3.1-SOL.23** - Publication of best-practices for sharing data with pilots		• Protocols and processes for sharing data from training to safety departments • Protocols and processes for sharing data with the pilots • Actual process to share training data with the safety department, if implemented • Current usage of the shared training data within the safety department, if considered • Details on current processes used to approve and audit data-related processes (e.g., data sharing mechanisms)
UC3.1-PS.4 – Safety Promotion regarding the Instructor Concordance Assurance Programme (ICAP)	• **UC3.1-SOL.4** – Promoting learning initiatives where forced concordance is addressed • **UC3.1-SOL.12** - Publication and promotion of best-practices for standardised metrics and methods to assess agreement and alignment • **UC3.1-SOL.14** - Publication and promotion of best-practices for concordance-related data management • **UC3.1-SOL.16** – Definition and introduction of a framework of indicators and data management considerations to assess the appearance of forced concordance	**Aviation industry bodies and associations:** • Facilitate the definition of best practices by bringing together experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data analysts and data scientists to bring their expertise to the development of data analysis methods focused on the instructor concordance assessment, EBT experts to provide their experience to the definition of concordance assessment methodologies and techniques) • Collaborate with operators and regulatory authorities to ensure alignment with industry standards • Promote for the adoption of best practices across the aviation industry • Establishing mechanisms for monitoring the implementation of best practices within the industry and gather feedback from stakeholders • **Regulatory authorities:** • Review the development of best-practices and ensure that they align with regulatory standards and requirements	• Data and parameters considered for the analyses focusing on concordance needs identification • List of metrics currently used within the Instructor Concordance Assurance Programme (ICAP) for assessing agreement and alignment • Methodology and techniques applied for concordance needs identification • Analyses and methodologies used to assess instructor alignment • De-identification techniques used for analysing instructors data respecting “just culture” policies • Information on the algorithms and pseudocodes employed for analysing and validating instructors’ data • Details on current processes used to approve and audit concordance data related processes

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Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
	• **UC3.1-SOL.21** - Publication of best-practices for instructor training and learning materials provision • **UC3.1-SOL.25** - Publication and promotion of best-practices for implementation and continuous improvement of ICAP • **UC3.1-SOL.26** - Publication of best-practices for methods to assess instructors' alignment	• Promote for the adoption of best practices across the aviation industry • Assess the feasibility of publishing the best-practices as GM or AMC **Operators:** • Adopt and implement the best-practices in their processes and day-to-day operations • Collaborate with industry bodies and regulatory authorities in the development and refinement of best practices • Train their personnel in the application of best practices **Providers:** • Implement and adhere to the best-practices • Collaborate with operators to ensure that the provided data solutions align with best practices	(e.g., instructor data analyses for concordance needs identification)
Solution package – Regulatory initiatives (Guidance Material or Acceptable Means of Compliance)			
UC3.1-PS.5 – Regulatory initiative regarding the conduction of the programmes, assessments and data gathering	• **UC3.1-SOL.6** - Regulatory requirements / Guidance Material for standard application of grading system and assessment method and techniques • **UC3.1-SOL.20** - Regulatory requirements / Guidance Material explicitly highlighting the importance of the debriefing • **UC3.1-SOL.22** - Publication of Guidance Material on how to satisfy the established Observable Behaviours	**Regulatory authorities:** • Develop and implement the regulatory initiatives, potentially GM and/or AMC • Collaborate with operators and other related stakeholders to ensure alignment with their specific needs • Collaborate with experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data analysts and data scientists to bring their expertise to the development of data analysis methods focused on the training needs identification, EBT experts to provide their experience to the definition of assessment methods) • Promote the adoption of GM/AMC across the industry • Establishing mechanisms for monitoring the implementation of GM/AMC within the industry and gather feedback from stakeholders **Operators:** • Implement GM/AMC for data source validation and integration • Collaborate with regulatory authorities in the development and refinement of GM/AMC • Train their personnel in the application of GM/AMC	• Criteria and methodology used for the conduction of pilots' assessments and the related data collection • Current criteria for satisfying the defined Observable Behaviours • Information on the debriefing technique • Data and parameters considered for the analyses focusing on the training needs identification • List of metrics currently used for training needs identification • Methodology and techniques applied for training needs identification • Protocols and processes for sharing data from training to safety departments • De-identification techniques used for analysing training data respecting "just culture" policies • Information on the algorithms and pseudocodes employed for analysing and validating training data

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Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
		• **Providers:** • Collaborate with regulatory authorities in the development and refinement of GM/AMC • Ensure that the provided solutions adhere to the GM/AMC	• Information on data fusing algorithms or methodologies • Details on current processes used to approve and audit data-related processes (e.g., training data collection, training data analyses for training needs identification)
UC3.1-PS.6 – Regulatory initiative regarding the Instructor Concordance Assurance Programme (ICAP)	• **UC3.1-SOL.17** – Development of guidance material for normalisation of instructors' data • **UC3.1-SOL.27** – Creation and provision of "Golden Standards" as reference videos to be used by any operator • **UC3.1-SOL.28** – Establishment of a governance framework of recurrent concordance meetings among operators to share best practices	**Regulatory authorities:** • Develop and implement the regulatory initiatives, potentially GM and/or AMC • Collaborate with operators and other related stakeholders to ensure alignment with their specific needs • Collaborate with experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data analysts and data scientists to bring their expertise to the development of data analysis methods focused on the instructor concordance assessment and the instructor normalisation, EBT experts to provide their experience to the development of reference materials for supporting the assessment of instructors' alignment) • Promote the adoption of GM/AMC across the industry **Operators:** • Implement GM/AMC for data source validation and integration • Collaborate with regulatory authorities in the development and refinement of GM/AMC • Train their personnel in the application of GM/AMC **Providers:** • Collaborate with regulatory authorities in the development and refinement of GM/AMC • Ensure that the provided solutions adhere to the GM/AMC	• Methodology and techniques applied for the normalisation of instructors' data • De-identification techniques used for analysing instructors data respecting "just culture" policies • Specific reference materials developed to assess instructors alignment and methodologies for creating them (e.g., reference videos or "Golden Standards" to be used in exercises to assess alignment") • Analyses and methodologies used to assess instructor alignment • Framework used for sharing concordance data with the authorities • Information on the algorithms and pseudocodes employed for analysing and validating instructors' data • Data and parameters considered for the analyses focusing on concordance needs identification • Methodology and techniques applied for concordance needs identification • Details on current processes used to approve and audit concordance data related processes (e.g., instructor data analyses for concordance needs identification)
Solution package – Innovation & Technology			
UC3.1-PS.7 –Initiatives to support the adoption of digital tools and capabilities for	• **UC3.1-SOL.1** - Regulatory requirements / Guidance Material explicitly capturing the potential risks	**Regulatory authorities:** • Develop guidelines to facilitate the adoption of digital solutions, and define the requirements to be met by the tools implemented	• Details on current tools used for training data generation and collection • Details on current tools used for the analysis of the collected data (e.g., trainees needs

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Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes

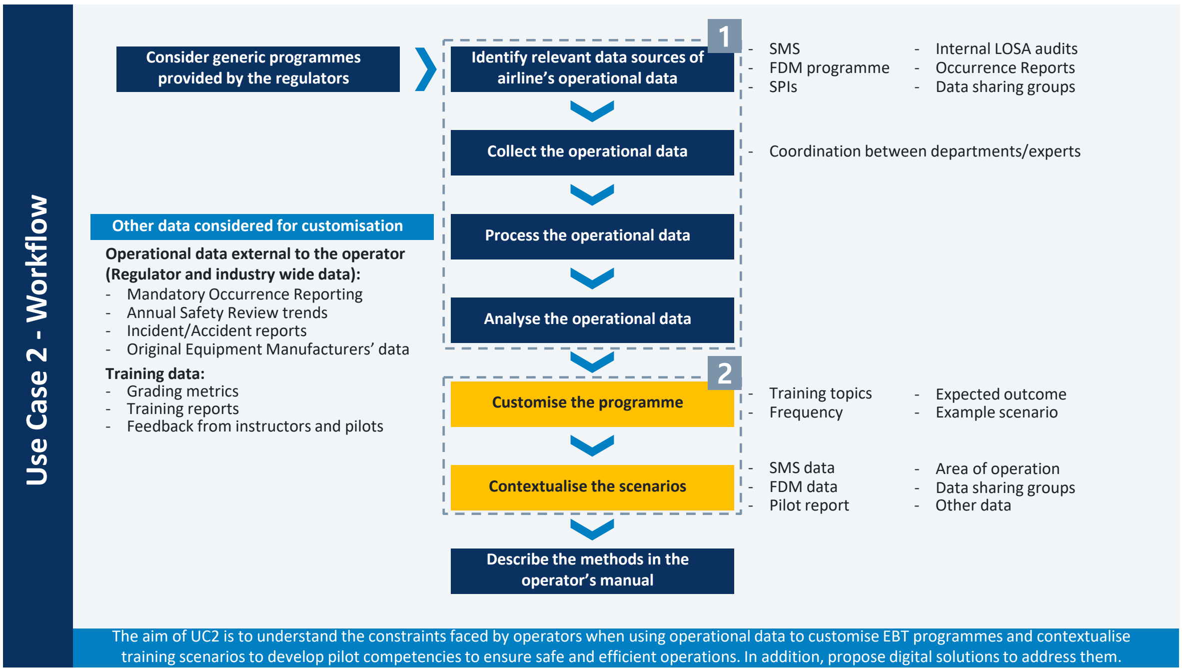
Solution package	Solutions included	Involved stakeholders (Definition, production, or implementation of the solution)	Data-related enablers
assisting training assessment and data analysis	related to the use of software or services supporting EBT evaluations • **UC3.1-SOL.5** - Regulatory requirements / Guidance Material explicitly capturing desirable capabilities for EBT software or services supporting EBT evaluations • **UC3.1-SOL.8** - Regulatory requirements / Guidance Material explicitly capturing desirable capabilities for data analysis supporting solutions to identify training needs and programme improvements • **UC3.1-SOL.9 –** Development and use of a generic data analysis tool for EBT programme • **UC3.1-SOL.10 –** Development of best-practices for the conduction of clustering analysis for training data • **UC3.1-SOL.13 –** Development and use of a generic tool for concordance analysis • **UC3.1-SOL.15 –** Implementation of a tool that allows the operators to manage the ICAP related data	• Oversee and support the adoption of digital tools to assist with data collection and the subsequent analysis of data (e.g., data collection tools supporting the instructors, data analysis tools regarding training needs identification and instructor concordance) • Define training programmes to enhance IT and analytical capabilities **Civil Aviation Authorities:** • Establish collaborative frameworks for coordination between authorities regarding data processes • Develop harmonised guidelines for data acquisition and analysis standards • Consider certification processes for personnel involved in EBT programmes approval and oversight **Operators:** • Consider the adoption of digital solutions and tools for digital data collection and analysis across the different areas of the EBT programmes	identification, instructor concordance assessment) • Details on current training programmes for personnel involved in the approval and oversight of EBT programmes

3.2 Use Case 3.2: Syllabus customisation and scenario contextualisation using operational data

The objective of UC3.2 is to provide details on how EBT programmes are customised and personalised to be adapted to the operators implementing them, as well as to understand the constraints faced by stakeholders and to propose solutions and assess their impact. Programmes customisation is based on various data sources, considering data external (e.g., industry wide data, data from the authority) and internal to the operator (e.g., the operator's own operational data, data collected through trainings in the context of EBT). These data are collected from the different origins, processed and finally analysed to design, adapt and continuously improve the training programme. In this way, it is possible to transform the generic programmes into tailored programmes for each operator.

The process followed by the operators is shown in Figure 3-3, where the main elements of the activity are reflected. The development of the use case has been focused on the core activities identified through the desk research and stakeholder consultation indicated by the dotted line in Figure 3-3 and summarised in Figure 3-4.

Figure 3-3 EBT programmes customisation workflow



For the purpose of simplifying the activities description, the activities of the workflow presented above have been grouped into two (2) key activities, indicated by the numbers in the previous figure. These activities are shown in the figure below and are described in depth in the subsequent sections of this document.

Figure 3-4 UC3.2 key activities

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3.2.1 Working process activities and limitations

3.2.1.1 Identification of relevant operational data sources for EBT and integration with safety department

To adapt EBT programmes to the specific needs of the operator, programmes are customised based on the current operational risks and the particular training needs identified from analysing the airline's operational data, the training data collected in the context of EBT and industry wide data external to the operator. The airline's operational data generally include key data sources such as SMS, FDM programme, SPIs, internal LOSA audits and Occurrence Reports. These allow the design and customisation of programmes to better meet the specific needs of the operator itself, enabling that pilots strengthen the development of defined competencies.

By collecting, structuring and analysing this data, it is possible to identify training needs that can be addressed by introducing specific training topics into the programme, following the process explained in the section ***3.2.1.2***, that allow to enhance the development of specific competencies. For this purpose and considering the major importance of safety data for the customisation of programmes, a proper integration between the airline's training and safety departments is essential.

3.2.1.1.1 Technology & Data

Operators must ensure that programmes are adapted to the needs of pilots and that the risks present in their daily operations are addressed. For this reason, it is necessary to identify and integrate data from different sources to identify the main points to be strengthened and improved.

In that regard and with the objective of properly customising the programmes, evidence is collected from both the operator's internal sources and from external sources. Furthermore, these data sources used for the customisation of the programmes can be classified in more detail according to whether they belong to the EBT programmes as such, or whether they are external to the programme:

- **Data from within the training activity and the EBT programme itself:** Including grading of the pilots, feedback from instructors/evaluators and pilots, deficiencies found in competencies, training session data, etc.
- **Data generated outside the EBT training programme**, including:
  - **Regulators and other industry wide data:** Data sources such as Mandatory Occurrence Reporting, Annual Safety Review trends and Original Equipment Manufacturers (OEM) data.
  - **Airline operational data:** Safety Management System (SMS) (e.g., Safety reports and incident data, results from safety audits and inspections, feedback from staff including pilots and other operational personnel), the Flight Data Monitoring (FDM) programme or Safety Performance Indicators (SPIs) are vital data sources for the EBT programmes.

Such data sources are highly relevant for identifying pilot training needs, both on an individual and group level, as well as for identifying improvements to be introduced into the programmes on a continuous basis.

Additionally, the collection and use of data from the Line Operations Safety Audits (LOSA) is also very beneficial as they focus more on human behaviours and provides a different perspective than the FDM data. It is interesting because pilots behave in a normal way, not as if they were in front of a test, and it allows to collect information in real environment. These evaluations are conducted by a network standard pilot, rather than instructors/evaluators, who observe and anonymously respond to a set of questions.

Finally, the data privacy component should not be neglected, and methodologies for data de-identification should be considered allowing to perform analysis at different levels while ensuring compliance with "just culture" policies, as well as regulating access to operational data ensuring data privacy. It must be guaranteed at all times that information is not used in a punitive manner.

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Limitations

- **UC3.2-TEC.1 – Lack of a common taxonomy shared between the safety and training departments:** In most operators, the training and the safety departments do not share a common taxonomy, which means that the exchange of safety events information to be introduced into the training programmes is not always efficient. An aspect that could help is that the data coming from the safety department is provided with a mapping to the competencies or the behaviours used in training. Thus, the communication would be smoother, and the training department could easily identify which training topics could contribute to mitigating the risks shared by safety. In that regard, work is being done in the working group C of EOFDM on the mapping between FDM methods and the proficiency check items of conventional training required per ORO.FC.230. Considering that, a similar direction could be explored for EBT.
- **UC3.2-TEC.2 – Need for protection of trainees from data misuse**: Considering that SMS requests training to include aspects in the programmes depending on the operation, the "just culture" and confidentiality aspects must be reinforced as they are crucial. Trainees must always be protected from data misuse.
- **UC3.2-TEC.3 – Limited interest from airlines in sharing their data**: EASA is waiting for Data4Safety to have a good and powerful programme to be able to bring data in and draw conclusions. Companies have little interest in sharing their data, which should always be de-identified, but it has a huge potential as it can provide a whole set of metrics. As well as being a privacy issue, there is also a competitive component.
- **UC3.2-TEC.4 – Need for encouraging the conduct of audits by the authority**: The operator is the main responsible for the programmes and the data to be incorporated, but the authorities should conduct more audits and gain more experience on EBT.

3.2.1.1.2 Organisation

The responsibility for the collection of data used for the customisation of EBT programmes mainly falls upon the airline's training department, but it involves collaboration between multiple departments within the airline and the aviation industry. In the most mature operators, the training department collaborates with other airline's departments such as the flight operations department and, specially, with the safety department. The training department requests the safety department to share trends and events that have been identified in the safety data, so that training programmes can be adapted and mitigating measures can be introduced into the programmes to respond to these potential risks. In that regard, ensuring that the safety department is able to acquire an understanding of the framework of competencies and behaviours that are used in training requires an effort of standardisation of the safety department on the operator's end, commonly materialised in EBT dissemination and promotion initiatives. What is observed is that, most mature operators are already implementing a type of mapping between safety events and training competencies, and they also have mixed profiles with both safety and training expertise. An example of this is safety staff who are also instructors/evaluators.

In addition, the training department also considers data provided by the authorities, since airlines must adhere to regulatory guidelines and standards set by aviation authorities and the training department works in compliance with these regulations while customising EBT programmes. The input from authorities and other industry stakeholders such as Original Equipment Manufacturers (OEM) is very valuable when customising programmes to address training needs and risks identified by the industry.

Limitations

- **UC3.2-ORG.1 – Need for strengthening the integration between the training and safety departments**: In less mature operators, the link between training and safety departments needs to be strengthened. More emphasis should be placed on encouraging a good working link and integration between the

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safety department and the training department. The most mature operators have improved a lot in this area since the start of the implementation, and it is considered to be essential for the correct development of the programmes.

- **UC3.2-ORG.2 – Limited support and recommendations from the authority**: The lack of support and recommendations from the authority translates into the operator mainly relying in the inner loop, mainly the training data, for the identification of training needs.
- **UC3.2-ORG.3 – Lack of data shared by the authority**: Operators do not use data from the authority, they do not ask for such data.
- **UC3.2-ORG.4 – Limited access to safety data and missing procedure:** Normally, there are few administrators and few training managers who can access the safety data, who are under an NDA, but in some cases the operators are missing a procedure, which is something that they could copy and paste but there is a manpower issue.
- **UC3.2-ORG.5 – The EBT Manager is given limited importance:** The figure of the EBT Manager is not promoted enough. He/she could potentially act as a gatekeeper to control how FDM data is extracted and used, and should be an instructor, accepted by the syndicate, uncorrupted, different from the training manager and in contact with the regulator. It could be promoted at EASA level, to have a regular EBT Manager meeting to find areas of improvement for the programmes.
- **UC3.2-ORG.6 – Need for increased awareness of responsibilities:** Not everyone is aware of their responsibilities. For people that is conducting the safety investigation is crucial to identify the root cause and all the nominated persons for crew training need to be actively involved in the SMS, attending the safety meetings and knowing their responsibilities.

3.2.1.1.3 Operations

Upstream customisation, understood as modifying the framework of competencies and training topics to be implemented, is something that is not usually considered by operators. They normally use the competency framework and the training topics provided by the regulator without introducing modifications, coming from the EBT DATA Report. The real customisation of the programmes takes place in-house, as a result of the interaction between the safety and the training departments. In the most mature operators, incipient initiatives for this coordination can be observed, which involves a governance framework of recurrent meetings where general safety trends and serious events are shared and discussed and are thus considered for tailoring specific training scenarios to mitigate the identified hazards. However, EBT is designed to develop competencies to solve underlying problems and errors inherent to the human being, the pilot, not just the most serious incidences. And that is where the challenge lies, at exploiting and jointly discussing relevant safety data, as an additional level of coordination between safety and training is required. FDM is vital for bringing the trainings closer to real operations and for deriving the introduction of certain situations that allow the training programmes to address specific identified risks. This is why it is so important that the training and safety departments have a good integration and communication that allows for a fluid exchange of information with the objective of customising the programmes.

Creating documentation reflecting the meetings discussion, the safety requests for training and how they will be introduced in the programmes is also very beneficial. Particular proposals from the safety department coming from observed trends in the safety data and included in the training programme should be recorded and documented. The changes integrated should be monitored to check their effectiveness.

Limitations

- **UC3.2-OPS.1 – Need to share more than just the most serious occurrences**: General things or serious occurrences are shared, but EBT is designed to solve the most common problems and mistakes, not just the most serious occurrences. FDM data is vital for EBT programmes and the integration between training and safety should be further enhanced. In addition, a proactive approach to safety should be promoted, generating proactive safety reports that capture leading indicators or precursor events, which could play a crucial role in enhancing safety. These reports could be valuable tools for identifying potential risks or issues before they escalate into serious occurrences, incidents or accidents. And as explained in the section ***3.1.1.4***, the bidirectional exchange of data between the training and safety departments could lead to even detecting potential risks before they appear in operations.

- **UC3.2-OPS.2 – Limited generation of documentation reflecting meeting discussions and programme implementations**: Something that mature operators find useful, but less mature operators do not normally do, is the generation of documentation that records what is discussed in meetings between safety and training departments, what is asked to be implemented and how it will be done. This documentation also facilitates the work of the authorities when performing audits and validating the programmes.

3.2.1.2 Customisation of the EBT programmes and contextualisation of scenarios

The customisation of the programmes consists of the introduction of training topics and scenarios derived from the analysis of the training needs and operational risks, allowing for programmes to better adapt to specific operators and trainees' needs. Such process of the customisation of the syllabi relies on evidence gathered to select the example scenario elements within a training topic and to contextualise the example scenario elements based on the operator's operational data (e.g., SMS and FDM programme) and training data. This customisation should be based on both internal and external data collected at three (3) different levels:

- **Inner loop:**
    - Individual evidence based on training data (e.g., grading metrics and training reports), analysed either for an individual pilot or a group of pilots;
    - Operator-specific evidence gathered through SMS;
- **Outer loop:**
    - Evidence gathered from external sources (e.g., safety plans from authorities, OEMs data).

Furthermore, reference training topics and scenarios are defined by the regulator in Appendices 2 to 6 of the ICAO Doc 9995 or in the AMC2 to AMC6 ORO.FC.232, which provides them considering the differences between the generation of aircraft. From these reference programmes provided by the regulators, and considering what has been discussed in the meetings between the training and safety departments, as well the abovementioned data inputs, the operators can determine the training topics and scenarios to be implemented, and how they will be distributed among the different modules.

Once the training topics and scenarios have been selected, operators are also required to use operational data for the contextualisation of the training scenarios, so that the training that is conducted and provided to pilots is as close as possible to the actual operations of the airline. By doing so, operators can ensure that trainees develop the defined competencies that are needed to be able to deal with any situation, both expected and unforeseen, that they may encounter in their actual day-to-day operations.

In that regard, syllabi can be customised at three different steps:

- **A syllabus for the whole pilots' population:** the operator customises the example scenario elements based on relevant operational data and the training topics within the module are the same. In this case, there would be a variety of different example scenario elements for the different crews within the same module.
- **Different syllabus or part of it for the different populations of pilots:** the module or part of the module is different for each population (e.g., different for the first officers and the captain, or by type of aircraft…) potentially including a different example scenario element for each population.

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- **Syllabi tailored to the individual pilot:** Individual syllabus customised for the pilot, linked to the procedures established for the tailored training and the additional training of the pilots.

In practice, most operators follow this explained process and use the training topics and reference scenarios provided by the regulator since they do not have the capacity to develop their own topics and scenarios.

3.2.1.2.1 Technology & Data

The aim of customising EBT programmes is to tailor them to the needs of operators, each of them having a different operational environment. For this reason, the outputs of the analyses performed are used, considering different sources of data, both from the operator itself and from the EBT training programmes themselves, as well as from regulators and the rest of the industry's stakeholders. All this information allows the operator to design its programme, following the guidelines and reference contents set by the authority, in a way that covers the training needs found and that can address the threats detected through the study of the airline's own operational data.

To ensure that the training scenarios included in the training programmes are as close as possible to the operator's actual operations, the use of the operator's own operational data such as the area of operation, SMS data, FDM data and pilots' reports is required for the contextualisation of the scenarios. That prepares pilots to handle a wide range of situations they may encounter during actual flight operations, since this contextualisation allow for training scenarios to closely represent real-world situations to help pilots develop the skills and knowledge they need to operate safely and effectively.

In terms of tools or solutions that facilitate the design of programmes, providing support in the selection of training topics and the training scenarios, it can be observed that the vast majority of operators use some basic tools that make the work easier but that are not too sophisticated. The same applies to the contextualisation of the chosen scenarios, another area where digital solutions could help to make the process simpler and with a higher level of detail and adaptation.

Limitations

- **UC3.2-TEC.5 – Basic tools used for the customisation of programmes:** Even if the tools used for the purpose of selecting the training topics and their frequency do work, it is generally observed that very basic tools are used (e.g., Excel sheets containing the training topics...) and this may be one of the areas where digital tools can be introduced to support the operators.
- **UC3.2-TEC.6 – Potential need for tools to assist in the scenario contextualisation:** Although the area where the introduction of digital solutions should be prioritised as a first step is the instructor concordance assurance, the next step could be to have a software to assist in the scenario contextualisation.

3.2.1.2.2 Organisation

The responsibility to customise EBT programmes mainly falls upon the airline's training department. The training department, typically headed by training managers, has a key role in tailoring EBT programmes. It is responsible for designing, developing, and implementing EBT programmes and they work together with subject matter experts and other stakeholders to ensure that training topics, scenarios, and content of the programmes are aligned with the operator's specific operational environment. This includes defining training modules, scenarios, and assessments that fit with the airline's operations and safety goals.

The EBT Manager is responsible, among other functions, for developing and implementing the EBT programme based on industry best practices, regulatory guidelines, and the airline's operational context. He/she also oversees the customisation process and manages the coordination of various stakeholders.

On top of that, the authority is also required to oversee and to ensure that the programmes are properly adapted and that any customisations made are in line and still comply with aviation regulations and guidelines.

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Limitations

- **UC3.2-ORG.7 – Difficulty in creating an environment similar to actual operations**: Different behaviours are observed in the simulator than in normal operation. It is difficult to create a realistic environment aligned with the real operations, and the instructor and the design of the module are very important to achieve it.

3.2.1.2.3 Operations

EBT programmes are designed based on the selection and adaptation of the training topics and scenarios defined in Appendices 2 to 6 ICAO Doc 9995 or AMC2 to AMC6 ORO.FC.232, which are used as a reference and that depend on the aircraft generation. The operator determines the distribution of training topics from these tables, considering its indicated frequency and their distribution among the different phases of the module. The expected outcome of the training is then defined and the example scenario element for each training topic is chosen and contextualised with the airline's operational data. These scenarios can involve emergencies, abnormal procedures, challenging weather conditions, technical failures, and other critical situations that pilots might face during actual flights.

This customisation is performed considering what has been agreed in the meetings held with other departments, mainly the safety department, and the outputs of the data analysis, all of which indicate what are the main areas to be reinforced during the programmes. The tables provided by the regulators have a final column indicating which competencies are relevant to each of the training topics and scenarios, thus making it easier to determine which scenarios should be included to respond to the identified needs.

Limitations

- **UC3.2-OPS.3 – Adapting the mapping between training topics and competencies**: Operators who have managed to collaborate with the safety department to have a common language and a competency mapping for the events that the safety department provides to training, consider that the AMC tables containing the training topics should be shifted to place the competencies at the beginning rather than at the end of the table, thus facilitating to select the training topics based on the competencies to be reinforced.
- **UC3.2-OPS.4 – Lack of capacity among the operators to create their own training topics**: Almost none of the operators currently have the capacity to implement their own training topics. It is clear that, at least for now, operators should not modify the training topics or their frequency. Operators should go to the tables, which will be updated upon new release of the EBT Data Report and take the training topics for the programmes

3.2.2 Limitations overview

The customisation of the EBT programmes presents a number of challenges and limitations that are manifested across different operational dimensions. This section presents a consolidated overview of all identified challenges, classified into the three (3) key categories (Technology and Data, Organisation and Operations), and categorised according to their corresponding process activity.

Table 3-4 Overview of limitations identified for Use Case 3.2

Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**
Identification of relevant operational data sources for EBT and integration with safety department	• UC3.2-TEC.1 – Lack of a common taxonomy shared between the safety and training departments • UC3.2-TEC.2 – Need for protection of trainees from data misuse • UC3.2-TEC.3 – Limited interest from airlines in sharing their data • UC3.2-TEC.4 – Need for encouraging the conduct of audits by the authority	• UC3.2-ORG.1 – Need for strengthening the integration between the training and safety departments • UC3.2-ORG.2 – Limited support and recommendations from the authority • UC3.2-ORG.3 – Lack of data shared by the authority • UC3.2-ORG.4 – Limited access to safety data and missing procedure • UC3.2-ORG.5 – The EBT Manager is given limited importance • UC3.2-ORG.6 – Need for increased awareness of responsibilities	• UC3.2-OPS.1 – Need to share more than just the most serious occurrences • UC3.2-OPS.2 – Limited generation of documentation reflecting meeting discussions and programme implementations
Customisation of the EBT programmes and contextualisation of scenarios	• UC3.2-TEC.5 – Basic tools used for the customisation of programmes • UC3.2-TEC.6 – Potential need for tools to assist in the scenario contextualisation	• UC3.2-ORG.7 – Difficulty in creating an environment similar to actual operations	• UC3.2-OPS.3 – Adapting the mapping between training topics and competencies • UC3.2-OPS.4 – Lack of capacity among the operators to create their own training topics

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3.2.3 Proposed digital solutions to address limitations

In an attempt to tackle the limitations identified from the different interviews with stakeholders, and described throughout each section of the activities present in the Use Case 3.2, a range of solutions have been proposed and are presented in detail in the following table:

➡ **Table 3-5** Proposed solutions identified for Use Case 3.2

Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data		
Limitation	**Solution**	**Description**
UC3.2-TEC.1 – Lack of a common taxonomy shared between the safety and training departments	**UC3.2-SOL.1** - Development of best-practices to map FDM event definition and EBT competencies and training topics	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines and industry best-practices to map FDM event definitions with EBT competencies and training topics. Some mature operators have implemented some methods to smooth the sharing of data between the safety and the training departments. In those cases, the data coming from the safety department is provided with a mapping to the competencies or the behaviours used in training. In that way, the training department is able to easily identify which training topics should be introduced into the programmes since they could contribute to mitigating the risks shared by safety. In that regard, work is being done in the working group C of EOFDM on the mapping between FDM events and the proficiency check items of conventional training as per ORO.FC.230. Considering that, a similar direction could be explored for EBT and best-practices could be developed and provided. The key aspects to be considered are the following: • Determine which FDM events and parameters are relevant and are strongly linked with the EBT competencies, and are then suitable for establishing a link • Establish a mapping framework that links specific FDM event definitions to the relevant EBT competencies, based on experts and industry input • Provide recommendations on the appropriate cooperation framework that allows the safety and the training department to efficiently share the data (e.g., establishing a framework of recurrent meetings where data is exchanged and jointly discussed) • Recommend performance thresholds or criteria for each competency that indicate when a training need may exist • Provide recommendations on how to select training topics for the programmes based on the identified needs and considering the defined mapping between the FDM events and the EBT competencies (e.g., using the tables containing the training topics and scenarios for each aircraft generation and provided by the authority)
UC3.2-TEC.2 – Need for protection of trainees from data misuse	**UC3.2-SOL.2** - Development of GM/AMC for avoiding operational data misuse	Develop guidelines for avoiding operational data misuse, especially safety data, to ensure that the use of the data is justified, enabling safe sharing and collaboration across departments while ensuring the confidentiality and privacy of sensitive information. Guidelines should be provided considering that operators should follow data privacy and "just culture" policies, so that trainees remain protected, while also retaining the analytical value. The aspects on which guidance should be provided are: • Complexities of accessing data that may not be controlled by a single department (e.g., FDM data is controlled and distributed by the safety department and the training department needs access to consider it for the

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Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data		
Limitation	**Solution**	**Description**
		customisation of the programmes). Thus, the guidelines should recommend mechanisms for seamless data sharing and collaboration between departments in an effective and ethic manner. • Potential de-identification techniques (e.g., blanking or aggregation) that ensure that sensitive information cannot be traced back to individuals or other operational characteristics • Specific guidelines regarding access controls and data sharing protocols within the organisation, limiting who can access operational and safety data • Development of Non-Disclosure Agreements (NDAs) to be signed by trainees and employees to protect sensitive data and prevent its misuse • Environments or technologies for secure data storage • Establishing mechanisms for performing monitoring and oversight on a regular basis, ensuring that the data usage is as expected • Developing a mechanism that allows the trainees or the instructors to report any incidence related to the data misuse, while promoting a feedback process • Promote transparency and ensure that the pilots are aware and understand how their data is used • Potential formation of a committee or syndicate who is responsible for ensuring that pilots rights are respected and that there is no data misuse, intervening if there is any discrepancy • Define the consequences in the case of any training data misuse or abuse of power
UC3.2-TEC.3 – Limited interest from airlines in sharing their data	**UC3.2-SOL.3** - Initiatives for promoting collaborative data sharing programmes	Incentivise the promotion of collaborative data programmes (e.g., Data4Safety) that could potentially provide data for the operators' programmes at national or European level, enabling a better customisation of the programmes, even filling data gaps that may be present in some operators' data (e.g., airports or routes for which not information is available since an operator does not operate there). Aviation stakeholders, including operators, regulatory authorities, industry associations, and safety organisations, should be encouraged to collaborate in establishing and supporting data-sharing programs aiming to collect, analyse, and disseminate data regarding different areas of the EBT programmes. Given the significant benefits and advances that can be triggered by the implementation of such programmes: • The potential added value for operators willing to participate should be underlined and promoted (e.g., access to information from other countries or regions, enhanced benchmarking capabilities, additional training needs identification capabilities, standardisation across the industry, networking and collaboration opportunities) • The safety improvements that can result from data sharing should be highlighted, promoting a strong safety culture among all the industry stakeholders • Tangible incentives, benefits and recognition to operators for participating in data sharing programmes should be explored and established (e.g., reduced regulatory reporting burdens, access to shared safety insights, or cost-sharing opportunities)
UC3.2-TEC.4 – Need for encouraging the conduct of audits by the authority	**UC3.2-SOL.4** - Development of best-practices that recommend a minimum number of audits or site visits	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines and industry best-practices that recommend the conduction of a minimum number of audits or site visits by the authorities, including recommendations on how to perform them.

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Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data

Limitation	Solution	Description
UC3.2-TEC.5 – Basic tools used for the customisation of programmes	**UC3.2-SOL.5** - Regulatory requirements / Guidance Material explicitly capturing desirable capabilities for EBT software regarding programmes' customisation	In the scenario in which digital tools are introduced to support operators in the process of customising the EBT programmes (e.g., selecting specific training topics and scenarios, structuring the programmes considering provided and required frequencies for the training topics…), guidelines should be developed defining the requirements to be met by the software to be implemented, mainly regarding the following areas: • Data gathering: What type of data is used and from which sources is collected • Customisation methodologies: Methodologies to be followed when performing the customisation of the programmes, providing step-by-step examples • Data integration: Methodologies to be used aiming to fuse data from different sources and from the different involved departments • Automation level: What level of automation can be achieved, always considering that the operator, usually the EBT manager or the training manager, is the main responsible for designing and adapting the programmes • Quality Assurance: Regularly ensure that the outputs of the software used are reliable • Alignment with regulation: Ensure that any support provided for the design and adaptation of the programmes remains aligned with the regulation
UC3.2-TEC.6 – Potential need for tools to assist in the scenario contextualisation	**UC3.1-SOL.6** - Regulatory requirements / Guidance Material explicitly capturing desirable capabilities for EBT software regarding the contextualisation of scenarios	Guidelines should be developed defining the requirements to be met by the software to be implemented, mainly regarding the following areas: • Data gathering: What type of data is used and from which sources is collected • Contextualisation methodologies: Methodologies to be followed when performing the contextualisation of scenarios, providing step-by-step examples. • Data integration: Methodologies to be used aiming to fuse data from different sources and from the different involved departments • Automation level: What level of automation can be achieved, always considering that the operator, usually the EBT manager or the training manager, is the main responsible for contextualising the scenarios to be included in the training programmes • Complexity: Creation of scenarios of varying complexity to challenge learners at different proficiency levels. • Library of scenarios creation: Ensure that the tool is able to provide a wide variety of scenarios and that the scenarios cover the defined competencies and training objectives. In addition, ensure that sufficient different scenarios are generated to prevent predictability. • Quality Assurance and Scenario Validation: Regularly ensure that the outputs of the software used are reliable, testing any scenario that is introduced into the programmes. • Checking alignment with operational context and data: Ensure that any generated scenario that is introduced into the programmes is aligned with the airline's actual operations, including the type of aircraft and routes, and real-world operational situations are reproduced • Alignment with regulation: Ensure that any support provided for the contextualisation of the scenarios remains aligned with the regulation

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Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data

Limitation	Solution	Description
UC3.2-ORG.1 – Need for strengthening the integration between the training and safety departments	**UC3.2-SOL.7 –** Development of best-practices on how to ease integration and governance of safety and training department cooperation	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines and industry best-practices on how to ease integration and governance of safety and training department cooperation in the context of EBT programmes. The best-practices should address key points including: • Specifying what type of data sources should be used and provide orientation on what type of events or occurrences shall be considered susceptible for the sharing of data between safety and training. • Promotion and recommendation of cross-departmental initiatives such as the establishment of a framework of recurrent meetings or workshops where the safety department shares data with the training department to be jointly discussed and analysed with the aim of introducing it to adapt the training programmes and introducing mitigating measures. In that regard, it has been observed that the most advanced operators are implementing that type of approach, including the conduction of meetings prior to the start of each EBT module. • Creation of documentation reflecting what has been discussed in the meetings and what has been included in the training programmes. In this respect, advanced operators create such documentation which allows them to have a record of the content of the meetings, as well as to monitor the effectiveness of what has been introduced into the programmes based on a safety input. • Development and implementation of training initiatives that enable both training and safety departments to gain an understanding of each other's procedures and activities (e.g., safety department becoming familiarised with the competencies used in training). Such initiatives can lead to improved standardisation in both departments. • Importance of the role of cross profiles with experience in both training and safety, in addition to data analytics. The most advanced operators have personnel who are proficient in all these areas, such as safety staff who are also instructors, and profiles that have extensive experience in the field of data analysis within one of these two departments. • Collaborative development of training scenarios, with the input of data and personnel support from the safety department. Therefore, involve safety experts in the development of training scenarios to ensure that they align with real safety risks and challenges, helping to fill the gap between training and operational safety. • Potential introduction of metrics and indicators common to safety and training that both departments can track.
	UC3.2-SOL.8 - Development of guidelines and industry best-practices to integrate / fuse inner loop data (safety-relevant and training data) for customisation and contextualisation of scenario elements	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines and industry best-practices to integrate / fuse inner loop data (safety-relevant and training data) for customisation and contextualisation of scenario elements. The fact that data sources with different origins have to be used for the customisation of programmes (e.g., safety data, training data) implies the need for the development of guidelines for data source integration to mitigate compatibility issues and ensure data accuracy and completeness. The guidelines should include best practices regarding: • Identification of the specific sources of training and safety data that will be considered for customisation of the programmes and that are susceptible to undergo the fusion process. • Compatibility of the different data sources, considering factors such as data formats, protocols, and frequencies. Define data standards and formats to ensure consistency and compatibility between different data sources (e.g., Integration protocols and standards that operators can follow when combining data from diverse sources).

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Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data		
Limitation	**Solution**	**Description**
		• Establishment of the ownership of the data from the various sources and establishment of data sharing agreements • Establishment of data governance policies and procedures • Definition of the methods and technologies to be used for the integration of data (e.g., data warehousing, ETL processes, data lakes) • Mapping data fields between different sources, to be able to perform the merging effectively. • Algorithms, techniques and methodologies to merge and analyse data from various sources (e.g., statistical methods, machine learning, artificial intelligence) • Strategies to identify and address data gaps, ensuring data completeness and quality assurance processes to continuously monitor and improve the accuracy, completeness, and reliability of fused data Defining and providing clarity and guidance in terms of the presented aspects could translate into better data insights and improved safety achieved through a sophisticated adaptation and customisation of the programmes effectively integrating safety and training concerns.
	UC3.2-SOL.9 - Regulatory requirements / Guidance Material explicitly capturing the need for integration of the EBT programme with the operator's management system to be used together with other relevant data sources for supporting safety risk management (SRM) and evaluate effectiveness of mitigation actions	Covered with **UC3.2-SOL.7 – Development of best-practices on how to ease integration and governance of safety and training department cooperation**, but complemented with the monitoring and effectives of the mitigation actions
	UC3.2-SOL.10 - Regulatory requirements to explicitly cover integration between FDM and EBT, identifying requirements for transmission of information and scope of data to be shared, similar to the FDM-related conditions captured in AMC1 ORO.FC.A.245 for ATQP programmes	Covered with **UC3.2-SOL.1 - Development of best-practices to map FDM event definition and EBT competencies and training topics**, but complemented with the required transmission channels
UC3.2-ORG.4 – Limited access to safety data and missing procedure	**UC3.2-SOL.11** – Development of procedures to foster the access to safety data for training managers ensuring a secure access	Promote the development of Non-Disclosure Agreements (NDAs) to be signed by those employees who would be allowed to access the safety data, which will include key aspects including: • Definition of the involved personnel • Purpose an NDA • Definition of what constitutes confidential information (e.g., type of data, documents…)

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Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data

Limitation	Solution	Description
		• Definition of the responsibilities of the involved parties • Consequences in the event of a breach of the NDA or unauthorized disclosure In addition to the development of NDAs, best-practices and recommendations regarding the procedures to manage the access to safety data should be provided, considering the input from the most experienced operators. Also in that regard, the provision of training to the training department personnel on the proper handling of safety data, including data security, confidentiality, and legal requirements should be considered.
UC3.2-ORG.5 – The EBT Manager is given limited importance	**UC3.2-SOL.12 –** Promote the figure of the EBT Manager	The figure of the EBT should be promoted and the importance of a role that has a key contribution in the EBT programmes should be highlighted. In this regard, guidance and recommendations should be given on the following topics: • Definition of the responsibilities, authority, and objectives of the EBT Manager within the organisation • Definition of the desired requirements regarding the role of an EBT Manager (e.g., EBT Manager should be an instructor, accepted by the syndicate, uncorrupted, well-connected with the regulator…) • Potential inclusion of EBT managers in the working groups and encourage their participation in the development of guidance material targeting the key industry’s stakeholders • Clear differentiation of the EBT Manager and Training Manager positions or roles • Collaboration between the EBT Manager and other departments, such as safety or operations, underlining the role's importance in bridging these departments • Ensuring that the EBT Manager has advanced analytical capabilities to evaluate training data, safety data and performance metrics • Potential additional roles to be performed by the EBT Manager (e.g., acting as the gatekeeper for monitoring the correct collection and use of the safety data) Additionally, it could be promoted at EASA level, to have regular EBT Manager meetings to find areas of improvement for the programmes. These meetings could serve as a means to share improvements, lessons learnt or even data among operators, all of this contributing to the continuous enhancement of the programmes and to the exposure of the EBT Managers.
UC3.2-ORG.6 – Need for increased awareness of responsibilities	**UC3.2-SOL.13 –** Development of Guidance Material for the definition of the responsibilities for the staff involved in EBT programme	Everybody who is involved in the EBT programmes should have a clear understanding of their responsibilities. In that regard, guidance material that clearly defines the roles and responsibilities of the potentially involved staff should be developed and published for guidance purposes, including: • Guidance that outlines the role, scope and responsibilities of the key staff involved in the EBT programmes • Recommendations on the specific trainings to be provided to each key role focusing on their defined responsibilities (e.g., role-specific workshops or meetings) • Recommendations on specific initiatives such as offering coaching services to help certain staff to help them better understand their particular functions • Encouraging the implementation of feedback mechanisms to allow the staff to raise specific doubts regarding their position

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Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data		
Limitation	**Solution**	**Description**
		• Encouraging fluid communication between different departments or roles to help them to have a clear picture of the functions performed by other staff members
UC3.2-ORG.7 – Difficulty in creating an environment similar to actual operations	**UC3.2-SOL.14 –** Development of Guidance Material for a proper EBT programme adaptation including realistic training scenarios	Develop guidelines for assisting operators in adapting the programmes and the training scenarios for creating an environment that properly mimics the real operations. The key components of these guidelines should include: • Guidelines on the simulator technology to be used, ensuring that the operators use state-of-the-art simulator technology that closely replicates real operations • Recommendations and detailed explanations on how to develop training scenarios that closely mimic real-world operational situations, and on creating a realistic environment for the trainings • Definition of the responsibilities of the different members involved in the design of the programmes and scenarios, highlighting the importance of the role of the EBT Manager and the instructors in this area • Promoting cross collaboration among instructors, pilots, expert safety staff, and EBT Managers, leading to continuous improvement of the trainings' design • Recommendations on the conduction of specific data analysis to identify discrepancies between simulator and actual performance
UC3.2-OPS.1 – Need to share more than just the most serious occurrences		Solution **"UC3.2-SOL.7 – Development of best-practices on how to ease integration and governance of safety and training department cooperation"** applies.
UC3.2-OPS.2 – Limited generation of documentation reflecting meeting discussions and programme implementations		Solution **"UC3.2-SOL.7 – Development of best-practices on how to ease integration and governance of safety and training department cooperation"** applies. Specifically, the aspect on encouraging and providing recommendations on the creation of documentation reflecting what has been discussed in the meetings that are conducted between the training and safety departments, reflecting what has been included in the training programmes after jointly discussing the provided data. It should be emphasised that this type of documentation can be very useful to properly monitor the effectiveness of the measures introduced in the programmes, as well as being a way to facilitate the conduction of audits by the authority.
UC3.2-OPS.3 – Adapting the mapping between training topics and competencies	**UC3.2-SOL.15** - Publication of additional or alternative tables for training topics and scenarios selection	Currently, EBT programmes are designed based on the selection and adaptation of the training topics and scenarios defined in Appendices 2 to 6 ICAO Doc 9995 or AMC2 to AMC6 ORO.FC.232, which include a mapping of the involved competencies for each defined training topic and scenario. In that regard, for all those operators starting to implement a mapping between FDM events and the training competencies or behaviours, it would be very useful to have tables that allow operators to select training topics and scenarios for the competencies to be trained.

As it can be observed in the previous table, no solution has been assigned for some of the limitations found for the different activities of the Use Case 3.2 due to the following:

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- For the solutions **"UC3.2-ORG.2 – Limited support and recommendations from the authority"** and **"UC3.2-ORG.3 – Lack of data shared by the authority"**, although they are limitations that also affects UC 3.2, they are addressed and covered by solutions provided in UC 3.3 because they are mainly related to the role of the authority and its relationship with the operators in the context of EBT programmes.
- In the case of limitation "**UC3.2-OPS.4 – Lack of capacity among the operators to create their own training topics"**, there is a lack of maturity and resources of operators in the EBT context to be able to develop their own scenarios, so they should currently continue to use the training topics and scenarios provided by the authority. As time advances and more operators implement EBT programmes, maturity will be built up and the programmes will gradually become more sophisticated, possibly enabling operators to be capable of introducing their own training scenarios based on their data.

3.2.4 Proposed solution packages

The potential digital solutions proposed in Section 3.2.3 have been strategically grouped into package solutions, drawing upon their commonalities and distinctive natures within the context of EBT programmes. The first category, encompassed within 'Safety promotion'. pertains to topics that are yet to find comprehensive industry-wide guidance and thus demand the initiation of industry-defined standards and development of industry best-practices. The second category, 'Regulatory initiatives' involving Guidance Material or Acceptable Means of Compliance, represents topics that have reached a level of maturity suitable for integration into formal regulations. Lastly, the third category, 'Innovation & Technology', centres on topics that may not be easily confined to regulatory frameworks but support the adoption and integration of digital solutions and capabilities. This categorisation enables a more focused approach to addressing the multifaceted challenges faced in EBT Programmes, ensuring that each package solution is tailored to its unique context and readiness for implementation.

Table 3-6 Solution package to address limitations of Use Case 3.2

Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
Solution package - Safety Promotion			
UC3.2-PS.1 – Safety Promotion regarding integration of relevant safety data within the EBT programmes	• **UC3.2-SOL.1** - Development of best-practices to map FDM event definition and EBT competencies and training topics • **UC3.2-SOL.8** - Development of guidelines and industry best-practices to integrate / fuse inner loop data (safety-relevant and training data) for customisation and contextualisation of scenario elements	**Aviation industry bodies and associations:** • Facilitate the definition of best-practices regarding the processes for programme customisation and scenario contextualisation by bringing together experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data analysts and data scientists to bring their expertise to the development of data analysis methods focused on the training needs identification, EBT experts to provide their experience on the proper adaptation of	• Criteria and methodology used for the customisation of the programmes and the contextualisation of scenarios • Data and parameters considered for the customisation of the programmes and the contextualisation of scenarios • List of metrics currently used for training needs identification based on the operational data • Methodology and techniques applied for training needs identification • Information about the defined mapping between safety and training data (e.g., mapping between FDM methods and competencies or training topics, if defined

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Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
		the programmes and scenarios, EBT and FDM experts to collaborate on the definition of a mapping between FDM and competencies or training topics) • Collaborate with operators and regulatory authorities to ensure alignment with industry standards • Promote for the adoption of best practices across the aviation industry • Establishing mechanisms for monitoring the implementation of best practices within the industry and gather feedback from stakeholders	• De-identification techniques used for analysing operational data respecting "just culture" policies • Information on the algorithms and pseudocodes employed for analysing and validating operational data • Information on data fusing algorithms or methodologies • Details on current processes used to approve and audit data-related processes (e.g., data fusion, integration of safety data, analyses for training needs identification) • Data and metrics provided to the operators for the customisation of the programmes
UC3.2-PS.2 – Safety Promotion regarding the proper governance of safety and training departments cooperation	• **UC3.2-SOL.4** - Development of best-practices that recommend a minimum number of audits or site visits • **UC3.2-SOL.7** – Development of best-practices on how to ease integration and governance of safety and training department cooperation • **UC3.2-SOL.11** – Development of procedures to foster the access to safety data for training managers ensuring a secure access	**Regulatory authorities:** • Review the development of best-practices and ensure that they align with regulatory standards and requirements • Promote for the adoption of best practices across the aviation industry • Assess the feasibility of publishing the best-practices as GM or AMC • **Civil Aviation Authorities:** • Oversee the processes and methods used for the customisation of the programmes and the contextualisation of the scenarios • Perform the oversight of the integration and collaboration mechanisms between the operators' training and safety departments **Operators:** • Adopt and implement the best-practices in their processes and day-to-day operations • Collaborate with industry bodies and regulatory authorities in the development and refinement of best practices • Train their personnel in the application of best practices • **Providers:** • Implement and adhere to the best-practices • Collaborate with operators to ensure that the provided data solutions align with best practices	• Criteria and methodology used for the customisation of the programmes and the contextualisation of scenarios • Data and parameters considered for the customisation of the programmes and the contextualisation of scenarios • List of metrics currently used for training needs identification based on the operational data • Methodology and techniques applied for training needs identification • Protocols and processes for sharing data from the safety to the training department • Data management and data access methodologies used with the shared safety data • Information on the documentation process for the meetings between safety and training, if performed • Methodology to monitor the effectiveness of the introduced measures • Details on current processes used to approve and audit data-related processes (e.g., integration of safety data, analyses for training needs identification) • Data and metrics provided to the operators for the customisation of the programmes

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<table>
<tr><th colspan="4">Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data</th></tr>
<tr><th>Solution package</th><th>Solutions included</th><th>Involved stakeholders
(Definition, production, or implementation of the solution)</th><th>Data-related enablers</th></tr>
<tr><td colspan="4">Solution package - Regulatory initiatives (Guidance Material or Acceptable Means of Compliance)</td></tr>
<tr><td>UC3.2-PS.3 – Regulatory initiative regarding the staff's responsibilities</td><td>• UC3.2-SOL.12 – Promote the figure of the EBT Manager
• UC3.2-SOL.13 – Development of Guidance Material for the definition of the responsibilities for the staff involved in EBT programme</td><td rowspan="2">Regulatory authorities:
• Develop and implement the regulatory initiatives, potentially GM and/or AMC
• Collaborate with operators and other related stakeholders to ensure alignment with their specific needs
• Collaborate with experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data analysts and data scientists to bring their expertise to the development of data analysis methods focused on the training needs identification, EBT experts to provide their experience on the proper operational data usage and on the creation of a training environment that mimics the real operations)
• Promote the adoption of GM/AMC across the industry
• Establishing mechanisms for monitoring the implementation of GM/AMC within the industry and gather feedback from stakeholders
Civil Aviation Authorities:
• Oversee the processes and methods used for the customisation of the programmes and the contextualisation of the scenarios
• Perform the oversight of the integration and collaboration mechanisms between the operators' training and safety departments
Operators:
• Implement GM/AMC for a proper programme customisation, using realistic scenarios and including operational or safety relevant data as a result of a good integration with the safety department
• Collaborate with regulatory authorities in the development and refinement of GM/AMC
• Train their personnel in the application of GM/AMC</td><td>• Current responsibilities of the staff involved in the EBT programmes'
• Functions performed by the EBT Manager
• Criteria and methodology used for the customisation of the programmes and the contextualisation of scenarios
• Methodology and techniques applied for training needs identification
• Current mechanisms employed for avoiding operational data misuse
• Protocols and processes for sharing data from the safety to the training department
• Data management and data access methodologies used with the shared safety data
• De-identification techniques used for analysing operational data respecting "just culture" policies
• Information on the documentation process for the meetings between safety and training, if performed
• Methodology to monitor the effectiveness of the introduced measures
• Current responsibilities of the staff involved in the EBT programmes' approval and oversight
• Details on current processes used to approve and audit data-related processes (e.g., data fusion, integration of safety data, analyses for training needs identification)</td></tr>
<tr><td>UC3.2-PS.4 – Regulatory initiative regarding the proper integration between the EBT training programme and the safety department processes</td><td>• UC3.2-SOL.2 - Development of GM/AMC for avoiding operational data misuse
• UC3.2-SOL.9 - Regulatory requirements / Guidance Material explicitly capturing the need for integration of the EBT programme with the operator's management system to be used together with other relevant data sources for supporting safety risk management (SRM) and evaluate effectiveness of mitigation actions</td><td>• Criteria and methodology used for the customisation of the programmes and the contextualisation of scenarios
• Data and parameters considered for the customisation of the programmes and the contextualisation of scenarios
• Safety data shared with the training department and considered for the customisation of the programmes
• List of metrics currently used for training needs identification based on the operational data
• Methodology and techniques applied for training needs identification
• Current mechanisms employed for avoiding operational data misuse</td></tr>
</table>

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Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data

Solution package	Solutions included	Involved stakeholders (Definition, production, or implementation of the solution)	Data-related enablers
	• **UC3.2-SOL.10 -** Regulatory requirements to explicitly cover integration between FDM and EBT, identifying requirements for transmission of information and scope of data to be shared, similar to the FDM-related conditions captured in AMC1 ORO.FC.A.245 for ATQP programmes	**Providers:** • Collaborate with regulatory authorities in the development and refinement of GM/AMC • Ensure that the provided solutions adhere to the GM/AMC	• Protocols and processes for sharing data from the safety to the training department • Information about the defined mapping between safety and training data (e.g., mapping between FDM methods and competencies or training topics, if defined • Data management and data access methodologies used with the shared safety data • De-identification techniques used for analysing operational data respecting "just culture" policies • Information on the documentation process for the meetings between safety and training, if performed • Information on the algorithms and pseudocodes employed for analysing and validating operational data • Information on data fusing algorithms or methodologies • Methodology to monitor the effectiveness of the introduced measures • Details on current processes used to approve and audit data-related processes (e.g., data fusion, integration of safety data, analyses for training needs identification) • Data and metrics provided to the operators for the customisation of the programmes
UC3.2-PS.5 – Regulatory initiative regarding the customisation of the programmes and contextualisation of scenarios	• **UC3.2-SOL.14** – Development of Guidance Material for a proper EBT programme adaptation including realistic training scenarios • **UC3.2-SOL.15 -** Publication of additional or alternative tables for training topics and scenarios selection		• Criteria and methodology used for the customisation of the programmes and the contextualisation of scenarios • Data and parameters considered for the customisation of the programmes and the contextualisation of scenarios • Safety data shared with the training department and considered for the customisation of the programmes • List of metrics currently used for training needs identification based on the operational data • Methodology and techniques applied for training needs identification • De-identification techniques used for analysing operational data respecting "just culture" policies • Methodology to monitor the effectiveness of the introduced measures • Details on current processes used to approve and audit data-related processes (analyses for training needs identification, contextualisation of the scenarios)

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Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
			• Data and metrics provided to the operators for the customisation of the programmes
Solution package – Innovation & Technology			
UC3.2-PS.6 – Initiatives to support the adoption of digital tools and capabilities for assisting on the customisation of the programmes	• **UC3.2-SOL.3** - Initiatives for promoting collaborative data sharing programmes • **UC3.2-SOL.5** - Regulatory requirements / Guidance Material explicitly capturing desirable capabilities for EBT software regarding programmes' customisation • **UC3.1-SOL.6** - Regulatory requirements / Guidance Material explicitly capturing desirable capabilities for EBT software regarding the contextualisation of scenarios	**Regulatory authorities:** • Develop guidelines to facilitate the adoption of digital solutions, and define the requirements to be met by the tools implemented • Oversee and support the adoption of digital tools to support the customisation of the programmes and the scenario contextualisation (e.g., training topics selection and distribution considering required frequencies, integration of the data coming from the safety department for the scenario contextualisation) • Define training programmes to enhance IT and analytical capabilities **Civil Aviation Authorities:** • Establish collaborative frameworks for coordination between authorities regarding data processes • Consider certification processes for personnel involved in EBT programmes approval and oversight **Operators:** • Consider the adoption of digital solutions and tools for the customisation of the EBT programmes and training scenarios contextualisation	• Details on current tools used for the customisation of the programmes and the contextualisation of scenarios • Details on current tools used for the integration of the shared operational data (e.g., data coming from the safety department) • Details on current training programmes for personnel involved in the approval and oversight of EBT programmes

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3.3 Use Case 3.3: Authorities support and role within EBT programmes

The Use Case 3.3 has changed from the definition originally adopted and presented in the previous deliverable "D1.2 Case study work plan, including analysis methods", aimed to analyse and develop a "Data-driven approach to support the derivation of training topics for CBTA programmes". Since CBTA is a wider concept and its current maturity is limited in the European context, the scope of Use Case 3.3 has been shifted to address the role of the authority in EBT programmes and their current challenges. EBT is much more of a challenge for NAAs than CBTA because CBTA is available without approval within the existing regulatory framework, however the output of this project will also provide significant guidance for NAAs overseeing operators progressing with CBTA programmes.

Regarding EBT, the role of national aviation authorities in the programmes is to regulate, oversee, and promote the implementation of EBT to enhance the safety and effectiveness of pilot training. Close collaboration and communication with the authorities is essential for the operators, since EBT programmes should rely on the usage of operational data. This data usually comes from the regulator and industry (e.g., Mandatory Occurrence Reporting, Annual Safety Review trends, Incident/Accident reports and Original Equipment Manufacturers' data), complemented by the operator's own operational data for programme customisation. In addition, communication between operators and authorities should be bidirectional as operators are required to provide indicators and metrics of their programmes to the authority on a regular basis and during the audits conducted. The reason for this is that the authorities assess, approve and oversee the implementation of EBT programme by the operators following EASA's regulation and guidance. They are also responsible for monitoring and verifying the correct functioning of the programmes, as well as identifying points of improvement that can be introduced in these training programmes.

The two (2) key activities encompassed in the context of the authorities support and role within EBT programmes are those presented in the following figure:

Figure 3-5 UC3.3 key activities

3.3.1 Working process activities and limitations

3.3.1.1 Assessment and approval of the programme providing inspection report and observations according to the level of implementation

Among the functions of the aviation authorities in the context of EBT programmes is the review and approval of EBT programmes proposed by training organisations and operators. They ensure that the programmes comply with regulatory requirements and that are based on the principles of Evidence-Based Training. Authorities work with operators and training organisations to develop EBT programmes that incorporate Evidence-Based methodologies, including the use of data to identify training needs and to adapt the syllabi accordingly. Also in that regard, they encourage a culture of continuous improvement in training by promoting the use of data-driven assessments and adjustments to training programmes, and they develop standards and guidelines for EBT implementation to ensure consistency and quality across the aviation industry. In addition, aviation authorities may facilitate the sharing of best practices and lessons learned among the operators to promote the widespread adoption of EBT principles, thus enabling an increasing number of operators to implement EBT programmes in a guided and facilitated way.

