European Aviation Safety Agency

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Small Helicopter Operational Monitoring Programme (HOMP) Trial

FINAL REPORT

RESEARCH STUDY EASA.2008/7

“SMALL HELICOPTER HOMP TRIAL”

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1 Acknowledgments

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2 Introduction

2.1 Context

In essence, Flight Data Monitoring (FDM) utilises the routine analysis of aircraft flight data to monitor compliance with defined operational criteria using a specialised computer program. The operational criteria include the corresponding aircraft flight manual limitations, safety margins around the operational interpretation of the flight manual, standard operating procedures and airmanship that pilot training programmes seek to instil. Where comparison of the actual operation of the aircraft with the defined criteria reveals reduced margins or non-compliances, appropriate remedial action can be taken in order to restore safety margins. As this process is continuous, the effectiveness of any corrective action taken is automatically monitored.

The monitoring of flight operations by means of a Flight Data Monitoring (FDM) programme, is now a mature and well-established practice among commercial airlines. The safety benefits of FDM have now been widely proven and in 2005, FDM was mandated by International Civil Aviation Organisation (ICAO) Standards and Recommended Practices (SARPs) for operators of commercial air transport aeroplanes of over 27 tonnes Maximum Take-Off Mass (MTOM) and recommended for those over 20 tonnes MTOM.

Following on from the success of FDM with fixed wing operations, the United Kingdom Civil Aviation Authority (UK CAA) commissioned research into the benefits of applying FDM to helicopters in a Helicopter Operations Monitoring Programme (HOMP) trial which included an in-service evaluation on Part 29 large commercial air transport helicopters. The results of this research were positive and most of the major international Part 29 helicopter operators have implemented, or have committed to implementing, HOMP in their operations. In addition, FDM is now an ICAO recommended practice for Flight Data Recorder (FDR) equipped commercial air transport helicopters.

A review of helicopter accidents has recently been carried out by the European Helicopter Safety Team (EHEST) which has shown that the majority of accidents involve small helicopters. Although the type of helicopter and the nature of these operations are very different to those which are currently subject to HOMP, the purpose of this research programme is to evaluate whether FDM could also provide a worthwhile safety benefit for small helicopters.

Unlike Part 29 commercial air transport helicopters, small helicopters are not required to be equipped with FDRs. Hence, a small helicopter operation monitoring programme would be dependent on the helicopter operator first installing a Flight Data Monitoring system. It is envisaged that light and relatively inexpensive flight data monitoring systems will soon be available for this category of helicopter and that the functionality of such systems will be sufficient to enable operators to implement an FDM programme.

2.2 Background

In order to evaluate the future potential of light helicopter HOMP it is necessary to understand the consequences of cost, space, weight, installation and maintenance overheads. It is also necessary to evaluate the optimum balance between the functionality that can be provided, the cost and weight penalties, and the associated safety benefits that can be achieved. There are also choices to be made regarding the technology that might be used. In particular, FDM functions could be implemented either using data recording or using cockpit video recording. Each technology has its strengths and weaknesses which need to be considered.

The strategy adopted for this research programme consists of two phases. The first was to evaluate the potential safety benefit of applying HOMP to light helicopter operations and then to recommend a suitable FDM specification which would enable these benefits to be realised. In order to achieve this it was necessary to consider the available technology and review previous studies that have examined the potential of HOMP.

The second phase of this programme involved the evaluation of an FDM data recorder and software, development of safety triggers and evaluation of how successfully such a HOMP system could be incorporated into light helicopter operations. This evaluation was carried out during a trial of 1069 flights and an amount of 758 flight hours using 4 helicopters.

2.3 Aims and objectives

The HOMP trial results should provide EASA with a better understanding of the factors which affect HOMP for light helicopter and its incorporation into routine operating practices. Accordingly, this report makes recommendations for future FDM systems and operations which are considered to have the potential to achieve a significant contribution to safety within a sustainable economical model. Within the consortium that undertook this research project the objectives of each of the individual members are as follows;

EUROCOPTER objective is to significantly decrease the accident rate of small H/Cs. FDM systems have been assessed for their contribution. The project had to:

- Refine the conditions enabling future FDM systems to be part of a basic small H/C configuration,
- Define and develop new customer support capabilities based on the availability of FDM provided data. These capabilities shall increase the safety and contribute both to accident investigations and operational activities optimization.

JSHS aims to improve flight operations safety through extension of current FDM use, such as:

- Derive from FDM analysis results if safety margins have been reduced,
- Use FDM analysis results for pilot training, aerial work, and passenger transport.

HELIDAX aims to monitor the flight data of the helicopter during training operations and identify contributions in training.

ISEI aims to demonstrate that the Safetyplane solution, compliant with ED155 recommendations, is effective and easily adaptable to FDM needs.

3 Executive summary

This report provides the findings of the light helicopter HOMP trial study, which was contracted by EASA to a consortium comprising of Eurocopter, JSHS (aerial work and public transport operator), Helidax (pilot training operator) and ISEI (avionic equipment manufacturer). The study was split into two parts.

The first part was to evaluate the potential safety benefit of applying HOMP to light helicopter operations and then to recommend a suitable FDM specification which would enable these benefits to be realised. In order to achieve this, it was necessary to consider the available technology and review previous studies that have examined the potential of HOMP. The part 1 study report is provided in Annex 9 of the present document.

The second part of this programme involved the evaluation of an FDM data recorder and software, development of safety triggers and evaluation of how successfully such a HOMP system could be incorporated into light helicopter operations. This evaluation was carried out during a trial of 758 hours using 4 helicopters. A summary of the work carried out is as follows;

Review of accident findings: Within the last 2 years the European Helicopter Safety Team (EHEST) has published the findings of an analysis of European helicopter accidents. This showed that a great majority of the accidents analysed involved Part 27 helicopters. A further review of Part 27 helicopter accidents was then carried out as part of this research programme. This showed that out of 205 accidents analysed, almost 50% involved general aviation operations. The total proportion of all the accidents where it was considered that FDM could have prevented the accident was estimated to be 26%. Furthermore, this figure rose to nearly 40% for general aviation operations.

Review of available FDM technologies and products: A total of 13 data recording systems have been compared in relation to the parameters recorded, memory, size and weight.

Summary of FDM specifications: A review of existing products has been performed and the following key requirements have been defined for the airborne equipment /ground segment:

-weight: 500g-1000g
-size: 200cm^3-800cm^3
-compliance to ED155 recommendations (DO160F , DO178B , memory robustness)
-recording capacity : 2 days of flights operations
-automatic wireless download after flight
-parameter list derived from ED155
-data protection during download
-functions : flight data acquisition – automatic detection of events and statistics
-3D flight replay

Analysis of costs: The total Non Recurring Costs (NRC are estimated to be between €7-16K per helicopter. The recurring costs are: GSM 15-20€ per month, Service costs per year : €2000 /helicopter, Data analysis up to 1day/helicopter/month plus maintenance costs between 15-20 % of NRC/year.-

Summary of potential benefits: Of course the benefit of prime interest to this study is the reduction in the accident rate. However, other benefits include; accurate recording of flight hours, potential for reduction in insurance fees and savings in maintenance activities.-

Flight testing achieved and mission reviewed: A total of 1069 flights have been monitored over a period of 758 flight hours. The missions analysed comprised training, which was performed by French EALAT training school (2 x EC120 accumulating 250 hours), and passenger transport & Executive charter (VIP), performed by JSHS (2 x Ecureuil B3 accumulating 500 hours). The aerial work performed by JSHS included, Filming and photography, power lines survey and Winching / crane services.

Methodology and success of triggers developed : The Initial trigger definitions have been derived from a previous CAA HOMP study (Oil & Gas operators). The triggers have been adapted to three main type of missions (passenger transport, Aerial work , training) and have been tuned by the operators. The triggers can be devided into 3 groups, helicopter attitude, engine conditions and flight manual limitation exceedances. Once the triggers had been defined, they were applied incrementally on the available flight data and adapted where needed. Trigger statistics have been produced and reviewed with the operators. Application of these triggers resulted in many successful alerts during the course of the trial, demonstrating the potential safety benefit of FDM for light helicopters.

An important factor affecting the future of HOMP is how easy it is to integrate into a light helicopter operator's routine daily schedule. The feedback from the two operators in the consortium was that the system is considered useful, and is capable of identifying events which can benefit from operator intervention, such as exceedances, entry into pre-vortex ring effect conditions and improvement in autorotation training. However, very limited man power is available within a typical light helicopter operator in order to carry out regular analysis of FDM data and fully understanding each trigger alert. However, feedback from pilots was positive and acceptance of FDM was not an issue after they had been briefed on the objectives of this project. The operators also stated that the benefits in relation to the cost of running a HOMP must be clearly demonstrated, before this will be widely adopted on a voluntary basis.

This research programme has succeeded in meeting the original objectives. Both technical and operational aspects have been satisfactorily addressed and the flight trial has demonstrated the feasibility of operating HOMP on light helicopters. In addition, the feasibility of processing HOMP triggers for dedicated missions has also been demonstrated. However, a significant finding was the level of support required by the operators necessary to analyze events that had generated trigger alerts. This, in conjunction with the limited manpower of a typical light helicopter operator, means that further work is required in order to understand how to minimise the impact of HOMP on operator time and resources.

Other notable findings of this study were that ;

- improved low cost sensors for attitude and ground height would significantly improve trigger performance.
- FDM may be more effective if carried out as part of a global fleet monitoring and management approach supported by the OEM.
- Incorporation of FDM into operators procedures should be integrated into a Safety Management System (SMS) is recommended.

4 Summary of part 1

The following objectives have been allocated to part 1:

- perform a small helicopter accident analysis in order to identify the potential contribution of FDM systems to a reduction of accidents,
- review existing FDM technologies and similar studies,
- perform a cost/benefit analysis,
- propose recommendations for FDM configurations and systems.

Section 4.1 below summarizes results from accident analysis; the other subjects are described in appendix 9.

4.1 Accident analysis

The consortium reviewed all the FAR27 helicopter accidents from the EHEST database (nearly 200 accidents, 98 (50%) for General Aviation flights). For each accident, the team analyzed the event description and the contributing factors of the accident.

