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D-5. 1 TO 5.5 – SUBSTANTIATION OF THE SAFETY RISKS OF THE 'TRIPLE ONE' CONCEPT AND IDENTIFICATION AND INVESTIGATION OF THE OPERATIONAL FACTORS OR OTHER CONSTRAINTS FOR THE NON-IMPLEMENTATION OF THE 'TRIPLE ONE' CONCEPT

IMPLEMENTATION OF THE AERODROME 'TRIPLE ONE' CONCEPT

Final Report
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Part I Objective and Scope of Task 5

I.1 The objective of this task is to analyse the safety risks arising from the implementation of the Triple One concept and its variants and to identify all the operational and other reasons for a non-implementation. Therefore, this report includes both the theoretical framework of the risks of Triple One implementation and further practical limitations in form of costs, operational constraints or other implementation risks.

I.2 The scope of this task is divided in three sub-tasks, namely:

- Subtask 5.1: Study the safety risk of the 'triple one' concept.
- Subtask 5.2: Study of the safety risks of the identified variations of the concept.
- Subtask 5.3: Study of the reasons leading to partial or non-implementation of the concept.
- Subtask 5.4: Study the cost of 'triple one' to the stakeholders in terms of training and labour cost etc.
- Subtask 5.5: Study other potential negative impacts of 'triple one' to the stakeholders.

I.3 The first two subtasks involve the investigation of the safety risks of the Triple One concept, including the characterisation of these risks and their weighting. Therefore, hazards were identified namely on basis of the results of Task 3, and potential consequences defined.

I.4 The risk profile strongly depends on the local characteristics of each aerodrome and a general risk assessment would not result in meaningful results. Notably, the estimation of likelihood of hazardous events strongly depends on airport infrastructural and operational individualities. Therefore, the risk assessment has been exemplarily performed on the basis of six sample airports to understand the differences.

I.5 The potential variations of the Triple One concept, in the sense of partial applications of the Triple One elements (see Task 3 report), were taken into consideration in the analysis as potential mitigation in the sense of reducing a potential risk level for certain aerodromes.

I.6 The fourth sub-task is aimed to study the cost for the implementation of both the Triple One concept and its variations. This includes the identification of cost items, factors which would mainly influence the resulting direct and indirect costs and which stakeholders would be affected. Regarding the training costs – which are estimated to be most dominant factor – some exemplary estimations by some aerodromes are given.

I.7 The study of reasons against an implementation of Triple One and other negative impacts are summarized as operational constraints and implementation risks.

Part II Study of the safety risks of the Triple One concept

II.1 Introduction

II.1.1 The implementation of the Triple One concept or any variation thereof means a change for those aerodromes which have not implemented all or any relevant components of it. This type of change would require to be subject to a safety assessment by the aerodrome operator and the local ANSP. In general, the implementation of the concept might imply new risks or a significant negative impact on existing risks. Notably, affected hazards and risks might not only be associated to runway incursions, but also other safety relevant areas of aerodrome operations.

II.1.2 It is not possible to carry out a complete safety assessment generally applicable to all aerodromes, as there are many locally specific factors with strong influence on individual hazards and risks. An aerodrome operator and the local ANSP provider would have to perform a safety assessment as part of their change management when introducing a new concept. The risk analysis as part of this study is therefore carried out on an exemplary level for six sample aerodromes. These aerodromes and their characteristics are based on aerodromes where workshops or interviews were conducted during Task 3 and thus the necessary background information is available. The complete methodology is described in the following section II.2. The identified hazards and the derived risks and possible mitigations are described in section II.3.

II.1.3 This part of the report only considers safety risks and no economic considerations or further implementation challenges.

II.2 Methodology

II.2.1 General

II.2.1.1 This risk analysis is structured along the common steps as per applicable EASA requirements. E.g., a safety assessment is required by the aerodrome operator proposing a change of the aerodrome, its operation, its organisation or its management system (ADR.OR.B.040 Changes). The safety assessment should include (GM1 ADR.OR.B.040(f) Changes):

- Scope of the change,
- Hazard identification,
- Determination of the safety criteria applicable to the change,
- Risk analysis,

- Risk mitigation, if required after risk evaluation,
- Monitoring to ensure that the aerodrome and its operation will continue to meet the safety criteria after the change has taken place.

II.2.1.2 Hazards have been identified during the on-site workshops at aerodromes and interviews held with aerodromes, performed during Task 3. The hazards and consequences were then summarised and generalised afterwards in further internal workshops.

II.2.1.3 The safety risk evaluation is based on severity and probability classification schemes and a risk matrix, described in section II.2.2.

II.2.1.4 The evaluation of safety risks is different for each aerodrome influenced by manifold factors such as on the number of runways, the runway and aerodrome layout, operational characteristics, traffic density, language proficiency of the vehicle drivers, stakeholders on the TWR frequency and many other parameters. Therefore, an evaluation on aerodrome level is necessary and this evaluation has been done for six exemplary aerodromes, described in section II.3.

II.2.1.5 Information on safety assessments by the aerodrome operators and local air navigation service providers were requested from those aerodromes which participated in the workshops and surveys. The analysis of these assessments was limited due to the following factors:

- The assessments carried out by aerodrome operators in this context focusing on the language proficiency exemption (ADR.OPS.B.029) do not fully match the scope of an assessment focusing on the Triple One concept and its elements. Specifically, this means that the assessment under ADR.OPS.B.029 (g) focuses only on the exemption regarding the language proficiency requirements for drivers and does not include the component on full or partial inclusion on the runway frequency. In addition, ADR.OPS.B.024 and ADR.OPS.B.029 are aimed at licensing vehicle drivers for the entire manoeuvring area, whereas the Triple One concept focuses only on the runway.
- Apart from ADR.OPS.B.029, there are no obligations for aerodrome operators to carry out safety assessments related to the non-implementation of the Triple One concept or elements thereof.
- There are aerodromes for which no decision has yet been taken at the level of the aerodrome operator or the competent authority/member state on how to deal with language proficiency requirements and a possible derogation. These aerodromes have therefore not been further analysed in this respect.

II.2.1.6 The hazards identified in the safety assessments of the deviation in language proficiency requirements for drivers provided to the study team have been considered in the hazard identification phase of this study.

II.2.2 Risk matrix

II.2.2.1 Once the hazards have been identified, it is necessary to define the associated consequences of the hazards and, in particular, the severity and likelihood of the possible consequences.

II.2.2.2 For the purpose of categorizing the severity and the probability of the consequences, ICAO provides guidance in the ICAO Document 9859 Safety Management Manual [1], and in ICAO Document 9981 PANS-Aerodromes [2] including five severity classes and five probability classes. This classification scheme results in a 5x5 risk matrix and is normally the basis for safety assessments. However, applying this classification requires detailed knowledge of the aerodrome. This information is not available to a sufficient extent and therefore a tailored risk matrix had to be developed. The risk matrix must be adapted so that the severity of the consequences and, above all, the probability are assessed with a lower level of detail. For this reason, a 3-level classification is used instead of a 5- level classification. The three-level severity classification scheme is shown in Table 1.

Table 1: Severity classification scheme

Severity class	Impact	Examples
A	High	Runway incursion
B	Medium	Neglection of safety critical tasks
C	Low	Increase in workload, increase in go-around rate

II.2.2.3 The three-level probability classification scheme is shown in Table 2.

Table 2: Probability classification scheme

Probablility class	Impact	Description
3	High	Likely to occur sometimes
2	Medium	Unlikely to occur (has occurred rarely)
1	Low	Very unlikely to occur

II.2.2.4 The resulting 3x3 risk matrix based on the previously defined 3-level severity and probability scheme is shown in Table 3. The risk tolerability shown in the risk matrix is based on following considerations: [3]

- Equal quantitative risks should have almost the same qualitative risk rating. As the quantitative risk is a multiplication of the severity and the probability, the classification into the risk tolerance classes should be based on the same quantitative risk levels. This result in a symmetric risk matrix.
- Very small changes in the quantitative risk (severity and probability) should not result in a big change in the qualitative risk rating (e.g. from green to red). This means that in the risk matrix, no transition from a green to a red risk may be possible, even on the diagonal, with a slight increase in the severity and the probability.

Table 3: Risk matrix

		Risk severity		
		High	Medium	Low
Risk probability		A	B	C
High	3	3A	3B	3C
Medium	2	2A	2B	2C
Low	1	1A	1B	1C

II.2.2.5 The different colours within the risk matrix above are codes for the risk level.

Table 4: Interpretation of the risk matrix

Level of Risk	Interpretation
High	The risk level is high. The change should not take place until sufficient major risk mitigating measures have been implemented to reduce the risk to an acceptable level.
Medium	The risk is of concern and risk mitigating measures should be put in place to reduce the level of risks to as low as reasonably practicable. Where further risk reduction / mitigation is not practicable or viable, the risk may be accepted provided endorsement is given by management.
Low	The risk is considered acceptable.

II.2.3 Exemplary aerodrome scenarios

II.2.3.1 In order to show and picture the potential hazards, the corresponding consequences and the resulting risk associated to the implementation of the Triple One concept, a group of representative aerodromes within EASA scope has been selected.

II.2.3.2 The reason to choose a group of exemplary aerodromes instead of only performing a generic risk analysis about the Triple One concept implementation lies in the strong dependency of local specific influencing factors. Some of those factors were identified as the relevant parameters as part of Task 3 (see "III.2 Relevant parameters" in the Task 3 report), namely:

- Dedicated ATC frequencies for active runways
- Frequency between ATC and vehicular traffic
- Language between TWR and vehicular traffic
- Language between ATC and vehicular traffic
- Language between ATC and pilots
- Language proficiency requirements for vehicle drivers
- Radio telephony certificate requirements

II.2.3.3 In addition to the mentioned relevant parameters and as per the Task 3 report, other additional parameters, mainly describing infrastructural and operational characteristics, have also been considered. These additional characteristics have been used to select the different aerodrome scenarios to be analysed.

II.2.3.4 The first criterion for the selection of the exemplary aerodromes has been the number of runways, together with their associated complexity. In this regard, aerodromes with a single runway, crossing runways and complex runway configuration (three or more runways) have been chosen.

II.2.3.5 Another highly influencing factor is the traffic density of the aerodrome, since the utilisation and management of common frequencies will definitely be impacted by the number of movements. Thus, aerodromes with different traffic densities have been selected within each runway configuration.

II.2.3.6 In addition to these two, different options from real aerodromes regarding other secondary criteria have been considered, such as:

- Traffic share between commercial flights and non-commercial flights;
- Controller position in the tower responsible for the vehicle communication on runways;

- Communication language that is currently being used between ATC and the vehicle drivers;
- Existing technical safety barriers in the aerodrome.

II.2.3.7 Nevertheless, it is important to mention that there is other required information which is not available for real airports and had to be defined. The main parameter of this kind is the overall current English language proficiency of the vehicle drivers or the local population, which has been estimated and defined in order to reflect a significant bandwidth.

II.2.3.8 Taking into consideration all the above-mentioned factors and the limited scope of the study, six aerodromes have been defined for the purpose of this analysis, whose main relevant characteristics are stated in the following table:

Table 5: Exemplary aerodrome scenarios selected for the risk analysis of the implementation of the Triple One concept

Aerodrome example	ADR I	ADR II	ADR III	ADR IV	ADR V	ADR VI
Runway complexity	single	single	crossing	crossing	complex	complex
Traffic density	light	medium	medium	heavy	medium	heavy
Traffic share (% of commercial flights over the total)	30%	95%	50%	98%	99%	98%
Number of runways	1	1	2	2	3	3
ATCO / Assistant	ATCO	assistant	ATCO	assistant	ATCO	ATCO
Actors on the runway[1]	I, W, T, F, R	I, W, T, R	I, W, F, R	I, W	I, W, F, R	I, W, T, R
Communication language between drivers and ATC	NAT	EN+NAT	NAT (EN)	NAT	NAT	NAT
Communication between drivers and ATC	Dedicated VHF	Dedicated VHF	Partially on TWR frequency	Dedicated VHF	Ded. VHF, cross-coupled with TWR	Ded. VHF, cross-coupled with TWR
English language proficiency	Low	Low	High	Low	Low	Medium

[1] I – Inspection, W – Wildlife, T – Towing, F – Follow Me, R – RFFS, M – Miscellaneous

Aerodrome example	ADR I	ADR II	ADR III	ADR IV	ADR V	ADR VI
Technical safety barriers	RWY guard lights, stop bars	RWY guard lights, stop bars, RWY barrier (e.g. microwave, induction loop), SMR, MLAT, Transponders on vehicles mandatory	RWY guard lights, stop bar	RWY guard lights, 24h stop bars, SMR, MLAT, Transponders on vehicles mandatory, EFS, moving maps, vehicle geofencing alert, RIMCAS	RWY guard lights, 24h stop bars, SMR, MLAT, Transponders on vehicles mandatory, EFS, RIMCAS	RWY guard lights, 24h stop bars, SMR, MLAT, Transponders on vehicles mandatory, EFS, RIMCAS

II.2.3.9 As it is shown in the Table 5, within each of the three runway configurations selected regarding complexity, an aerodrome with a lower traffic density and an aerodrome with a higher traffic density have been included.

II.2.3.10 Regarding the use of the English language, aerodromes where the communications between drivers and ATC take place either in the native language, in English, or in a combination of both have been considered. In this way, it will also be possible to evaluate and compare the risks associated to Triple One implementation in airports where some aspects of Triple One are currently in use (e.g. English communication only with certain stakeholders or in certain areas of the airport, vehicle drivers able to listen to the tower frequency) or others where no variation of the concept is implemented at all.

II.2.3.11 Finally, it is worth to mention that these aerodromes already have a wide variety of technical safety barriers implemented, as shown in the last row of the table.

II.3 Hazard and consequences identification

II.3.1 General

II.3.1.1 Before identifying and defining the hazards associated with the implementation of Triple One, it is important to establish the assumptions that have been considered for the subsequent analysis.

II.3.1.2 Firstly, it was considered that the frequencies used for communication on dependent runways should not change from current practice. Namely, the frequency on dependent and primary crossing runways will not be split if they are currently controlled on a common frequency. In order to ensure the situational awareness of pilots during

approach and go-around, it is essential that they can hear communications from adjacent and dependent runways. This is essential to plan the go-around correctly and to estimate the distance to other aircraft approaching in parallel. Frequency splitting of dependent runways would also have negative consequences for ATCO coordination.