3.3.1.1.1 Technology & Data

Although the EBT programmes currently implemented by the operators are initially based on the airline's own operational data, with a strong influence of the data shared by the safety department which are jointly discussed in regular meetings, the operator should ideally be able to make use of additional data provided by the authority. Data that the authority can provide to operators for the customisation and adaptation of EBT programmes could be Mandatory Occurrence Reporting, Annual Safety Review trends and Incident/Accident reports.

However, EBT implementation has been driven by the operators in their aim to ensure safe operation and competent pilots. In this context, authorities have limited resources to keep the pace with this and many other developments running in parallel, so they are not able to provide data for EBT customisation. Therefore, the limited support and recommendations from the authorities is translated into the operators mainly relying on their own data for the identification of training needs.

The relationship between the operator and the authority should be bidirectional, but what happens in practice is that the operators share the information that the authority requests from them, but the authority does not have the capacity to provide data nor recommendations to the operators. Given that the EBT is a relatively new concept, it is expected that as more and more operators implement EBT programmes, the authority will gain maturity and will be able to provide operators with data that will allow them to tailor programmes considering the authority's input and experience.

Limitations

- **UC3.3-TEC.1 – Lack of input for programme definition**: Operators provide information on the programmes to the authority, whereas the authority generally does not provide data, standards nor reference values. The lack of support and recommendations from the authority translates into the operator mainly relying on the inner loop, mainly the training data, for the identification of training needs. Communication with the authority is really important and should be bidirectional, the authority providing guidance and support.
- **UC3.3-TEC.2 – Limited access to safety data and to data-sharing platforms**: Authorities do not have many staff with access to operators' safety data, they are not able to declassify this information, and do not have access to data-sharing platforms.
- **UC3.3-TEC.3 – Limited interest from operators in sharing their data:** Companies have little interest in sharing their data, which should always be de-identified, but it has a huge potential as it can provide a whole set of metrics. EASA is waiting for Data4Safety to have a good and powerful programme to be able to bring data in and draw conclusions.
- **UC3.3-TEC.4 – Insufficient maturity for sharing gradings' data**: There is a benefit for concordance on sharing data between operators, but we are not prepared for sharing gradings due to differences between operators. Having concordance-focused meetings between EBT Baseline operators' experts could be very positive. A first step could be to share instructor concordance data to ensure that the instructors have the proper standardisation, but without sharing gradings data, and a further step would be to be able to share gradings data once more standardisation is reached.
- **UC3.3-TEC.5 – Authorities do not receive data from other countries:** Authorities claim that they are not provided with data from other countries. The authorities would be interested in receiving data from EASA regarding other countries to be able to provide it to their operators, since the use that they can make of the data that the operators share with the authority is to compare with what was previously in place and with other countries operators' data.
- **UC3.3-TEC.6 – Need for collaborative programmes**: Operators will need collaborative programmes to meet regulatory requirements. Collaborative programmes can be of great interest in the area of

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instructor concordance, as operators need support to manage data and comply with regulations, either through digital solutions or by the regulator.

3.3.1.1.2 Organisation

On the one hand, the approval of Evidence-Based Training (EBT) programmes is mainly the responsibility of the relevant aviation authority in a specific country or region, who has the function of ensuring that the operators' EBT programmes are aligned with the current regulations, guidelines and standards.

On the other hand, the operators are responsible of designing, customising and implementing the EBT programmes, always following the requirements and the recommendations included in the guidelines and the regulation that are developed and provided by the authority.

For these reasons, operators must work closely with the aviation authority with the objective of ensuring compliance with regulations, obtaining approval of programs from the authority, and assuring that the trainings are properly adapted to the operator and that are provided in an effective manner.

However, the situation that can currently be observed is that, since EBT programmes are a relatively new concept, the authorities are still in a process of learning and adaptation, and that they do not have many resources and staff with relevant experience in EBT.

Limitations

- **UC3.3-ORG.1 – Lack of resources and trained staff:** The authorities find a lack of resources and trained staff in EBT to be able to gain further maturity and to provide more support to operators, everything requires a lot of time and patience and there is still a lot of progress to be made.
- **UC3.3-ORG.2 – Limited experience in EBT:** Although the operator is the primary responsible for the programmes and the data to be incorporated, the authorities need to gain more experience to be able to conduct the approval and subsequent monitoring processes of the programmes in a proper and efficient way, having the capacity to check the implementation of the programmes in more detail.

3.3.1.1.3 Operations

Depending on whether the operator is in the EBT Mixed or EBT Baseline phase, the latter being a continuation of the first phase, the approval process varies. Furthermore, whilst EBT needs to be specifically approved by the authority, when an operator wishes to move from standard Appendix 9 checking programme to Mixed EBT, there is still a requirement for Approval by the NAA in accordance with ORO.FC.145 (c) even though the Mixed EBT regulations are contained in GM only (GM1 ORO.FC.230(a);(b);(f)). For these reasons, operators should work closely with their aviation authority and follow the guidance provided for their specific phase of EBT implementation.

Considering that, the operators develop an EBT programme adapted to the regulations and tailored to their specific operations. The aim is to design the programmes in a manner that allows to improve pilot training and proficiency based on actual evidence and data, ensuring that the trainees develop the defined competencies. Before applying for approval of their EBT programme, operators try to obtain guidance and recommendations, as well as data, from the authority. Once the programme has been designed and customised, the operator submits a formal application for EBT approval to the relevant aviation authority, including detailed documentation of the EBT programme (e.g., training syllabus, procedures, reference data, etc.). Then, the aviation authority performs a review of the application and conducts an assessment of the operator's EBT programme. In the case that the authority detects that modifications need to be implemented, it notifies the operator, who is responsible for correcting them and reapplying for approval of its EBT programme, and the same applies to potential improvements that are identified. Once the authority considers that the EBT programme submitted by the operator is fully compliant, it must proceed with the approval of the programme. The operator is then authorised to implement the proposed EBT programme, and it is the responsibility of the

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authority to monitor that the EBT programme remains aligned with the regulation and that training is provided in an effective manner.

Limitations

- **UC3.3-OPS.1 – Lack of safety promotion driven by EBT programmes**: No feed into the safety risk management at state-level that could be derived from identifying potential risks based on pilots' performance (or lack of). They are not provided with data from operators in other countries to share it with their operators for best practices identification.
- **UC3.3-OPS.2 – Flexibility in the grading system definition**: All companies should respect the rules and work on the same basis, otherwise it is difficult to compare companies' data. The more mature operators may be willing to share their data, as long as it can be compared on a consistent basis in accordance with the rules in order to be effective.

3.3.1.2 Conduct EBT oversight following the existing regulation and guidance

Besides having the role of approving EBT programmes after verifying that they are correctly adapted to the regulation and properly customised, the authority has a key responsibility in performing oversight of the EBT programmes. That oversight mainly consists in ensuring that the programmes remain aligned with the regulatory requirements, that they are delivered efficiently and that the content is relevant and adapted to the needs of the trainees. To this end, the authorities require operators to share data and metrics, as well as documentation, from the programmes to verify the correct functioning of the programmes on an ongoing basis. In addition, the authority is responsible for conducting audits to verify that the programme continues to be effective and to better understand how the programme processes are being implemented and executed. Therefore, a close collaboration between the operator and the authority is needed, which enables the authority's oversight procedures to be conducted in a simple and straightforward manner.

3.3.1.2.1 Technology & Data

In the context of the EBT programmes' oversight process, aviation authorities use data to verify that operators are complying with regulatory requirements, guidelines, and standards. In this way it is possible to ensure that the operators are aligned with the defined procedures and that are maintaining the necessary training and safety standards. For this reason, operators should maintain complete records and provide accurate responses to authority requests for data as part of that oversight process.

It is essential that operators are compliant and provide the data required by the authority as it is a means of demonstrating programme compliance, safety performance and continuous improvement of EBT programmes. By analysing this data, the authorities are able to assess the effectiveness of EBT programmes and can determine whether the programmes that have been implemented are achieving pilot competency development, safety improvement and reduction of related incidents. Moreover, authorities may use the data to adapt regulations to the observed trends, procedures or technologies observed in the industry.

Some authorities use templates by which they request operators to provide them with programme's data in which they are interested. Some of the data or metrics that are usually requested are the following:

- Number of pilots
- Simulator sessions
- How many pilots had a grade 1
- Number of grades 2
- How much extra training the operator had per year
- How many grades 5
- How many pilots have had at least a grade 2 since the programme has been implemented

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Thus, authorities usually ask for data related to the number and distribution of trainees' grades, as well as training records and employed safety data. In addition, they are also interested in information and metrics related to the concordance of instructors, on the measures implemented to mitigate identified training needs and on the effectiveness of the programmes.

Limitations

- **UC3.3-TEC.7 – Limited visibility on gradings distribution data:** The authority is interested in seeing the evaluation grades (e.g., Level 1) according to the competence framework and not only the Level 0. They would be interested to see which competencies have more X-gradings (e.g., a competency has more 3's than another competency…) than another, for example, and operators should start to have such data even though they have low maturity. It would be beneficial to encourage the sharing of more data related to the distributions of gradings and the concordance of instructors on a regular basis.
- **UC3.3-TEC.8 – Undefined framework for monitoring EBT programmes:** There is a need for a defined framework intended to monitor EBT programmes. Currently, there is an incipient and undefined framework that is intended to monitor programmes but not to improve EBT programmes or feed into the state-level safety net. The sharing of metrics from the operator to the authority is a way for the authorities to check the correct implementation and functioning of EBT programmes, but it is not clear what metrics should be shared and in which way. More transparency is needed at state level to see the differences between operators, as well as to facilitate oversight and efficiency of the system.
- **UC3.3-TEC.9 – Lack of reporting framework for concordance**: NAAs do not ask for indicators to monitor the instructors' concordance on a regular basis, they ask for it in the audits to ensure it is assessed and evaluated by the operators. There is no reference on the minimum levels nor the type of indicators to be assessed. That is probably due to a lack of resources of the authorities.
- **UC3.3-TEC.10 – Limited capacity to exploit the data**: The authorities have scattered data sources and limited capacity to exploit these data and they lack staff and expertise to properly monitor and enhance the implementation of the EBT.

3.3.1.2.2 Organisation

As with the approval of the EBT programmes, the aviation authority is the primary responsible for the oversight and for verifying that the programmes implemented by the operators are always in line with the requirements established by the regulations and that their functioning and effectiveness is aligned with what is expected on a continuous basis.

In this regard, the importance of operators closely cooperating with the authority to facilitate the work of the authorities through the sharing of the documentation and data required by the authority is highlighted.

However, what is actually found is that even if operators share the metrics and information requested by the authority, the lack of resources, staff and EBT experts from the authorities' side translates into the authorities not being able to analyse all the received data and not conducting as many audits as they would like to, leading to a limited capacity to effectively monitor the programmes.

Limitations

- **UC3.3-ORG.3 – Limited visibility on EBT implementation**: Audits and inspections allow authorities to verify the functioning of the programmes, so it would be interesting to carry them out more frequently and periodically, but due to lack of resources and staff they cannot carry out as many as they would like to. This also hinders the inspectors to gain knowledge and expertise in EBT context.
- **UC3.3-ORG.4 – Authority's limited access to operators' safety data:** The authority has very few people authorised to declassify safety data when conducting audits.

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3.3.1.2.3 Operations

Oversight is an ongoing process where aviation authorities continuously monitor the operator's EBT programme to monitor the effectiveness and to ensure it maintains safety standards and achieves the intended safety and training objectives. With the purpose of conducting the oversight and monitoring of EBT programmes, the authorities request operators to share programme documentation, data and metrics with them in a regular basis. Additionally, and ideally also on a regular and periodic basis, the authorities should perform audits that allow them to assess whether the programmes are compliant with regulations and standards. In practice, it is in these audits that the authorities can actually observe how the programmes are conducted and if the desired requirements are met, as well as checking the effectiveness of the trainings in more depth. Although they actually have limited access to this type of data, authorities should also check that the events and trends reported by safety are introduced as a means of customising the programmes.

By analysing the data provided by operators, and what they are able to observe and discuss during audits, an important objective of the authorities is to find improvements and modifications that can be introduced into the programmes on an ongoing basis and ensuring that the operators implement these changes when they are requested to.

Limitations

- **UC3.3-OPS.3 – Lack of visibility on remedial training hours**: Some authorities are trying to collect data on simulator hours in Europe as it has been detected that in some countries more hours of remedial or tailored training are being delivered than other countries and want to understand why.
- **UC3.3-OPS.4 – Existing resistance from operators to share their data:** There is a competitive component that influences some operators not willing to share their data. There are few areas in which operators can play, economically speaking, and training is one of them, which may mean that one operator does not want another operator to achieve with a smaller amount what they are getting with a larger investment.
- **UC3.3-OPS.5 – Ensuring consistency of EBT programmes:** With regard to the actual role of the authority in the EBT context, it is currently to ensure that the programme has been correctly implemented according to what the regulation says, and then to perform the oversight of the programmes. This role could be potentially evolved and give the authority the possibility of ensuring the consistency of the programme once implemented. This is mainly motivated by the fact that the more mature operators that already have mechanisms in place to assess instructor concordance in a more advanced manner detect that, over time, there may be a shift in the grading curves as instructors and pilots improve or deteriorate as they develop competencies. This can lead to over or downgrading, so there should be adequate monitoring of trainees learning curve and a framework of key performance indicators to demonstrate the improvement of pilots over time, and how there is a flow between good gradings and low gradings. Currently, the proposed system for checking consistency is comparison to appendix 9, but a framework of performance indicators could be developed to monitor the effectiveness of EBT programmes and their consistency over time. The authority could have the role of monitoring and checking the consistency of such operators' curves, but for this it is very important to strengthen the exchange of data from the operators with the authorities.
- **UC3.1-OPS.6 – Need for further transparency and benchmarking capabilities:** The framework for sharing data with the authority must change, promoting more transparency and being able to see the differences between operators, as well as to facilitate oversight and efficiency of the system.

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3.3.2 Limitations overview

As highlighted throughout the description of the different activities encompassed in the Use Case 3.3, the current role of the authorities and the need for recommendations and data provision from these authorities involves a number of challenges and limitations that are reflected across different operational dimensions. This section presents a consolidated overview of all identified challenges, systematically classified into the three (3) key categories (Technology and Data, Organization and Operations), and categorised according to their corresponding process activity.

➨ **Table 3-7** Overview of limitations identified for Use Case 3.2

Use Case 3.3 Authorities support and role within EBT programmes			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**
Assessment and approval of the programme providing inspection report and observations according to the level of implementation	• UC3.3-TEC.1 – Lack of input for programme definition • UC3.3-TEC.2 – Limited access to safety data and to data-sharing platforms • UC3.3-TEC.3 – Limited interest from operators in sharing their data • UC3.3-TEC.4 – Insufficient maturity for sharing gradings' data • UC3.3-TEC.5 – Authorities do not receive data from other countries • UC3.3-TEC.6 – Need for collaborative programmes	• UC3.3-ORG.1 – Lack of resources and trained staff • UC3.3-ORG.2 – Limited experience in EBT	• UC3.3-OPS.1 – Lack of safety promotion driven by EBT programmes • UC3.3-OPS.2 – Flexibility in the grading system definition
Conduct EBT oversight following the existing regulation and guidance	• UC3.3-TEC.7 – Limited visibility on gradings distribution data • UC3.3-TEC.8 – Undefined framework for monitoring EBT programmes • UC3.3-TEC.9 – Lack of reporting framework for concordance • UC3.3-TEC.10 – Limited capacity to exploit the data	• UC3.3-ORG.3 – Limited visibility on EBT implementation • UC3.3-ORG.4 – Authority's limited access to operators' safety data	• UC3.3-OPS.3 – Lack of visibility on remedial training hours • UC3.3-OPS.4 – Existing resistance from operators to share their data • UC3.3-OPS.5 – Ensuring consistency of EBT programmes • UC3.1-OPS.6 – Need for further transparency and benchmarking capabilities

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3.3.3 Proposed digital solutions to address limitations

The following table presents and details the solutions that have been proposed with the objective of addressing the limitations identified during the different interviews with stakeholders and explained through the sections dedicated to each activity in Use Case 3.3:

➨ **Table 3-8** Proposed solutions identified for Use Case 3.3

Use Case 3.3 Authorities support and role within EBT programmes		
Limitation	**Solution**	**Description**
UC3.3-TEC.1 – Lack of input for programme definition	**UC3.3-SOL.1** - Development of best-practices for sharing authority data with operators	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines and industry best-practices to encourage an effective and efficient sharing of data from the authority to the operators, enabling an enhanced customisation of the programmes. These best practices should address issues related to: • Data sources: What data sources and specific information should be considered by the authorities when sharing data with operators. • Data sharing methodologies or standards: What methodologies or standards could be implemented to allow effective data sharing that actually enable the introduction of improvements or mitigating measures into EBT programmes (e.g., official publications to be introduced and used as a reference, notifications/circulars with updates, organise workshops or forums, use of data sharing platforms…). • Frequency: How often should authorities share data with operators (e.g., periodic data sharing, sharing data during audits and inspections, sharing data during the conduct of organised workshops...).
UC3.3-TEC.2 – Limited access to safety data and to data-sharing platforms	**UC3.3-SOL.2 –** Development of initiatives to facilitate access to safety data by the authority	Initiatives should be implemented to facilitate access to operators' safety data by the authority, which is necessary for both the approval process and the monitoring and oversight of the programmes. These initiatives include the following actions: • Reduce administrative burdens and simplify the process of authorisation to allow the authorities to access the operators safety data • Develop formal data access agreements between operators and regulatory authorities to define the terms, conditions and protocols for data access • Apply data de-identification techniques that allow authorities' staff to access operators' safety data without compromising the privacy of involved personnel • Conduct training initiatives for the authorities' staff regarding safety data privacy and management In addition, measures should be considered to ensure that authorities have sufficient staff to be able to access safety data.
UC3.3-TEC.3 – Limited interest from operators in sharing their data	**UC3.3-SOL.3** - Incentivise the creation of collaborative data-driven mechanisms among Authorities and operators (e.g., Data4Safety) supporting the continuous customisation of EBT programmes through evidence gathered from external safety-relevant sources (i.e., outer loop)	Since this limitation is significantly relevant to both Use Case 2 (**see solution UC3.2-TEC.3**) and Use Case 3, the proposed solution has been included in both. Incentivise the promotion of collaborative data programmes (e.g., Data4Safety) that could potentially provide data for the operators' programmes at national or European level, enabling a better customisation of the programmes, even filling data gaps that may be present in some operators' data (e.g., airports or routes for which not information is available since an operator does not operate there). Aviation stakeholders, including operators, regulatory authorities, industry associations, and safety organisations, should be encouraged to collaborate in establishing and

Use Case 3.3 Authorities support and role within EBT programmes		
Limitation	**Solution**	**Description**
		supporting data-sharing programs aiming to collect, analyse, and disseminate data regarding different areas of the EBT programmes. Given the significant benefits and advances that can be triggered by the implementation of such programmes: • The potential added value for operators willing to participate should be underlined and promoted (e.g., access to information from other countries or regions, enhanced benchmarking capabilities, additional training needs identification capabilities, standardisation across the industry, networking and collaboration opportunities) • The safety improvements that can result from data sharing should be highlighted, promoting a strong safety culture among all the industry stakeholders • Tangible incentives, benefits and recognition to operators for participating in data sharing programmes should be explored and established (e.g., reduced regulatory reporting burdens, access to shared safety insights, or cost-sharing opportunities)
UC3.3-TEC.4 – Insufficient maturity for sharing gradings' data	**UC3.3-SOL.4** – Development of best-practices for sharing gradings' data among operators	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines and industry best-practices to standardise the sharing of grading data among operators. Operators could have visibility on the other operators' data, but always in an aggregated and de-identified manner. These best practices should include recommendations on: • Standardisation of the grading data or of the grading system application to be able to compare between operators in a de-identified, aggregated and fair manner. • Phased implementation of an ecosystem for the sharing of operators' data, starting with the sharing of concordance data while continuing to gain maturity in the EBT domain, and leading to gradually moving towards the sharing of gradings data. • Implementation of a framework of regular meetings between the EBT experts of the operators aiming to share and discuss data on both concordance and gradings, seeking continuous improvements for the programmes. • Development of a data governance framework, addressing data sharing protocols, privacy protection, and the cultivation of a 'just culture' within the context of gradings data
UC3.3-TEC.5 – Authorities do not receive data from other countries	**UC3.3-SOL.5** – Development of best-practices to encourage the sharing of data from operators in other countries	Development of best practices to encourage the sharing of data from operators in other countries at EASA level for benchmarking purposes. In that regard, encourage operators in the different countries to share data on their programmes so that EASA can provide them to the different NAAs. Thus, giving NAAs the possibility to provide data to their operators for customising their programmes, identifying training needs and finding potential improvements through benchmarking based on de-identified and aggregated data.
		Solution **"UC3.3-SOL.3 - Incentivise the creation of collaborative data-driven mechanisms among Authorities and operators (e.g., Data4Safety) supporting the continuous customisation of EBT programmes through evidence gathered from external safety-relevant sources (i.e., outer loop)"** applies.
UC3.3-TEC.6 – Need for collaborative programmes	**UC3.3-SOL.6** – Development of best-practices for the establishment of collaborative data-driven mechanisms among Authorities and operators (e.g.,	Alongside the efforts to promote collaborative programmes, guidelines and industry best practices shall be developed for the successful establishment of such programmes for the sharing of operators' data (e.g., Data4Safety). These guidelines and best practices should provide clarity on key points including: • Objective of the data sharing programmes, specifying which will be the use of the data provided by the operators

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Use Case 3.3 Authorities support and role within EBT programmes		
Limitation	**Solution**	**Description**
	Data4Safety) supporting the different areas of EBT programmes	• Different data sources, data types, parameters and data formats that will be considered (e.g., grading metrics, instructor concordance data, FDM data…) • Processes and protocols for an efficient data sharing • Data integration and fusion techniques to enable the visualisation and analysis of data in an aggregated manner • Definition of Key Performance Indicators (KPIs) for the data sharing programmes that enable further data analysis, training needs identification and benchmarking on an individual operator basis and also among operators • Frequency at which operators and other stakeholders may share their data • Granularity at which operators and other stakeholders may share their data • Data sharing agreements (e.g., Non-Disclosure Agreements (NDAs)) outlining the conditions for sharing the data • Data de-identification techniques needed for data sharing without neglecting data privacy and "just culture" policies • Management of the access to the data, implementing roles and defining who has access to the programme's data • Implementation of data quality assurance processes to ensure data reliability and completeness • Training initiatives focusing on the correct functioning of data sharing programmes for all the involved stakeholders
UC3.3-TEC.7 – Limited visibility on gradings distribution data	**UC3.3-SOL.7** - Regulatory requirements / Guidance Material for the sharing of gradings distribution data with authorities	Regulatory requirements / Guidance Material regarding the sharing of operators' grading distribution data with their authorities aiming to facilitate the programmes' monitoring and oversight. Such guidelines should specify: • Level of the metrics to be shared (e.g., Level 0, Level 1, Level 2, Level 3 grading metrics) and its granularity • De-identification techniques to be used for the shared data • Process to be followed by operators when providing grading distribution data to the authority and the frequency of data reporting • Clear objective of the data usage by the authorities (e.g., Monitoring of the programme efficiency, support on the training needs identification, follow-up on the pass-fail percentages or determined gradings such as number of grades 2, benchmarking across operators or countries to detect outliers)
UC3.3-TEC.8 – Undefined framework for monitoring EBT programmes	**UC3.3-SOL.8** - Regulatory requirements / Guidance Material defining a recommended framework of KPIs for oversight of EBT programmes by Authorities	Regulatory requirements / Guidance Material defining a recommended framework of KPIs for oversight of EBT programmes by Authorities, supporting the continuous evaluation of their effectiveness and acceptable instructor concordance (e.g., GM to ARO.OPS.226-d). These guidelines should provide recommendations and clear examples on the following key topics: • Selection and definition of the relevant KPIs in the context of the different areas of the EBT programmes (e.g., instructor concordance, training data…), and how to calculate them • Data sources to be considered for each defined KPI • Thresholds definition for the established KPIs, providing potential mitigating measures when these thresholds are undershot • KPIs reporting frequency based on the programmes and oversight needs • Process to be followed and channel to be used by operators when reporting the KPIs to the authorities

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Use Case 3.3 Authorities support and role within EBT programmes

Limitation	Solution	Description
		• Process to document and record-keeping of the KPIs • Potential conduction of specific meetings to be held between operators and their authorities focusing on the regularly reported KPIs • Integration of the defined KPI framework with the audits conducted by the authority, facilitating the process of monitoring and oversight of the programmes.
UC3.3-TEC.9 – Lack of reporting framework for concordance		Solution **"UC3.3-SOL.8 - Regulatory requirements / Guidance Material defining a recommended framework of KPIs for oversight of EBT programmes by Authorities"** applies.
UC3.3-TEC.10 – Limited capacity to exploit the data	**UC3.3-SOL.9** - Support the definition of specific trainings for the enhancement of the authorities' IT capabilities	Beyond progressively centralising and standardising data collection by the authority, through initiatives such as the definition of frameworks for the sharing of operators' data explained in other limitations, support should be given to authorities to develop their expertise regarding data analytics and digital solutions usage. Tailored trainings should be provided to NAAs with the aim of improving their employees' skills in the area of analytical and IT capabilities, including the use of digital solutions that can support the processes related to the approval and monitoring of EBT programmes. For this purpose, specific initiatives such as the organisation of workshops or seminars should be considered for enhancing these capabilities, even including the opportunity for staff to obtain certifications that validate their knowledge.
UC3.3-ORG.3 – Limited visibility on EBT implementation	**UC3.3-SOL.10 –** Development of best-practices for enhancing authorities' visibility on EBT programmes	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines and industry best-practices to increase the authority's visibility on EBT programmes, alleviating the possible lack of resources for conducting the desired number of audits. These best practices should provide recommendations for: • Require the operators to proactively and regularly report on the progress and outcomes of their EBT programs, by means of initiatives and mechanisms like defined frameworks for sharing KPIs, metrics and data with the authorities as detailed in potential solutions to some of the previous limitations • Prioritise those programme areas where the main needs have been identified both by the operators themselves and by the authority based on the data and metrics provided by the operators, even conducting targeted audits focusing on the specific identified needs • Continuously enhance the data analytics and IT capabilities of the authorities' staff by means of specific training, enabling the proper use of digital solutions or tools that support the data management and analysis • Implement initiatives that allow for a streamlined data sharing and collection such as conduction of regular meetings with the operators, or the development and introduction of defined templates that operators must fill with programmes' specific metrics and finally provide to the authorities • Foster collaboration among different national authorities, sharing best practices and lessons learned and even performing collective oversight when possible • Push for increased resources and staffing within aviation authorities to support effective oversight of EBT programs

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Use Case 3.3 Authorities support and role within EBT programmes		
Limitation	**Solution**	**Description**
UC3.3-ORG.4 – Authority's limited access to operators' safety data		Solution **"UC3.3-SOL.2 – Development of initiatives to facilitate access to safety data by the authority"** applies.
UC3.3-OPS.1 – Lack of safety promotion driven by EBT programmes	**UC3.3-SOL.11** – Definition of safety management process to identify risks from operators' training data	Considering the framework defined in the solution **"UC3.3-SOL.8 - Regulatory requirements / Guidance Material defining a recommended framework of KPIs for oversight of EBT programmes by Authorities"**, safety management process should be defined at state level to be able to identify potential risks from pilots training data shared by the operators in the context of EBT oversight.
UC3.3-OPS.2 – Flexibility in the grading system definition		Solution **"UC3.3-SOL.4 – Development of best-practices for sharing gradings' data among operators"** applies.
UC3.3-OPS.3 – Lack of visibility on remedial training hours	**UC3.3-SOL.12** - Regulatory requirements / Guidance Material defining the requirements for the reporting of simulator hours	Require operators to report simulator hours, especially the hours needed for tailored or remedial training, so that authorities can detect potential deviations between their operators or between data from different countries. These data could be included as one of the indicators or metrics to be reported within a defined data reporting framework of the programmes, as explained for other limitations, through which operators should share data with the authority.
UC3.3-OPS.4 – Existing resistance from operators to share their data		Solution **"UC3.3-SOL.3 - Incentivise the creation of collaborative data-driven mechanisms among Authorities and operators (e.g., Data4Safety) supporting the continuous customisation of EBT programmes through evidence gathered from external safety-relevant sources (i.e., outer loop)"** applies.
UC3.3-OPS.5 – Ensuring consistency of EBT programmes	**UC3.3-SOL.13** - Development of Industry best-practices for standardised metrics to monitor the consistency of EBT programmes	Publication and promotion by industry bodies or relevant regulatory working groups of Industry best-practices for standardised metrics or indicators to properly monitor the consistency of EBT programmes over time. By properly defining and implementing a framework of metrics, the authority could be able to assume the function of monitoring the consistency of operators' programmes, extending its role beyond the approval and oversight of the programmes. The established framework or set of metrics should allow the monitoring of: • Evolution of gradings over time • Evolution of instructor concordance over time • Flow between good gradings and bad gradings and vice versa And for that purpose, guidance should be provided regarding: • Standardised metrics or indicators to be recorded by the operators and shared with the authority • Type of analysis to be performed aiming to obtain the established metrics • Frequency and granularity with which data will be shared with the authority To achieve this, and as discussed in some solutions for other limitations, it is essential to promote and clearly define the requirements for the sharing of data from operators' programmes with the authority.
	UC3.3-SOL.14 - Development of best-practices for the research on alternative	Publication and promotion by industry bodies or relevant regulatory working groups of Industry best-practices for the research on alternative means other than Part-FCL Appendix 9 to verify the accuracy of the grading system.

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Use Case 3.3 Authorities support and role within EBT programmes		
Limitation	**Solution**	**Description**
	means to verify the accuracy of the grading system	
UC3.1-OPS.6 – Need for further transparency and benchmarking capabilities		Solution **"UC3.3-SOL.8 - Regulatory requirements / Guidance Material defining a recommended framework of KPIs for oversight of EBT programmes by Authorities"** applies.

In the case of limitations "**UC3.3-ORG.1 – Lack of resources and trained staff"** and "**UC3.3-ORG.2 – Limited experience in EBT"** a solution cannot be directly provided, EBT regulation has been built up on the basis of the progress made by operators and the authorities have been left a little bit behind. In that regard, there is a lack of maturity and resources from authorities in the EBT context but as time advances and more operators implement EBT programmes, maturity will be gradually built up and the programmes will continue to advance integrating enhancements, while authorities will gain experience in performing their tasks regarding the approval and oversight of the programmes and will count on trained staff.

3.3.4 Proposed solution packages

The potential digital solutions proposed in Section 3.3.3 have been strategically grouped into package solutions, drawing upon their commonalities and distinctive natures within the context of EBT programmes. The first category, encompassed within 'Safety promotion'. pertains to topics that are yet to find comprehensive industry-wide guidance and thus demand the initiation of industry-defined standards and development of industry best-practices. The second category, 'Regulatory initiatives' involving Guidance Material or Acceptable Means of Compliance, represents topics that have reached a level of maturity suitable for integration into formal regulations. Lastly, the third category, 'Innovation & Technology', centres on topics that may not be easily confined to regulatory frameworks but support the adoption and integration of digital solutions and capabilities. This categorisation enables a more focused approach to addressing the multifaceted challenges faced in EBT Programmes, ensuring that each package solution is tailored to its unique context and readiness for implementation.

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Table 3-9 Solution package to address limitations of Use Case 3.3

<table>
<tr><th colspan="4">Use Case 3.3 Authorities support and role within EBT programmes</th></tr>
<tr><th>Solution package</th><th>Solutions included</th><th>Involved stakeholders
(Definition, production, or implementation of the solution)</th><th>Data-related enablers</th></tr>
<tr><th colspan="4">Solution package - Safety Promotion</th></tr>
<tr>
<td>UC3.3-PS.1 – Safety promotion for the improvement of authorities' visibility on EBT programmes and the proper bi-directional sharing of data between authorities and operators</td>
<td>• UC3.3-SOL.1 - Development of best-practices for sharing authority data with operators
• UC3.3-SOL.2 – Development of initiatives to facilitate access to safety data by the authority
• UC3.3-SOL.5 – Development of best-practices to encourage the sharing of data from operators in other countries
• UC3.3-SOL.10 – Development of best-practices for enhancing authorities' visibility on EBT programmes</td>
<td rowspan="2">Aviation industry bodies and associations:
• Facilitate the definition of best-practices regarding the processes for sharing data with authorities and the related data analyses for performing the oversight of the programmes by bringing together experts and stakeholders from both the aviation and data/digitalisation industry
• Collaborate with operators and regulatory authorities to ensure alignment with industry standards
• Promote for the adoption of best-practices across the aviation industry
• Establishing mechanisms for monitoring the implementation of best-practices within the industry and gather feedback from stakeholders
Regulatory authorities:
• Review the development of best-practices and ensure that they align with regulatory standards and requirements
• Promote for the adoption of best-practices across the aviation industry
• Assess the feasibility of publishing the best-practices as GM or AMC
Civil Aviation Authorities:
• Provide information on what operator-specific data and metrics may be useful to perform the oversight of the programmes
• Ensure that the sharing of information with operators is done in a bidirectional manner and as expected
• Perform the approval and the oversight of the programmes based on the data shared by the operators</td>
<td>• Protocols, process and mechanisms for sharing data with the authorities
• Specific data and metrics currently shared with the authorities (e.g., gradings data, concordance data, safety data)
• Granularity and periodicity with which the data is provided to the authority
• Template currently used for providing data to the authority
• Data management and data access methodologies used with the shared safety data
• De-identification techniques used for sharing data respecting "just culture" policies
• Details on current processes used to approve and audit data sharing related processes
• Protocols, process and mechanisms for sharing data with the operators
• Specific data and metrics currently shared with the operators</td>
</tr>
<tr>
<td>UC3.3-PS.2 – Safety promotion for the monitoring of EBT programmes' effectiveness and consistency</td>
<td>• UC3.3-SOL.11 – Definition of safety management process to identify risks from operators' training data
• UC3.3-SOL.13 - Development of Industry best-practices for standardised metrics to monitor the consistency of EBT programmes
• UC3.3-SOL.14 - Development of best-practices for the research on alternative means to verify the accuracy of the grading system</td>
<td>• Specific data and metrics regarding the gradings and the concordance over time, which could be shared with the authority to check the consistency
• Methodology and techniques applied for training needs identification
• De-identification techniques used for analysing data respecting "just culture" policies
• Methodology and process currently used to verify the accuracy of the grading system</td>
</tr>
</table>

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Use Case 3.3 Authorities support and role within EBT programmes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
		• Monitor the consistency of the programmes over time **Operators:** • Adopt and implement the best-practices in their processes and day-to-day operations • Collaborate with industry bodies and regulatory authorities in the development and refinement of best-practices • Train their personnel in the application of best-practices	• Details on current processes used to approve and audit data analysis related processes • Specific data and metrics that should be requested to operators to check the consistency of the programmes • Protocols, process and mechanisms for sharing data with the operators • Specific data and metrics currently shared with the operators • Methodologies to monitor the consistency and effectiveness of the EBT programmes
Solution package – Regulatory initiatives (Guidance Material or Acceptable Means of Compliance)			
UC3.3-PS.3 – Regulatory initiative regarding the oversight of EBT programmes’	• **UC3.3-SOL.7** - Regulatory requirements / Guidance Material for the sharing of gradings distribution data with authorities • **UC3.3-SOL.8** - Regulatory requirements / Guidance Material defining a recommended framework of KPIs for oversight of EBT programmes by Authorities • **UC3.3-SOL.12** - Regulatory requirements / Guidance Material defining the requirements for the reporting of simulator hours	**Regulatory authorities:** • Develop and implement the regulatory initiatives, potentially GM and/or AMC • Collaborate with operators, authorities and other related stakeholders to ensure alignment with their specific needs • Collaborate with experts and stakeholders from both the aviation and data/digitalisation industry • Promote the adoption of GM/AMC across the industry • Establishing mechanisms for monitoring the implementation of GM/AMC within the industry and gather feedback from stakeholders **Civil Aviation Authorities:** • Provide information on what operator-specific data and metrics may be useful to perform the oversight of the programmes • Ensure that the sharing of information with operators is done in a bidirectional manner and as expected • Perform the approval and the oversight of the programmes based on the data shared by the operators	• Protocols, process and mechanisms for sharing data with the authorities • Specific data, KPIs and metrics currently shared with the authorities (e.g., gradings distribution data, concordance data, safety data, data on simulator hours) • Granularity and periodicity with which the data is provided to the authority • Template currently used for providing data, metrics and KPIs to the authority • De-identification techniques used for sharing data respecting “just culture” policies • Details on current processes used to approve and audit data sharing related processes • Specific data, KPIs and metrics currently provided by the operators and used by the authority to perform the oversight of the programmes (e.g., gradings distribution data, concordance data, safety data, data on simulator hours) • Protocols, process and mechanisms for sharing data with the operators

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Use Case 3.3 Authorities support and role within EBT programmes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
		• Monitor the consistency of the programmes over time **Operators:** • Implement GM/AMC for a proper sharing of data with the authority, enabling an adequate oversight of the programmes based on a smooth collaboration between operators and authorities • Collaborate with regulatory authorities in the development and refinement of GM/AMC • Train their personnel in the application of GM/AMC	• Specific data and metrics currently shared with the operators • Methodologies to monitor the consistency and effectiveness of the EBT programmes
Solution package – Innovation & Technology			
UC3.3-PS.4 – Initiatives to support the adoption of digital tools and capabilities for assisting authorities	• **UC3.3-SOL.3** - Incentivise the creation of collaborative data-driven mechanisms among Authorities and operators (e.g., Data4Safety) supporting the continuous customisation of EBT programmes through evidence gathered from external safety-relevant sources (i.e., outer loop) • **UC3.3-SOL.4** – Development of best-practices for sharing gradings' data among operators • **UC3.3-SOL.6** – Development of best-practices for the establishment of collaborative data-driven mechanisms among Authorities and operators (e.g., Data4Safety) supporting the different areas of EBT programmes • **UC3.3-SOL.9** - Support the definition of specific trainings for the enhancement of the authorities' IT capabilities	**Regulatory authorities:** • Develop guidelines to facilitate the adoption of digital solutions, and define the requirements to be met by the tools implemented • Oversee and support the adoption of digital tools to support the sharing of data between authorities and operators (e.g., collaborative data sharing tools or programmes) • Define training programmes to enhance IT and analytical capabilities • **Civil Aviation Authorities:** • Establish collaborative frameworks for coordination between authorities regarding data processes • Consider certification processes for personnel involved in EBT programmes approval and oversight **Operators:** • Consider the adoption of digital solutions and tools for the sharing of data and metrics with the authorities	• Details on current tools used for the sharing of data with the authorities • Details on current tools used for the integration of the shared operational data (e.g., data coming from the safety department) • Details on current training programmes for personnel involved in the approval and oversight of EBT programmes • Information on the digital tools used for analysing the data received from the operators aiming to perform the oversight and monitoring of the programmes (e.g., dashboards or other reporting tools)

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3.4 Impact assessment of proposed solution packages

Finally, an impact assessment has been conducted taking as an input the different solution package established in the previous section, which encompass the different solutions defined with the aim of addressing the identified limitations. Traditional impacts such as economic, social, environmental and proportionality impacts will be assessed but most importantly the impact on aviation safety will be assessed as it is an essential criterion for determining the suitability of the package solutions. In the following subsections, package solutions will notably be assessed in relation to the capacity to address the identified limitations and challenges. The different impact categories that have been used, together with the criteria that have been followed, are presented in the following table:

Table 3-10 Categories and criteria used for the impact assessment

Category	Scores categories and associated criteria		
Safety	Highly positive impact	+3	• Significant improvements in pilot situational awareness, decision-making, and response to critical situations during simulated and operational flight scenarios • Substantial reduction in safety incidents, errors, and accidents attributed to enhanced pilot competencies and effective application of EBT principles
	Low positive impact	+1	• Moderate enhancements in pilot skills and performance, leading to increased situational awareness and improved decision-making capabilities during training and operational activities • Some reduction in safety incidents and errors, indicating a positive trend in safety performance
	No impact	+0	• No changes in pilot competencies and safety performance, suggesting a lack of significant improvements or advancements resulting from the implementation of the solutions • There is no contribution to the reduction of incidents, accidents or risks
	Low negative impact	-1	• Minor disruptions in pilot training and performance without significant implications for overall safety standards • Marginal growth in safety accidents, incidents or errors stemming from transitional issues associated with the EBT program's integration
	Highly negative impact	-3	• Notable decline in pilot competencies and safety performance during training and operational activities • Substantial increase in safety incidents, errors, or accidents
Environmental	Highly positive impact	+3	• Highly promoting sustainable aviation practices and reducing the industry's environmental impact • Implementation of advanced training technologies and methodologies that minimize the program's overall environmental footprint • Substantial reduction in fuel consumption and carbon emissions, demonstrating a strong commitment to environmental sustainability and eco-friendly practices
	Low positive impact	+1	• Efforts to integrate environmentally responsible practices and its potential to further enhance sustainability measures within the aviation industry • Adoption of eco-friendly initiatives and technologies that contribute to a more efficient use of resources and a reduced carbon footprint

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Category	Scores categories and associated criteria		
			• Moderate decrease in resource consumption and emissions, indicating a gradual shift toward more sustainable practices and reduced environmental impact within the aviation training environment
	No impact	+0	• No changes in resource utilisation and environmental practices, suggesting a lack of significant advancements or developments • Stable environmental practices with no alterations in resource consumption or environmental impact • No evidence on promoting sustainable aviation practices and reducing the industry's environmental impact
	Low negative impact	-1	• Minor challenges or inefficiencies in resource management and eco-friendly practices, leading to temporary environmental implications that can be addressed through targeted improvements and adjustments • Marginal increase in the program's environmental footprint attributed to transitional issues associated with solutions implementation
	Highly negative impact	-3	• Noticeable escalation in resource consumption and environmental impact • Clear increase in carbon emissions and environmental footprint
Social	Highly positive impact	+3	• Enhanced pilot well-being and job satisfaction, leading to a positive work culture • High increase of trainees and instructors confidence • Significant reduction of the workload of the different involved staff (e.g., training department, instructors) • Promotion of diversity, inclusivity, and equal opportunities within the training environment
	Low positive impact	+1	• Moderate improvements in pilot engagement and satisfaction • Moderate increase of trainees and instructors confidence • Slight reduction of the workload of the different involved staff (e.g., training department, instructors) • Initial steps toward promoting diversity, inclusivity and supportive environment
	No impact	+0	• No observable changes in pilot well-being and job satisfaction • No change in the confidence of trainees and instructors • No reduction of the workload of the different involved staff
	Low negative impact	-1	• Slight disruptions among stakeholders or programme's participants due to the introduced changes, leading to temporary challenges • Slight increase of the workload of the EBT programme-related staff
	Highly negative impact	-3	• Noticeable strain or dissatisfaction among pilots, indicating a decline in job satisfaction due to significant shortcomings or inadequacies in the implementation of the solutions • Notable decline in staff's well-being and engagement • Highly increased workload of the different involved staff (e.g., training department, instructors)
Economic	Highly positive impact	+3	• Substantial cost savings and improved cost-efficiency resulting from the implementation of streamlined training methodologies and optimised resource utilisation within the EBT program • Reduction of training-related costs
	Low positive impact	+1	• Moderate reductions in training expenditures and operational costs • Slightly increased effectiveness of resource utilisation

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Category	Scores categories and associated criteria		
	No impact	+0	• No observable changes in training expenditures and financial practices • No variations on the resource allocation capabilities and flexibility
	Low negative impact	-1	• Minor inefficiencies or temporary financial constraints associated with the transitional phase of implementing the solutions, without significant long-term implications • Marginal increase in training-related costs
	Highly negative impact	-3	• Significant escalation in training expenditures and operational costs • Marked increase in budgetary constraints and financial challenges • Clear constraints with regard to efficiency and flexibility of resource allocation
Proportionality	**Highly positive impact**	+3	• Implementation of EBT practices and solutions that are scalable and adaptable to the diverse needs and operational capacities of both large and small operators, fostering a level playing field for training and competency development • Equitable access to EBT resources, methodologies • Contribution to promoting a balanced and proportionate approach to training and competency development across the aviation industry, irrespective of the scale or scope of operations
	Low positive impact	+1	• Efforts to provide tailored EBT solutions that address the different needs and resources of both large and small operators • Support mechanisms that enable both large and small operators to participate in EBT initiatives and leverage relevant training resources based on their specific operational requirements • Efforts to bridge the gap between large and small operators, facilitating a more balanced and inclusive training environment within the aviation industry
	No impact	+0	• No observable changes in the accessibility and applicability of EBT practices for large and small operators • No changes in the training opportunities available to large and small operators
	Low negative impact	-1	• Minor discrepancies or challenges in providing tailored EBT solutions for large and small operators, leading to temporary disparities in access to training resources and opportunities • Slight inconsistencies or operational constraints that affect the proportionate participation of large and small operators in EBT initiatives
	Highly negative impact	-3	• Significant differences and imbalances in the accessibility and implementation of EBT practices between large and small operators • Major inequalities or operational constraints that limit the participation and benefits of small operators compared to larger operators.

By applying the criteria presented in the table above, and the solution packages established in the context of Use Case 3.1, the impact of each package is determined according to the different impact categories used. An additional dimension named “Maturity Level” is also considered and helps to define the current context. All of these are presented in the following table:

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Table 3-11 Impact Assessment of proposed solution packages for Use Case 3.1

<table>
<tr><th colspan="8">Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes</th></tr>
<tr><td rowspan="3">UC3.1-PS.1 – Safety Promotion regarding the conduction of the programmes, assessments and data gathering</td><td rowspan="2">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+1</td><td>0</td><td>+1</td><td>-1</td><td>+1</td><td>+2</td></tr>
<tr><td></td><td colspan="6">Justification: The solutions included in the package UC3.1-PS.1 could positively influence on the enhancement of safety performance beginning from the assessment of the trainees, since they treat the inclusion and collection of additional metrics (e.g., percentage of repetition for certain manoeuvres) for easing the identification of training needs, the contextualisation of the gathered data by means of a metric that somehow represents the difficulty of the programme, and ensure that the operators have the means and receive recommendations to avoid the appearance of forced concordance. All these factors have an influence on the development of the defined competencies by pilots, and on the collection of truly reliable data by instructors, both of which ultimately have an impact on the operational safety.

On the social dimension, the proposed solutions could help to increase the confidence of pilots in the generated and collected data by instructors, who in turn would receive more support and guidance in the conduction of the assessments and thus the collection of data.

In the case of collecting additional metrics from programmes, however, operators may need to implement, or ask their existing training data collection solution providers to implement, specific functionalities to collect such data, which would result in extra costs in terms of the economic aspect. In addition, it would be advisable for operators to allocate part of their budget to provide specific training for instructors to prevent the collection of data that present a forced concordance.

Finally, in terms of proportionality, this package of solutions could help both mature and smaller or inexperienced operators to have access to guides for implementing metrics that help to contextualise and analyse data, as well as to avoid the appearance of forced concordance. Thus, there would be no difference between operators in that case.</td></tr>
<tr><td></td><td>Maturity level</td><td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices. In addition, it is possible to start to find the implementation of incipient measures in some areas by the more mature operators, but not sufficiently extended to the rest of the operators to be considered mature at an industry level.</td></tr>
<tr><td rowspan="3">UC3.1-PS.2 – Safety Promotion regarding the analysis of gathered training data</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+3</td><td>0</td><td>+3</td><td>-1</td><td>+1</td><td>+6</td></tr>
<tr><td colspan="6">Justification: In the case of the package of solutions UC3.1-PS2, there is a large potential influence on the enhancement of pilots’ competencies, which clearly contributes to increased safety, as defining methodologies to be used for data analysis would contribute to better identification of pilot training needs, which could</td></tr>
</table>

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<table>
<tr>
<td></td>
<td></td>
<td colspan="6">then be addressed through additional training. The identification of training needs is of utmost important when seeking to improve the performance of the pilots, which leads towards safer operations and improved awareness.

On the social dimension, the proposed solutions would highly benefit the well-being of the training department's staff, since would set the basis for having sophisticated tools to support their tasks regarding the data analysis for training needs identification based on the recommended methodologies. The guidelines would represent a way of easing their job in that regard, even leading to a decrease in their workload if accompanied by the implementation of supportive analytical tools.

From the instructors and trainees' perspective, there would also be a contribution towards enhancing the confidence on the analyses performed over their data, analyses that ultimately translate in tailored training better adapted to their needs improving their performance. Furthermore, they would feel more comfortable and adequately protected regarding the use of the data, as mechanisms would be defined to prevent data misuse.

On the economic side, there could perhaps be a negative impact, although minimal, as some operators may want to reorient the methodology used to extract training needs, possibly leading to some costs in terms of having to change the processes of their tools.

Regarding proportionality, the implementation of this set of solutions would partially allow to help specially the small or the inexperienced operators on the area of the training data analysis, providing clarity on the recommended methodologies to be used. That would allow for setting a level playing field considering that the most mature operators are more familiar with analysing their training data and have been able to dedicate more time and mainly resources to develop their own methodologies and tools.</td>
</tr>
<tr>
<td></td>
<td>Maturity level</td>
<td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices. In addition, it is possible to find that the more mature operators have more experience on these areas, but not sufficiently extended to the rest of the operators to consider the solutions as mature at an industry level.</td>
</tr>
<tr>
<td rowspan="3">UC3.1-PS.3 – Safety Promotion regarding the sharing of the training data within the operator</td>
<td rowspan="3">Benefits and constraints</td>
<td>Safety</td>
<td>Environmental</td>
<td>Social</td>
<td>Economic</td>
<td>Proportionality</td>
<td>Total</td>
</tr>
<tr>
<td>+3</td>
<td>0</td>
<td>+1</td>
<td>0</td>
<td>+1</td>
<td>+5</td>
</tr>
<tr>
<td colspan="6">Justification: Developing and implementing the solutions proposed in the UC3.1-PS.3 package would greatly contribute to improving the safety of operations, as it would allow operators to have clear guidance and recommendations on how to share training data with the safety department, and on how to use it appropriately. The reason for this is that by receiving such training data, the safety department would have an additional source from a very different origin than the one they normally use, and would have another perspective through which to find risks present in the operations. In addition, one of the objectives of these solutions would be that operators could start to find risks present in trainings, which would be difficult to identify in real operations, even before they occur, in a safety-proactive way.</td>
</tr>
</table>

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<table>
<tr><th colspan="8">Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes</th></tr>
<tr><td rowspan="2"></td><td></td><td colspan="6">In terms of the social component, such solutions can enhance pilots' trust in the programmes by promoting transparency from the operator to the pilots, allowing them to access their data in a secure way. And from the safety department's point of view, the solutions could be seen as offering measures to help the safety department to identify risks and providing recommendations on how to use the data shared by training in an effective and efficient way. The provision of guidelines could also indirectly result in a small reduction of their workload, as they could provide clarity on the processes to be carried out with the data.

The development of solutions in this package would also positively contribute to proportionality and equal opportunities for both large and small operators, as it would support the first operators who are starting to share training data (e.g., sharing training data with safety department) but especially set the stage for less experienced operators to know how to proceed being able to follow these initial steps.</td></tr>
<tr><td>Maturity level</td><td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices. In addition, it is possible to start to find the implementation of incipient measures in some areas by the more mature operators, but not sufficiently extended to the rest of the operators to be considered mature at an industry level.</td></tr>
<tr><td rowspan="3">UC3.1-PS.4 – Safety Promotion regarding the Instructor Concordance Assurance Programme (ICAP)</td><td rowspan="3">Benefits and constraints</td><th>Safety</th><th>Environmental</th><th>Social</th><th>Economic</th><th>Proportionality</th><th>Total</th></tr>
<tr><td>+1</td><td>0</td><td>+1</td><td>+1</td><td>+3</td><td>+6</td></tr>
<tr><td colspan="6">Justification: The solutions included in the package UC3.1-PS.4 indirectly impact safety since they ultimately highly contribute to enhancing the reliability of the data generated and collected during the trainings. By correctly implementing the Instructor Concordance Assurance Programme (ICAP) and using metrics and methodologies to analyse the data collected by instructors and find areas for improvement, operators can ensure that their instructors assess in the appropriate manner, which results in increased confidence in the reliability of the gathered data which reflects the performance of the pilots.

Regarding the social component, the proposed solutions could contribute to increasing the confidence of the instructors since would establish the basis for a more sophisticated approach to detecting potential instructor concordance needs, leading to an enhanced performance of the instructors after applying proper mitigating measures and further training, even translating into a decrease of the instructors’ workload. They would also contribute into an increase of the confidence among pilots regarding the collected data on their performance and towards the instructors themselves. In addition, most of the solutions included in this package are clearly focused on facilitating the work of the staff responsible for conducting the analysis of the instructors' concordance, by clearly defining the methodologies, analysis and metrics to be used.

On the economic side, it is true that, although the tools dedicated to analysing the data are expensive, operators could benefit from better visibility on the needs arising from ICAP, and could allocate their resources more clearly and efficiently, something that is currently more complicated.

Finally, in terms of proportionality, these solutions can assist bigger operators in the implementation and proper functioning of the ICAP but are especially valuable for smaller operators and those with less experience and resources, as these are often the ones who encounter the greatest difficulties in implementing the ICAP due to a lack of guidance.</td></tr>
</table>

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Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes							
	Maturity level	**LOW:** This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices. In addition, it is possible to find that the more mature operators have more experience on these areas, but not sufficiently extended to the rest of the operators to consider the solutions as mature at an industry level.					
UC3.1-PS.5 – Regulatory initiatives regarding the conduction of the programmes, assessments and data gathering	Benefits and constraints	**Safety**	**Environmental**	**Social**	**Economic**	**Proportionality**	**Total**
		+1	0	+1	0	+1	**+3**
		Justification: The main objective of the **"UC3.1-PS.5"** solution package is to clearly establish the basis for performing the assessment of pilots in an optimal and more standardised way, seeking to ensure the collection of reliable data on the behaviour and performance of the pilots mainly by providing further support and guidance to the instructors. Therefore, the development and implementation of the solutions framed in this package may represent a step forward in terms of the correct implementation of the methodologies for conducting the assessments, contributing to an increase in the quality and standardization of the data collection. This could lead to potential improvements in the field of operational **safety**, since such data are subsequently used to find areas of improvement for pilots, which can be corrected by means of adapted training. As for the **social** aspect, it is true that instructors could benefit from a better understanding of the process, methodology and techniques for conducting the assessments and the corresponding final assignment of a grade to the competencies. These potential benefits could include a reduction in their workload resulting from the reduction of the ambiguity that currently exists in this area, alleviated with the proposed guidance materials. Bringing clarity to the whole process surrounding the conduction of assessments, including the methodology, the specific steps to be followed and the techniques to be used by the instructor, may positively and indirectly influence pilots to feel that they are being assessed fairly and to clearly understand on which basis and in which way they are being assessed. All this can contribute to a purely constructive and more fair training environment. Finally, regarding proportionality, considering that any operator implementing an EBT programme needs to conduct the assessments of the trainees, the proposed solutions would benefit all types of operators without any differences. The aim is that any operator could adopt EBT programmes, and properly clarifying the methodology and process for conducting assessments for generating and collecting the data could represent a major step towards this goal.					
	Maturity level	**Medium:** This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations. Moreover, progress is already being made in this direction at EASA level.					

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<table>
<tr><th colspan="8">Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes</th></tr>
<tr><td rowspan="4">UC3.1-PS.6 – Regulatory initiatives regarding the Instructor Concordance Assurance Programme (ICAP)</td><td rowspan="3">Benefits and constraints</td><th>Safety</th><th>Environmental</th><th>Social</th><th>Economic</th><th>Proportionality</th><th>Total</th></tr>
<tr><td>+1</td><td>0</td><td>+1</td><td>+1</td><td>+3</td><td>+6</td></tr>
<tr><td colspan="6"> Justification: The "UC3.1-PS.6" package contains solutions that would enable operators to have resources and guidance material focused on specific parts of the Instructor Concordance Assurance Programme (ICAP) where it has been observed that operators remain confused about how to proceed given the current lack of clarity. These solutions would allow operators to have a clear reference on practices and materials that can be effective for their ICAP and can therefore contribute to making the data collected by instructors more reliable, thus having a positive impact on safety resulting from an improved conduction of risk and training needs analysis using such data. In the same line, defining mechanisms for sharing and integrating the improvements achieved in the context of ICAP by the different operators could also have an indirect positive impact on safety, as the aim is to pursue the implementation of increasingly mature, reliable and appropriately adapted EBT programmes.
In terms of the social dimension, these solutions could result in the operator having a much clearer vision and approach to ICAP, which would translate into an improvement of the data analysis focused on finding concordance needs, and therefore lead to an enhancement of the confidence and performance of the instructors through the provision of specific training. Furthermore, pilots could also experience increased confidence in the programmes, and feel that they are being assessed fairly, as operators would have references on effective methodologies to check that there are no deviations or discrepancies in the data collected or in the way in which instructors assess (e.g., data normalisation, studies and analysis of alignment with the support of the Golden Standards). Finally, the staff responsible for conducting ICAP-related analyses could also see their work facilitated and their workload potentially reduced, as there would be clear guidelines on how to proceed.
On the economic side, operators could have improved visibility on the needs arising from ICAP and the effective methodologies to be applied, what would be translated into an increase of the resource allocation and utilisation effectiveness.
Considering the effects with respect to the proportionality aspect, the proposed solutions could greatly assist operators with less experience or limited resources by providing them with clear guidelines on how to implement and execute their ICAP, including the provision of initial or basic reference materials (e.g., Golden Standards) to start analysing alignment, which would be time and resource consuming if they had to develop it themselves as happens currently. Nevertheless, these solutions would also help mature and well-resourced operators, as most of them still lack clarity and knowledge in the area of instructor concordance. </td></tr>
<tr><td>Maturity level</td><td colspan="6">Medium: This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations.</td></tr>
</table>

DATAPP - D-2.1 - Development of case studies

<table>
<tr><th colspan="8">Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes</th></tr>
<tr><td rowspan="4">UC3.1-PS.7 – Initiatives to support the adoption of digital tools and capabilities for assisting on the assessment conduction and programme’s data analysis</td><td rowspan="3">Benefits and constraints</td><th>Safety</th><th>Environmental</th><th>Social</th><th>Economic</th><th>Proportionality</th><th>Total</th></tr>
<tr><td>+3</td><td>0</td><td>+3</td><td>-1</td><td>+3</td><td>+8</td></tr>
<tr><td colspan="6"> Justification: The "UC3.1-PS.7" solution package is composed of initiatives[1] to support and guide the adoption of digital tools that would be used in several areas of the EBT programmes, from the conduction of pilots’ assessments (i.e. ORCA), to data analysis for identifying pilot training needs and programme improvements, all the way to performing analysis to ensure a proper concordance of instructors. Therefore, and considering that such guidelines for the correct implementation of digital solutions would contribute to avoid risks that compromise the quality and reliability of the data, as well as would mark the desired analytical capabilities and the type of tools to be implemented, the operational safety could be highly benefited given the increased capacity to find potential risks and needs at various levels of the EBT program (e.g., pilots, instructors, the program itself). Moreover, the implementation of various solutions contained in this package would materialise the introduction of digital tools to support the aforementioned activities, which would represent a major step forward in terms of the sophistication and maturity of EBT programmes, having a highly positive impact on the operators' safety.
In the same direction, the provision of such guidelines and the implementation of the tools themselves could provide further benefits in the social side. It would represent an improvement in the sophistication and effectiveness of the processes for performing the assessments and the analysis of the gathered data, also leading to a reduction of the workload of the different employees involved in the process, especially of the instructors and the staff responsible for identifying training needs both for pilots and at the instructor concordance level. And ultimately, it would contribute to ensure that both pilots and instructors have the necessary support and consider that the analyses performed with their respective data are conducted with adequate detail and proficiency, providing confidence in the process and the tools themselves as well as the outputs in the form of areas for improvement.
Regarding the economic impact, the introduction of digital tools involves significant associated costs in terms of the development or purchase of the tools, the hiring of expert staff and specific training for the employees. This is accentuated in the scenario where operators are responsible for implementing their own tools, and would have less impact in the case of implementing generic solutions accessible to any operator.
In terms of proportionality, the possibility of the introduction of generic tools developed and available to all operators, without discriminating by size or level of experience or resources, stands out. Such solutions would be particularly beneficial for operators with less maturity and resources to cover basic needs in terms of data analytics but would also be available and useful for the most experienced operators. For this reason, a positive impact would be generated in terms of a level playing field for any type of operator, at least in terms of the minimum or most basic analyses to be performed for the implementation of effective EBT programmes. </td></tr>
<tr><td>Maturity level</td><td colspan="6">MEDIUM: This package includes a set of solutions that focus on providing support to the implementation of digital tools that assist on the conduction of analyses within different areas of the EBT programmes, also including the creation of basic tools to be used by any operator. It is possible to find that the most mature operators</td></tr>
</table>

[1] Initiative means safety promotion, or rulemaking or a combination of both see impact assessment.