The team analyzed the accident in the following way: “if the customer had had an FDM program in his company, would this accident have been avoided?”

Three answers have been considered:

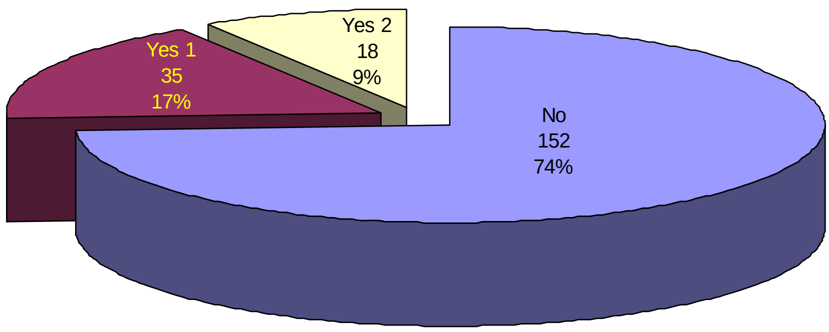
No: self explanatory (example: breakdown of a blade in flight which leads to a loss of control of the helicopter);

Yes 1: possible (example: the accident shows a general behaviour of the pilot which is not safe like a flight at low

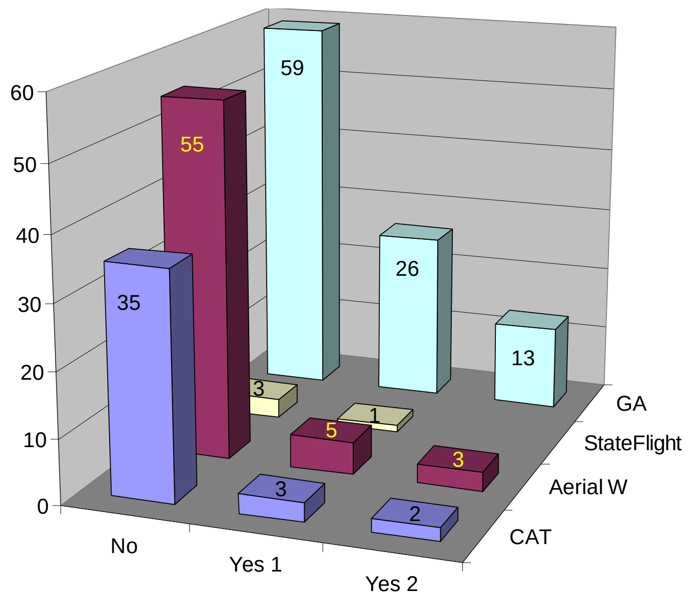
altitude without any reason for the mission which leads to a wire strike. With an FDM program monitoring the height cruise, the FDM manager could have detected this behaviour and the pilot would have been recalled to fly above 500ft/ground which is the minimum height regulation in case of day flight);

Yes 2: probable (example: the accident shows clearly that there was a problem of piloting quality like an excessive pitch attitude near the ground during landing phases which leads to a tail boom strike). With an appropriate Flight Data Monitoring program, this behaviour would have been detected and the pilot would have had an appropriate training for this specific flight phase).

The result of the analysis is the following:



This result shows that 26% of the analyzed accidents have a probability to be avoided using an FDM system. .



Accidents in General Aviation Flights represents around 50% of the total (98 accidents among 205).

This histogram shows that FDM would be more effective for General Aviation (approximately 40% potential for reduction of accidents).

5 Part 2 : In-service trial

The objective of part 2 is the “in-service” trial of a HOMP system configuration involving the operational use of the system by Part 27 helicopter owner/operator.
Half of the flight trials have been allocated to pilot training, the remaining have been allocated to other missions.
In-service trial addressed the following main activities:

- Installation of FDM systems,
- Definition of mission-specific safety triggers,
- Collection of flight data,
- Processing of flight data,
- Demonstration of effectiveness,
- Recommendation of use.

5.1 JSHS missions

The following missions were planned to be performed by JSHS and monitored by the HOMP system:

- Passenger transport
- Executive charter (VIP)
- Aerial work, (including; Filming and photography, Power lines survey, Fire-fighting ,Winching and crane services)
- Post-maintenance flight check

The effective flights monitored during part 2 of the project covered the missions as indicated below (see paragraph 5.3).
Note: The original intention was to identify different types of mission and to set mission specific triggers. However, for reasons explained later, this approach was not feasible

5.2 HELIDAX missions

Two mission types have been defined; training when the flight is done with both the trainer and the trainee on board, VIP when the trainee is performing a solo flight. Only training flights have been performed during the study. Solo flights are considered to be very close to VIP missions, the trainee being requested to have “smooth” flight manoeuvres.

5.3 Flight and mission statistics

The table below provides the summary of flight activities performed during the study.

	H/C	Nb of Flights	Flight hours	Analysed Flights	Analysed FH	VIP Flights	VIP FH	AW Flights	AW FH	Training Flights	Training FH	Flights without mission	Flight hours without mission
JSHS	EH	620	343	542	318	465	242	76	76	0	0	78	25
	IN	719	492	580	411	261	163	319	248	0	0	139	81
	total	**1339**	**835**	**1122**	**729**	**726**	**405**	**395**	**324**	**0**	**0**	**217**	**106**
HELIDAX	KA	318	318	239	308	0	0	0	0	239	308	79	10
	KD	164	167	118	163	0	0	0	0	118	163	46	4
	total	**482**	**485**	**357**	**471**	**0**	**0**	**0**	**0**	**357**	**471**	**125**	**14**
TOTAL		**1821**	**1320**	**1479**	**1200**	**726**	**405**	**395**	**324**	**357**	**471**	**342**	**120**

H/C : identifies each of the 4 helicopters of the study
Number of flights : total number of flights monitored by the system during the study
Flight hours : total number of flights hours monitored by the system during the study
Analysed flights : total number of flights analysed (applying mission triggers) during the study
Analysed FH : total number of flights hours (FH) analysed (applying mission triggers) during the study
VIP flights : total number of VIP flights analysed (applying VIP triggers) during the study
VIP FH : total number of VIP flights hours (FH) analysed (applying VIP triggers) during the study
AW flights : total number of AW flights analysed (applying AW triggers) during the study
AW FH : total number of AW flights hours (FH) analysed (applying AW triggers) during the study
Training flights : total number of training flights analysed (applying training triggers) during the study
Training FH : total number of training flights hours (FH) analysed (applying training triggers) during the study
Flights without mission: total number of flights with no mission identified
Flight hours without mission: total number of flight hours with no mission identified

The amount of flight hours requested for training (500 h) could not be achieved due to insufficient training flights performed by HELIDAX in the timeframe of this project. However, it is considered that the lack of training flight hours does not significantly impact the result of the study, as it has been possible for the corresponding triggers to be sufficiently defined and tuned during the flights which have been performed.

5.4 Design HOMP analysis system(s) and software

5.4.1 Parameters monitored by the system (flight/ground)

The FDM system used for the flight trials was the “Safetyplane” system, designed and manufactured by ISEI, one of the consortium partners. The table below provides the parameters available in the Safetyplane system and compares this with those recommended by ED155. Note: When VEMD (Vehicle & Engine Monitoring and Display) is indicated as the source of the data in the table below, the acquisition capability of Safetyplane, for helicopters not equipped with VEMD, is also indicated.

					Safetyplane	Safetyplane
ED155	**ED155**	**Safetyplane**	**Digital external**	**Analog external**	**Internal**	**computed**
parameters	**requirements**	**capability**	**sensor**	**sensor**	**sensor**	**data**
	for turbine HC					
Relative time count	E	Y			Y	
Heading (Magnetic or true)	R	Y	(AHRS)			
Pitch attitude	E	Y	(AHRS)			
Roll attitude	E	Y	(AHRS)			
Yaw rate	E	Y	(AHRS)			
Pitch rate	E	Y	(AHRS)			
Roll rate	E	Y	(AHRS)			
Latitude	E	Y	Y (GPS)			
Longitude	E	Y	Y (GPS)			
Estimated error	E	N				
Altitude	E	Y	Y (GPS)			
Time	E	Y	Y (GPS)			
Ground speed	E	Y	Y (GPS)			
Track	E	Y	Y (GPS)			
Normal acceleration	E	Y			Y	
Longitudinal acceleration	E	Y			Y	
Lateral acceleration	E	Y			Y	
External static pressure	R	Y			Y	
Outside air temperature	R	Y	Y (VEMD)	Y		
Indicated air speed	R	Y			Y	
Main rotor speed	R	Y	Y (VEMD)	Y		
Engine RPM	NA					
Engine Oil Pressure	R	Y	Y (VEMD)	Y		
Engine Oil Temperature	R	Y	Y (VEMD)	Y		
Fuel flow	R	Y	Y (VEMD)	Y		
Manifold pressure	NA					
Engine torque	R	Y	Y (VEMD)	Y		
Engine gaz generator NG	R	Y	Y (VEMD)	Y		
Free power turbine speed NF	R	Y	Y (VEMD)	Y		
Collective pitch	R	N				
Coolant temperature	NA					
Fuel burner pressure	NA					
Enveloppe surface temperature	NA					
Main voltage	R	Y			Y	
Cylinder head temperature	NA					
Flaps position	NA					

Primary flight control surface position	NA					
Fuel quantity	R	Y	Y (VEMD)	Y		
EGT or TOT	R	Y	Y (VEMD)	Y		
Emergency voltage	R	N				
Trim surface position	R	N				
Landing gear position	R	Y		Y		
OTHERS PARAMETERS						
Vertical speed	No request	Y			Y	
Ground height	No request	Y				Y
Battery operating time	No request	Y				Y
Engine operating time	No request	Y				Y
Cycles counting	No request	Y				Y

Note:

- The key for the table is; E = essential, R = recommended, Y= yes, AHRS = Attitude Heading Reference System, VEMD = Vehicle & Engine Monitoring and Display (Standard Equipment on AS350B3)
- Digital external sensor : means that the data is provided (or should be provided) by a digital sensor. AHRS was not available during the study, nevertheless the attitude parameters have been provided by Safetyplane sensors.

Analog external sensor : in case the helicopter is not fitted with a VEMD, the external sensors need to be used instead. This would lead to additional wiring and limited additional cost.