II.3.1.3 Secondly, the hazard identification assumes that the change is described towards a full Triple One concept implementation, whereas variations or graduations thereof will be considered to counteract or mitigate certain risks.

II.3.2 Overview of identified hazards

II.3.2.1 Throughout the study of the implementation of the Triple One concept in the previous tasks, together with the specific workshops for hazards identification carried out by the safety experts, four main hazards have been determined:

HZ.1. More transmissions on tower frequency: The implementation of one single frequency will lead to an increase of radio transmissions on that frequency (local tower frequency), potentially resulting in the congestion of the frequency.

HZ.2. Insufficient English language skills: The utilisation of the English language as the language for all radio communications implies that, in order to have a clear and efficient communication between the involved stakeholders, all of them must be sufficiently proficient in the use of English. Nevertheless, the implementation of English language in substitution of the national language for radio communications in an airport will not be immediate, and it is expected that not every person will have the same proficiency in the use of English. Thus, all these factors could potentially lead to miscommunication.

HZ.3. Higher training / qualification requirements. The implementation of the Triple One concept will result in the need of more training for the aerodrome employees, including also new fields for training, namely, to get prepared for the use of the tower frequency, English proficiency or radio phraseology. Thus, this increase of the qualification requirements will lead to a difficulty to find suitable personnel to operate on the runway and might result to a shortage of resources for safety critical tasks.

HZ.4. More stakeholders on tower frequency. This hazard focus on the transmission of more information. The increase in the number of stakeholders present in the tower frequency has the implication of a higher amount and different types of information transmitted on the tower frequency, leading to the consequent information overload for all the involved actors. In difference to HZ.1 it is not about the physical

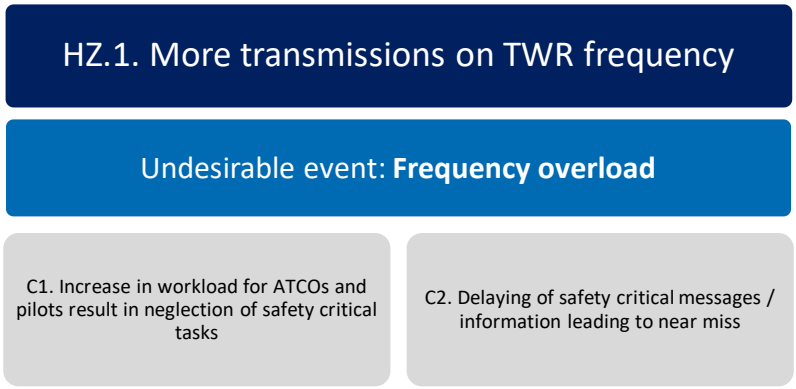
congestion of the frequency but relates to the additional type of information transmitted on the tower frequency, namely related also to vehicle movements.

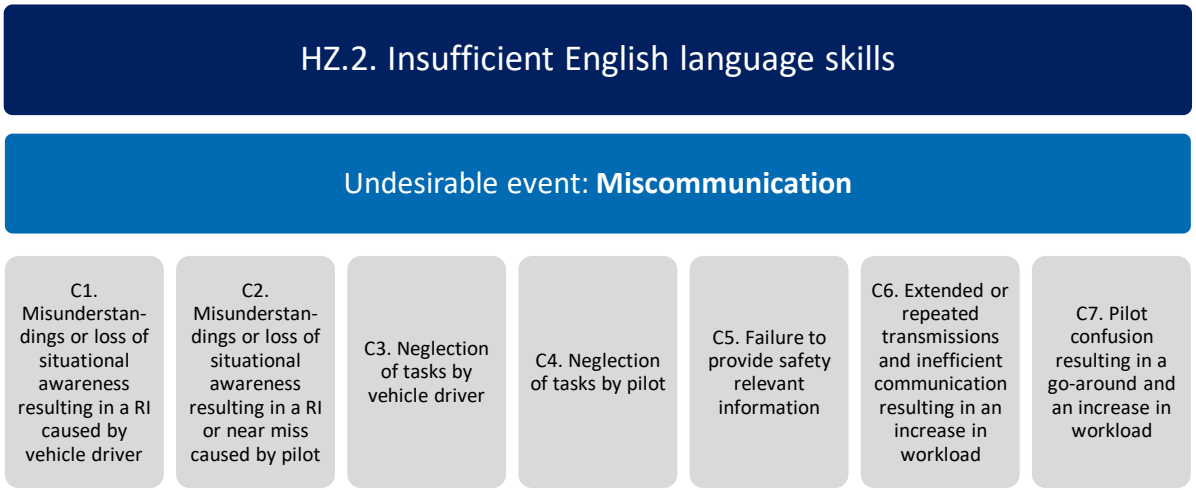
II.3.3 Description of consequences and occurrences

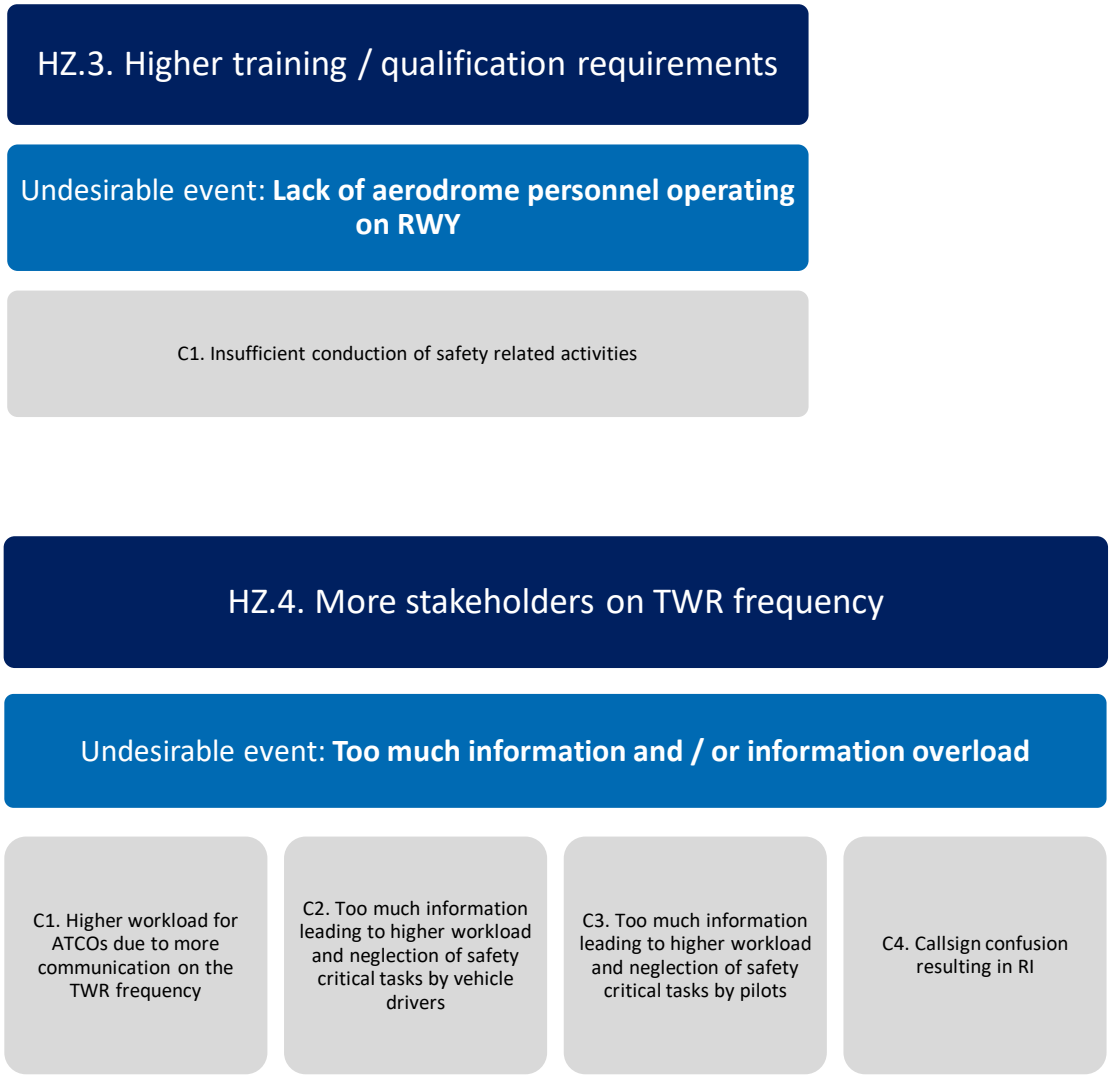
II.3.3.1 Overview

II.3.3.1.1 Each of the hazards described above may result in different consequences, this is, different outcomes of the undesirable event associated to the hazard [4].

II.3.3.1.2 These consequences derived from the hazards will be presented and analysed in this section. The following diagrams provides both the undesirable event and a first overview of the consequences associated to each hazard:







II.3.3.2 Hazard HZ.1: More transmissions on TWR frequency

II.3.3.2.1 **Consequence C1.HZ.1**: Increase in workload for ATCOs and pilots result in neglection of safety critical tasks.

The congestion of the tower frequency is translated into an increase in workload for ATC personnel and pilots, since the controllers or pilots may not be able to obtain a slot in the radio in the moment when they need to establish communication, resulting in distraction or neglection of tasks that are critical in terms of safety, considering also that a higher workload increases also the susceptibility to errors.

II.3.3.2.2 **Examples of occurrences for Consequence C1.HZ.1**:

- Single pilot is focused on trying to establish communication with ATC and skips important element of the landing checklist like correct flap setting, resulting in unstable approach.

II.3.3.2.3 **Consequence C2.HZ.1**: Delaying of safety critical messages / information leading to near miss.

The attempt of communication by ATC with the pilot results in a delay in the radio transmission due to the high usage of the tower frequency. Thus, flights in approach may result in a near miss.

II.3.3.2.4 **Examples of occurrences for Consequence C2.HZ.1**:

- Go-around instruction of ATCO is delayed, resulting in a RI.
- Take-off clearance cannot be issued due to frequency overload, resulting in near miss of an approaching aircraft.

II.3.3.3 Hazard HZ.2: Insufficient English language proficiency (ELP)

II.3.3.3.1 **Consequence C1.HZ.2**: Misunderstandings or loss of situational awareness resulting in a RI caused by vehicle driver.

The lack of ELP of the vehicle drivers in the use of English language for radio communications may lead to misunderstandings, such as misinterpretation of a clearance or inability to follow instructions, resulting in a runway incursion.

II.3.3.3.2 **Examples of occurrences for Consequence C1.HZ.2**:

- Vehicle driver misunderstands RWY crossing clearance of another vehicle and enters RWY without clearance, resulting in a RI.

II.3.3.3.3 **Consequence C2.HZ.2**: Misunderstandings or loss of situational awareness resulting in a RI or near miss caused by pilot.

The lack of ELP of some pilots (especially non-commercial pilots) in the use of English language for radio communications may lead to misunderstandings, such as misinterpretation of a clearance or inability to follow instructions, resulting in a runway incursion or a near miss.

II.3.3.3.4 **Examples of occurrences for Consequence C2.HZ.2**:

- Pilot misunderstands RWY entry clearance of another aircraft and enters RWY without clearance, resulting in a RI.

II.3.3.3.5 **Consequence C3.HZ.2**: Neglection of tasks by vehicle driver.

The lack of English proficiency of the vehicle drivers may lead to the neglection of important tasks due to, for example, an unclear understanding of the task or a distraction provoked by an excessive attention for the interpretation of the runway related communication and instructions.

II.3.3.3.6 **Examples of occurrences for Consequence C3.HZ.2**:

- Vehicle driver misses FOD during RWY inspection.
- Maintenance personnel forget tool or other parts on the RWY.

II.3.3.3.7 **Consequence C4.HZ.2**: Neglection of tasks by pilot.

The lack of English proficiency of some pilots (especially non-commercial pilots) may lead to the neglection of important tasks due to, for example, an unclear understanding of the ATC instructions or a distraction / interruption provoked by an excessive attention for the interpretation of the runway related communication and instructions.

Examples of occurrences for Consequence C4.HZ.2:

- Pilot is interrupted during take-off preparation (before take-off checklist) and missed to set correct flap setting.

II.3.3.3.8 **Consequence C5.HZ.2**: Withholding of safety relevant information.

The lack of English proficiency of the vehicle drivers may lead to situations in which they do not inform ATC about a task that they are performing on an aircraft movement area, or about a safety situation that they are observing, due to the inability to communicate in English what they require in that moment or to insecurity and fear of making mistakes.

II.3.3.3.9 **Examples of occurrences for Consequence C5.HZ.2**:

- Vehicle driver stops during RWY inspection without informing ATC to collect FOD or similar.
- Wildlife inspection does not report birds, controller and pilots are not warned, bird strike.

II.3.3.3.10 **Consequence C6.HZ.2**: Extended transmissions and inefficient communication resulting in an increase in workload.

When the vehicle drivers have a low English proficiency, the radio communications with ATC are less efficient in terms of the ability to express clear and precise information, usually requiring more and longer radio transmissions, and therefore leading to a higher workload.

II.3.3.3.11 **Examples of occurrences for Consequence C6.HZ.2**:

- RWY inspection found an unidentifiable item on the RWY and described this item to ATC, but ATC needed to ask for clarification, resulting in an increase in workload for the ATCO.

II.3.3.3.12 **Consequence C7.HZ.2**: Pilot confusion resulting in a go-around and an increase in workload.

When vehicle drivers with a low English proficiency try to report their position or some relevant information regarding the airfield conditions, they may utilise unclear, unprecise or ambiguous vocabulary that could result in a confusing situation for a pilot on approach and influence his decision-making process.

II.3.3.3.13 **Examples of occurrences for Consequence C7.HZ.2**:

- A vehicle driver reports his position with ambiguous wording so that the pilot (on final approach) cannot get a clear picture of where the vehicle is and the pilot decides to go-around.

II.3.3.4 Hazard HZ.3: Higher training / qualification requirements

II.3.3.4.1 **Consequence C1.HZ.3**: Insufficient conduction of safety related activities.

The increase of the required qualification for the aerodrome personnel (e.g. English language proficiency, frequency usage, phraseology) may result in a higher difficulty to find adequate people, thus having less personnel who shall then take a higher workload and responsibility, or who will be insufficiently qualified due to a shortened training process, together with reduced inspection intervals, with the consequent reduction of effectivity and efficiency, and therefore, reduction in safety.