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Use Case 3.1 Use of flight crew training and instructor data to drive EBT programmes		
		have more experience on these areas, indeed having sophisticated tools even including in-house developed solutions, but that is not the case for most operators implementing EBT programmes. Therefore, there is not a high level of maturity regarding that type of tools at an industry level.

Likewise, the potential impact of the solution package established in the context of Use Case 3.2 is assessed:

➨ **Table 3-12** Impact Assessment of proposed solution packages for Use Case 3.2

Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data								
UC3.2-PS.1 – Safety Promotion regarding integration of relevant safety data within the EBT programmes	**Benefits and constraints**	**Safety**	**Environmental**	**Social**	**Economic**	**Proportionality**	**Total**
		+3	0	+1	0	+3	**+7**
		Justification: The solutions under **'UC3.2-PS.1'** are intended to enable the integration of safety data into EBT programmes by providing a mapping between safety and training data, and by providing guidelines on methods and techniques for the fusion of such data. Establishing such a mapping is important because FDM data provides real-world insights into pilot performance and aircraft operations, and by mapping these data to EBT competencies, organisations can conduct a data-driven analysis of training needs, considering actual performance data rather than assumptions. In addition, it allows the operators to proactively identify areas where safety-related competencies may need improvement. From the programme customisation perspective, this mapping also plays an important role, as it enables a better adaptation of the programmes to the safety priorities identified by the safety department and to the risks detected in actual operations, for example with the help of the FDM programme. Finally, ensuring that the FDM data from the operator itself is well-integrated into the programmes is also crucial from a regulatory compliance point of view, since the regulations state that operators must demonstrate that they customise their programmes using their own operational data. Given all these considerations, the impact of the proposed solutions in terms of **safety** could be significantly positive. On the **social** domain, these solutions could have a positive contribution in facilitating the work of both the training department and the safety department, as it would allow for the establishment of a kind of common language that would facilitate the exchange of information, and its integration into the EBT programmes. In addition, both departments and their respective employees would gain visibility on the other department and its processes, providing them with further cross-functional expertise. And finally, in terms of **proportionality**, a positive impact could also be expected, as these guides can be very valuable, especially for less experienced operators who experience more difficulties when it comes to sharing data between departments. In this way, they could follow the lead of the more mature operators who are already starting to implement methodologies for easing the sharing and integration of safety data.					

<table>
<tr><th colspan="8">Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data</th></tr>
<tr><td></td><td>Maturity level</td><td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices. In addition, it is possible to start to find the implementation of incipient measures in some areas by the more mature operators, but not sufficiently extended to the rest of the operators to be considered mature at an industry level.</td></tr>
<tr><td rowspan="4">UC3.2-PS.2 – Safety Promotion regarding the proper governance of safety and training departments cooperation</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+3</td><td>0</td><td>+1</td><td>0</td><td>+3</td><td>+7</td></tr>
<tr><td colspan="6">Justification: The solution package "UC3.2-PS.2" is intended to provide operators with guidelines and references on how to approach the cooperation between the safety department and the training department, also defining requirements for initiatives such as audits by the authorities for monitoring this cooperation. It aims to define a governance framework and clarify how to proceed to ensure that the information shared by safety is effectively integrated into training programmes. Establishing these measures and providing recommendations for effective interdepartmental collaboration, ensuring secure access to safety data and its integration into EBT programmes, and on the respective oversight by the authority can have a positive impact on the operational safety. This positive impact would mainly derive from a better adaptation of EBT programmes by including the risks and occurrences provided by safety.

On the social side, these measures can help create an environment of continuous collaboration between departments, making the exchange of data more fluid. This would help employees in both departments to be more familiar with how to approach in the context of EBT programmes and their effective adaptation. Moreover, it can result in greater engagement with pilots, and an increase in their confidence, as a result of improved adaptation of the programmes to the real challenges encountered in the operations and analysed by safety.

In terms of proportionality, this would also have a very positive impact, as experienced operators have an advanced cooperation with the safety department, but for less mature operators such cooperation is not achieved. These solutions could support operators who encounter greater difficulty in accessing safety data and in effectively integrating it into training programmes.</td></tr>
<tr><td>Maturity level</td><td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices. In addition, it is possible to start to find the implementation of incipient measures in some areas by the more mature operators, but not sufficiently extended to the rest of the operators to be considered mature at an industry level.</td></tr>
</table>

<table>
<tr><th colspan="8">Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data</th></tr>
<tr><td rowspan="4">UC3.2-PS.3 – Regulatory initiatives regarding the staff’s responsibilities</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>0</td><td>0</td><td>+3</td><td>+1</td><td>+1</td><td>+5</td></tr>
<tr><td colspan="6">Justification: The solutions included in the "UC3.2-PS.3" package seek to define the main functions and roles of the employees involved in EBT programmes and to promote the figure of the EBT Manager. Such solutions can have a positive impact on the social aspect, as they would allow the operator to better define and dimension the different involved teams or departments and their functions. In this way, staff would also be clearer about their roles and more comfortable with the tasks to be performed and would benefit from a more balanced workload. And no less important, the promotion of the EBT Manager, the definition of his/her responsibilities and his/her potential involvement in overseeing processes such as access to and use of safety data, can help to create an environment of trust and confidence for pilots and instructors.

Clearly defining the responsibilities of the staff involved in running EBT programmes could help operators to have better visibility on how they should allocate their resources in an efficient and effective way. Thus, this would be a positive aspect to consider in the economic field.</td></tr>
<tr><td>Maturity level</td><td colspan="6">Medium: This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations.</td></tr>
<tr><td rowspan="3">UC3.2-PS.4 – Regulatory initiatives regarding the proper integration between the EBT training programme and the safety department processes</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+3</td><td>0</td><td>+1</td><td>0</td><td>+3</td><td>+7</td></tr>
<tr><td colspan="6">Justification: The solution package "UC3.2-PS.4" is intended to provide operators with guidance on how to properly integrate the data coming from the safety department (e.g., FMD data) with the EBT programmes, also addressing data misuse potential issues. Clearly defining the transmission requirements and the scope of data to be shared by safety can have an indirect impact on safety. This impact would be positive, as achieving a good integration of safety data with EBT programmes, while applying good practices regarding data security, use and management, results in programmes that are better adapted and responsive to the risks and challenges encountered by operators.

On the social side, these solutions would provide clarity on the requirements to be fulfilled from the safety and training departments on those areas, fostering a more effective collaboration between departments. From the point of view of data usage, introducing measures to prevent the pilots' data misuse may also have a positive impact through increased pilots' confidence in the programmes.

Considering the aspect of proportionality, these solutions would allow any operator implementing an EBT programme to have clear references on what safety data to use and how to use it, regardless of its size or level of resources.</td></tr>
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<table>
<tr><th colspan="8">Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data</th></tr>
<tr><td></td><td>Maturity level</td><td colspan="6">Medium: This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations.</td></tr>
<tr><td rowspan="4">UC3.2-PS.5 – Regulatory initiatives regarding the customisation of the programmes and contextualisation of scenarios</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+3</td><td>0</td><td>+1</td><td>+1</td><td>+1</td><td>+6</td></tr>
<tr><td colspan="6">Justification: The "UC3.2-PS.5" package encompasses solutions aimed to enable a good adaptation of the implemented programmes and scenarios. The selection of the topics and scenarios to be introduced in the programmes, together with the appropriate contextualisation of these scenarios to reflect the reality of the operations, is what makes the programmes effective. Therefore, these solutions could have a positive impact on the safety of operations, resulting from EBT programmes that better address the risks of operations and are thus more effective.

From this improvement in the adaptation of programmes and scenarios to train with a focus on real potential risks, a positive impact on the social aspect could also be derived, as pilots' confidence would increase. Pilots would feel progressively more comfortable in dealing with any kind of situation they might encounter in real-life operations.

In economic terms, having references and guidelines on how to better adapt the programmes may lead to operators being able to allocate and use their resources more efficiently and reduce training costs.

And finally, in terms of proportionality, materials would be provided so that less experienced operators could also achieve EBT programmes that are appropriately tailored to their needs and reflect their actual operations. They would also support mature operators to enhance their customisation and contextualisation processes.</td></tr>
<tr><td>Maturity level</td><td colspan="6">Medium: This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations.</td></tr>
<tr><td rowspan="3">UC3.2-PS.6 – Initiatives to support the adoption of digital tools and capabilities for assisting on the customisation of the programmes</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+3</td><td>0</td><td>+1</td><td>-1</td><td>+1</td><td>+4</td></tr>
<tr><td colspan="6">Justification: The "UC3.2-PS.6" solution package is composed of initiatives to support and guide the adoption of digital tools within the context of the customisation of the programmes and the contextualisation of the scenarios. Therefore, and considering that such guidelines for the correct implementation of digital solutions would define the desired analytical capabilities and the type of tools to be implemented, the operational safety could be highly benefited through the enhanced capabilities in terms of the design and adaptation of the programmes. For that reason, the implementation of these tools itself could have a positive impact in safety since they would support the above-mentioned activities with the objective of enhancing programmes. Regarding the promotion of data sharing programmes, it could</td></tr>
</table>

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Use Case 3.2 Syllabus customisation and scenario contextualisation using operational data		
		also bring **safety** benefits. Promoting a culture of collaboration and safety could motivate operators to proactively participate in data sharing programmes, resulting in improved **safety**, performance, and operational efficiency in the industry. In the same direction, the provision of such guidelines and the implementation of the tools themselves could provide further benefits in the **social** side. It would represent an advance in terms of the adaptation of the programmes and scenarios, which would potentially lead to a reduction of the workload of the different employees involved in the process. Likewise, pilots could also receive training that is better adapted to their needs and that addresses real risks that they may encounter, which can result in an increase in their confidence and performance. Regarding the **economic** impact, the introduction of digital tools involves significant associated costs in terms of the development or purchase of the tools, the hiring of expert staff and specific training for the employees. This is accentuated in the scenario where operators are responsible for implementing their own tools and would have less impact in the case of implementing generic solutions accessible to any operator. With respect to data-sharing programmes promotion, these types of programmes could provide economic benefits, since the operators that participate would benefit from more data and capabilities to consider when customising and contextualising their programmes without incurring in extra costs. In terms of **proportionality**, such solutions would be particularly beneficial for operators with less maturity and resources, allowing them to have visibility on their needs in terms of data analytics for that area, but would also be useful for the most experienced operators which do not have sophisticated solutions either.
	Maturity level	**MEDIUM:** This package includes a set of solutions that focus on providing support to the implementation of digital tools that assist on the customisation of the programmes and the contextualisation of scenarios. In that regard, it is possible to find that the most mature operators have more experience on these areas, indeed having sophisticated tools even including in-house developed solutions, but that is not the case for most operators implementing EBT programmes since the tendency is to use functional but very basic tools. Therefore, there is not a high level of maturity regarding that type of tools at an industry level.

Finally, following the same approach, the potential impact of the solution packages defined for Use Case 3.3 has also been assessed:

Table 3-13 Impact Assessment of proposed solution packages for Use Case 3.3

Use Case 3.3 Authorities support and role within EBT programmes							
UC3.3-PS.1 – Safety Promotion for the improvement of authorities' visibility on EBT programmes and the proper bi-directional sharing of data between authorities and operators	**Benefits and constraints**	**Safety**	**Environmental**	**Social**	**Economic**	**Proportionality**	**Total**
		+3	0	+1	0	+1	+5
		Justification: The solutions in the "UC3.3-PS.1" package aim at improving the authorities' visibility on EBT programmes, as well as ensuring an efficient exchange of data between authorities and operators, and vice versa. The fact that authorities can easily access the information needed to ensure that EBT programmes are effective, while they also share data with their operators to enable them to adapt programmes to address identified risks, can have a positive impact on **safety**. In the **social** field, it is also of great importance to ensure that the authority's staff have the necessary data to perform the approval and monitoring of EBT programmes. This enables them to perform their work more efficiently and effectively and enhances their ability to benchmark and find areas for programme improvement. In addition, having references in terms of how to do proper data sharing and how to improve access to data can help these processes to become more standardised and straightforward, slightly reducing their workload. From the operator's point of view, there would also be a positive impact resulting from the increased clarity in this area, as well as empowering staff by giving them more data to use in the customisation of programmes. And with regard to **proportionality**, this would ensure that both the more mature operators who have a good relationship with the authority and have set the path for the development of requirements, and the less mature operators can achieve a seamless collaboration with their authority.					
	Maturity level	**LOW:** This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices. In addition, it is possible to start to find the implementation of incipient measures in some areas by the more mature authorities and operators, but not sufficiently extended to the rest of the operators to be considered mature at an industry level.					
UC3.3-PS.2 – Safety Promotion for the monitoring		**Safety**	**Environmental**	**Social**	**Economic**	**Proportionality**	**Total**
		+3	0	+1	0	+1	+5

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<table>
<tr>
<td rowspan="2">of EBT programmes' effectiveness and consistency</td>
<td>Benefits and constraints</td>
<td colspan="6">Justification: In the case of the "UC3.3-PS.2" solution package, a positive impact could be expected in the area of safety. Ensuring that authorities have references and means to be able to monitor the effectiveness and consistency of EBT programmes contributes in a very positive manner to the enhancement of safety, as it helps to ensure that the programmes work as expected and that they respond to the risks encountered in operations. In this regard, improving the safety of operations requires verifying that programmes are conducted effectively and efficiently, and that their consistency is maintained over time.

On the social level, a positive impact could also be achieved by clearly supporting the authorities' staff in their tasks of identifying training needs and risks and assessing the effectiveness of programmes. In addition, measures and means would be developed to support the monitoring of the effectiveness and consistency of the programmes. However, it is true that a slight increase in the workload could be observed if the authorities were assigned the task of monitoring the consistency of the programs.

And finally in terms of proportionality, benefits would again be expected for any authority and operator, regardless of their level of maturity or resources.</td>
</tr>
<tr>
<td>Maturity level</td>
<td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices.</td>
</tr>
<tr>
<td rowspan="4">UC3.3-PS.3 – Regulatory initiatives regarding the oversight of EBT programmes'</td>
<td rowspan="3">Benefits and constraints</td>
<td>Safety</td>
<td>Environmental</td>
<td>Social</td>
<td>Economic</td>
<td>Proportionality</td>
<td>Total</td>
</tr>
<tr>
<td>+3</td>
<td>0</td>
<td>+3</td>
<td>0</td>
<td>+1</td>
<td>+7</td>
</tr>
<tr>
<td colspan="6">Justification: The objective of the solution package "UC3.3-PS.3" is to define the requirements for the sharing of specific operator data such as the distribution of gradings or the number of simulator hours, as well as for the establishment of a framework of KPIs used to perform the monitoring of the programs by the authority. Clearly defining the data and metrics to be used to monitor programs could have a positive impact on safety, as it would ease the authority's task of finding areas of improvement and needs for the programmes, which must be corrected to ensure that the programmes are effective.

Similarly, the introduction of these solutions could bring benefits from a social perspective, mainly for the authority's employees, who would see their oversight job facilitated through increased standardisation of the data reception and the definition of a clearer structure or framework for the key metrics for the programmes.

In terms of proportionality, a positive impact can also be expected, as the more inexperienced operators and authorities would have a clearer reference regarding data sharing and program oversight, but it would also help the more mature ones as the current framework is not clear. This would support any operator or authority to comply with the requirements associated with the monitoring and oversight of the programmes.</td>
</tr>
<tr>
<td>Maturity level</td>
<td colspan="6">Medium: This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations.</td>
</tr>
</table>

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<table>
<tr><td rowspan="4">UC3.3-PS.4 – Initiatives to support the adoption of digital tools and capabilities for assisting authorities</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+3</td><td>0</td><td>+1</td><td>+1</td><td>+1</td><td>+6</td></tr>
<tr><td colspan="6">Justification: Promoting and implementing tools or programmes to support authorities in managing data shared by operators would have a positive impact in terms of safety. This impact would be motivated by a potential improvement in the monitoring of programmes based on the received data, motivating a continuous search for improvements to be introduced in the programmes. Likewise, ensuring that authorities develop expertise in IT and data analytics tools can contribute to a more active participation in the detection of risks and training needs, contributing to a potential increase of safety in operations.

On the social dimension, these solutions would allow the authorities' staff to gain experience in the field of analytical tools, and to have more data to suggest improvements to their operators. In addition, they would benefit from more effective and standardised data reception, and their workload would be balanced, allowing them to spend more time on what is really important, namely effective programme monitoring. Moreover, operators and their employees, including pilots, could gain confidence in the authorities and in their performance in monitoring the programmes.

Another area where a positive impact could appear is the economic one, especially with the participation of operators and authorities in data sharing programmes. Data-sharing programmes facilitate the sharing of operational data from multiple sources, allowing operators and authorities to collectively analyse trends, identify inefficiencies and develop cost-effective solutions. By leveraging shared information, operators and authorities can streamline operational processes, optimise resource allocation and reduce overall operational costs. Through such initiatives, efforts could be directed towards developments that benefit the whole industry, including operators and their EBT programmes. And participating operators and stakeholders could enjoy these benefits by contributing with their data.

Finally, the solutions in this package would have a positive impact in terms of proportionality, as any operator or authority could benefit from them, promoting a level playing field regardless of size and resources.</td></tr>
<tr><td>Maturity level</td><td colspan="6">LOW: This package includes solutions that focus on the creation of collaborative data programmes and on the definition of specific training to enhance authorities IT capabilities, so they have not reached a notable level of maturity yet.</td></tr>
</table>

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4. Development of Case Study 4: Digital fuel management

4.1 Use Case 4.1: Leveraging aircraft-specific fuel data for fuel performance-based schemes

The use of fuel-related data within the context of fuel schemes involves several key activities to ensure efficient and safe fuel usage in airline operations. The process begins with the **collection and processing of aircraft-specific fuel data**, obtained from sources such as the Aircraft Communications Addressing and Reporting System (ACARS) or the Quick Access Recorder (QAR), which provides FDM data. This first activity enables operators to analyse current fuel consumption patterns and usage. Furthermore, the collection of fuel-related data allows operators to build a valuable data repository of historical information, which serves as a foundation for potential future initiatives, such as the introduction of individual fuel schemes.

By leveraging historic aircraft-specific fuel data, operators can apply data analytics techniques on fuel consumption. These analyses facilitate the **creation of statistical or predictive models** that provide insights into fuel usage for overall flights as well as specific flight phases. Armed with this information, operators can plan fuel allocation more efficiently. The development of these models not only enable the identification of opportunities for reducing fuel amounts when deemed safe, but also help operators detect potential situations where fuel consumption trends deviate, and additional fuel needs to be added.

Moreover, in addition to the utilization of historical data for fuel planning purposes, advanced analytics techniques are applied to the **post-ops analysis of fuel consumption data**. This analysis is designed to uncover trends, patterns, and areas for improvement in fuel usage. By leveraging the power of data analytics, operators can make data-driven decisions to optimise fuel performance, reduce costs, and enhance operational efficiency while ensuring the utmost safety in their operations.

Based on this comprehensive process description, the use of fuel-related data within fuel schemes can be divided into four (4) key activities, presented in Figure 4-1.

➨ **Figure 4-1** Process activity breakdown for Use Case 4.1

4.1.1 Working process activities and limitations

4.1.1.1 Fuel-related data collection and quality assessment

Data plays a vital role in fuel efficiency programmes, and the collection of fuel-related data serves as the initial step in the fuel planning and management process. Airlines engage in the collection of aircraft-specific fuel data utilizing sources such as the Aircraft Communications Addressing and Reporting System (ACARS) or Flight Data Monitoring (FDM) data, collected through the Quick Access Recorder (QAR). Additionally, some operators rely on manual processes to gather specific parameters during in-flight planning and management. These data collection systems provide essential fuel-related information during each flight phase, which serve as a crucial input for subsequent analysis and decision-making.

The collection of fuel-related data can be analysed and understood through three (3) key dimensions: Technology & Data, Organisation, and Operations, which provide insights into the various aspects and challenges associated with the data collection process.

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4.1.1.1.1 Technology & Data

This activity encompasses the collection of fuel-related data, with a specific emphasis on gathering aircraft-specific fuel data. The technology supporting this activity is **hardware** located within the aircraft, as airlines typically retrieve aircraft-specific fuel data from:

- Aircraft Communications Addressing and Reporting System (ACARS): Airlines commonly extract fuel-related parameters from OOOI events, which constitute a significant function of ACARS. This system automatically detects and reports the commencement of major flight phases, encompassing events out of the gate, off the ground, on the ground, and into the gate. At the start of each flight phase, an ACARS message is transmitted to the ground, providing details regarding the specific phase, its corresponding time, and additional related information such as the amount of fuel on board.
- (Wireless) Quick Access Recorder ((W)QAR): This airborne equipment records flight parameters, similar to the Flight Data Recorder (FDR). However, the QAR possesses the advantage of being more accessible and easier to download, facilitating the retrieval of the desired fuel-related data.

The first versions of the fuel regulation include an analytical framework to support the performance-based fuel reduction schemes. This defines the parameters (GM1 CAT.OP.MPA.185) to be recorded by means of ACARS / (W)QAR data sources and also the set of safety performance indicators that should be monitored to ensure an equivalent safety baseline (GM2 CAT.OP.MPA.180). The list of essential fuel data to be recorded for the Basic Fuel Scheme from the guidance material provided by EASA in GM1 CAT.OP.MPA.185 includes:

- Off-block fuel;
- Take-off fuel, if this data can be recorded automatically;
- ‘MINIMUM FUEL’ declarations;
- ‘MAYDAY MAYDAY FUEL’ declarations;
- Fuel after touchdown if this data can be recorded automatically;
- On-block fuel;
- Remaining fuel amount at regular intervals.

Mapping the requested fuel parameters and KPIs against the data parameters within the available data sources of operators (ACARS / QAR) for their FCMS is not trivial. Operators face limitations in terms of defining a robust framework for monitoring fuel schemes and the minimum list of necessary parameters to be collected to meet these needs.

The stakeholder consultation allowed discussions with different operators to understand which parameters are commonly used in fuel reduction schemes, in particular with those who recurrently use FDM as data source. Focusing on the core parameters of fuel schemes (i.e. excluding contextual data relating to operations such as procedures and infrastructure in use), operators having FDM data as source use all the minimum parameters necessary for FDR, as per Table 1 in AMC1.1 CAT.IDE.A.190, mostly for flight operations characterisation (e.g., flight positioning, flight profile…). These are complemented by the list of flight parameters in Table 2 of the same document AMC1.1 CAT.IDE.A.190. Considering the available list in Table 2 and other examples of parameters extracted from the interviews held with stakeholders under the scope of the project, Table 4-1 presents a proposed non-exhaustive list of parameters that could support the fuel schemes.

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Table 4-1 Proposed list of minimum parameters to support the fuel schemes in addition to the mandatory parameters for FDR

Parameter	Reference No* in AMC1.1 CAT.IDE.A.190 (Table 2)
Fuel flow	35F
Fuel cut-off lever position	35G
Fuel Quantity Indication	-
Additional engine parameters: **Engine Pressure Ratio (EPR)** **N1** **N2** **TLA** **N3**	35: 35a 35b 35d - 35h
Landing gear: **Landing gear position** **Gear selector position**	32: 32a 32b
Ground speed	31
Radio altitude	20
Navigation data: **Drift angle** **Wind speed** **Wind direction** **Latitude** **Longitude** **GNSS augmentation in use**	33: 33a 33b 33c 33d 33e 33f
Gross weight	-
Zero fuel weight	-
Departure airport	-
Destination airport	-

Operators have the flexibility to choose the appropriate data source to collect fuel-related parameters that covers all their specific needs and requirements. However, the lack of a guidelines to define robust data input frameworks that deal with **data source selection** and comprehensive **lists of fuel-related parameters to record**, and **data quality assessments** poses significant limitations and challenges for operators.

The challenges and limitations identified through the stakeholder consultation process are:

- **UC4.1-TEC.1 - Limited usefulness of fuel data depending on the data source selection:** The operator's choice of which data source to use for collecting fuel-related data can be a challenge, as they need to navigate the existing trade-offs between existing sources. This can be especially challenging for small operators who face limited resources and manpower. In general, operators lack guidance for choosing the most suitable data source that covers all their specific needs in terms of sampling rate, availability, and control.
  - **UC4.1-TEC.1A - Limited usefulness of fuel data in ACARS due to limited fuel parameters with sampling rate limitations:** Some operators only rely on ACARS data, but this approach has limitations, as ACARS only allows to collect a limited set of fuel parameters at specific points of flights. As a result, these operators may lack all necessary data points to justify certain fuel reductions. For instance, operators aiming to reduce trip fuel for specific approaches with repetitive holdings might need a detailed operation mapping that can't be performed with only

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ACARS data. On the other hand, FDM data offers a wider range of parameters with increased sampling rate.

- **UC4.1-TEC.1B - Limited usefulness of fuel data from the FDM programme due to delayed availability:** ACARS data is transmitted in real-time, but FDM data isn't. Instead, operators must wait until the FDM data is transmitted when the aircraft reaches the destination or when manually downloaded, which can, for the latter case, sometimes cause delays in accessing relevant information or an overall delay in the availability of data. In addition, not having the information in real time limits in-flight replanning capabilities.
- **UC4.1-TEC.1C - Limited usefulness of fuel data in FDM due to limited data control:** The management of FDM data usually resides within the safety department, as they are responsible for data storage, processing, and de-identification. In such cases, the fuel department relies on collaboration with the safety department to access the data, leading to potential delays in the monitoring of parameters related to fuel performance.

- **UC4.1-TEC.2 - Limited FDM data collection capability for operators with non-Airbus or Boeing aircraft:** Airbus and Boeing, being big aircraft manufacturers, may offer a set of sophisticated, mature and robust hardware and software solutions tailored for FDM data collection. These maturity of their FDM solution ecosystem has favoured development in other areas of analytical exploitation, including FCMS among others. Airbus and Boeing have a lot of R&D and have contributed to the development of FDM and FOQA programmes in their respective geographies, leading the development and being in the vanguard. This experience widens the gap with other providers who, although mandatory, have not had as much opportunity to develop FDM-related analytical capabilities as FCMS. In that regard, some operators with diverse fleets, not limited to Airbus and Boeing, have expressed that they have more limited tools and resources to collect and exploit FDM data. These operators sometimes lack access to such sophisticated tools, hindering their ability to collect and utilise FDM data for fuel planning and management purposes. Moreover, this gap is even wider for some operators with small aircraft fleets (MCTOM of less than 27,000 kg) which may not have the obligation to implement FDM Programmes, further hindering their data collection capabilities.
- **UC4.1-TEC.3 – Limited recording capacity of airborne systems on board older aircraft limiting the possibilities to record new flight parameters:** Operators with older aircraft face a unique challenge when it comes to incorporating new flight parameters. These operators may encounter difficulties due to limited data capacity within their FDM data frames. The limited space within the FDM data frames compounds the challenge, potentially preventing operators from accommodating additional fuel-related data.
- **UC4.1-TEC.4 - Duplicated parameters coming from different sources:** Operators sometimes find discrepancies and inconsistencies in parameters coming from different sources, namely ACARS and FDM data. As discussed with some operators, ACARS and FDM are consistent, but the ACARS reading is within 2% error. They come from the same sensors but there is a 1% error in the tank and a 1% error in the display. These duplicated parameters, together with these discrepancies, lead to difficulties in integrating data sources or choosing which source to prioritise for each duplicated parameter.
- **UC4.1-TEC.5 – Lack of guidance to address data quality problems:** Some operators experience problems in the data quality of some parameters depending on the aircraft model, such as degradations, spurious peaks, or limited sampling rate depending on which sensor is providing the data (e.g., the Fuel Quantity Indicator sensor). The lack of guidelines on data quality assessments with minimum accuracy requirements for fuel parameters or guidelines on how to ensure data consistency poses a big challenge for operators.
- **UC4.1-TEC.6 - Integration of data sources:** Operators may encounter limitations when integrating fuel-related data from multiple sources. Compatibility issues between these sources (as it could be the ones

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mentioned in UC4.1-TEC.4, UC4.1-TEC.5 and UC4.1-TEC.6) can give rise to discrepancies or constraints in the collected data, potentially compromising its accuracy and completeness.

4.1.1.1.2 Organisation

Operators should define and establish procedures within their organization to collect fuel-related data, ensuring that fuel planning and management processes are data-driven methods. Responsibility and knowledge over this activity is sometimes split over multiple departments within the operator, depending on the technology used. For instance, operators collecting fuel-related data from the FDM programme rely on the coordination of the fuel department with the FDM/Safety department.

The challenges and limitations identified through the stakeholder consultation process are:

- **UC4.1-ORG.1 - Definition of relevant fuel data to be recorded:** The guidance material provided by EASA in GM1 CAT.OP.MPA.185 outlines the essential fuel data to be recorded for the Basic Fuel Scheme. However, this list of parameters is not extended to the Basic Fuel Scheme with Variations or Individual Fuel Schemes. This creates a limitation as the defined set of parameters may not be sufficient for operators seeking to implement fuel reductions and assess the safety implications. Operators are left with the responsibility of identifying additional parameters to supplement the existing set, ensuring they offer the necessary level of detail to support safe reductions. The lack of comprehensive lists of fuel-related data to be recorded for each fuel scheme also brings two additional limitations:
  - **UC4.1-ORG.1A - Verification of selected relevant fuel data to be recorded:** Authorities also face challenges in verifying that the selected parameters maintain the safety of reductions, which, in turn, may limit their ability to promote effective, scaled-up, and standardised approval of these initiatives.
  - **UC4.1-ORG.1B - Lack of visibility on future fuel data to be recorded:** The lack of defined parameters for performance-based schemes also creates a lack of visibility for operators that hinders their ability to collect the necessary parameters well in advance to meet the two-year data requirement to access performance-based schemes.
- **UC4.1-ORG.2 - Recording of fuel data at regular intervals:** The guidance material provided by EASA in GM1 CAT.OP.MPA.185 defines a requirement for a minimum data frequency on short and long-range flights (30 and 60 minutes, respectively). However, some operators argue whether these frequencies are always adequate, and some operators propose fuel annotation by waypoints rather than at fixed time intervals. On the other hand, this prescribed frequency raises questions about the performance of the data as it requires considering data coming from FDM which is not available with ACARS. Each source allows access to data at different frequencies, and this varies the performance of data collection.
- **UC4.1-ORG.3 - Reliance on manual data collection:** The reliance on manual data collection among some operators bring some limitations that become evident as both the manual collection and subsequent digitalization introduce the potential for errors, which can accumulate and undermine the overall quality and reliability of data. This challenge is further compounded when dealing with parameters such as the Fuel Quantity Indicator, where the inherent errors associated to the indicator can be magnified during manual collection, resulting in significant deviations. This challenge is not exclusive to small operators, as even some larger operators resort to manual collection of specific fuel-related parameters. For example, certain operators manually record parameters required for CO_2 emissions reporting, which closely resemble the parameters specified in the fuel schemes regulation. These parameters may include, for instance, fuel amounts at the in-block and off-block moments, which are largely used in fuel performance analysis. In fact, GM1 CAT.OP.MPA.181 (c) states that where possible, data should be collected automatically; however, manual recording of data does not preclude an operator from participating in a fuel consumption monitoring system. Despite the allowance for manual data collection in current regulations, it is crucial to recognize the inherent limitations and

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potential risks associated. While manual data collection may be permitted, additional guidelines and standards should be developed to ensure the reliability and quality of the collected data.

- **UC4.1-ORG.4 - Misalignment of available flight data parameters and fuel-related parameters needs:** One of the challenges faced by operators that use flight data for fuel planning and management is the discrepancy between the set of flight parameters available from the FDM programme and the parameters required for fuel performance-based schemes (CAT.OP.MPA.185). As the set of parameters used in FDM programmes is not standardised (and the list of minimum parameters required to be captured in FDRs is limited for these purposes (see AMC1.1 CAT.IDE.A.190)), there is a significant misalignment with the requirements from fuel schemes. As a result, operators may face difficulties in leveraging their existing flight data capabilities and incorporating the required parameters for fuel-related purposes.
- **UC4.1-ORG.5 - Establishment of FDM data governance agreements:** The fuel department relies on collaboration with the safety department to access FDM data. In this regard, operators should establish comprehensive governance agreements to ensure the smooth flow of FDM fuel-related data within the organization. In fact, the specific operators' data governance frameworks ruling over FDM programmes can be a blocking point to sharing this data outside the FDM department itself. Implementing data governance agreements that encompass data sharing protocols with privacy protection and the cultivation of a 'just culture' can present significant challenges for operators, particularly in the absence of detailed guidance on implementing such frameworks within the context of fuel planning and management. In that context, "just culture" is understood as a climate of trust is established wherein individuals are not only encouraged but also rewarded for sharing crucial safety-related information. However, it is equally important that there is clarity regarding the boundaries distinguishing acceptable from unacceptable behaviour.
- **UC4.1-ORG.6 - Adoption of digitalisation solutions or methodologies for the collection of fuel-related data:** Some operators still rely on manual methods for collecting fuel-related data, which involve personnel manually recording fuel-related parameters, increasing the workload and potential transcription errors or data entry mistakes. To improve efficiency and reduce the likelihood of errors, operators should consider transitioning to more automated and digitalized data collection methods (e.g., adoption of Electronic Flight Bags or other digital tools specifically designed for collecting fuel data). However, integrating digital methods into existing processes may encounter obstacles such as long and complex approval processes. Despite the benefits of digitalization, navigating these approval processes and managing the associated time and effort can pose real obstacles for operators.

4.1.1.1.3 Operations

During flight operations, operators engage in the collection of fuel-related data, an essential aspect of fuel planning and performance analysis. This activity involves the integration of data into fuel management systems, enabling operators to make informed decisions regarding fuel usage. However, there are specific limitations associated with the operational aspects of data collection that operators must address.

- **UC4.1-OPS.1 - Lack of resources or manpower for the implementation of performance-based schemes:** The lack of clear guidelines on data collection processes and data quality assessments for performance-based schemes creates and overall limitation for operators, as they may face difficulties in identifying and allocating the necessary manpower and resources to meet the requirements for successful implementation. Without sufficient resources, small operators may struggle to effectively implement performance-based schemes, potentially missing potential fuel savings and operational improvements.
- **UC4.1-OPS.2 - Limited expertise in CAAs for auditing and approving data-related processes:** The limited IT expertise within Civil Aviation Authorities to effectively approve data-related processes poses a challenge in the context of fuel schemes. The approval process for procedures associated with fuel-

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related data collection and quality assessment can be particularly challenging for authorities, as they often lack the necessary expertise to comprehensively assess and validate the methodologies or techniques employed by operators. This knowledge gap poses a significant barrier to the establishment of robust auditing and approval procedures, impeding the thorough validation of the necessary fuel-related parameters and overall quality of fuel-related data.

- **UC4.1-OPS.3 - Lack of standardization and alignment between CAAs in data acquisition and verification processes:** The regulator's intention was to establish a framework of soft rules where fuel planning and management allowed for more flexibility, ultimately understanding individual fuel schemes as an opportunity to be able to reduce specific fuel components for specific operational circumstances. However, this lack of definition has led to a lack of standards that the authorities have compensated by developing their own guidelines, resulting in a lack of alignment between CAAs. This misalignment poses a challenge for operators with more than one AOC, as they face difficulties in harmonizing practices and requirements (i.e., Operations Manuals) across multiple jurisdictions to ensure uniformity in their fuel data acquisition and verification processes. The absence of standardised standards can result in inefficiencies, inconsistencies, and increased administrative burden.

4.1.1.2 Development of fuel consumption models

As operators continue to advance in their efforts to optimise fuel consumption and enhance operational efficiency, the development of fuel consumption models emerges as a key component in the overall process. This activity closely follows the fuel-related data collection, where operators diligently gather and analyse essential data related to fuel usage and performance. With a wealth of valuable data in hand, the next phase involves the construction of fuel consumption models.

During this activity, operators are currently focused on developing statistical methods for contingency or taxi fuel estimation, laying the groundwork for further advancements in fuel management. By leveraging various statistical techniques and methodologies, operators aim to build robust and reliable models that accurately capture fuel usage patterns across different operational scenarios. By mastering these statistical methods, operators set the stage for future advancements, including the incorporation of cutting-edge technologies like Artificial Intelligence and Machine Learning.

The development of fuel consumption models can be analysed and understood through three (3) key dimensions: Technology & Data, Organisation, and Operations, which provide insights into the various aspects and challenges associated.

4.1.1.2.1 Technology & Data

In the field of fuel consumption estimation, operators face significant challenges related to the technology and data used behind the development of statistical or predictive models. On one hand, the development of models relies on the collection of fuel-related historic data, and operators need to ensure that the data collected is sufficient to build reliable models. Additionally, integrating diverse data formats and aircraft fleets further adds to the complexity of this task.

On the other hand, operators must carefully investigate and select an appropriate technical approach that aligns with their specific operational realities. This is crucial to ensure that the developed model provides accurate and reliable results, addressing the unique requirements and characteristics of their operations.

- **UC4.1-TEC.7 - Generalization of fuel consumption models:** The first limitation is about the generalization of these models across different aircraft or operational contexts. EASA's guidance material, specifically GM1 CAT.OP.MPA.181, states that data collected from one aircraft should not be used as the basis for varying the performance figures of another aircraft away from the predicted values. While this approach aims to ensure accuracy and avoid potential safety risks, it raises questions about the limits of generalization in these models. For example, operators may apply a statistical contingency or taxi fuel model developed for one aircraft tail to other tails of the same aircraft model.

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However, without specific guidelines on the extent of generalization allowed, operators face uncertainties in determining whether it is acceptable or not. Establishing clear guidelines that strike the right balance between standardization and generalisation is crucial to enable operators to confidently apply generalised statistical models with enough consistency and safety while allowing for some flexibility in fuel reduction initiatives.

- **UC4.1-TEC.8 - Limited regulatory details regarding the set of statistically relevant data:** The concept of what is considered statistically relevant is crucial in fuel reduction initiatives. While the current standard requires a minimum of two years of operational data, it is important to recognize that fuel reductions should be tailored to specific operations. Therefore, beyond the minimum data requirement, clear guidelines are needed to ensure the reliability, accuracy, and other factors that determine the model's input quality.
- **UC4.1-TEC.9 - Limited availability of representative data:** Limitation *UC4.1-TEC-8* brings additional challenges for some operators, specifically for operators who do not operate periodic routes or engage in a wide variety of routes. These operators have limited datasets, which pose a challenge in accurately analysing fuel consumption patterns and extracting meaningful insights. Thus, the lack of clear guidelines regarding the definition of statistically relevant data and the absence of guidelines for data consistency revalidation present challenges for operators in ensuring that their fuel planning is based on a relevant and statistically significant dataset.
- **UC4.1-TEC.10 - Integration with operational reality:** Operators may encounter difficulties in adapting fuel consumption models into their operational reality. Real-world operational complexities, diverse aircraft fleets, and varying operational scenarios can complicate the development and implementation of fuel models, requiring customised approaches to suit each operator's unique needs.
- **UC4.1-TEC.11 - Limited capitalisation of knowledge regarding statistical estimations:** Another challenge lies in the capitalisation of knowledge when computing statistical contingency or taxi fuel through providers' digital tools. Operators face difficulties in accessing pseudocode and algorithm details, which limits their understanding of the underlying calculations performed by these tools. As a result, operators may also not be able to fully to validate the model's performance, make informed decisions, and have confidence in the effectiveness of fuel planning.
- **UC4.1-TEC.12 - Insufficient manufacturer data for fuel consumption planning:** One of the challenges encountered in fuel planning pertains to the weakness of manufacturer data, for instance the lack of detailed segregation of fuel consumption by flight level. This limitation presents a significant challenge for operators as they strive to fulfil their fuel planning needs with accurate and reliable data. The absence of data completeness hinders operators' ability to precisely assess fuel consumption patterns, impeding their efforts to plan and optimise fuel usage. To overcome this challenge, some operators resort to interpolation techniques. However, interpolation sometimes leads to the loss of data points and compromises the ability to accurately quantify fuel consumption.

4.1.1.2.2 Organisation

Within the landscape of fuel consumption models development, organisational complexities also pose a set of challenges. The absence of standardised models for specific fuel reductions necessitates operators to navigate a landscape characterised by soft rules and basic guidelines without concrete methodologies. Concurrently, the lack of visibility into fuel calculation processes may raise concerns and mistrust among pilots, potentially leading to suboptimal fuel planning and management.

- **UC4.1-ORG.7 - Absence of standardised models for proposing reductions in specific fuel amounts:** While EASA's guidance material provides some generic guidelines for reducing contingency or taxi fuels through statistical models, there is a notable absence of standardised models that provide specific methodologies or recommendations. For now, there are only very basic guidelines for building statistical models. There is a lack of guidelines for the generation of reduction models, such as specific guidelines for simple standard models or concrete regulatory frameworks for complex models.

- **UC4.1-ORG.8 - Lack of visibility by pilots on fuel planning:** Limitation *UC4.1-TEC.20 - Limited capitalisation of knowledge regarding statistical estimations* brings additional challenges for operators, as the lack of visibility and detailed information on how fuel is calculated sometimes leads to concerns and mistrust among pilots. Without comprehensive insight into the fuel planning process, pilots often compensate for this uncertainty by adding more discretionary fuel, undermining the efforts to achieve optimal fuel efficiency. The lack of detailed information regarding the statistical and predictive models used, including the specific input data, processes, considerations, and underlying hypotheses, further worsens the issue.

- **UC4.1-ORG.9 - Interpreting fuel planning information provided to pilots:** Pilots frequently face difficulties in interpreting the fuel-related information they receive at the planning phase. In the context of flight planning and fuel management, it is crucial for pilots to have a clear understanding of the data and calculations provided to make informed decisions regarding fuel load and flight operations. Moreover, the timely receipt of fuel-related information is paramount for pilots to adequately review and validate the planning process. If pilots do not receive the information with sufficient time for analysis, they may feel rushed due to limited planning time and may add more discretionary fuel to ensure safety. Thus, addressing this challenge involves improving the clarity and presentation of fuel-related information provided to pilots.

4.1.1.2.3 Operations

Embarking on the journey of fuel consumption models development, both operators and authorities encounter a spectrum of challenges. Limited IT expertise within CAAs to audit and approve statistical and predictive models create a significant barrier, as well as the absence of standardised evaluation processes across different CAAs, which impedes operators to conduct a streamlined development of fuel initiatives.

- **UC4.1-OPS.4 - Limited expertise in CAAs for auditing and approving statistical and predictive models:** A significant challenge arises from the limited expertise and resources within authorities to effectively audit and approve statistical and predictive fuel consumption models developed by operators. The complex nature of these models, especially advanced AI/ML algorithms, requires specialised knowledge and technical skills to thoroughly assess their accuracy, reliability, and safety implications. Additionally, the lack of a standardised approach for evaluating these models may lead to inconsistent auditing practices and hinder the efficient deployment of fuel reduction initiatives.

- **UC4.1-OPS.5 - Lack of standardisation and alignment between CAAs in the development and approval of statistical/predictive models:** Another significant challenge in the implementation of fuel consumption models lies in the lack of standardisation and alignment between different CAAs regarding the development and approval processes for statistical and predictive models. Each CAA may have its own set of requirements, guidelines, and evaluation criteria, leading to inconsistencies and varying levels of complexity for operators seeking approval in different regions.

4.1.1.3 Deployment of fuel consumption models

After the development of fuel consumption models, the next crucial step involves their deployment and integration into the operational workflow. Some fuel consumption models may need to undergo rigorous validation processes to ensure that they produce accurate and consistent results. However, the lack of comprehensive validation guidelines presents a challenge during deployment, as operators may face uncertainties about the reliability and safety of the models.

The deployment of fuel consumption models can be analysed and understood through three (3) key dimensions: Technology & Data, Organisation, and Operations, which provide insights into the various aspects and challenges associated.

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4.1.1.3.1 Technology & Data

In the process of deploying fuel consumption models, operators encounter challenges rooted in technology and data. These challenges encompass the technical aspects of integrating these models into existing systems and the complexities of handling diverse data formats. The adequacy of tools and technologies, as well as the seamless incorporation of data-driven insights, are central concerns in this category.

- **UC4.1-TEC.13 - Adaptability of flight planning digital tools:** Some operators face challenges in the integration of fuel calculations, estimations, and models into the Operational Flight Plan (OFP) software, as many existing solutions are not readily equipped to integrate the changes required for data-driven fuel policies. One aspect of this challenge arises from the lack of adaptability from some OFP software that can't accommodate new fuel calculations and estimations based on statistical or predictive models developed in-house by operators. On the other hand, in some cases, operators find that their current flight planning tool assumes direct flight paths or simplistic fuel consumption algorithms, which may lead to suboptimal fuel estimations that need to be manually modified by operators. Addressing these limitations may require significant software customisation or switching to a different OFP software provider. Such changes can be resource-intensive, time-consuming, and may incur additional costs, particularly for operators with established workflows and contracts with existing OFP software suppliers.

4.1.1.3.2 Organisation

The deployment of fuel consumption models necessitates a well-structured organizational approach. This category delves into the establishment of guidelines and frameworks for model validation, re-assessment, and building trust. In fact, the establishment of effective organisational processes helps ensuring that the deployment of fuel consumption models is underpinned by reliability, safety, and continuous improvement.

- **UC4.1-ORG.10 - Lack of validation guidelines:** The absence of comprehensive validation guidelines poses a significant challenge in the deployment of fuel reductions or variations. Without a robust validation process, operators may face uncertainties about the reliability and safety of the models' results. Currently, there is no systematic methodology for the deployment of these models, including verification phases in the integration process. Establishing validation frameworks is essential to ensure that the fuel planning models are not only efficient but also safe and reliable.
- **UC4.1-ORG.11 - Lack of re-assessment guidelines for models:** Models may need to be periodically re-evaluated and adjusted to ensure they remain accurate and reliable as flight operations evolve. For this reason, deployment frameworks should also outline how to guarantee the trustworthiness and learning assurance approach of models, allowing continuous monitoring and assessment of their performance over time.
- **UC4.1-ORG.12 - Potential overlap in tasks performed by fuel planning team and dispatch:** The implementation of fuel planning processes presents a significant challenge when tasks performed by the fuel planning team and dispatch are not clearly defined or separated. In certain cases, the fuel planning team primarily focuses on computing contingency and/or taxi fuel amounts using in-house developed statistical models. On the other hand, dispatch handles the computation and allocation of the remaining fuel amounts for the flight, often through automated estimation performed by flight planning tools. This scenario poses potential challenges for operators on multiple fronts. Firstly, the lack of a well-defined workflow for data sharing, verification, and approval can hinder operators' ability to ensure consistency throughout the entire fuel planning process. It may lead to variations in the planning approach adopted by each team, potentially impacting overall operational efficiency. Secondly, the absence of alignment between the fuel planning team and dispatch regarding their respective methodologies and understanding of fuel-related variables may result in planning and operational disruptions. Differing approaches and interpretations can lead to discrepancies in fuel calculations and allocation, posing safety risks and operational inefficiencies. As a summary, addressing

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the challenge of potential overlap in tasks requires a coordinated effort to establish clear roles, responsibilities, and methodologies for each team.

4.1.1.3.3 Operations

The deployment of fuel consumption models presents some challenges to the operational landscape, such as establishing trust among pilots, transitioning from statistical to advanced AI/ML models, and aligning roles within the fuel planning and dispatch teams. The challenges within this category involve refining operational strategies, fostering confidence, and ensuring a smooth evolution towards more effective fuel consumption predictions.

- **UC4.1-OPS.6 - Lack of trust among pilots:** The lack of a comprehensive validation framework poses a significant challenge in the deployment of fuel reductions or variations. Operators are currently implementing some fuel variations but sometimes face a lack of trust from pilots in the statistical methods and data relevance used. Addressing this trust issue during the initial stages of implementing simple variations is crucial to prevent further challenges when introducing more advanced reductions within individual fuel schemes.
- **UC4.1-OPS.7 - Progression from statistical to AI/ML models:** The absence of a solid foundation in statistical methods may hamper the seamless integration of AI/ML models, which are often regarded as black boxes. Operators lack a clear progression from deterministic models to AI/ML models, allowing them to build upon a strong statistical basis and build trust among pilots.

4.1.1.4 Post-ops analysis of fuel consumption

Once flight operations are completed, the analysis of fuel consumption performance is a crucial activity for optimising future fuel planning and management. Post-ops analysis involves comparing planned fuel consumption with actual fuel usage during flight operations. However, this analysis faces several challenges due to several factors, such as insufficient fuel consumption data, operational variability, lack of flexible digital solutions for different types of operations, and limited pilot involvement in fuel performance assessment.

The post-operational analysis of fuel consumption can be analysed and understood through two (2) key dimensions: Technology & Data and Organisation, which provide insights into the various aspects and challenges associated.

4.1.1.4.1 Technology & Data

Challenges in this category pertain to the technical and data-related aspects of post-ops fuel consumption analysis. The technology supporting this activity is **software** developed by the operators (in-house systems) or adopted from third-party providers. Airlines typically perform the post-ops analysis of aircraft-specific fuel performance through:

- Fuel Consumption Monitoring Systems (FCMS): These systems aim to compare the achieved in-flight fuel performance to the predicted consumption. FCMS gather and process data to enable operators to assess the accuracy of fuel estimations and identify areas for improvement.
- Flight Planning tools: Certain aspects of post-ops fuel analysis may also involve flight planning tools. These tools, designed to assist in pre-flight planning, can provide valuable data for comparison between planned and actual fuel consumption.

These technological solutions play a crucial role in evaluating fuel consumption in aviation operations. The challenges in this category revolve around effectively integrating and utilising these tools to ensure accurate post-ops analysis.

The **data** used in post-ops analysis comes from several sources, but in the context of Use Case 4.1, the focus is on challenges associated with fuel-related data. Challenges associated to the operational data and to operating conditions data sources are addressed in the other Use Cases.

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- **UC4.1-TEC.14 - Insufficient fuel consumption manufacturer data:** One of the challenges encountered in fuel data collection pertains to the weakness of manufacturer data, for instance the lack of detailed segregation of fuel consumption by flight level. This limitation presents a significant challenge for operators as they strive to fulfil their fuel planning needs with accurate and reliable data. The absence of data completeness hinders operators' ability to precisely assess fuel consumption patterns, impeding their efforts to compare planned vs. actual fuel consumptions. To overcome this challenge, some operators resort to interpolation techniques. However, interpolation sometimes leads to the loss of thousands of data points and compromises the ability to accurately quantify fuel consumption. The reliance on weak manufacturer data and the subsequent need for interpolation pose substantial obstacles to operators seeking to accurately compare fuel amounts at post-ops stages.
- **UC4.1-TEC.15 - Difficult comparison between planned and actual fuel consumption due to variability in flight operations:** A significant challenge in the post-ops fuel performance analysis is encountered by operators whose flights usually deviate from the original Operational Flight Plan (OFP) due to frequent changes in destinations, flight levels, or speeds. These operational variations introduce complexities when comparing the planned fuel consumption with the actual fuel performance. The dynamic nature of flight operations often leads to deviations from the initially planned flight profiles. As a result, operators face difficulties in accurately assessing the performance of fuel consumption, as the actual flight trajectories may differ significantly from the planned routes and parameters.
- **UC4.1-TEC.16 - Lack of flexible digital solutions' requirements for different types of operations:** All operators aiming to apply fuel reductions must operate under data-driven methods. To achieve this, operators are requested to implement a Fuel Consumption Monitoring System to compare the achieved in-flight performance to the predicted one (GM1 CAT.OP.MPA.181). However, integrating such systems into existing infrastructure has posed difficulties for some operators. On one hand, some operators had already implemented systems for carbon dioxide emissions reporting, but these systems fell short for the approval of fuel schemes. As a result, operators had to adopt new solutions, requiring significant effort and investment, particularly for smaller operators with limited resources. On the other hand, some authorities are concerned about the requirements set for FCMS, in particular when it comes to requirements for analysis. Some of these requirements might be more than reasonable for commercial regular operations but might not be flexible enough for other operational scenarios, as it could be those operators who may frequently experience deviations from planned flights. In such cases, potentially, a more flexible framework should be allowed, considering their operational characteristics and challenges in comparing planned versus actual performances.
- **UC4.1-TEC.17 - Lack of enough segregation in pilots' self-assessment tools:** The provision of self-assessment tools to pilots that lack sufficient route segregation capabilities presents a challenge for pilots in the context of post-ops analysis on fuel performance. The absence of route segregation restricts pilots from effectively evaluating fuel performance under specific conditions and flight profiles, hindering their ability to identify areas for improvement and optimise fuel usage.

4.1.1.4.2 Organisation

The main challenge identified within the Organisational category encompasses aspects related to the coordination and roles involved in post-ops fuel consumption analysis.

- **UC4.1-ORG.13 - Limited pilot involvement in fuel performance assessment:** The lack of active participation of pilots throughout the complete post-ops fuel performance assessment process presents a significant challenge. Insufficient training and participation result in a lack of confidence and trust in the accuracy of fuel estimations among pilots. Pilots require clear and transparent information regarding fuel-related issues, as well as access to comprehensive training programs that familiarise them with the reduction models used in fuel estimations.

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4.1.2 Limitations overview

As seen throughout the challenges description, the use of fuel data for the implementation of fuel reduction schemes brings forth a set of challenges and limitations that manifest across various operational dimensions. This section presents a consolidated overview of all identified challenges, systematically categorized into the three (3) fundamental categories (Technology & Data, Organisation, and Operations), and classified according to their corresponding process activity.

Table 4-2 Overview of limitations identified for Use Case 4.1

Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**
Fuel-related data collection and quality assessment	• UC4.1-TEC.1 - Limited usefulness of fuel data depending on the data source selection • UC4.1-TEC.2 - Limited FDM data collection capability for operators with non-Airbus or Boeing aircraft • UC4.1-TEC.3 – Limited recording capacity of airborne systems on board older aircraft limiting the possibilities to record new flight parameters • UC4.1-TEC.4 - Duplicated parameters coming from different sources • UC4.1-TEC.5 – Lack of guidance to address data quality problems • UC4.1-TEC.6 - Integration of data sources	• UC4.1-ORG.1 - Definition of relevant fuel data to be recorded • UC4.1-ORG.2 - Recording of fuel data at regular intervals • UC4.1-ORG.3 - Reliance on manual data collection • UC4.1-ORG.4 - Misalignment of available flight data parameters and fuel-related parameters needs • UC4.1-ORG.5 - Establishment of FDM data governance agreements • UC4.1-ORG.6 - Adoption of digitalisation solutions or methodologies for the collection of fuel-related data	• UC4.1-OPS.1 - Lack of resources or manpower for the implementation of performance-based schemes • UC4.1-OPS.2 - Limited expertise in CAAs for auditing and approving data-related processes • UC4.1-OPS.3 - Lack of standardization and alignment between CAAs in data acquisition and verification processes
Development of fuel consumption models	• UC4.1-TEC.7 - Generalization of fuel consumption models • UC4.1-TEC.8 - Limited regulatory details regarding the set of statistically relevant data • UC4.1-TEC.9 - Limited availability of representative data • UC4.1-TEC.10 - Integration with operational reality • UC4.1-TEC.11 - Limited capitalisation of knowledge regarding statistical estimations	• UC4.1-ORG.7 - Absence of standardised models for proposing reductions in specific fuel amounts • UC4.1-ORG.8 - Lack of visibility by pilots on fuel planning • UC4.1-ORG.9 - Interpreting fuel planning information provided to pilots	• UC4.1-OPS.4 - Limited expertise in CAAs for auditing and approving statistical and predictive models • UC4.1-OPS.5 - Lack of standardization and alignment between CAAs in the development and approval of statistical/predictive models

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Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**
	• UC4.1-TEC.12 - Insufficient manufacturer data for fuel consumption planning		
Deployment of fuel consumption models	• UC4.1-TEC.13 - Adaptability of flight planning digital tools	• UC4.1-ORG.10 - Lack of validation guidelines • UC4.1-ORG.11 - Lack of re-assessment guidelines for models • UC4.1-ORG.12 - Potential overlap in tasks performed by fuel planning team and dispatch	• UC4.1-OPS.6 - Lack of trust among pilots • UC4.1-OPS.7 - Progression from statistical to AI/ML models
Post-ops analysis of fuel consumption	• UC4.1-TEC.14 - Insufficient fuel consumption manufacturer data • UC4.1-TEC.15 - Difficult comparison between planned and actual fuel consumption due to variability in flight operations • UC4.1-TEC.16 - Lack of flexible digital solutions' requirements for different types of operations • UC4.1-TEC.17 - Lack of enough segregation in pilots' self-assessment tools	• UC4.1-ORG.13 - Limited pilot involvement in fuel performance assessment	

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4.1.3 Proposed digital solutions to address limitations

The following table presents and details the solutions that have been proposed with the objective of addressing the limitations identified during the different interviews with stakeholders and explained through the sections dedicated to each activity in Use Case 4.1:

Table 4-3 Proposed solutions identified for Use Case 4.1

Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes		
Limitation	**Solution**	**Description**
UC4.1-TEC.1 - Limited usefulness of fuel data depending on the data source selection	**UC4.1-SOL.1** - Development of guidelines for minimum conditions and selection criteria of fuel-related data sources	Develop guidelines for assisting operators in evaluating data sources by outlining the strengths and limitations of each source, helping operators select and use fuel-related data sources effectively. The guidelines should provide details on the limitations of specific fuel-data sources such as: • Sampling rate: Define the necessary sampling rate of fuel-related data for different types of analyses. • Availability: Recommend specific sources for different applications and/or define strategies to mitigate delays. • Data control: Suggest mechanisms for seamless collaboration between departments (e.g., define data access protocols).
	UC4.1-SOL.2 - Development of guidelines for FDM data governance frameworks to allow for fuel-related developments	Develop guidelines for the making FDM data governance framework allow the use of data for fuel schemes, focusing on the definition of the framework (outline the structure of the framework, including data collection, storage, processing, and accessibility). The guidelines should also focus on: • Data quality: Define standards across different stages of data governance (e.g., data validation processes, error handling, data discrepancies, etc.). • Collaboration: Propose mechanisms to enhance coordination between departments to ensure timely access to data. • Data privacy and security: Outline procedures for de-identifying and protecting sensitive information while making it accessible for fuel-related analysis.
	UC4.1-SOL.3 - Development of industry best-practices for uniform data formatting and standards	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices to establish uniform data formatting and standards, ensuring seamless integration regardless of the source. The key components of these guidelines should include: • Standardised data formats: Define standardised formats for fuel-related data, encompassing data structure, attributes, and naming conventions. • Cross-source data mapping: Insights into mapping data attributes across different sources. • Other potential components such as aligning data sampling rate across sources to ensure different sources can be merged without loss of essential details.
UC4.1-TEC.4 - Duplicated parameters coming from different sources	**UC4.1-SOL.4** - Development of industry best-practices for selection criteria of duplicated fuel-related data parameters	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices that can be used by operators as a roadmap to help effectively manage duplicated parameters and ensure data consistency across various sources (e.g., ACARS and FDM data). Guidelines should include, at least: • Parameter alignment: Framework to identify and align duplicated parameters across different data sources.

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Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes		
Limitation	**Solution**	**Description**
		• Priority determination: Methodologies to compare and validate similar parameters from different sources, identifying outliers and inaccuracies. In cases where multiple sources provide the same parameter, guidelines for determining which source should take precedence based on factors such as data quality, timeliness, and relevance to specific analyses.
	UC4.1-SOL.5 - Development of industry best-practices for data validation guidelines for duplicated parameters	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices for data validation guidelines to address data quality issues and ensure consistency and reliability across parameters. These guidelines should deal with: • Data consistency checks: Set of recommended consistency checks to be performed on duplicated parameters. • Validation procedures: Steps operators can follow to assess the reliability of parameters (e.g., statistical analyses, identification of outliers, etc.). • Thresholds: Establish threshold values beyond which data discrepancies should be further investigated.
	UC4.1-SOL.6 - Development of GM/AMC accounting for specificities in regard with validation of fuel data through the adoption of standards	Select a set of existing standards (e.g., EUROCAE ED-76(A) standards or similar standards) that ensure a coherent approach to data validation for the implementation of fuel reductions and that cover a wide range of aspects, including data collection procedures, accuracy checks, error identification, and quality assurance practices.
UC4.1-TEC.5 – Lack of guidance to address data quality problems	**UC4.1-SOL.7** - Development of industry best-practices for generic data validation guidelines	Develop data validation guidelines by industry bodies or relevant regulatory working groups that establish best practices for assessing the quality, accuracy, and consistency of fuel-related data. The guidelines should cover a wide range of parameters, including those that tend to exhibit degradation or inconsistencies, and should include: • Minimum accuracy requirements for key fuel-related parameters across different aircraft models. • Methodologies to ensure data consistency across different aircraft models and sensors. • Standards for data collection intervals and resolution for crucial parameters (e.g., fuel consumption and flow rates).
	UC4.1-SOL.8 - Development of GM/AMC accounting for specificities in regard with validation of fuel data through the adoption of standards	Select a set of existing standards (e.g., EUROCAE ED-76(A) standards or similar standards) that ensure a coherent approach to data validation for the implementation of fuel reductions and that cover a wide range of aspects, including data collection procedures, accuracy checks, error identification, and quality assurance practices.
UC4.1-TEC.6 - Integration of data sources	**UC4.1-SOL.9** - Development of GM/AMC for minimum requirements and selection criteria of fuel-related data sources	Develop guidelines for data source integration to mitigate compatibility issues and ensure data accuracy and completeness. The guidelines should include best practices regarding: • Compatibility of different data sources, considering factors such as data formats, protocols, and frequencies. • Mapping data fields between different sources. • Integration protocols and standards that operators can follow when combining data from diverse sources. • Strategies to identify and address data gaps, ensuring data completeness.