Discussion about sensors and data acquisition

The acquisition frequency (0,5 Hz / 2 seconds) is the result of a trade-off between the accuracy of the parameters and the amount of data to be downloaded after flight ; the current average download time per flight hour is about 3 minutes which is considered acceptable during operations.

Heading sensor : The helicopter metallic environment of the heading sensor does not enable a reliable measurement of the heading.; this problem is compounded by the use of low-cost sensor technology.

Pitch and roll sensors : The Micro-Electro-Mechanical Systems (MEMS) technology used provides an accuracy of approximately 3 degrees which enables most of the attitude trigger analysis. Nevertheless a higher accuracy level would be helpful.

Ground Height computation : As the provision of Radio-altimeter on a Part 27 helicopter is usually prohibitively high, it has been necessary to develop another means to acquire height above ground. This has led to the implementation of a the ground station computation, based on the GPS altitude, position and the ground altitude of the position retrieved from the web site www.geonames.org. The accuracy is about 100 feet which unfortunately is not sufficient for monitoring flights very close to the ground.

GSM (Global System for Mobile communication)/GPRS (General Radio Packet Service) transmission: Is only possible on-ground when power switched-off. The antenna position has been modified to improve the access to mobile networks.

The design of the “Safetyplane” system used in phase 2 of the study has been based on the specification recommended in phase 1 of this study. The recommended parameters (list 1-2-3) are available on the “Safetyplane” system with the following exceptions: heading, video recording and warnings.

Airborne system components used on the Safetyplane HOMP system

Installation kit that allows connecting the main body « V4 » to various sensors and the general supply of the aircraft	V4 main body whose functions are the acquisition, recording and transmission of flight parameters	Battery's function is to feed the V4 main body during data transmission	SIM Card which is responsible for connecting to the transmission network.
			
PN 4450	PN 4400	PN 4002	PN 2802
Take off switch sensor that allows to detect the take off of the aircraft	GSM antenna that allows to transmit data at the end of the flight.	GPS mouse if no embedded GPS available	
			
PN 4212	PN 4203	PN 4204	

- Supplemental Type Certificates (STC) have been approved for installation of the Safetyplane system on to the AS350B3 and EC120. The STC related to Ecureuil B3 has been granted by EASA on 13/11/2009 and the STC related to EC120 has been granted by EASA on 3/12/2009. (See **Annex 1** for STC forms).

5.4.2 Ground Station Operation

5.4.2.1 Initial status

The initial product has been designed for light airplanes and monitored 3 parameters (engine RPM, dynamic pressure, load factor) on top of GPS (Global Positioning System) data.

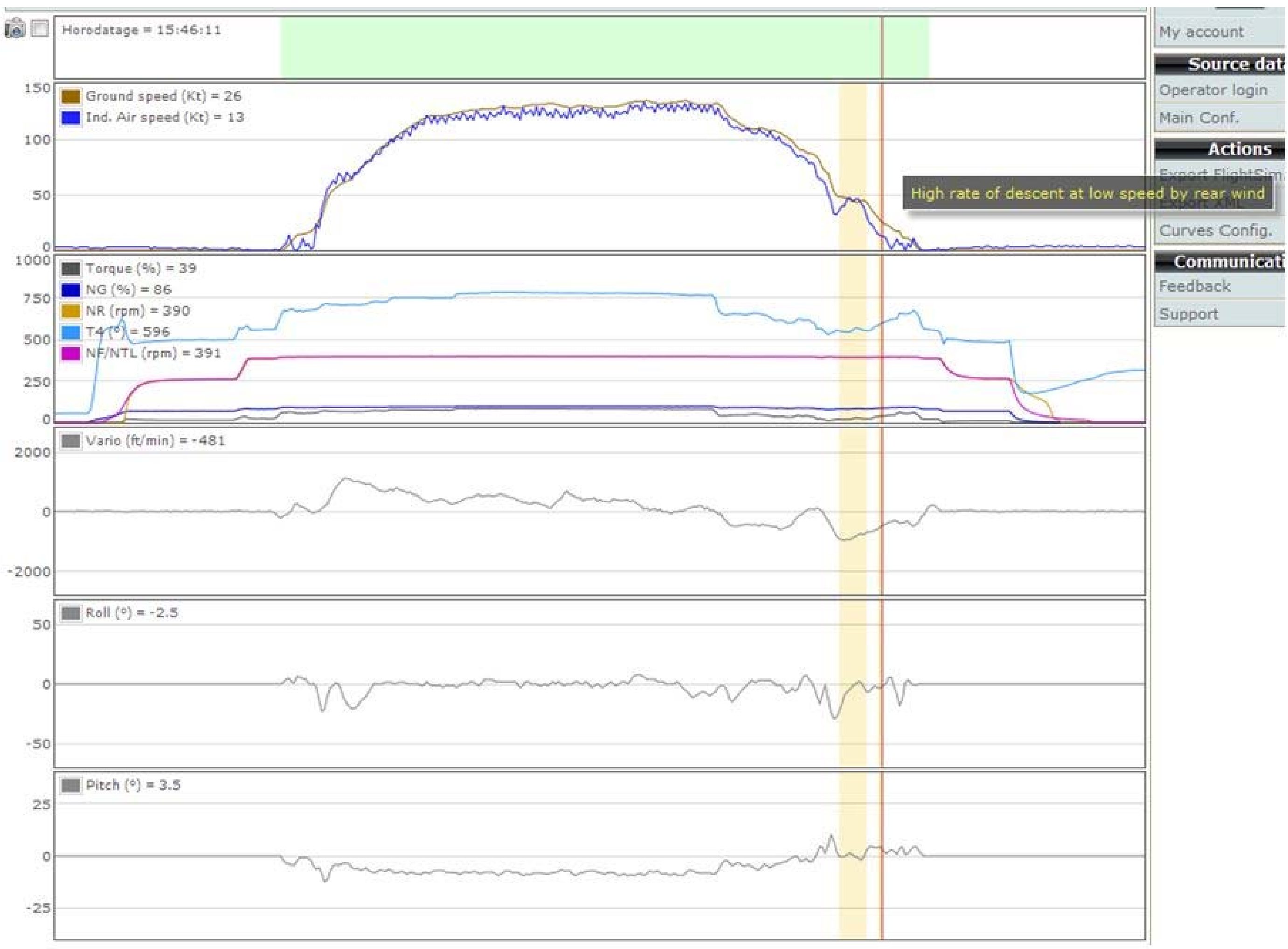
Extension for helicopters required the monitoring of a significant set of additional data and a trigger management capability to detect predefined events.

5.4.2.2 Trigger management function

The trigger management function has 3 main components: the trigger definition, the display of data computation results and the trigger statistics. (The corresponding Safetyplane screenshots are provided in Annex 8.) The definition of triggers is performed per helicopter and mission and the configuration window provides the type of mission , available triggers, list of mission related triggers, dedicated trigger features. The trigger definition is based on selected flight data conditions and time to confirm the conditions.

Display of trigger results: A list of all flights where triggers were activated is available. From this list, access to the data graphs is provided enabling the time of the event and the associated data.

Analysis of trigger results: Trigger analysis results are shown on the telemetry data page, the vertical yellow areas indicate where the trigger has matched the conditions (see example below).



Export of flight data for statistical analysis: An export function has been implemented to generate an excel file containing all the required data for statistical analysis. This function is to be used when additional flights have been monitored, to enable the trigger processing over a complete set of flight data.

5.4.2.3 DO178 B compliance

The software has been developed based on Commercial Off The Shelf (COTS) components and has no safety requirements, thus leading to DO178B level E. A HOMP program does not require a higher integrity level as the information is advisory and does not directly affect the operation of the helicopter. However, should the operator wish to use the system for exceedance monitoring and associated maintenance actions, this may require additional measures as for instance a cross-check with data from another source which does have the necessary level of integrity.

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5.4.2.4 Required means to operate the FDM system

Safetyplane ground segment requires only a standard PC running Windows XP and a web browser with internet access. The access to the web site (www.saferhelicopter.com) can also be provided using a smartphone with internet access. The wireless GSM connection to download the flight data is provided as a service by ISEI.

5.5 Installation of FDM systems

A total of 4 turbine engine powered helicopters where planned for the trial and have been equipped with Safetyplane V4 FDR system (now identified as Helicom V1). Though the initial tender requested 10 helicopters, the study showed that the main focus has been the definition and processing of triggers for the missions flown by the operators and not the number of different helicopter types. Triggers are almost not specific to a given helicopter type (except limitation thresholds) but address mission specific features.

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JSHS : Two systems have been installed in January 2010 on Ecureuil B3 (F-GSEH & F-HEIN) and the equipment is located in the cockpit as shown in figure 1 and 2

Picture 1 – Installation on F-HEIN (Ecureuil B3)

HELIDAX : Two systems have been installed on EC120 (F-HBKA & F-HBKD). The equipment is located in the in rear part of the EC120 as shown in picture 2 (no space available in cockpit). Access to the rear part is not needed during training operations; for other operations where access would be used, the recommended installation would be similar to the one presented in picture 1. The date of installation of these systems has been constrained by the delivery of the helicopters from HELIDAX to the military flight school (EALAT) which delayed the start of the flight trials.


Picture 2 – installation on EC120

<u>Support from ISEI to JSHS & Helidax:</u> ISEI has performed the following support activities in the frame of this project:

- presentation of the product and associated IT tools,
- on-site availability during system installation and configuration,
- hot line support,
- on-site update of airborne software.

The estimated support time is approximately 60 hours for both operators. Installation time is about 16 hours plus 2 hours system configuration. Helicopter downtime to perform the installation is roughly 2 days.,where the installation has been grouped with other maintenance operations. The impact on helicopter wiring is limited to power supply and connection with sensors not located in the system (eg take-off switch, GPS, VEMD cross-talk, anemometry)

5.6 *Data acquisition, Ground Station & Trigger tuning*

5.6.1 Trigger rationale and definition

5.6.1.1 Background and rationale

In order to define the triggers, the consortium choose to refer to CAP 739 and CAA paper 2004/12. These two reports described the studies of HFDM implementation in Off Shore Helicopter companies operating in the North Sea. Among the results of these reports, these documents propose a list of predefined triggers including a dedicated definition per flight phase (see annex 3). The consortium did originally select the same methodology to define its own triggers, however, after some initial problems to identify specific flight phases this approach was dropped. The two main reasons were as follows:

- compared to an offshore mission, a lot of aerial work and training missions have approach phases without a complete landing (eg autorotation with recovery, hover during logging without landing),
- as the approach phase in CAA study is identified by the reference of the landing, it is not applicable in a number of cases.