II.3.3.4.2 **Examples of occurrences for Consequence C1.HZ.3**:

- Due to increased intervals between inspections or lack of attention due to fatigue, RWY inspection is missing FOD, resulting in damage to aircraft (e.g. tire damage, engine ingestion).

II.3.3.5 Hazard HZ.4: More stakeholders on TWR frequency

II.3.3.5.1 **Consequence C1.HZ.4**: Higher workload for ATCOs due to more communication on the TWR frequency.

The presence of a higher number of different stakeholders constantly communicating on the tower frequency will produce an increase in the workload for the ATC personnel,

resulting in distraction, confusion or omission of non-safety[2] critical information for the vehicle drivers or the pilots.

II.3.3.5.2 **Examples of occurrences for Consequence C1.HZ.4**:

- The numerous incoming radio transmissions on the tower frequency causes the ATCO to be confused and to reply to one of the stakeholders with non-safety[2] critical information that was required by another.

II.3.3.5.3 **Consequence C2.HZ.4**: Too much information leading to higher workload and neglection of safety critical tasks by vehicle drivers.

The presence of a higher number of actors constantly communicating on the tower frequency will result in an information overload that could signify a distraction for the ground personnel in their safety critical tasks, together with an increase in the susceptibility to errors.

II.3.3.5.4 **Examples of occurrences for Consequence C2.HZ.4**:

- Information overload causes a vehicle driver performing a RWY inspection to be distracted from his/ her actual task. As a result, FODs are missed.

II.3.3.5.5 **Consequence C3.HZ.4**: Too much information leading to higher workload and neglection of safety critical tasks by pilots.

The presence of a higher number of actors constantly communicating on the tower frequency will result in an information overload that could signify a distraction for the pilots in their performance of safety critical tasks, especially relevant for single pilot cockpit.

II.3.3.5.6 **Examples of occurrences for Consequence C3.HZ.4**:

- Pilot is distracted by many position reports from vehicles while performing the landing checklist and omits an element, which results e.g. in an overrun due to incorrectly set flaps or speed brakes.

II.3.3.5.7 **Consequence C4.HZ.4**: Callsign confusion resulting in RI.

The presence of a higher number of stakeholders constantly communicating on the tower frequency will result in an information overload that could lead to distraction or omission of details from the radio transmission, with the possibility of turning out in a runway incursion produced by a callsign confusion.

[2] It is assumed that the ATCOs are able to handle high workload, therefore it is considered that an increase in workload could only affect non-safety critical issues.

II.3.3.5.8 **Examples of occurrences for Consequence C4.HZ.4**:

- Having vehicle driver and pilots on the same frequency results in callsign confusion (e.g. Airline XX and Airline XX maintenance) and RI.

II.3.4 Risks analysis

II.3.4.1 General

II.3.4.1.1 Once the hazards associated to the implementation of the Triple One concept and the derived consequences have been described and analysed, it is possible to study the severity and probability of each one of the consequences.

II.3.4.1.2 As presented in the section II.2, the risk matrix to be utilised for the risk analysis is different from the one that is most commonly used as it is simplified and divided in only three levels for the severity and three levels for the probability. Additionally, this process will be carried out for each of the exemplary aerodromes that have been selected for this aim (see section II.2.3).

II.3.4.1.3 Regarding all hazards that have been derived, it has been considered that the severity associated to each consequence of each hazard is unique and not dependent on the specific aerodrome scenario. Nevertheless, the probability is considered to change for each aerodrome, taking into account the different factors that are characteristic of each scenario and may influence the consequences of the hazards.

II.3.4.2 Hazard HZ.1: More transmissions on TWR frequency

Table 6: Risk analysis for the consequences of the hazard HZ.1

Consequences	Risk analysis	ADR I	ADR II	ADR III	ADR IV	ADR V	ADR VI
C1.HZ.1. Increase in workload for ATCOs and pilots result in neglection of safety critical tasks	Severity	B					
	Probability	1	2	2	2	3	3
	Risk	Low	Medium	Medium	Medium	Medium	Medium
C2.HZ.1. Delaying of safety critical	Severity	A					
	Probability	1	2	2	2	3	3

Consequences	Risk analysis	ADR I	ADR II	ADR III	ADR IV	ADR V	ADR VI
messages/ information leading to near miss	Risk	Medium	Medium	Medium	Medium	High	High

II.3.4.2.1 The severity associated to the consequence C1.HZ.1 is B, since the outcome is likely to be limited to a delayed flight or a go-around.

II.3.4.2.2 The probability associated to the consequence C1.HZ.1 is mostly related to the traffic density and the presence of more or less stakeholders on the runway. Thus, it is category 1 for the aerodrome with light traffic, category 2 for those with a higher traffic density and having many groups on the runway, except aerodrome IV, which has a heavy traffic but not so many stakeholders on the runway, and category 3 for those with heavy traffic and many groups or activities on the runway.

II.3.4.2.3 The severity category associated to the consequence C2.HZ.1 is A, since the outcome in this case could be more serious, such as a runway incursion or a near miss.

II.3.4.2.4 The probability associated to the consequence C2.HZ.1 is related to the same factors with for the first consequence. Therefore, the probabilities follow the same tendency with for the first consequence.

II.3.4.3 Hazard HZ.2: Insufficient English language skills

Table 7: Risk analysis for the consequences of the hazard HZ.2

Consequences	Risk analysis	ADR I	ADR II	ADR III	ADR IV	ADR V	ADR VI
C1.HZ.2. Misunderstandings or loss of situational awareness resulting in a RI caused by vehicle driver	Severity	A					
	Probability	1	1	1	1	1	2
	Risk	Medium	Medium	Medium	Medium	Medium	Medium
C2.HZ.2. Misunderstandings or loss of situational	Severity	A					
	Probability	2	3	1	1	1	1

Consequences	Risk analysis	ADR I	ADR II	ADR III	ADR IV	ADR V	ADR VI
awareness resulting in a RI or near miss caused by pilot	Risk	Medium	High	Medium	Medium	Medium	Medium
C3.HZ.2. Neglection of tasks by vehicle driver	Severity	A					
	Probability	2	3	1	3	3	2
	Risk	Medium	High	Medium	High	High	Medium
C4.HZ.2. Neglection of tasks by pilot	Severity	A					
	Probability	2	3	1	1	1	1
	Risk	Medium	High	Medium	Medium	Medium	Medium
C5.HZ.2. Withholding of safety relevant information	Severity	B					
	Probability	3	3	1	3	3	2
	Risk	Medium	Medium	Low	Medium	Medium	Medium
C6.HZ.2. Extended transmissions and inefficient communication resulting in an increase in workload	Severity	C					
	Probability	2	3	1	3	3	2
	Risk	Low	Medium	Low	Medium	Medium	Low
C7.HZ.002. Pilot confusion resulting in a go-around and an increase in workload	Severity	C					
	Probability	2	2	1	2	2	2
	Risk	Low	Low	Low	Low	Low	Low

II.3.4.3.1 The severity category associated to the consequence C1.HZ.2 is A, since the result is a runway incursion.

II.3.4.3.2 The probability associated to the consequence C1.HZ.2 is mainly related to the available means that the airports have to prevent runway incursions (technical safety barriers). Thus, considering that all the selected aerodromes have stops bars, which is expected

to decrease significantly the probability, the associated category is rated as 1, except for the case of the last aerodrome, since the complexity of the runway configuration (many crossing points) together with the heavy traffic could increase the potential for a runway incursion.

II.3.4.3.3 The severity category associated to the consequence C2.HZ.2 is A, since the outcome is again a runway incursion.

II.3.4.3.4 The probability associated to the consequence C2.HZ.2 is related to the English language proficiency of the pilots and also to the traffic share (proportion between commercial and non-commercial flights in the aerodrome), since in general the non-commercial pilots may not be used to utilising English for radio communications. In the large aerodromes such as the numbers IV, V and VI, the percentage of non-commercial flights over the total is very low, thus the probability of occurrence is 1. In case of aerodrome III, the English proficiency is considered very good. On the other side, aerodrome II has a considerable number of non-commercial flights, taking into account the higher traffic density, and in addition, the English proficiency is considered as low, therefore the probability category 3 was selected. Airport I has a very low commercial share (only around 30% of the flights are commercial), together with a low English proficiency, but the traffic is also considered very light, so the assigned probability is 2.

II.3.4.3.5 The severity category associated to the consequence C3.HZ.2 is A, since the outcome is the presence of FOD on the runway.

II.3.4.3.6 Since the focus in this case is on the vehicle drivers, the probability associated to the consequence C3.HZ.2 is related to the English proficiency of the vehicle drivers and the air traffic density of the airports. Thus, the aerodrome III has a very low probability due to the high English proficiency of the drivers. The aerodromes II, IV and V have a higher amount of traffic on the radio, and the English proficiency is categorised as low, therefore the probability is 3. The vehicle drivers in aerodrome I also have a low English proficiency, but the traffic is significantly lower, and in aerodrome III, although managing a heavy traffic, the English level is considered medium, thus the probability in these aerodromes is 2.

II.3.4.3.7 The severity associated to the consequence C4.HZ.2 is A, since the outcome is the missing of an important part during the flight preparation, with a potentially fatal result.

II.3.4.3.8 The probability associated to the consequence C4.HZ.2 is back again centred in the pilots, thus related mainly to the English language proficiency of the pilots and also to the traffic density and traffic share. Therefore, the probabilities associated to each one of the exemplary aerodromes for this consequence are the same with those for the second consequence.

II.3.4.3.9 The severity associated to the consequence C5.HZ.2 is B, since the result is only related to safety relevant information, and not considering safety critical information.

II.3.4.3.10 The probability associated to the consequence C5.HZ.2 is mostly related to the English proficiency of the vehicle drivers. Thus, those aerodromes with a low proficiency in this language have received a probability classification of 3, while the one with a medium proficiency was assigned a 2, and the aerodrome with high proficiency has a probability of 1.

II.3.4.3.11 The severity associated to the consequence C6.HZ.2 is C, since the outcome will only be translated into an increase in workload.

II.3.4.3.12 The probability associated to the consequence C6.HZ.2 is related to the same factors than for the third consequence, English language proficiency and air traffic density. Thus, the assigned values for the probability are the same, since the lack of proficiency in the use of English for radio communications will lead to a lower efficiency of the communications, both in terms of clarity and time, and this inefficiency may be translated into a higher workload which will be more noticeable if the ATC has to manage a heavy traffic density.

II.3.4.3.13 The severity associated to the consequence C7.HZ.2 is C, since the result could only be an increase in go-around rate, and therefore higher workload for ATCO and the pilot.

II.3.4.3.14 The probability associated to the consequence C7.HZ.2 is only related to the English proficiency of the vehicle drivers, as it was also for the consequence number 5. Nevertheless, the probability consideration for this case has been less strict, since the likelihood of the pilot having to perform a go-around is lower compared to the situation presented in the fifth consequence. Therefore, for all the aerodromes the probability of occurrence has been selected to 2, except for the aerodrome III, where the English proficiency is considered high.

II.3.4.4 Hazard HZ.3: Higher training / qualification requirements

Table 8: Risk analysis for the consequences of the hazard HZ. 3

Consequences	Risk analysis	ADR I	ADR II	ADR III	ADR IV	ADR V	ADR VI
C1.HZ.003. Insufficient conduction of safety related activities	Severity	A					
	Probability	2	3	1	3	3	2
	Risk	Medium	High	Medium	High	High	Medium

II.3.4.4.1 The severity associated to the consequence of this hazard is A, since the outcome could be the presence of FOD on the runway, provoking consequent critical damage to an aircraft.

II.3.4.4.2 The probability of this consequence is closely related on one hand to the average English language proficiency, since in the places where this proficiency is lower it will be more difficult to find personnel who could meet the qualification requirements, and on the other hand the traffic density, which will influence the workload of the ground personnel. Thus, in the aerodromes where the English proficiency is low and the traffic density is medium to heavy (aerodromes II, IV and V), the probability is high, while if the English level is medium (aerodrome VI) or if the traffic is light (aerodrome I), the probability will be medium. Finally, the aerodrome III where the English language proficiency is considered very good will have a low probability.

II.3.4.5 Hazard HZ.4: More stakeholders on TWR frequency

Table 9: Risk analysis for the consequences of the hazard HZ.4

Consequences	Risk analysis	ADR I	ADR II	ADR III	ADR IV	ADR V	ADR VI
C1.HZ.004. Higher workload for ATCOs due to more communication on the TWR frequency	Severity	C					
	Probability	1	2	1	2	1	1
	Risk	Low	Low	Low	Low	Low	Low
C2.HZ.004. Too much information leading to higher workload and neglection of safety critical tasks by vehicle drivers	Severity	A					
	Probability	1	2	1	2	2	1
	Risk	Medium	Medium	Medium	Medium	Medium	Medium
C3.HZ.004. Too much information leading to	Severity	A					
	Probability	1	2	1	2	2	2

Consequences	Risk analysis	ADR I	ADR II	ADR III	ADR IV	ADR V	ADR VI
higher workload and neglection of safety critical tasks by pilots	Risk	Medium	Medium	Medium	Medium	Medium	Medium
C4.HZ.004. Callsign confusion resulting in RI	Severity	A					
	Probability	1	2	1	2	2	2
	Risk	Medium	Medium	Medium	Medium	Medium	Medium

II.3.4.5.1 The severity category associated to the consequence C1.HZ.4 of this hazard is C, since the only expected outcome is an increase in the workload for ATCO with no further result that could compromise safety.

II.3.4.5.2 The probability of the consequence C1.HZ.4 is related to the management of the air traffic in the aerodrome, therefore depending on the traffic density, but especially on the controller position who is responsible for the radio communication with the vehicle drivers. In this context, the aerodromes II and IV, where the radio communication with the vehicle drivers is managed from the position of an assistant, the probability will be higher than in the other aerodromes, where the ATCO handles this communication. In any case the probability has been considered as medium or low, since one of the requirements for the ATC controllers is the ability to manage high workload.

II.3.4.5.3 Regarding the consequence C2.HZ.4, the outcome could imply the presence of FOD on the runway, therefore having a high severity associated.