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Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes		
Limitation	**Solution**	**Description**
	UC4.1-SOL.10 - Development of industry best-practices for data compatibility and integration guidelines	Establish industry best-practices for data validation and compatibility and provide guidelines and standards that operators can follow when dealing with data integration to ensure data accuracy and completeness.
	UC4.1-SOL.11 - Development of GM/AMC accounting for specificities in regard with validation of fuel data through the adoption of standards	Select a set of existing standards (e.g., EUROCAE ED-76(A) standards or similar standards) that ensure a coherent approach to data validation for the implementation of fuel reductions and that cover a wide range of aspects, including data quality assurance practices (e.g., data completeness assurance).
UC4.1-TEC.7 - Generalization of fuel consumption models	**UC4.1-SOL.12** - Development of GM/AMC that establish a standardised framework for generalising statistical models	Develop regulatory requirements or guidance material explicitly establishing a standardised framework for generalizing statistical models across different aircraft or operational contexts, as well as defining the limits of models' generalization for each operational context. The requirements or guidance should include the principles and methodologies for generalizing statistical fuel consumption models and guidelines on how to apply statistical models to different aircraft or operational scenarios. Additionally, definitions of the limits of model generalization for each operational context should be included (i.e., when and to what extent statistical models can be applied).
UC4.1-TEC.8 - Limited regulatory details regarding the set of statistically relevant data	**UC4.1-SOL.13-** Development of GM/AMC specifying what constitutes statistically relevant data	Develop regulatory requirements or guidance material explicitly capturing what constitutes statistically relevant data, considering factors like representativeness, completeness, and timeliness. Industry bodies and regulatory working groups should define what qualifies as statistically relevant data by including minimum data requirements.
UC4.1-TEC.9 - Limited availability of representative data	**UC4.1-SOL.14** - Development of GM/AMC specifying criteria for assessing the adequacy of data for statistical analysis	Develop guidelines that offer specific provisions to assist operators, particularly those with limited datasets or operating irregular routes, in ensuring that their fuel planning is based on statistically significant data. The guidelines should: • Establish criteria for assessing the adequacy of data for statistical analysis while considering operational variations. • Provide a detailed approach and methodology, similar to other specific regulations already in place such as passenger and baggage weight surveys for mass and balance (CAT.POL.MAB.100). • Provide recommendations on effective data sampling techniques. • Guidance on how to revalidate datasets over time.
	UC4.1-SOL.15 - Development of industry best-practices for data sharing and collaboration among operators	Encourage the development of a framework that facilitates the voluntary sharing of fuel-related data among operators in a secure manner, addressing key topics such as data de-identification and confidentiality.
UC4.1-TEC.10 - Integration with operational reality	**UC4.1-SOL.16** - Development of industry best-practices for the generalisation of statistical models	Develop regulatory requirements or guidance material explicitly establishing a standardised framework for generalising statistical models across different aircraft or operational contexts, as well as defining the limits of models' generalisation for each operational context and step-by-step instructions on how to adapt general models to specific needs while ensuring safety.

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Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes		
Limitation	**Solution**	**Description**
UC4.1-TEC.11 - Limited capitalisation of knowledge regarding statistical estimations	**UC4.1-SOL.17** - Development of GM/AMC capturing the need for transparency in algorithm details provided by vendors	Develop regulatory requirements or guidance material explicitly capturing the need for transparency in algorithm details for fuel reduction schemes when these are provided by vendors, at the level required to ensure traceability, support decision-making and ease oversight by authorities. These requirements should specify the level of detail and documentation that vendors must provide regarding the algorithms used in their tools.
UC4.1-TEC.16 - Lack of flexible digital solutions' requirements for different types of operations	**UC4.1-SOL.18** - Development of GM/AMC that allow for more flexibility regarding fuel consumption monitoring systems	Study some additional regulatory provisions that allow for more flexibility regarding the requirements specified for fuel consumption monitoring systems, in accordance with the operational nature of operators and the expected fuel initiatives.
UC4.1-ORG.1 - Definition of relevant fuel data to be recorded	**UC4.1-SOL.19** - Development of industry best-practices for the definition of a comprehensive fuel data framework	Develop guidelines for defining a comprehensive fuel data framework that provides clarity and guidance on the essential fuel data parameters to be recorded for each fuel scheme. The two key components of the framework should be: • Parameter standardisation: Standardise the list of fuel-related parameters to be recorded for different fuel schemes. • Scheme-specific requirements: Define scheme-specific data requirements, specifying the additional parameters necessary for the Basic Fuel Scheme with Variations or Individual Fuel Schemes.
UC4.1-ORG.3 - Reliance on manual data collection	**UC4.1-SOL.20** - Development of GM/AMC for minimum requirements regarding fuel-related parameters that are manually collected	Develop guidelines that include specific procedures for manual data collection, data entry, and quality control to minimize errors. The guidelines should provide operators with strategies for mitigating errors associated with manual data collection (e.g., regular data validation checks, error detection mechanisms, etc.) and validation processes for all manually collected data.
	UC4.1-SOL.21 - Development of industry best-practices for validation guidelines of manually collected data	Develop data validation guidelines by industry bodies or relevant regulatory working groups that establish best practices for assessing the quality, accuracy, and consistency of manually collected fuel-related data. The guidelines should include minimum accuracy requirements for key fuel-related parameters that are collected manually.
	UC4.1-SOL.22 - Development of GM/AMC accounting for specificities in regard with validation of fuel data through the adoption of standards	Select a set of existing standards (e.g., EUROCAE ED-76(A) standards or similar standards) that ensure a coherent approach to data validation for the implementation of fuel reductions and that cover a wide range of aspects, including data quality assurance practices for manually collected data.
	UC4.1-SOL.23 - Support the adoption and integration of IoT devices into aircraft systems	Integrate specific devices, such as Electronic Flight Bags (EFBs) into aircraft systems to allow a digitalised or automated collection of fuel-related data.
UC4.1-ORG.4 - Misalignment of available flight data parameters and fuel-	**UC4.1-SOL.24** - Alignment of FDM and fuel schemes guidelines regarding relevant parameters to be collected under performance	Define flight parameters needed to support the fuel scheme and the minimum performance needed, enabling operators to fully capitalize on FDM data for fuel optimisation and participation in fuel performance-based schemes. This solution involves engaging with regulatory authorities to revise FDM guidelines to include fuel scheme-relevant parameters.

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Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes		
Limitation	**Solution**	**Description**
related parameters needs		
UC4.1-ORG.5 - Establishment of FDM data governance agreements	**UC4.1-SOL.25 -** Development of GM/AMC for FDM data governance agreements	Collaborate with industry experts, regulatory bodies, and relevant stakeholders to adapt FDM data governance frameworks and make them compatible with FDM data use for fuel planning and management. These frameworks should address data sharing protocols, privacy protection, and the cultivation of a 'just culture' within the context of fuel management.
UC4.1-ORG.7 - Absence of standardised models for proposing reductions in specific fuel amounts	**UC4.1-SOL.26 -** Development of industry best-practices for standardised statistical and advanced fuel-reduction models	Publication and promotion by industry bodies or relevant regulatory working groups of establish standardised statistical methods and best-practices for advanced fuel-reduction models beyond statistical approaches. While statistical models are important, this solution also encompasses advanced fuel-reduction models, including AI and ML-based models. Thus, industry bodies and regulatory working groups should collaborate to: • Define standardised statistical methods for fuel-reduction models that ensure consistency and reliability in fuel consumption modelling. • Provide a detailed approach and methodology, similar to other specific regulations already in place such as passenger and baggage weight surveys for mass and balance (CAT.POL.MAB.100). • Guide operators and stakeholders in the use of advanced fuel-reduction models (e.g., data preparation, model validation, and model maintenance).
UC4.1-ORG.8 - Lack of visibility by pilots on fuel planning	**UC4.1-SOL.27 -** Development of GM/AMC that enhance the modification of the Operation Manual to provide pilots with insights on models	Development of Appendixes to OM to provide pilots with insights on statistical/predictive models (i.e., data used, algorithm details and insights, factors considered, etc.).
UC4.1-ORG.10 - Lack of validation guidelines	**UC4.1-SOL.28 -** Development of industry best-practices for fuel-related model validation frameworks	Develop regulatory requirements or guidance material explicitly capturing detailed guidelines for operators to establish a comprehensive model validation framework. The guidelines should outline the steps and procedures for verifying the accuracy and reliability of fuel-related models (e.g., data and model validation).
UC4.1-ORG.11 - Lack of re-assessment guidelines for models	**UC4.1-SOL.29 -** Development of industry best-practices for the deployment of fuel-related models	Develop regulatory requirements or guidance material explicitly capturing detailed guidelines for operators and authorities to ensure trustworthy deployment of fuel-related models (both statistical and other AI-applications) in alignment with future industry standards (e.g., EUROCAE WG-115 / SAE G-34). The guidelines should outline the steps and procedures for verifying the performance of fuel-related models.
UC4.1-OPS.2 - Limited expertise in CAAs for auditing and approving data-related processes	**UC4.1-SOL.30 -** Support the definition of specific trainings for the enhancement of analytical capabilities	This solution focuses on enhancing the IT and analytical capabilities of CAAs through specialised training and collaboration with industry experts. This solution should begin by assessing the current IT and analytical capabilities within CAAs to identify areas where expertise is lacking and where improvements are needed. Based on this assessment, a training program should be developed and could consider collaboration with recognized industry experts and training institutions to deliver the training programs (e.g., workshops, seminars, etc.). Finally, the solution could also consider a certification process to validate the IT and analytical competence of CAA personnel involved in the approval and auditing process of fuel schemes.

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Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes		
Limitation	**Solution**	**Description**
UC4.1-OPS.3 - Lack of standardization and alignment between CAAs in data acquisition and verification processes	**UC4.1-SOL.31** - Development of industry best-practices for collaboration and coordination between Authorities regarding the harmonization of fuel-related data processes	Promote a close collaboration and coordination between CAAs to establish common standards, harmonised guidelines, and streamlined processes. Key components of this solution include: • CAAs to establish a collaborative framework that facilitates regular communication and information sharing. • Facilitate discussions and initiatives among CAAs to define standardised data acquisition and verification standards and practices for fuel planning and management (e.g., defining common data parameters, reporting formats, and validation criteria). • Develop harmonised guidelines that CAAs can adopt to ensure uniformity in their requirements and expectations from operators regarding data collection methods, reporting intervals, and verification processes.
UC4.1-OPS.4 - Limited expertise in CAAs for auditing and approving statistical and predictive models	**UC4.1-SOL.32** - Support the definition of specific trainings for the enhancement of IT capabilities regarding statistical and advanced models	This solution focuses on enhancing the IT and analytical capabilities of CAAs through specialised training and collaboration with industry experts. This solution should begin by assessing the current IT and analytical capabilities within CAAs to identify areas where expertise is lacking and where improvements are needed. Based on this assessment, a training program should be developed and could consider collaboration with recognized industry experts and training institutions to deliver the training programs (e.g., workshops, seminars, etc.). Finally, the solution could also consider a certification process to validate the IT and analytical competence of CAA personnel involved in the approval and auditing process of fuel schemes.
UC4.1-OPS.5 - Lack of standardization and alignment between CAAs in the development and approval of statistical/predictive models	**UC4.1-SOL.33** - Development of industry best-practices for collaboration and coordination between Authorities regarding the harmonization of fuel consumption estimation models	Promote a close collaboration and coordination between CAAs to establish common standards, harmonized guidelines, and streamlined processes. Key components of this solution include: • CAAs to establish a collaborative framework that facilitates regular communication and information sharing. • Facilitate discussions and initiatives among CAAs to define standardised fuel reduction models approval processes.

4.1.4 Proposed solution packages

The potential digital solutions proposed in Section 4.1.3 have been strategically grouped into solutions packages, drawing upon their commonalities and distinctive natures within the context of aviation fuel planning and management. The first category, encompassed within 'Safety promotion'. pertains to topics that are yet to find comprehensive industry-wide guidance and thus demand the initiation of industry-defined standards and development of industry best-practices. The second category, 'Regulatory initiatives' involving Guidance Material or Acceptable Means of Compliance, represents topics that have reached a level of maturity suitable for integration into formal regulations. Lastly, the third category, 'Innovation & Technology', centres on topics that may not be easily confined to regulatory frameworks but support the adoption and integration of digital solutions and capabilities. This categorisation enables a more focused approach to addressing the multifaceted challenges faced in fuel planning and management, ensuring that each solution package is tailored to its unique context and readiness for implementation.

Table 4-4 Solution packages to address limitations of Use Case 4.1

Use Case 4.1: Leveraging aircraft-specific fuel data for fuel performance-based schemes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
Solution package – Safety promotion			
UC4.1-PS.1 - Development of industry best-practices for fuel-related data validation and integration	• **UC4.1-SOL.3** - Development of industry best-practices for uniform data formatting and standards • **UC4.1-SOL.4** - Development of industry best-practices for selection criteria of duplicated fuel-related data parameters • **UC4.1-SOL.5** - Development of industry best-practices for data validation guidelines for duplicated parameters • **UC4.1-SOL.7** - Development of industry best-practices for generic data validation guidelines • **UC4.1-SOL.10** - Development of industry best-practices for data compatibility and integration guidelines • **UC4.1-SOL.19** - Development of industry best-practices for the definition of a comprehensive fuel data framework	**Aviation industry bodies and associations:** • Facilitate the definition of best-practices by bringing together experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data scientists to contribute their expertise to the development of data validation and integration methods and minimum requirements) • Collaborate with operators and regulatory authorities to ensure alignment with industry standards • Promote for the adoption of best-practices across the aviation industry **Regulatory authorities:** • Review the development of best-practices and ensure that they align with regulatory standards and requirements • Promote for the adoption of best-practices across the aviation industry • Assess the feasibility of publishing the best-practices as GM or AMC **Operators:** • Adopt and implement the best-practices in their processes and day-to-day operations • Collaborate with industry bodies and regulatory authorities in the development and refinement of best-practices • Train their personnel in the application of best-practices	• Existing fuel-related data sources and parameters used in fuel planning and management • List of identified duplicated parameters • List of manually collected parameters • Data attributes and structure used in current data analysis processes • Criteria used for evaluating the strengths and limitations of different data sources • Information on the algorithms and pseudocodes employed for analysing and validating fuel-related data • Information on data integration algorithms or methodologies • Details on current processes used to approve and audit data-related processes

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Use Case 4.1: Leveraging aircraft-specific fuel data for fuel performance-based schemes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
	• **UC4.1-SOL.21** - Development of industry best-practices for validation guidelines of manually collected data	**Providers:** • Implement and adhere to the best-practices • Collaborate with operators to ensure that their data solutions provided align with best-practices	
UC4.1-PS.2 - Development of industry best-practices for fuel consumption estimation models	• **UC4.1-SOL.15** - Development of industry best-practices for data sharing and collaboration among operators • **UC4.1-SOL.16** - Development of industry best-practices for the generalization of statistical models • **UC4.1-SOL.26** - Development of industry best-practices for standardised statistical methods and advanced fuel-reduction models • **UC4.1-SOL.28** - Development of industry best-practices for fuel-related model validation frameworks • **UC4.1-SOL.29** - Development of industry best-practices for the deployment of fuel-related models	**Aviation industry bodies and associations:** • Facilitate the definition of best-practices by bringing together experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data scientists to contribute their expertise to the development of standardised statistical methods and advanced fuel-reduction models and assist in defining the limits of models' generalization) • Collaborate with operators and regulatory authorities to ensure alignment with industry standards • Promote for the adoption of best-practices across the aviation industry **Regulatory authorities:** • Review the development of best-practices and ensure that they align with regulatory standards and requirements • Promote for the adoption of best-practices across the aviation industry • Assess the feasibility of publishing the best-practices as GM or AMC **Operators:** • Adopt and implement the best-practices in their processes and day-to-day operations • Collaborate with industry bodies and regulatory authorities in the development and refinement of best-practices • Train their personnel in the application of best-practices • Share relevant data in collaborative frameworks **Providers:** • Implement and adhere to the best-practices • Collaborate with operators to ensure that their data solutions provided align with best-practices	• Fuel consumption datasets and related parameters from various aircraft types and operational contexts • Additional data used in existing fuel planning processes, including data related to flight routes, weather conditions, aircraft performance, etc. • Details on statistical models and predictive analytics • Details about the methodologies currently employed for validating and deploying fuel-related models in the operational context • Details about algorithms and pseudocodes used in statistical and predictive models for fuel planning • Details on current processes used to approve and audit statistical and advanced fuel consumption models
Solution package - Regulatory initiatives (Guidance Material or Acceptable Means of Compliance)			
UC4.1-PS.3 - Regulatory initiatives for fuel-related	• **UC4.1-SOL.1** - Development of guidelines for minimum conditions and selection criteria of fuel-related data sources	**Regulatory authorities:** • Develop and implement the regulatory initiatives, potentially GM and/or AMC	• Existing fuel-related data sources and parameters used in fuel planning and management

Use Case 4.1: Leveraging aircraft-specific fuel data for fuel performance-based schemes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
data collection and validation	• **UC4.1-SOL.2** - Development of guidelines for FDM data governance frameworks to allow for fuel-related developments • **UC4.1-SOL.6** - Development of GM/AMC accounting for specificities in regard with validation of fuel data through the adoption of standards • **UC4.1-SOL.8** - Development of GM/AMC accounting for specificities in regard with validation of fuel data through the adoption of standards • **UC4.1-SOL.9** - Development of GM/AMC for minimum requirements and selection criteria of fuel-related data sources • **UC4.1-SOL.11** - Development of GM/AMC accounting for specificities in regard with validation of fuel data through the adoption of standards • **UC4.1-SOL.20** - Development of GM/AMC for minimum requirements regarding fuel-related parameters that are manually collected • **UC4.1-SOL.22** - Development of GM/AMC accounting for specificities in regard with validation of fuel data through the adoption of standards • **UC4.1-SOL.24** - Alignment of FDM and fuel schemes guidelines regarding relevant parameters to be collected under performance • **UC4.1-SOL.25** - Development of GM/AMC for FDM data governance agreements	• Collaborate with operators and other related stakeholders to ensure alignment with their specific needs • Collaborate with experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data scientists to contribute their expertise to the development of data validation and integration guidelines) • Promote the adoption of GM/AMC across the industry **Operators:** • Implement GM/AMC for data source validation and integration • Collaborate with regulatory authorities in the development and refinement of GM/AMC • Train their personnel in the application of GM/AMC **Providers:** • Collaborate with regulatory authorities in the development and refinement of GM/AMC	• List of manually collected parameters • Details about the data attributes and structure used in current fuel-related analysis processes • Criteria used for evaluating the strengths and limitations of different data sources • Information on the algorithms and pseudocodes employed for analysing fuel-related data and for fuel-related data quality checks • Data source integration protocols and standards • Information on the structure of FDM data governance frameworks, collaboration mechanisms, and data privacy and security measures • Data access needs of each department • Information on data integration algorithms or methodologies • Details on current processes used to approve and audit data-related processes

Use Case 4.1: Leveraging aircraft-specific fuel data for fuel performance-based schemes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
UC4.1-PS.4 - Regulatory initiatives for fuel consumption estimation models	• **UC4.1-SOL.12** - Development of GM/AMC that establish a standardised framework for generalizing statistical models • **UC4.1-SOL.13**- Development of GM/AMC specifying what constitutes statistically relevant data • **UC4.1-SOL.14** - Development of GM/AMC specifying criteria for assessing the adequacy of data for statistical analysis • **UC4.1-SOL.17** - Development of GM/AMC capturing the need for transparency in algorithm details provided by vendors • **UC4.1-SOL.18** - Development of GM/AMC that allow for more flexibility regarding fuel consumption monitoring systems • **UC4.1-SOL.27** - Development of GM/AMC that enhance the modification of the Operation Manual to provide pilots with insights on models	**Regulatory authorities:** • Develop and implement the regulatory initiatives, potentially GM and/or AMC for standardised framework development and generalization of statistical fuel consumption models • Collaborate with operators and providers to ensure alignment with their specific needs • Collaborate with experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data scientists to define what constitutes statistically relevant data, specify criteria for assessing the adequacy of data for statistical analysis, etc.) • Promote the adoption of GM/AMC across the industry **Operators:** • Implement GM/AMC • Collaborate with regulatory authorities in the development and refinement of GM/AMC • Train their personnel in the application of GM/AMC **Providers:** • Collaborate with regulatory authorities in the development and refinement of GM/AMC • Collaborate with operators to meet transparency requirements	• Details on what is considered as statistically relevant data • Details on developed or used statistical and advanced models • Details about the methodologies currently employed for validating fuel-related models • Details on implemented FCMS (in-house system / provider, limitations, specific needs, etc.) • Details on current processes used to provide pilots with insights on statistical or predictive models • Details about algorithms and pseudocodes used in statistical and predictive models • Details on current processes used to approve and audit fuel consumption models
Solution package – Innovation & Technology			
UC4.1-PS.5 - Support the adoption of digital tools and capabilities for fuel-related data collection and analysis	• **UC4.1-SOL.23** - Support the adoption and integration of IoT devices into aircraft systems • **UC4.1-SOL.30** - Support the definition of specific trainings for the enhancement of analytical capabilities • **UC4.1-SOL.31** - Definition and publication of industry best-practices for collaboration and coordination between	**Regulatory authorities:** • Oversee and support the adoption of IoT devices for digital data collection (e.g., enable fast processes to adopt EFBs for data collection) • Define training programmes to enhance IT and analytical capabilities **Civil Aviation Authorities:** • Establish collaborative frameworks for coordination between authorities regarding data processes • Develop harmonized guidelines for data acquisition and verification standards	• Details on current IoT devices used for fuel-related data collection • Details on current training programmes for personnel involved in fuel scheme approval and auditing

DATAPP - D-2.1 - Development of case studies

Use Case 4.1: Leveraging aircraft-specific fuel data for fuel performance-based schemes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
	Authorities regarding the harmonization of fuel-related data processes • **UC4.1-SOL.32 -** Support the definition of specific trainings for the enhancement of IT capabilities regarding statistical and advanced models • **UC4.1-SOL.33** - Definition and publication of industry best-practices for collaboration and coordination between Authorities regarding the harmonization of fuel consumption estimation models	• Consider certification processes for personnel involved in fuel scheme approval and auditing **Operators:** • Consider the adoption of IoT devices for digital data collection	

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4.2 Use Case 4.2: Characterising the safety performance indicators for fuel schemes

The adoption of performance-based fuel schemes brings an imperative activity - the introduction of the safety dimension to fuel policies and procedures. This necessitates a structured approach to ensure that any modifications to fuel strategies maintain or elevate safety standards. This activity begins with the definition of a safety performance framework, which encompasses a series of strategic actions aimed at establishing a robust safety baseline for the proposed fuel scheme.

Once the safety performance framework is defined, operators need to ensure that extracted insights are continuously monitored and meticulously managed. Thus, the second key activity is the monitoring and re-assessment of approved fuel schemes. This ongoing evaluation aligns with the directive of CAT.OP.MPA.180 (b), which mandates operators to establish robust reporting systems to the competent authority.

Based on this process description, the characterisation of safety performance within fuel schemes can be divided into two (2) key activities, presented in Figure 4-2.

Figure 4-2 Process activity breakdown for Use Case 4.2

4.2.1 Working process activities and limitations

4.2.1.1 Definition of safety performance framework

The first key action involved in the definition of a safety performance framework involves **measuring the baseline safety performance of the existing operation** under the current fuel scheme. This evaluation is facilitated through the **selection of pertinent safety performance indicators** that provide a comprehensive understanding of the safety landscape. By identifying these indicators and their targets and thresholds, operators gain insights into the safety strengths and areas that require improvement within their current operational context.

Based on the safety analysis performed, operators undertake a **hazard identification process linked to the fuel scheme**. Potential hazards are systematically recognised and documented, setting the stage for a comprehensive safety risk assessment. This assessment serves as the foundation for establishing an effective mechanism for continuous risk monitoring and risk control to **ensure an equivalent or enhanced level of safety** compared to the existing fuel scheme.

The challenges associated to the definition of safety frameworks are analysed and understood through two (2) key dimensions: Technology & Data and Organisation, which provide insights into the various aspects and challenges associated.

4.2.1.1.1 Technology & Data

The Technology & Data category revolves around the fundamental data used in Safety Performance Indicators (SPIs), encompassing aircraft-specific fuel data and other necessary operational data for analysing safety occurrences, events, and operational scenarios. Within this category, operators have the flexibility to strategically select SPIs that align with their fuel and safety goals. However, an important challenge arises from the absence of comprehensive guidelines that effectively guide the establishment of robust safety performance frameworks and SPIs selection.

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- **UC4.2.TEC.1 - Mixed nature of proposed safety indicators:** A key limitation in the definition of SPIs lies in their mixed nature. The SPIs proposed by EASA in GM2 CAT.OP.MPA.180 combine parameters, such as planned vs. actual trip fuel, with events monitoring, such as MAYDAY and MINIMUM FUEL declarations. This blending of different types of indicators may not offer the most efficient approach for monitoring the safety of fuel reductions, creating challenges for both operators and authorities.

4.2.1.1.2 Organisation

This category addresses limitations that primarily pertain to the organisational aspects of defining a safety performance framework for fuel schemes. It delves into the challenges associated with resource allocation, change management, integration within the Safety Management System (SMS), and the control and reporting of safety events. All organisational limitations reflect the difficulties of orchestrating comprehensive safety initiatives within the operational context.

- **UC4.2-ORG.1 - Difficulty in defining Safety Performance Indicators for Basic Fuel Scheme with Variations:** Operators implementing fuel variations face challenges in defining SPIs due to the current regulation's lack of specific requirements for monitoring SPIs or safety performance in these cases. While some operators proactively monitor SPIs for Basic Fuel Scheme with Variations, they encounter difficulties in determining the appropriate indicators. Similarly, for the Individual Fuel Scheme, although some SPIs are defined in GM2 CAT.OP.MPA.180, operators struggle to create comprehensive lists of SPIs to assess the stability and safety of fuel reductions effectively.
- **UC4.2-ORG.2 - Need for additional SPIs or more flexible SPIs:** Another limitation is the need for additional parameters to be included in the SPIs, regardless of the fuel scheme being implemented. The current list of parameters outlined by EASA is considered too basic by some operators and lacks the necessary flexibility to capture the full range of safety considerations. For example, some operators monitor fuel consumption by time rather than by amount, and others have defined reliability indicators or data quality indicators that are essential for comprehensive safety monitoring.
- **UC4.2-ORG.3 - Monitoring of safety trends:** In addition to monitoring individual parameters, operators must also track thresholds and trends over time to ensure comprehensive safety performance assessment. Continuous evaluation of trends allows operators to identify potential deviations or anomalies in the safety performance of fuel reductions, enabling timely corrective actions to mitigate risks. The necessity for trend analysis adds complexity to the monitoring process, which operators must address to ensure robust safety management within their fuel management initiatives.
- **UC4.2-ORG.4 - Limited resources for implementing Individual Fuel Schemes:** The implementation of individual fuel schemes poses a significant challenge due to the lack of manpower for operators. As operators are currently focused on implementing variations of fuel schemes, such as the Basic Fuel Scheme with Variations, they may face limitations in allocating resources to prioritise the actions needed to implement an individual fuel scheme. The successful implementation of individual fuel schemes requires dedicated personnel with the expertise and knowledge to design, develop, and maintain a comprehensive safety performance framework. However, operators may struggle to allocate sufficient manpower to this task, as their resources are already stretched thin with ongoing initiatives. Furthermore, implementing individual fuel schemes requires specific trainings and skill sets that may not be readily available within the organisation.
- **UC4.2-ORG.5 - Absence of guidelines that promote the integration of fuel initiatives within the SMS:** The implementation of fuel schemes brings about significant organisational changes for operators. The transition to new fuel schemes requires effective change management strategies to ensure smooth adoption and minimise disruption to daily operations. One main challenge in terms of coordination across different departments is the alignment of fuel schemes within SMS and within the safety or FDM department. In fact, AMC1 CAT.OP.MPA.180 states that operators wishing to implement an individual fuel scheme should adapt its management system to ensure that processes and procedures are

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established, flight crew and personnel are trained and the implementation and effectiveness of such processes, procedures, and training are monitored. This brings changes to the Operations Manual (OM), which at the same time brings changes to SMS.

- **UC4.2-ORG.6 - Lack of detailed guidelines regarding the de-identification of data when shared with other departments within an organisation:** In many cases, fuel-related data needs to be shared with various departments for different purposes, such as safety analysis, operational planning, or performance evaluation. However, ensuring the confidentiality and privacy of sensitive data becomes a critical concern. Without well-defined procedures for de-identifying data, there is a risk of inadvertently exposing sensitive information, which may include aircraft-specific details, crew information, or operational parameters.

4.2.1.2 Monitoring and re-assessment of fuel schemes

The second key activity in the context of safety performance is the **monitoring and re-assessment of approved fuel schemes**. This ongoing evaluation is currently based on the directive of CAT.OP.MPA.180 (b), which mandates operators to establish robust reporting systems to the competent authority. Through consistent reporting, operators should provide a clear overview of the safety performance and regulatory compliance status of individual fuel schemes. Moreover, this continuous flow of information enables timely identification of any deviations or safety concerns, empowering operators to take timely corrective measures. In fact, the harmonious execution of this activity depends on the effective organisational and operational strategies established by operators and authorities. In this regard, the limitations associated to the monitoring and re-assessment of fuel schemes can be analysed and understood through the Operations dimension.

4.2.1.2.1 Operations

In the domain of Operations, a pivotal concern emerges regarding the continuous reporting of safety performance, mainly due to the lack of detailed guidelines concerning reporting frequency and format, which limits the establishment of consistent and standardised reporting practices.

- **UC4.2-OPS.1 - Continuous reporting of fuel and safety performance:** EASA's AMC1 CAT.OP.MPA.180 (b) states that operators should establish effective continuous reporting systems to the competent authority on the safety performance and regulatory compliance of the individual fuel scheme. While operators collect and analyse data for safety performance evaluation, they lack guidelines for the continuous reporting, including for instance the reporting frequency and format, which limits their ability to establish consistent reporting practices and may lead to inconsistencies in the reporting across different operators or even across operations.

- **UC4.2-OPS.2 - Fragmented control and monitoring of safety events:** Fuel schemes require for monitoring of the equivalent level of safety, including some SPIs that might be cross governed by both fuel department (e.g., the monitoring of safety margins for overburn situations) and safety department (e.g., mayday or minimum fuel reports). The separation of monitoring efforts between fuel and safety department (if they are not integrated), might in some cases result in duplicate processes and inhibits effective identification of safety occurrences and variations in fuel performance trends. This segregation creates a potential risk as it leads to fragmented control and monitoring of safety events for operators and authorities.

- **UC4.2-OPS.3 - Lack of alignment between CAAs in the monitoring and re-assessment of safety performance:** The lack of a clearly defined guidelines regarding the monitoring and re-assessment of safety performance has led to a lack of standards that the authorities have compensated by developing their own guidelines, resulting in a lack of alignment between CAAs. This misalignment poses a challenge for operators with more than one AOC, as they face difficulties in harmonising practices and requirements across multiple jurisdictions to ensure uniformity in their safety framework monitoring and re-assessment. The absence of standardised standards can result in inefficiencies, inconsistencies, and increased administrative burden.

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4.2.2 Limitations overview

As seen throughout the challenges description, the characterisation of safety performance in the context of fuel reduction schemes brings forth a set of challenges and limitations that manifest across various operational dimensions. This section presents a consolidated overview of all identified challenges, systematically categorized into the three (3) fundamental categories (Technology & Data, Organisation, and Operations), and classified according to their corresponding process activity.

Table 4-5 Overview of limitations identified for Use Case 4.2

Use Case 4.2 Characterising the safety performance indicators for fuel schemes			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**
Definition of safety performance framework	• UC4.2-TEC.1 - Mixed nature of proposed safety indicators	• UC4.2-ORG.1 - Difficulty in defining Safety Performance Indicators for Basic Fuel Scheme with Variations • UC4.2-ORG.2 - Need for additional SPIs or more flexible SPIs • UC4.2-ORG.3 - Monitoring of safety trends • UC4.2-ORG.4 - Limited resources for implementing Individual Fuel Schemes • UC4.2-ORG.5 - Absence of guidelines that promote the integration of fuel initiatives within the SMS • UC4.2-ORG.6 - Lack of detailed guidelines regarding the de-identification of data when shared with other departments within an organization	
Monitoring and re-assessment of fuel schemes			• UC4.2-OPS.1 - Continuous reporting of fuel and safety performance • UC4.2-OPS.2 - Fragmented control and monitoring of safety events • UC4.2-OPS.3 - Lack of alignment between CAAs in the monitoring and re-assessment of safety performance

4.2.3 Proposed digital solutions to address limitations

In an effort to address the various limitations previously identified and described throughout the sections dedicated to each of the activities of the Use Case 4.2, a set of solutions have been proposed, which are presented and described in the following table:

Table 4-6 Proposed solutions identified for Use Case 4.2

Use Case 4.2 Characterising the safety performance indicators for fuel schemes		
Limitation	**Solution**	**Description**
UC4.2-TEC.1 - Mixed nature of proposed safety indicators	**UC4.2-SOL.1** - Development of industry best-practices for the definition and differentiation of safety indicators and events	Publication and promotion by industry bodies or relevant regulatory working groups that facilitate the preliminary definition of safety indicators and events, ensuring a clear distinction between parameters meant for safety monitoring and mandatory safety event reporting. The working group should: • Establish a clear definition for SPIs as parameters used for proactive monitoring and assessment of fuel-related safety performance (i.e., track trends, deviations, and potential safety risks associated with fuel management). • Emphasize that safety events like MAYDAY and MINIMUM FUEL declarations, which are subject to mandatory reporting, should be treated as separate safety indicators but retained as essential elements for event reporting and investigation. In this regard, safety indicators could be divided into two categories: performance indicators (focused on parameters related to planned vs. actual fuel consumption, fuel efficiency, and operational performance) and event indicators (designed to trigger alerts when specific safety events occur).
	UC4.2-SOL.2 - Development of GM/AMC for standardised lists of SPIs	Develop regulatory requirements explicitly capturing standardised lists of fuel and safety-related parameters to streamline and enhance the monitoring of fuel reductions, making the process more efficient and effective for both operators and regulatory authorities. The guidelines should include comprehensive lists of parameters relevant to both fuel management and safety monitoring to allow for a holistic assessment of fuel management initiatives while maintaining a clear distinction between fuel performance metrics and safety events monitoring.

UC4.2-ORG.1 - Difficulty in defining Safety Performance Indicators for Basic Fuel Scheme with Variations	**UC4.2-SOL.3** - Development of industry best-practices for the definition of safety frameworks to specific fuel reductions	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices that provide clear guidelines and frameworks for operators to establish safety monitoring systems tailored to their specific fuel reduction initiatives. These best-practices empower operators to proactively define SPIs that accurately assess the stability and safety of their fuel-saving measures. The best-practices should:
		• Guide operators in tailoring safety frameworks to the unique characteristics of their fuel reduction programs.
		• Emphasize the importance of conducting comprehensive risk assessments to identify potential safety implications associated with fuel reduction initiatives.
		• Provide operators with guidance on identifying critical parameters that are essential for monitoring safety.
		• Outline a structured approach for defining SPIs that align with the operator's safety framework.
		• Recommend specific thresholds and target levels to help operators set meaningful benchmarks for SPIs. These values should be based on a comprehensive analysis of:
		  • Precursor events (such as FDM precursor events detected through the EOFDM)
		  • Safety margins (e.g., selection of alternates, monitoring of extra fuel, etc.)

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Use Case 4.2 Characterising the safety performance indicators for fuel schemes		
Limitation	**Solution**	**Description**
		• Monitoring of operating conditions • Analysis of ASR consequential events
	UC4.2-SOL.4 - Creation and promotion of collaborative data programmes for the definition of SPIs	Incentivise the creation and promotion of collaborative data programmes (e.g., Data4Safety) that provides factual-based information at national or European level for the definition of SPIs. This solution encourages aviation stakeholders, including operators, regulatory authorities, industry associations, and safety organisations, to collaborate in establishing and supporting data-sharing programs dedicated to analysing and disseminating SPIs related to fuel management and safety.
UC4.2-ORG.2 - Need for additional SPIs or more flexible SPIs	**UC4.2-SOL.5** - Development of industry best-practices for the definition of expanded lists of SPIs	Publication and promotion by industry bodies or relevant regulatory working groups for the definition of an expanded list of SPI parameters that operators can choose from when defining their safety monitoring criteria. This broader range of parameters should encompass various aspects of fuel management, including time-based monitoring, reliability indicators, data quality metrics, and other relevant safety factors. Additionally, operators should be encouraged to periodically review and update their SPI definitions and thresholds based on evolving operational conditions, technological advancements, and lessons learned from fuel-saving initiatives.
UC4.2-ORG.3 - Monitoring of safety trends	**UC4.2-SOL.6** - Development of industry best-practices for the monitoring of fuel-related safety trends	Publication and promotion by industry bodies or relevant regulatory working groups for the effective monitoring of safety trends, which is crucial for operators to assess the long-term performance and stability of fuel reductions, detect potential safety deviations, and implement corrective actions in a proactive manner. The working group should establish clear criteria for selecting and tracking trends that align with their specific safety objectives and that are based on a comprehensive analysis of: • Precursor events (such as FDM precursor events detected through the EOFDM) • Safety margins (e.g., selection of alternates, monitoring of extra fuel, etc.) • Monitoring of operating conditions • Analysis of ASR consequential events Moreover, the best-practices should include recommendations on regular monitoring schedule to review safety trends. The frequency of monitoring should align with the specific fuel management initiative, considering factors like operational volume and complexity.
	UC4.2-SOL.7 - Creation and promotion of collaborative data programmes for safety monitoring	Incentivise the creation and promotion of collaborative data programmes (e.g., Data4Safety) that provides factual-based information at national or European level for the monitoring of equivalent level of safety for fuel-related initiatives, definition of thresholds and for the analysis of specific trends. This solution encourages aviation stakeholders, including operators, regulatory authorities, industry associations, and safety organisations, to collaborate in establishing and supporting data-sharing programs dedicated to collecting, analysing, and disseminating data related to fuel management and safety. These programmes allow for a broader spectrum of safety information, which is accessible for trend monitoring and analysis, encompassing various operators and regions.
UC4.2-ORG.5 - Absence of guidelines for the alignment of fuel initiatives and the SMS	**UC4.2-SOL.8** - Development of GM/AMC for the alignment of fuel initiatives with Safety Management System (SMS)	Develop guidelines to provide operators with a structured framework for aligning fuel-related initiatives within their existing SMS processes. The guidelines should address a set of key topics, described below. • The fuel department must monitor fuel-related safety performance indicators, but any fuel initiatives affecting safety should also be monitored by Safety Risk Management (SRM), which is part of the SMS. Thus, the guidelines should address how to establish clear communication channels and protocols for monitoring safety performance indicators related to fuel initiatives. This ensures that both departments are aware of safety-related issues arising from fuel schemes.

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Use Case 4.2 Characterising the safety performance indicators for fuel schemes		
Limitation	**Solution**	**Description**
		• Guidelines on how to address the complexities of accessing data that may not be controlled by a single department (e.g., FDM data is controlled and distributed by the safety department and the fuel department might need it to monitor specific SPIs). Thus, the guidelines should recommend mechanisms for seamless data sharing and collaboration between departments to monitor safety levels effectively. • Guidelines for regulatory authorities to conduct independent audits of safety monitoring processes within both the fuel department and the safety department to ensure that safety aspects of fuel initiatives are rigorously assessed.
UC4.2-ORG.6 - Lack of detailed guidelines regarding the de-identification of data when shared with other departments within an organization	**UC4.2-SOL.9** - Development of GM/AMC for the de-identification of fuel-related data	Develop guidelines for the de-identification of fuel-related data, enabling safe sharing and collaboration across departments while ensuring the confidentiality and privacy of sensitive information. The GM/AMC should establish potential approaches to remove sensitive information from datasets while retaining their analytical value. The GM/AMC should: • Provide a framework for classifying fuel-related data based on sensitivity to assist operators in the identification of information that requires de-identification (e.g., aircraft-specific details, crew information, or operational parameters). • Provide potential de-identification techniques (e.g., anonymisation or aggregation) that ensure that sensitive information cannot be traced back to individuals or other operational characteristics. • Provide specific guidelines regarding access controls and data sharing protocols within the organisation. • Establish mechanisms for monitoring and auditing compliance with de-identification guidelines.
UC4.2-OPS.1 - Continuous reporting of fuel and safety performance	**UC4.2-SOL.10** - Development of GM/AMC for the continuous reporting of fuel-related safety performance	Further develop current guidelines (e.g., EASA's AMC1 CAT.OP.MPA.180 b) regarding the reporting to the competent authority regarding the safety performance and regulatory compliance of fuel schemes. The GM/AMC should specifically address reporting requirements, frequency, format, and content. In this regard, the GM/AMC should, at least: • Specify reporting frequencies that align with regulatory expectations and industry best practices and provide clarity on how often operators should submit reports to the competent authority, ensuring a consistent approach across the industry. • Define standardised report formats to facilitate efficient and uniform reporting (e.g., types of data and information that must be included in the reports).
UC4.2-OPS.2 - Fragmented control and monitoring of safety events	**UC4.2-SOL.11** - Development of industry best-practices for the monitoring of fuel-related safety events	Publication and promotion by industry bodies or relevant regulatory working groups for the definition of a unified approach to monitor safety performance indicators related to fuel schemes. The framework should ensure that both the safety and fuel departments are actively involved in evaluating safety-related issues arising from fuel initiatives without duplicating efforts. These best-practices should provide specific instructions on how to integrate safety and fuel monitoring efforts seamlessly, as well as establish protocols for the concurrent evaluation of indicators, trends, and events.
UC4.2-OPS.3 - Lack of alignment between CAAs in the monitoring and re-assessment of safety performance	**UC4.1-SOL.12** - Development of industry best-practices for collaboration and coordination between Authorities regarding the monitoring and re-assessment of safety performance	Promote a close collaboration and coordination between CAAs to establish common standards, harmonised guidelines, and streamlined processes. Key components of this solution include: • CAAs to establish a collaborative framework that facilitates regular communication and information sharing. • Facilitate discussions and initiatives among CAAs to define standardised fuel reduction models approval processes.

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4.2.4 Proposed solution packages

The potential digital solutions proposed in Section 4.2.3 have been grouped into solution package, following the Safety promotion, Regulatory initiatives and Innovation & Technology grouping.

➨ **Table 4-7** Solution packages to address limitations of Use Case 4.2

Use Case 4.2: Characterising the safety performance indicators for fuel schemes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
Solution package – Safety promotion			
UC4.2-PS.1 - Development of industry best-practices for the definition and monitoring of SPIs framework	• **UC4.2-SOL.1** - Development of industry best-practices for the definition and differentiation of safety indicators and events • **UC4.2-SOL.3** - Development of industry best-practices for the definition of safety frameworks to specific fuel reductions • **UC4.2-SOL.5** - Development of industry best-practices for the definition of expanded lists of SPIs • **UC4.2-SOL.6** - Development of industry best-practices for the monitoring of fuel-related safety trends • **UC4.2-SOL.11** - Development of industry best-practices for the monitoring of fuel-related safety events • **UC4.1-SOL.12** - Development of industry best-practices for collaboration and coordination between Authorities regarding the monitoring and re-assessment of safety performance	**Aviation industry bodies and associations:** • Facilitate the definition of best-practices for SPIs related to fuel management initiatives by bringing together experts and stakeholders from both the aviation and data/digitalisation industry (e.g., data scientist and analysts to contribute expertise to define safety indicators and events and assist in developing methods for monitoring and analysing SPIs) • Play a critical role in implementing data-driven approaches for safety trend analysis) • Collaborate with operators and regulatory authorities to ensure alignment with industry standards **Regulatory authorities:** • Review the development of best-practices for SPIs definition and monitoring • Ensure that they align with regulatory standards and requirements • Promote for the adoption of best-practices across the aviation industry • Assess the feasibility of publishing the best-practices as GM or AMC **Operators:** • Adopt and implement the best-practices in their processes and day-to-day operations. Specifically, establish protocols for concurrent evaluation of indicators, trends, and events, based on the defined best-practices • Collaborate with industry bodies and regulatory authorities in the development and refinement of best-practices (e.g., provide data and information related to SPIs) • Establish collaborative methodologies between safety and fuel departments to align monitoring efforts • Train their personnel to effectively utilize the SPI framework in daily operations and safety assessments **Civil Aviation Authorities:**	• Existing safety and fuel-related data sources (e.g., FDM data, safety reports, etc.) • List of SPIs used to monitor safety related to fuel performance • Identified safety precursor events relevant to fuel • Criteria for evaluating the significance of safety events in the context of fuel planning and management • Information on methodologies for analysing safety and fuel-related data • Historical safety data and reports

Solution package	Solutions included	Involved stakeholders (Definition, production, or implementation of the solution)	Data-related enablers
Use Case 4.2: Characterising the safety performance indicators for fuel schemes			
		• Collaborate with other CAAs to establish common standards and harmonized guidelines regarding the definition and monitoring of SPIs	
Solution package - Regulatory initiatives (Guidance Material or Acceptable Means of Compliance)			
UC4.2-PS.2 - Regulatory initiatives for the definition and monitoring of safety performance	• **UC4.2-SOL.2** - Development of GM/AMC for standardised lists of SPIs • **UC4.2-SOL.8** - Development of GM/AMC for the alignment of fuel initiatives with Safety Management System (SMS) • **UC4.2-SOL.9** - Development of GM/AMC for the de-identification of fuel-related data • **UC4.2-SOL.10** - Development of GM/AMC for the continuous reporting of fuel-related safety performance	**Regulatory authorities:** • Develop and implement the regulatory initiatives (potentially based on published industry best-practices) • Define and enforce requirements related to standardised lists of SPIs, alignment with the SMS, de-identification of data, and continuous reporting and ensure practicality and alignment with industry standards • **Operators:** • Adhere to the standardised lists of SPIs, align fuel initiatives with SMS, implement de-identification guidelines, and ensure compliance with reporting requirements • **Civil Aviation Authorities:** • Conduct audits to ensure compliance with new regulatory initiatives	• Safety and fuel-related data sources (e.g., FDM data, safety reports, fuel performance data, etc.) • List of SPIs used to monitor safety related to fuel performance • Information on methodologies for analysing safety and fuel-related data • Data de-identification methods and tools • Data sharing protocols and mechanisms to facilitate cross-departmental collaboration
Solution package – Innovation & Technology			
UC4.2-PS.3 - Support the adoption of digital tools and capabilities for safety performance analysis	• **UC4.2-SOL.4** - Creation and promotion of collaborative data programmes for the definition of SPIs • **UC4.2-SOL.7** - Creation and promotion of collaborative data programmes for safety monitoring	**Operators:** • Participate in collaborative data-sharing programmes aimed at defining SPIs and safety monitoring criteria • Share historical fuel-related data, analysed KPIs, and SPIs to contribute to the development of comprehensive safety monitoring frameworks • Benefit from improved safety monitoring and analysis capabilities provided by benchmarking tools or similar solutions • Provide guidance and expertise to implement safety analysis capabilities effectively **Regulatory authorities:** • Encourage and oversee the establishment of collaborative data programmes within the aviation industry • Define guidelines, standards, and minimum requirements related to data-sharing programmes, ensuring they align with safety and regulatory objectives • Monitor compliance with established guidelines and standards to maintain data programmes effectiveness	• Historical fuel-related data encompassing various operational aspects and safety-related parameters • Analysed KPIs and SPIs data • Access to benchmarking tools and digital solutions that enhance safety performance analysis • Safety analysis capabilities

Use Case 4.2: Characterising the safety performance indicators for fuel schemes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
		• Support the dissemination of information and insights generated through collaborative data programmes **Aviation industry bodies and associations:** • Facilitate collaboration among stakeholders and promote the establishment of data-sharing programmes • Provide industry-specific guidance and best practices for the implementation of safety analysis capabilities • Support the dissemination of information and insights generated through collaborative data programmes	

4.3 Use Case 4.3: Using operating conditions data to support performance-based fuel schemes

There is a foundational precept in EASA's fuel regulations: the concept of fuel reduction schemes is fundamentally data-driven. A fundamental aspect of the flexibility provided by EASA is, in turn, to gain and establish control over operational data and monitor it to ensure that safety levels are sufficient and remain constant. CAT.OP.MPA.180 exemplifies this paradigm by stating that operators must ensure a minimum of operational capabilities for individual schemes. Moreover, CAT.OP.MPA.181 states that operators shall ensure that the planning of flights include the collection and continuous monitoring of a set of reliable operating conditions data, such as anticipated meteorological conditions, the state of the infrastructure to be used, expected arrival or departure operations and delays. This data-driven approach proposed by EASA unfolds in three interlinked activities: the collection of operating conditions data per se, the integration or fusion of the collected data with other data layers (e.g., fuel-related data or safety indicators), and the use of the operating conditions data along the whole fuel planning and management process.

Based on this comprehensive process description, the use of fuel-related data within fuel schemes can be divided into three (3) key activities, presented in Figure 4-3.

Figure 4-3 Process activity breakdown for Use Case 4.3

4.3.1 Working process activities and limitations

4.3.1.1 Collection of operating conditions data

The first activity entails the systematic collection of operating conditions data, as stipulated by CAT.OP.MPA.181, which states that operators shall ensure that the planning of flights includes the operating conditions under which the flight is to be conducted. The operating conditions shall include at least aircraft fuel/energy consumption data, anticipated masses, anticipated meteorological conditions, the effects of deferred maintenance items and/or of configuration deviations, the expected departure and arrival routing and runways, and the anticipated delays.

The limitations related to the collection of operating conditions data can be analysed and understood through three (3) key dimensions: Technology & Data, Organisation, and Operations, which provide insights into the various aspects and challenges associated with the data collection and quality assessment processes.

4.3.1.1.1 Technology & Data

This activity encompasses the collection of operating conditions data, with a specific emphasis on gathering the minimum set of data sources mandated in CAT.OP.MPA.181 (b):

- aircraft fuel/energy consumption data
- anticipated masses
- the effects of deferred maintenance items and/or of configuration deviations
- the expected departure and arrival routing and runways
- anticipated delays

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For most operators, this data collection process involves the adoption of software or digital tools that provide the necessary data. However, some data sources are difficult to collect in a standardised or systematic way, which leads to limitations for operators.

- **UC4.3-TEC.1 - Collecting all necessary operating conditions data sources:** One of the significant challenges encountered in the collection of operating conditions data is the difficulty faced by some operators, especially small ones with limited resources and investment constraints, in gathering all the necessary sources. Some data sources, such as meteorological conditions, are relatively easy to collect as they are usually provided and integrated within most flight planning solutions. However, challenges arise with other data types, such as delays or runway configuration, which are harder to systematically gather due to the lack of a single source or provider that offers all the information for all airports.
  - **UC4.3-TEC.1A - Difficulty in collecting delays information:** Some operators face challenges in systematically collecting delays information. Delays can significantly impact fuel planning and optimisation, and operators need accurate and up-to-date delay data to make informed decisions. However, delays information may not be available in a standardised way for all airports and regions. As a result, operators and specially pilots may rely on their experience and gut feeling, rather than statistical data, when planning for delays at specific destinations.
  - **UC4.3-TEC.1B - Difficulty in collecting runway configuration information:** Operators recognise the importance of accurate runway configuration information for fuel planning and optimisation. However, obtaining precise and reliable data on runway configurations can be challenging. While some digital tools provide such information, they may lack accuracy, introducing potential discrepancies in the fuel planning process. Ensuring standardised methods for obtaining runway configuration data is crucial for operators seeking to enhance fuel planning accuracy and efficiency.

4.3.1.1.2 Organisation

The Organisation dimension introduces constraints related to the data collection process, specifically to the assessment of data quality. Operators do not have a harmonised framework defined for the assessment of the quality of operating conditions data. The data sources collected are very different from each other, not only in their content but also in their size. Thus, assessing the reliability, accuracy and completeness of the data becomes a challenging process for operators.

- **UC4.3-ORG.1 - Assessment of operating conditions data quality:** In addition, there is also a lack of guidelines on how to assess the quality of these data sources. Operators need further guidance on the criteria to evaluate the reliability, accuracy, and completeness of the operating conditions data they collect. An example of this could be GM1 CAT.OP.MPA.185, which establishes the minimum requirements to be met by the data sources from which delay is obtained. Specifically, it indicates the minimum characteristics to be met in a basic fuel scheme by the delay information, such as accuracy, where it is regulated that the delay should be communicated with its corresponding gap error and this error should be added to the base value. In the same way as for delays, this concept of quality indications should be scaled to the other potential data sources used in fuel planning and management, establishing a common framework for all of them.

4.3.1.1.3 Operations

In the Operations dimension, the limitations of data-driven decision-making and the lack of detail provided in the regulations converge. CAAs play a key role in auditing and approving data-related processes, ensuring adequate data collection processes and quality standards. However, the limited expertise of CAAs in assessing data-driven processes may lead to some limitations in the oversight of such processes. In addition, the lack of standardisation among different authorities regarding minimum operating conditions data for fuel schemes and data quality requirements introduces some operational complexities for operators.

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- **UC4.3-OPS.1 - Limited expertise in CAAs for auditing and approving data-related processes:** CAAs may encounter challenges in auditing and approving the collection of operating conditions data due to limited expertise in this specific area. The process of gathering comprehensive and reliable operating conditions data for fuel planning and management requires a deep understanding of aviation operations, data sources, and data quality assessments. Without the necessary expertise, CAAs may struggle to effectively evaluate the operators' data-related activities, leading to potential gaps in compliance and data accuracy. To ensure the robustness of fuel planning and management processes, it is essential to provide CAAs with clear guidelines and training in auditing data collection practices. This would facilitate more accurate assessments and promote alignment with safety standards and regulations.
- **UC4.3-OPS.2 - Lack of standardisation and alignment between CAAs regarding minimum operating conditions data for fuel schemes:** The absence of consistent practices and standardisation among CAAs regarding the minimum operating conditions data required for fuel schemes, as well as in terms of data quality requirements, can create challenges for operators. Different CAAs may have varying requirements and expectations for the data needed to support fuel planning and management initiatives. As a result, operators may face complexities in adapting their procedures and data management practices to comply with these divergent regulations. This lack of alignment may lead to additional administrative burdens for operators, as they would need to tailor their data collection and reporting processes to meet different CAA requirements.

4.3.1.2 Integration and fusion of operating conditions data

As operators continue to move forward in their efforts to have more knowledge and up-to-date information on the operating environment of each flight, the integration or fusion of operating conditions data with fuel or safety related data emerges as a key component in the overall fuel planning and management process.

The limitations related to this activity can be analysed through two (2) key dimensions: Technology & Data and Organisation, which provide insights into their challenges associated.

4.3.1.2.1 Technology & Data

In the dynamic field of aviation fuel planning and management, the integration or fusion of data from diverse sources is essential for informed decision-making. The Technology & Data challenges for such fusion revolve around the high variability of data and the flexibility of the systems used by operators, which can hinder compatibility and prevent efficient integration of data sources.

- **UC4.3-TEC.2 - Integration of data into a single system:** One of the limitations in fuel planning and management is the integration of operating conditions data from various sources into a unified software or digital solution. Flight planning systems, for instance, may not easily accommodate additional or non-standard data feeds, resulting in potential data gaps. Moreover, some data providers might have proprietary systems that are not easily compatible with external platforms, making it challenging for operators to integrate data sources effectively.
- **UC4.3-TEC.3 - Difficulty in digitalising and standardising NOTAMs:** While NOTAMs are available, their integration into operational processes can be challenging, as they often contain free text fields and unstructured information, making it difficult to extract relevant data automatically. Converting NOTAMs into activatable ones, where the information can be easily processed and integrated into operational systems, requires significant effort and resources.

4.3.1.2.2 Organisation

Beyond the technological domain, the effectiveness of data fusion depends on some organisational aspects, such as establishing processes for effective data integration and collaboration among different departments.

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- **UC4.3-ORG.2 - Integration of data coming from diverse sources:** One of the limitations in fuel planning and management is the integration of operating conditions data from various sources into a single activable dataset. Different types of data, including meteorological conditions, delays, runway configurations, or traffic information, often come from distinct sources with varying formats. This diversity can create complexities when attempting to merge the data seamlessly with the purpose of comprehensive analysis of all operating conditions that intervene in a specific flight.
- **UC4.3-ORG.3 - Fusion of operating conditions data sources with fuel-related data:** Beyond defining which data sources should be used, it is important to understand that a further challenge lies ahead, which is the merge of all these data sources. In the end, the development of advanced statistics will be done in the context of FCMS, and operators will be faced with the challenge of parameter fusion. This fusion is not trivial, and the technical approach will be highly constrained by the data sources used (ACARS, FDM...). As an example, in FDM, fusion is a very current topic, dealt with in the context of collaborative working groups such as the EOFDM. In fact, integrating operating conditions data with fuel-related data may also encounter challenges related to data format and compatibility. Different data sources may use varying formats and structures, making it challenging to seamlessly merge the data.
- **UC4.3-ORG.4 - Interoperability between systems for the fusion/integration of data:** Integrating operating conditions data with fuel-related data may involve multiple systems and platforms used by different departments within the organisation. Ensuring interoperability between these systems is critical to enable seamless data exchange and collaboration. Operators may encounter challenges related to system compatibility and may need to invest in integrating technologies to achieve efficient data integration.
- **UC4.3-ORG.5 - Data sources synchronisation and real-time updates:** Maintaining data synchronisation and real-time updates between operating conditions data and fuel-related data is crucial for accurate and timely in-flight fuel planning and management. Operators may face difficulties in ensuring that data from different sources are up-to-date and consistently synchronised, especially when dealing with dynamic operational conditions and frequent changes.

4.3.1.3 Use of operating conditions data along fuel planning and management

The culmination of all efforts related to the collection and integration of operating conditions data is the use of such data within the context of fuel planning and management. In this regard, operators need to ensure that they have access to operating conditions data at all stages of the process, including planning, in-flight re-planning and management and post-ops analysis. This is clearly specified in CAT.OP.MPA.185(a), which states that the operator should establish procedures for in-flight fuel management that ensure continual validation of the assumptions made during the planning stage, as well as re-analysis and adjustment, if necessary. This implies some difficulties because operators need to be able to integrate or compare data used at the planning stage with the actual conditions experienced during flight. This is crucial for the efficient and realistic analysis of planned vs. actual fuel consumption.

The limitations related to this activity can be analysed through two (2) key dimensions: Organisation and Operations, which provide insights into their challenges associated.

4.3.1.3.1 Organisation

Effective organisation plays a key role in harnessing the full potential of operating conditions data. This category deals with the challenges arising from the interplay of various organisational aspects: from streamlining data sources to ensuring comprehensive training, these challenges highlight the importance of cohesive coordination within an operator's structure.

- **UC4.3-ORG.6 - Governance of different data sources for operating conditions data:** Another significant challenge encountered in the collection of operating conditions data is ensuring its consistency not only at different stages of the process but also across operations. Operators need to consider that operating conditions data might be collected from different sources. For instance, operators can access delay information from different data sources, depending on the airport. This can pose a challenge when performing models or conducting post-ops analysis of fuel performance, as the data may not align seamlessly. The fact that operators have different data sources will affect their approach to model reduction per se, as well as its validation and deployment. Not only will they have to ensure the data origin from a completeness and representativeness point of view, but they will also have to analyse the impact of their use in the definition of models (whether they have to generate separate models depending on the origin of the data source for the same variable or not, or how these discrepancies have to be managed at OCC level, operationally and in terms of dispatcher training).