5.6.1.2 Types of missions:

The initial list of missions was Passenger transport, Executive charter (VIP), Aerial work (including filming and photography, power lines survey and fire-fighting Sling (external load transportation)), post-maintenance flight checks and training

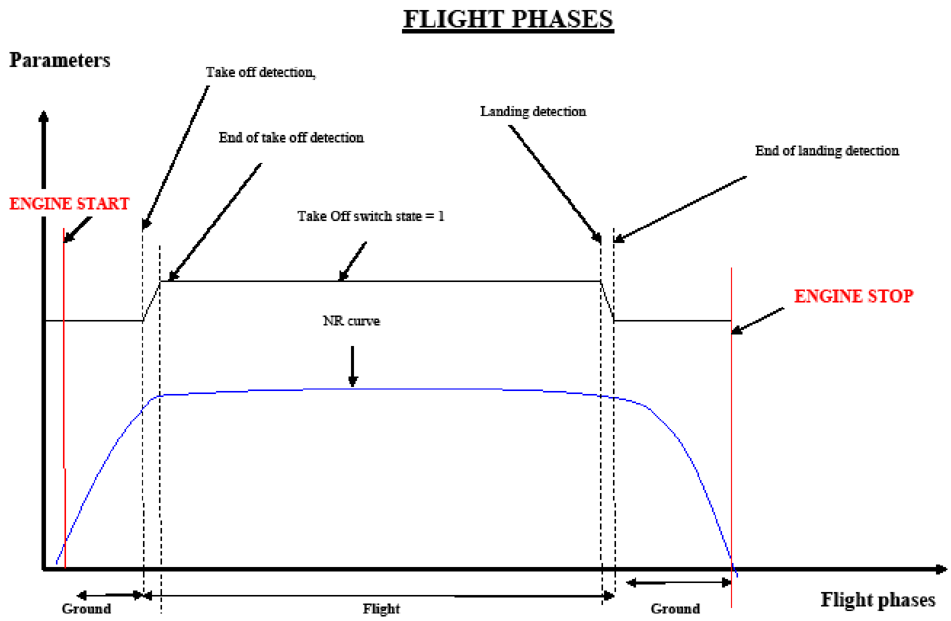
The initial list was identifying the activities performed by the operators without any link to potential trigger definition. This initial list does not match with the required / available flight parameters; as an example, power line survey triggers would need the availability of an accurate altitude data to monitor the risk of collision with obstacles. In addition, several missions included a number of common points (e.g. passenger transport=executive charter for trigger definition). To cope with the above constraints, three mission types have been retained for trigger definition.

- VIP (passenger transport and Executive charter)
- Aerial work (all the others)
- Training (flights with trainer & trainee on board)

For training flights, the need to monitor “solo” flights performed by the student pilots has been raised. These flights are navigation flights with only the student on board as pilot in command and the consortium wanted to know what the behaviour of such young pilot was during these particular flights. So, it was decided to apply the “VIP” triggers.

5.6.1.3 Flight phases:

As previously explained, it was not possible to define several flight phases linked to each type of mission,. The consortium decided to define two phases, ground and flight phases (see figure below).



5.6.1.4 Trigger definition:

The definition of triggers faced two main challenges. The first was to identify the significant threats to light helicopter operations and how they could lead to an accident. The second challenge was to establish a standardized list of trigger which can be used for every type of mission.

In order to address this issue, an accident causal tree has been built to provide inputs to the trigger definition (see Annex 5). An accident has three immediate consequences which are as follows:

- Aircraft damages
- Injuries/death for aircrew and passengers
- Injuries/death for third parties (outside the aircraft or in the vicinity)

As a result eight scenarios of accident have been setup (see **Annex 6**):

- Aircraft damaged in flight without loss of control:
  - o Controlled Flight Into Terrain (CFIT)
  - o Midair collision
- Aircraft damaged in flight with loss of control
- Aircraft damages on ground (for example, runway excursion)
- Aircraft damaged by fire or by explosion
- Passengers/aircrew injured by strike, fire or physiological event
- Third parties injured by strike, fire or physiologic event

Subsequent to these scenarios, a list of precursor incidents which could lead to these scenarios has been defined; these precursors were renamed as “Undesirable Event”.

The following step was to define a list of triggers starting from the list published in the CAA studies and adapting it to the Undesirable Events and flight phases. The following table shows the link between the triggers and the Undesirable Events (refer to list of triggers in **Annex 4**).The complete list of Undesirable Event is provided in Annex 6.

Air crew behaviour		
Undesirable Event	**Related Trigger code**	**Comments**
Inappropriate action of the crew (HF, regulations), entry in Vortex conditions	**01A to 18A**	
Non stabilized approach	**01A, 02A, 06A, 06B, 08A, 08D**	
Variation of en route trajectory	**01B, 02B, 06C, 06D, 08B**	***Could be improved with heading information***
Aircraft state		
Undesirable Event	**Related Trigger code**	**Comments**
Failure systems aircraft (other that only one GTM), events linked with an incident of maintenance, critical damage aircraft undetected before the flight (Altimeters, pitot tube…)	**17A to 24D, 31A, 32A**	
Loss of engine on single engine helicopter	**25A, 25B, 43A to 49C**	
In flight operations		
Undesirable Event	**Related Trigger code**	**Comments**
Nature/slope of helipad ground (mud, grass…)	**29A to 29D**	Excessive slope of helipad
Heavy rate of descent	**08B**	

The triggers have been allocated to three categories (**see annex 4**):

- Attitude, to monitor Operational parameters set by the operators Flight Exploitation Manual
- Engine, to monitor the engine limitations exceedance
- Limitation, to monitor that the aircraft remains in the approved flight manual envelope.

<u>Mission-specific aspects</u>

The aim of passenger transportation is to conduct a flight safely from the airfield departure to the destination with smooth manoeuvres and significant safety margins. For this kind of flight, the target of the triggers is to monitor that the flight has been conducted according to the SOP (Standard Operating Procedures) of the company.

The constraint of aerial work is to fly near the relief or the obstacles, near the aircraft limitations, often in high density altitude conditions. The target of the triggers is, in this case, to be sure that the aircraft had not passed the operating limitations and that the pilot had avoided VORTEX conditions.

The aim of ab initio training flying is to monitor that the trainee remains within defined criteria's that allow a successful landing after an autorotation exercise. Information like roll and pitch attitude, rate of descent, ground speed, the gap between heading and runway axis, rotor rate are vital, mainly in the last hundred feet above the ground. Solo flights will be monitored using the VIP triggers as this type of mission is close to passenger transport. The associated parameters are the same concerning attitude triggers and are specific ones concerning engine & limitations (helicopter dependent).

Event criticality: Three levels of safety have been defined to identify the potential safety impact:

- Level 1 : low level impact on flight safety
- Level2 : significant impact on flight safety
- Level 3 : high impact on flight safety.

Attitude triggers: The lack of precise height reference (despite the fact that ISEI has developed a calculation with web based GPS reference) led to establish a division of vertical space in four parts:

- ground height > 500 Ft
- 300 Ft < ground height < 500 Ft/
- 100 Ft < ground height < 300 Ft
- ground height < 100 Ft

As the system is not able to distinguish between day flight and night flight , the attitude triggers are applicable to day flights only. Night flights would need another category > 1000 Ft.

IAS reference

It was decided to adopt an Indicated Air Speed (IAS) threshold to determine if the flight has been conducted safely during operation at low altitude and low speed. This value was set at 40 Kts (sometimes 30 kts, depending on the flight phases). An example of this is monitoring of High Roll attitude below 500 FT/Gnd and below 40 kts. The alarm was set at 30° Roll angle because it has been considered that the loss of lift due to the high roll angle could lead to a heavy loss of height. The consequence could be a loss of control of the aircraft followed by a crash.

The Helidax EC 120 are fitted with an autopilot and consequently it was not possible to plug the ISEI IAS sensor on the anemometric circuit. To do this would have required re-certification on the autopilot system, which would have been time consuming. . However, any future systems shall be implemented with the provision for IAS recording. The consequence (due to inaccurate IAS) was a lot of false alarm triggers (high rate of descent on approach by rear wind) and, the inability to detect some other attitude triggers linked to IAS information such as:

- High speed at low alt
- Excessive roll attitude below or above 500 Ft/Gnd
- High rate of descent by rear wind (to prevent VORTEX)
- High rate of descent at low speed (to prevent VORTEX)
- VNE exceedances
- Over torque limitations
- T4 exceedances

Heading indication: The lack of reliable heading information meant that it was not possible to define triggers to monitor :

- the helicopter heading during autorotation landing,
- heavy yaw rate in hover or during translation phases
- the drift caused by transverse wind during cruise flight,

To solve the problem, heading sensors that are used on medium/heavy helicopters would be needed, however this would have a significant cost impact on the FDM system.

Involvement of operators: Based on a list of triggers proposed by Eurocopter and enriched by the operators, the setting of parameters has been discussed and finalized with the operators to ensure pertinent thresholds. JSHS was interested to detect “pre-VORTEX” vortex ring effect conditions in order to identify in which flight phase additional training should be made. The trigger is intended to identify a potential entrance into vortex ring conditions. Helidax also raised the need to monitor more accurately autorotation.