II.3.4.5.4 The probability of the consequence C2.HZ.4 is connected to several factors, namely, the air traffic density, the number of stakeholders on the runway (how much radio communication with the ground personnel) and the type of communication between vehicle drivers and ATC. In the aerodrome I there is not much radio communication and the traffic is light, therefore the chosen probability is 1. Regarding the aerodromes III, IV and VI, the drivers have currently the possibility to listen to the tower frequency, thus the potential for distraction is low. The aerodrome II has a medium probability associated, since the traffic density is medium and there are many stakeholders on the runway, the same as the aerodrome IV, which has less stakeholders on the runway but a heavier traffic density.

II.3.4.5.5 The consequence C3.HZ.4 is similar to the previous one, but setting the focus now on the pilots' outcome. The severity is also high (A), since the neglection of this kind of tasks may have a critical safety impact (e.g. overrun, runway excursion).

II.3.4.5.6 The probability associated to each airport is mostly dependent on the air traffic density and on the number of stakeholders on the runway. Hence, the probability is considered medium for the aerodromes II, IV, V and VI since the traffic is medium or heavy and/or they have many stakeholders on the runway, while for the aerodromes I and III the probability is set as 1, due to low traffic and not many stakeholders, respectively.

II.3.4.5.7 Lastly, the consequence C4.HZ.4 of this hazard may have a runway incursion as a result; thus, the severity has been selected as A.

II.3.4.5.8 Regarding the probability of the consequence C4.HZ.4, the main factor of influence is the number of stakeholders on the runway. Therefore, the aerodromes I and III will have a low probability associated. The aerodrome II has a relevant number of cargo traffic, hence the likelihood of having a callsign confusion due to stakeholders with similar callsign is higher, stated in this case as 2. For the remaining aerodromes IV, V and VI, the traffic is higher and the possibility of confusion could also exist, so the probability is also set as 2.

II.3.4.6 Conclusions of the risk analysis

II.3.4.6.1 In view of the results of the risk analysis related to the implementation of the Triple One concept in the scenarios depicted through the six airports that have been considered, the following conclusions have been extracted:

- There are in total 5 risks which fall into the red region (high risk) for at least one of the aerodromes – see Table 10.

Table 10: Risks that have been assigned to high risk level for at least one aerodrome

Risk ID	Hazard	Consequence	Aerodromes in which the risk is high (red region)
C2.HZ.001	More transmissions on TWR frequency	Delaying of safety critical messages / information leading to near miss	V, VI
C2.HZ.002	Insufficient English language skills	Misunderstandings or loss of situational awareness resulting in a RI or near miss caused by pilot	II
C3.HZ.002.		Neglection of tasks by vehicle driver	II, IV, V
C4.HZ.002.		Neglection of tasks by pilot	II
C1.HZ.003.	Higher training / qualification requirements	Insufficient conduction of safety related activities	II, IV, V

- There are two risks (C7.HZ.2, C1.HZ.4) that have been assigned to low risk level (green) for all of the selected aerodromes.
- The number of risks classified within the different regions for each exemplary aerodrome is the following:

Table 11: Risk classification for each of the exemplary aerodromes

	ADR I	ADR II	ADR III	ADR IV	ADR V	ADR VI
High risk	0	4	0	2	3	1
Medium risk	10	8	10	10	9	10
Low risk	4	2	4	2	2	3

- The initial safety risk is lower for the smaller airports in comparison with the larger airports.
- The English language proficiency of the vehicle drivers has the most significant impact on the safety risk.

- Highest safety risks arise for complex aerodromes with low English language proficiency of the vehicle drivers.

II.3.5 Mitigations and variations

II.3.5.1 General

II.3.5.1.1 Taking into consideration that many risks within the yellow region (medium risk) and red region (high risk) have been identified, the discussion of mitigation measures is necessary, with special attention to the high risks, whose risk level shall be mandatorily addressed and reduced.

II.3.5.1.2 Notably, in certain cases the application of a Triple One variation may also be a suitable solution to reduce associated risks.

II.3.5.2 Mitigation MIT.1: Frequency cross-coupling

II.3.5.2.1 Hazards affected: HZ.1

II.3.5.2.2 Frequency coupling is a method for voice communication between pilots and controllers in which multiple frequencies are used. If a radio message is received on one of the frequencies, it is automatically re-transmitted on the others by the ground station. Thus, pilots are also able to hear all communication [5].

II.3.5.2.3 Therefore, the implementation of a frequency cross-coupling could be a suitable solution to prevent the blockage of radio messages, since in this way there is no need to instruct the pilots to make frequency changes in these situations. Thus, frequency overload is reduced and a potential loss of communication is also diminished.

II.3.5.3 Variation VAR.1: Reduction of vehicle communication on TWR frequency to important standard phrases

II.3.5.3.1 Hazards affected: HZ.1, HZ.4

II.3.5.3.2 In order to have an adequate situational awareness, pilots need to know when a vehicle enters and exits a runway. Therefore, standard phrases, such as "enter runway", "runway vacated", "hold short of runway" could be sufficient to ensure the situational awareness of pilots [6]. All other communication related with coordination, queries or operations could be conducted on a separate frequency (e.g. trunked radio).

II.3.5.4 Mitigation MIT.2: Intensive radiotelephony training for vehicle drivers

II.3.5.4.1 Hazards affected: HZ.1

II.3.5.4.2 Radio discipline, standard phraseology and understanding radio communication should be properly trained, not only in theory but also practically. The vehicle drivers should receive intensive preparation and practice in the correct and efficient usage of the radio, the common frequency and the phraseology in order to enhance radio communication and therefore reduce the frequency utilisation.

II.3.5.5 Variation VAR.2: Mandatory use of English standard phraseology only

II.3.5.5.1 Hazards affected: HZ.2, HZ.3

II.3.5.5.2 In order to have an adequate situational awareness, pilots need to know when a vehicle enters and exits a runway. Therefore, standard phrases, such as "enter runway", "runway vacated", "Hold short of runway" could be sufficient to ensure the situational awareness of pilots. All other communication related with coordination, queries, operations or - under specific conditions - even abnormal situations should be possible to be conducted in the local language. No English level language proficiency would be required for vehicle drivers on the manoeuvring area.

II.3.5.6 Mitigation MIT.3: Development and publishing of vehicle driver related standard phraseology

II.3.5.6.1 Hazards affected: HZ.2

II.3.5.6.2 The use of standard phraseology is prescribed. However, there is no specific standard phraseology dedicated to vehicle drivers on the runway and/or manoeuvring area published. In order to use consistent phrases across airports, a limited number of phrases, tailored to situations in which drivers find themselves at the airport, should be developed and published in the EASA rules.

II.3.5.7 Mitigation MIT.4: Exemptions for runways that are inactive for maintenance (not per NOTAM)

II.3.5.7.1 Hazards affected: HZ.1, HZ.3, HZ.4

II.3.5.7.2 With the objective of reducing the number of staff requiring high English language proficiency, exemptions should be made for runways that are temporarily not available due to maintenance works or inspections. The runway does not necessarily have to be deactivated by NOTAM.

II.3.5.8 Mitigation MIT.5: Exemptions for abnormal situations

II.3.5.8.1 Hazards affected: HZ.2, HZ.3

II.3.5.8.2 Exceptions to the English language level requirement for abnormal situations are absolutely necessary. Inadequate expressiveness during abnormal situations because of being forced to communicate in a foreign language can lead to considerable safety risks.

II.3.5.9 Mitigation MIT.6: Exemptions for abnormal situations

II.3.5.9.1 Hazards affected: HZ.1, HZ.4

II.3.5.9.2 Exemptions for one frequency to be used may be necessary in abnormal situations. Coordination of RFFS may then be handled on a separate frequency[3].

[3] This will have to be accompanied with other mitigating measures, such as the closure of the part of the manoeuvring area required for the movement of the vehicles responding to the accident.

Part III Cost analysis

III.1 Cost factors

III.1.1 General

III.1.1.1 Adopting the Triple One concept at aerodromes, where the Triple One itself or any of its components is not yet in place, requires investments for both its initiation and upkeep. The extent of this investment varies significantly across different aerodromes, influenced by several factors such as the current staff's proficiency in English, the availability of skilled labour, the scale of aerodrome operations, the number of personnel involved, and the pre-existing technical infrastructure and protocols, just to name a few examples. Consequently, it is impractical to standardize the associated costs and their determinants across all aerodromes as a tailored evaluation that considers these diverse elements is essential for each aerodrome.

III.1.1.2 Using the "Bottom-Up" calculation methodology[4], it is possible to discern the different economic factors that directly or indirectly influence costs, as outlined as part of the prerequisites analysis in Task 4. However, this cost analysis does not account for the financial expenses associated with the enactment of regulations by legislative entities. Therefore, the identified costs are relevant only to the affected stakeholders and do not include the regulatory bodies involved.

III.1.1.3 Additionally, it is important to note that most identified cost factors, particularly those related to training and personnel, primarily apply to aerodromes that deviate from the existing English language proficiency requirements following a safety assessment and the issuance of a derogation by the respective State, as per ADR.OPS.B.029 [7]. For aerodromes without such a derogation, the costs associated with implementing the Triple One concept are likely already accounted for.

III.1.2 Training costs

III.1.2.1 General

III.1.2.1.1 The most significant factor influencing the total expenses is anticipated to be the additional training required for all parties engaged in tower frequency radio communications, particularly ground personnel (i.e. vehicle drivers). The adoption of a

[4] The "Bottom-Up" calculation methodology offers a detailed and accurate approach to identify project costs or resource requirements. It involves starting at the most granular level of data, such as work packages, activities or tasks, and aggregating them to form an overall performance estimation. This method considers details that can impact a project's overall requirements and outcomes.

policy mandating English as the language of communication for all involved parties, including ATCOs, pilots and vehicle operators with runway access, necessitates a sufficient level of English proficiency by each participant.

III.1.2.1.2 ATCOs must already fulfil the language proficiency standards mandated by ATCO.B.030 (c) [7], which is reinforced by SERA.14015 [8]. Consequently, there are no supplementary expenses for language training for ATCOs during the Triple One implementation expected.

III.1.2.1.3 Commercial pilot license holders are required to have a minimum of English Level 4. However, this requirement does not extend to private or non-commercial pilots who do not hold an instrument flight rating and operate solely within their own country with a radio and language certificate in their native language, as per FCL.055 (d) [10], referred to as "non-commercial VFR pilots." These pilots are currently permitted to use aerodromes within the EASA scope, even without an English language certificate, also regardless of whether a Control Zone is present. The survey conducted for Task 2 revealed that 54 of the 69 participating aerodromes (78.3 %) offer local frequencies in the national language besides English (refer to Part 4.4.4 of the Task 2 report). The effectiveness of the Triple One initiative is dependent on the English proficiency across all pilot groups. Alternatively, non-commercial VFR pilots without the required English certification are limited to using aerodromes outside the EASA scope.

III.1.2.1.4 Under ADR.OPS.B.029 (a) [10], it is mandated that vehicle drivers with access to the manoeuvring area must demonstrate proficiency in English at an operational level, specifically in the application of standard phraseologies as well as plain language use. With the exception of this regulation, which will come into force in 2026, it is not mandatory for drivers to be able to speak English until then. Consequently, it is currently presumed that most vehicle drivers have not obtained a certificate of English language proficiency.

III.1.2.1.5 It is anticipated that significant training, including initial and recurrent training, will be required at those aerodromes where drivers are not currently trained in English. With regard to the implementation of the Triple One concept, this only applies to drivers with access to the runway - in contrast to ADR.OPS.B.029 [10], which also requires this for the entire manoeuvring area.

III.1.2.1.6 During the study, aerodrome operators participating in the workshops were asked whether the already estimated required training time, number of trainees or even costs. Most respondents did not make own estimations – mainly due to missing knowledge about required standards and training capabilities. For those aerodromes where numbers or estimations were provided, these were factored in in this analysis.

III.1.2.2 Initial language training

III.1.2.2.1 To implement the Triple One concept at an aerodrome, it is mandatory for vehicle drivers with access to active runways and non-commercial VFR pilots, including those with PPL, LAPL, SPL, and those operating drones, helicopters, airships or gyrocopters, to achieve a specified proficiency in English. The level of English proficiency required for vehicle drivers on runways varies based on the pursued level of implementation type. For a full implementation, "Aviation English" (i.e. English operational level 4 or dedicated aviation related phraseology) is necessary. In contrast, for partial implementation, understanding comprehensive instructions and/or using a basic set of aviation-specific phraseology may suffice.

III.1.2.2.2 The abovementioned group of pilot license holders is required to undergo training that meets Level 4 standards, regardless of any Triple One implementation status at aerodromes within the EASA scope as required in FCL.055 [9].

III.1.2.2.3 The overall effort that is needed to train the mentioned pilot groups and vehicle drivers with runway access, to the required level of English depends on individual factors as well as on environmental and practical factors. These factors shall be analysed in the following.

III.1.2.2.4 It should be noted that although certain groups of General Aviation pilots would incur additional language training costs, it can be estimated that the highest training costs will be incurred by aerodromes. The impact on General Aviation is more likely to be an opportunity cost due to the expected migration to other aerodromes that are not in the EASA scope or are exempted (see III.3.2.5).

Individual Factors

III.1.2.2.5 Individual factors include the English language skills one has acquired through formal education or other experiences and qualifications. The disparity between a person's current level of English and the proficiency required influences the amount of training necessary. Consequently, the extent of training required can be tailored based on the results of an English language assessment. The initial test outcomes can then be used to classify the training needs in terms of the number of lessons needed.

III.1.2.2.6 While the estimated training hours can be guided by experiences specific to an aerodrome, it is important to note that trainees might need more time if their performance, skill level, or eagerness to learn is not up to par with the average. Additionally, a trainee's age may influence their learning pace, as it has been frequently noted that younger learners often have a more innate capacity for acquiring new skills than older learners.

III.1.2.2.7 Upon completion of the initial training, it is mandatory for the vehicle operator to undergo an English proficiency assessment to ensure compliance with the requested standards.

Environmental/Practical Factors

III.1.2.2.8 In addition to individual characteristics, the environment in which language training occurs significantly impacts the level of effort required. This includes the linguistic culture and policies of each member state, along with the financial cost of each lesson, the quality of the training available, and other pragmatic considerations.

III.1.2.2.9 The level of English proficiency in a particular country or region (i.e. the average level of English proficiency) often depends on the level of English language teaching in the education system. If English is a mandatory subject and students are taught to a high standard, they are likely to develop a solid base in the language before starting a career.