- **UC4.3-ORG.7 - Operator training and awareness in large volume of data analysis:** The abundant amount of operating conditions data presents operators with the opportunity to extract valuable insights for informed decision-making. However, effectively harnessing this data's potential may require specialised training and expertise in data analysis and digital tools. To fully leverage the benefits of operating conditions data for fuel management, operators need to ensure that their staff, including pilots, dispatchers, and fuel planners, possess the necessary skills to analyse and utilise the data effectively. Adequate training and awareness are essential to equip personnel with the capability to handle the large volume of data and derive meaningful conclusions from it.
- **UC4.3-ORG.8 - Operating under a segregated ecosystem of OCCs:** One of the significant challenges faced by operators is operating within a segregated ecosystem of OCCs. The existence of separate OCCs within an organisation lead to fragmented data management and hinder the seamless integration and utilisation of operating conditions data for fuel planning and management. The segregated nature of OCCs may result in varying practices and procedures across the fuel team, dispatch, and crew. This lack of standardisation and consistency can create difficulties in ensuring that all stakeholders have access to the same, accurate, and up-to-date operating conditions data. In addition, the absence of specific guidelines regarding the allowance of segregated ecosystem of OCCs can also pose challenges for authorities. The lack of specific guidelines may create uncertainties and ambiguities in the evaluation process, making it difficult for authorities to justify the approval or denial of OCCs for each fuel scheme.

4.3.1.3.2 Operations

Using operating conditions data along the whole fuel planning and management process brings a set of challenges related with the real-time considerations and day-to-day practicalities that operators face when integrating data insights into their operational workflows. The ability to monitor and deliver accurate data to key stakeholders, such as flight crew, can significantly impact fuel efficiency and flight safety.

- **UC4.3-OPS.3 - Continuous monitoring of operating conditions data during flight operations:** The effective monitoring of operating conditions data, such as weather information, is crucial for fuel dispatch in the context of in-flight re-planning and management. However, the manual monitoring of numerous data sources for multiple flights can be highly challenging and resource-intensive for dispatch personnel. This limitation becomes of utmost importance in the context of individual fuel schemes, where precise monitoring is essential to ensure safety of flight operations at all points. Operators may consider automating the monitoring process by implementing advanced technological solutions, which would allow dispatchers to focus on critical decision-making tasks rather than spending excessive time on data analysis tasks. Alternatively, operators may opt to increase the manpower in the dispatch team to handle the manual monitoring requirements efficiently. However, both approaches present limitations in terms of resource constraints and cost considerations.
- **UC4.3-OPS.4 - Operating conditions data availability for crew:** The accessibility and provision of relevant and accurate operating conditions data to flight crew members pose significant challenges for operators. Ensuring that pilots have comprehensive and easily interpretable information during flight planning and in-flight re-planning stages is crucial for making informed decisions related to fuel

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management. One of the main limitations faced by operators is the lack of streamlined processes for delivering operating conditions data to flight crew members. While flight planning tools and systems may provide some data, pilots may still encounter gaps in the availability of critical information, such as real-time weather updates, unexpected delays, or specific runway configurations. As a result, pilots might have to rely on their own experience and intuition rather than data-driven insights when planning fuel for a specific route.

4.3.2 Limitations overview

As seen throughout the challenges description, the collection and use of operating conditions data in the context of fuel reduction schemes brings forth a set of challenges and limitations that manifest across various operational dimensions. This section presents a consolidated overview of all identified challenges, systematically categorized into the three (3) fundamental categories (Technology & Data, Organisation, and Operations), and classified according to their corresponding process activity.

Table 4-8 Overview of limitations identified for Use Case 4.3

Use Case 4.3 Using operating conditions data to support performance-based fuel schemes			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**
Collection of operating conditions data	• UC4.3-TEC.1 - Collecting all necessary operating conditions data sources	• UC4.3-ORG.1 - Assessment of operating conditions data quality	• UC4.3-OPS.1 - Limited expertise in CAAs for auditing and approving data-related processes • UC4.3-OPS.2 - Lack of standardization and alignment between CAAs regarding minimum operating conditions data for fuel schemes
Integration and fusion of operating conditions data	• UC4.3-TEC.2 - Integration of data into a single system • UC4.3-TEC.3 - Difficulty in digitalizing and standardizing NOTAMs	• UC4.3-ORG.2 - Integration of data coming from diverse sources • UC4.3-ORG.3 - Fusion of operating conditions data sources with fuel-related data • UC4.3-ORG.4 - Interoperability between systems for the fusion and integration of data • UC4.3-ORG.5 - Data sources synchronization and real-time updates	
Use of operating conditions data along fuel planning and management		• UC4.3-ORG.6 - Governance of different data sources for operating conditions data • UC4.3-ORG.7 - Operator training and awareness in large volume of data analysis • UC4.3-ORG.8 - Operating under a segregated ecosystem of OCCs	• UC4.3-OPS.3 - Continuous monitoring of operating conditions data during flight operations • UC4.3-OPS.4 - Operating conditions data availability for crew

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4.3.3 Proposed digital solutions to address limitations

To tackle the limitations identified from the different interviews with stakeholders, and described throughout each section of the activities present in the Use Case 3.2, a range of solutions have been proposed and are presented in detail in the following table:

➡ **Table 4-9** Proposed solutions identified for Use Case 4.3

Use Case 4.3 Using operating conditions data to support performance-based fuel schemes		
Limitation	**Solution**	**Description**
UC4.3-TEC.1 - Collecting all necessary operating conditions data sources	**UC4.3-SOL.1** - Development of GM/AMC for the definition of minimum set of operating conditions data sources	Develop guidelines that establish minimum set of operating conditions data sources required for specific fuel reduction applications and fuel scheme.
	UC4.3-SOL.2 - Promote the implementation of systems that consolidate operating conditions data from various sources into a centralized platform	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines to promote the implementation of systems that consolidate operating conditions data from various sources into a centralized platform. Development and implementation of a centralised system to report operating conditions data from diverse sources (e.g., expected waiting times, current runway usage, etc.) by relevant stakeholders. The objective is to create a unified platform where stakeholders report and share critical information related to operating conditions, enabling operators to access comprehensive data for improved fuel planning and management. The key components of the solution are: • Establish a centralised digital platform accessible to airports, airlines, and relevant aviation authorities that serves as a hub for reporting and sharing operating conditions. • Define standardised data formats and reporting procedures to ensure consistency and compatibility among diverse data sources. • Allow for real-time updates, ensuring that operators receive the most updated information regarding operating conditions at each airport. • Collaboration with authorities to ensure adherence to industry standards and regulatory requirements.
UC4.3-TEC.2 - Integration of data into a single system	**UC4.3-SOL.2** - Development of industry best-practices for the integration of operating conditions data sources	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices that facilitate seamless data integration, ensuring that operators can access and utilize comprehensive operating conditions data effectively. The best-practices should, at least: • Define standardised data formats and protocols that data providers should adopt to ensure consistency and compatibility among various data sources. • Provide strategies for operators to integrate data from various sources into their fuel planning processes seamlessly.
UC4.3-ORG.1 - Assessment of operating conditions data quality	**UC4.3-SOL.3** - Development of GM/AMC for the definition of minimum requirements for operating conditions data sources	Develop guidelines that establish minimum requirements for operating conditions data sources in collaboration with authorities and stakeholders for specific fuel reduction applications. The key components of these guidelines should include: • Quality assurance: Quality assurance measures to ensure the accuracy and reliability of collected data (e.g., guidelines on data validation and verification processes).

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Use Case 4.3 Using operating conditions data to support performance-based fuel schemes		
Limitation	**Solution**	**Description**
		• Methodologies to regularly assess the data collection processes and quality.
	UC4.3-SOL.4 - Development of GM/AMC accounting for specificities in regard with validation of operating conditions data	Select a set of existing standards (e.g., EUROCAE ED-76(A) or similar standards) accounting for specificities in regard with validation of operating conditions data (data reliability) that cover a wide range of aspects, including data collection procedures, accuracy checks, error identification, and quality assurance practices. The regulatory initiative should: • Develop comprehensive GM/AMC that outlines the specific requirements and procedures for validating operating conditions data according to the adopted standards. • Define clear and standardised criteria for evaluating the quality and reliability of different types of operating conditions data (e.g., criteria related to accuracy, completeness, timeliness, etc.).
UC4.3-ORG.2 - Integration of parameters coming from diverse data sources	**UC4.2-SOL.5** - Development of GM/AMC for the integration of operating conditions data	Develop guidelines for data source integration to mitigate compatibility issues and ensure data accuracy and completeness. The guidelines should address compatibility of different data sources, considering factors such as data formats, protocols, and frequencies, and should include integration protocols and standards that operators can follow when combining data from diverse sources.
UC4.3-ORG.6 - Governance of different data sources for operating conditions data	**UC4.3-SOL.6** - Development of industry best-practices for operating conditions data analysis and validation for fuel estimation models	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices regarding the use of different data sources in modelling, validation, and deployment of fuel performance models. The best-practices should provide guides to operators to assess the suitability and compatibility of various data sources for use in their fuel performance models (i.e., consider data completeness, accuracy, reliability, and relevance). The best-practices should include: • Recommendations on how operators should adjust their modelling strategies to accommodate variations in data sources, which may involve developing separate models based on data source characteristics or implementing data transformation techniques. • Guidance on validating fuel performance models in scenarios where data from multiple sources are utilized, including methods for evaluating model accuracy and reliability across diverse data inputs. • Instructions on how to effectively deploy fuel performance models that account for variations in data sources, specifically regarding the operational considerations for fuel department, dispatchers, and crew staff.
	UC4.3-SOL.2 - Promote the implementation of systems that consolidate operating conditions data from various sources into a centralised platform	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines to promote the implementation of systems that consolidate operating conditions data from various sources into a centralized platform. Development and implementation of a centralized system to report operating conditions data from diverse sources (e.g., expected waiting times, current runway usage, etc.) by relevant stakeholders. The objective is to create a unified platform where stakeholders report and share critical information related to operating conditions, enabling operators to access comprehensive data for improved fuel planning and management. The key components of the solution are: • Establish a centralized digital platform accessible to airports, airlines, and relevant aviation authorities that serves as a hub for reporting and sharing operating conditions. • Define standardised data formats and reporting procedures to ensure consistency and compatibility among diverse data sources.

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Use Case 4.3 Using operating conditions data to support performance-based fuel schemes		
Limitation	**Solution**	**Description**
		• Allow for real-time updates, ensuring that operators receive the most updated information regarding operating conditions at each airport. Collaboration with authorities to ensure adherence to industry standards and regulatory requirements.
UC4.3-ORG.8 - Operating under a segregated ecosystem of OCCs	**UC4.3-SOL.7 -** Development of GM/AMC for the definition of communication channels / OCCs to share operating conditions data seamlessly	Develop guidelines specifically aimed at addressing the challenges associated with the existence of segregated Operational Control Capabilities within organizations. The GM/AMC should: • Define clear communication channels and protocols for seamless sharing of operating conditions data (e.g., types of data that should be shared, format in which it should be exchanged, etc). • Promote data standardization across OCCs to ensure that all stakeholders work with consistent data formats and structures. • Establish procedures for granting access and authorization to OCCs, ensuring that all authorized personnel can access and use operating conditions data. • Encourage real-time or near-real-time data sharing to enable timely decision-making for fuel planning, flight dispatch, and crew members.
	UC4.3-SOL.8 - Development of industry best-practices for the coordination between dispatchers, fuel team and crew members	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines on coordination between pilot/dispatch/fuel team to ensure consistent data usage across different phases (planning, in-flight re-planning, management, and post-ops analysis). The guidelines should cover coordination between the pilot, dispatch, and fuel team across various phases of flight operations: • Planning: Define roles, responsibilities, and data requirements for each team during flight planning. • In-Flight re-planning and management: Establish procedures for real-time data sharing and communication between the pilot and dispatch in case of route changes, weather updates, or other factors affecting fuel consumption. • Post-operations analysis: Outline procedures to capture and store the actual conditions experienced during the flight, and procedures for data analysis and feedback loops after the flight to improve future planning and decision-making. Additionally, the guidelines should define clear communication protocols and channels for sharing critical information among teams at all phases.
UC4.3-OPS.1 - Limited expertise in CAAs for auditing and approving data-related processes	**UC4.1-SOL.9 -** Support the definition of specific trainings for the enhancement of analytical capabilities	This solution focuses on enhancing the IT and analytical capabilities of CAAs through specialized training and collaboration with industry experts. This solution should begin by assessing the current IT and analytical capabilities within CAAs to identify areas where expertise is lacking and where improvements are needed. Based on this assessment, a training program should be developed and could consider collaboration with recognized industry experts and training institutions to deliver the training programs (e.g., workshops, seminars, etc.). Finally, the solution could also consider a certification process to validate the IT and analytical competence of CAA personnel involved in the approval and auditing process of fuel schemes.
UC4.3-OPS.2 - Lack of standardization and alignment between CAAs regarding minimum	**UC4.1-SOL.10 -** Development of industry best-practices for collaboration and coordination between Authorities	Promote a close collaboration and coordination between CAAs to establish common standards, harmonized guidelines, and streamlined processes. Key components of this solution include: • CAAs to establish a collaborative framework that facilitates regular communication and information sharing.

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Use Case 4.3 Using operating conditions data to support performance-based fuel schemes		
Limitation	**Solution**	**Description**
operating conditions data for fuel schemes	regarding the harmonization of operating conditions data processes	• Facilitate discussions and initiatives among CAAs to define standardised data acquisition and verification standards and practices for fuel planning and management (e.g., defining common data parameters, reporting formats, and validation criteria). Develop harmonized guidelines that CAAs can adopt to ensure uniformity in their requirements and expectations from operators regarding data collection methods, reporting intervals, and verification processes.
UC4.3-OPS.3 - Continuous monitoring of operating conditions data during flight operations	**UC4.3-SOL.11** - Development of industry best-practices for monitoring operating conditions data	Publication and promotion by industry bodies or relevant regulatory working groups of industry best-practices regarding the monitoring of operating conditions data during flight operations with the aim to strike a balance between automation and manual monitoring, considering the specific needs and constraints of operators. The best practices should offer comprehensive guidance on how to monitor operating conditions data effectively, focusing on key areas: • Provide guidance on the use of advanced technological solutions, such as automated monitoring tools and data analytics platforms, to streamline the monitoring process and reduce the burden on dispatch personnel. • Outline procedures for manual monitoring when automation is not feasible or cost-effective and define roles and responsibilities within the dispatch team for data analysis tasks. • Develop training programmes that cover both manual and automated monitoring processes.
UC4.3-OPS.4 - Operating conditions data availability for crew	**UC4.3-SOL.8** - Development of industry best-practices for the coordination between dispatchers, fuel team and crew members	Publication and promotion by industry bodies or relevant regulatory working groups of guidelines on coordination between pilot/dispatch/fuel team to ensure consistent data usage across different phases (planning, in-flight re-planning, management, and post-ops analysis). The guidelines should cover coordination between the pilot, dispatch, and fuel team across various phases of flight operations: • Planning: Define roles, responsibilities, and data requirements for each team during flight planning. • In-Flight re-planning and management: Establish procedures for real-time data sharing and communication between the pilot and dispatch in case of route changes, weather updates, or other factors affecting fuel consumption. • Post-operations analysis: Outline procedures to capture and store the actual conditions experienced during the flight, and procedures for data analysis and feedback loops after the flight to improve future planning and decision-making. Additionally, the guidelines should define clear communication protocols and channels for sharing critical information among teams at all phases.

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4.3.4 Proposed solution packages

The potential digital solutions proposed in Section 4.3.3 have been grouped into solution package, following the Safety promotion, Regulatory initiatives and Innovation & Technology grouping.

Table 4-10 Solution packages to address limitations of Use Case 4.3

Use Case 4.3 Using operating conditions data to support performance-based fuel schemes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
Solution package – Safety promotion			
UC4.3-PS.1 - Development of industry best-practices for the use and monitoring of operating conditions data	• **UC4.3-SOL.6** - Development of industry best-practices for operating conditions data analysis and validation for fuel estimation models • **UC4.3-SOL.8** - Development of industry best-practices for the coordination between dispatchers, fuel team and crew members • **UC4.1-SOL.10** - Development of industry best-practices for collaboration and coordination between Authorities regarding the harmonization of operating conditions data processes • **UC4.3-SOL.11** - Development of industry best-practices for monitoring operating conditions data	**Aviation industry bodies and associations:** • Play a facilitating role in the publication and promotion of industry best-practices • Advocate for the adoption of best-practices within the aviation community • Provide guidance and support to operators in implementing best-practices • Contribute to the development of guidelines for coordination between dispatchers, fuel teams, and crew members **Regulatory authorities:** • Encourage and support the publication and promotion of industry best-practices for operating conditions data analysis and validation • Ensure that best-practices align with regulatory standards and safety requirements • Promote the adoption of these best-practices across the industry • Assess the feasibility of publishing the best-practices as GM or AMC • Facilitate discussions and initiatives among CAAs to establish common standards and harmonized guidelines **Operators:** • Adopt and implement the best-practices in their processes and day-to-day operations	• Operating conditions data sources used for fuel planning and management • Tools and methodologies to analyse operating conditions data • Collaboration tools and communication protocols for coordination among pilot, dispatch, and fuel teams during different phases of flights • Data capture and storage mechanisms for post-flight analysis

Use Case 4.3 Using operating conditions data to support performance-based fuel schemes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
		• Collaborate with industry bodies and regulatory authorities in the development and refinement of best-practices	
Solution package - Regulatory initiatives (Guidance Material or Acceptable Means of Compliance)			
UC4.3-PS.2 - Regulatory initiatives for the collection, validation, and communication of operating conditions data	• **UC4.3-SOL.1** - Development of GM/AMC for the definition of minimum set of operating conditions data sources • **UC4.3-SOL.3** - Development of GM/AMC for the definition of minimum requirements for operating conditions data sources • **UC4.3-SOL.4** - Development of GM/AMC accounting for specificities in regard with validation of operating conditions data • **UC4.2-SOL.5** - Development of GM/AMC for the integration of operating conditions data • **UC4.3-SOL.7** - Development of GM/AMC for the definition of communication channels / OCCs to share operating conditions data seamlessly	**Regulatory authorities:** • Develop and implement the regulatory initiatives (potentially based on published industry best-practices) for the definition of minimum set of operating conditions data sources, their minimum requirements, and validation methodologies • Ensure compliance with regulatory standards • Evaluate and assess data collection processes and data quality regularly to maintain standards **Operators:** • Implement GM/AMC • Collaborate with regulatory authorities in the development and refinement of GM/AMC • Establish communication protocols for seamless sharing of operating conditions data as per GM/AMC • Ensure that authorized personnel have access to operating conditions data • Train their personnel in the application of GM/AMC **Providers:** • Ensure that their solutions follow GM/AMC criteria for evaluating data quality and reliability	• Operating conditions data sources used for fuel planning and management • Tools and methodologies for data collection, validation, and quality assurance • Tools and technologies for real-time or near-real-time data sharing
Solution package - Innovation & Technology			
UC4.3-PS.3 - Support the adoption of digital tools and capabilities for the exploitation of operating conditions data	• **UC4.3-SOL.2** - Promote the implementation of systems that consolidate operating conditions data from various sources into a centralized platform	**Airports:** • Support the implementation of systems that consolidate and report operating conditions data to the centralized platform • Ensure data accuracy and timeliness for the benefit of operators	• Operating conditions data sources used for fuel planning and management • Details on current training programmes for personnel involved in fuel scheme approval and auditing

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Use Case 4.3 Using operating conditions data to support performance-based fuel schemes			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
	• **UC4.1-SOL.9 -** Support the definition of specific trainings for the enhancement of analytical capabilities	• Collaborate with airlines and aviation authorities to establish standardised data formats and reporting procedures • Contribute to real-time updates on operating conditions at their respective airports **Regulatory authorities:** • Oversee the adherence to standardised data formats and reporting procedures • Establish regulatory frameworks that encourage the adoption of digital tools for operating conditions data • Support specialised training programs for enhancing analytical capabilities within CAAs. **Operators:** • Use the centralised platform to access and report up-to-date information on operating conditions	

4.4 Impact assessment of proposed solution packages

Finally, an impact assessment has been conducted taking as an input the different solution packages established in the previous section, which encompass the different solutions defined with the aim of addressing the identified limitations. Traditional impacts such as economic, social, environmental and proportionality impacts will be assessed but most importantly the impact on aviation safety will be assessed as it is an essential criterion for determining the suitability of the solution packages. In the following subsections, solution packages will notably be assessed in relation to the capacity to address the identified limitations and challenges. The different impact categories that have been used, together with the criteria that have been followed, are presented in the following table:

Table 4-11 Categories and criteria used for the impact assessment

Category	Scores categories and associated criteria		
Safety	Highly positive impact	+3	• Improvements in pilot situational awareness, decision-making, and response to critical situations during operations • Substantial reduction in safety incidents, errors, and accidents attributed to enhanced capabilities in fuel management
	Low positive impact	+1	• Moderate enhancements in fuel management, leading to increased situational awareness and improved decision-making capabilities during operational activities • Some reduction in safety incidents and errors, indicating a positive trend in safety performance
	No impact	+0	• No observable changes in terms of fuel management and safety performance, suggesting a lack of significant improvements or advancements resulting from the implementation of the solutions • There is no contribution to the reduction of incidents, accidents or risks
	Low negative impact	-1	• Minor disruptions in fuel management and performance without significant implications for overall safety standards • Marginal growth in safety accidents, incidents or errors stemming from transitional issues associated with the solutions' integration
	Highly negative impact	-3	• Notable decline in fuel management capabilities and safety performance during operational activities • Substantial increase in safety incidents, errors, or accidents
Environmental	Highly positive impact	+3	• Highly promoting sustainable aviation practices and reducing the industry's environmental impact • Implementation of advanced technologies and methodologies that minimise the overall environmental footprint • Substantial reduction in fuel consumption and carbon emissions, demonstrating a strong commitment to environmental sustainability and eco-friendly practices
	Low positive impact	+1	• Efforts to integrate environmentally responsible practices and its potential to further enhance sustainability measures within the aviation industry • Adoption of eco-friendly initiatives and technologies that contribute to a more efficient use of resources and a reduced carbon footprint • Moderate decrease in resource consumption and emissions, indicating a gradual shift toward more sustainable practices and reduced environmental impact within the aviation industry
	No impact	+0	• No observable changes in resource utilisation and environmental practices, suggesting a lack of significant advancements or developments • Stable environmental practices with no alterations in resource consumption or environmental impact

Category	Scores categories and associated criteria		
			• No evidence on promoting sustainable aviation practices and reducing the industry's environmental impact
	Low negative impact	-1	• Minor challenges or inefficiencies in resource management and eco-friendly practices, leading to temporary environmental implications that can be addressed through targeted improvements and adjustments • Marginal increase in the program's environmental footprint attributed to transitional issues associated with solutions implementation
	Highly negative impact	-3	• Noticeable escalation in resource consumption and environmental impact • Clear increase in carbon emissions and environmental footprint
Social	**Highly positive impact**	+3	• Enhanced pilot well-being and job satisfaction, leading to a positive work culture • High increase of pilots confidence • Significant reduction of the workload of the different involved staff (e.g., fuel department) • Promotion of diversity, inclusivity, and equal opportunities
	Low positive impact	+1	• Moderate improvements in pilot engagement and satisfaction • Moderate increase of pilots confidence • Slight reduction of the workload of the different involved staff (e.g., fuel department) • Initial steps toward promoting diversity, inclusivity and supportive environment
	No impact	+0	• No observable changes in pilot well-being and job satisfaction • No change on the confidence of pilots • No reduction of the workload of the different involved staff
	Low negative impact	-1	• Slight disruptions among stakeholders due to the introduced changes, leading to temporary challenges • Slight increase of the workload of the related staff
	Highly negative impact	-3	• Noticeable strain or dissatisfaction among pilots, indicating a decline in job satisfaction due to significant shortcomings or inadequacies in the implementation of the solutions • Notable decline in staff's well-being and engagement • Highly increased workload of the different involved staff (e.g., fuel department)
Economic	**Highly positive impact**	+3	• Substantial cost savings and improved cost-efficiency resulting from the implementation of streamlined fuel management methodologies and technologies, and optimised resource utilisation within the EBT program • Reduction of fuel-related costs
	Low positive impact	+1	• Moderate reductions in fuel-related expenditures and operational costs • Slightly increased effectiveness of resource utilisation
	No impact	+0	• No observable changes in fuel-related expenditures and financial practices • No variation on the resource allocation capabilities and flexibility
	Low negative impact	-1	• Minor inefficiencies or temporary financial constraints associated with the transitional phase of implementing the solutions, without significant long-term implications

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Category	Scores categories and associated criteria		
			• Marginal increase in fuel-related costs
	Highly negative impact	-3	• Significant escalation in fuel expenditures and operational costs • Marked increase in budgetary constraints and financial challenges • Clear constraints with regard to efficiency and flexibility of resource allocation
Proportionality	Highly positive impact	+3	• Implementation of fuel management practices and solutions that are scalable and adaptable to the diverse needs and operational capacities of both large and small operators, fostering a level playing field • Equitable access to fuel management related resources and methodologies • Contribution to promoting a balanced and proportionate approach to fuel management across the aviation industry, irrespective of the scale or scope of operations
	Low positive impact	+1	• Efforts to provide tailored fuel management related solutions that address the different needs and resources of both large and small operators • Support mechanisms that enable both large and small operators to participate in fuel management related initiatives and leverage relevant resources based on their specific operational requirements • Efforts to bridge the gap between large and small operators, facilitating a more balanced and inclusive environment within the aviation industry
	No impact	+0	• No observable changes in the accessibility and applicability of fuel management specific practices for large and small operators • No changes in the overall opportunities available to large and small operators
	Low negative impact	-1	• Minor discrepancies or challenges in providing tailored fuel management related solutions for large and small operators, leading to temporary disparities in access to the resources and opportunities • Slight inconsistencies or operational constraints that affect the proportionate participation of large and small operators in fuel related initiatives
	Highly negative impact	-3	• Significant differences and imbalances in the accessibility and implementation of fuel management related practices between large and small operators • Major inequalities or operational constraints that limit the participation and benefits of small operators compared to larger operators.

By applying the criteria presented in the table above, and the solution packages established in the context of Use Case 4.1, the impact of each package is determined according to the different impact categories used. An additional dimension named "Maturity Level" is also considered and helps to define the current context. All of these are presented in the following table:

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Table 4-12 Impact Assessment of proposed solution packages for Use Case 4.1

<table>
<tr><th colspan="8">Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes</th></tr>
<tr><td rowspan="3">UC4.1-PS.1 - Development of industry best-practices for fuel-related data validation and integration</td><td rowspan="3">Benefits and constraints</td><th>Safety</th><th>Environmental</th><th>Social</th><th>Economic</th><th>Proportionality</th><th>Total</th></tr>
<tr><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+5</td></tr>
<tr><td colspan="6"> Justification: Solution packages UC4.1-PS.1, UC4.1-PS.3, and UC4.1-PS.5 collectively focus on improving the quality and validation of fuel-related data. While they don't directly impact safety, they play a crucial role in enhancing data quality. When data discrepancies are minimised thorough validation, operators can rely on consistent data, reducing the potential for errors in fuel planning and analysis due to data-related issues. This indirectly contributes to aviation safety by giving operators a clearer understanding of their safety level in fuel-related aspects. Additionally, these solutions aim to include fuel scheme-specific requirements, such as lists of relevant fuel-related parameters to be collected for each fuel scheme. Defining specific relevant fuel parameters ensures accurate data collection, reducing the risk of critical information gaps. This fuel-scheme specific approach minimises the potential for errors in data collection, indirectly enhancing safety analysis.
Also, the increased quality of data resulting from these solutions has a ripple effect on safety. It allows for more effective post-operations analysis of fuel consumption and fuel performance, enabling operators to identify trends and areas for improvement. This, in turn, contributes to long-term safety enhancements by facilitating data-driven decision-making and continuous safety refinement.
As previously introduced, Solution packages UC4.1-PS.1, UC4.1-PS.3 and UC4.1-PS.5 collectively centre on the improvement of fuel-related data quality, validation, and compatibility. While their primary objectives are data-centric, they have an indirect positive impact on the environment. These Solution packages are aimed at ensuring the consistency and reliability of fuel-related data, which minimises the risk of using incorrect information for fuel consumption and environmental analyses. Accurate data is indispensable for precisely assessing fuel consumption performance and to effectively identify opportunities for fuel savings and emission reductions, contributing to broader sustainability goals.
Additionally, UC4.1-PS.1 aims to establish guidelines for data compatibility and integration for fuel-related data. These guidelines streamline the holistic analysis of fuel consumption across various sources, making it easier to identify opportunities for fuel efficiency. When data from diverse sources can be integrated consistently, operators gain a comprehensive view of their fuel consumption, enabling them to make data-driven decisions that reduce their environmental footprint.
In terms of potential social impact, the solutions included in packages UC4.1-PS.1, UC4.1-PS.3 and UC4.1-PS.5 can lead to a positive impact through increased pilots' confidence. Improved data quality and validation may result in pilots having more confidence in the analyses performed and the estimates provided to them. In addition, it fosters the facilitation of data-driven decision-making. In addition, they could also load to reducing the staff workload' through streamlined validation processes.
Considering the economic aspect, the solutions included in UC4.1-PS.1 and UC4.1-PS.3 reduce the time and resources required by operators for the definition of data collection and validation procedures, resulting in cost savings. If operators adopt the new methodologies, it allows them to address data quality of fuel-related </td></tr>
</table>

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<table>
<tr><td rowspan="2"></td><td></td><td colspan="6">parameters, which can reduce the potential economic consequences of decision-making based on erroneous data, such as inaccuracies in fuel planning leading to suboptimal routes or increased fuel costs.

On the other hand, the implementation of these Solution packages not only benefits operators but also CAAs. CAAs would benefit from these solutions as they would face less effort and resource requirements in the approval and auditing of fuel-related data processes. The establishment of standardized guidelines would enable CAAs to streamline their approval procedures, resulting in cost and time savings.

Finally, these solutions are likely to have a significant impact in terms of proportionality within the aviation sector. By focusing on the development of industry best-practices, these initiatives aim to establish standardised protocols and guidelines for data formatting, parameter selection, validation procedures, and data integration across the industry. This standardisation promotes a balanced approach to data management, ensuring that all operators, regardless of size or resources, can adhere to uniform standards and practices.</td></tr>
<tr><td>Maturity level</td><td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices</td></tr>
<tr><td rowspan="3">UC4.1-PS.2 - Development of industry best-practices for fuel consumption estimation models</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+5</td></tr>
<tr><td colspan="6">Justification: Regarding UC4.1-PS.2 and UC4.1-PS.4, these solutions indirectly promote aviation safety by addressing various aspects related to fuel consumption estimation and predictive models. Firstly, they define what constitutes statistically relevant data, considering factors like representativeness, completeness, and timeliness. This sets a standard for data quality, ensuring that analyses and decisions are based on accurate and representative information. This, in turn, leads to more accurate fuel planning, reducing the likelihood of fuel-related safety incidents.

Moreover, these solutions deal with the generalisation and validation of models. On one hand, they establish clear limits for model generalisation across different aircraft and operational contexts, preventing inappropriate or unsafe model applications. On the other hand, they promote the rigorous validation of models, boosting operator confidence in model results. This confidence leads to safer decision-making in fuel consumption planning and management. Furthermore, UC4.1-PS.2 and UC4.1-PS.4 aim to define model deployment frameworks to ensure a gradual and safe introduction of models into operations. This progressive deployment allows operators to validate model results through real operations without immediately applying fuel reductions, ensuring the maintenance of safety levels established as a baseline.

In addition, UC4.1-PS.2 encourages data sharing among operators, indirectly contributing to safety. Collaborative data sharing enables operators to collectively enhance their understanding of fuel-related data and to share insights and data trends, allowing operators to identify potential safety improvements.

UC4.1-PS.2 and UC4.1-PS.4 also have a positive and indirect impact on the environment through their focus on fuel consumption estimation models and predictive analytics (e.g., generalisation of statistical models, model validation frameworks, etc.). These Solution packages advocate for the establishment of trustworthy fuel</td></tr>
</table>

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		consumption estimation models, which allows operators to increase their potential to optimise and ultimately reduce fuel consumption, resulting in tangible reductions in their CO2 emissions. Furthermore, both Solution packages encourage operators to share fuel-related data, which allows for the collective analysis of fuel consumption patterns, leading to more informed decisions regarding fuel efficiency. By sharing insights and best practices, operators can identify opportunities to optimise fuel consumption and reduce emissions collectively. Similarly, encouraging rigorous validation of models to ensure the quality and representativeness of the data can also have a positive impact in the **social** domain. The confidence in the models by the operators themselves would increase considerably, but pilots would also gain confidence and feel more comfortable with the inputs received regarding fuel planning and fuel consumption management, and decision making in this respect would be significantly enhanced. On the **economic** field**, UC4.1-PS.2 and UC4.1-PS.4** define standardised statistical models, which may reduce the time and resources required by operators for the definition of such models, resulting in cost savings. Additionally, it also results in less effort and resources needed by civil aviation authorities in the approval and auditing of fuel-related models, as guidelines are already defined and can be used as “step-by-step” approval processes. However, it's important to acknowledge that developing these guidelines, standards, and best practices, as well as organising working groups and regulatory initiatives, entails setup costs for regulatory bodies (e.g., development and dissemination of guidelines, conducting industry consultations, etc.). Finally, it's worth noting that the implementation of these solutions might face resistance from industry stakeholders when adopting new procedures. Addressing this resistance may require additional resources, including investments in communication strategies to ensure operators' crews have confidence in the new fuel consumption estimation models. Additionally, training on analytical capabilities may be necessary for dispatch and fuel teams to effectively implement these new standards, adding to the overall economic considerations. In conclusion, while these Solution packages offer substantial benefits in terms of cost savings and efficiency improvements for operators, they also involve setup costs and may require additional investments. However, the long-term economic advantages (e.g., improved data quality, streamlined regulatory processes, etc.) could potentially outweigh the initial investments. Finally, these solutions are poised to have a significant impact in terms of **proportionality** within the aviation sector. By advocating for the development of industry best-practices, these initiatives aim to establish standardised protocols and guidelines for data sharing, statistical modelling, fuel-reduction models, and model deployment among operators. This standardisation promotes a balanced and equitable approach to data collaboration and model generalisation, ensuring that all operators can effectively utilise these tools regardless of their size or resources.
	Maturity level	**LOW:** This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices.

		Safety	Environmental	Social	Economic	Proportionality	Total
UC4.1-PS.3 - Regulatory initiatives for fuel-related data		+1	+1	+1	+1	+1	+5

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Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes

collection and validation	**Benefits and constraints**	**Justification:** As explained in the Package Solution **UC4.1-PS.1**, same benefits in terms of **safety** should be expected for **UC4.1-PS.1, UC4.1-PS.3 and UC4.1-PS.5.** But it is worth noting that **UC4.1-PS.3** and **UC4.1-PS.5** can have a more significant impact on safety than **UC4.1-PS.1** because they address more mature topics and can be more easily integrated into regulations as Guidance Material or Acceptable Means of Compliance. Consequently, these solutions can accelerate the implementation of guidelines into daily operations, leading to faster safety improvements in aviation. Regarding the **environmental** and the **social** impacts, again, what has been explained in the Package Solution **UC4.1-PS.1** applies**.** And similarly for the **economic** impact**,** the explanation provided in the **UC4.1-PS.2** also applies. In addition to these explained benefits, **UC4.1-PS.3** goes further by setting minimum requirements and selection criteria for fuel-related data sources. This would allow operators to make more informed decisions regarding their investments in data sources. Operators can allocate their resources to data sources that align precisely with their specific needs. This approach potentially reduces unnecessary spending on redundant or less valuable data sources. UC4.1-PS.3 also aims to align FDM regulatory requirements with fuel scheme parameters. This synchronization would allow operators to make full use of FDM data for fuel planning and management. Consequently, operators could significantly reduce their efforts related to decoding and analysing data from multiple sources (e.g., ACARS and FDM), streamlining their processes and achieving cost savings. And lastly, the initiatives outlined are expected to significantly impact **proportionality**. By focusing on the development of guidance material and acceptable means of compliance, these initiatives seek to establish minimum requirements, selection criteria, and governance frameworks for fuel-related data sources and validation standards. This approach ensures that all operators, regardless of their size or resources, can adhere to uniform and standardized guidelines and practices, facilitating a more balanced and equitable playing field.
	Maturity level	**Medium:** This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations.
UC4.1-PS.4 - Regulatory initiatives for fuel consumption estimation models	**Benefits and constraints**	See scores and justification below.

UC4.1-PS.4 – Benefits and constraints:

Safety	Environmental	Social	Economic	Proportionality	Total
+1	+1	+1	+1	+1	**+5**

Justification: In terms of **safety** impact, what has been explained in the **UC4.1-PS.2** applies but considering that **UC4.1-PS.4** can have a faster impact on safety than **UC4.1-PS.2** because it addresses more mature topics and can be more easily introduced into regulation as Guidance Material or Acceptable Means of Compliance.

As happens with the safety impact, regarding the **environmental,** the **social** and the **economic** impact what has been explained in the Package Solution **UC4.1-PS.2** applies**.**

The proposed solutions are expected to bring about a substantial impact on **proportionality** within the aviation industry. By focusing on the development of guidance material and acceptable means of compliance, these initiatives seek to establish frameworks, criteria, and transparency requirements for statistical

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<table>
<tr><th colspan="8">Use Case 4.1 Leveraging aircraft-specific fuel data for fuel performance-based schemes</th></tr>
<tr><td></td><td></td><td colspan="6">models, data relevance, and algorithm details. Thus, promoting a fair and equitable approach to data analysis and model implementation, ensuring that all operators can access and use these tools efficiently and effectively.</td></tr>
<tr><td></td><td>Maturity level</td><td colspan="6">Medium: This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations</td></tr>
<tr><td rowspan="4">UC4.1-PS.5 - Support the adoption of digital tools and capabilities for fuel-related data collection and analysis</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+1</td><td>+1</td><td>+1</td><td>0</td><td>+1</td><td>+4</td></tr>
<tr><td colspan="6">Justification: As explained in the Package Solution UC4.1-PS.1, same benefits in terms of safety should be expected for UC4.1-PS.1, UC4.1-PS.3 and UC4.1-PS.5. But it is worth noting that UC4.1-PS.3 and UC4.1-PS.5 can have a more significant impact on safety than UC4.1-PS.1 because they address more mature topics and can be more easily integrated into regulations as Guidance Material or Acceptable Means of Compliance. Consequently, these solutions can accelerate the implementation of guidelines into daily operations, leading to faster safety improvements in aviation.

Regarding the environmental and the social impacts, again, what has been explained in the Package Solution UC4.1-PS.1 applies.

The outlined initiatives are set to contribute significantly to proportionality within the aviation industry. By focusing on supporting the adoption of IoT devices, enhancing analytical and IT capabilities through specific training, and facilitating collaboration and coordination between authorities, these measures aim to ensure that all industry stakeholders can benefit from technological advancements and expertise equally.</td></tr>
<tr><td>Maturity level</td><td colspan="6">Low: This package includes a range of solutions, including the development of best-practices on topics that currently lack maturity and comprehensive industry-wide guidance, and the definition of specific training in the area of analytical and IT capabilities. Therefore they are not in an advanced stage of maturity yet.</td></tr>
</table>

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Likewise, the potential impact of the solution packages established in the context of Use Case 4.2 is assessed:

Table 4-13 Impact Assessment of proposed solution packages for Use Case 4.2

<table>
<tr><th colspan="8">Use Case 4.2 Characterising the safety performance indicators for fuel schemes</th></tr>
<tr><td rowspan="3">UC4.2-PS.1 - Development of industry best-practices for the definition and monitoring of SPIs framework</td><td rowspan="3">Benefits and constraints</td><th>Safety</th><th>Environmental</th><th>Social</th><th>Economic</th><th>Proportionality</th><th>Total</th></tr>
<tr><td>+3</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+7</td></tr>
<tr><td colspan="6">Justification: UC4.2-PS.1 and UC4.2-PS.2 both focus on the definition of Safety Performance Indicators related to fuel planning and management. They provide clarity regarding which indicators and events should be proactively analysed for safety, particularly in the context of fuel planning and management. This clarity enhances proactive safety management by enabling the early identification and mitigation of safety issues before they escalate into critical events. Moreover, these solutions aim to encourage operators to adapt the SPI to the complexity of their operational context and the extent of deviations from the fuel scheme, allowing for a much more accurate and case-specific safety level analysis. By precisely defining relevant SPIs that are suitable for operators, these solutions empower operators to effectively track trends, deviations, and potential safety risks linked to fuel.

Another direct impact in safety of UC4.2-PS.1 and UC4.2-PS.2 arises from the definition of comprehensive methodologies for the monitoring of fuel-related safety parameters and events. The implementation of these solutions promotes the assessment of long-term performance and stability of fuel reductions, which allows operators to proactively detect potential safety deviations and implement timely corrective actions. Monitoring empowers operators to stay ahead of safety issues, preventing incidents or deviations related to fuel performance and, most importantly, allows detecting when the level of safety drops compared to the established safety baseline performance. In this regard, these solutions enable operators to carefully compare safety performance before and after the application of performance-based fuel schemes, ensuring that safety levels are maintained or improved. This proactive approach is especially vital in ensuring that safety remains a top priority in fuel-related initiatives.

As previously explained, UC4.2-PS.1 and UC4.2-PS.2 revolve around the definition and monitoring of safety performance indicators, primarily emphasising proactive monitoring and assessment of fuel-related safety performance. While their primary aim is to enhance safety, these SPIs can indirectly contribute to environmental sustainability. By defining SPIs that centre on the proactive monitoring of fuel-related safety performance, operators gain the capability to track trends, deviations, and potential safety risks associated with fuel management. This proactive approach is key in identifying and addressing repetitive operations or flight phases that may result in overburn situations, where excessive fuel is consumed. Additionally, by identifying potential safety risks associated with fuel management in advance, operators not only enhance safety but also indirectly contribute to environmental sustainability by preventing incidents that could result in additional fuel burn and emissions.

The solutions outlined in UC4.2-PS.1 and UC4.2-PS.2 also offer significant benefits in the social domain, mainly for the related staff and pilots' well-being. By establishing clear definitions of Safety Performance Indicators (SPIs) and facilitating proactive safety management, these solutions foster confidence and job</td></tr>
</table>

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<table>
<tr><th colspan="8">Use Case 4.2 Characterising the safety performance indicators for fuel schemes</th></tr>
<tr><td rowspan="2"></td><td></td><td colspan="6">satisfaction among staff and pilots, promoting a supportive and secure work environment and potentially reducing stress and workload. In addition, they empower staff and pilots with the necessary tools for proactive decision-making and risk management.

The approach of the solutions contained in UC4.2-PS.1 enhances the likelihood of early and timely identification of fuel-related safety risks, which, in turn, significantly reduces the potential economic consequences of incidents or accidents. Another economic advantage resulting from UC4.2-PS.1 is the standardised reporting format. It simplifies the reporting process for safety indicators and events, reducing the time and resources required for reporting.

And finally, the initiatives mentioned play a vital role in ensuring proportionality within the aviation sector, specifically in the context of safety management and fuel-related safety trends. By focusing on the development of industry best-practices for the definition and differentiation of safety indicators and events, safety frameworks, and expanded lists of SPIs, these initiatives aim to establish clear and consistent safety standards that apply to all operators, regardless of their scale or operational complexity.</td></tr>
<tr><td>Maturity level</td><td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices.</td></tr>
<tr><td rowspan="4">UC4.2-PS.2 - Regulatory initiatives for the definition and monitoring of safety performance</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+3</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+7</td></tr>
<tr><td colspan="6">Justification: In terms of safety, environmental and social impact, what has been explained in the UC4.2-PS.1 applies.

Regarding the economic dimension, UC4.2-PS.2 provides guidelines for establishing clear communication channels and protocols between different departments within an organisation. By streamlining communication, it enables quicker decision-making and more efficient problem resolution. This, in turn, allows faster decision-making and issues can be addressed promptly, reducing operational disruptions or delays in resolving safety-related concerns.

In terms of proportionality, the development of GM/AMCs for standardised lists of SPIs and the alignment of fuel initiatives with SMS ensure that safety measures are consistent across all operators, irrespective of their scale, resources or operational complexities. Furthermore, the emphasis on de-identification of fuel-related data and continuous reporting of fuel-related safety performance ensures a balanced approach to data privacy and safety transparency.</td></tr>
<tr><td>Maturity level</td><td colspan="6">Medium: This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations.</td></tr>
<tr><td rowspan="2">UC4.2-PS.3 - Support the adoption of digital tools and</td><td rowspan="2"></td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+3</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+7</td></tr>
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Use Case 4.2 Characterising the safety performance indicators for fuel schemes		
capabilities for safety performance analysis	**Benefits and constraints**	**Justification: UC4.2-PS.3** focuses on data sharing among operators, regulatory authorities, industry associations, and safety organizations for the establishment of safety performance indicators. By fostering collaboration among aviation stakeholders, **UC4.2-PS.3** ensures a comprehensive and collective effort in defining SPIs. The collective input provides a broader spectrum of **safety** information accessible to operators and thus, a more comprehensive assessment of safety-related trends and issues linked to fuel management. By bringing together the expertise and data resources of multiple stakeholders, **UC4.2-PS.3** facilitates a holistic approach to safety in the context of fuel planning and management, ultimately enhancing the overall safety of aviation operations. While the primary aim of **UC4.2-PS.3** is to enhance safety monitoring and collaboration, these initiatives have a parallel positive impact on the **environment**, as participating in data sharing programs fosters collaboration among operators, enabling them to collectively identify opportunities to optimise fuel consumption and reduce emissions. This collaborative effort could also bring benefits on the **social** side, enhancing staff and pilots' well-being by fostering a supportive and cooperative work culture. The collective input from multiple stakeholders facilitates a broader safety assessment, providing staff and pilots with a more comprehensive understanding of safety-related trends and fuel management issues, and also increasing their confidence regarding safety. In terms of the **economic** impact, collaborative data programmes can lead to reduced costs for individual operators by pooling resources and expertise, as resources would otherwise be spent on collecting and analysing data independently. However, there are costs associated with **UC4.2-PS.3**, especially for EASA. These costs can include the creation and maintenance of digital tools and platforms necessary for effective data sharing and analysis. By promoting collaborative data programs, a positive impact in terms of **proportionality** could also be expected. That is because operators of varying sizes and capacities can participate and contribute to the establishment of SPIs, enabling a collective understanding of safety performance that is reflective of the industry. This approach promotes fairness and transparency, allowing all stakeholders to contribute to and benefit from the industry's safety initiatives.
	Maturity level	**LOW:** This package includes solutions that focus on the creation and promotion of collaborative data programmes, so they have not reached a notable level of maturity yet.

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And finally, following the same approach, the potential impact of the solution packages defined for Use Case 4.3 has also been assessed:

Table 4-14 Impact Assessment of proposed solution packages for Use Case 4.3

<table>
<tr><th colspan="8">Use Case 4.3 Using operating conditions data to support performance-based fuel schemes</th></tr>
<tr><td rowspan="3">UC4.3-PS.1 - Development of industry best-practices for the use and monitoring of operating conditions data</td><td rowspan="3">Benefits and constraints</td><th>Safety</th><th>Environmental</th><th>Social</th><th>Economic</th><th>Proportionality</th><th>Total</th></tr>
<tr><td>+3</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+7</td></tr>
<tr><td colspan="6">Justification: Similar to Solution packages related to fuel data collection and validation, UC4.3-PS.1 and UC4.3-PS.2 aim to improve data quality but focus on operating conditions data. While their primary goal is not to directly enhance safety, they play a critical role in ensuring operational safety in aviation. By enhancing the quality of operating conditions data, these solutions contribute to maintaining safety levels, as operating conditions data directly affect flight operations. Both UC4.3-PS.1 and UC4.3-PS.2 specifically address the validation of operating conditions data, which has an indirect but positive impact on aviation safety. Quality assurance measures and regular assessment of data collection processes guarantee that operating conditions data meet specified standards. This, in turn, enhances the safety of flight planning and operations by reducing the likelihood of relying on erroneous or outdated data.

Additionally, UC4.3-PS.1 and UC4.3-PS.2 also aim to define the necessary coordination and communication channels to share operating conditions data seamlessly. This improved coordination positively impacts aviation safety as it reduces the likelihood of miscommunication or data discrepancies during flight operations. In fact, effective coordination during flight planning, in-flight re-planning, and post-operations analysis ensures that all teams have access to accurate and up-to-date information and facilitates better decision-making, especially in scenarios where route changes, weather updates, or other factors affecting fuel consumption arise. Thus, both solution packages enhance the safety of flight operations, as they help operators to increase its capability to exercise adequate operational control and to ensure the exchange of relevant safety information between the operational control personnel and the flight crew.

Regarding the environmental dimension, some positive effects can also be expected. Solution packages UC4.3-PS.1 and UC4.3-PS.2 focus on the use of operating conditions data for improved accuracy in fuel estimation models and the effective monitoring and communication of such data. By promoting the use of various operating conditions data sources in the modelling, validation, and deployment of fuel performance models, both packages contribute to improved accuracy in these models and a better overview of the conditions under which flights are performed. This enables operators to effectively detect flight operations with favourable operating conditions and thus, to identify flights that can carry fewer fuel reserves without compromising safety, resulting in reduced unnecessary fuel consumption and emissions.

Furthermore, these packages also aim to improve communication and coordination between teams during flight operations. By establishing procedures for real-time data sharing and communication, operators gain operational control over flight operations. This proactive approach allows pilots to make better decisions during flight, such as adjusting routes based on weather updates. Ensuring that flights follow the most fuel-efficient paths not only enhances operational efficiency but also reduces emissions, as less fuel is consumed when flights are optimized for efficiency.</td></tr>
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<table>
<tr><td></td><td></td><td colspan="6">On the economic dimension, as they define specific methodologies and guidelines, the solutions in UC4.3-PS.1 and UC4.3-PS.2 reduce the time and resources required by operators for the definition of data collection and validation procedures, resulting in cost savings. Additionally, it also results in less effort and resources needed by civil aviation authorities in the approval and auditing of data-related processes, as guidelines are already defined and can be used as “step-by-step” approval processes. Additionally, the development of best practices/guidelines for operating conditions data analysis and validation can lead to more accurate fuel consumption estimations. This accuracy can result in cost savings for operators, as they are more aware of operational realities and therefore can either reduce the amount of fuel for a specific flight (when operating conditions are optimal) or increase the amount and increase the safety of the flight and therefore reduce the possibility of incidents. Also regarding the economic aspect, these solutions may require an initial investment in training and process adjustments.

On the social aspect, guidelines on coordination between departments can improve the efficiency of the analysis and monitoring of operating conditions data, allowing to reduce the workload on dispatch.

UC4.3-PS.1 and UC4.3-PS.2 solutions would have a positive impact on the social side, since they play a crucial role in ensuring staff and pilots' well-being within the aviation sector by enhancing the quality and coordination of operating conditions data. These solutions foster a safer operational environment, reducing the likelihood of errors and miscommunications during flight planning and operations. In addition, they enable improved and safer decision-making, empowering staff and pilots with the necessary tools for informed and efficient operational control, even with changing conditions, which ultimately positively influences their confidence and workload.

Finally, these solutions would also have a significant impact in terms of proportionality, since are intended to support both large and small operators in the use and monitoring of operating conditions data, regardless of the level of resources or experience.</td></tr>
<tr><td></td><td>Maturity level</td><td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices.</td></tr>
<tr><td rowspan="3">UC4.3-PS.2 - Regulatory initiatives for the collection, validation, and communication of operating conditions data</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+3</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+7</td></tr>
<tr><td colspan="6">Justification: In terms of safety impact, what has been explained in the UC4.3-PS.1 applies. Besides this, UC4.3-PS.2 also aims to define the minimum set of operating conditions data sources needed for each specific case, ensuring that operators have access to essential data sources required for specific fuel reduction applications. The definition of the minimum set of operating conditions data sources indirectly benefits safety, as it guarantees that crucial operating conditions data (e.g., fuel consumption data, anticipated masses, meteorological conditions, etc.) are consistently available and considered during fuel planning and management processes, contributing to safer flight planning and execution.

In addition, and as happens for the safety dimension, in the case of the impact in terms of the environmental and social dimension what has been explained in UC4.3-PS.1 applies.</td></tr>
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<tr>
<td></td>
<td></td>
<td>And the same in terms of the economic impact but adding that the definition of minimum set of operating conditions data sources helps operators invest in essential data sources for each specific fuel reduction application. This may enable cost savings, as operators focus resources on collecting and managing only the necessary data. However, achieving data standardization across OCCs may require investments in updating existing systems and technologies to ensure compliance with standardised data sharing protocols.

Additionally, the proposed solutions would also have a positive impact in terms of proportionality, since are intended to support both large and small operators in the collection, validation, and communication of operating conditions data, regardless of the level of resources or experience. In this way, the aim is to ensure that even operators with fewer resources have references and tools regarding the operating conditions data.</td>
</tr>
<tr>
<td></td>
<td>Maturity level</td>
<td>Medium: This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations.</td>
</tr>
<tr>
<td>UC4.3-PS.3 - Support the adoption of digital tools and capabilities for the exploitation of operating conditions data</td>
<td>Benefits and constraints</td>
<td>
<table>
<tr><th>Safety</th><th>Environmental</th><th>Social</th><th>Economic</th><th>Proportionality</th><th>Total</th></tr>
<tr><td>+3</td><td>+1</td><td>+1</td><td>+1</td><td>+1</td><td>+7</td></tr>
</table>
Justification: UC4.3-PS.3 aims to support the adoption of digital tools and capabilities for the exploitation of operating conditions data. It specifically promotes the implementation of systems that consolidate operating conditions data from various sources into a centralised platform. This consolidation streamlines access to data, enabling more informed decision-making during flight operations, specifically for pilots and dispatchers, that can access up-to-date data from a single source, reducing the potential for errors that can arise when relying on disparate data streams. This enhances flight safety, particularly during in-flight re-planning, where timely access to accurate data is crucial.

The Solution packages proposed in Use Case 4.3 promote the adoption of automated systems or procedures that identify deviations or anomalies in operating conditions data. This capability allows dispatch personnel to take timely actions to optimise fuel consumption during flight, leading to reduced emissions and a more environmentally responsible approach to flight operations.

Regarding the social dimension, these solutions would also have a positive impact. The single-source data accessibility minimises the potential for errors associated with disparate data streams, empowering pilots and dispatchers to make informed decisions swiftly and efficiently. The enhanced access to up-to-date data ensures a safer and more seamless in-flight re-planning process, reducing operational stress and promoting a supportive and efficient operational environment for staff and pilots.

On the economic side, the implementation of systems that consolidate operating conditions data from various sources into a centralised platform may require investment by airports but also reduces costs for operators (centralised databases with operating conditions data and less time acquiring such information).

The proposed solutions would also have a positive impact on proportionality. The promotion of centralised platforms for operating conditions data consolidation ensures that all operators, regardless of size and resources level, have access to comprehensive and centralised data management systems, levelling the playing field and allowing for efficient data access and analysis for all. Similarly, supporting the definition of specific trainings for analytical capabilities ensures that
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		operators, regardless of their scale, have access to the necessary skill development resources, promoting fairness and parity in skills development across the industry.
	Maturity level	**LOW:** This package includes a set of solutions to address the need for centralising operating conditions data from diverse sources and that additionally focus on facilitating specific training programs for improving analytical capabilities within the sector. In that case, these solutions are not on a mature stage yet.

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5. Development of Case Study 5: Flight data models for safety

Case Study 5 Flight data models for safety has been developed in a different context than the other two case studies. While flight data has been used for decades, with-mandatory usage for Flight Data Monitoring programmes in EASA Member States since 2008, developments in digital fuel management and EBT/CBTA are more recent and have had less penetration across the industry. Responding to this difference, this case study presents some particularities:

- It focuses on common organisational or otherwise process-related issues which reduce the efficiency and effectiveness of the whole industry and cannot be resolved by individual efforts, instead requiring industry-wide agreements. Some of these are generally not discussed publicly given their sensitive nature but have been covered here to ensure a comprehensive picture of the industry is made.
- It contains extended descriptions of the process activities, as the specificity of limitations and solutions requires a significant degree of contextualisation. These descriptions represent a generalised version of the actual processes followed, as there is a high level of variability in technologies and methods.

During the development of this Case Study 5, it was necessary to modify and adapt the structure proposed in deliverable D-1.2 Case Study Work Plan to the actual processes and activities performed by the different industry participants. The adjustment of the use cases is detailed in **Section 1.2** above. The description, limitations and solutions in this section are presented following the two use cases under this case study.

5.1 Use Case 5.1: Identification, decoding and processing of flight data for an FDM programme

The usage of flight data must be preceded by the collection, decoding and processing of such data. This process consists of a set of technical activities where technologies and data interact with one another to, in the end, produce a set of information, data points or knowledge that can be of use for either Flight Data Monitoring programmes, or other uses.

The process begins with the **collection of flight data**, which is generated by the many sensors and systems contained within the aircraft and compiled into a recording following a data encoding standard. This first step is a key enabler of all latter activities, with the technologies used and limitations faced having an impact over the whole process downstream.

Once collected, **flight data is transmitted from the aircraft to a computer server** controlled by the operator, or a software vendor contracted by the operator. The transmission itself depends on the technology used, ranging from a physical transmission of data from the aircraft recorder to a memory disk and from there to the computer server, to a wireless transmission through a satellite connection that directly connects to the server.

At this point, data remains encoded following the ARINC 717 standard (or 767 or 573), which stores the information in binary. To enable processing of the data by any system, **flight data is decoded into engineering values** (values that have either a physical meaning or can be traced to a system state). Decoding is a complex process requiring in-depth expertise, adequate tools, and sufficient resources, which limits the number of stakeholders that can develop and maintain this capability.

In order to enable the final usage of the data, **a set of FDM events and measurements must be implemented**. Decoded flight data is processed by splitting the data stream into flights and flight phases, fusing contextual data when required, and computing the FDM events. Such computations are key concepts in the current practice of FDM programmes and serve to detect safety occurrences where a set of flight parameters surpasses

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any combination of thresholds. The resulting events are the basic building blocks of the latter safety analysis of FDM programmes and Safety Risk Management processes.

Based on this comprehensive process description, the collection, decoding and processing of flight data can be divided into four (4) key activities, presented in Figure 5-1.

Figure 5-1 Process activity breakdown for Use Case 5.1

5.1.1 Working process activities and limitations

5.1.1.1 Collection of flight data within the aircraft

The process of collecting flight data is the initial step of any Flight Data Monitoring programme, where the main dataset of information is generated and recorded. It is a computer-automated process, continuously performed in parallel to the flight operation, such that at the end of the flight all selected information from the various sensors within the aircraft has been parsed, transformed, and recorded.

This activity is described through two of the possible analysis dimensions: Technology & Data, and Organisation. The Operations dimension is discarded, as the process is heavily automated and requires little to no human intervention once configured.

Technology & Data description

The technology supporting this activity is located within the aircraft and connected to the internal network, consisting of a combination of hardware and software solutions that govern the data recording and storage.

Hardware includes:

- The Flight Data Acquisition Unit (FDAU) or equivalent equipment that collects data from the internal aircraft network, converts it into compressed binary and sends it to a storage device.
- The Flight Data Recorder (FDR), that records the data received from the FDAU while the flight is being operated in case it is necessary for an accident investigation. Generally not used in day-to-day operations, given the difficulty to access it.
- The Quick Access Recorder (QAR) that, akin to the FDR, records the data received from the FDAU while the flight is being operated, but allows for an easier access and transmission afterwards.
- The Digital ACMS Recorder (DAR) also records data received form the FDAU and is easily transmitted, but, in contrast with the QAR, it allows for an operator-customised Data Frame Layout (see below).

Software includes all the programmes that are used to govern the aforementioned hardware. Of particular interest, given its relevance to all stakeholders of a FDM programme, is the Data Frame Layout.

The Data Frame Layout (DFL), also known as logical frame layout, data mapping, dataframe, etc. is a set of instructions used when collecting and decoding data, serving three main functions:

- It identifies which sensor parameters from the aircraft internal network must be recorded.
- It determines how the collected parameters are converted from engineering values into compressed binary by the FDAU, and back into engineering values by the FDM software.
- It dictates the position within the FDR/QAR/DAR memory where each parameter is recorded, and from where it can be retrieved.

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This set of instructions can themselves be separated into three different components according to their role in the different activities of this process:

- The DFL encoding file, an Operational Programme Configuration (OPC) file that is loaded onto the FDAU as the instructions to be followed to record flight data. It is the only component relevant for the flight data collection activity.
- The DFL documentation file, usually a text-based document that contains all relevant information on which parameters are captured, where are they positioned and how to convert them into engineering values (see section **5.1.1.3 Decoding flight data into engineering values**).
- The DFL decoding file, a computerized version of the DFL documentation file which is loaded onto the FDM software and instructs it on how to extract and transform data from the binary data stream recorded by the FDR/QAR/DAR (see section **5.1.1.3 Decoding flight data into engineering values**).