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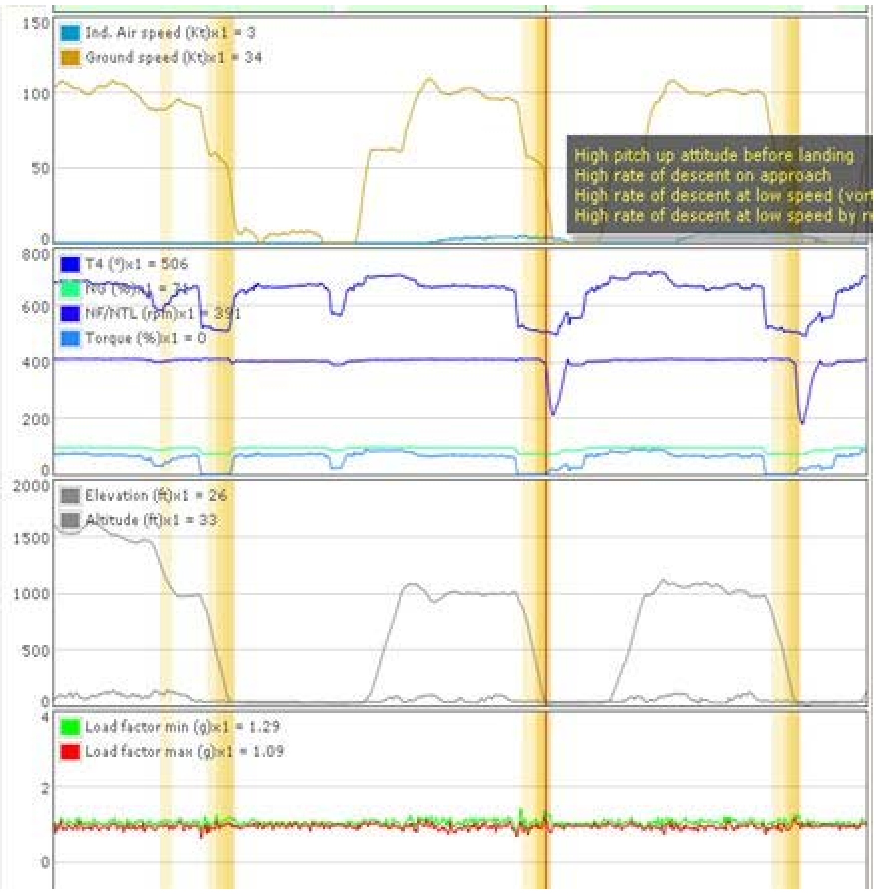
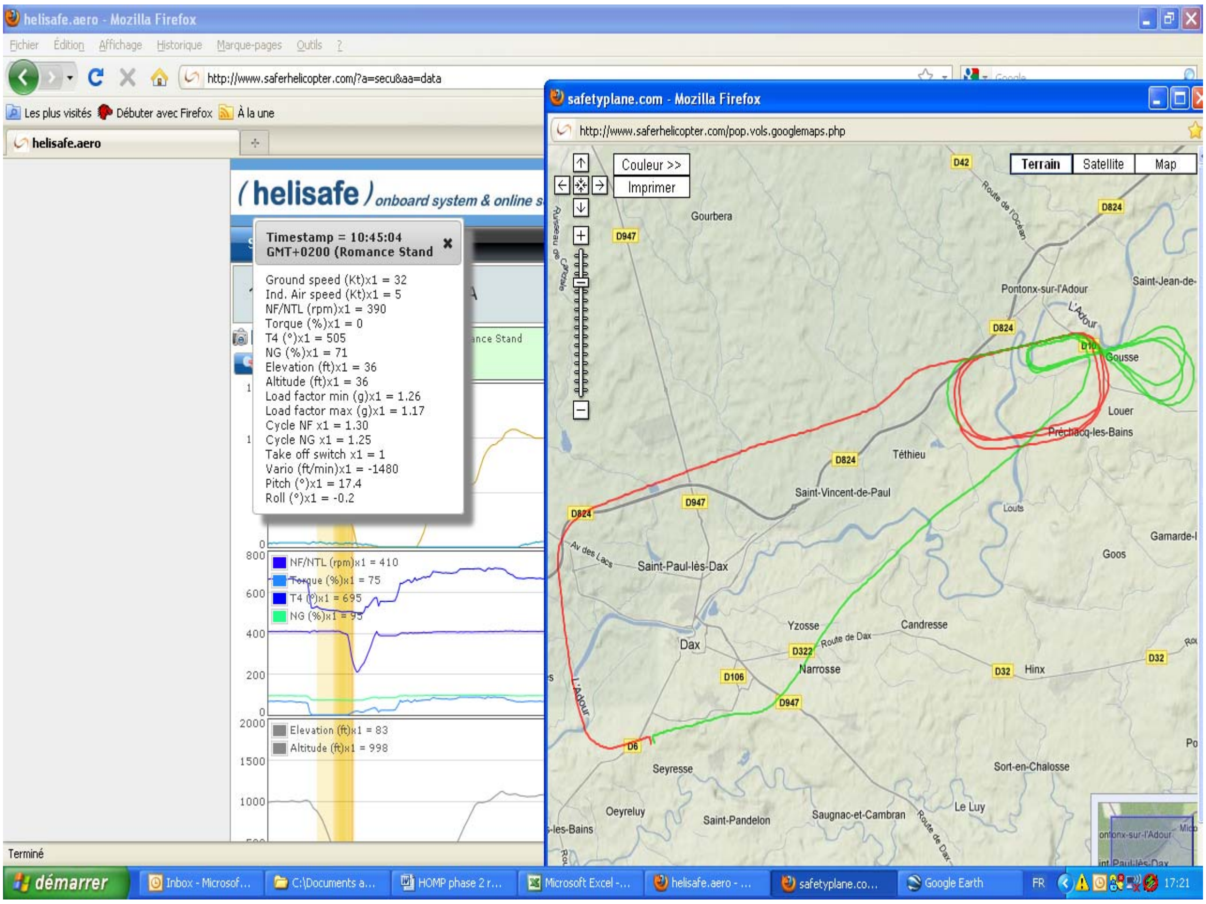
The figures below show how the autorotation trigger (1C) is displayed. The identified hazards are an excessive pitch attitude before touch down to prevent tail rotor strike, excessive roll angle before touch down and excessive skidding ground speed after the touch down.



Link of the event with the trajectory (red and green colours split the trajectory in 2 equal parts: red=first half, green=second part)



5.6.2 Flight data analysis

The tuning of triggers has been performed in a two step approach:

1 – Analysis of dedicated flights where a trigger had matched, in order to confirm the relevance of the trigger in the flight context and the parameters thresholds,

2 – Once the above test was successful, the trigger has been applied to the whole set of relevant flight data for confirmation. or corrective action if needed.

The mission type provided by the operator is critical in determining the correct trigger processing; this has been confirmed when a wrong mission type had been captured in the tool, leading to unusable results (eg VIP attitude triggers used for aerial work results in many trigger alerts generated by normal aerial work flying conditions).

The analysis of events needs to be performed by personnel with helicopter piloting experience. This analysis is necessary in order to remove the occurrence of triggers with no safety impact (e.g. "high rate of descent on approach" during autorotation). For the remaining events, it is essential to properly understand the reason of the event using the available flight context and data. Sometimes it is necessary to discuss the results of post- alert analysis with the pilot in command and also to discuss the findings, when required, with the flight safety officer of the operator.

5.7 Demonstration of effectiveness

5.7.1 Triggers

The following tables indicate for each mission the number & percentage of trigger occurrences (i.e. when the trigger conditions have been matched) over the performed flights. High occurrence rates indicate that the associated conditions which have been set when the trigger definition were originally defined, are often exceeded in flight.
The relationship between the different triggers and Undesirable Events can be seen using table in paragraph 5.6.1.4.

(refer to list of triggers in **Annex 4**)

5.7.1.1 VIP mission

A VIP labelled flight can include one segment with passengers and one segment without passengers (drop of skier on top of a mountain).It can lead to a lot of VIP events generated during the segment without passengers. The analyst has to filter these events.

The filtered triggers relating to attitude are confirmed as being well related to the mission type; the analysis of the flight data only resulted in a small number of events which are consistent with smooth flight manoeuvres during passenger transportation.

Though the most of the triggers related to engine and aircraft limitations are already available via the VEMD, the easier access through the FDM system provides a significant added value as there is no need to display data on-board the aircraft or to download them.

Statistics

VIP triggers per flight	01A	01B	02A	02B	03A	06A	06B	08A	08B	08D	10A	10B	10C
At least 1 match(No.)	33	1	248	14	5	20	25	362	223	160	54	15	31
At least 1 match(%)	7,69%	0	57,8%	3,3%	1,2%	4,7%	5,8%	84,4%	52,0%	37,3%	12,6%	3,5%	7,2%
2 to 5 matches(No.)	8		75	1	1	2	4	171	92	82	8	5	12
2 to 5 matches (%)	1,86%		17,5%	0,2%	0,2%	0,5%	0,9%	39,9%	21,4%	19,1%	1,9%	1,2%	2,8%
More than 5 Matches (No.)	2		8			7	2	50	17	23			
More than 5 Matches (%)	0,47%		1,9%			1,6%	0,5%	11,7%	4,0%	5,4%			

VIP triggers per flight	17A	18A	24A	24C	25A	29B	29E	31A	32A	44A	44C	48C	49B
At least 1 match (No.)	3	10	1	4	18	5	4	5	1	9	1	4	6

At least 1 match (%)	0,7%	2,3%	0,2%	0,9%	4,2%	1,2%	0,9%	1,2%	0,2%	2,1%	0,2%	0,9%	1,4%
2 to 5 matches (No.)	1	4		2	7		1	1	1		1	2	2
2 to 5 matches (%)	0,2%	0,9%		0,5%	1,6%		0,2%	0,2%	0,2%		0,2%	0,5%	0,5%
More than 5 Matches (No.)		1			5	4	2	3					
More than 5 Matches (%)		0,2%			1,2%	0,9%	0,5%	0,7%					

5.7.1.2 Aerial works

The mission leads to flight operations which are close to approved flight manual limitations (VNE, load factor,…).

As a consequence, the triggers have to be less severe than those related to the VIP mission, except for pre-vortex conditions.

The extended thresholds enable to detect events in more critical flight conditions only which should be consistent with the company SOP.

The triggers related to engine and aircraft limitations are the same than for the VIP mission.