III.1.2.2.10 Given the necessity to train a substantial number of vehicle drivers at aerodromes, it's important to recognize that the cost per individual training session can significantly impact the total expenses of the training program. The nature of the training (e.g. hiring external language trainers or utilizing online platforms and mobile applications) can affect not only the costs but also the success rate of the trainees' learning outcomes. Additionally, if the services of external trainers are engaged, potential additional travel expenses incurred either by the trainer or the trainees must be considered.

III.1.2.2.11 The quality of training plays a crucial role in determining the number of hours required to achieve proficiency in English, potentially reducing costs if the training program is sufficiently effective to achieve the required language standards within less than the projected hours. On the other hand, enhanced training quality, such as content customized for the learner's needs, might increase the cost per hour. However, this could be justified by the faster rate of learning. It is also essential to acknowledge that specialized language certification and courses designed for vehicle drivers or non-commercial pilots are generally lacking, requiring the need for custom-designed courses or modifications to existing ones. Especially when language schools first start offering courses, pre-packaged "off the shelf" trainings are typically unavailable, necessitating the creation of specialized training materials for aviation (see also Part IV.2.1). This requirement can lead to higher costs per lesson and additional expenses for updating training content.

III.1.2.2.12 In addressing the practical aspects, it is essential to consider the broader context of language training programs. This includes the examination fees associated with obtaining official language proficiency certifications, which are subject to variation across different member states and regions. Furthermore, costs for the provision of

training materials (learning tools, exercise books, notebooks, pens, folders, etc.) for the training participants or language trainer must be taken into account.

III.1.2.3 Recurrent language training

III.1.2.3.1 Maintaining ongoing language skills requires recurrent training. ATCOs and commercial pilots undergo regular assessments of their English language abilities according to ATCO.B.035 (a) [7] and FCL.055 (c) [9]. The adoption of the Triple One concept would extend this requirement to non-commercial pilot license holders without an English qualification and vehicle drivers on runways, mandating their participation in routine evaluations. This would be the case, unless they have already demonstrated language proficiency at an expert level (English level 6), as referred to FCL.055 (c) for pilots [9] and ADR.OPS.B.029 (d) for vehicle drivers [10] – which is rarely expected to occur in countries where English is not common mother tongue.

III.1.2.3.2 Typically, the expenses associated with recurrent language training are influenced by factors similar to those affecting the initial training costs, such as personal and environmental/practical elements. Nevertheless, it is important to take into account additional cost factors like the duration of validity for the initial or preceding English language proficiency certification, the effectiveness of the prior training sessions (which also hinges on the training quality), and the extent of English language usage in day-to-day operations. The latter can differ among various groups based on how often they access the runway system.

Validity Period

III.1.2.3.3 The validity period of the language proficiency certificate is defined by the English level that was demonstrated.

III.1.2.3.4 If the Triple One concept will be fully implemented, the radio communication participants must meet certain English language proficiency requirements (i.e. "Aviation English" or English level 4 at least). In this case, similarly as required by ADR.OPS.B.029 (d) [10], the language proficiency shall be re-assessed every four years for English Level four and every six years for English Level 5 (extended).

III.1.2.3.5 In certain cases where only a variation of the Triple One concept is applied, necessitating solely the listening comprehension and the application of specific terminology there are no costs for recertification. There would rather be only costs related to maintaining the listening comprehension or the application of specific terminology.

III.1.2.4 Radio certification for vehicle drivers

III.1.2.4.1 Vehicle drivers, who operate on the manoeuvring area at an aerodrome, must receive detailed training in radiotelephony according to ADR.OPS.B.024 (b)(2) and further explained in AMC3 ADR.OPS.B.024(b) [10]. This would also include runway access licences subject to the Triple One concept. However, integrating vehicle drivers into the tower frequency requires them to possess a valid radiotelephony certificate, which is essential for specific communications on aviation channels (see also Part IV.2.5). It is important to recognize that the initial language proficiency training provided to vehicle drivers prepares them with the ability to communicate in English, but it does not encompass the specialized knowledge and skills required for effective aviation radio communication.

III.1.2.4.2 In contrast to vehicle drivers, ATCOs and pilots licencing system already provide the prove of certification through a nationally accredited radiotelephony certificate. Therefore, additional radio certification costs only apply for vehicle drivers with access to a runway at aerodromes, where it is not required to date. Often, vehicle drivers communicating on a dedicated, non-aviation frequency, are in most cases not subject to official radio certificates. The survey for Task 2 indicates that out of the 69 aerodromes involved, 19 (representing 27.5 %) already issue official radio certifications to drivers accessing runways. Consequently, these aerodromes will not incur extra expenses since such costs have been accounted for in their financial planning.

III.1.2.4.3 The projected expenses for the initial radio certification are subject to factors similar to those impacting the costs of initial language training. These factors include the number of vehicle drivers, costs per training lesson, training quality, certification fees, and additional expenses for training material, if this has to be developed specifically for vehicle drivers.

III.1.2.4.4 Furthermore, it is required that vehicle drivers undergo recurrent training in radiotelephony communication. Although the effort and costs for carrying out the ongoing radiotelephony training can be expected to be much fewer than for recurrent language training, similar factors should be considered for estimation, such as the validity period of the certificate, success of the initial or previous training, practice of radiotelephony (depends on how often the drivers actually operate on the runway), costs per training lesson, certification fees, and additional expenses for training material.

III.1.2.5 Training costs estimation

III.1.2.5.1 As inferred from preceding discussions, a general estimation of training expenses for all parties involved, such as aerodrome operators or pilots, is not possible. This is due to a multitude of variating elements that significantly impact the overall costs, including the diverse initial language proficiency levels and the varying expenses per instructional session.

III.1.2.5.2 Nevertheless, it is feasible to create a correlation between the identified factors and expenses by formulating cost equations. These equations are particularly tailored for vehicle driver training. Considering the various elements that contribute to the cost, including the volume of personnel trained and the extra expenses for radiotelephony certification, it is anticipated that these training costs will be the most significant. However, the subsequent cost equations, notably those for language proficiency training, may also be applicable to pilots, provided that all variables and multipliers are customized to each pilot's specific circumstances.

III.1.2.5.3 The total expenses for training can be described as the sum of all costs associated with English language proficiency and radiotelephony instruction in English, which varies based on the stakeholder receiving the training. Specifically for aerodrome vehicle drivers, the applicable formula is as follows:

III.1.2.5.4 $$C_{training} = C_{language\ training} + C_{radiotelephony\ training}$$

III.1.2.5.5 The costs associated with training can be further broken down based on the analysis above. This implies that the expenses for language training can be categorized into the initial costs for language proficiency training and the recurrent costs for maintaining language skills, as follows:

III.1.2.5.6 $$C_{language\ training} = C_{initial\ language\ training} + C_{recurrent\ language\ training}$$

III.1.2.5.7 Considering the factors outlined in section III.1.2.2, it is possible to establish specific equations for calculating the costs associated with initial training and language proficiency development:

III.1.2.5.8 $C_{initial\ language\ training} = C_{training\ per\ language\ lesson} \cdot n_V \cdot n_{lt} \cdot f_{il} + C_a$ with

$C_{training\ per\ language\ lesson}$: Costs per language training lesson (depends on type of training)

n_v: Number of vehicle drivers operating on an active runway

n_{lt}: Average number of language training lessons per person needed

f_{il}: Individual language factor (incl. individual English level baseline, learning success and training quality), f_{il} should be ≤ 1 but may be > 1,

C_a: Additional costs (incl. certification fees and training material)

III.1.2.5.9 It should be recognized that the cost estimation model for initial language training excludes the level of English proficiency vehicle drivers must achieve. Consequently, for the comprehensive adoption of the Triple One concept, the average number of necessary training hours (n_{lt}) is expected to rise in comparison to a variation in language proficiency, owing to the more stringent English language proficiency prerequisites. This increment is also relevant to the costs associated with recurrent language training.

III.1.2.5.10 In the worst-case scenario, if all vehicle drivers lack English proficiency and need to start learning the language from scratch, there will be a significant gap between their current level and the required proficiency. Consequently, this situation would lead to the highest costs due to the extensive training hours needed for these drivers. It can be plausible to anticipate that these drivers will require more training time than typically expected to achieve the necessary language proficiency.

III.1.2.5.11 In addition to the initial training expenses, a formula can be established for the ongoing costs associated with language proficiency training, taking into account the factors outlined in part III.1.2.3, as follows:

III.1.2.5.12 $C_{recurrent\ language\ training} = C_{training\ per\ language\ lesson} \cdot n_V \cdot n_{rlt} \cdot f_{il} + C_a$ with

$C_{training\ per\ language\ lesson}$: Costs per language training lesson (depends on type of training)

n_v: Number of vehicle drivers operating on an active runway and directly communicating to ATS

n_{rlt}: Number of recurrent language taining lessons per person needed (depends on English language practice and success of initial/previous training)

f_{il}: Individual language factor (incl. individual English level baseline, learning success and training quality), f_{il} should be ≤ 1

C_a: Additional costs (incl. certification fees and training material)

III.1.2.5.13 The costs associated with radiotelephony training are cumulative, similar to those of language training. They are calculated by adding together the initial costs of radiotelephony training and the costs that recur over time:

III.1.2.5.14 $C_{radiotelephony\ training} = C_{initial\ radiotelephony\ training} + C_{recurrent\ radiotelephony\ training}$

III.1.2.5.15 Taking into account the specified factors outlined in section III.1.2.4, it is possible to establish the following formula to calculate the initial costs associated with radiotelephony training:

III.1.2.5.16 $C_{initial\ radiotelephony\ training} = C_{training\ per\ radio\ lesson} \cdot n_V \cdot f_{ir} + C_a$ with

$C_{training\ per\ radio\ lesson}$: Costs per radiotelephony training lesson (depends on type of training)

n_v: Number of vehicle drivers operating on an active runway

f_{ir}: Individual radiotelephony factor (incl. learning success

and training quality), f_{ir} should be ≤ 1

C_a: Additional costs (incl. certification fees and training material)

III.1.2.5.17 The following equation can be established as an equivalent for calculating the ongoing costs associated with radiotelephony training:

III.1.2.5.18 $C_{recurrent\ radiotelephony\ training} = C_{training\ per\ radio\ lesson} \cdot n_V \cdot n_{rrt} \cdot f_{ir} + C_a$ with

$C_{training\ per\ radio\ lesson}$: Costs per radiotelephony training lesson (depends on type of training)

n_v: Number of vehicle drivers operating on an active runway and directly communicating to ATS

n_{rrt}: Number of recurrent radiotelephony training hours per person needed (depends on radiotelephony practice and success of initial/previous training)

f_{ir}: Individual radiotelephony factor (incl. validity period of certificate, learning success and training quality), f_i should be ≤ 1 but may be > 1

C_a: Additional costs (incl. certification fees and training material)

III.1.2.5.19 While the current equations provide an insight into the relationship between cost factors and total training expenses, a more detailed specification of these cost factors is essential for a thorough comprehension of their impact. Consequently, an in-depth analysis of each cost factor referenced in the equations is necessary. This analysis will be reinforced by quantified estimates derived from the responses and insights from some aerodromes participating in the survey in Task 3. Such data will offer a rough projection of the necessary training efforts, that is, the aggregate training costs. The subsequent section will detail these factors as follows:

- Costs per language training lesson ($C_{training\ per\ language\ lesson}$):

  The cost of driver training can vary significantly based on the chosen approach. While a specialized course might offer a single session lasting only 45 minutes or one hour, language app subscriptions could extend to a full month. To ensure comparability, it's essential to normalize the cost of language training sessions by calculating them over a uniform duration, such as per hour or per month.

  In practical terms, language applications present an economical alternative, typically charging less than 50 € for each session (monthly), not accounting for the driver's salary or any possible decrease in work capacity. Conversely, hiring specialized external language teachers can significantly elevate expenses, potentially costing several hundred euros per session (hourly or daily)[5].

[5] Note: one training session could include multiple applicants, so that the training cost per participant depends on the number of participants.

Additionally, larger aerodromes may opt for in-house training, which, while not directly invoiced, still incurs indirect labour expenses.

- Costs per radiotelephony training lesson ($C_{training\ per\ radio\ lesson}$):

  Radiotelephony training is typically provided as a comprehensive course, encompassing everything from the basics to full certification, making it challenging to determine the extra cost per individual lesson. Moreover, many aerodromes have integrated radiotelephony instruction into their training for runway vehicle drivers, eliminating the need for separate charges for these training sessions. However, the overall expense for radiotelephony courses, including supplementary costs for educational materials and certification, is generally estimated to fall between 150-400 €, with an average of 250 € for private individuals, not accounting for bulk discounts.

- Number of vehicle drivers operating on an active runway (n_v):

  The quantity of vehicle drivers required for training at an aerodrome is influenced by various factors that contribute to this figure. Specifically, the number is contingent upon the aerodrome's layout, functionality, dimensions, and the volume of air traffic, as well as the roles of different stakeholders such as runway inspections, wildlife, ground operators responsible to tow aircraft across the runway or winter services. Consequently, this determines the necessary workforce to manage runway operations effectively.

  Based on responses from airports participating in the workshops and interviews, the number of drivers typically ranges between 20 to 40 for smaller aerodromes with a single runway and low air traffic density. In contrast, medium-sized aerodromes with up to two runways and moderate air traffic density may require 75-150 people to train. Large aerodromes, featuring at least two runways and heavy air traffic density, may necessitate up to between500 drivers, specific aerodromes reported up to800 drivers. However, these figures can vary based on unique operational needs of an aerodrome (i.e. the type of runway activities, e.g. inspection, towing, maintenance, etc.). Additionally, the current classification of driver permits for apron, taxiway, and runway areas may necessitate a higher or lower count of permitted vehicle operators on the runways.

- Average number of initial language training lessons per person needed (n_{lt}):

  The provision of English education, influenced by the national language policy and cultural factors, results in varying baseline levels of English proficiency. Additionally, the implementation of the Triple One concept necessitates a

certain level of English, which further diversifies the initial count of language lessons needed across different aerodromes. Consequently, it is essential to tailor the number of initial language lessons to the specific requirements of each aerodrome. To accurately calculate the language costs, it's essential to standardize the average number of lessons on the same time frame as the costs per lesson, such as hourly or monthly.