An aircraft may simultaneously have two (in some cases even three) different DFLs:

- The Standard DFL, used by the FDR and, in some cases, the QAR. All aircraft with an FDR will have its Standard DFL defined by the aircraft manufacturer and certified with the aircraft. It cannot be customised, as it is subject to a number of regulations over what parameters must be captured and with which resolution and frequency (see implementing rule **CAT.IDE.A**.190 from **EASA Air Operations**).
- Any customised DFL, which allows operators to access most of the data generated by the aircraft and higher flexibility when determining its performance (resolution and frequency). These are recorded by the DAR and, in some cases, are accessible to the QAR as well. Custom DFLs can be produced by the operator, the aircraft manufacturer or the equipment manufacturer, depending on the specific case.

Data consists on the flight data generated as continuous or discrete sensor information, which is captured by the FDAU from the aircraft network and, following the instructions from the DFL encoding file, converted into a compressed binary format, and recorded.

Data is compressed and recorded following the ARINC 717 standard (or ARINC 767 for more recent aircraft, ARINC 573 for older equipment). This standard defines a data framework consisting in 4-second “frames”, further broken down into 1-second “subframes”, and these into 12-bit “words”. The number of “words” available for any “frame” represents the recording capacity of the system, with older equipment being capable of only 64 “words-per-second (wps)”, reaching up to 1024 and 2048 words-per-second in current systems. Nonetheless, some aircraft/equipment manufacturers may define DFL’s with a variation of the aforementioned standards (e.g., capacity of up to 20,000 words-per-second).

The DFL specifies which bits and “words” store each of the compressed flight data parameters, which determines:

- The frequency of each parameter, as the number of words assigned to a parameter during the 4-second “frame” determines the number of data samples recorded.
- The resolution of each parameter, as the number of bits assigned to an individual value determines the number of significant digits recorded, and thus how precise the sample value is.

Organisation description

The organization of this activity results in a distribution of responsibilities and knowledge among multiple departments and teams at the operator, as well as with the aircraft or equipment manufacturer:

- The aircraft or equipment manufacturer is responsible for the definition of the DFL, the production of the DFL encoding file and the delivery of the DFL documentation to the operator. As the responsible entity, they hold in-depth knowledge on the DFL and are the ultimate reference point for an operator (or software vendor of an operator) if any issues arise with it.

- The maintenance department of the operator is responsible of ensuring the performance of the flight data collection activity through the monitoring of the health of the data network and all related equipment. Their knowledge is limited to the servicing of the equipment.
- The FDM team within the safety department of the operator (or any other designated data team) is responsible for the monitoring of the performance of the data collection process by checking that data is being collected within the expectations of completeness and quality. As the main interested party, this team may hold significant knowledge on the DFL used and the process followed for data collection.

5.1.1.1.1 Technology & Data

The following limitations have been identified for this activity within the Technology & Data dimension:

- **UC5.1-TEC.1 – Need to decode data before usage:** The ARINC 543, 717 and 767 standards are rooted on the structuring of data before being fed into the Flight Data Recorder. These standards, based on having defined frames of continuously recorded binary data, were defined for safety investigations, as optimal tools that record up to the last instants of a flight when there was very little recording capacity. This technical framework, however, is not optimal for other uses, as it requires data to be converted from engineering units to binary in the aircraft before being recorded, and to perform a decoding process outside the aircraft that transforms parameters back to engineering units in order to use it. This process is complex, expensive to set up, and does not provide any additional benefit to the end user beyond enabling the usage of the data (see section **5.1.1.3 Decoding flight data into engineering values**).
- **UC5.1-TEC.2 - Limited recording capacity in older equipment:** The demand for more flight data from operators has continuously grown during the last decades, as its utility has been demonstrated by both FDM and other processes (e.g., continuing airworthiness, fuel management, etc.). Such demand increase has been met through the usage of modern recorders and data acquisition units with better performance and higher capacity to process and record data (which now goes to 1024, 2048 and even more words-per-second). Still, not all aircraft are equipped with modern equipment, which results in fewer parameters recorded and with lower flight parameters performance (lower sampling rate, lower recording resolution).
- **UC5.1-TEC.3 - Need to use multiple DFLs:** As operators generally want to use their flight data in a uniform manner across their fleet, the expectations on parameters and their resolution/frequency are shared across different aircraft and fleets. Still, operators need multiple DFLs to capture equivalent parameters in different fleets, which increases the complexity and cost to obtain flight data (see limitation **UC5.1-ORG.7**). Three main causes exist:
    - Broadly across the industry, aircraft are fitted with different equipment (e.g., engines) and sensors. The variety of aircraft systems and of the data they output ultimately translate into different parameters.
    - Specifically for each aircraft family, manufacturers can update the FDR DFL every few months of years to add new parameters or improve their performance. Otherwise, they may introduce new DFLs for different aircraft variants within the same family.
    - Some operators may customise the DFL (by themselves through the DAR or by the supplier) so that the next operator of the concerned aircraft will have to deal with a customised DFL.

  Overall, there exists a significant lack of standardisation across the industry on how DFLs should be structured, and parameters named, defined, and distributed.
- **UC5.1-TEC.4 - Specific limitations for operators of smaller aircraft:** While only aeroplanes with a MCTOM of more than 27 000 kg are subject to a mandatory FDM programme, operators of smaller aircraft (MCTOM of less than 27 000 kg), may nevertheless decide to voluntarily establish FDM

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programmes to improve their operational safety or to exploit their flight data for other purposes. Given their situation, operators of smaller aircraft, and particularly those of business jets and turboprop aircraft types (see limitation **UC5.1-OPS.6**), face a number of unique limitations:

- **UC5.1-TEC.4A - No possibility to customise the DFL for operators of smaller aircraft:** Smaller aircraft are usually equipped with hardware that can only contain the standard DFL. As such, the operator cannot customise anything, and is restricted to the selection of parameters and parameter performance of the manufacturer. This restriction is very limiting for three main reasons:
  - Manufacturers of such smaller aircraft are usually less mature in the field of flight data exploitation, and the selection of parameters that they include in the standard DFL is insufficient for operators.
  - Manufacturers have no mechanisms to consult operators on their preferences before the standard DFL is certified, thus the operators cannot influence the selection.
  - Manufacturers are not keen on modifying the DFL and recertifying it, given the associated cost of doing so and the lack of capacity to absorb it given the low production numbers of such aircraft.
- **UC5.1-TEC.4B – No airborne equipment to support the FDM programme on smaller aircraft:** Equipment necessary to collect flight data is not as widely available as for bigger aircraft. This is the result of:
  - Given the low production numbers of small aircraft, the lack of a mandate to have an FDM programme, and the big diversity in aircraft types, it is not economically feasible for equipment manufacturers to certify their equipment (particularly QARs) for all of them. The combination of the need to cover certification costs and the lack of competition results in high prices for operators to acquire such equipment.
  - Some aircraft do not equip a QAR or equivalent equipment from factory, so that the operator must either perform a costly and difficult retrofitting (not viable for business jet operators) or use data from the FDR.
- **UC5.1-TEC.4C – Limitations when using the FDR data for FDM:** Usage of the FDR for data collection severally limits the performance and availability of flight data. In addition to the lack of control over the DFL previously mentioned, the recording duration of FDRs is very limited, given the cost of adding extra memory while complying with mandatory flight recorders specifications (such as crash testing conditions). And, as the FDR is a MMEL item, any manipulation of the equipment to read out the data must be performed by a certified engineer, which is expensive. The combination of costly retrievals and limited capacity can be an important disincentive to having an FDM programme, if forced to use FDR data.

- **UC5.1-TEC.5 - Lack of standardisation of flight parameters:** Within an FDM programme, flight parameters will be used for the computation of FDM events, measurements and flight phases. Such usage, however, faces limitations from the lack of standardisation of the flight parameters themselves, which can take two different forms:
  - **UC5.1-TEC.5A - Limitations from lack of parameter performance:** For many operators, the resolution and frequency of their parameters is insufficient for some FDM uses (e.g., low resolution for latitude and longitude prevents the accurate identification of the touchdown point during landing). Since many performance specifications are historically derived from those used in FDRs, they are not optimised for FDM. This issue is further compounded by some operator customisations to the DFL that do not fully address the need to maintain high resolution and frequency for key parameters (see limitation **UC5.1-ORG.4**).

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- **UC5.1-TEC.5B - Limitations from missing or inadequate parameters:** The selection of parameters available depends on the specific DFL and aircraft. Important parameters are sometimes not captured at all, requiring software vendors or operators to derive them from other data, or discarding the possibility of capturing particular events and safety risks. Alternatively, sub-optimal parameters may be used due to lack of specific knowledge on alternatives available in the DFL or on the characteristics of the aircraft capturing the data (e.g., which sensors capture more accurate data).

5.1.1.1.2 Organisation

The following limitations have been identified for this activity within the Organisation dimension:

- **UC5.1-ORG.1 - Limitations to the customisation of DFLs:** In order to enable the use of flight data for particular purposes (e.g., computing a specific FDM event), operators need to align the DFL with their needs, to customise it. Such customisation, however, is not easily done. The past prevalence of DARs across fleets has decreased as manufacturers have expanded the number of parameters captured by the FDR's Data Frame Layout and thus recorded in the QAR, which makes the choice of installing and maintaining a DAR less economically sensible[2]. Given this situation, operators who want to customise their DFLs nowadays need to both:
    - Engage with their aircraft or equipment manufacturer to modify the DFL encoding file and documentation. Given the complexity of the procedure and the need to install the software on the aircraft and validate its outputs, this service is generally slow and expensive. Additionally, manufacturers may not offer the service, or limit what can be customised. Not being able to customise what data is captured can be a blocking point to its usage.
    - Engage with their software vendor to modify the DFL decoding file (see section **5.1.1.3 Decoding flight data into engineering values** for more information).
- **UC5.1-ORG.2 - Limitations to increasing the recording capacity of DFLs**: As explained in limitation **UC5.1-TEC.2**, the volume of data per second that can be captured by an operator is dependent on both the equipment used and the pre-established capacity determined by the manufacturer. To increase their DFL capacity, the operator needs to engage with the manufacturer and request, when possible, an update of the DFL. As with the customisation of DFLs, this procedure is complex, slow, and expensive, and the manufacturer may not offer the service.
- **UC5.1-ORG.3 - Errors in DFLs for smaller aircraft**: Both the DFL and its documentation, produced by the manufacturer, must be correct in order serve the operator when trying to decode or use the data. While errors are infrequent and manufacturers are generally responsive to any request from the operator to address them, not all of them are. Related with limitation **UC5.1-TEC.4**, some manufacturers of smaller aeroplanes (MCTOM of less than 27 000 kg) and with less maturity on the exploitation of flight data may not respond to requests from operators to address such problems if the DFL has already been certified and the parameter affected is not mandatory. Such situations leave operators with undesired or faulty parameters that cannot be substituted.
- **UC5.1-ORG.4 - Lack of information for operator-requested DFL customisation:** The documentation that operators receive from the aircraft or equipment manufacturer contains the list of parameters that their current DFL includes, in addition to information on where they are located, how to transform them from binary to engineering values, etc. When requesting a customisation, however, an operator will need additional information on what flight parameters are available, how are they recorded, and

[2] While it may be argued that aircraft leasing could impact the usage of DARs due to the necessary customisation of the DFL, feedback gathered during stakeholder consultation process clearly stablished the capacity for operators to retrofit their leased aircraft with their own DFL.

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which are best for a particular purpose. For instance, the position of the aircraft (latitude/longitude) may be computed by multiple systems within the aircraft, and operators may need to decide among them which to record. Thus, lack of experience and knowledge of the operator on the aircraft systems, as well as the different levels of information provided by manufacturers, are a barrier to the customisation of the DFL.

- **UC5.1-ORG.5 - Modification of the DFL by the manufacturer:** The definition and modification of the FDR's Data Frame Layout is the responsibility of the aircraft/equipment manufacturer. While it is generally operators who request a modification of the DFL, manufacturers may decide by themselves to modify it to address any issues, improve its performance, standardise the definition, comply with new regulatory requirements, etc. While such occurrences were infrequent in the past, some manufacturers have started to actively modify the DFL and deliver this change as part of a software update. In cases where such DFL modifications result in a significant number of changes from the previous version of the DFL, the economic impact is significant on both operators and software vendors (see **UC5.1-OPS.5**).

5.1.1.2 Transmission of flight data to a computer server

Once flight data has been collected and stored within the aircraft, it can be transmitted to a computer server for ease of access and long-term storage. Like the flight data collection process, data transmission is a technology-heavy activity that can achieve a high degree of automation. Unlike it, there is an alternative method that requires human intervention. Finally, while data is usually transmitted when the aircraft is on the ground, some technologies allow for real-time transmission throughout the flight.

This activity is described through the three analysis dimensions of Technology & Data, Organisation and Operations.

Technology & Data description

The technology supporting this activity consists on hardware partially located within the aircraft, partially "on the ground", either at the operator or vendor premises. Additionally, usage of public internet infrastructure and communication protocols is generally required but will not be developed here given it is not relevant or specific to flight data transmission.

Hardware includes:

- The Quick Access Recorder (QAR) or equivalent equipment, where data has been previously stored. From the perspective of data transmission, two main types exist with different capabilities:
    - Wireless Quick Access Recorders (WQARs) consist of devices that, through a wireless connection (e.g. mobile broadband, Wi-Fi, satellite) can transfer data over the internet either on arrival to the airport gate at the end of the flight, or throughout the -flight (only satellite network WQARs).
    - Non-Wireless Quick Access Recorders (non-WQARs) consist of devices that can only transfer data through a direct cable connection to a computer device or through a physically removable storage medium (e.g. USB, PC card) once the aircraft has arrived to the airport gate at the end of the flight or to the operator's hangar or maintenance facility.
- In the case of non-WQARs, a removable storage medium (e.g., PCMCIA card) and/or the computer device is necessary to transmit data from the non-WQAR to the computer server.
- In the case of WQARs using Wi-Fi, a ground station or similar computer device may be necessary for transmitting data between the WQAR and the computer server.

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- The computer server where raw flight data transmitted from the aircraft is stored before decoding. This server may be controlled by the operator or by the FDM software vendor and may be procured either in-house or be cloud-based.

Data includes the stream of binary information transmitted from the aircraft to the software, which maintains the ARINC 543, 717 or 767 encoding. No changes are applied to the data itself during this activity.

Organisation description

The organization of this activity results in a distribution of responsibilities and knowledge among multiple departments and teams at the operator, including the aircraft/equipment manufacturer:

- The manufacturer is responsible for the delivery and set-up (directly or through a 3rd party) of the equipment used. Their knowledge is limited to the initial set-up and to the technical design and specifications of the equipment but does not generally cover its specific mode of operation by a particular operator.
- The maintenance department is responsible for the serviceability of the hardware housed within the aircraft (the QAR), and for the retrieval and upload of data in non-WQARs, a task performed by a certified technician. Their knowledge is limited to the servicing of the equipment and, in the case of non-WQARs, the part of the activity concerning the retrieval of the removable medium of storage, the extraction of the data and the upload to the computer server.
- The FDM team within the safety department of the operator (or any other designated data team) is responsible for the monitoring of the reliability and timeliness of the process, ensuring that flight data arrives to the designated computer server when expected. As the main interested party, the team is generally knowledgeable over the whole activity.
- The IT department is responsible for the setup and monitoring of the infrastructure that supports the reception of flight data, notwithstanding the source (directly from the WQAR, or indirectly through a computer device). Their knowledge is limited to the infrastructure they deploy, the part of the activity that develops over their systems, and, in the case of WQARs, the infrastructure used for transmission (given their technical expertise).

Operations description

The execution of this activity is dependent on the capabilities of the equipment used, as these condition the available level of automation. Two main modes of operation exist:

- **Wireless transmission**: Data transmission with most WQARs is a fully automated process, with the WQAR connecting to the available internet network and initiating data transmission by itself to the computer server of the operator. As the volume of data to be transmitted can be significant and is generally not time-critical, operators prefer to use lower-cost networks when available. Thus, the time of transfer and network used will depend on both the WQAR capabilities and the operator's decision:
    - For Wi-Fi enabled WQARs, data is transmitted at the end of the operation by either:
        - Connecting to a local network that the airport or operator may own and directly sending data to the computer server.
        - Connecting to an airborne modem (which may use a satellite network) and directly sending data to the computer server.
        - Generating itself a Wi-Fi source that can be accessed from a computer device (e.g., laptop, tablet) and from where data can be downloaded and sent to a computer server through a public interface. Unlike the other two, this mode of operation requires human intervention.

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- For mobile broadband network enabled WQARs, data is transmitted at the end of the operation when the WQAR automatically connects to the local mobile network and sends data directly to the operator's computer server. Given the charges associated with sending data over a mobile broadband network, an operator may prioritise Wi-Fi transmission when possible, or restrict connection within certain regions.
- For satellite enabled WQARs, data can either be transmitted real-time throughout the flight operation or at the end of the operation. Given the higher cost-factor involved with using satellite networks, operators may prefer to use the network for its real time capabilities in higher-risk operations (e.g., offshore), or at the end of the operation when no alternative internet network is available or is economical (e.g., remote locations, regions with very expensive roaming charges for mobile networks).

- **Physical transmission:** Operation of non-WQARs is not automated, requiring the physical interaction of a certified technician with the storage equipment to extract and transmit the data. While the transmission technology may vary (e.g., PC card, USB, Ethernet), it generally requires copying data into a removable storage medium and from there into a computer device, or directly from the non-WQAR into the computer device, to be finally uploaded into the computer server. Depending on the technology used, the copying step may be performed on board the aircraft or within the operator's premises (substituting the removable storage medium previously mounted in the aircraft with a new, clean one). From there, a public interface is required to upload/forward the data onto the operator's computer server. As this is a manual task requiring time, equipment and personnel, operators will usually schedule it every few days to minimize cost and impact on aircraft operation, while ensuring data is received in a timely fashion.

5.1.1.2.1 Technology & Data

The following limitations have been identified for this activity within the Technology & Data dimension:

- **UC5.1-TEC.6 - Cost of maintaining fleets with a mix of WQAR and non-WQAR:** The decision by an operator to equip WQARs or non-WQARs is generally based on a cost-benefit analysis, where the benefits of having a fully automated process are weighted against the additional costs of the equipment (generally higher in WQAR) and of transmitting the data (see section **5.1.1.2.3 Operations** for more detail), while taking into account the applicability of the Supplemental Type Certificate of the QAR to each aircraft. Some operators may decide to use a mixture of both systems to either avoid retrofitting older equipment with newer WQARs or while they transition their fleets from one technology to the other. Such mixtures, however, entail additional costs that are not present in fleets with common equipment. These result from the need to sustain multiple data pipelines to receive flight data from both WQAR and non-WQAR, increasing the cost and complexity of the IT infrastructure. In addition, servicing multiple types of equipment and maintain parallel processes is a source of inefficiencies.
- **UC5.1-TEC.7 - Risk of data loss when recovering data from non-WQARs:** The usage of a non-WQAR requires a removable memory medium that is used to transfer data between the airplane and a computer device that can be connected to the internet to upload the data into the computer server. Such an intermediary device, which usually consists of a PCMCIA card (also called PC card) introduces an additional link to the data storage chain, and with it, an increase to the risk of data corruption due to improper handling of the memory device or due to hardware malfunction.

5.1.1.2.2 Organisation

The following limitation has been identified for this activity within the Organisation dimension:

- **UC5.1-ORG.6 - Data loss or corruption due to lack of monitoring:** While the operator is responsible for the flight data transmission, the task itself is divided among different teams. Operators where the channels of communication are not properly established, or where the task ownership is not clear, can

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face issues of data loss or corruption, or issues with the transmission technology, due to inconsistent monitoring of the activity and lack of proper reporting (e.g., corruption of removable storage devices detected by the FDM team but not controlled by the maintenance department, lack of compatible internet networks in specific airports due to misunderstandings between the IT department and the FDM team, etc.).

5.1.1.2.3 Operations

The following limitations have been identified for this activity within the Operations dimension:

- **UC5.1-OPS.1 - Data loss due to transmission delays:** While FDRs are subject to stringent requirements on their capabilities, equipment manufacturers have more flexibility when designing QARs, including in the amount of memory that these incorporate. As such, newer models have benefitted from the decrease on unit costs that computer memory has enjoyed over the past years and incorporated the capacity to register hundreds or thousands of flight hours. Nonetheless, not all aircraft incorporate such new QARs, nor the memory capacity is limitless. If an operator faces delays in the transmission of data, the memory within the QAR can be filled, which results in new recordings overwriting older ones before the QAR data could be downloaded.
- **UC5.1-OPS.2 - Cost of and delays to data transmission from non-WQARs:** One key factor behind the development and usage of QARs is that they greatly facilitate access to flight data, while not impacting the serviceability of the FDR. While WQARs facilitate such access by not requiring the manual transmission of data, non-WQARs do so by being installed in an accessible position (generally within the avionics bay at the front of the aircraft instead of the back, where the FDR resides). As such, physical transmission of data from a non-WQAR can require personnel to access the avionics bay, which is an additional and sometimes lengthy task that must be performed by a certified technician or other authorised personnel. Depending on the operational network of the operator, their policies on timeliness of data retrieval, and their agreements with maintenance service providers, the cost of outsourcing the physical transmission of data can be significant. As an additional consequence, operators have an incentive to delay the retrieval of flight data, as the cost increases with the number of retrieval services performed.
- **UC5.1-OPS.3 - Cost of and delays to data transmission from WQARs:** The spread of wireless networks has revolutionized communications, allowing devices to connect, transmit and receive data seamlessly, remotely and instantly. In exchange for the services, network operators generally charge users on a volume basis, such that higher volumes of data are more expensive to transmit. Additionally, each network operator is generally free to charge according to their own cost structure and market conditions. The combination of both factors means that wireless transmission of data in some regions of the world can be very expensive, with operators responding by implementing restrictive policies on which data can be transmitted from where. Overall, this situation both increases the cost to use WQARs, and the delay in receiving data for FDM and other flight data-based programmes.

5.1.1.3 Decoding flight data into engineering values

Flight data previously collected and transmitted to the computer server for storage cannot be directly used for the analysis of safety performance and the production of safety intelligence. As explained in section **5.1.1.1 Collection of flight data**, collected flight data was converted, in accordance with the DFL, into a compressed binary format (usually referred to as “raw flight data”). Thus, following a decoding process, data must be converted back from the compressed binary format into engineering values (i.e., numerical values in the decimal system, properly scaled, signed and with the corresponding unit of measurement).

This activity is described through the three analysis dimensions of Technology & Data, Organisation and Operations.

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Technology & Data description

The technology supporting this activity is mainly software-based: the instructions present in the DFL decoding file, the FDM software performing the decoding, and the computer servers that provides the resources and the storage. Given that the hardware is a relatively generic equipment, not specific to a FDM programme or other flight data-based programmes, it is not be covered in detail.

Hardware includes the computer server from where the FDM software draws the computational resources to perform the decoding activity, and the computer server where raw flight data and decoded flight data is stored (operators may decide to split storage into multiple computer servers). These computer servers may be owned, operated and maintained by the operator (so called "in-house"), or may be acquired as a service from a specific provider (so called "cloud-based").

Software includes:

- The Data Frame Layout (DFL), which, for the purpose of this activity, includes:
    - The DFL documentation file, a text-based document that contains all relevant information necessary for a user to decode flight data from a particular data stream that has been produced with the matching DFL encoding file. This includes information on which parameters are captured, where they are positioned within the "frame" and "subframe", and which transformations must be applied to convert the binary data into engineering values.
    - The DFL decoding file, which represents an electronic version of the DFL documentation file directly interpretable by the FDM software. Many proprietary formats exist for the DFL decoding file, with open formats such as ARINC 647A FRED (Flight Recorder Electronic Documentation) currently presenting limited adoption.

  Alternatively, DFL documentation available in electronic form (e.g., XML file in FRED format) can be found in ARINC 767 data streams or can be provided by some manufacturers (e.g. Airbus' Flight Data Recording Parameter Library contains the basic manufacturer dataframe per aircraft type). Such electronic documentation contains the same information as the text-based document on parameters, positions and transformations, but in a format that is machine-readable (usually ARINC 647A FRED). In such cases, the DFL documentation file and the DFL decoding file can be the same, depending on the level of compatibility from the specific FDM software used with the particular format of the electronic DFL documentation.

- The FDM software, a specialized software package for flight data analysis that is generally commercially available from specialised software vendors through a license acquisition or access subscription. The main capabilities of such software in the context of this activity include:
    - Identification of the applicable DFL decoding file to each particular stream of flight data. This includes switching between specific versions of a DFL decoding file, if any customisation was performed and the DFL for a particular aircraft was modified.
    - Interpretation and execution of the instructions in the DFL decoding file.
    - Automated validation of decoded flight data, including detection of corrupted parameters and outlier values.
    - Enrichment of decoded flight parameters with additional information (e.g., timestamping of each parameter value, normalization of nomenclature, addition of units, etc.), converting it into a time series.
    - Management of the computational resources used to execute all tasks required.

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Data includes:

- Raw flight data collected by the aircraft, converted into compressed binary format and transmitted from the aircraft to a computer server. While most flight data is still encoded based on the ARINC 717 standard, flight data using the ARINC 767 standard is characterised by including the DFL documentation file in electronic form in the FRED format with the data stream transmitted from the aircraft. Raw flight data is usually stored long-term, in case the operator decides to switch to a new software package and older data is required for validation.
- Decoded flight data outputted by the FDM software in engineering units and time series format based on the information available within the data stream of raw flight data. Decoded flight data may be stored medium-term for ease of access and to avoid repeating the decoding step.

Organisation description

The organization of this activity results in a distribution of responsibilities and knowledge among the software vendor, the team responsible for decoding, and the IT department:

- The software vendor is responsible for the production and validation of a DFL decoding file compatible with their FDM software package, covering all parameters required to conduct the FDM programme. To do so it will require the DFL documentation for each aircraft, notifying any errors that it encounters within the documentation to ensure they are addressed by the manufacturer.
- The FDM team (or designated data team), as DFL manager, is responsible for maintaining and making available all DFL documentation and related files for all their aircraft, ensuring errors in the documentation are addressed by the manufacturer, and providing all necessary information when required to the software vendor tasked with the production of the DFL decoding file.
- The team responsible for the execution of the decoding activity is not as pre-determined as other roles. While the FDM team generally assumes a prominent position, the execution of the activity itself does not require safety-specific knowledge and, as it follows a relatively streamlined process, can be outsourced outside the FDM team. Three main models of organisation exist:
  - FDM team as key responsible: This model has the FDM team as the entity responsible for the execution of the decoding activity, including the operation of the FDM software and the validation of decoded flight data. The FDM team can develop different levels of knowledge on the activity, from simply understanding how to operate the FDM software to maintaining in-depth knowledge on how their DFLs are configured, allowing them to support their software vendor when producing the DFL decoding file.
  - Outsourcing to a different department: A variation of the previous model, it consists of a specific team (usually within the Data department) in charge of all data decoding and DFL management activities. Such outsourcing is useful to operators when usage of flight data is spread within their organization, as it avoids duplicating decoding efforts and helps organise and establish data governance activities (e.g., determine which parameters to record in capacity-constrained DFLs by balancing the needs from multiple teams).
  - Outsourcing to a service provider: In this model, the execution of the decoding activity is performed by a service provider contracted by the operator. The service provider receives raw flight data from the operator, decodes and validates it within their systems, and returns the decoded flight data. Many service providers are FDM software vendors themselves, thus offering the whole package (software & execution) as a Software-as-a-Service (SaaS) offering.
- The IT department is responsible for the setup and monitoring of the infrastructure that supports the storage of flight data and the execution of the FDM software. Their knowledge is limited to the infrastructure they deploy. The tasks performed by the IT department can also be outsourced to a

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service provider (usually the same software vendor of the FDM software), who may allow for the storage and decoding of flight data in their own computer servers as part of their SaaS offering.

Operations description

The decoding activity can be divided between the production of the DFL decoding file, an infrequent task that requires an important level of human intervention, and the decoding of data itself, a frequent task automated with the DFL decoding file. While the actual execution of the former will vary from case to case, the latter decoding of data follows a relatively standardised workflow.

The **production of the DFL decoding file** can be divided into the following steps:

- Documentation request and reception: The software vendor requests the DFL documentation file from the operator, who usually provides a text-based version. If not available, the operator can request it from the manufacturer. Provision of the document by the operator ensures some degree of protection against IPR claims for the software vendor.
- Decoding file matching: Given the potential commonality of DFLs, the software vendors start the production process by checking if they have previously produced a DFL decoding file that matches the needs of the operator. Software vendors generally compile libraries of DFL decoding files to save on production costs.
- Production of the decoding file: If the DFL is not present in the library, a decoding file is produced. Depending on the availability or not of electronic documentation, the process may consist of either transforming the electronic document into the necessary format compatible with the FDM software, or a labour-intensive process of data entry from the documentation into the vendor's DFL decoding file template, a manual digitalisation of the documentation.
- Validation: The resulting DFL decoding file, either found in the vendor's library or newly produced, must first be validated before it is released to the operator. The software vendor usually requests multiple snippets of raw flight data from the operator, decodes them using the new DFL decoding file, and ensures that all parameters are correctly transformed from binary to engineering units. The operator can be engaged in the validation process, particularly if it is transitioning between vendors and can compare old and new decoded data for the same flight.

The **decoding of flight data** consists of the following steps:

- Data selection and retrieval: With the FDM software launched, the specific data stream to be decoded is selected and retrieved from storage in the computer server.
- DFL selection: The DFL decoding file applicable to the data stream is selected. This may entail a manual selection by an operator, or a pre-selection based on any feature of the data (e.g., based on registration number of the aircraft from which the data originates).
- Decoding: Based on the instructions contained in the DFL decoding file, the FDM software identifies each parameter and applies a set of transformations to the data stream, converting it from a compressed binary format to a set of independent parameters in engineering units, named and timestamped (a time series). Both the identification and transformation have their own particularities:
    - The identification step consists of determining which subset of binary data represents each flight data parameter. This includes identifying the particular "words" for a frame, as well as the bits inside the "word" that correspond to the parameter. Two corner cases exist:
        - If a single value for a parameter is stored in bits corresponding to multiple "words", the DFL points to both and includes the order and method to combine them to form a single chain of binary values (through concatenation or overlap of bits).

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        - If a parameter is recorded less than once per second ("subframe"), the concerned bits or "word" may be reused for a different parameter, in which case the DFL identifies which "subframe" corresponds to which parameter.
    - The transformation to be applied will differ depending on the type of parameter and how it was compressed and stored in the first place. The main types of conversion include:
        - *Discrete*: Each bit or group of bits represents a specific "state" (e.g., the state of aircraft gear: 0->retracted or 1->deployed).
        - *Resolution/Slope*: Each group of bits represents a decimal number, which may be multiplied by a second value (the resolution) to convert it into the actual decimal value of the engineering unit (e.g., airspeed captured with a resolution of 0.5 is show in raw binary as 10010110, which converts to decimal 150, which is multiplied by 0.5 to represent 75 knots).
        - *Signed or Offset*: Each group of bits has a sign (positive or negative). In order to represent negative values, two strategies exist: either specify a bit to indicate the sign of the decimal number (e.g., 0->negative, 1->positive) or offset the decimal value by the negative operational limit (e.g., if the negative operational limit of vertical acceleration is -3, offset the decimal value by 3). Choosing one strategy over the other depends on which solution requires less bits.
- Validation: Each time series is validated to remove anomalies or corrupted data, and to check that the decoding has been correctly performed. It includes identifying and discarding corrupted data, identifying and removing outliers (e.g., jumps of 1000ft in altitude in 1 second), ensuring values are within operational limits (e.g., flap angle not exceeding limits) and that values and their variations are consistent between related flight parameters (e.g., the heading value increases when the roll angle value indicates a right turn).
- Return to storage: Once data has been decoded and validated, it is returned to the storage server, pending its latter retrieval by the event computation module of the FDM software.

5.1.1.3.1 Technology & Data

The following limitations have been identified for this activity within the Technology & Data dimension:

- **UC5.1-TEC.8 - Usage of proprietary formats in DFL decoding files:** Flight Data Monitoring software packages have existed for decades in different forms and by different providers. During this period, a multitude of different formats for the DFL decoding file have been produced by FDM software vendors, most of which cannot be accessed without proprietary tools only available to the format originator. Software vendors historically had 4 main reasons to define a proprietary format:
    - The fact that no open industry standard existed.
    - The technical requirement to produce DFL decoding files compatible with their software.
    - The commercial incentive to protect their investment in digitising the DFL documentation when producing the DFL decoding file.
    - The commercial incentive to dissuade operators from easily changing for another vendor by making such change very costly for the operator.

  These reasons notwithstanding, the usage of proprietary formats significantly hinders the capacity of operators and other software vendors to use these files for any purpose outside the purview of the original software vendor. These include:

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   - Most operators cannot decode flight data by themselves or share decoded flight data between software solutions, which prevents them from gaining efficiency through the centralisation of all decoding activities (see **UC5.1-ORG.7** for more detail).
   - Software vendors must produce a new DFL decoding file every time they incorporate a new operator with fleets for which they do not have a compatible DFL, which increases costs and prevents competitors without decoding capabilities from entering the market (see **UC5.1-OPS.4** for more detail).

- **UC5.1-TEC.9 - Limitations to computational resources for flight data decoding:** As stated in **CAT.IDE.A.190** from EASA's **Air Operations Regulation**, "*the FDR* (and thus the QAR) *shall start to record the data prior to the aeroplane being capable of moving under its own power and shall stop after the aeroplane is incapable of moving under its own power*". Given the time elapsed between both milestones during normal operation, an operator has at its disposal a significant volume of data per flight, which is a key factor when selecting the technology to be used in decoding. Two considerations must be taken:
   - On a daily basis, most operators must decode a manageable amount of raw flight data (e.g., a 30 aircraft fleet recording 1024 words per second, each 12-bit, with an average utilization of 12h per day, generates ~2GB per day). If an operator retrieves flight data every few days through a physical transmission, the peak volume of data to be processed will be higher, requiring it to schedule the retrieval and processing of flight data or to delay the processing depending on the computational resources available.
   - When performing a specific study or analysis which can require a longer historical period and for which only raw flight data has been stored, re-decoding flight data will be a lengthy process (e.g., maintaining same assumptions as above, 6 months of data would require partial re-decoding of 360 GB of data). In such situations, the amount of data to be processed can be high enough as to disrupt the daily decoding activity.

  Overall, depending on the way the operator conducts its FDM programme, it can suffer from peaks of demand for computational resource which it may not be able to respond to, given their IT infrastructure. Thus, the IT infrastructure of choice ("in-house" or "cloud"), which is also a factor on the FDM software package selection process, can be a limit to the operator capacity to perform specific studies and expand their FDM programme beyond the review of events and monitoring of basic trends.

5.1.1.3.2 Organisation

The following limitations have been identified for this activity within the Organisation dimension:

- **UC5.1-ORG.7 - Operators losing ownership of their DFL decoding file:** Usual practice in the industry is for operators to outsource the production of the DFL decoding file to a specialized service provider (the software vendor) with the technical expertise to perform the task more efficiently than the operator. Such an arrangement, however, has resulted in a lack of control and ownership by the operator of their DFLs. This presents multiple issues:
   - **UC5.1-ORG.7A - Cost of producing the DFL decoding file for operators:** Operators must dedicate significant financial resources to pay the software vendor to produce the DFL decoding file. Charging schemes differ between vendors, but are generally based either on the number of DFL decoding files to be produced (an issue given the high number an operator may need, see **UC5.1-TEC.3** for more details), or the number of aircraft tails the operator needs to decode data from.
   - **UC5.1-ORG.7B - Cost of updating the DFL decoding file after a change to the DFL by the manufacturer:** Operators are subject to the decision by the manufacturer to modify the DFL,

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which can have a significant impact on their flight data-based programmes as it requires the operator to finance the production of a new DFL decoding file (see **UC5.1-ORG.5**).

  - **UC5.1-ORG.7C - Dependence on the software vendor to produce the DFL decoding file:** Operators are dependent on their software vendor for any decoding of flight data or usage of the decoded data. For instance, an operator cannot share their DFL decoding file with a software vendor for a different flight data service (e.g., fuel management), and if it wants to share decoded flight data, they may need to enter into an agreement with their own decoding service provider first. This limits the ability of the operator to centralise all flight data decoding into a single service provider, which could improve efficiency of operators.

- **UC5.1-ORG.8 - Intellectual Property Rights in flight data decoding:** As part of the established process for the decoding of flight data, multiple stakeholders must intervene by providing information (manufacturers), processing it (software vendors) and using it (operators). In such a context, the issue of Intellectual Property Rights (IPRs) is a contentious topic, still minor but increasingly important. Two main issues have recently arisen over IPRs that can impact the decoding (and use) of flight data:
  - **UC5.1-ORG.8A - DFL documentation file as IPR:** Some business jet manufacturers, for whom an FDM programme is not mandatory, have started to consider the DFL documentation file as their Intellectual Property, and charge operators for access to the document. Given that this document is essential for decoding of flight data, charging extra can impact the decision of an operator to voluntarily stablish an FDM programme.
  - **UC5.1-ORG.8B Flight data as IPR:** Some manufacturers of aircraft for which an operator must establish and maintain an FDM programme have started to consider the data collected by the aircraft as their Intellectual Property, and started requiring any software vendor working with their aircraft's flight data (for FDM or other purposes) to sign a data agreement and pay significant fees to the manufacturer. This situation limits the capacity of the operator to use their data and increases the cost of their FDM programme.

- **UC5.1-ORG.9 - Lack of operator knowledge management of DFLs:** The key input when producing a DFL decoding file is the DFL documentation that the operator should maintain for each of the aircraft in their fleet. It is essential both because it contains the necessary information to produce the decoding file, and because it identifies which version is applicable to each aircraft, helping prevent the usage of an incorrect DFL decoding file for an aircraft with a similar DFL. Many operators, however, do not have proper documentation safekeeping processes, instead relying on the DFL decoding file previously produced to understand their own DFL. Such lack of safekeeping processes can impact the decoding activity in multiple ways:
  - It requires operators to request the DFL documentation to the original manufacturer, which may take some time to locate (delaying the DFL decoding file production service) and may be a payable service.
  - In the case of DARs, documentation may not be recoverable, requiring the operator to reprogram the equipment or use data from the FDR.
  - If documentation is not available for an older version of the DFL, and the corresponding DFL decoding file can no longer be used (e.g., because this decoding file correspond to an FDM software package that is not used any more by the operator), it will not be possible to decode old data.

- **UC5.1-ORG.10 - SaaS business model not adapted to the production of DFL decoding files:** Though FDM software vendors offer their products through different offerings, ranging from licensing to subscriptions, the Software-as-a-Service (SaaS) model has gained prominence in the past several years. This business model is based on offering a software package that resides on cloud-based computer

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servers and, being cloud-based, addresses many of the capacity issues that in-house solutions present (see **UC5.1-TEC.9**) while liberating operators (and their IT departments) from investing resources into setting up, expanding and maintaining the entire IT infrastructure of the FDM programme. The exception, however, is the production of the DFL decoding file. Both infrequent and expensive, the production of the DFL decoding file does not fit in the SaaS model, with the cost being charged separately to the operator or absorbed by the vendor. This mismatch results in lower adoption of the SaaS model.

- **UC5.1-ORG.11 - Limitations to communication across the industry:** Communication among stakeholders of an industry generally allows for the resolution of common problems through consensual solutions. While initiatives were launched by EASA to generate these channels of communication in the institutional (European Authorities Coordination Group on Flight Data Monitoring – EAFDM) and operator side (European Operators Flight Data Monitoring forum – EOFDM), FDM service providers, software vendors and manufacturers have not established their own channels of communication, instead participating in the operator channels. While organisations in the commercial sector have an interest to not communicate with one another to protect their individual competitive advantage, the current situation is a source of limitations:
  - **UC5.1-ORG.11A - Operators as intermediaries between vendors and manufacturers:** Operators must act as intermediaries in communications between software vendors and manufacturers. This is relevant in the context of flight data decoding as software vendors need to produce the DFL decoding file (and later, use flight parameters) based on the information provided by the DFL documentation from the manufacturer. Any error or issues encountered needs to follow a longer path of communication, decreasing the efficiency of the activity.
  - **UC5.1-ORG.11B - Lack of communication channels for technical discussions for FDM service providers:** When issues arise that can impact both the safety of aviation and the usage of flight data (e.g., 5G interferences on radio altimeter recordings in some United States airports), software vendors willing to share their experience with other vendors see their options limited, as their participation in industry channels is generally low. This also impacts operators, who could benefit from such communications if they occurred.
  - **UC5.1-ORG.11C - Lack of communication channels for organisational discussions for FDM service providers:** Common organisational or otherwise process-related issues which reduce the efficiency and effectiveness of the whole industry, cannot be resolved by individual efforts, instead requiring industry-wide agreements. These topics, however, cannot be discussed publicly or directly with EASA, as there is no adequate industry forum, or a direct channel of communication with the regulator.

5.1.1.3.3 Operations

The following limitation has been identified for this activity within the Operations dimension:

- **UC5.1-OPS.4 - Cost and complexity of producing a DFL decoding file for software vendors:** Under the current system of encoding flight parameters values into a binary format on board the aircraft, and decoding these values into engineering units on the ground, the DFL decoding file is essential. Still, maintaining and exercising the capacity to produce DFL decoding files from text based DFL documentation requires software vendors to dedicate extensive human, technical and financial resources. While such investments have been accepted as necessary, the generalized usage of text based DFL documentation presents several issues:
  - A significant portion of the cost of producing a DFL decoding file is driven by the manual labour required in the data entry process, which is why most vendors try to minimise the need for data entry by maintaining extensive libraries of already-digitised DFL documentation as DFL decoding files.

- o Producing a new DFL decoding file can be very slow, depending on the familiarity of the software vendor with similar DFLs. In addition to delaying the full inclusion of new aircraft into a data programme, it requires temporary solutions while being produced (e.g., decoded flight data in csv files instead of the FDM software pipeline), and, if an operator has contracted multiple flight data services with different software vendors, may result in a mismatch between the decoding files used by each, if some are slower than others in producing an updated version..
- o The progressive growth in size and complexity of DFLs (from 64 wps to 1024 and 2048 wps), in the number of parameters captured, and in the frequency by which manufacturers update the DFL, is increasing the total investment necessary to produce and maintain a single DFL decoding file.
- o While better tools are being developed by software vendors to help extract information from the text based DFL documentation file, which can even validate the outcome semi-automatically, the challenge remains to ensure the data entry process is complete and valid.
- o Currently available electronic documentation cannot fully substitute text-based documentation, as they only partially address the need (e.g., manufacturer libraries are usually generic documentation, without specific aircraft customisations) or are still rare (only the ARINC 767 standard includes the DFL documentation file in electronic form within the data stream and is itself used in very few aircraft families).

Overall, high costs and lack of alternatives creates an important incentive for the software vendor to not share its DFL decoding file nor the DFL documentation in electronic form, and to protect it by using proprietary formats (see **UC5.1-TEC.8**). Still, this lack of transparency also impacts the vendor when new operators are onboarded to their FDM software and a DFL decoding file must be produced for each of their fleet. The result is, there is a significant repetition of the same task within the system, without a clear net benefit.

5.1.1.4 Implementation of FDM events and measurements

Finally, event and measurement algorithms are applied over each flight, resulting in a list of events which can be traced back to a specific instant of the flight, and a list of measurements to understand the normal operation of the flight. In order to convert decoded flight data into a usable product, it is first necessary to process the data and, for FDM, compute events and measurements. It is during this processing that the continuous data stream is divided into individual flights, flights into phases, and within these, events and measurements. Like the decoding process, flight data processing in this step is heavily automated through software. However, the operator should have a leading role in the definition of FDM events and measurements.

This activity is described through the three analysis dimensions of Technology & Data, Organisation and Operations.

Technology & Data description

The technology supporting this activity consists mainly on the FDM software where all computations are performed, and the computer servers that provides the resources and the storage. Given that the hardware is a relatively generic equipment, non-specific to a FDM programme (or to the aviation industry), it will not be addressed in detail.

Hardware includes the computer server from where the FDM software draws the computational resources, and the computer server where decoded flight data is stored.

Software includes:

- The flight-splitting algorithm, to separate individual flights from one another based on their start and end. It is based on the identification of gaps in the data or of periods where the aircraft is stationary.

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- The flight-phase-splitting algorithm, to identify the various flight phases for each individual flight. Implementations can vary, but are generally based on different flight configurations and aircraft states, akin to those used by flight crews and other operational teams.
- The fusion algorithms, to add contextual or additional data to the flight for later use (e.g., to determine which runway was used for landing, fuse data on the length of the runway). Contextual data may be added based on matching timestamps and locations, or on any other number of factors.
- The event algorithms, to produce a list of relevant events for each flight that can serve to detect instances where deviations from aircraft flight manual limits and standard operating procedures occurred. They are generally based on the evaluation of the value of a parameter or combination of parameters over a time period, with a threshold denomination the point over or under which the value can indicate an unsafe or risky event, or the potential for it (severity levels are used to differentiate potentials).
- The measurement algorithms, to produce a list of measurements for each flight that can serve to represent the normal of operation of the flight. Similar to the event algorithms, they evaluate the value of a parameter or combination of parameters over a time period, but focused on recording the maximum, minimum or otherwise specified value.
- The FDM software, a specialized application for which the operator requires a license or subscription to use. The core capabilities of such software in the context of this activity include:
    - Pre-processing of the decoded data stream to identify individual flights and their flight phases, correspondingly splitting and assigning data from the stream.
    - Creation of a single flight register that consolidates operational data (e.g., registration, flight number, airport) and decoded flight data (e.g., airspeed).
    - Fusion or computation of additional operational or contextual data (e.g., runway used, weather during approach phase).
    - Computation of events and measurements, including timestamping and severity assessment based on pre-defined thresholds.
    - Management of the computational resources used.

Data includes:

- Flight data originating in the FDAU, including both the decoded flight data used as an input and the resulting list of unique flights with their associated events and measurements. Both datasets are stored medium-term in case they must be retrieved at some point to review past events, for testing, validation and trend analysis of newly defined events/measurements, or for specific studies. Storage of data is also useful as it allows operators to account for seasonal variations, to help in FDM software transitions, and as evidence for disputes with authorities or other stakeholders.
- All contextual data recorded or produced outside the FDAU. This can include weather data through METAR, operational data from flight plans, ATC interactions through CPDLC, information on particular events from ASRs, maintenance data, recorded ATIS, flight crew fatigue data, etc. Data is generally collected and offered free of charge or for a fee by third-party organisations. Contextual data is useful as an augmentation of flight data value. An operator can benefit from fusion through:
    - Improved event definition: Events can incorporate additional conditions based on the fused data, improving their reliability and precision.
    - Additional context for event analysis: Analysts can use the additional data to perform a better assessment of the risk of an event, including the impact of the surrounding environment and the assessment from the flight crew.

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Organisation description

While the decoding of flight data does not require safety-specific knowledge and can be outsourced seamlessly, such is not the case, for the definition, design and adaptation of flight phase, event and measurement algorithms. It is the responsibility of the operator to adapt what is monitored by their FDM programme to its operational context, and to maintain the knowledge about the source of data and the algorithms used to produce FDM events and measurements.

Nevertheless, operators may decide to use and adapt pre-defined algorithms, which can, from their perspective, further blur who is the actual responsible (while, as per regulations, they maintain the responsibility). Two main models of organising the activity exist:

- FDM team as key responsible: Under this model of organisation, the FDM team is responsible for most tasks related with the execution of the activity, including the operation of the FDM software. The FDM team within the operator will require a higher headcount, as the workload increases, but will ensure control over the activity. In terms of preparatory tasks, such as the definition and implementation of FDM events, three main organisational models exist:
    - FDM team only: The operator takes full ownership of the definition, design and adaptation process, with all knowledge of the algorithms used for each flight phase, measurement and event residing in-house, together with the capability to implement these in the FDM software. The most mature operators generally follow this model to ensure control and to maximize the utility of their FDM programmes.
    - FDM team with implementation support from the service provider: A variation of the previous model, the operator retains responsibility over the execution of the FDM software and the definition of flight phase/event/measurement, but requires the service provider to implement these algorithms into the software solution. This model is generally temporary, used when an operator with a mature FDM programme is transitioning between different FDM software solutions and may not fully control the programming language or the tools of the new environment.
    - FDM team with definition support from the service provider: While the operator is responsible for the execution of the software, it uses service-provider-defined algorithms as a basis, adapting them when necessary to suit their needs.
- Outsourcing to service provider: In this model of organisation, the execution of the activity is performed by a service provider contracted by the operator. It is usually coupled with the outsourcing of the decoding, such that both tasks (and the software that supports them) are offered as a Software-as-a-Service (SaaS). Under this model, operators may use service provider-defined algorithms, to which they can require additions of new events/measurements or adaptations.

The IT department within the operator is responsible for the setup and monitoring of the infrastructure that supports the storage of flight data and the execution of the FDM software. These tasks can also be outsourced to a service provider, who may allow for the storage and processing of flight data in their own computer servers as part of their SaaS offering.

Finally, the aviation authority has a role in the implementation of FDM events and measurements. The mandatory nature of FDM programmes in Europe is currently contained in the **Air Operators regulation**, point **ORO.AOC.130**, with accompanying Acceptable Means of Compliance (AMC) and official Guidance Material (GM). EASA establishes the requirement to adapt events and algorithms to the particular context of an operator (see **Air Operations Regulation AMC1 ORO.AOC.130(c)(1)** *"A set of core events should be selected to cover the main areas of interest to the operator and as much as possible, the most significant risks identified by the operator. The event definitions should be continuously reviewed to reflect the operator's current operating procedures."*)). In parallel, it is National Aviation Authorities in EASA Member States, who are responsible for

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the oversight of FDM programmes in their jurisdictions, and who perform SMS audits of operators to validate their programmes comply with the Acceptable Means of Compliance.

Operations description

The implementation of FDM events and measurements can be divided into the definition of the FDM event and programming of the algorithms used (in this particular case, for FDM events), an infrequent task that requires an important level of human intervention, and the computation of FDM events itself, a frequent task automated with the mentioned algorithms. While the actual execution of the former will vary from case to case, the latter processing of data follows a relatively standardised workflow.

The **definition and implementation of events** can be divided into the following steps:

- Event definition: The rationale followed by the event is defined as the set of conditions or requirements necessary to characterise a safety occurrence, from the value of particular physical variables (thresholds), to the state of the aircraft and the timeframe in which to evaluate. These conditions are derived from the knowledge on the operation of the aircraft and on the safety occurrence.
- Selection of parameters: From the parameters available in the DFL, the most adequate are selected based on their resolution, frequency and representativeness in relation to the conditions and requirements from the event definition.
- Algorithm development: The actual algorithm is developed, converting the conditions and requirements into code evaluated over the selected parameters. Additional considerations on the quality of the data, how to best approximate the event definition, and to be resource-efficient are also taken into account.
- Algorithm validation: The resulting algorithm must first be validated before it enters normal operation. To do so, both a set of flight representative of normal operation and specific snippets of flight data with a recorded safety occurrence are used to ensure that all conditions and requirements are properly implemented, and that minor data quality issues do not generate false positives or false negatives.

The **computation of FDM events** consists of the following steps:

- Data selection and retrieval: With the software launched, the specific data stream to be analysed is selected and retrieved from storage.
- Flight splitting: Algorithms are used to detect the start and end of a flight in order to split the data stream. Periods not corresponding to a flight are discarded, including the turnaround and, possibly, the taxiing. Each flight is assigned a unique identifiable key.
- Flight phase splitting: For each unique flight, the phases of operation and the points of transition between phases are identified.
- Fusion of operational and contextual data: With each flight uniquely identified and separated in flight phases, other contextual and operational data is fused. This includes fusing based on the flight identification (e.g., operational data from the flight plan), based on the time and location of a flight phase (e.g., weather for an approach at a particular airport on a particular day and hour).
- Measurement computation: Based on pre-defined algorithms, measurements are performed for each flight and flight phase (e.g., touchdown point), and stored into the measurements database for statistical comparison.
- Event computation: Based on pre-defined algorithms, parameter exceedances are detected in the context of particular flight phases (e.g., high vertical acceleration during touchdown). The severity of an event is determined based on which of the multiple thresholds defined was exceeded during the event. Events are timestamped and reported with all data of interest (parameter time series, contextual information) back to the analyst.

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5.1.1.4.1 Technology & Data

The following limitations have been identified for this activity within the Technology & Data dimension:

- **UC5.1-TEC.10 - Lack of standardisation of FDM event definitions:** The safety risks that operators face during a flight can be either common across the industry, or specific to their operation and operational context. Still, the definition of events and flight phases, the algorithms that represent these definitions, and even the parameters used, are not standardised, with each operator and software vendor using their own. This results in, among others, three main issues:
    - **UC5.1-TEC.10A - Limitations to benchmarking of events:** Operators use very different event definitions, so that they cannot directly benchmark their event trends and rates, which reduces the utility of the benchmarking exercise.
    - **UC5.1-TEC.10B - Lack of guidance for production or adaptation of FDM event definitions:** Operators and software vendors face difficulties when trying to adapt events, flight phases and thresholds or define and develop new ones, as the amount of information available regarding best industry practices, specific definitions and algorithms, and how to implement and adapt them for particular aircraft and operational contexts is still small.
    - **UC5.1-TEC.10C - Limited applicability of best-practice on defining an FDM event:** Operators and software vendors sharing or receiving information and best practices on FDM event definitions from other operators or software vendors see the effectiveness of these communications reduced, as they may not be applicable to their own programmes. This issue can also impact their willingness to actively participate in industry forums and exchanges.
- **UC5.1-TEC.11 - Limitations to fusion of flight data with contextual data:** While the fusion of flight data with contextual data can be very beneficial for the operator, many cannot enjoy these benefits due to three main limitations:
    - **UC5.1-TEC.11A - Lack of fusion capabilities in software:** Many software solutions still incorporate very limited fusion capabilities, ranging from only including weather data and runway data, to also offer fusion of flight plans and ASRs. In some cases, operators must develop by themselves fusion tools, as these are not available from the software vendor.
    - **UC5.1-TEC.11B - Cost and complexity of accessing contextual data:** Access to contextual data sources is complex and expensive for both operators and software vendors. Data sources may not offer public access through APIs or similar technology, may charge fees to access (such as NOTAMs) or may present limited scopes (e.g., specific to an airport or region).
    - **UC5.1-TEC.11C - Lack of standardisation of contextual data:** Contextual data is generally not standardised, which can impact both the technical fusion process and the utility of the data. The fusion process can be affected if multiple formats are used, particularly when some are proprietary or very complex, requiring further technical developments or discarding part of the data based on its format. As for the utility, it can be impacted if factors such as resolution, frequency, information captured or others are affected by the specific format followed resulting in the contextual data no longer being useful (e.g., METAR data updated once a week).
- **UC5.1-TEC.12 - Limitations to computational resources for FDM events and measurements:** As explained in the context of raw flight data decoding (see limitation **UC5.1-TEC.9**, the volume of data to process for the computation of flight splitting algorithms, flight phases, measurements, events, etc. is significant. Thus, peaks of demand for computational resources may surpass the capacity of the IT infrastructure, which can limit the potential of the FDM programme (or other flight data-based programmes) to perform retroactive computations of events when a definition is modified, or to fulfil requests for measurements from other internal (e.g., maintenance) or external (e.g., airports, authorities) stakeholders.

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5.1.1.4.2 Organisation

The following limitations have been identified for this activity within the Organisation dimension:

- **UC5.1-ORG.12 - Insufficient operator control over the definitions of FDM events and measurements:** Historically, the main model of organisation for the implementation of FDM events and measurements was that of the FDM team as key responsible, with some level of support from the service provider. Nowadays, however, part of the industry is moving towards a significantly higher level of outsourcing, be it for the potential cost savings, ease of use, pressure from flight crews, or because it is the only modality offered by the software vendor. Like raw flight data decoding (see limitation **UC5.1-ORG.7**), outsourcing has resulted in a partial loss of control and ownership by the operator of the events and other algorithms used in their FDM programmes, with three main consequences:
  - Operators are subject to the software vendor-defined algorithms and definitions, otherwise generally having to pay for an adaptation to their desired definition.
  - Changes of software vendor represent a loss of continuity in the FDM programme, as results are not comparable. Operators are either forced to maintain both software solutions until the new one has adapted their definitions, or to accept the new event definitions.
  - Software vendors share incomplete information and documentation, resulting in some operators losing access to the actual event definition and, ultimately, losing knowledge on the innermost components of their FDM programme.
- **UC5.1-ORG.13 - Limitations to the role of the authority in FDM programmes:** While EASA, has had different levels of engagement with the industry in both FDM programmes and safety intelligence more broadly (e.g., EOFDM and EAFDM forums, Data4Safety, updates to the AMC and GM). some regulatory limitations remain:
  - **UC5.1-ORG.13A - Limitations to standardisation of events and flight parameters by authorities:** As the event definitions must be reviewed by the operator, authorities cannot be too prescriptive on the particular definition of events in order to standardise them, as operators may decide to use the definition proposed by the authority without adapting it to their operational context (see limitation **UC5.1-TEC.10**). Additionally, the variety of aircraft models, types of operations, airfields, as well as SOPs, potential contributing factors, safety barriers implemented, etc. makes it impossible to define an exhaustive list of FDM event definitions. Such a limitation also affects industry associations such as the EOFDM, which focuses on risk areas instead of solutions.
  - **UC5.1-ORG.13B – Difficulties in assessing the selection and definition of FDM events by operators:** While good practice on the assessment of the selection and definition of FDM events by authorities has been shared by the EAFDM coordination group, and these audits are performed with regularity, authorities can face limitations. These result from the lack of objective criteria to determine relevant events, which allows operators to easily justify their choices based on their knowledge of their own operation, and in turn can result in a minority of operators following bad practices. These bad practices can range from changing thresholds into clearly inadequate values, to discarding events for spurious reasons. Additionally, given the lack of direct channels of communication between the industry and authorities (see limitation **UC5.1-ORG.11.C**), software vendors who detect such practices cannot address them.
- **UC5.1-ORG.14 – Lack of support from FDM software services providers regarding contextual data acquisition:** Fusion of contextual information is a capability that is still being generalised, and, as such, best practices have not extended throughout the industry yet. While contextual data is varied and can range from internal information on the operation (e.g., schedules), to environmental information captured by other organisations (e.g., METAR data), the responsibility over who shall provide it is not

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clear. In some cases, software vendors provide the capability to fuse contextual data but not the data itself. While such an arrangement is normal when the data is produced by the operator, it is not efficient when the data is external, as it is up to the operator to source and, in some cases, partially process the data before fusion. Having the operator perform the sourcing and processing results in a loss of efficiency, as each operator must now establish the processes and maintain their own database of contextual data.

- **UC5.1-ORG.15 - Lack of operator knowledge management of FDM events:** When the level of outsourcing is low, most of the event implementation tasks are the responsibility of the operator, allowing it to develop their expertise and knowledge on the matter. Still, knowledge and documentation management practices in many operators are under-developed, particularly regarding the production and storage of documentation on historic or previous event definitions, flight phases and measurement definitions and algorithms, their rationale, and the evolution followed within the FDM programme. This lack of documentation risks the capacity to maintain such knowledge within the operator with time (loss of understanding), is a blocking point for knowledge capitalisation (necessary for continuous improvement) and can become a soft limit to the events an operator can manage.
- **UC5.1-ORG.16 - Knowledge transmission from manufacturers to software vendors:** While manufacturers generally have a deeper knowledge on their aircraft and how to operate them, it is software vendors who sell operational and safety intelligence products and, thus, who also sell their expertise. This dichotomy is usually resolved by the latter developing sufficient knowledge and expertise to provide complete products to operators. Still, not all cases can or have been resolved. For less common aircraft, such as regional or business jets, where the level of knowledge among software vendors can be lower, communication between manufacturers and software vendors can be beneficial in resolving common problems and sharing insights (in line with limitation **UC5.1-ORG.11**). These communications, however, do not currently have a supporting framework under which to be conducted. This has resulted in a disincentive to sharing information, as manufacturers assume a cost to support vendors without benefit.

5.1.1.4.3 Operations

The following limitation has been identified for this activity within the Operations dimension:

- **UC5.1-OPS.5 - Lower quality of FDM events and measurements in the case of regional aircraft:** Regional aircraft with a MCTOM of less than 27 000 kg, and particularly those equipped with turboprop engines, do not currently fall under the provision to be covered by an FDM programme. Many operators, however, choose to include these aircraft into their existing FDM programmes to benefit from both safety intelligence and the kick-start to their flight data-based programmes more broadly. Such users are currently limited by the lower quality of events, measurements, flight phases and other flight data-related algorithms, when compared to those of aeroplanes with MCTOM > 27 000 kg, resulting from a lower understanding of the specificities of these aircraft and their operation (see limitation **UC5.1-ORG.16**). Given the planned extension of scope for aeroplanes requiring an FDM programme (ICAO plans to extend it to those with an MCTOM of more than 15 000 kg and a MOPSC of more than 19 000 kg), this limitation may gain in relevance in the future.