Statistics

AW triggers/flight	01A	02A	02B	03A	08A	08B	08C	08D	10A	10B	10C
At least 1 match (No.)	3	15	1	3	113	2	132	132	23	7	22
At least 1 match (%)	1,4%	6,8%	0,5%	1,4%	51,4%	0,9%	60,0%	60,0%	10,5%	3,2%	10,0%
2 to 5 matches (No.)		3		2	45	1	45	35	4	2	8
2to 5 matches (%)		1,4%		0,9%	20,5%	0,5%	20,5%	15,9%	1,8%	0,9%	3,6%
More than 5 Matches (No.)		2			27		58	55			3
More than 5 Matches (%)		0,9%			12,3%		26,4%	25,0%			1,4%

AW triggers/flight	17A	18A	24C	25A	32A	49B
At least 1 match (No.)	3	13	1	24	1	1
At least 1 match (%)	1,4%	5,9%	0,5%	10,9%	0,5%	0,5%
2 to 5 matches (No.)	2	6		11		
2 to 5 matches (%)	0,9%	2,7%		5,0%		
More than 5 Matches (No.)				3		
More than 5 Matches (%)				1,4%		

5.7.1.3 Training

Specific triggers have been defined for autorotation training; they have been tested successfully and provide relevant support for debriefing. The following conditions leading to potential incidents/accidents can be detected:

- rotor rate over speed
- tail rotor strike,
- hard landing,
- roll-over on ground,
- Excessive skidding landing speed on ground.

The triggers related to engine and aircraft limitations are the same than for the VIP mission.
(An extended monitoring of trainee pilots for events of over torque has been requested by Helidax)

Statistics

Training triggers/flight	01A	01B	01C	02A	02B	06A	06B	06E	06F	08A	08B	08C	08D
At least 1 match (No.)	4	1	59	5	4	10	13	2	2	114	75	127	127
At least 1 match (%)	2,9%	0,7%	42,4%	3,6%	2,9%	7,2%	9,4%	1,4%	1,4%	82,0%	54,0%	91,4%	91,4%

2 at 5 matches (No.)	4		13		2	4	6	1		34	19	34	37
2 at 5 matches (%)	2,9%		9,4%		1,4%	2,9%	4,3%	0,7%		24,5%	13,7%	24,5%	26,6%
More than 5 Matches (No.)			41	4		2	2			63	45	82	71
More than 5 Matches (%)			29,5%	2,9%		1,4%	1,4%			45,3%	32,4%	59,0%	51,1%

Training triggers/flight	09A	10A	10E	18A	24A	24B	24C	25A	29A	29E	31A	48C	49B
At least 1 match (No.)	2	64	1	1	49	3	1	2	1	1	4	52	3
At least 1 match (%)	1,4%	46,0%	0,7%	0,7%	35,3%	2,2%	0,7%	1,4%	0,7%	0,7%	2,9%	37,4%	2,2%
2 at 5 matches (No.)	1	33			14		1	1			4	23	
2 at 5 matches (%)	0,7%	23,7%			10,1%		0,7%	0,7%			2,9%	16,5%	
More than 5 Matches (No.)		14										28	
More than 5 Matches (%)		10,1%										20,1%	

5.7.1.4 Operator feedback on trigger statistics

The most significant results have been analysed and discussed with the operators and are stated as follows:

- VNE exceedence : several event occurrences have been detected, some of them with more than 20 kts,
- Low fuel: several event occurrences have been detected, the complementary analysis has shown for some of them, a landing with a very low fuel level. In some cases, the event is the consequence of a defined operational practice (aerial work).
- Pre-vortex conditions: a significant number of occurrences have been detected. According to the operator, it can be the result of an operational practise in aerial work, nevertheless an in-depth analysis of the flight data case by case is necessary to assess the safety impact.
- Pitch down attitude: a significant number of occurrences have been detected. According to the operator, it can the result of an operational practise, nevertheless an in-depth analysis of the flight data case by case is necessary to assess the safety impact.
- Autorotation events in training: a lot of high pitch-up before landing have been detected; it could be used by the trainer to show to the trainee how to improve its autorotation practice

For the events assessed to be safety critical, the safety officer has to take the relevant actions towards the pilots.

5.7.2 Cost/benefit feedback

5.7.2.1 Assessment of benefits

The expected and identified benefits described in the Part 1 of the study have been assessed after the performed flight monitoring campaign and results are provided here below..

5.7.2.1.1 Benefits for training school*:*

- Potential reduction of accident/incident rate : needs a longer term data collection and analysis to get feedback - see recommendations
- Follow-up of trajectories, speed, attitudes : confirmed
- Validation/update of training programs : needs a longer term data collection and analysis to get feedback
- Analysis of trainee's behaviour during solo flights (eg Flight replay) : no solo flights have been performed so far.
- Analysis of trainee's behaviour during dedicated phases (eg start-up procedure) : yes, in particular critical autorotation training can be monitored more accurately.
- Analysis of flight incidents: the system provides an easy access to a set of flight data which is a key contribution to incident analysis . confirmed by operators
- Awareness of pilots with respect to maintenance actions linked to exceedances : confirmed, examples linked to monitoring of load factors and exceedances.

5.7.2.1.2 Benefits for helicopter operations:

- Potential reduction of accident/incident rate : needs a longer term data collection and analysis to get feedback -see recommendations
- Monitoring of trajectories, speed, attitudes : confirmed
- Compliance to Standard Operating Procedures (SOP) and adjustment of SOPs : specific events detected can be linked to SOP and/or lead to SOP adjustments
- Availability of flight hours after each flight for maintenance purposes: confirmed, the system provides accurate data which generate savings compared to flight reports.
- Availability of helicopter positions after each mission : confirmed,
- Management of pilot flight hours : currently separate management
- Fleet planning and booking : not yet used
- Management of invoicing and payment : not used by JSHS & Helidax
- Visibility on dry-rental flight conditions : confirmed
- Support for OPS3 requirements (section 515 & following): Exposure Time-flights in hostile environments : confirmed
- Potential reduction of insurance fees : not addressed
- Fuel savings (adherence to SOPs) : not addressed
- Analysis of flight incidents (not a primary goal of HOMP systems): the system provides an easy access to flight data which is a key contribution to incident analysis.
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5.7.2.1.3 Benefits for maintenance activities:

- Reliable and accurate identification and storage of limitations exceedance : confirmed, easy access to VEMD data
- Reliable identification and storage of red & amber warnings : H/C warning not available in the system
- Support for planning of maintenance activities : yes in case of exceedances
- Support for failure diagnostic based on selected data : confirmed
- Detection of events requiring maintenance actions (eg hard landing) : confirmed, monitoring of load factors (Helidax)
- Helicopter localization when landing after failure : confirmed when GSM network available
- Forecast of Spare orders based on status provided by the system : not addressed
- Engine power check (analyzed after flight) : not addressed, capability planned

5.7.2.1.4 Benefits for the helicopter manufacturer:

- Potential reduction of accident/incident rate : needs a longer term data collection and analysis to get feedback -see recommendations
- Support to accident/incident analysis : see recommendations
- Better knowledge of fleet status(flight hours/product and mission) : confirmed,
- Support to “By The Hour” contracts : not addressed, capability planned
- Support to Spares forecast : not addressed, capability planned
- Contribution to product and training improvement :not addressed
- Support to Training Need Analysis : not addressed
- Comparing the performance of dedicated H/C with the fleet average : not addressed
- Early support to Manufacturer technical support activities : no case identified
- Decision aid in the frame of deviation requests (Time Between Overhaul , Service Life Limit, …): not addressed

5.7.2.1.5 Benefits for Aviation Authorities

- Potential reduction of accident/incident rate : needs a longer term data collection and analysis to get feedback -see recommendations
- Support to accident/incident analysis : see recommendations

5.7.2.2 Cost analysis

The following costs based on available commercial data from ISEI, have been updated.

5.7.2.2.1 Identification of Non-Recurring Costs

Procurement	Airborne Hardware	8000 €
	Take-off & antenna	500 €
	Support tool	500 €
Installation	cables	300 €
	GPS	300 €
	Workload	16 hours
	System configuration	2 hours
Training	Installation	400 €
	Operations	800 €

5.7.2.2.2 Identification of Recurring Costs

Operations	Data transfer (H/C-GS)	GSM yearly cost: 200 €
	Access to services	1800 € / HC / year
	Data analysis effort	0,5 - 1 day / HC / month
Maintenance	Airborne equipment	Maintenance contract of HW: 500 € per year

5.7.2.2.3 Estimated savings

The implementation of an FDM program will increase the overall fleet safety, reduce incidents/accidents occurrence and therefore reduce the risk of associated consequences:

- Fatalities
- Unavailability of aircraft
- Loss of business
- Investigation/expertise
- Repair costs.

Other benefits have been identified / assessed:

- Invoicing and payment: the saving is estimated between 5 and 10 € per invoice
- Savings in maintenance activities: potential benefit not assessed by the operators
- Savings in manual capture of administrative data (helicopter & pilot flight hours, fuel consumption, engine & aircraft cycles…): potential benefit not assessed by the operators
- Fleet planning and booking: was not used by operators
- Pilot electronic log book: was not evaluated by operators
- Potential Insurance reduction : potential benefit not assessed by the operators

The cost/benefit feedback from operators is more linked to operational and maintenance benefits than safety benefits. It confirms what has been indicated in part 1 of the study. The assessment of effective savings has not been quantified by the operators, and so it is not possible at this point to determine whether light helicopter FDM would be cost effective. However, based on the safety benefit alone, the cost benefit for GA operations could be worthwhile. Accordingly, it is recommended that EASA / EHEST carry out a cost benefit analysis based on EHEST data to better understand the justification for incorporating FDM on light helicopters.

5.8 Recommendations

From the experience gained during this programme and feedback from the operators, the following recommendations are made in order to reach the desired potential of a small helicopter HOMP.

5.8.1 Technical recommendations

Memory robustness

Recommendations provided in ED155 (chapter I-3) should be considered to provide crash investigation capability. The feature is planned in the next version of the Safetyplane product (Helicom V2). Even if not directly linked to HOMP, this feature is recommended to provide access to critical data required during accident investigations.

Download

Improvement of GSM/GPRS is recommended to reduce the download time or provide a higher amount of data per flight. A 3G modem will be implemented in Helicom V2.
The increase of the sampling rate enabled by 3G transfer rate is recommended to provide a better knowledge of parameters

Parameters

The parameter acquisition & recording rate should be increased as mentioned above.