The estimated number of initial language lessons needed varies significantly according to consulted aerodromes, with English proficiency level 4 being the standard requirement. Theoretical calculations based on the CEFR ("Common European Framework of Reference for Languages") suggest that approximately 150 hours or lessons are necessary to advance from one language level to the next, culminating in a total of 600 hours to progress from beginner to level 4[6]. However, actual empirical estimations of consulted aerodromes vary between 80 and 304 hours per person. It is also noted that 15-75% of vehicle drivers possess limited or no English language skills, although many already have basic English skills at levels 1 or 2.

- Average number of recurrent language training lessons per person needed (n_{rlt}):

  The calculation of the average number of recurrent training sessions is influenced by several factors. These include the amount of English used in the workplace, the duration of the language proficiency certification, and the level of English proficiency required, which is determined by the implementation of the Triple One concept. Furthermore, personal elements such as the effectiveness of previous training sessions and the specific approach to training at each aerodrome play a significant role. Consequently, it's not possible to assign a fixed value to the average number of recurrent training sessions. Instead, this figure must be estimated for each aerodrome and each individual.

  Aerodromes that were consulted could not determine the frequency of recurrent training due to these varying factors[7].

- Average number of recurrent radiotelephony training lessons per person needed (n_{rrt}):

  The knowledge acquired from initial or previous radiotelephony training may influence the need for further training sessions. It is anticipated that the number

[6] It must be noted that the CEFR levels do not correspond to the ICAO or SERA ELP levels.
[7] According to ADR.OPS.B.029 (d) [10], the language proficiency shall be re-assessed every four years for English Level four and every six years for English Level 5 (extended).

of required training lessons will be fewer than those needed for the initial training, given that radiotelephony skills have been maintained through practice. Nevertheless, there may be a necessity for individuals to undertake a new radiotelephony course upon the expiration of their certification, due to the possibility that training institutions only offer basic or initial courses, without the option for recurrent training.

- Individual language factor (f_{il}):

  The individual language factor refers to a unique variable that accounts for the diverse elements such as the quality of language instruction received, the initial level of language proficiency, or the extent of learning achievement. These elements vary widely, not just between different aerodromes but also among individuals. Consequently, this factor must be individually tailored for each person and then aggregated for the collective training of personnel at a single aerodrome. The objective for this factor is to achieve a value of 1 or lower, indicating superior average language abilities and a reduction in the total language training expenses. However, the value of this factor could exceed 1, if a significant number of trainees demonstrate English language proficiency below the average, coupled with inadequate learning outcomes.

  While the aerodromes consulted were unable to fully predict this particular aspect, there remains a level of anticipation concerning the success of the training. It is projected that between 10-20% of the personnel undergoing training may not pass the language proficiency examination required for certification. This suggests a potential rise in both the aforementioned aspect and the supplementary expenses should there be a need to substitute individuals who persistently do not meet the criteria.

  When assessing the individual language factor for recurrent language training, it is essential to consider the validity period of the initial or previous certification, too. This period varies based on the level of English proficiency that needs to be achieved.

- Individual radiotelephony factor (f_{ir}):

  The radiotelephony component, as a variable in the equation, includes elements like the success of learning and the quality of instruction. This component, however, exhibits less variability that the individual language factor as training is initiated from the foundational level for everyone. Consequently, this element is expected to be consistent across all trainees, although variations may arise due to differing failure rates. The goal is to achieve a factor not exceeding 1.

Additionally, the certification's expiration date should be factored in for ongoing training.

- Additional costs (C_a):

  In addition to training expenses, it's essential to account for certification charges and supplies costs, such as writing utensils and notebooks, to ensure a precise cost projection. The variability of these additional costs is influenced by multiple elements, including the nature of the training, the quantity of vehicle drivers being trained, and the prevailing local rates. Thus, these costs necessitate individual assessment at each aerodrome to achieve an accurate financial appraisal.

III.1.2.5.20 It is important to recognize that while the previously provided numerical ranges might suggest a rough estimate for training expenses, numerous aerodromes have reported an inability to determine precise costs. Nevertheless, these aerodromes anticipate very high expenses, attributed to factors such as a large number of runway-authorized vehicle operators, a basic level of English language proficiency, or significant failure rates.

III.1.2.6 Training costs summary

III.1.2.6.1 In conclusion, the overall training costs result though language training for runway accessed vehicle drivers and non-commercial pilots without an English language and IFR certificate as well as radiotelephony training costs for mentioned drivers.

III.1.2.6.2 Considering especially the language training, costs are depending on the personal/individual language baseline and environmental/practical factors such as the member state influenced average language baseline, the quality of training and other circumstances of the training and type of trainer contracting.

III.1.2.6.3 Due to the high variation of the language baselines across states, between federal states or even between individual vehicle drivers, it is impossible to value the language training costs generally. Hence, the cost estimation for the initial and recurrent language training must be conducted for each aerodrome individually based on the present on-site situation.

III.1.3 Technical equipment costs

III.1.3.1 General

III.1.3.1.1 To facilitate communication on a common frequency among all parties involved in the Triple One concept, including ATCOs, pilots, and vehicle drivers, it is essential to purchase and maintain the required technical equipment.

III.1.3.1.2 Subsequently, a thorough examination of the necessary technical equipment shall be conducted, and associated costs estimated.

III.1.3.2 Purchase and maintenance of radios

III.1.3.2.1 In accordance with the Triple One concept, which necessitates the use of the tower frequency for communication, it is essential that every participant in radiotelephony is equipped with a radio that has the capability to operate on VHF ("Very High Frequency").[8]

III.1.3.2.2 According to ADR.OPS.B.027 (c) [10], it is mandatory for vehicle drivers to set up satisfactory two-way radio communication with the appropriate air traffic services unit (aerodrome control tower) when they intend, or are in the process of, operating within the manoeuvring area. This implies that a fundamental technical requirement for aerodromes is the provision of radio equipment in these vehicles, as also indicated by ADR.OPS.B.026 (a) [10].

III.1.3.2.3 However, vehicles equipped with radio systems may not support VHF due to the predominantly use of UHF ("Ultra High Frequency"). In some instances, aerodromes have supplied vehicle drivers with additional radios capable of receiving tower frequency communications on VHF. Nevertheless, these do not have transmitting capabilities (a variation of the Triple One concept). Depending on how the Triple One concept is applied (such as in a full implementation scenario), it may be necessary to upgrade to radios that support two-way communication and are VHF-capable. Consequently, the total number of vehicles will influence the anticipated expenses for purchasing and labour associated with the installation or upgrade process.

[8] ADR.OPS.B.027, like other requirements, uses the term "appropriate air traffic services frequency". Although it can be interpreted to mean an aeronautical VHF frequency, this term is nowhere defined in this way in European regulations. Rather, it must be interpreted to mean that there must be a locally agreed frequency with the appropriate air traffic services unit (tower), irrespective of the frequency band. In the case of aerodromes, where vehicles currently communicate on a separate frequency other than the tower frequency, this can be done on any other frequency, thus meeting this requirement.

III.1.3.2.4 In the context of calculating purchase costs, the price of a single VHF-capable two-way radio may range between 400-800 €[9]. This variation is attributed to factors such as the quality of the device, the choice of supplier, and the breadth of features offered.

III.1.3.2.5 Regular maintenance is required for the purchased VHF-capable radio systems used by vehicle drivers, regardless of the existing UHF radios in operation. The frequency and cost of this maintenance will vary based on the life span of the radios acquired, the total number of vehicles in use, and the associated labour expenses.

III.1.3.2.6 Concerning the communication between air traffic services unit (aerodrome control tower) and pilots, voice or data link, or both, shall be used according to ATS.OR.400 [12]. Therefore, it is certain that both pilots and the air traffic services unit (aerodrome control tower) are equipped with VHF capable radios. Hence, no radio related costs are expected.

III.1.3.3 Purchase and maintenance of VHF repeaters

III.1.3.3.1 Due to the inherent physical properties of VHF radio waves, users must maintain a direct visual path for effective communication. However, the expansive nature of aerodromes, combined with natural (e.g. the earth's curvature) and man-made obstructions (e.g. buildings), can lead to signal disruptions. To ensure comprehensive coverage across the entire aerodrome and maintain connectivity with vehicle operators, the acquisition of VHF repeaters may be necessary. Equivalent to purchased radios, the repeaters must be maintained frequently or replaced if necessary.

III.1.3.3.2 The incurred expenses are largely influenced by the aerodrome's configuration and its capacity to fulfil the line-of-sight criteria. Consequently, aerodromes are required to perform an assessment to determine the necessity for VHF repeaters. Should these be deemed necessary, the associated costs will be influenced by the quantity of repeaters installed and the labour expenses involved. Furthermore, the maintenance expenditures are also affected by the repeaters' quality, which dictates the extent of maintenance required.

III.1.3.3.3 It can be assumed that ATCOs and pilots are within the line-of-sight range, given that VHF radios are already operational in their workflows. Therefore, the requirement for VHF repeaters is likely limited to vehicle operations.

[9] Cost projections derived from market analysis.

III.1.3.4 Restructure of tower infrastructure

III.1.3.4.1 Current ATC procedures may include dedicated controllers, who manage vehicle traffic from a distinct workplace within the tower, separate from the ATCOs handling air traffic. Therefore, implementing the one frequency concept requires centralising the control for managing both air and vehicle traffic into a single workspace (executive runway controller). This may require infrastructural modifications, such as relocating control panels to operate gates and lights for vehicle traffic or to enable vehicle drivers to communicate directly with the executive ATCO.

III.1.3.4.2 It is challenging to estimate the financial investment required due to the distinct nature of the current workplace environment. However, it is important to note that the expenses could potentially escalate to an incalculable amount.

III.1.3.5 Initial technical equipment costs summary

III.1.3.5.1 In summary, the aerodrome may incur acquisition expenses, if radios capable of two-way and VHF communication are not already supplied to vehicle drivers (see also Part IV.2.4).

III.1.3.5.2 Additionally, the purchase of VHF repeaters may be necessary to overcome communication barriers between vehicle drivers and other radio users.

III.1.3.5.3 Furthermore, the division of responsibilities between ATCOs overseeing air traffic and specialized controllers managing vehicle traffic may require infrastructure changes at some aerodromes to centralise control tasks within a single workspace.

III.1.4 Change management and personnel costs

III.1.4.1 General

III.1.4.1.1 The implementation of the Triple One concept or a variation requires each aerodrome operator and ANSP to put effort into the change management process. Besides, additional personnel costs are expected to arise or existing ones to increase due to the more stringent requirements.

III.1.4.2 Change management costs

III.1.4.2.1 The changes in the operation of an aerodrome resulting from the implementation of Triple One entail costs for personnel to support this process and for essential preparatory work for its operational implementation.

III.1.4.2.2 Generally, calculating the costs associated with change management is not feasible due to the varying scope of change and the diverse coordination required for the primary Triple One stakeholders. These differences require a tailored approach for implementation at each aerodrome. Furthermore, each aerodrome encounters its own set of unique challenges that could retrospectively influence the costs. However, it is possible to determine specific change management cost parameters for the Triple One stakeholders aerodrome operators and ANSPs.

III.1.4.2.3 In the context of change management expenses for vehicle operators, substantial integration and upkeep efforts are necessary. Specifically, specialized managers need to direct the Triple One project's execution, which includes defining the project's scope, designing procedures for vehicle operators such as aerodrome-specific communication protocols, executing feasibility and risk assessments, consulting stakeholders, planning training, and managing documentation. Following the project's successful launch, ongoing maintenance of the Triple One-related procedures is essential to ensure sustained execution. Consequently, ongoing efforts must be dedicated to continuous planning activities like regular training review and routine reviews of the risk analysis.

III.1.4.2.4 While the implementation brings numerous alterations and obstacles for vehicle drivers, ATCOs are going to experience a lesser impact. Nevertheless, for ATM service providers, this represents a change to the functional system as per Regulation (EU) 2017/373 [12] ATM/ANS.OR.A.045 and requires a change management and approval process. ATC workflows are to adapt to the inclusion of vehicle drivers on tower frequencies. Consequently, based on the existing ATC procedural framework, there may be a need to revise and record vehicle coordination and communication protocols, as well as phraseology, which could result in change management costs.

III.1.4.3 Personnel costs

III.1.4.3.1 Triple One implementation will likely lead to an increase in personnel expenses. Similar to the costs associated with change management, it is possible to identify the factors that will affect personnel costs. However, assigning a specific value to these costs is challenging due to the diverse conditions at each airport, such as the varying average

English proficiency or the number of vehicle drivers, and the desired level of English skills (i.e. the gap between the present and the desired proficiency levels).

III.1.4.3.2 The majority of the costs related to personnel are mainly related to the employment of the driver. Recruitment challenges, in particular the need for language skills, result in fewer applications and increased recruitment efforts (see also Part IV.2.3). These efforts are compounded as the demand for more staff grows.

III.1.4.3.3 In addition to hiring challenges, existing staff and unions may ask for salary increases due to the new language prerequisites, thus higher qualification, and increased workload due to the use of English for communication. Salary adjustments are influenced by each driver's individual contract and the position of local trade unions.

III.1.4.3.4 Furthermore, there is a potential for higher turnover rates among staff due to factors such as job burnout, failure to pass language assessments, or a lack of willingness to undertake further language training, which may vary based on individual factors like age, initial language proficiency, and learning ability (see also Part IV.2.3).

III.1.4.3.5 In addition to the costs associated with employment, it is necessary to arrange for substitutes at the workplace to cover for the absence of staff undergoing training. This may result in other employees working overtime or the need to hire additional staff to ensure that work capacity is maintained during this period.

III.1.4.4 Initial change management and personnel costs summary

III.1.4.4.1 In conclusion, it is not possible to precisely predict the costs associated with change management and staffing due to the diverse conditions and obstacles unique to each aerodrome.

III.1.4.4.2 However, it is essential to acknowledge the expenses (i.e. change management costs) incurred from the implementation and ongoing maintenance of the Triple One concept, as well as the preparation of ATC workflows.

III.1.4.4.3 Furthermore, it is anticipated that the need for higher language skills will lead to increased personnel costs for vehicle drivers, which may cause recruitment challenges, elevated salary demands, higher turnover rates and the need for temporary replacements during training periods.