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5.1.2 Limitations overview

As seen throughout the challenges description, the identification, decoding and processing of flight data brings forth a set of challenges and limitations that manifest across various operational dimensions. This section presents a consolidated overview of all identified challenges, systematically categorized into the three fundamental categories (Technology & Data, Organisation, and Operations), and classified according to their corresponding process activity.

Table 5-1 Overview of limitations identified for Use Case 5.1

Use Case 5.1: Identification, decoding and processing of flight data for an FDM programme			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**

Collection of flight data within the aircraft	• UC5.1-TEC.1 – Need to decode data before usage
	• UC5.1-TEC.2 - Limited recording capacity in older equipment
	• UC5.1-TEC.3 - Need to use multiple DFLs
	• UC5.1-TEC.4 - Specific limitations for operators of smaller aircraft
	  ○ UC5.1-TEC.4A - No possibility to customise the DFL for operators of smaller aircraft
	  ○ UC5.1-TEC.4B - No airborne equipment to support the FDM programme on smaller aircraft
	  ○ UC5.1-TEC.4C – Limitations when using the FDR data for FDM
	• UC5.1-TEC.5 - Lack of standardisation of flight parameters
	  ○ UC5.1-TEC.5A - Limitations from lack of parameter performance
	  ○ UC5.1-TEC.5B - Limitations from missing or inadequate parameters
		• UC5.1-ORG.1 - Limitations to the customisation of DFLs
		• UC5.1-ORG.2 - Limitations to increasing the recording capacity of DFLs
		• UC5.1-ORG.3 - Errors in DFLs for smaller aircraft
		• UC5.1-ORG.4 - Lack of information for operator-requested DFL customisation
		• UC5.1-ORG.5 - Modification of the DFL by the manufacturer	

Transmission of flight data to a computer server	• UC5.1-TEC.6 - Cost of maintaining fleets with a mix of WQAR and non-WQAR • UC5.1-TEC.7 - Risk of data loss when recovering data from non-WQARs	• UC5.1-ORG.6 - Data loss or corruption due to lack of monitoring	• UC5.1-OPS.1 - Data loss due to transmission delays • UC5.1-OPS.2 - Cost of and delays to data transmission from non-WQARs • UC5.1-OPS.3 - Cost of and delays to data transmission from WQARs

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Use Case 5.1:
Identification, decoding and processing of flight data for an FDM programme

Activity	Limitations		
	Technology & Data	**Organisation**	**Operations**
Decoding flight data into engineering values	• UC5.1-TEC.8 - Usage of proprietary formats in DFL decoding files • UC5.1-TEC.9 - Limitations to computational resources for flight data decoding	• UC5.1-ORG.7 - Operators losing ownership of their DFL decoding file ○ UC5.1-ORG.7A - Cost of producing the DFL decoding file for operators ○ UC5.1-ORG.7B - Cost of updating the DFL decoding file after a change to the DFL by the manufacturer ○ UC5.1-ORG.7C - Dependence on the software vendor to produce the DFL decoding file • UC5.1-ORG.8 - Intellectual Property Rights in flight data decoding ○ UC5.1-ORG.8A - DFL documentation file as IPR ○ UC5.1-ORG.8B Flight data as IPR • UC5.1-ORG.9 - Lack of operator knowledge management of DFLs • UC5.1-ORG.10 - SaaS business model not adapted to the production of DFL decoding files • UC5.1-ORG.11 - Limitations to communication across the industry	• UC5.1-OPS.4 - Cost and complexity of producing a DFL decoding file for software vendors
Implementation of FDM events and measurements	• UC5.1-TEC.10 - Lack of standardisation of FDM event definitions ○ UC5.1-TEC.10A - Limitations to benchmarking of events ○ UC5.1-TEC.10B - Lack of guidance for production or adaptation of FDM event definitions ○ UC5.1-TEC.10C - Limited applicability of best-practice on defining an FDM event • UC5.1-TEC.11 - Limitations to fusion of flight data with contextual data ○ UC5.1-TEC.11A - Lack of fusion capabilities in software ○ UC5.1-TEC.11B - Cost and complexity of accessing contextual data	• UC5.1-ORG.12 - Insufficient operator control over the definitions of FDM events and measurements • UC5.1-ORG.13 - Limitations to the role of the authority in FDM programmes ○ UC5.1-ORG.13A - Limitations to standardisation of events and flight parameters by authorities ○ UC5.1-ORG.13B – Difficulties in assessing the selection and definition of FDM events by operators • UC5.1-ORG.14 – Lack of support from FDM software services providers regarding contextual data acquisition:	• UC5.1-OPS.5 - Lower quality of FDM events and measurements in the case of regional aircraft

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Use Case 5.1: Identification, decoding and processing of flight data for an FDM programme			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**
	○ UC5.1-TEC.11C - Lack of standardisation of contextual data • UC5.1-TEC.12 - Limitations to computational resources for FDM events and measurements	• UC5.1-ORG.15 - Lack of operator knowledge management of FDM events • UC5.1-ORG.16 - Knowledge transmission from manufacturers to software vendors	

5.1.3 Proposed digital solutions to address limitations

To address the various limitations previously identified and described throughout the sections dedicated to each of the activities of the Use Case 5.1, a set of solutions have been proposed, which are presented and described in the following table:

Table 5-2 Proposed solutions identified for Use Case 5.1

Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme		
Limitation	**Solution**	**Description**
UC5.1-TEC.1 - Need to decode data before usage	**UC5.1-SOL.1** - Recording of flight data in non-binary formats for safety use	Explore the potential of recording flight data within the aircraft in a non-binary format that can be used for safety-relevant activities with minimal or no decoding.
UC5.1-TEC.2 - Limited recording capacity in older equipment	**UC5.1-SOL.2** - Set an objective for minimum data recovery	Define the minimum performance that operator data recovery processes should achieve by establishing the proportion of data or flights for which data should be recovered, and the time frame to do so. This should include objective evaluation criteria while including provisions for exceptional situations where compliance is not possible.
UC5.1-TEC.3 - Need to use multiple DFLs	**UC5.1-SOL.3** - Develop a Flight Parameter Reference document for FDM	Develop a Flight Parameter Reference (FPR) document containing a comprehensive list of flight parameters to serve as a common baseline for Data Frame Layouts used in FDM. This document should include: • A list of necessary and recommended parameters for FDM. • A standard nomenclature for flight parameters. • Minimum and recommended performance (recording frequency and resolution) for flight parameters. • For parameters capturing the same physical dimension but sourced from different equipment within the aircraft, the recommended one.

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Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme		
Limitation	**Solution**	**Description**
		It should be ensured that DFL documentation produced by manufacturers can be related to the Flight Parameter Reference document, including: • Linking manufacturer and FPR nomenclature. • Identifying differences in established performance between manufacturer DFL and the recommended FPR values. • Additional parameters that are included in the DFL but not covered in the FPR. This solution should help in gradually standardising DFLs within and across operators, while reducing the cost of producing DFL decoding files by facilitating the interpretation of DFL documentation.
	UC5.1-SOL.4 - Definition by manufacturers of DFLs with a wide selection of parameters	Development by manufacturers of Data Frame Layouts with an extensive number of flight parameters usable for a multitude of purposes and for most operators, addressing the data needs of FDM, fuel management, continuing airworthiness and others. By increasing the utility of the standard DFL, the need to adapt and customise can be minimised and the number of DFLs reduced. Development of this solution should be coordinated with solution "**UC5.1-SOL.3 - Develop a Flight Parameter Reference document for FDM**" to ensure the standardisation of these extensive DFLs.
UC5.1-TEC.4 - Specific limitations for operators of smaller aircraft	**Previously defined solution**	Solutions "**UC5.1-SOL.3 - Develop a Flight Parameter Reference document for FDM**" applies to limitation "**UC5.1-TEC.4A - Lack of DFL customisation options for small aircraft**" by providing manufacturers of small aircraft with a reference on which parameters should be captured for FDM. Solution "**UC5.1-SOL.4 - Definition by manufacturers of DFLs with a wide selection of parameters** also addresses this limitation by increasing the overall number of parameters captured in the aircraft, thus removing the need to customise.
	UC5.1-SOL.5 - Install WQAR equipment on newly-manufactured smaller aircraft	Installation of WQAR equipment in small aircraft from the factory line, to enable the conduction of FDM programmes. The action should distribute information on the benefits of enabling flight data use and the limitations that exist in using the FDR for the same functions. This is a mitigation solution applicable to "**UC5.1-TEC.4B - Lack of available equipment in small aircraft**" and "**UC5.1-TEC.4C - Limitations from the usage of FDR flight data for FDM**", as the non-mandatory nature of conducting FDM programmes for aircraft below the established MTOW threshold limits the options for EASA to increase the usage of QAR among such aircraft.
UC5.1-TEC.5 - Lack of standardisation of flight parameters	**Previously defined solutions**	Solution "**UC5.1-SOL.3 - Develop a Flight Parameter Reference document for FDM**" addresses this limitation by supporting a gradual standardisation of DFLs within and across operators and establishing a baseline level of parameter performance. Solution "**UC5.1-SOL.4 - Definition by manufacturers of DFLs with a wide selection of parameters**" addresses this limitation by increasing the overall number of parameters captured in the aircraft, thus removing the issue of missing parameters or them being inadequate for specific uses (beyond very specific parameters not included in the standard DFL).
UC5.1-TEC.6 - Cost of maintaining fleets with a	**None**	The increase in cost and complexity of maintaining fleets with mixed QARs is inherent to the usage of different technologies in parallel, with the only solution being to retrofit aircraft to one or other type of QAR.

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Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme		
Limitation	**Solution**	**Description**
mix of WQAR and non-WQAR		
UC5.1-TEC.7 - Risk of data loss when recovering data from non-WQARs	**Previously defined solution**	Solution "**UC5.1-SOL.2 - Set an objective for minimum data recovery**" applies as, by defining these guidelines on minimum data analysis recovery, the operator will have to consider the de-risking of its operation. Such considerations will impact their cost-benefit analysis of hardware solution for data transmission and, ultimately, push them towards solutions with wireless capabilities that lower the risk of data loss due to memory overflow.
UC5.1-TEC.8 - Usage of proprietary formats in DFL decoding files	**UC5.1-SOL.6** - Create the conditions for open access to DFL electronic documentation	Create conditions to ensure availability and access to DFL electronic documentation in an open format. Such conditions should include: • Aircraft and equipment manufacturers providing operators with the DFL electronic documentation in an open format (such as the FRED format) for newly-manufactured aeroplanes. • DFL electronic documentation should be included as part of the required aircraft documentation, delivered at the same time and with the same level of detail and completeness as the DFL paper document contained in the Aircraft Maintenance Manual (AMM). It shall also be delivered to an operator leasing an aircraft. • Operators converting their DFL paper documentation into electronic documentation, by themselves or through a service provider. With manufacturers providing the DFL electronic documentation, and software vendors using it, the production of DFL decoding files is simplified and the cost can be significantly reduced. Ultimately, the need to use proprietary formats is indirectly addressed, as it is no longer capable of dissuading operators from changing between service providers given the reduction in the cost of producing the decoding file.
UC5.1-TEC.9 - Limitations to computational resources for flight data decoding	**UC5.1-SOL.7** - Conditions for minimum data analysis capabilities	Define the minimum performance that operator data analysis processes should achieve by establishing the proportion of data or flights for which data should be processed after transmission to a computer server, and the time frame to do so. This should include the objective evaluation criteria of the minimum performance while including provisions for exceptional situations where compliance is not possible. By defining these guidelines on minimum data analysis capabilities, the operator will have to consider the need to ensure scalability of its software solution, which will impact their cost-benefit analysis when choosing software solutions and, ultimately, push them towards better scalable solutions.
UC5.1-TEC.10 - Lack of standardisation of FDM event definitions	**UC5.1-SOL.8** - Minimum list of risk areas to be monitored through FDM	Develop guidelines on the minimum list of risk areas that should be monitoring within the FDM programme. The guidelines should provide references on how these risk areas can be monitored and include provisions for exceptional situations where compliance is not possible (particularly due to lack of available data).
	UC5.1-SOL.9 - Development of industry-agreed FDM algorithms and logics	As part of the normal functioning of the Data4Safety programme, different approaches, algorithms and logics to identify and measure safety occurrences from flight data are tested and validated and published (see "Guidance for identifying unstable approach with flight data", published on DATA4SAFETY | EASA (europa.eu)). Such an approach already allows for benchmarking of events across operators, and logics and algorithms can be shared and promoted across software vendors, operators, and other users of flight data.

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Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme		
Limitation	**Solution**	**Description**
UC5.1-TEC.11 - Limitations to fusion of flight data with contextual data	**UC5.1-SOL.10** - Establishment of open contextual data repository	As part of the normal functioning of the Data4Safety programme, contextual data such as METAR, airport and runway information and other such data is sourced, processed, and fused with flight data. A contextual data repository could be created by making available such contextual data already processed and formatted for use by operators. By establishing this repository, both limitations "**UC5.1-TEC.11B - Cost and complexity of accessing contextual data**" and "**UC5.1-TEC.11C - Lack of standardisation of contextual data**" would be addressed.
	UC5.1-SOL.11 - Industry best-practices on contextual data fusion	Production of best practice for operators on the fusion of flight data with contextual data, based on the experiences and developments occurring within the Data4Safety programme. Such best practices shall facilitate the development of fusion capabilities by operators when not enabled by their FDM software. The results and capabilities of the programme itself can also serve as a showcase of the utility of fusing flight data with contextual data for operators without visibility or access to such capabilities.
UC5.1-TEC.12 - Limitations to computational resources for flight data processing	**Previously defined solution**	Solution "**UC5.1-SOL.7 - Conditions for minimum data analysis capabilities**" applies. By defining these guidelines on minimum data analysis capabilities, the operator will have to consider the need to ensure scalability of its software solution, which will impact their cost-benefit analysis when choosing software solutions and, ultimately, push them towards better scalable solutions.
UC5.1-ORG.1 - Limitations to the customisation of DFLs	**Previously defined solution**	Solution "**UC5.1-SOL.4 - Definition by manufacturers of DFLs with a wide selection of parameters**" addresses this limitation by increasing the number of parameters captured, ultimately removing the need to customise the DFL for most operators.
UC5.1-ORG.2 - Limitations to increasing the recording capacity of DFLs	**Previously defined solution**	Solution "**UC5.1-SOL.4 - Definition by manufacturers of DFLs with a wide selection of parameters**" addresses this limitation by increasing the number of parameters captured in aircraft, ultimately removing the need to increase the recording capacity beyond that established in the standard DFL.
UC5.1-ORG.3 - Errors in DFLs and accompanying documentation for smaller aircraft	**None**	DFLs used in small aircraft and accompanying documentation must pass a certification process before the aircraft can be operational. Addressing any errors that may exist is already part of the normal working process, and should be reported to the manufacturer for correction and, if necessary, to the competent authority.
UC5.1-ORG.4 - Lack of information for operator-requested DFL customisation	**Previously defined solutions**	Solution "**UC5.1-SOL.3 - Develop a Flight Parameter Reference document for FDM**" applies. Particularly relevant for this limitation is the information on the sources of each parameter within the aircraft, helping operators discern the proper parameter to add to the DFL. Solution "**UC5.1-SOL.4 - Definition by manufacturers of DFLs with a wide selection of parameters**" also applies by minimising the need of operators to customise their DFLs.
UC5.1-ORG.5 - Modification of the DFL by the manufacturer	**Previously defined solution**	Solution "**UC5.1-SOL.6 - Create the conditions for open access to DFL electronic documentation**" applies. By requiring manufacturers to produce and deliver the DFL electronic documentation, the production of DFL decoding files is simplified and the cost can be significantly reduced, mitigating the overall impact that modifications of the DFL by the manufacturer cause on operators and software vendors.

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Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme		
Limitation	**Solution**	**Description**
UC5.1-ORG.6 - Data loss or corruption due to lack of monitoring	**Previously defined solution**	Solution "**UC5.1-SOL.2 - Set an objective for minimum data recovery**" applies. By defining these guidelines, an incentive is created for operators to properly structure the tasks and responsibilities concerned with monitoring of data recovery, identification of issues and implementation of mitigation measures.
UC5.1-ORG.7 - Operators losing ownership of their DFL decoding file	**Previously defined solution**	Solution "**UC5.1-SOL.6 - Create the conditions for open access to DFL electronic documentation**" applies. By requiring manufacturers to produce and deliver the DFL electronic documentation, and software vendors to share it as well, this limitation is fully addressed: • The production of DFL decoding files is simplified by removing the data entry process, which significantly reduces the cost of production, addressing limitations "**UC5.1-ORG.7A - Cost of producing the DFL decoding file for operators**" and "**UC5.1-ORG.7B - Cost of updating the DFL decoding file after a change to the DFL by the manufacturer**". • As the DFL electronic documentation is now fully in control of the operator, its freedom to share it with different vendors is ensured. In parallel, the leverage that the software vendor has to prevent sharing of flight data is reduced, as the cost for the operator to request a new decoding from another vendor is lower than currently. The combination of factors can, in contrast, enable further centralisation of decoding by reducing the risk and cost for the operator. Thus, the solution addresses limitation "**UC5.1-ORG.7C - Dependence on the software vendor to produce the DFL decoding file**".
UC5.1-ORG.8 - Intellectual Property Rights in flight data decoding	**UC5.1-SOL.12** - Addressing Intellectual Property Rights in FDM	Develop guidelines on Intellectual Property Rights in the context of FDM, flight data decoding and DFL documentation. The guidelines should be preceded by a legal evaluation of the different claims to IPRs in this context and should provide industry stakeholders with a clear understanding of what can be considered IPR and what cannot.
UC5.1-ORG.9 - Lack of operator knowledge management of DFLs	**UC5.1-SOL.13** - Maintaining knowledge and documentation on flight data and DFLs	Ensure that a minimum set of knowledge and documentation is maintained by the operator on the flight data used for the FDM programme and on the DFLs of their aircraft. Among these, it should include: • Documentation on the flight parameters collected or used for the FDM programme, including nomenclature and performance. • The DFL documentation in both paper (i.e., pdf file) and electronic versions (i.e., FRED file or equivalent open format), linked to each aircraft tail number and including its time period of applicability. Should the operator customise its DFL by themselves or through a vendor, such customisation should be captured in the DFL documentation. • The data quality process followed to clean flight data before further processing. This solution is partially dependent on the application of solution "**UC5.1-SOL.6 - Create the conditions for open access to DFL electronic documentation**", as access to the electronic version of the DFL documentation will otherwise not be possible for many operators.
UC5.1-ORG.10 - SaaS business model not adapted to the production of DFL decoding files	**Previously defined solution**	Solution "**UC5.1-SOL.6 - Create the conditions for open access to DFL electronic documentation**" applies. By decreasing the cost of producing the DFL decoding file, it can be more easily incorporated into the subscription cost of the service. Additionally, given that software vendors are required to share the DFL electronic documentation but not their DFL decoding files, absorbing the cost, and capitalising on past developments remains an option for vendors.
UC5.1-ORG.11 - Limitations to communication across the industry	**None**	Software Vendors and other stakeholders can already participate in the European Operators FDM forum, which is the adequate platform for technical discussion on FDM and flight data applications for safety. Additionally, industry stakeholders can raise issues to EASA through the Stakeholders Advisory Body (SAB). Otherwise, and for discussions of an organisational nature or for lobbying activities, it is up to the private companies to set up a group or industry association for such purposes.

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Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme		
Limitation	**Solution**	**Description**
UC5.1-ORG.12 - Insufficient operator control over the definitions of FDM events and measurements	**Previously defined solutions**	Solutions "**UC5.1-SOL.8 - Minimum list of risk areas to be monitored through FDM**", and "**UC5.1-SOL.9 - Development of industry-agreed FDM algorithms and logics**" apply. By standardising the logics and algorithms used across software vendors, the impact of changing between vendors and being subject to some degree to the software vendor-defined algorithms can be mitigated.
UC5.1-ORG.13 - Limitations to the role of the authority in FDM programmes	**Previously defined solutions**	Solutions "**UC5.1-SOL.8 - Minimum list of risk areas to be monitored through FDM**", and "**UC5.1-SOL.9 - Development of industry-agreed FDM algorithms and logics**" apply. The minimum list of risk areas to be monitored, coupled with the information on standardised FDM-based indicators and the logics, algorithms and thresholds used in the Data4Safety programme can support the regulator with limitation "**UC5.1-ORG.13B – Difficulties in assessing the selection and definition of FDM events by operators**". They also serve to partially address "**UC5.1-ORG.13A - Limitations to standardisation of events and flight parameters by authorities**", as these standardised indicators and industry-agreed algorithms are not directly sanctioned by the authority but instead presented as potential alternatives to be adapted.
UC5.1-ORG.14 – Lack of support from FDM software services providers regarding contextual data acquisition:	**Previously defined solution**	Solution "**UC5.1-SOL.10 - Establishment of open contextual data repository**" applies. By facilitating the acquisition and processing of contextual data, the overall cost for software vendors to offer this capability is reduced. This creates an incentive for them to offer the service, as more competitors will be capable of doing so.
UC5.1-ORG.15 - Lack of operator knowledge management of FDM events	**UC5.1-SOL.14** - Maintaining knowledge and documentation on FDM events and algorithms	Ensure that a minimum set of knowledge and documentation is maintained by the operator on the FDM events and algorithms covered within the FDM programme. It should include: • A description of the logic of algorithms related to flight splitting, flight phase identification, FDM events and FDM measurements, including thresholds when relevant. The description should be sufficiently detailed to enable evaluation against the SOPs and flight manual limitations of the operator. • Flight parameters used and their performance.
UC5.1-ORG.16 - Knowledge transmission from manufacturers to software vendors	**UC5.1-SOL.15** - Integration of manufacturers of smaller aircraft into the EOFDM forum	Invite manufacturers, particularly of smaller aircraft or with less presence in such forums, into the European Operators FDM forum to provide a platform for technical and organisational discussions on flight data and its use in FDM and other safety-relevant activities that are specific of their type of operation.
UC5.1-OPS.1 - Data loss due to transmission delays	**Previously defined solution**	Solution "**UC5.1-SOL.2 - Set an objective for minimum data recovery**" applies. By defining these guidelines, an additional incentive is created for operators to ensure the proper execution of the data retrieval and transmission process, while affecting the cost-benefit calculus of upgrading to new equipment that is either not impacted by transmission delays thanks to higher memory capacity or can minimise delays by automatically transmitting data at low cost.

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Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme		
Limitation	**Solution**	**Description**
UC5.1-OPS.2 - Cost of and delays to data transmission from non-WQARs	**Previously defined solution**	Solution "**UC5.1-SOL.2 - Set an objective for minimum data recovery**" applies. By defining these guidelines, an additional incentive is created for operators to ensure the proper execution of the data retrieval and transmission process, which ultimately affects the cost-benefit calculus of upgrading to new equipment that does not require usage of maintenance service providers or certified technicians (reducing the cost) and that does not face the constrain of being charged per data transfer and not per volume of data transferred (reducing the delay).
UC5.1-OPS.3 - Cost of and delays to data transmission from WQARs	**None**	Note: This limitation should be gradually mitigated as more connectivity options are enabled, particularly for satellite data transmission. Nonetheless, the volume of data will also gradually increase over time, with the final equilibrium still to be determined.
UC5.1-OPS.4 - Cost and complexity of producing a DFL decoding file for software vendors	**Previously defined solutions**	Solution "**UC5.1-SOL.6 - Create the conditions for open access to DFL electronic documentation**" applies. By eliminating the manual labour required for data entry of the paper DFL documentation into a computer and validation of this process, the overall cost of production is reduced, and the process is simplified. This result can help software vendors minimise invested resources to maintain their decoding capabilities. Solution "**UC5.1-SOL.4 - Definition by manufacturers of DFLs with a wide selection of parameters**" also applies by minimising the need of operators to customise DFLs, which should further simplify the production process of the DFL decoding file and allow software vendors to re-use previously produced decoding files more easily.
UC5.1-OPS.5 - Lower quality of FDM events and measurements in the case of regional aircraft	**Previously defined solutions**	Solution "**UC5.1-SOL.3 - Develop a Flight Parameter Reference document for FDM**" applies by providing clear information over the capabilities in terms of parameters and performance of regional aircraft, when compared with those values established in the FPR document. In addition, it nudges manufacturers, including those of regional aircraft, towards further standardisation of parameters and their performance as recorded by their aircraft. Solution "**UC5.1-SOL.15 - Integration of manufacturers of smaller aircraft into the EOFDM forum**" applies by supporting manufacturers in communicating the specificities of their aircraft and operation, which should help software vendors and operators in defining higher quality events, measurements, and algorithms, better adapted to regional aircraft. Solution "**UC5.1-SOL.9 - Development of industry-agreed FDM algorithms and logics**" applies by enabling a platform, the Data4Safety programme, where manufacturers of regional aircraft can collaborate themselves in the definition of algorithms and logics, later shared and publicised across the wider FDM community.

5.1.4 Proposed solution packages

The potential digital solutions proposed in Section 5.1.3 have been strategically grouped into package solutions, drawing upon their commonalities and distinctive natures within the context of flight data processing for FDM. The first category, encompassed within 'Safety promotion'. pertains to topics that are yet to find comprehensive industry-wide guidance and thus demand the initiation of industry-defined standards and development of industry best-practices. The second category, 'Regulatory initiatives' involving Guidance Material or Acceptable Means of Compliance, represents topics that have reached a level of maturity suitable for integration

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into formal regulations. Lastly, the third category, 'Innovation & Technology Research', centres on topics that require further research or the development of new technologies. This categorisation enables a more focused approach to addressing the multifaceted challenges faced in flight data processing for FDM, ensuring that each package solution is tailored to its unique context and readiness for implementation.

Table 5-3 Solution package to address limitations of Use Case 5.1

Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
Solution package - Safety promotion			
UC5.1-PS.1 - Promotion of industry best-practices and technologies among industry stakeholders	• **UC5.1-SOL.5** - Install WQAR equipment on newly-manufactured smaller aircraft • **UC5.1-SOL.11** - Industry best-practices on contextual data fusion	**Aviation industry bodies and associations:** • Promote the adoption of best-practices across the aviation industry **Operators:** • Adopt on a voluntary basis, the best practice **Software vendors:** • Collaborate with operators to ensure that their data solutions provided align with best-practices **Aircraft and equipment manufacturers:** • Implement and adhere to the issued recommendations on installation of WQAR equipment • Promote usage and benefits of using WQAR equipment for FDM among their operators	
UC5.1-PS.2 - Integration of industry stakeholders into existing communication platforms	• **UC5.1-SOL.15** - Integration of manufacturers of smaller aircraft into the EOFDM forum	**EOFDM forum:** • Integrate new participants into the discussions held in each Working Group • Manage knowledge transmission within the forum to ensure maximum reach across the industry **Aircraft manufacturers:** • Participate in the discussions held within the forum • Conduct knowledge transmission activities towards other participants	
Solution package - Regulatory initiatives (Guidance Material or Acceptable Means of Compliance)			
UC5.1-PS.3 – Development of regulatory initiatives for performance of FDM programmes	• **UC5.1-SOL.2** - Set an objective for minimum data recovery • **UC5.1-SOL.7** - Conditions for minimum data analysis capabilities	**Regulatory authorities:** • Develop and implement the regulatory material (rulemaking process) **Operators:**	• Information on the time necessary for data retrieval and transmission, and total data retrieved

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Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
	• **UC5.1-SOL.8 -** Minimum list of risk areas to be monitored through FDM • **UC5.1-SOL.13 -** Maintaining knowledge and documentation on flight data and DFLs • **UC5.1-SOL.14 -** Maintaining knowledge and documentation on FDM events and algorithms	• Implement regulations into their processes, procedures and internal training **Software vendors:** • Update their software solutions to ensure compliance by operators • Provide information to operators as required on the updates **Equipment and aircraft manufacturers:** • Install airborne equipment that enables the implementation by operators	• Information on the time necessary for data processing, and total data processed • Documentation available from software vendors and manufacturers on DFLs, flight data, and algorithms used • Information on the algorithms and pseudocodes employed • Information on data integration algorithms or methodologies • Electronic documentation on the DFL
UC5.1 - PS.4 - Development of regulatory initiatives for DFL documentation	• **UC5.1-SOL.3 -** Develop a Flight Parameter Reference document for FDM • **UC5.1-SOL.6 -** Create the conditions for open access to DFL electronic documentation • **UC5.1-SOL.12 -** Addressing Intellectual Property Rights in FDM	**Regulatory authorities:** • Develop and implement the regulatory initiatives (rulemaking process) **Operators:** • Implement regulations into their processes, procedures and internal training **Software vendors:** • Update their software solutions to ensure compliance by operators • Provide information to operators as required on the updates **Equipment and aircraft manufacturers:** • Implement regulations into their processes and procedures	• Information on parameters used for FDM programmes, nomenclatures, performance, etc. • Information on proportion of customised DFLs in fleets and on documentation available • Information on electronic documentation safekeeping processes at the operator • Information on existing IPR claims within FDM • Information on DFL decoding file production process • Information on capacity to export DFL documentation in open formats • Information on process followed for DFL definition • Information on capacity to produce electronic DFL documentation
Solution packages – Innovation & Technology Research			

UC5.1-PS.5 - Initiatives to develop technical solutions to the collection of flight data	• **UC5.1-SOL.1 -** Recording of flight data in non-binary formats for safety use
	• **UC5.1-SOL.4 -** Definition by manufacturers of DFLs with a wide selection of parameters
		Regulatory authorities:
		  • Oversee and support research
		Equipment and aircraft manufacturers:
		  • Develop new airborne systems capable of recording flight data in non-binary formats for FDM use
			• Information on parameters used by operators for their FDM programmes and required performance
			• Information on progress of research developments into new data systems
			• Information on parameters captured for FDM programmes and their performance

Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
UC5.1-PS.6 - Initiatives to adopt digital capabilities on FDM events and fusion	• **UC5.1-SOL.9** - Development of industry-agreed FDM algorithms and logics • **UC5.1-SOL.10** - Establishment of open contextual data repository	**Data4Safety programme:** • Develop and publish contextual data repository, with adequate documentation and access points for use by operators and software vendors **Operators** • Use of contextual data from the Data4Safety repository for their FDM programmes **Software vendors** • Use contextual data from the Data4Safety repository for their software solutions	• Information on contextual data sources processed and available within the Data4Safety programme • Information on the algorithms and logics they use

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5.2 Use Case 5.2: Usage of flight data for FDM and other safety-relevant activities

Decoded and processed flight data has shown to be useful in several domains within aviation, both for uses that directly benefit the operator and others that may do so more indirectly. Among those relevant to safety, they range from FDM programmes to flight crew training or safety investigations, as shown in Figure 5-3. They are also used in other **flight data-based programmes** such as the maintenance programme, the fuel conservation programme, etc. In all such activities, however, data always remain subject to the data access policies agreed with flight crews, which ultimately conditions how and what can be done.

In the context of **flight data use in FDM**, the data is processed to identify events and measurements. These are analysed both individually and on aggregate, and serve as an input to the Safety Risk Management process, where safety risks are identified and assessed, and mitigation measures defined and monitored. For all these activities, flight data is a key component in enabling an objective understanding of the state of the aircraft and its surroundings.

As for **other safety-relevant activities**, flight data is processed using domain-specific logics and for different purposes. Their commonality resides in a common source of information that is flight data, and by how the current organisation of activities and responsibilities inherited from FDM may misalign with the needs and objectives of each safety-relevant use.

Finally, and transversal to all uses, flight data is subject to the **implementation of the data access policies** agreed between the operator and its flight crews. Different models are used across operators, in accordance with their particular policy and knowledge, but many elements are common and can have a determining impact on the usage of the data.

Based on this comprehensive process description, usage of flight data for FDM and other safety-relevant activities a can be divided into three (3) key activities, presented in Figure 5-2.

Figure 5-2 Process activity breakdown for Use Case 5.2

5.2.1 Working process activities and limitations

5.2.1.1 Analysis of FDM events and definition of mitigation measures

In continuity with the process presented in the previous Use Case, this activity focuses on the "classical" usage of flight data: validation and analysis of FDM events, and definition of safety measures of improvement, prevention and assurance.

This activity is described through the three analysis dimensions of Technology & Data, Organisation and Operations as follows.

Technology & Data description

The technology supporting this activity consists mainly on the FDM software containing the event analysis suite, the dashboards and 3D visualisations, the Safety Management System (SMS) software that integrates output from the FDM programme and other safety data, and the computer servers that provides the resources and the storage. Given that the hardware is a relatively generic equipment, non-specific to a FDM programme (or to the aviation industry), it will not be addressed in detail.

Hardware includes the computer server from where the FDM and SMS software draws the computational resources, and the computer server where decoded flight data, event information and other data is stored.

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Software includes:

- The FDM software, a specialized application for which the operator requires a license or subscription to use. The main capabilities of such software in the context of this activity include:
  - Presentation of information over an FDM event in a structured way to facilitate understanding of the context and potential causes, including time series representations of data.
  - Analysis tools for data manipulation, computation of new measurements and comparison with statistics from normal operations.
  - Generation of 3D visualisations on specific instances of the operation, including visualisation of both the aircraft state and the control panels.
  - Production, operation, and visualisation of dashboards with aggregate data from multiple operations, including statistics on FDM events and measurements.
  - Management of the computational resources used.

  Alternative software suites may be interconnected with the FDM software or used independently to support the analysis. These alternatives further develop on some of the capabilities of the FDM software when these are deemed insufficient, mainly in the themes of 3D visualisations of aircraft operation and on the production, operation, and visualisation of dashboards.
- The SMS software, a specialized application for which the operator requires a license or subscription to use. The main capabilities of such software in the context of this activity include:
  - Aggregation of safety information from multiple sources within the operator.
  - Recording of risk mitigation and safety improvement initiatives.
  - Recording of safety risk assessments.
  - Management of safety risk registers.
  - Management of the computational resources used.

  An FDM programme is destined to be integrated into the operator's Safety Management System (SMS), allowing to detect, confirm and assess safety issues and to check the effectiveness of corrective actions.

Data includes events, measurements, and all accompanying data and information, from contextual data previously fused, to the decoded flight data coming from the FDAU of the aircraft.

Organisation description

The organization of this activity generally results in a concentration of responsibilities and knowledge into one or two organisations, depending on the model followed. It results from the type of knowledge required to perform the activity (a combination of operational and safety-specific knowledge), and from the variability in the actual execution of the activity. Two main models of organising this activity exist:

- FDM team as single participant: Under this model of organisation, the FDM team is responsible for most tasks related with the execution of the activity, including the operation of the FDM software. The FDM team within the operator will require a higher headcount, as the workload increases, but will be able to ensure control over the analysis process and the criteria followed for validation, understanding and definition of mitigation measures.
- FDM team supported by service provider: In this model of organisation, part of the activity is executed by a service provider (generally the software vendor) contracted by the operator. It usually takes the form of an analyst that validates events, produces an initial assessment of its potential causes and also performs trend analysis. Some may also include participation in internal safety briefings and, if asked, provision of advice to the operator on potential approaches to address safety issues. The engagement

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with the SMS system of the operator, crew debriefings, and the definition, implementation and control of prevention remains the responsibility of the FDM team.

Finally, the IT department is responsible for the setup and monitoring of the infrastructure that supports the storage of data and the execution of the FDM and SMS software. These tasks can also be outsourced to a service provider, who may allow for the storage of data and analysis of events in their own computer servers as part of their SaaS offering.

Operations description

The analysis of FDM events and mitigation measures can be divided into two work streams, with a shared outcome. The first work stream consists of the individual validation and analysis of selected FDM events, where the causes and contributing factors are determined. The second work stream consists of the statistical analysis of events, where system-wide or case-specific trends are identified and reviewed. The common outcome is the definition of measures to prevent further events and improve safety in operations, which is produced and controlled in the context of the SMS system of the operator.

The **individual analysis of events** can be divided into the following steps:

- Event validation: Time series data on the event is reviewed, in combination with available information from ASRs and other data to validate if the event is a true positive or a false positive. In case of the latter, the event is marked as false, and the process ends. Not every FDM event is manually validated, as there may be many low-severity events which are only used for statistical analysis, but which do not require and immediate corrective or mitigation action.
- Severity and risk assessment: The analyst assesses the severity and risk of the event based on the event definition, which already incorporates multiple thresholds to reflect different severity levels. While FDM event severity level denotes the significance of the event based on the value evaluated, the risk is indicative of the actual operational risk which can only be assessed after contextualisation of the event with additional data. Therefore, safety risk assessment of events usually involves other skills than FDM and is performed under the responsibility of the operator's safety manager.
- Understanding of causes and contributing factors: The underlying factors and causes of the particular event are identified and reviewed, to serve as a baseline for the latter definition of improvement and mitigation measures. Additional information may be sought from conducting debriefings with flight crews, reviewing ASRs, reviewing 3D visualisations, gathering feedback from other operational teams, etc.

The **statistical analysis of events and measurements (trend analysis)** consists of the following steps:

- Definition and computation of metrics: A set of metrics is selected and developed to represent the temporal evolution of events and measurements across the fleet (e.g., event rates), as well as segregating by other characteristics (e.g., aircraft type, airport, etc.).
- Production and operation of dashboards: Dashboards are produced to facilitate the visualisation of the aforementioned metrics, and their temporal evolution.
- Trend analysis: Using the dashboards, metrics and other statistical tools, patterns, deviations, and recurring trends are identified and analysed to detect anomalies and anticipate adverse safety trends even before they trigger a higher-severity FDM event.

Finally, the FDM programme is an important data source for the **Safety Risk Management (SRM)** process of the operator, which covers the **identification of risks and definition of mitigation measures**:

- Identification of safety issues from the FDM events and measurements: Together with other sources of information (e.g., occurrence data captured by the operator, relevant risks from the European Plan for Aviation Safety, etc.), FDM is used to identify the main safety issues for the operator.

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- Assessment of safety issues: A comprehensive risk assessment is conducted for the safety issues identified, which allows for a deeper understanding of the issue and of the organization-wide implications.
- Definition of corrective measures: Measures are defined in accordance with the risks identified, their assessed impact, and aligned with the rest of safety measures.
- Implementation of corrective measures.
- Improvement monitoring: In coordination with the trend analysis, flight data and other relevant safety data continue to be monitored, to ensure the effectiveness of implemented measures. If necessary, adjustments are made to the mitigation strategies based on ongoing data analysis and feedback from operational experiences.

5.2.1.1.1 Technology & Data

The following limitations have been identified for this activity within the Technology & Data dimension:

- **UC5.2-TEC.1 - Lack of interoperability with complementary software solutions for FDM analysis:** The level of variability in terms of capabilities across FDM software is significant, as software vendors aim to differentiate their products from one another and there is no certification process for FDM software requiring any minimum capabilities. Operators are sometimes faced with the need to complement their main FDM software with additional capabilities from other software solutions (e.g., 3D visualisation engines, dashboarding software, etc.). Enabling interoperability between such software, however, is technically complex and, in some cases, expensive, which ultimately limits the options of operators to choose the tools they need for FDM analysis.
- **UC5.2-TEC.2 - Lack of integration of FDM software with SMS software:** Both the FDM and SMS software are key tools for the analysis of events and trends, and the definition of mitigation measures and their monitoring. Information must be shared across both systems to ensure FDM statistics and relevant safety information is available in the SMS software, and that information on the mitigation measures is shared from the SMS software to the FDM analysis suite to facilitate their control and evaluation. While some FDM software already allows for the exchange of data with SMS, such capabilities are not generalised. The end result is that operators must manage both software suites separately, and transfer information manually, which is less efficient and can be more prone to human error.

5.2.1.1.2 Organisation

The following limitation has been identified for this activity within the Organisation dimension:

- **UC5.2-ORG.1 - Factors hindering the build-up of FDM knowledge at operators:** Historically, the main model of organisation was that of the FDM team as the single responsible and participant entity, particularly in the case of bigger operators with big safety teams, the capacity to developed in-depth knowledge into FDM and data analysis, and the willingness to do so. The growth in the number of operators that have FDM programmes thanks to the introduction of the mandate to have an FDM programme for all aircraft with MTOW above 27 000 kg, coupled with the corresponding growth in service offerings by specialised firms (including software vendors), has helped democratise access to this knowledge, increasing the proficiency of operators in the field. Still, there remain limitations:
  - **UC5.2-ORG.1A - Variability in the level of competency of FDM analysts:** The level of competency in FDM within the industry is very variable, particularly among individual analysts on the operator side. Given the lack of a standard course or set of competencies required for FDM analysis or FDM programme management, many individuals lack the knowledge and experience required. This can result in a lack of understanding on the limitations of the data, bad practice on analysis of events and trends.

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- **UC5.2-ORG.1B - Limitations to knowledge transfer for FDM analysis:** Some software vendors and manufacturers make efforts to train and transfer knowledge to operators. Such efforts face limitations due to:
    - Lack of capacity in the operator side to absorb this knowledge, as safety departments are generally busy with daily operations and may not have learning and development processes established.
    - Lack of capacity in the manufacturer and software vendor side to create effective spaces and methods for knowledge transfer, as they generally must absorb the cost of this support which limits their size.
    - In many cases, knowledge transfer follows a reactive model, where the operator asks multiple questions and the service provider or manufacturer answers each individually. While some proactive approaches exist, such as training courses, seminars and forums, such public channels are less common.

5.2.1.1.3 Operations

The following limitations have been identified for this activity within the Operations dimension:

- **UC5.2-OPS.1 - Usage of multiple software solutions for the SRM process:** The analysis of events, causes and contributing factors, patterns, and the definition of proper responses, greatly benefits and in many cases requires the combination of many sources of information which, when pieced together, offer a comprehensive picture of the operation. To facilitate this process, the usage of technological solutions can automate many of the more cumbersome tasks of data aggregation. But, as has been commented already (see limitations **UC5.1-TEC.11**, **UC5.2-TEC.1, UC5.2-TEC.2**), information fusion and integration still faces limitations, ultimately impacting the actual operation by requiring the usage of many software solutions that are not interoperable, by requiring a lot of manual work to perform an analysis, and by blocking or delaying access to key information. This latter point is particularly impactful for FDM analysts that work for software vendors and provide an analysis service to operators, given that they have a comparatively lower access to internal operator process and information sharing than an analyst working for an operator.
- **UC5.2-OPS.2 - Difficulties in capturing useful contextual information for FDM event analysis:** The FDM programme, and thus the outcomes of the FDM analysis, are one of the inputs used in the SRM process. While analysis of FDM events can be very instructive and reveal safety risks by themselves, neither the practice has evolved much over the years (focus on events detected by exceedance algorithms with pre-determined threshold values) nor it can gather all the necessary information. For instance, the study of crew behaviours and human factor risk assessment can help explain the root causes of safety occurrences and provide a baseline to define mitigation measures, but is still not generalised for two main reasons:
    - The complexity of establishing causal relations between specific FDM events or trends and crew behaviours and human factors. Potential tools are still under development, including mapping diagrams of particular observable variations in FDM trends and potential causal factors that could be producing them.
    - Access to data sources that could facilitate the analysis is not possible due to lack of acquisition (e.g., fatigue data) or the regulatory constraints applicable to sensitive personal data (e.g., CVR data).

5.2.1.2 Implementation of data access policies

Under the current regulatory framework in EASA Member States, data access and security policies are integral to the usage of flight data by operators (see **Air Operations Regulation AMC1 ORO.AOC.130(j)***" The data access*

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and security policy should restrict information access to authorised persons. When data access is required for airworthiness and maintenance purposes, a procedure should be in place to prevent disclosure of crew identity."). The policies restrict information access to authorised persons and prevents unjustified disclosures of crew identity and are freely agreed by corporate and flight crew representatives to adapt to their needs and to the existing level of trust between both parties.

This activity, the implementation of data access policies, is conducted in a distributed manner across the different flight data-based programmes of an operator. Here it is captured as a programme-agnostic task, such that the limitations identified are relevant to all or most uses.

This activity is described through the three analysis dimensions of Technology & Data, Organisation and Operations.

Technology & Data description

The technology supporting this activity consists mainly of the software (from either FDM or other flight data-based programmes) that enables access to the data and holds the de-identification/re-identification algorithms, and the pilot self-assessment applications that flight crews can use to access their own flight data. Given that the hardware is a relatively generic equipment it will not be addressed in detail.

Hardware includes the computer server from where the flight data software draws the computational resources, the computer server where decoded flight data, event information and other data is stored, and the portable electronic device or other mobile computing device (i.e., tablet, smartphone) that allows the pilot to visualise their flight data.

Software includes:

- The FDM software or other software using flight data that enables access visualisation and manipulation of data. The main capabilities of such software in the context of this activity include:
  - System of account-level permissions to access, visualise and manipulate data, capable of restricting different users to different sets of data.
  - Algorithms for the de-identification and re-identification of decoded flight data, removing (or recovering) any identifiable information on the flight crew or flight to which the data relates.
  - Flexibility in configuring the access system to adapt to the different models and access policies used by operators.
  - Management of the computational resources used.
- The pilot self-assessment application, which facilitates flight crews access to their individual flight data in a mobile system, with accompanying FDM events, measurements and/or 3D visualisations, depending on the system.

Data includes all data that can be used to identify a specific flight crew and that is used within a flight data-based programmes. It can include different types of data depending on the level and the moment of de-identification that the operator has established, but usually includes: decoded flight data with information on the its origin (e.g., aircraft registration, date, etc.), individual events and measurements that contain information on the moment and aircraft where they occurred, and data previously fused as contextual data that may identify the crew (e.g., flight plan).

Organisation description

The implementation of data access policies is organised through the interaction of two different groups within the operator: the "corporate representatives" (e.g., safety manager, flight data team) and the flight crews and their representatives (e.g., individual crew members, flight crew unions). This organisation is the result of the regulatory framework, which considers some flight data elements to be personal information from the flight

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crews, mandates the non-punitive nature of flight data-based programmes, but maintains the ownership and right of use of the data with the operator. The roles and responsibilities of the different groups are:

- "Corporate representatives" (safety manager, flight data team or otherwise): The corporate representatives are responsible for the flight data access policies that shall be followed by the operator, and for controlling the effective implementation of the policies and the actual access to the data. In addition, these data access policies should be agreed by the flight crews or their representatives. Given they have a duty in enabling the use of flight data (which has evolved from only the FDM programme to other flight data-based programmes), they are also responsible for the communication with flight crews over the use of the data, and of ensuring the application of "Just Culture" principles.
- Flight crews and their representatives (crew members, unions, etc.): They should be involved in the definition and agreement of the data access policies of the operator, and in controlling the effective implementation of the policies. To do so, flight crews are usually represented by unions or other collective organisations, which negotiate on their behalf and have mechanisms available for control of the implementation. Their main interest is to ensure that their personal data is properly protected, and that it is not used in a punitive form.
- Honest broker (training manager, line pilot, etc.): The honest broker is a figure within the operator that facilitates the implementation of the flight data access policy by performing the crew contacts when required. Their position as a third-party broker, mutually acceptable to both flight crews and corporate representatives, eases the contact between parties (see **AMC1 ORO.AOC.130(k)(3)**).
- Finally, the IT department is responsible for the setup and monitoring of the infrastructure that supports the storage of data and the execution of the any software. These tasks can also be outsourced to the software provider.

Operations description

As the implementation of data access policies will always depend, to a certain degree, on the context where they are to be implemented, the actual operation of this activity has been divided into three examples: an FDM programme, a different flight data-based programme, and a pilot self-assessment application.

- Within an **FDM programme**, the FDM team will need to contact flight crews after a severe FDM event to debrief with them, have them file an ASR if needed, and obtain additional information on any particular event. While the model by which this contact is established can vary a lot from operator to operator, the most common system is that of the gatekeeper. The gatekeeper, usually a flight crew representative or other senior flight crew figure, serves the role of intermediary between the FDM team and flight crews, so that the former does not have access to the identity of the latter. Alternatively, some FDM teams do have access to identifiable data, but have strict controls on its use and ability to share it. Such systems are procedure-based, and can impact processes in other areas (e.g., participants to an FDM investigation cannot serve any training or supervisory role over crews under investigation).
- For **other flight data-based programmes** than FDM, the actual access to data is more complex. Most of these programmes have been initiated later than the FDM programme, which has resulted in a prevalence of the latter over the former, and in most data access policies only allowing access to de-identified data for the FDM programme. Thus, operators have devised different modalities to be able to use the data for fuel management, continuing airworthiness, and others, which may be used separately or in conjunction:
    - Non-disclosure agreements (NDAs): The flight data-based programme team signs an NDA with the FDM team in order to access the data, even when this data is transmitted in a de-identified format (data remains sensitive once de-identified).

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  - Delayed delivery of data with flight filtering: Flight data-based programmes other than the FDM programme have access to flight data but delayed in time (2-3 weeks) to ensure ample time for the FDM programme to eliminate any sensitive flights.
  - External processing of flight data: flight data-based programmes other than the FDM programme do not have access to either raw or decoded flight data, with all processing outsourced to a third party. These other flight data-based programmes receive the end reports and aggregated results.
- **Pilot self-assessment applications** automatically receive data from the FDM programme or other flight data-based programmes as soon as it is ready for release, already filtered to show each individual pilot only their own data. Applications usually use a login-based system to ensure proper protection of data from device tampering, and may show different information depending on the particular capabilities of the software and the data access policy of the operator.

5.2.1.2.1 Technology & Data

The following limitation has been identified for this activity within the Technology & Data dimension:

- **UC5.2-TEC.3 - Software solutions not capable of enabling the operator's data access policy:** The differences between definitions and implementations of particular data access policies are significant. Additionally, they may evolve as new agreements between operators and their flight crews come into force. Thus, software vendors must produce flexible solutions capable of adapting to the needs of each operator, which increases the complexity and cost of their developments. While most software solutions can adapt, particular conditions may be significantly limiting and even preclude the usage of a specific software solution (e.g., requirements for storage of flight data only in-house or in computer servers within the operator's country of residence may not be possible for some cloud-based solutions, as the tool may only be deployed in the software vendor private cloud, or may require a cloud provider not available within the specific country).

5.2.1.2.2 Organisation

The following limitations have been identified for this activity within the Organisation dimension:

- **UC5.2-ORG.2 - Obsolete flight data access policies:** Historically, flight data was used only in FDM programmes, with very restrictive access and use. While both operators' and flight crews' perceptions on the value of flight data have progressively changed, with a bigger emphasis on openness and on generating safety benefits for both crews and operators, data access policies remain anchored to FDM programmes. Resulting from the lack of preparedness over digitalisation across both operators and flight crews and their representatives, this situation presents multiple limitations:
  - **UC5.2-ORG.2A - Complex compliance with internal flight data access policies:** Some operators have pushed ahead with internal developments that depend on flight data but that are not addressed in data access policy agreements. In order to comply with the established policies, they must maintain additional systems of de-identification and data sharing that complicate the use of the data and limit the potential benefits (e.g., requirement of crew consent for safety studies aimed at producing safety promotion material even if data will not be identifiable).
  - **UC5.2-ORG.2B - Limitations to external flight data usage from data access policies:** Demand for data has grown outside operators. From industry-wide data exchange programmes that enable new benchmarking capabilities for operators, both for safety-related metrics and other operational concerns (e.g., fuel consumption), to authority or academia-driven safety studies on particular matters, more external stakeholders request flight data from operators for legitimate reasons. In parallel, the operation can benefit from sharing data by enabling new uses outside their field of expertise, and by pooling resources with other stakeholders.

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Restrictive data access policies and inadequate data governance frameworks, however, can become an impediment to sharing flight data outside the operator.

- **UC5.2-ORG.3 - Lack of trust impacting agreements on data access policies:** The level of trust existing between flight crews and operators influences data access policies. Lack of trust can result in more cumbersome policies, with less flexibility to adapt to the new uses and less efficiency in the use of flight data (e.g., usage of a gatekeeper can generate inefficiencies in data analysis), and can affect the actual behaviour of flight crews (e.g., flight crews flying within some artificial limits to avoid triggering FDM events, which may impact aircraft performance).
- **UC5.2-ORG.4 - Buy-in of pilot self-assessment applications based on flight data**: The usage of pilot self-assessment applications, how they must be implemented, and which data should be available remains a contentious topic:
    - Its proponents defend their capacity to enable pilot self-debriefing, improve training and aircraft operation through objective evaluation of the operation, and provide access to flight data to a more data-literate population than in the past.
    - Its detractors consider that competitive tools can generate perverse incentives that impact operation safety (e.g., competition between pilots on who used the least amount of fuel), and that presenting data (e.g., flight data, events, 3D animations) without validation and contextualisation can be a hazard if it affects the focus of the flight crew or result in misinterpretation of the data.
- While some stakeholders (e.g., IFALPA) have published their position on how these applications should be used and defined, and software vendors have adapted to different degrees their offering to fulfil the different demands, their usage remains constrained as pushback remains.

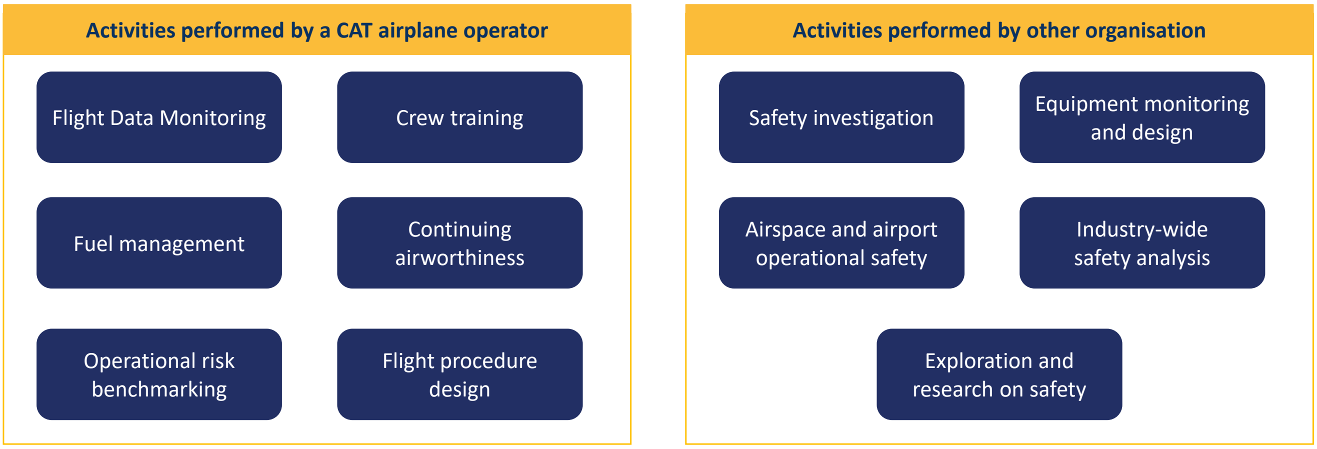
5.2.1.2.3 Operations

No limitations have been identified for this activity within the Operations dimension.

5.2.1.3 Usage of flight data for other safety-relevant activities

Beyond FDM programmes, flight data can be used in many safety-relevant activities to either improve the overall safety level of the operation or to reduce costs. These activities are not restricted to the operator, with other stakeholders capable of producing safety products to address their own needs or those of the industry more broadly (e.g., large data exchange programmes). Figure 5-3 shows a selection of the most significant current uses of flight data, separating between those performed within the operator and those conducted by other organisations.

Figure 5-3 Safety-relevant activities that use flight data



Each of these safety-relevant activities uses flight data for different purposes and in different ways:

- Flight Data Monitoring: Flight data is used for safety occurrence identification and analysis, and to monitor the effectiveness of risk mitigation measures. Examples include the detection of unstable approaches to an airport, the severity of such approaches, and, in the context of the Safety Risk Management (SRM) process, the evaluation of its risk.
- Crew training: Flight data is used for safety promotion and awareness and in the context of Evidence Based Training (EBT) programmes. Additionally, techniques used in flight data analysis can be used to work with simulator data. In the context of the Evidence-Based Training (EBT) programmes, for example, flight data is used for adapting the training topics and contextualising the training scenarios to better address the operators' and trainees' identified training needs based on the analysis of such data.
- Fuel management: Flight data is used for the definition of the safety baseline and for continuous monitoring in performance-based fuel schemes. For example, an operator may monitor fuel levels throughout the flight using flight data, and correlate it with the type of operation, to produce the safety baseline.
- Continuing airworthiness: Flight data is used to evaluate if an aircraft complies with its airworthiness requirements by identifying structural limit exceedances during operation and by supporting maintenance troubleshooting.
- Operational risk benchmarking: Flight data is used for comparative analysis of operational safety metrics in relation with the wider industry. For instance, large data exchange programmes generally enable operators to compare their safety performance on standardised metrics with the wider community within the programme, which serves to contextualise their performance amongst their peers. These standardised metrics are computed using flight data from the operators.
- Flight procedure design: Flight data is used for assessment of optimum flight procedures and issuance of guidance to flight crews. For example, flight data can be used to identify procedures that present higher rates of safety occurrences, analyse why, and produce new designs that address the present issues.
- Safety investigation: Flight data is used to better understand the events leading to the safety occurrence. In particular, flight data captured in the Quick Access Recorder and not included in the Flight Data Recorder can be used to gain access to a wider set of flight parameters, and to perform a comparative analysis of flight data for that specific aircraft type or operation.
- Equipment monitoring and design: Flight data is used to identify safety systems in the aircraft that may present issues and improve their design. For instance, a manufacturer may look at deviations between parameters, or at reported values for specific moments of the operation, that can serve to identify issues in equipment design and address them.
- Airspace and airport operational safety: Flight data is used for safety assessment at airport and airspace level by ATC or airport operators. For example, an airport operator can use data on thrust levels during taxi to identify taxiways or other areas with higher risk of pavement wear.
- Industry-wide safety analysis: Flight data is used for analysis of collective safety risks for aviation stakeholders through the aggregation of safety occurrences. The clearest examples are the large data-exchange programmes (e.g., EASA’s DATA4SAFETY, the FAA’s ASIAS), where standardised FDM-based indicators are computed using flight data from many operators.
- Exploration and research on safety: Flight data is used for ad-hoc research initiatives by public and private institutions and organisations. For example, a research group at a university may use flight data

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from an operator to investigate the potential usage of Machine Learning algorithms to identify safety occurrences without using pre-defined events.

Given that flight data is used in multiple safety-relevant activities, each with its set of domain-specific challenges that may fall outside the scope of this study, the limitations captured here are defined in an activity-agnostic form such that they remain relevant to all or most uses.

This activity is described through the three analysis dimensions of Technology & Data, Organisation and Operations.

Technology & Data description

The technology supporting these safety-relevant activities consists mainly of the software that enables access to the data and holds all domain-specific algorithms used to process it, and the flight data itself. Hardware is relatively generic, consisting of computer servers capable of supporting the aforementioned software, and, for crew training, flight simulators, which are not addressed in detail.

Hardware includes the computer server from where the domain software using flight data draws the computational resources, the computer server where raw or decoded flight data and any other data is stored, and domain-specific equipment, including flight simulators used for flight crew training. Data from such simulators can be processed by FDM software, or be otherwise related with flight data for comparative analysis.

Software includes:

- All relevant algorithms required both for processing of flight data (i.e., flight splitting algorithms and similar, as explained in section **Technology & Data**) and for the production of relevant outputs in each of the specific domains (e.g., prediction of faulty components in continuing airworthiness, or computation of optimal fuel load in fuel management).
- The domain-specific software (e.g., digital fuel management software, flight procedure design and simulation software) that can make use of flight data. The main capabilities of such software in the context of this activity generally include:
    - Decoding of raw flight data into engineering values, or interpretation of decoded flight data exported from other software solutions (with all the specific capabilities it entails regarding DFL interpretation and flight data decoding, as explained in section **5.1.1.3.1 Technology & Data**).
    - Processing of decoded flight data for the specific purposes of the software, which may include fusion of additional data sources, detection of events, computation of statistics or other types of analysis (with all or part of the capabilities required to enable processing of decoded flight data, as explained in section **5.1.1.4.1 Technology & Data**).
    - Generation of relevant outputs, which may include dashboards, 3D visualisations, technical documentation, work orders for maintenance teams, or other types of numerical results (including some of the capabilities explained in section **5.2.1.1.1 Technology & Data**).
    - Data access control mechanisms to ensure compliance with the operator's data access policies, even when the data is used by external organisations (including some of the capabilities explained in section **5.2.1.2.1 Technology & Data**).
    - Management of the computational resources used.

Data includes:

- Flight data originating in the FDAU, including either the raw flight data, or the decoded flight data as and the resulting list of unique flights already split.

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- Additional sources of data not stored in the QAR but captured within the aircraft (e.g., ACARS fuel reports, ACMS data).
- Other data recorded or produced outside the aircraft, which can include weather data through METAR, operational data from flight plans, maintenance data, engine fuel consumption rates and emissions rates, etc.