A solution to solve the heading acquisition would enable the detection of additional safety events.(eg loss of tail rotor effectiveness). No low cost solution is currently available.
This issue should be addressed by OEM and/or equipment manufacturers.

Missing low-cost radio-altimeter has been mitigated using web altitudes. This data is not accurate enough for dedicated triggers. Availability of a radio-altimeter sensor at a reasonable cost would be a significant improvement for FDM systems. However, currently no low cost solution has been identified. It is recommended that the Global Helicopter Flight Data Monitoring Steering Group work with equipment manufacturers to determine if a solution to this problem can be found.

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Position of flight controls: Availability of flight controls position would enable additional triggers to be defined (eg accident investigation, controls stops).
The acquisition of the data would need additional sensors and impact the overall cost of the system; the availability of that data is considered to be a lower priority for small helicopters (impact on H/C certification). The study does not recommend including these parameters into a HOMP system for small helicopters.

Functions

- For each flight:
  - Automatic detection of event triggers and information of responsible person (SMS or email): this capability is strongly recommended to enable operator access to meaningful events that need attention (available capability not yet used during project).
  - Event analysis through 3D replay, parameter replay: this capability is recommended to ease flight analysis (training debriefing and incident/accident investigation) as a complementary feature to data display (capability available not deployed).
- Statistics related to events: to provide the trends of trigger occurrences over time.
- Availability of a crew input allowing (e.g. button) to record a time stamp allowing further ground investigation has been suggested by Helidax

- o Flight tracking function is a feature requested by the operators to be able to localize the fleet in operations.
- o A message transfer capability (ground to flight) has been indicated as a desirable feature.
- o Cockpit Camera: this capability is highly recommended for incident/accident investigation. The automated analysis of cockpit video is not considered to be a sufficient mature technology for recurring FDM activities.
- o Ambient noise recording: this capability would provide added value for accident investigation.

5.8.2 Operational recommendations

Flight data analysis: After several months of trial, it became apparent that it was very difficult for the operators to spend the necessary time for regular analysis of the recorded data . Consequently, it was necessary for Eurocopter to spend significant time to help the operators for defining and tuning the triggers, and analyzing the flight data.
The estimated effort for the implementation of such HFDM programme, for a fleet of four light helicopters, is approximately one man-day per week within the operator's organization, at least at the beginning of the programme.
As soon as the process becomes mature, the resources required could be reduced to half a man-day per week.
Additionally, the operators were more focused on usage data (engine limitation exceedance for example) than on pure operational safety aspects like excessive pitch attitude during landing (which is more stringent than limitations of the Rotorcraft Flight Manual). The exception is the training activity where instructors are interested to monitor accurately the trainee, especially for autorotation.
It is clear that due to the very hard commercial competition that exists between small helicopter operators, it will be difficult for HFDM to be adopted by operators unless a financial benefit can be demonstrated. Of course there maybe some operators that already have a proactive safety culture and may be convinced that an HFDM Programme can be cost effective in the long term,.
The evolution of a safety culture is normally quite a slow process. Accordingly, it was not possible to monitor such an evolution within the operators that took part in this trial over such a short time period.
In order to help alleviate the operator's resource issues, consideration should be given to setting up a third party data analysis service, to perform the required HFDM tasks.

Incentives: Additional incentives like insurance fee reductions could not be checked by the operators due to time constraints; Eurocopter signed an agreement with an insurance company leading to improved insurance conditions linked to yearly pilot recurrent training performed within Eurocopter. Hopefully a similar approach could be applied to HFDM.

Some companies now specify that helicopters used to service their contracts must be fitted with a Health and Usage Monitoring System "HUMS". Though this has normally only affected Part 29 helicopters, some companies have now requested HUMS on Part 27 helicopters. When this is the case, this would significantly reduce the start up costs for adopting an HFDM programme.
HFDM part of SMS: Safety Management System (SMS) is becoming a regulatory standard, at least for operators flying for public transportation. The availability of HFDM technologies at a reasonable cost could be envisaged as a meaningful component of the SMS regulation. It would provide a means to identify additional safety events which will be managed within the Safety Management System, therefore increasing the efficiency of the SMS.

5.9 Conclusions

The objectives of the study are considered to have been met. Relevant technical and operational aspects of light helicopter HFDM have been assessed and recommendations made where considered to be appropriate.

The study demonstrated the following key items which need to be considered when HFDM systems for small rotorcraft are envisaged:

- Detection of events related to pre-define "safety triggers" can be achieved and can be a real contribution to safety improvement. The feasibility of this approach has been confirmed though VIP and training missions are considered to be better suited to HFDM, as these flight operations are generally more repeatable,
- Pilot acceptance has not been an issue during this study, once the objectives of the study have been explained.
- The HFDM system needs to be as "user transparent" as possible in terms of data acquisition, download to ground and ground processing. In order to avoid additional HFDM-specific data capture, the system needs to be integrated with the overall operator data management system.
- The cost (RC+NRC) is considered to be at a reasonable level. Nevertheless the overall cost of an HFDM program needs to be compensated by equivalent savings, which could not be quantified by the operators during the period of this study.
- Additional sensors need to be developed, as explained in the recommendations above, to provide more accurate pitch & roll attitude, reliable heading and more accurate ground height data needed for HOMP at an affordable cost,
- The data analysis effort to be performed by operators, as experienced during the last phase of the study (when triggers are defined), is not considered by the operators to be compatible with their daily operations. This is currently seen to be the highest barrier to deployment of HFDM on a voluntary basis for small size operators. As well as making outsourced data analysis services available to the operators, the flight data analysis effort needs to be reduced to a lower level by either limiting the number of triggers or confirming that the triggers are properly tuned.

- The system has been assessed to be a valuable support in case of incidents and exceedance monitoring,
- The system seems to be better adapted to public transportation and training activities than for aerial work due to diversity and specific characteristics of flight profiles which are performed very often close to the ground,
- HFDM can be deployed on any fleet size.

In general this research programme has demonstrated a significant potential safety benefit which can be provided by incorporating HFDM on light helicopters. It is considered that HOMP systems should be promoted as part of a more global approach to helicopter fleet monitoring and management.

6 Reference documents

- SERVICE CONTRACT No. EASA.2008.C50 "Small Helicopter Operational Monitoring Programme (HOMP) Trial CONTRACT NUMBER – EASA.2008.C50
- EHOMP CONSORTIUM TECHNICAL PROPOSAL EASA.2008.OP.33 "SMALL HELICOPTER HOMP TRIAL" – ETFR 08.11.20 dated 6/10/2009
- EHOMP CONSORTIUM-PART 1 REPORT-EASA.2008.OP.33 "SMALL HELICOPTER HOMP TRIAL" ETFR 09.08.25
- CAA paper 2004/12 Final report on follow-on activities to the HOMP Trial
- CAP 739 Flight Data Monitoring – A guide to good practice – 29th August 2003

7 Annex 1 : Supplemental Type Certificates

European Aviation Safety Agency

SUPPLEMENTAL TYPE CERTIFICATE

10027431

Project reference: 0060004475-001
Reference: P-EASA.R.S.01543

This Supplemental Type Certificate is issued by EASA, acting in accordance with Regulation (EC) No. 216/2008 on behalf of the European Community, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation and in accordance with Commission Regulation (EC) No. 1702/2003 to

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Le Mercure B, 80
Rue Charles Duchesne
13851 AIX EN PROVENCE CEDEX 3
FRANCE

and certifies that the change in the type design for the product listed below with the limitations and conditions specified meets the applicable Type Certification Basis and environmental protection requirements when operated within the conditions and limitations specified below:

Original Product TC Number:	**EASA.R.008**
TC Holder:	**EUROCOPTER**
Model:	**AS350 B3, EC130 B4**

EASA Certification Basis:
EASA Certifcation Basis as per EASA TCDS.R.008

The Certification Basis for the original product and the following additional or alternative airworthiness requirements are applicable to this certificate/ approval

The change complies with CS27 First Issue

The certificated noise and/ or emissions levels of the original product are unchanged and remain applicable to this certificate/ approval

Description of Design Change:
-Installation of Safetyplane Equipment
-Installation of a system for tracking a set of flight and system parameters during operation of the rotorcraft. The modification is based on ISEI change N-EC130 AS350B3 as defined in Dossier de Définition de la Modification-F-A-03, dated 26.06.2009.

Associated Technical Documentation:
-Dossier d'approbation de modification N-EC130 AS350B3 Approbation-F-A-02, dated 23.07.2009
-Dossier de Définition de la Modification N-EC130 AS350B3 Définition-F-A-03, dated 26.06.2009
-Dossier d'Installation N-EC130 AS350B3 Installation F-A-04, dated 28.07.2009

or later revisions of the above listed documents approved by EASA

Limitations:
None

Conditions:
The approval holder shall fulfil the obligations of Part 21, Paragraph 21.A109.

Prior to installation of this modification it must be determined that the interrelationship between this modification and any other previously installed modification and/ or repair will introduce no adverse effect upon the airworthiness of the product.

This Certificate shall remain valid unless otherwise surrendered or revoked.