III.2 Overview of costs

III.2.1 For the full or partial implementation of the Triple One concept, qualitative costs were identified as shown in Table 12. Cost factors arising from the prerequisites outlined in the Task 4 report are identified by associating each cost factor with its corresponding prerequisite(s).

Table 12: Qualitative Costs for full or partial implementation of the Triple One concept

ID	Category	Cost factor	Applicability (Partial/ Full/ All)	Direct/ Indirect	Description	Influencing factors	Affected Stakeholders (payer)
T.1 a	Training Costs	Initial language training for vehicle drivers	Full	Direct	New and existing employees must be sufficiently trained to attain an adequate level of English to understand communication between ATC and pilots. Full Triple One implementation requires vehicle drivers to achieve operational English level (English level 4). Initial language training must be provided for each vehicle driver with access granted to an active runway. Related to Prerequisites: 11, 12, 15, 16 See Part III.1.2.2	• Number of vehicle drivers to be qualified • Required level of English to be obtained (i.e. English level 4) • Costs per training lesson (depending on type of training, e.g. local commission of external trainers or usage of online platforms) • Individual/average English level baseline of personnel and applicants (depending on national language policy/culture) • Individual learning success, willingness, competence, aptitude • Quality of training • Certification costs (e.g. test fees for official certificates) • Training material (e.g. learning books, notebooks, etc.)	• Aerodrome operator • Third party contractors • Government/ state for RFFS or military
T.1 b			Partial		New and existing employees must be sufficiently trained to attain an adequate level of English (only listening comprehensives and usage of phraseology required) to understand communication between ATC and pilots. Initial language training must be provided for each vehicle driver with access granted to an active runway. Related to Prerequisites: 11, 15, 16 See Part III.1.2.2	• Number of vehicle drivers to be qualified • Required level of English to be obtained (i.e. only listening comprehensives and airside specific phraseology) • Costs per training lesson (depending on type of training, e.g. local commission of external trainers or usage of online platforms) • Individual/average English level baseline (depending on national language policy/culture) • Individual learning success, willingness, competence, aptitude • Quality of training • Certification costs (e.g. test fees) • Training material (e.g. learning books, notebooks, etc.)	

ID	Category	Cost factor	Applicability (Partial/ Full/ All)	Direct/ Indirect	Description	Influencing factors	Affected Stakeholders (payer)
T.2	Training Costs	Radiotelephony certification for vehicle driver	Full	Direct	In addition to the language qualification, new and existing employees to might be required obtain a radiotelephony license to ensure correct use and understanding of equipment, to attain radio discipline (incl. phraseology) and to understand certain characteristics (e.g. 'clipped' transmissions and how they are handled). Related Prerequisites: 16, 17, 18 See Part III.1.2.4	• Number of vehicle drivers • Costs per training lesson (depending on type of training, e.g. commission of external trainers or usage of online platforms) • Quality of training • Certification costs (e.g. test fees for official certificates) • Training material (e.g. learning books, notebooks, etc.)	• Aerodrome operator • Third party contractors • Government/ state for RFFS or military
T.3		Initial language training for non-commercial pilots without an instrument flight rating and a valid English language certificate	All	Direct	Non-commercial pilots (e.g. PPL/LAPL/SPL holders, remote, helicopter and gyrocopter pilots) without an instrument flight rating and English language proficiency certificate (i.e. only operate in their native country under VFR conditions) are demanded to meet English language proficiency requirements on operational level (commercial pilots are already capable to communicate on English level 4). Initial language training is required in self-reliance. Related Prerequisites: 8, 10, 13 See Part III.1.2.2	• Costs per training lesson (depending on type of training, e.g. commission of external trainers or usage of online platforms) • Individual/average English level baseline (e.g. national language policy/culture) • Individual learning success/willingness/competence/aptitude • Quality of training • Certification (e.g. test fees)	• Pilots (general aviation)
T.4 a		Recurrent language training for vehicle drivers	Full	Indirect	Recurrent training shall maintain English language proficiency (English aviation phraseology or ICAO level 4) and certification validity. Related Prerequisites: 16, 19 See Part III.1.2.3	• Number of vehicle drivers • Validity period of certificate (4 years for ICAO English level 4) • Required level of English to be obtained (i.e. ICAO English level 4) • Success of initial training (depending on quality of training) • Practice of English language (depending on operation density of individual vehicle driver on the runway) • Costs per training lesson (depending on type of training, e.g. commission of external trainers or usage of online platforms) • Certification (e.g. test fees.) • Training material (e.g. learning books, notebooks, etc.)	• Aerodrome operator • Third party contractors • Government/ state for RFFS or military

ID	Category	Cost factor	Applicability (Partial/ Full/ All)	Direct/ Indirect	Description	Influencing factors	Affected Stakeholders (payer)
T.4 b	Training Costs		Partial		Recurrent training shall maintain English language proficiency on adequate level (listening comprehensives and runway specific phraseology) and certification validity. Related Prerequisites: 16, 19 See Part III.1.2.3	• Number of vehicle drivers • Validity period of certificate • Required level of English to be obtained (i.e. English listening comprehensives and airside specific phraseology) • Success of initial training (depending on quality of training) • Practice of English language (depending on operation density of individual vehicle driver on the runway) • Costs per training lesson (depending on type of training, e.g. commission of external trainers or usage of online platforms) • Certification (e.g. test fees.) • Training material (e.g. learning books, notebooks, etc.)	
T.6		Recurrent radiotelephony training for vehicle drivers	Full	Indirect	Recurrent radiotelephony training shall maintain correct usage of equipment, radio discipline (incl. phraseology), understanding of certain characteristics (e.g. 'clipped' transmissions and how they are handled) and certification validity. Related Prerequisites: 16, 19 See Part III.1.2.4	• Number of vehicle drivers • Validity period of certificate • Success of initial training (depending on quality of training) • Practice of radiotelephony (depending on operation density of individual vehicle driver on the runway) • Costs per training lesson (depending on type of training, e.g. commission of external trainers or usage of online platforms) • Certification (e.g. test fees) • Training material (e.g. learning books, notebooks, etc.)	• Aerodrome operator • Third party contractors • Government/ state for RFFS or military
T.7		Recurrent language training for non-commercial pilots	All	Indirect	Recurrent training shall maintain English language proficiency on operational level (ICAO level 4) and certification validity. Related Prerequisites: 16, 19 See Part III.1.2.3	• Validity period of certificate • Success of initial training (depending on quality of training) • Practice of English language (depending on operation density of individual vehicle driver on the runway) • Costs per training lesson (depending on type of training, e.g. commission of external trainers or usage of online platforms) • Certification (e.g. test fees.) • Training material (e.g. learning books, notebooks, etc.)	• Pilots

ID	Category	Cost factor	Applicability (Partial/ Full/ All)	Direct/ Indirect	Description	Influencing factors	Affected Stakeholders (payer)
E.1	Equipment Costs	Purchase of radios	All	Direct	If not already provided, all vehicles must be equipped with radio transceivers, which are capable of providing VHF-connections and/or cross coupling. The purchased radios must provide sufficient transmission quality. Related Prerequisites: 22, 23, 24 See Part III.1.3.2	• Number of vehicles • Radio capability of VHF and/or cross coupling • Labour costs for implementation or replacement	• Aerodrome operator • Third party contractors • Government/ state for RFFS or military
E.2		Purchase of VHF repeaters	All	Direct	If objects and the topography of the airfield disrupt the line-of-sight between the radios (i.e. obstacles, e.g. tower and vehicle), VHF repeaters need to be installed. Related Prerequisite: 26 See Part III.1.3.3	• Number of required VHF repeaters (depending on line-of-sight obstacles, e.g. topography or buildings) • Labour costs for implementation	• Aerodrome operator • (ANSPs)
E.3		Maintenance of radios	All	Indirect	Radio equipment must be maintained regularly and replaced if necessary. Related Prerequisites: 22, 23, 24 See Part III.1.3.2	• Number of vehicles • Quality of radio • Labour costs for maintenance	• Aerodrome operator • Third party contractors • Government/ state for RFFS or military
E.4		Maintenance of VHF repeaters	All	Indirect	Implemented VHF repeaters must be maintained regularly or replaced if necessary. Related Prerequisite: 26 See Part III.1.3.3	• Number of required VHF repeaters • Quality of VHF repeaters • Labour costs for maintenance	• Aerodrome operator
E.5		Restructure tower infrastructure	All (except for vehicle listening only)	Direct	At some towers, procedures, responsibilities and controller workstations might need restructuring to allow that vehicle drivers communicate with the local TWR executive ATCO directly. The associated costs would also include change management efforts and possibly ATCO briefings or trainings. See Part III.1.3.4	• Current controller working position setup, procedures • Number of ATCOs	• ANSPs

ID	Category	Cost factor	Applicability (Partial/ Full/ All)	Direct/ Indirect	Description	Influencing factors	Affected Stakeholders (payer)
M.1	Change Management Costs	Implementation planning and maintaining process	All	Direct	Management efforts are required for integration and maintenance (incl. scope, procedure planning, feasibility and risk assessment, stakeholder consultation, training planning, documentation, etc.). For safety assurance, risks, such as frequency congestions and other issues, need to be addressed. Related Prerequisites: 1-10, 19-21 See Part III.1.4.2	• All influencing factors for the initial and recurrent training • Effort of planning needed and employee availability • Labour costs for planning and maintaining (analysing, auditing, involvement)	• Aerodrome operator • Third party contractor • Government/ state for RFFS or military
M.2		ATC workflow preparation	All	Direct	Including vehicle drivers on the tower frequency requires changes in documentation concerning communication procedures adjustment, phraseology and coordination procedures. Related Prerequisites: 9, 20, 21 See Part III.1.4.2	• Current procedure landscape	• ANSPs
P.1	Personnel Costs	Higher recruiting costs in future due to additional language requirements	All	Indirect	Higher recruiting costs may result through higher effort needed for recruiting, caused by higher language proficiency requirements. See Part III.1.4.3	• Average language level of country and region (language policy/culture) • Number of personnel to be recruited	• Aerodrome operator • Third party contractor • Government/ state for RFFS or military
P.2		Raise of Salary	All	Indirect	A salary raise may be the result for higher language proficiency requirements and thus higher qualification for vehicle drivers. See Part III.1.4.3	• Additional proficiency requirements (language, radiotelephony) and gap to average baselines • Additional workload • Average area-based salary • Individual contract	• Aerodrome operator • Third party contractor • Government/ state for RFFS or military
P.3		Raise of Turnover rates	All	Indirect	More requirements and workload may cause a high turnover rate resulting in more costs to train new employees (i.e. higher costs for onboarding). People also might fail language tests or might be insufficient motivated to conduct additional language trainings. See Part III.1.4.3	• Possible work overload for vehicle drivers • Higher level of requirements during and after training • Individual motivation (depending on e.g. age, language baseline and learning aptitude)	• Aerodrome operator • Third party contractor • Government/ state for RFFS or military

ID	Category	Cost factor	Applicability (Partial/ Full/ All)	Direct/ Indirect	Description	Influencing factors	Affected Stakeholders (payer)
P.4	Personnel Costs	Missing work capacity at workplace must be replaced in the meantime due to training	All	Indirect	When employees are in training, the missing workforce must be substituted through overtime by other colleagues or additional personnel. See Part III.1.4.3	• All influencing factors for the initial and recurrent training	• Aerodrome operator • Third party contractor • Government/ state for RFFS or military

III.3 Opportunity Costs

III.3.1 General

III.3.1.1 The previous chapters cover the direct and indirect costs, which must be considered for the implementation of the Triple One concept or a variation thereof. The financial recourses, which are tied up for the implementation efforts, are therefore no longer available for other investments or cause financial loss.

III.3.1.2 The foregone benefits that would have been achieved by runway safety improvement options other than the Triple One concept or the benefits that would have been lost due to the implementation of Triple One, i.e. the opportunity costs, shall be analysed. Opportunity costs are excluded from the total cost calculation as the applicability and magnitude of these costs cannot be determined due to the different conditions at each aerodrome.

III.3.2 Opportunity cost factors

III.3.2.1 **Missing budget for technical or other runway incursion mitigation measures:** Although the benefit analysis of the Task 3 report shows that the implementation of the Triple One concept or a variation thereof has the potential of improving runway incursion risks, the analysis also showed that for example other technical runway incursion mitigation measures (e.g. integration vehicle transponders or stop bars) have also a positive impact which - depending on the local characteristics - could be even stronger. These alternative mitigation measures might be associated with less initial and running costs. The obligatory introduction of the concept could therefore lead to the costs to be invested being channelled towards less efficient measures.

III.3.2.2 **Missing budget at other place:** The implementation and maintenance of the Triple One concept equals an investment for the aerodrome's operator, which will be taken from the overall budget. Through this, other investments can only be carried out with delay (e.g. maintenance or improvement of infrastructure) or other units might expect a reduction of provided financial resources (e.g. for the purchase of new vehicles).

III.3.2.3 **Missing working capacity due to transfer of employees with better English skills:** Personnel with few or no English proficiency skills might be exchanged with vehicle drivers, who do possess better English proficiency skills (i.e. a higher language baseline/level). This causes additional onboarding costs and a loss of work-related knowledge, which results in a necessary work capacity substitution while onboarding training is conducted.

III.3.2.4 **Loss of capacity:** Due to new communication and coordination procedures and phraseology to be included into the vehicle driver's operation, runway capacity might be impacted, e.g. due to required capacity caps to mitigate frequency overload. The decrease of capacity at high traffic density airports could lead to a loss of income.

III.3.2.5 **Decrease of general aviation:** The implementation of the Triple One concept by aerodromes within the scope of EASA, mandating English as the sole communication language also for non-commercial pilots, could prompt other aviation users such as flight schools (Declared Training Organizations as per Part-DTO) and aeroclubs to move their operations to aerodromes outside of EASA scope to avoid associated hurdles due to extra certification. Notably, this would apply foremost to DTOs specialised at private pilots. This shift could lead to a decrease in revenue for EASA-regulated aerodromes, also affecting their financial sustainability.

III.3.2.6 **Delay of other professional training:** The implementation of essential language and radiotelephony training may necessitate the postponement of other developmental training for employees, due to budgetary constraints or limited operational capacity. Such delays could also potentially diminish employee satisfaction.

III.4 Cost summary

III.4.1.1 The adoption of the Triple One concept, or its variants, leads to diverse costs that are challenging to predict due to the unique conditions and required changes each aerodrome would encounter. Consequently, it is essential for aerodromes to perform their own cost analysis whereas the considerations in this part of the report could serve as guidance. Common cost elements that all aerodromes must consider include expenses related to training, technical equipment, change management and personnel.