Organisation description

The usage of flight data for safety-relevant processes beyond FDM is organised differently depending on the type of use, the participating organisations and the relationship between them. In this case, knowledge over the specific domains is very dependent on the use, and does not necessarily follow the same pattern as the actual organisation of activities. Models of organisation can be classified by the role of the operator:

- Internal activities where the product of flight data use results in a direct benefit to the operator, be it in improved safety or more efficient operation, are characterised by:
    a. Operator-vendor relationships, where a software vendor provides the tools, the expertise and, sometimes, the service, are similar to those presented in sections **5.1.1.3 Decoding flight data into engineering values** and **5.1.1.4 Implementation of FDM events and measurements** for FDM.
    - Relationship between FDM team and the other domain-specific team (training, maintenance, etc.). In these relationships, the FDM team provides access to flight data (raw or decoded) or develops the data products (i.e., reports, analysis and aggregated data) that are used by the other domain-specific teams.
- External activities where the result benefits another organisation only, or both other organisations and the operator, follow different models depending on the balance of power and the incentives that the operator has to participate in these activities:
    - Collaborative models are followed in activities such as large data exchange programmes, research programmes, or engagements with airports and ANSPs. In such cases, the operator has a significant degree of freedom as the data owner, and might be either persuaded to participate through incentives or to selflessly support aviation safety. The operator maintains a significant degree of control over the data and its use, and profits from the knowledge developed and value created from it.
    - Supplier-operator models may be followed in some data exchange programmes and data collection activities, when the supplier can provide deep expertise and support not available to the operator (such as large aircraft manufacturers with most operators, or software vendors with very small operators). The operator trades part of its control over the data in exchange for the expertise and support from the supplier.
    - Regulatory compliance models are followed mainly for official safety investigation tasks and, a small minority of cases, large data exchange programmes or other research programmes led by an authority and with mandatory participation. The model predicates in the operator complying with the established regulations and ceding control of the data for the specific uses required.

Operations description

The actual operation of each of the different activities will be heavily dependent on the expected products, information or other outcomes expected from it. Within that variability, however, some common steps are required in order to prepare flight data for further use, which can be differentiated into two paths depending on whether flight data must be decoded or not:

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If **flight data must be decoded**, the operation can be divided in the following steps:

- Data selection, DFL selection and decoding of data: The specific binary data stream to be decoded is retrieved from storage, the appropriate DFL decoding file selected, and the instructions of the DFL decoding file followed to convert the binary data to engineering values (equivalent to the process followed in **5.1.1.3.3 Operations**).
- Data processing and usage: In the context of each specific domain, flight data is processed in order to extract the relevant information and/or data points necessary for the purposes of the activity. For instance, a benchmarking tool from a large data exchange programme will compute a series of common events with data from multiple operators, generate a set of statistics, and present them for use in a comparative analysis.

If **decoded flight data can be accessed**, the operation will require the following steps:

- Reception and interpretation of data: The specific data stream to be processed is either retrieved from storage or requested from another software tool that has previously decoded it (usually from the FDM software). The data is parsed and internally reconstructed from the storage or transmission format into the necessary one for further processing.
- Data processing and usage, equivalent to the step presented above for cases where flight data must be decoded.

5.2.1.3.1 Technology & Data

The following limitations have been identified for this activity within the Technology & Data dimension:

- **UC5.2-TEC.4 - DFLs not fully adequate for other uses of flight data than FDM:** Neither the set of necessary parameters nor their optimal performance are shared across different use cases of flight data. The historic prevalence of FDM over other uses has resulted in many activities adapting to whatever flight data is available, or requiring the addition of new parameters in the DFL. Still, constraints in terms of capacity in the DFL (see limitation **UC5.1-TEC.2**) and in parameters available for recording has resulted in limitations to the usage of flight data beyond FDM, particularly when external specifications need to be met (such as for large data exchange programmes or for fuel management).
- **UC5.2-TEC.5 - Lack of integration of software solutions across uses of flight data:** The level of integration between different software solutions that use flight data is low, which introduces additional complexity into the process and increases both costs and complexity. This lack of integration can be attributed to multiple factors, ranging from the technical complexity of stablishing formats for sharing data (e.g., software for flight procedure definition with software for fuel management) to specific policies that restrict access to the data (e.g., connection of FDM software with flight simulators). In extreme cases, operators may be blocked from using flight data for activities where they already have a hardware provider without software capabilities nor integrated solutions from other vendors (e.g., continuing airworthiness of engines without manufacturer software and data files in proprietary format with, potentially, manufacturer encryption).
- **UC5.2-TEC.6 - Lack of common definitions across uses of flight data:** While the particular use of flight data in the different safety-relevant activities will depend on the specific use case at hand, the data ultimately refers to the same flights, the same recordings of sensor data and the same changes to the environment or the state of the aircraft. Without harmonisation of definitions, operators can find themselves with differing definitions, logics or algorithms for the same flight concepts, blocking interoperability between activities, efficient information sharing and knowledge capitalization (e.g. different definitions of what represents a take-off in fuel management and in FDM).

5.2.1.3.2 Organisation

The following limitations have been identified for this activity within the Organisation dimension:

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- **UC5.2-ORG.5 - Limitations to maintaining the FDM team in a central role for any use of flight data:** In the context of safety-relevant activities performed within the operator and where flight data is used, the FDM team can maintain a significant role in controlling such data and providing support to other teams. It results from both the restrictions imposed on data access (see limitation **UC5.2-ORG.2.2**) and the experience FDM teams have over flight data use. This, however, can be a limitation for teams performing these safety-relevant activities, as their freedom to adapt flight data and resulting products to their specific needs may be curtailed. In parallel, it places the burden of support on the FDM team, who may not have the capacity or resources to support other teams or address their requests at the necessary level to fully realize the benefits from these activities. Finally, it can limit the learning process of other teams and, at the same time, prevent FDM teams from learning from others (as few knowledge on flight data is generated independently from the FDM team).
- **UC5.2-ORG.6 - Limitations to the collaborative model for use of flight data outside the operator:** The collaborative model is based on the operator usually providing data to a third party and receiving a direct or indirect benefit in exchange. These can range from new capabilities that could not be obtained otherwise (e.g., benchmarking in a large data exchange programme) to access to new safety knowledge (e.g., specific studies conducted by a research institute) or to support relevant stakeholders for the operator in their safety needs (e.g., airports, regulators, partner operators), etc. This model, while very positive in its capacity to enable new uses of flight data, presents three main limitations:
  - It disincentivises the organisation receiving the data from establishing strict conditions (in terms of resolution, available parameters, responsiveness of the operator, etc.) in order to remain attractive for operators, which can impact the overall result of the collaboration.
  - For large data exchange programmes or research initiatives, collaborations can present conflicting incentives in having to provide short-term benefits and results to operators and other stakeholders, when many of the benefits will be realised long-term by building a fully-featured programme. Depending on how the collaboration is defined, it can be difficult to convince operators to share data.
  - The proper governance framework and environment must be put in place to ensure that operators are confident in sharing the data.

5.2.1.3.3 Operations

The following limitations have been identified for this activity within the Operations dimension:

- **UC5.2-OPS.3 - Processing of flight data by the FDM programme not adapted to other safety-relevant activities:** While the traditional use of flight data for FDM has resulted in different configurations for the collection, transmission and decoding of flight data, these models of operation are not always adequate for other uses. Delays to the transmission and decoding of flight data, which can be allowed in FDM with some margin, can have an outsized impact on continuing airworthiness, while filtering out data during engine start-up and pushback may be viable for FDM but not for fuel management. Thus, the lack of adaptation and rigidity of processes to new uses can reduce the effective benefits that can be derived from them.

UC5.2-OPS.4 - Duplication of flight data decoding activities for other uses: Decoding flight data is a complex process requiring expertise and significant resources, while benefiting from capitalising on past developments. Given these conditions, there is a clear benefit for operators to centralise decoding with one supplier and share it with the rest. Still, many software vendors and other organisations (e.g., large data exchange programmes) require their own decoding of the data, as it guarantees them the control over the process, the quality check followed, minimises dependence on other vendors and avoids IPR conflicts. The result is the duplication of efforts for decoding and a resulting higher cost for both software vendors, operators and other organisations using their flight data (see limitation **UC5.1-OPS.4**).

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5.2.2 Limitations overview

As seen throughout the challenges description, the usage of flight data for FDM and other safety-relevant activities brings forth a set of challenges and limitations that manifest across various operational dimensions. This section presents a consolidated overview of all identified challenges, systematically categorized into the three fundamental categories (Technology & Data, Organisation, and Operations), and classified according to their corresponding process activity.

Table 5-4 Overview of limitations identified for Use Case 5.2

Use Case 5.2: Usage of flight data for FDM and other safety-relevant activities			
Activity	**Limitations**		
	Technology & Data	**Organisation**	**Operations**

Analysis of FDM events and definition of mitigation measures	• UC5.2-TEC.1 - Lack of interoperability with complementary software solutions for FDM analysis
	• UC5.2-TEC.2 - Lack of integration of FDM software with SMS software
		• UC5.2-ORG.1 - Factors hindering the build-up of FDM knowledge at operators
		  ○ UC5.2-ORG.1A - Variability in the level of competency of FDM analysts
		  ○ UC5.2-ORG.1B - Limitations to knowledge transfer for FDM analysis
			• UC5.2-OPS.1 - Usage of multiple software solutions for the SRM process
			• UC5.2-OPS.2 - Difficulties in capturing useful contextual information for FDM event analysis

Implementation of data access policies	• UC5.2-TEC.3 - Software solutions not capable of enabling the operator's data access policy	• UC5.2-ORG.2 - Obsolete flight data access policies
		  ○ UC5.2-ORG.2A - Complex compliance with internal flight data access policies
		  ○ UC5.2-ORG.2B - Limitations to external flight data usage from data access policies
		• UC5.2-ORG.3 - Lack of trust impacting agreements on data access policies
		• UC5.2-ORG.4 - Buy-in of pilot self-assessment applications based on flight data	

Usage of flight data for other safety-relevant activities	• UC5.2-TEC.4 - DFLs not fully adequate for other uses of flight data than FDM • UC5.2-TEC.5 - Lack of integration of software solutions across uses of flight data • UC5.2-TEC.6 - Lack of common definitions across uses of flight data	• UC5.2-ORG.5 - Limitations to maintaining the FDM team in a central role for any use of flight data • UC5.2-ORG.6 - Limitations to the collaborative model for use of flight data outside the operator	• UC5.2-OPS.3 - Processing of flight data by the FDM programme not adapted to other safety-relevant activities • UC5.2-OPS.4 - Duplication of flight data decoding activities for other uses

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5.2.3 Proposed digital solutions to address limitations

In an effort to address the various limitations previously identified and described throughout the sections dedicated to each of the activities of the Use Case 5.2, a set of solutions have been proposed, which are presented and described in the following table:

➡ **Table 5-5** Proposed solutions identified for Use Case 5.2

Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities		
Limitation	**Solution**	**Description**
UC5.2-TEC.1 - Lack of interoperability with complementary software solutions for FDM analysis	**UC5.2-SOL.1** - Define minimum FDM software capabilities	Define the minimum capabilities that an FDM software should have to fulfil its purpose as a flight data processing and safety analysis tool. Given the current lack of certification process of FDM software, the guidelines should provide a list of capabilities that would be advantageous for the software. These capabilities could include, among others: • Capacity to export FDM events and measurements in an open format. • Capacity to replay flight data in a flight animation. • Capacity to display aggregated and individual information on summary reports or dashboards. • Capacity to exchange information with the SMS software in an open format.[3] The objective is that software vendors incorporate such capabilities into their FDM software. They may either decide to develop this capability internally (which voids the need to interoperate in the context of this limitation) or to supplement their software with solutions offered by a different provider (which will require enabling interoperability between solutions by technological means that can be reused with many other vendors, decreasing the unit cost of enabling each connection).
UC5.2-TEC.2 - Lack of integration of FDM software with SMS software	**Previously defined solution**	Solution "**UC5.2-SOL.1 - Define minimum FDM software capabilities**" applies by helping software vendors to facilitate the exchange of data between their FDM software and the SMS software of the operator.
	UC5.2-SOL.2 - Technical standards for FDM-SMS integration	Produce technical standards on how to exchange data between FDM and SMS software. The initiative shall determine which information should be transferred between both software solutions (e.g., monitoring targets from SMS to FDM, event rates from FDM to SMS), the format of the data and the protocols to be used in the data exchange. By developing such standards, the technical limitation on integration will be significantly mitigated, as software vendors will not have to develop custom integrations for each other's software.
	UC5.2-SOL.3 - Industry best-practices on FDM-SMS integration	Find solutions to increase the level of awareness and implementation of "Breaking the Silos: Fully integrating Flight Data Monitoring into the Safety Management System" document produced in the context of the EOFDM forum as industry best-practices. Among other topics, the document covers practical information on the organisational integration of FDM into SMS, including the competences of each team, benefits of such integration, and examples on how it can be done.

[3] There is currently no standardised data format for SMS software. Solving this issue goes beyond the scope of FDM programmes.

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Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities		
Limitation	**Solution**	**Description**
		By promoting industry best-practices, operators across the industry are exposed to new ideas on the importance and potential methodologies to ensure integration between both systems on an organisational and practical level.
UC5.2-TEC.3 - Software solutions not capable of enabling the operator's data access policy	**UC5.2-SOL.4** - Industry best-practices on data access policies for FDM	Re-edit the "Preparing a Memorandum of Understanding for an FDM programme" document, produced in the context of the EOFDM forum in 2015 (with a re-edition in 2017), incorporating updated best-practices and new topics of concern (e.g., storage of flight data outside the operator, usage of flight data beyond FDM, individualised reporting tools). Promotion of the same document among flight crews and operators. While it remains up to the flight crews and operators to agree on any change to a data access policy, providing them with objective information on best practices and alternative solutions will aid them in eliminating technologically-limiting conditions where relevant. Nonetheless, the organisational and social dimension takes precedence over the technical within a reasonable limit, and it will be up to software vendors to work around the most limiting conditions.
UC5.2-TEC.4 - DFLs not fully adequate for other uses of flight data than FDM	**Previously defined solutions**	Solution "**UC5.1-SOL.4 - Definition by manufacturers of DFLs with a wide selection of parameters**" addresses this limitation by increasing the overall number of parameters captured in the aircraft, thus mitigating the need to add new parameters or of them not being adequate for other uses beyond FDM. Solution "**UC5.1-SOL.1 - Recording of flight data in non-binary formats for safety use**" applies by developing new systems for data collection and retrieval that are not dependent on the FDR or constrained by binary data standards.
UC5.2-TEC.5 - Lack of integration of software solutions across uses of flight data	**UC5.2-SOL.5** - Define cross-domain data formatting standards	Develop cross-domain data formatting standards, ensuring cross-interoperability of data in software solutions for different safety-relevant activities. These set of documents should include: • Standardised data formats for the main data outcomes in each domain, encompassing data structure, attributes, and naming conventions. • Insights into mapping data attributes across different data sources. • Other potential components such as aligning data granularity across sources to ensure different sources can be merged without loss of essential details.
UC5.2-TEC.6 - Lack of common definitions across uses of flight data	**UC5.2-SOL.6** - Explore flight data governance and concept mapping across flight data-based programmes	Explore the possibilities to map reference concepts across domains and processes within the operator to facilitate alignment across its multiple teams using flight data. The scope should include: • A reference mapping of concepts and definitions across different domains, of usual methodologies followed in each domain (e.g., algorithms, statistical analysis, etc.), existing needs in terms of data availability, quality, etc. and potential alignments. • Processes for data governance at the operator, including information sharing across teams and capitalisation of knowledge from different domains.
UC5.2-ORG.1 - Factors hindering the build-up of	**UC5.2-SOL.7** - Certification of FDM analyst competency	Develop a system of evaluation and certification of FDM analyst competency, establishing a curriculum and an examination process through a collaborative process with relevant industry stakeholders. Topics should include: • Knowledge on the data collection, decoding and quality assurance processes.

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Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities		
Limitation	**Solution**	**Description**
FDM knowledge at operators		• Flight data characteristics and limitations. • Flight phase, event and measurement definition, implementation, and computation. • Analysis of individual events and trends, including identification of causal factors. • SMS implementation and the SRM process. This solution addresses limitation "**UC5.2-ORG.1A - Variability in the level of competency of FDM analysts**" by ensuring that the body of analysts across the industry achieves a shared level of understanding on best practices and minimum knowledge.
	Previously defined solutions	Solution "**UC5.1-SOL.15 - Integration of manufacturers of smaller aircraft into the EOFDM forum**" addresses limitation "**UC5.2-ORG.1B - Limitations to knowledge transfer for FDM analysis**" by: • Converting insights from manufacturers into practical best-practices that can be easily absorbed by operators, while framing it as an "industry best-practice" instead of a "recommendation from a supplier". • Pooling resources from multiple stakeholders, which can add capacity and support manufacturers in the process. • Pooling knowledge from multiple stakeholders, creating a public forum of discussion where knowledge can be transferred on a proactive basis.
UC5.2-ORG.2 - Obsolete flight data access policies	**UC5.2-SOL.8** - Address data access policies for other uses of flight data	Develop best-practices on organisation, methods and data access policies compatible with different uses of flight data outside FDM while ensuring non-disclosure of crew identity. This document should include: • A list of activities using flight data for safety-relevant purposes, and the requirements in terms of data access and identification of specific flights. • The main models of data access policies, how they interact with the aforementioned requirements, and how to adapt them without changing the essential mechanisms of the model. By producing this document and distributing it across operators and flight crew representatives and associations, all parties will be better informed on the pros and cons of each model and can adapt their data access policies to their needs.
UC5.2-ORG.3 - Lack of trust impacting agreements on data access policies	**Previously defined solutions**	Solutions "**UC5.2-SOL.4 - industry best-practices on data access policies for FDM**" and "**UC5.2-SOL.8 - Address data access policies for other uses of flight data**" shall represent an effort of transparency and objective evaluation of the different models for data access policies and topics of present relevance. While the level of trust between operators and flight crews will always depend on their day-to-day interactions, providing objective information to both parties on best practices can help them evolve into a trust-based environment.
UC5.2-ORG.4 - Access to data through pilot self-assessment applications	**Previously defined solution**	Solution "**UC5.2-SOL.4 - industry best-practices on data access policies for FDM**" shall address this limitation by establishing a consensual opinion on individualised reporting of flight data that can address remaining doubts or concerns on the implementation of such applications.
UC5.2-ORG.5 - Limitations to	**Previously defined solutions**	Solutions "**UC5.2-SOL.5 - Define cross-domain data formatting standards**" and "**UC5.2-SOL.6 - Explore flight data governance and concept mapping across flight data-based programmes**" apply to this limitation by producing

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Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities		
Limitation	**Solution**	**Description**
maintaining the FDM team in a central role for any use of flight data		documentation and knowledge that can be accessed by teams other than the FDM, giving them more independence and their own platforms for knowledge sharing. Solution "**UC5.2-SOL.7 - Certification of FDM analyst competency**" also addresses this limitation by democratising access to FDM knowledge. With an external certification to pass, it is not necessary to be part or have experience in an FDM team in order to acquire knowledge on flight data and FDM. While the depth of expertise between a practicing expert and a certified analyst without experience will be wide, it represents a base on which to build.
UC5.2-ORG.6 - Limitations to the collaborative model for use of flight data outside the operator	**UC5.2-SOL.9** - Industry best-practices for sharing flight data in collaborative frameworks	Best-practices on how to structure a collaboration between operators and other entities, accounting for the experiences of both parties and finding a middle ground. It should include: • Roles and responsibilities of each member of the collaboration. • Governance mechanisms. • Possible collaboration roadmaps and how to agree on short-term and long-term goals. • Typical environments of development. • Management of data access.
UC5.2-OPS.1 - Usage of multiple software solutions for the SRM process	**Previously defined solutions**	Solutions "**UC5.2-SOL.1 - Define minimum FDM software capabilities**" and "**UC5.2-SOL.2 - Technical standards for FDM-SMS integration**" address this limitation by enabling and facilitating the use of technological means to improve the execution of analysis, eliminating the need to use multiple independent systems.
UC5.2-OPS.2 - Difficulties in capturing useful contextual information for FDM event analysis	**UC5.2-SOL.10** - Industry best-practices on FDM causal factor analysis	Develop a list of frequent causal and contributory factors to the most relevant FDM events (e.g., those outlined in the European Plan for Aviation Safety), to serve as a reference and support document for analysis of FDM events and identification of root causes. It should include: • A list of frequent contributory or causal factors, categorised by their origin (e.g., environmental, human, technical, etc.). • Mapping between FDM events or trends and causal factors, including criteria to confirm if the existence of a causal relationship and data necessary
UC5.2-OPS.3 - Processing of flight data by the FDM programme not adapted to other safety-relevant activities	**Previously defined solutions**	Solution "**UC5.2-SOL.6 - Explore flight data governance and concept mapping across flight data-based programmes**" covers the organisational requirements of the different domains utilising flight data, serving as a base from which different teams within the operator can discuss how to adapt current process to serve everyone's interests.
UC5.2-OPS.4 - Duplication of flight data decoding activities for other uses	**Previously defined solutions**	Solution "**UC5.2-SOL.6 - Explore flight data governance and concept mapping across flight data-based programmes**" covers the data quality requirements of the different domains utilising flight data, serving as a base from which different teams within the operator can agree on a common data quality framework.

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Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities		
Limitation	**Solution**	**Description**
		Solution "**UC5.1-SOL.12 - Addressing Intellectual Property Rights in FDM**" addresses the topic of IPR and, depending on the result, may remove it as an incentive to duplicate decoding. Solution "**UC5.2-SOL.5 - Define cross-domain data formatting standards**" addresses the technical element of having flight data available in an interpretable format. Alternatively, solution "**UC5.1-SOL.6 - Create the conditions for open access to DFL electronic documentation**" can partially address this limitation by decreasing the cost of producing DFL decoding files and, thus, the cost of decoding data.

5.2.4 Proposed solution packages

The potential digital solutions proposed in Section 5.2.3 have been grouped into solution package, following the Safety promotion, Regulatory initiatives and Innovation & Technology grouping.

Table 5-6 Solution package to address limitations of Use Case 5.2

Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
Solution package - Safety promotion			
UC5.1-PS.1 - Development of industry best-practices on cross-system and cross domain usage of flight data	• **UC5.2-SOL.3 -** Industry best-practices on FDM-SMS integration • **UC5.2-SOL.5** - Define cross-domain data formatting standards • **UC5.2-SOL.6** - Explore flight data governance and concept mapping across flight data-based programmes • **UC5.2-SOL.9 -** Industry best-practices for sharing flight data in collaborative frameworks	**Aviation industry bodies and associations:** • Promote the adoption of best-practices across the aviation industry • **Regulatory authorities:** • Review the development of best-practices and ensure that they align with regulatory standards and requirements • **Operators:** • Adopt and implement the best-practices in their processes and day-to-day operations • **Software vendors:** • Implement the best-practices	• Information on main outcomes and needs from each domain where flight data is used • List of main concepts and definitions used with regards to flight data or derived products for each domain • Information on main methodologies of usage and analysis of flight data • Processes for information sharing across teams • Processes for capitalisation of flight data knowledge • Information on previous collaborations, including on roles, responsibilities, and governance mechanisms

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Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
		• Collaborate with operators to ensure that their data solutions provided align with best-practices	• Information on main outcomes and needs from each domain where flight data is used
UC5.2-PS.2 - Development of industry best-practices on data access policies	• **UC5.2-SOL.4** - industry best-practices on data access policies for FDM • **UC5.2-SOL.8** - Address data access policies for other uses of flight data	**Aviation industry bodies and associations:** • Promote for the adoption of best-practices across the aviation industry **Regulatory authorities:** • Review the development of best-practices and ensure that they align with regulatory standards and requirements **Flight crew representatives:** • Collaborate with industry bodies and regulatory authorities in the development and refinement of best-practices **Operators:** • Implement the best-practices in their data access policies • Collaborate with industry bodies and regulatory authorities in the development and refinement of best-practices **Software vendors:** • Implement software changes that enable the best-practices	• Information on common data access policies and main mechanisms • Objective criteria to evaluate alignment with regulations • Information on common data access policies, main issues from their perspective and new topics of concern • Information on common data access policies and their limitations to activities • Requirements to access data from safety-relevant activities • Information on the impact of different data access policies to the design and operation of their software solutions
UC5.2-PS.3 - Development of industry best-practices on FDM causal factor analysis	• **UC5.2-SOL.10** - Industry best-practices on FDM causal factor analysis	**Aviation industry bodies and associations:** • Promote for the adoption of best-practices across the aviation industry **Regulatory authorities:** • Review the development of best-practices and ensure that they align with regulatory standards and requirements **Operators:** • Implement the best-practices in their processes and day-to-day operations	• Processes and mechanisms they follow for causal factor analysis • Specific information and data points used • Processes for validation of causal relationships • Methodology for definition of corrective measures and monitoring of these • Preliminary mapping of causal factors identified in flight crew training or from other sources
Solution packages - Regulatory initiatives (Guidance Material or Acceptable Means of Compliance)			
UC5.2-PS.4 - Development of regulatory initiatives for integration of flight data	• **UC5.2-SOL.1** - Define minimum FDM software capabilities • **UC5.2-SOL.2** - Technical standards for FDM-SMS integration	**Regulatory authorities:** • Develop and implement the regulatory material (rulemaking process) **Operators:** • Implement regulations into their processes	• Information on the main capabilities required for FDM analysis and not provided in FDM software • Information on the process they follow for FDM analysis and the tools they use

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Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities			
Solution package	**Solutions included**	**Involved stakeholders** (Definition, production, or implementation of the solution)	**Data-related enablers**
		Software vendors: • Update their software solutions to ensure compliance by operators **Standards organisations:** • Support regulators with the development of standards for data integration	• Information on the capabilities of their software in terms of FDM analysis • Information on the pipelines, systems or otherwise methods available to them for interoperability with other software solutions • Information on data formats and data created as part of the FDM analysis activities supported • Information on methodologies followed for standard definition • Equivalent standards for interoperability between software solutions
UC5.2 - PS.5 - Development of regulatory initiative for certification of FDM analysts	• **UC5.2-SOL.7** - Certification of FDM analyst competency	**Regulatory authorities:** • Develop and implement the regulatory material (rulemaking process) **Operators:** • Certify their FDM analysists as per regulatory requirements **Software vendors:** • Certify their FDM analysists as per regulatory requirements	• Information on requirements for certification of personnel in safety topics within aviation • Information on processes followed for FDM analysis and the SRM process • Information on best-practices, specificities from different operators and innovations in analysis of events and definition of mitigation measures • Information on specificities of different aircraft types

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5.3 Impact assessment of proposed solution packages

Finally, an impact assessment has been conducted taking as an input the different solution package established in the previous section, which encompass the different solutions defined with the aim of addressing the identified limitations. Traditional impacts such as economic, social, environmental and proportionality impacts will be assessed but most importantly the impact on aviation safety will be assessed as it is an essential criterion for determining the safety benefit of the package solutions. In the following subsections, package solutions will notably be assessed in relation to the capacity to address the identified limitations and challenges. The different impact categories that have been used, together with the criteria that have been followed, are presented in the following table:

Table 5-7 Categories and criteria used for the impact assessment

Category	Scores categories and associated criteria		
Safety	Highly positive impact	+3	• Significant improvements in flight crew safety awareness, decision-making, and adherence to standard operating procedures during line operation. • Substantial reduction in safety incidents, errors, and accidents attributable to improved flight crew preparation, refined standard operating procedures, or other improvements to flight operations derived from flight data usage in FDM programmes and other safety-relevant activities.
	Low positive impact	+1	• Moderate enhancements in flight crew performance, leading to increased safety awareness, improved decision-making capabilities and better adherence to standard operating procedures during line operation. • Some reduction in safety incidents and errors, indicating a positive trend in safety performance.
	No impact	+0	• No observable changes in flight crew safety awareness and on operator safety performance, suggesting a lack of significant improvements or advancements resulting from the implementation of the solutions. • There is no contribution to the reduction of incidents, accidents or risks.
	Low negative impact	-1	• Minor disruptions in flight crew performance or adherence to standard operating procedures without significant implications for overall safety standards. • Marginal growth in safety accidents, incidents or errors stemming from a decrease of effectiveness of the FDM programme or other safety-relevant activities.
	Highly negative impact	-3	• Notable decline in pilot competencies, safety performance and adherence to standard operating procedures during line operation. • Substantial increase in safety incidents, errors, or accidents.
Environmental	Highly positive impact	+3	• More sustainable aviation practices and reducing the industry's environmental impact. • Implementation of technologies and methodologies that greatly minimise the program's overall environmental footprint. • Substantial reduction in fuel consumption and carbon emissions, demonstrating a strong commitment to environmental sustainability and eco-friendly practices.
	Low positive impact	+1	• Slightly more environmentally responsible practices within the aviation industry. • Adoption of eco-friendly initiatives and technologies that contribute to a more efficient use of resources and a reduced carbon footprint.

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Category	Scores categories and associated criteria		
			• Moderate decrease in resource consumption and emissions, indicating a gradual shift toward more sustainable practices and reduced environmental impact within the aviation usage of flight data.
	No impact	+0	• No observable changes in resource utilisation and environmental practices, suggesting a lack of significant advancements or developments. • Stable environmental practices with no alterations in resource consumption or environmental impact. • No evidence on promoting sustainable aviation practices and reducing the industry's environmental impact.
	Low negative impact	-1	• Minor challenges or inefficiencies in resource management and eco-friendly practices, leading to temporary environmental implications that can be addressed through targeted improvements and adjustments. • Marginal increase in the environmental footprint attributed to transitional issues associated with solutions implementation.
	Highly negative impact	-3	• Noticeable increase in resource consumption and environmental impact. • Clear increase in carbon emissions and environmental footprint.
Social	Highly positive impact	+3	• Enhanced staff well-being and job satisfaction, leading to a positive work culture. • High increase of confidence on flight data outputs from other personnel (e.g., flight crews, executives, team members not directly working with data, etc.). • Significant reduction of the workload of the different involved staff (e.g., FDM team, data analytics team, support staff in software vendors or manufacturers, etc.). • Successful diversity, inclusivity, and equal opportunities within the flight data environment.
	Low positive impact	+1	• Moderate improvements in staff engagement and satisfaction. • Moderate increase of confidence on flight data outputs from other personnel. • Slight reduction of the workload of the different involved staff. • Enhanced diversity, inclusivity and an equal opportunities environment.
	No impact	+0	• No observable changes in staff well-being and job satisfaction. • No change on the confidence on flight data outputs. • No reduction of the workload of the different involved staff.
	Low negative impact	-1	• Minor decrease in staff engagement and satisfaction. • Decrease of confidence on flight data outputs from other personnel not involved in its production. • Slight disruptions to working processes and increases in workload due to the introduced changes, leading to temporary challenges. • Slight increase of the FDM programme or other safety-relevant activities-related staff.
	Highly negative impact	-3	• Noticeable strain or dissatisfaction among staff, indicating a decline in job satisfaction due to significant shortcomings or inadequacies in the implementation of the solutions. • Significant decrease of confidence on flight data outputs. • Notable decline in staff's well-being and engagement. • Highly increased workload of the different involved staff.

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Category	Scores categories and associated criteria		
Economic	Highly positive impact	+3	• Substantial global cost savings, improved efficiency and increased resource allocation flexibility resulting from the implementation of streamlined processes and optimised resource utilisation during the processing and preparation of flight data. This criteria is evaluated at an industry-wide level. • Reduction of flight data usage-related costs for operators or other stakeholders.
	Low positive impact	+1	• Slight reduction of global costs and small improvements to efficiency in the processing of flight data. • Moderate reductions in usage-related costs.
	No impact	+0	• No observable changes in the economic calculus of flight data processing at a system-level, with small variations at stakeholder level being compensated with one another. • No variations on the expenses derived from the usage of flight data for FDM and other safety-relevant activities.
	Low negative impact	-1	• Minor inefficiencies or temporary financial constraints associated with the transitional phase of implementing the solutions, without significant long-term implications for the whole industry. • Marginal increase in usage-related costs.
	Highly negative impact	-3	• Significant increase of flight data processing costs, with loss of efficiency and resource allocation flexibility at an industry-level. • Marked increase in budgetary constraints and financial challenges.
Proportionality	Highly positive impact	+3	• Improved access and adaptability of technologies and methodologies to the diverse needs and operational capacities of both large and small operators (or operators of small and large aircraft), fostering a level playing field for flight data processing. • Significantly more balanced and proportionate approach to flight data usage across the aviation industry than it is today, irrespective of the scale or scope of operations
	Low positive impact	+1	• More tailored flight data solutions that address the different needs and resources of both large and small operators (or operators of small and large aircraft). • Support mechanisms that enable operators of any size and aircraft type to participate in flight data initiatives in FDM and other domains, leveraging relevant data resources based on their specific operational requirements. • Slightly more balanced and inclusive flight data environment within the aviation industry.
	No impact	+0	• No observable changes in the accessibility and applicability of flight data practices for diverse operators. • No changes in the overall opportunities available to operators irrespective of their size and the aircraft types they operate.
	Low negative impact	-1	• Minor discrepancies or challenges in providing tailored flight data solutions for operators, leading to temporary disparities in access resources and opportunities for data usage. • Slight operational constraints that impact access and participation of some operators in the usage of flight data for diverse applications.
	Highly negative impact	-3	• Significant differences and imbalances in the accessibility and implementation of flight data technologies, methodologies and uses between large and small operators (or between operators of small and large aircraft). • Major inequalities or operational constraints that limit the participation and benefits of small operators compared to larger operators.

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By applying the criteria presented in the table above, and the solution packages established in the context of Use Case 5.1, the impact of each package is determined according to the different impact categories used. An additional dimension named "Maturity Level" is also considered and helps to define the current context. All of these are presented in the following table:

Table 5-8 Impact Assessment of proposed solution packages for Use Case 5.1

Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme							
UC5.1-PS.1 - Promotion of industry best-practices and technologies among industry stakeholders	**Benefits and constraints**	**Safety**	**Environmental**	**Social**	**Economic**	**Proportionality**	**Total**
		+1	0	+1	0	+1	**+3**
		Justification: Package **UC5.1-PS.1**, concerned with the promotion of various industry best-practices and technologies, can have a positive, albeit minor, impact on aviation **safety**. This results from the improvement in methodologies and equipment used to conduct the FDM programme, particularly among less mature operators for whom these best-practices can aid in expanding their capabilities and the effectiveness of their FDM programmes. **Socially**, staff at the operator will benefit from an improved access to knowledge and information that can be directly applied to their day-to-day operations to facilitate their analysis (best-practices on contextual data fusion), their event detection (best-practices on standardised FDM-based indicators) or their overall FDM programme (if manufacturers implement the recommendations on QAR equipment). Nonetheless, there will also be a minor impact in terms of increased workload to implement all these changes. The **economic** impact will be negligeable, as the promotion itself has a very small cost, and the adoption of the methods and technologies promoted is inexpensive for operators. Only manufacturers of small aircraft may be impacted on the short-term due to the addition of QAR equipment to their aircraft, but even for them the cost will be low relative to the overall development cost of new aircraft. Finally, in terms of **proportionality**, this package of solutions would generally benefit more operators of small aircraft or smaller operators with less mature FDM programmes. Still, all operators can benefit from further guidance on standardised FDM indicators and on reference information of contextual data sources.					
	Maturity level	**HIGH:** The solutions included in this package focus on topics that are mature and where developments have already been achieved at an industry-wide level. In this case, the solutions focus on the promotion of documents, resources and knowledge that has already been produced and can be generalised among a wider public.					
UC5.1-PS.2 - Integration of industry stakeholders into		**Safety**	**Environmental**	**Social**	**Economic**	**Proportionality**	**Total**
		+1	0	+1	0	0	**+2**

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Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme

existing communication platforms	Benefits and constraints	**Justification:** In the case of the package of solutions **UC5.1-PS2**, the **safety** benefit exists but remains minor. Integration of new stakeholders will improve knowledge transfer across different types of stakeholders, while creating a common platform of discussion for new topics. Still, the translation of this new knowledge into safety performance improvements is not direct, and will require time and effort. On the **social** dimension, the proposed solutions would promote further diversity and inclusivity of different stakeholders into industry-relevant discussions. It would also facilitate interactions between stakeholders without current channels of communication, which can help in reducing the workload for some staff and improve staff engagement by allowing their voices (and those of their organisations) to be heard. There would be no noticeable **environmental**, **economic** or **proportionality** impact, as the nature of their integration and participation in safety-focused discussions would not entail sustainability improvements nor have a significant cost beyond the man-hours to participate. Proportionally, participation is open to all, and the negligeable cost to participate does not preclude any stakeholder from involving itself.
	Maturity level	**HIGH:** Proposed solutions account for the usage of existing forums and industry association bodies for the integration of new participants, of which there are already present and past precedents.
UC5.1-PS.3 – Development of regulatory initiatives for performance of FDM programmes	Benefits and constraints	Safety: +3; Environmental: 0; Social: -1; Economic: 0; Proportionality: +1; Total: +3 **Justification:** Developing and implementing the solutions proposed in the **UC5.1-PS.3** package would greatly contribute to improving the **safety** of operations, as it would establish a set of criteria for the minimum performance of FDM programmes that does not currently exist. These criteria, by covering the whole process from data collection to analysis, including risk areas and knowledge management, would require operators to ensure the proper conduction of their FDM programmes and, through its outcomes, improved safety performance, adherence to SOPs and better preparation of flight crews. In terms of the **social** component, the implementation of such solutions will result in a noticeable increase of workload for staff members, as a significant number of processes may require adaptation to ensure compliance with the new regulations. Particularly impactful may the requirements to maintain knowledge on different aspects of the programme, as many operators do not currently manage such documentation and information by themselves, and it can be a time-consuming task. There is no expected decrease of confidence on flight data outputs or long-term staff engagement (beyond the period of change). These solutions would positively contribute to **proportionality** by mandating a minimum level of performance that increases the baseline level of operators and results in less mature operators developing further and gaining access to new opportunities for usage of flight data in FDM and other safety-relevant activities.
	Maturity level	**MEDIUM:** This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations. Discussions on the specific criteria to be included may require some time and agreement among stakeholders.

Safety	Environmental	Social	Economic	Proportionality	Total
+3	0	-1	0	+1	+3

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Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme							
UC5.1 - PS.4 - Development of regulatory initiatives for DFL documentation	**Benefits and constraints**	**Safety**	**Environmental**	**Social**	**Economic**	**Proportionality**	**Total**
		+1	0	+3	+3	+3	**+10**
		Justification: The solutions included in the package **UC5.1-PS.4** indirectly impact **safety** by facilitating access to DFL documentation and knowledge associated with it, in addition to support the standardisation of DFLs. Such improved access can help operators and software vendors to better understand flight parameters and their performance, which can further support the definition of more accurate event detection algorithms. In the same vein, standardised DFLs can facilitate the definition of more general algorithms that remain applicable for more aircraft, further allowing for more refinements and advance algorithms. From the **social** perspective, these solutions would contribute to a significant reduction of the workload for software vendors to produce DFL decoding files, and for operators to support them in this effort through validations and other tasks. By accelerating and simplifying the production of DFL decoding files, these solutions would also increase staff well-being and job satisfaction, as the data-entry task of this production process would be eliminated for the most part. Finally, by clarifying Intellectual Property Rights in the context of flight data and FDM programmes, these solutions would support the creation of an environment with higher confidence on outputs (and the possibility to use them without encountering legal claims) and with more equal opportunities (as the rules would be clarified for all stakeholders). On the **economic** side, the efficiency increases in DFL decoding file production would result in global cost savings across the industry. Software vendors would not require such high investments in the production of decoding files, software vendors would not have to assume these costs, and equipment and aircraft manufacturers are well positioned technologically to be able to provide DFL electronic documentation at a low cost. Clarifying the topic of IPRs would also help increase efficiency, as it could result in less duplication of decoding efforts by facilitating data sharing (further incentivised by lowering the threshold of decoding flight data and removing the incentive for software vendors to “protect” their decoding process and flight data outputs). Finally, in terms of **proportionality**, these solutions would significantly contribute to balancing access to flight data and democratise its use. Simplifying the process to decode data, providing more information on parameters, and clarifying whose IPRs apply to each component of the process, would allow operators to better adapt data to their purposes and needs irrespective of the size of the operator, their technical capabilities, the type of aircraft they operate or the software vendor, equipment supplier or other stakeholder they are engaged with. Additionally, it facilitates access to the data for third-parties by simplifying the decoding process and resolving the IPR topics.					
	Maturity level	**LOW:** Solutions included in this package address topics for which there is no clear consensus among stakeholders, which can have a significant repercussion and whose development is still pending. Agreement on the framing of the topics and on the optimal solution is also pending.					

<table>
<tr><th colspan="8">Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme</th></tr>
<tr><td rowspan="4">UC5.1-PS.5 - Initiatives to develop technical solutions to the collection of flight data</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>0</td><td>0</td><td>+1</td><td>+1</td><td>+1</td><td>+3</td></tr>
<tr><td colspan="6"> Justification: Solutions included in package UC5.1-PS.5 aim to improve the current process of flight data collection in the aircraft, including an increase on the volume of data captured and the technology used. As such, there is no safety or environmental impact directly resulting from them. In the social dimension, the increase in the number of parameters captured in standard DFLs would serve to eliminate the need for customised DFLs, as these standard DFLs would be able to address most uses of flight data and in a more standardised form across fleets. As such, the amount of work necessary for an FDM programme would decrease, and staff workload with it. From the economic perspective, the lack of customisation and the potential for the elimination of decoding altogether does have a positive impact on the overall industry, as is more efficient for manufacturers to define a small set of standard DFLs than for operators and suppliers to create many customisations which software vendors have to convert into DFL decoding files. Still, the increase in the number of parameters would partially compensate the decrease in the number of DFLs. As for the research effort, the cost would have to be assumed before any benefits could be realised, which further impacts the overall economic score for the solution package. Finally, regarding proportionality, access to opportunities of flight data usage would be furthered by both solutions included in the package. Removing the need to customise would allow operators with less resources to access the same or similar flight data to that of mature operators, and with a similar performance. Additionally, eliminating the need to decode flight data by recording data in non-binary formats would facilitate access to data for all stakeholders (but the positive impact is mitigated by the fact that the solution relates to research efforts that may not resolve the underlying issue). </td></tr>
<tr><td>Maturity level</td><td colspan="6">LOW: Solutions included in this package address topics that are still on a research phase and for which there is no clear consensus among stakeholders, which can have a significant repercussion and whose development is still pending. Agreement on the framing of the topics and on the optimal solution is also pending.</td></tr>
<tr><td rowspan="3">UC5.1-PS.6 - Initiatives to adopt digital capabilities on FDM events and fusion</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+1</td><td>0</td><td>+1</td><td>+1</td><td>+3</td><td>+6</td></tr>
<tr><td colspan="6">Justification: Solution package UC5.1-PS.6 would have a positive impact on aviation safety by allowing operators the direct usage of FDM event algorithms, fusion algorithms, and contextual data in their own FDM programmes. These algorithms have already been defined, implemented, validated, and reviewed by participants of the Data4Safety programme, and contextual data has been processed and is in usage in the programme. By expanding the capabilities of operators to better inform their analysis of events through benchmarking capabilities and the addition of new information, the safety performance of operators, flight crews and other teams can be improved.</td></tr>
</table>

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Use Case 5.1 Identification, decoding and processing of flight data for an FDM programme		
		On the **social** side, the centralisation of some developments in the Data4Safety programme can help increase efficiency and reduce workloads of staff at each operator. These savings would be partially compensated by the effort of participating in the programme, adapting the algorithms and definitions to their own needs, and implementing the fusion algorithms, but a positive result remains. Additionally, the volume of documentation produced for each of these algorithms would facilitate the work of staff at operators and software vendors when incorporating them, enhancing staff well-being. Finally, additional confidence on the outputs of flight data-based programmes would be generated for personnel other than that directly involved, given the origin of the algorithms and data in a European industry-wide programme. The same benefits that apply socially in terms of efficiency gain, apply to the **economic** dimension, with global cost savings resulting from a partial centralisation of developments. It is important, however, to consider the potential limitations due to restrictions imposed by the Intellectual Property Rights holders of the contextual data being shared. From the perspective of **proportionality**, there would be a significant improvement to the access to new technologies, capabilities, and methods, across operators and software vendors. Issues on contextual data formatting and fusion are common even among mature operators, with less mature ones lacking the capability altogether. As for the algorithms on FDM events, facilitating access to the code, the logic and the explanation behind it would aid both big and small operators to implement such FDM events into their programmes or adapt their current definitions if deemed beneficial.
	Maturity level	**LOW:** This package includes a set of solutions that address topics that have reached some level of maturity, but where developments are still pending and mechanisms for the specific implementation must first be agreed.

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Likewise, the potential impact of the solution package established in the context of Use Case 5.2 is assessed:

Table 5-9 Impact Assessment of proposed solution packages for Use Case 5.2

<table>
<tr><th colspan="8">Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities</th></tr>
<tr><td rowspan="4">UC5.2-PS.1 - Development of industry best-practices cross-system and cross-domain usage of flight data</td><td rowspan="3">Benefits and constraints</td><th>Safety</th><th>Environmental</th><th>Social</th><th>Economic</th><th>Proportionality</th><th>Total</th></tr>
<tr><td>+1</td><td>0</td><td>+1</td><td>0</td><td>+3</td><td>+5</td></tr>
<tr><td colspan="6">Justification: Solutions included in solution package UC5.2-PS.1 focus on simplifying the usage of flight data across systems and domains, covering knowledge sharing, working processes and organisation of responsibilities. All these improvements are geared ultimately towards improving safety performance. These improvement results from the new possibilities of capitalising on safety knowledge, by enabling cross-domain developments and by fostering successful collaboration methodologies that push the envelope of safety research and flight data applications.

On the social aspect, the solutions support and enhance the execution of processes that cover multiple systems or domains of flight data usage. By improving the baseline processes and technology (data formats), the workload for staff members dedicated to such topics is reduced, and their productivity increases.

By establishing these mappings and formats that assist in translating terms, connecting concepts, and sharing data across domains, operators from across the industry can benefit significantly from new capabilities and methods to work with flight data, with a positive impact on proportionality. It also supports in balancing access to such capabilities, as they are not restricted to in-house development by the major and mature operators.</td></tr>
<tr><td>Maturity level</td><td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices.</td></tr>
<tr><td rowspan="3">UC5.2-PS.2 - Development of industry best-practices on data access policies</td><td rowspan="3">Benefits and constraints</td><th>Safety</th><th>Environmental</th><th>Social</th><th>Economic</th><th>Proportionality</th><th>Total</th></tr>
<tr><td>0</td><td>0</td><td>+3</td><td>0</td><td>0</td><td>+3</td></tr>
<tr><td colspan="6">Justification: Solution package UC5.2-PS.2, focusing on the topics of data access policies for FDM and other flight-relevant activities, has eminently a strong social impact. Through the discussion to be held as part of the production of these industry best-practices, the focus would be to increase confidence of flight data usage and outputs from flight crews, facilitate access to the data for other stakeholders, ensure engagement and job satisfaction by both teams working with the data and flight crews having their data used, and to promote a diverse and inclusive environment. Additionally, some of the solutions that may result can have a positive impact on reducing the workload of some staff members, particularly in FDM teams when sharing data or contacting flight crews, and in software vendors when adapting their software solutions to the data access policies of each operator.</td></tr>
</table>

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<table>
<tr><th colspan="8">Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities</th></tr>
<tr><td></td><td>Maturity level</td><td colspan="6">MEDIUM: This package includes a set of solutions that address topics that have reached a significant level of maturity, have already had previous discussions, but would still require additional or new developments.</td></tr>
<tr><td rowspan="4">UC5.2-PS.3 - Development of industry best-practices on FDM causal factor analysis</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>+1</td><td>0</td><td>0</td><td>0</td><td>+1</td><td>+2</td></tr>
<tr><td colspan="6">Justification: The objective of solution package UC5.2-PS.3 is to improve root cause analysis practices across operators. It would have a positive impact on aviation safety by providing better methodologies for operators to comprehend the causal factors behind their safety occurrences, enabling the definition of better defined mitigation and corrective measures that address the actual root of the problem.
Their social and economic impact is very limited, as the implementation of industry best-practices will result in an evolution of processes without significant variations on workload with respect to what operators already do for identification of causal factors and definition of mitigation measures. Nonetheless, the complexity of implementing this solution package must be highlighted, as it may require the adaptation of ECCAIRS2 taxonomy or the definition of an entirely new one, which is a long and complex process.
In terms of proportionality, the resulting best-practices will benefit both mature operators and those with less experience in the development of such analysis, at the same time bridging the gap between both in terms of capabilities. The positive impact remains minor given the narrow scope of the solution package.</td></tr>
<tr><td>Maturity level</td><td colspan="6">LOW: This package includes a set of solutions that focus on topics that currently lack maturity and comprehensive industry-wide guidance, requiring the establishment of industry-defined standards and the development of best-practices.</td></tr>
<tr><td rowspan="3">UC5.2-PS.4 - Development of regulatory initiatives for integration of flight data</td><td rowspan="3">Benefits and constraints</td><td>Safety</td><td>Environmental</td><td>Social</td><td>Economic</td><td>Proportionality</td><td>Total</td></tr>
<tr><td>0</td><td>0</td><td>+1</td><td>+1</td><td>+1</td><td>+3</td></tr>
<tr><td colspan="6">Justification: Neither safety nor environmental considerations are impacted by solution package UC5.2-PS.4. The former given that improvements from this solution package do not add new software capabilities for analysis, the latter given that there is no increase or decrease of sustainability of the final activity.
Socially, the staff workload at the operator is slightly reduced by facilitating the exchange of information between their various systems used for analysis, and particularly between the FDM and SMS systems. The automation of the tedious task of copying information from one system to another also results in improved staff satisfaction.</td></tr>
</table>

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Use Case 5.2 Usage of flight data for FDM and other safety-relevant activities

		The establishment of technical standards has a positive **economic** impact for the industry, as software vendors may enable interoperability with other software in a more seamless and efficient manner. It also expands the possibilities for operators, who have more freedom in choosing which software solutions they prefer irrespective of their current interoperability. In terms of **proportionality**, the solutions included in the package would facilitate operator access to the different capabilities required for an FDM software, while also support smaller software vendors to provide solutions to the market, event if with a narrow scope, tailored to the needs and resources of different operators. Overall there would be a positive impact.
	Maturity level	**MEDIUM:** This package includes a set of solutions that address topics that have reached a significant level of maturity and could be potentially integrated into formal regulations. Discussions on the specific criteria to be included may require some time and agreement among stakeholders.

UC5.2-PS.5 - Development of regulatory initiatives for certification of FDM analysts

Benefits and constraints

Safety	Environmental	Social	Economic	Proportionality	Total
+3	0	-1	-1	+1	+2

Justification: The main benefit of implementing a certification process for FDM analysts resides in the domain of **safety** performance. Thanks to an improvement to the baseline knowledge of analysts across the industry (both in operators and software vendors), in addition to the promotion of advanced methodologies for analysis of events, for root cause analysis and for the definition and monitoring of corrective and mitigation measures, the overall safety of the operation can be greatly affected. SOPs can be better defined, flight crew training improved and focused on the specific areas of concern detected, and the definition and understanding of safety events further advanced across the whole industry.

From the **social** perspective, the need to certify all currently acting analysts would represent an additional increase of workload for FDM teams across the industry, coupled with a level of dissatisfaction resulting from the need to prepare for the certification at an individual level. While it would be partially compensated through the acquisition of new capabilities and knowledge, resulting in further engagement of staff with their tasks, the net result would be a negative impact.

Economically, the need to certify FDM teams would increase costs for operators. First, they would generally have to pay for training and certification process of their employees. Secondly, they would see their pool of potential candidates for FDM roles decrease, which could result in higher personnel costs. These costs could be partially compensated from the efficiency gains of better trained staff and shorter on-boarding periods for new entrants.

Finally, **proportionality** would be positively impacted by the increase in overall knowledge across the industry, facilitating access to such knowledge to smaller operators or those with less mature programmes and which would not have access to it without certified personnel.

Maturity level

LOW: Solutions included in this package address topics for which there is no clear consensus among stakeholders, which can have a significant repercussion and whose development is still pending. Agreement on the framing of the topics and on the optimal solution is also pending.

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6. Conclusions

The investigation performed for the development of each of the Case Studies has gone into the details of the current situation and the challenges faced by the involved stakeholders. The main input for the results presented throughout this document comes from the interviews held with aircraft operators, software providers, national aviation authorities, European organisations and aircraft manufacturers. This wide range of perspectives and individual situations seen during the interview gives reliability to the analysis, while bringing complexity at the time of concluding and synthetising into a clear message.

The case studies development has been highly dependent on the stakeholder consultation process. This has been reflected through the changes applied to the initial work plan in terms of use cases definition update and adjustment of the consultation process. The flight training data for EBT (CS3) is structured on the use of flight crew training and instructor data to drive EBT programmes (UC3.1), syllabus customisation and scenario contextualisation using operational data (UC3.2) and at the authorities' support and role within EBT programmes. The digital fuel management (CS4) studies how to leverage aircraft-specific fuel data for fuel performance-based schemes (UC4.1), characterise the safety performance indicators for fuel schemes (UC4.2) and how to use operating conditions data to support performance-based fuel schemes (UC4.3). Finally, the development of the flight data models for safety (CS5) is broken into the identification, decoding and processing of flight data for an FDM programme (UC5.1) and the usage of flight data for FDM and other safety-relevant activities (UC5.2).

Data stays at the heart of EBT programme from its definition to its implementation and continuous improvement. Training data generated and collected within EBT rely on what and how instructors assess during the training and evaluation sessions. The work and data flow in this process indicate high complexity on instructors' assessment and evaluation. Identified needs go from additional guidance on the assessment methodology to adequate supporting tools, including advice on the metrics to be used both for identifying training needs and ensuring instructors concordance. The main area of where further maturity and guidance is needed to reach the baseline EBT programme is the Instructor Concordance Assurance Programme.

EBT programmes are designed through the selection and adaptation of the training topics and scenarios by the operator based on its operation context, as EBT programme applies only to recurrent training at this stage in Europe. The internal collaboration between training and safety departments is essential to be able to adapt the pilot's training need to the operation. For this purpose, a framework is missing where a common taxonomy should be defined and continuous collaboration ensured. EBT involves a change of paradigm in terms of training, its understanding at operator level should not be underestimated. In this context, safety and training should have close relationship to exchange information bidirectionally, on one hand, to reinforce the training modules and, on the other, to foresee potential risks.

The implementation of EBT has been driven by the operator in the need of improving pilots' competences and adjusting the training to a more effective methodology. Authorities have followed from outside, following the guidance from EASA, but in a difficult position of keeping the pace with the operators' evolution. This is reflected in the lack of a reporting framework for EBT implementation, leaving it to the capacity of the NAA who do not have full visibility. The role of NAAs should be strengthened at national level, allowing them to become a link among EBT operators and guiding toward the continuous improvement of the programmes.

EBT community is increasing, but there is still low maturity at European level, with few advanced operators and several ones in the process. The establishment of a strong reference with best practices coming more mature operators that have overcome multiple challenges would ease the implementation pace for the new commers and will help create a standardised framework both for reporting and for evaluating EBT's effectiveness.

Focusing on the usage of data within EBT and the limitations identified during the working process definition, the solutions proposed through this document mainly consist in safety promotion initiatives driven by the different EBT implementation maturities at which operators currently are. On overall, European EBT maturity is low as it is new and few operators have adopted it. However, among the ones that did, several are very advanced and their approach would bring value to the community and would soften the pace for the new ones. In this context, EASA plays a key role of gathering and establishing working groups to draw guidance and reliable reference in terms of data analysis, metrics definition and supporting tools.

The solution packages go beyond the safety promotion and propose regulatory initiatives to produce new and/or amend existing acceptable means of compliance providing more detailed information based on input from the industry. The proposals include addition details on training assessment methods, strengthening the debriefing within the evaluation, data for instructor concordance and reference standards, responsibilities within EBT programme and close collaboration with safety department.

In terms of innovation and technology, the proposals support the adoption of digital tools and the development of capabilities for assisting training assessment and data analysis, including related automation risks. Transition and implementation to EBT is resource demanding, so the development of a generic data analysis tool for training data and instructor concordance could foster its implementation. This would represent a basis on which smaller operators could build on and establish their EBT programme with the objective of better prepared pilots.

Looking at Case Study 4, operators are actively exploring and adopting digital solutions to optimise fuel consumption. However, despite the growing interest and adoption of digital tools, the regulatory landscape, intentionally defined as a set of soft rules to favour a flexible approach for adoption, has resulted in a lack of definition of certain aspects that hinder the seamless adoption, integration and management of the most advanced schemes, as well as the digital solutions on which they should be leveraged. This is reflected in the list of limitations identified when analysing the activities under the use cases in this case study. The most recurrent constraints captured through the stakeholder consultation are fuel-related data challenges, the establishment and monitoring of fuel and safety performance as well as the collection and integration of operating conditions data.

The analysis of the fuel-related data processing and the fuel consumption models concludes in the need for safety promotion to share industry best-practices in terms of data formatting, standards, validation, compatibility and integration. The maturity across operators could be improved if involved in collaborative initiatives and sharing of success stories to better understand the considerations of the fuel consumption models and parameters. Current regulation should be adjusted to include details on statistical methods and minimum requirements to ensure data representativeness in the models supporting performance-based reductions. In terms of capabilities, operators need internal knowledge on data analytics to be able to take full advance of the insights data could provide. Therefore, specific trainings should be promoted, complemented with a close collaboration between operators and national aviation authorities for the harmonisation of fuel-related data processes.

One of the key challenges when monitoring the safety levels of fuel reductions is the lack of a detailed framework to define Safety Performance Indicators (SPIs). These indicators should be proportional to the complexity of the operational context and to the extent of the deviations, but further guidance is needed in this regard. Safety promotion and regulatory initiatives should cover standardised lists of fuel and safety-related parameters, alignment with the Safety Management System (SMS) and link to the safety events beyond the low-consequential events prescribed in the regulation. These would streamline the monitoring of fuel reductions, making the process more efficient and effective for both operators and regulatory authorities. Additionally, the safety performance framework linked to fuel would facilitate the continuous monitoring by the NAAs.

The current framework for the implementation of the fuel performance-based schemes gives flexibility to operators when using operational data as far as they ensure safety levels are sufficient and remain constant.

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This is very challenging as there is need for additional guidance on the reliable sources, the analysis and the validation of the used models. This should be complemented by regulatory initiatives on the minimum requirements for the selected data sources and their usage throughout the operators' departments. The integration of the operating conditions data should be strengthened through regulatory initiatives detailing its validation and communication among different departments that should use the same source.

As for Case Study 5, the industry is facing a period of evolution, with the generalisation of new capabilities and tools among operators and software vendors, and the valorisation of flight data by all stakeholders. However, many challenges remain regarding the current organisation of flight data-based programmes, with a distribution of roles, responsibilities and tasks across the many stakeholders that is not optimal and can remain an obstacle if not directly addresses. These issues are not limited to the organisation, also extending to the technologies used and the operations and processes followed by operators and other stakeholders, as reflected in the extensive list of limitations identified when analysing the activities under the use cases in this case study. The most recurrent limitations to the functioning of FDM programmes, and to the usage of flight data for other safety-relevant activities, includes the cost and complexity around the usage of the Data Frame Layouts (from customisation to production of the decoding file), the lack of standardisation of parameters, definitions, algorithms, processes, etc., and the management of knowledge.

The analysis of the role of the Data Frame Layout in the processing of flight data, and of all associated tasks, has allowed to identify the need for regulatory intervention to implement a reorganisation of the processes followed. Such intervention would take the form of a requirement to produce DFL documentation in electronic format and for such documentation to be shared openly with operators and software vendors, supporting efforts to digitise and facilitate the production of decoding files, an integral part of the processing process. Current regulations should be adjusted to specify that manufacturers (or third parties that modify the DFL) must produce and keep this documentation, and that operators must ensure its safekeeping in case the aircraft is transferred to a new owner.

Another key recurring challenge, the lack of standardisation, should be addressed through a combination of complementary efforts that address the wide spectrum of topics relevant to FDM programmes and flight data usage more broadly. Manufacturers should develop bigger, standard DFLs that can cover most safety-relevant use cases for flight data and avoid the need for operator-led customisations of DFLs, while ensuring that differences between fleets from the same manufacturer are minimised. They should include the enablement of standardised capabilities, by sharing contextual data previously processed in the Data4Safety programme, or the algorithms, definitions and developments produced on the context of that industry-wide data exchange programme.

Finally, specific solutions have been proposed to address the lack of knowledge management that can be observed in some stakeholders and which can impact their capacity to effectively use flight data for safety. To ensure that operators maintain a sufficient level of knowledge to be able to adequately conduct their FDM programmes and other safety-relevant activities, while software vendors and manufactures can effectively capitalise on the knowledge they produce, initiatives range from regulation establishing the level of documentation that shall be maintained, to the development of best-practices on cross-system and cross-domain usage of flight data, enabling further capitalisation and valorisation of knowledge.

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