III.4.1.2 Training expenses encompass both initial and ongoing instruction for language skills and radiotelephony. These requirements significantly impact vehicle operators and non-commercial pilot licence holders without ICAO English language certificate who operate solely within their nation, possessing radio and language certifications in their native language only. The financial outlay for vehicle driver training can be determined by considering various elements, including the expense per training session, average, individual and multiplying factors and additional costs.

III.4.1.3 Furthermore, expenses for technical equipment may arise due to inadequate radio functionalities, such as incompatibility with VHF or the inability to transmit, or because of line-of-sight constraints that require the purchase and maintenance of additional radios and/or repeaters. Additionally, redesigning ATC workstations to consolidate

control tasks in a unified workspace might be necessary, especially if dedicated ground controllers are currently integrated into tower operations.

III.4.1.4 Due to the implementation of the Triple One concept, associated change management expenses for both implementation and ongoing maintenance as well as costs related to change of a functional system for the ANSP must be considered. Additionally, personnel expenses are incurred due to challenges in recruitment, increasing salary demands, higher turnover rates and the need to compensate for workforce shortages during training periods.

Part IV Implementation risks and operational constraints

IV.1 General

IV.1.1 While the safety risks and costs encompass many prerequisites and potential consequences of implementing the Triple One concept, it is important to also consider factors or portions thereof that could complicate these efforts, including their organizational, operational, and logistical aspects.

IV.1.2 This chapter aims to study the potential negative impacts of the Triple One concept on the stakeholders' operations, which may support the decision for a partial or non-implementation. The considerations in this chapter do not focus on safety risks, such as language issues for vehicle drivers analysed in Part II, or economic factors like language training costs for vehicle drivers discussed in Part III. Instead, the focus is on remaining disadvantages or potential operational constraints. These cannot be fully separated from risks or costs; for example, language proficiency carries inherent risks, generates training costs, and presents logistical challenges.

IV.1.3 The aspects identified and described in this Part are mainly based on the results of the workshops and interviews as part of Task 3. Aerodrome operators and local ANSPs identified rationales for their currently established concepts which often also entails the argumentation speaking against the Triple One implementation. The rationales are listed in detail in the respective sections for each concept typology (Triple One Variation or No Triple One). It must be noted that rationales are as individual as each aerodrome environment and characteristics and so are implementation risks and operational constraints. This Part summarizes these aspects in a structured way.

IV.1.4 The combined analysis of operational constraints and implementation risks reveals a complex landscape. Successful implementation of the Triple One concept requires addressing a range of socio-economic, organizational, and operational challenges. Each factor must be carefully managed to realize the full potential of the concept. It is important to recognize that these implementation risks cannot be generalized, as each aerodrome faces unique circumstances. Moreover, accurately quantifying these risks is challenging, so they are listed and qualitatively described in general terms.

IV.2 Implementation risks

IV.2.1 **Availability of Language Training and Certification Resources**: A potential lack of available language schools or qualified trainers could pose a significant obstacle to the implementation of the Triple One concept. This includes the need for initial language level testing and subsequent lessons to achieve the required proficiency and it is also dependent on the target level of proficiency (basic phraseology vs. Level 4). Varying levels of English proficiency among staff must be considered when organizing language courses, adding an additional constraint. It is known that some airport operators are working hand in hand with language schools to develop a suitable training programme for vehicle drivers, even though that there are yet no common standards. This is certainly an approach which not all aerodrome operators, notably smaller size organizations, can follow. Beyond the availability of language trainers and fit training programs, the capacity to train a large number of personnel within a limited timeframe is a logistical challenge. Organizing staff travel to language schools or arranging for teachers to travel to the aerodrome, along with providing sufficient training premises, and the absence time of employees are all part of this complex process. Ensuring that training is both effective and timely is crucial. The process and its results could be influenced by the language culture of each state, the location of the aerodrome, the quality of public educational system, and the quality of the available language training programs. After the initial certification, organizing recurring training and certification is necessary. This requirement poses significant logistical and resource challenges for large aerodromes with many staff members needing language certification. Aerodromes in rural areas may also face logistical problems in sourcing suitable teachers.

IV.2.2 **Lack of Standards on Language Certification**: The issue of availability of language training resources is compounded by the absence of standardized certification processes. Currently, there are no European-wide standards for language certification in this context and no centralized mechanism for recognizing certificates from various national authorities or private institutions. Although EASA and ICAO have set standards for language proficiency, these may be implemented differently across European countries, leading to inconsistencies. Additionally, dialects and regional accents can affect comprehension and communication effectiveness, adding another layer of complexity to ensuring uniform language standards. This lack of a unified recognition mechanism further hinders effective implementation and complicates the validation of language proficiency across countries. These factors collectively challenge the uniform adoption of the Triple One concept across Europe in practice.

IV.2.3 **Staff Turnover, Recruiting and Knowledge Drain**: High staff turnover can undermine the implementation of the Triple One concept. The initial English proficiency

of already employed staff can vary due to cultural nuances and individual factors. A shared rationale among many aerodromes, as detailed in the Task 3 Report, indicates that a significant operational barrier to implementing the Triple One concept is the lack of English proficiency among existing staff, particularly senior and experienced personnel or highly specialized employees like rescue and firefighting personnel. The potential departure of seasoned staff due to new language requirements could lead to a loss of valuable knowledge and skills crucial for maintaining operational efficiency and safety. This, in turn, could impact staff resources during critical phases of the transition to the Triple One concept. Imposing certain language proficiency requirements could also reduce the pool of eligible applicants, making recruitment more challenging. This might increase the already existing difficulties in recruiting in some regions. Despite the fact that general English proficiency has increased over the recent decades in the context of language globalization of younger generations and the fact that all EU member states are ranked with moderate, high or very high English Proficiency Index [13], the overall English proficiency is reportedly a serious concern in many regions. A study from 2014 [14] evaluating the general English proficiency at the 27 countries of the European Union revealed that the percentage of people who speak English as a foreign language or mother tongue ranges from around 15.4 % (Bulgaria) to 99.5 % (Ireland and UK) which illustrates the huge differences amongst the member states. This issue is exacerbated in regions with high staff turnover, such as aerodromes with high seasonality, and a limited pool of qualified candidates, where demanding language requirements could further diminish the number of suitable applicants and strain resources. Fluctuating staffing levels can lead to inconsistent operational performance and increased pressure on remaining staff, ultimately impacting the overall effectiveness of Triple One implementation and negatively impacting safe operations. Additionally, these recruitment challenges are influenced by factors such as the country's labour market conditions, urban versus rural settings, and varying educational levels, further highlighting the complexities of finding and retaining qualified personnel.

IV.2.4 **The Need to Obtain New Equipment/Upgrade Equipment**: The integration of the Triple One concept may necessitate the acquisition of new radios or upgrades to existing communication equipment. Ensuring that all relevant vehicles/personnel are equipped with compatible radios is essential for effective communication and operational efficiency. This requirement involves not only financial, but logistical considerations and impacts the overall implementation process. Additionally, the purchase of VHF repeaters may need to be timely planned, depending on the assessment of aerodrome's configuration and its capacity to meet line-of-sight criteria, to overcome potential communication barriers.

IV.2.5 **Radiotelephony Training and Certification**: Efforts must be made to ensure relevant staff hold valid radiotelephony certificates, including planning for timely availability of training. Both initial and recurring certification/training are required and cause further administrative and logistical challenges to aerodrome operators which is also associated to the availability of training and assessment capabilities in the respective region.

IV.2.6 **Training Rostering and Scheduling Complexity**: Integrating new training requirements adds complexity to rostering and scheduling. Adapting existing systems to accommodate these additional training needs can disrupt established workflows and require adjustments to shift patterns. This complexity arises from the logistical challenges of ensuring that a large number of personnel meet the new requirements without straining existing resources and adversely affecting day-to-day operations. The success of these efforts will directly impact the implementation process, potentially complicating it further. This applies to both the need for initial training and the organization of recurring training. The staff responsible must take on these added efforts and address these logistical challenges to ensure smooth implementation. This is particularly critical for heavy traffic aerodromes with large number of staff, where coordinating training schedules and daily operations can be especially challenging. But also smaller organisations with thin staffing levels could be heavily affected.

IV.2.7 **Operational disruption**: Transitioning to the Triple One concept may lead to temporary disruptions in aerodrome operations, which can be challenging to manage without impacting overall efficiency. During this transition, reallocating staff to meet new English proficiency requirements may reduce available working capacity in other areas, potentially affecting operational flow and causing delays in other critical training programs for vehicle drivers. Furthermore, the implementation might result in a loss of flight capacity due to extended procedure times on the runway.

IV.2.8 **Enforcement Issues with Governmental Organizations**: Enforcing compliance with Triple One prerequisites among governmental entities, such as Rescue and Firefighting Services (RFFS), which are state-run in some countries or aerodromes, and military operations at mixed-use aerodromes, can be particularly challenging. Determining who will bear the costs of such implementation adds another layer of complexity. Addressing these demanding and intricate challenges involves navigating specific responsibilities, funding sources, and timelines, which can be difficult to define clearly. Variations in state regulations, administrative structures, and political factors further impact the standardization process, making the challenge of achieving standardization more pronounced in certain countries compared to others, thus complicating efforts for Europe-wide consistency.

IV.2.9 **Third-Party Compliance**: Ensuring compliance from third-party entities, where applicable, presents another significant challenge. The diverse interests and priorities among stakeholders complicate efforts to enforce uniform standards, making standardization difficult and requiring careful coordination and oversight. This challenge is especially pronounced at aerodromes with multiple third-party stakeholders operating on the runway (e.g. ground handling personnel for towing aircraft crossing the runway), where uniform implementation becomes more complex due to the varied nature of these entities, including potentially different regulatory frameworks and operational practices.

IV.2.10 **Union Opposition**: Unions may oppose the implementation of the Triple One concept due to the increased requirements and additional responsibilities it imposes on their members. They might advocate for higher salaries or improved benefits to address the heightened demands on staff, leading to negotiations that could delay the adoption of the new concept. Such resistance can create significant obstacles in aligning organizational goals with union expectations, complicating and potentially hindering the implementation process. This challenge can be particularly pronounced in countries with strong unions, where collective bargaining power is more influential, and opposition may be more formidable.

IV.2.11 **English Proficiency in General Aviation**: A prerequisite for a successful Triple One implementation is that all parties are sufficiently proficient in Aviation English, which includes also all pilot licence holders which are allowed to operate at EASA aerodromes (see Task 4 report Part III). This includes also a large group of private licence holders which are as of today not required to obtain an English language certificate as it is required for commercial licences, IFR ratings or flights in countries where the national language is not the mother tongue. This presumably mainly affects large area member states where this community has a considerably volume, like Spain, France, Germany or Italy. Beside the regulatory adjustments which would be associated to involve this group of pilots, a huge resistance from these groups can be expected. As the higher qualification costs would affect a huge market, also other stakeholders in the general aviation industry including smaller aerodromes in the scope might be opponent to the concept as flight schools and pilots could divert their activities to aerodromes out of the EASA scope.

IV.2.12 **Change Management**: The successful implementation of the Triple One concept demands extensive change management efforts from aerodromes and Air Navigation Service Providers (ANSPs). This involves not only financial investment (as mentioned in III.1.4.4) but also a strategic approach to managing the transition. Aerodromes and ANSPs will need to allocate resources for training, technology upgrades, and procedural changes. Effective change management also requires engaging stakeholders,

addressing oppositions, and ensuring that all personnel are adequately prepared for the new operational requirements. The complexity of these efforts underscores the need for a well-coordinated approach to achieve a smooth transition and effective adoption of the Triple One concept.

IV.3 Operational constraints

IV.3.1 **Communication Gaps Due to Shadow Effect**: The shadow effect, where for example pilots may not hear vehicle communications due to runway slopes or other obstructions, can presents a significant operational constraint at some aerodromes. This issue can create critical communication gaps, potentially leading to unsafe situations on the runway or the Triple One concept not being effective as the establishment of common situational awareness is impaired. Addressing the shadow effect, particularly in relation to runway configuration, should be considered as a prerequisite for the successful implementation of the Triple One concept. Effective mitigation like additional repeaters is essential to ensure clear and reliable communication, thereby maintaining safety and operational efficiency.

IV.3.2 **Interoperability with existing systems:** Ensuring standardized communication systems and procedures across aerodromes can be a significant challenge. The successful integration of the Triple One concept with established aerodrome operations is crucial. Incompatibilities between new and upgraded radios and communication procedures, and existing systems and procedures, can lead to operational inefficiencies and disruptions. Effective technical setup, ongoing maintenance, and procedural alignment are essential prerequisites for the smooth integration of the Triple One concept into current aerodrome operations.

IV.3.3 **Control Frequency Restructuring**: Certain aerodrome layouts, particularly those with crossed runways or complex configurations, may require a comprehensive restructuring of air traffic control (ATC) procedures, frequency layout, and frequency management. This restructuring might involve redefining areas of responsibility and reconfiguring controller working positions within the control tower to manage these divisions effectively. Such changes necessitate significant adjustments to existing procedures and the development of new operational protocols to ensure seamless communication and coordination across different control areas. In some cases, this could result in a loss of efficiency in traffic management and additional handover points. Some aerodrome operators reported about serious challenges restructuring areas of frequencies which are tailored to the local traffic flows aiming on a balanced workload for each ATCO while adhering to applicable regulations.

List of Abbreviations

ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
CWP	Controller Working Position
DOC	Document
DTO	Declared Training Organizations as per Part-DTO
EAPPRI	European Action Plan for the Prevention of Runway Incursions
EASA	European Union Aviation Safety Agency
ECCAIRS	European Coordination Centre for Accident and Incident Reporting Systems
EU	European Union
FOD	Foreign Object Debris
ICAO	International Civil Aviation Organization
ID	Identification
PANS-ATM	Procedures for Air Navigation Services – Air Traffic Management
RFFS	Rescue and Fire Fighting Services
RIMCAS	Runway Incursion Monitoring and Conflict Alert System
RTF	Radio Telephony
RWY	Runway
THR	Threshold
TWR	Tower
UHF	Ultra High Frequency
UK	United Kingdom
VHF	Very High Frequency

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