For the European Aviation Safety Agency,

Date of issue: 30.09.2009

Massimo MAZZOLETTI
Certification Manager
Rotorcraft, Balloons, Airships

European Aviation Safety Agency

MINOR CHANGE APPROVAL

10027967, REV. 1

This Minor Change Approval is issued by EASA, acting in accordance with Regulation (EC) No. 216/2008 on behalf of the European Community, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation and in accordance with Commission Regulation (EC) No. 1702/2003 to

ISEI
Le Mercure B
80 Rue Charles Duchesne
13851 AIX EN PROVENCE CEDEX 3
FRANCE

and certifies that the change in the type design for the product listed below with the limitations and conditions specified meets the applicable Type Certification Basis and environmental protection requirements when operated within the conditions and limitations specified below:

Original Product TC Number:	**EASA.R.008**
TC Holder:	**EUROCOPTER**
Model:	**AS 350B3, EC130 B4**

EASA Certification Basis:
CS 27 First Issue

Description of Design Change:
Minor Changes to the Rotorcraft Configuration and the required technical documents related to EASA STC 10027431

Associated Technical Documentation:
- N1-AS350-Reference Documents Version E, Edit B, Rev. 02 dated 16/11/2009
- N2-AS350-Approval Change Document Version E, Edit B, Rev. 02 dated 16/11/2009
- N3-AS350-Experience Feedback Version E, Edit B, Rev. 02 dated 16/11/2009
- N4-AS350-Safety Assessment Version E, Edit B, Rev. 02 dated 16/11/2009
- N5-AS350-Design Document Version E, Edit B, Rev. 02 dated 16/11/2009
- N6-AS350-Installation Document Version E, Edit B, Rev. 02 dated 16/11/2009
- N7-AS350-Maintenance Manual Supplement Version E, Edit B, Rev. 02 dated 16/11/2009

See Continuation Sheet(s)

For the European Aviation Safety Agency,

Date of issue: 03.12.2009

Massimo MAZZOLETTI
Certification Manager
Rotorcraft, Balloons, Airships

European Aviation Safety Agency

SUPPLEMENTAL TYPE CERTIFICATE

10027889

Project reference: 0010000019-001

This Supplemental Type Certificate is issued by EASA, acting in accordance with Regulation (EC) No. 216/2008 on behalf of the European Community, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation and in accordance with Commission Regulation (EC) No. 1702/2003 to

ISEI
Le Mercure B
80 Rue Charles Duchesne
13851 AIX EN PROVENCE CEDEX 3
FRANCE

and certifies that the change in the type design for the product listed below with the limitations and conditions specified meets the applicable Type Certification Basis and environmental protection requirements when operated within the conditions and limitations specified below:

Original Product TC Number:	**DGAC FRANCE TC N. 189**
TC Holder:	**EUROCOPTER**
Model:	**EC 120 B**

EASA Certification Basis:
The Certification Basis for the original product and the following additional or alternative airworthiness requirements are applicable to this certificate/approval:
CS 27.25, CS 27.27, CS 27.307, CS 27.561, CS 27.1301, CS 27.1309, CS 27.1351, CS 27.1353,. CS 27.1357, CS 27.1365.

Description of Design Change:
Installation of Safetyplane Equipment in accordance with ISEI Installation Document: N-EC120-Installation E-A-07.

Associated Technical Documentation:
- Definition and Installation in accordance with:

ISEI N-EC120- Design document E-A-07 dated 21/10/09
ISEI N-EC 120-Installation E-A-07 dated 21/10/09

- Inspection and Maintenance in accordance with:

ISEI N-EC 120- Sup. Maint. Manual E-A-05 dated 21/10/09

Limitations:
Not Applicable.

Conditions:
Prior to installation of this modification it must be determined that the interrelationship between this modification and any other previously installed modification and/ or repair will introduce no adverse effect upon the airworthiness of the product.

8 Annex 2 : Helicom V2-V3 features

The table below indentifies the main features of Helicom product roadmap.

Mechanical features				
	HELICOM V1	HELICOM V2	HELICOM V2+	HELICOM V3
Equipment Weight	550 g	800 g	900 g	900 g
Equipment Dimension	26 X 158 X 170	44 X 158 X 170	54 X 158 X 170	54 X 158 X 170
Rack weight	350 g	400 g	450 g	450 g
Rack dimension	30 X 160 X 200	48 X 160 X 200	58 X 160 X 200	58 X 160 X 200
Connector	37 Pts	37 Pts	2 X 37 Pts	2 X 37 Pts

Electrical features				
	HELICOM V1	HELICOM V2	HELICOM V2+	HELICOM V3
Input power	8V - 32V	8V - 32V	8V - 32V	8V - 32V
Consommation	2W	3W	4W	4W

Hardware resources				
	HELICOM V1	HELICOM V2	HELICOM V2+	HELICOM V3
3 axis Accelerometer	1	1	1	1
Calender (with battery)	1	1	1	1
Battery 800 mAh	1	1	1	1
Power management	1	1	1	1
Memory for storage and GSM transfer	16 Mo	16 Mo	16 Mo	16 Mo
Crah resistant Memory		16 Mo	16 Mo	16 Mo
Memory for on-board data storage		2 Go	2 Go	2 Go
SD Card (Windows compatible)		2 Go	2 Go	2 Go

Acquisition Interfaces	HELICOM V1	HELICOM V2	HELICOM V2+	HELICOM V3
Digital links (ARINC 429/RS232/RS485/CAN)	1	1	1	1
ARINC 429 for AIS		1	1	1
RS232 for GPS	1	1	1	1
CAN bus for AHRS	1	1	1	1
Ethernet for video		1	1	1
Crew input	1	1	1	1
Take off switch input	1	1	1	1
NR analog input	1	1	1	1
Total pressure input	1	1	1	1
Static pressure input	1	1	1	1
Counter input	4		4	TBD
Programmable analog inputs	8		8	TBD
Inputs for vibration monitoring				TBD

Display	HELICOM V1	HELICOM V2	HELICOM V2+	HELICOM V3
2 X 20 caracters & joystick		1	1	1

Communication interfaces	HELICOM V1	HELICOM V2	HELICOM V2+	HELICOM V3
USB	1	1	1	1
WIFI		1	1	1
Bluetooth		1	1	1
GSM 2G	1			
GSM 2G or 3G		1	1	1
Satellite		1	1	1

9 Annex 3 : Triggers from CAA study

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
01A	High Pitch-Up Attitude Below 20 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect the risk of a tail rotor strike.
01B	High Pitch-Up Attitude Above 20 ft and Below 500 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect excessive flare angle i.e. rushed final approach, likely to alarm passengers or cause crew to lose visual reference
01C	High Pitch-Up Attitude Above 500 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect excessive pitch up attitude in flight.
01D	High Pitch-Up Attitude Below 90 knots IAS	AS332L, S76	Air	Pitch Attitude, Indicated Airspeed	To detect excessive pitch up attitude at lower speeds.
01E	High Pitch-Up Attitude Above 90 knots IAS	AS332L, S76	Air	Pitch Attitude, Indicated Airspeed	To detect excessive pitch up attitude at higher speeds.
02A	High Pitch-Down Attitude Below 20 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect excessive nose down pitch attitude during take-off transition which might result in striking the ground if an engine failed
02B	High Pitch-Down Attitude Above 20 ft and Below 500 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect excessive nose down pitch attitude during take-off transition and at other lower level flight conditions.
02C	High Pitch-Down Attitude Above 500 ft AGL	AS332L, S76	Air	Pitch Attitude, Radio Altitude	To detect excessive pitch down attitude in flight.
02D	High Pitch-Down Attitude Below 90 knots IAS	AS332L, S76	Air	Pitch Attitude, Indicated Airspeed	To detect excessive pitch down attitude at lower speeds.
02E	High Pitch-Down Attitude Above 90 knots IAS	AS332L, S76	Air	Pitch Attitude, Indicated Airspeed	To detect excessive pitch down attitude at higher speeds.
03A	High Pitch Rate Below 500 ft AGL	AS332L, S76	Air	Pitch Rate, Radio Altitude	To detect excessive rate of change of pitch attitude at lower level flight conditions.

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
03B	High Pitch Rate Above 500 ft AGL	AS332L, S76	Air	Pitch Rate, Radio Altitude	To detect excessive rate of change of pitch attitude in flight.
04A	Low Maximum Pitch Rate on Rig Take-Off	AS332L, S76	Rig Take-Off	Pitch Rate	To detect a low helicopter rotation rate during rotation on a take-off from a helideck which could result in a deck strike if an engine failed
04B	High Maximum Pitch Rate on Rig Take-Off	AS332L, S76	Rig Take-Off	Pitch Rate	To detect a high helicopter rotation rate during rotation on a take-off from a helideck, which might cause crew disorientation and passenger alarm
05A	Low Maximum Pitch-Down Attitude on Rig Take-Off	AS332L, S76	Rig Take-Off	Pitch Attitude	To detect a low nose down pitch attitude during rotation on a take-off from a helideck, which could result in a deck strike if an engine failed
05B	High Maximum Pitch-Down Attitude on Rig Take-Off	AS332L, S76	Rig Take-Off	Pitch Attitude	To detect a high nose down pitch attitude during rotation on a take-off from a helideck, which might cause crew disorientation and passenger alarm
06A	Roll Attitude Above 30 deg Below 300 ft AGL	AS332L	Air	Roll Attitude, Radio Altitude	To detect exceedence of the Flight Manual roll attitude limit for weights above 18,410 lb at lower level flight conditions.
06B	Roll Attitude Above 40 deg Below 300 ft AGL	AS332L, S76	Air	Roll Attitude, Radio Altitude	To detect exceedence of the Flight Manual roll attitude limit for weights above 17,200 lb at lower level flight conditions.
06C	Roll Attitude Above 30 deg Above 300 ft AGL	AS332L	Air	Roll Attitude, Radio Altitude	To detect exceedence of the Flight Manual roll attitude limit for weights above 18,410 lb.
06D	Roll Attitude Above 40 deg Above 300 ft AGL	AS332L, S76	Air	Roll Attitude, Radio Altitude	To detect exceedence of the Flight Manual roll attitude limit for weights above 17,200 lb.
07A	High Roll Rate Below 500 ft AGL	AS332L, S76	Air	Roll Rate, Radio Altitude	To detect excessive roll rate at lower level flight conditions.
07B	High Roll Rate Above 500 ft AGL	AS332L, S76	Air	Roll Rate, Radio Altitude	To detect excessive roll rate in flight.

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
08A	High Rate of Descent Below 500 ft AGL	AS332L, S76	Air	Rate of Descent, Radio Altitude	To detect an excessive rate of descent at low height.
08B	High Rate of Descent Above 500 ft AGL	AS332L, S76	Air	Rate of Descent, Radio Altitude	To detect an excessive rate of descent.
08C	High Rate of Descent Below 30 knots LAS	AS332L, S76	Air	Rate of Descent, Indicated Airspeed	To detect an excessive rate of descent at low airspeed (where there is danger of entering the vortex ring state).
09A	Low Airspeed Above 500 ft AGL	AS332L, S76	Take-Off, Cruise	Indicated Airspeed	To detect flight at an unusually low airspeed.
10A	Normal Acceleration Above 500 ft AGL	AS332L, S76	Air	Normal Acceleration, Radio Altitude	To detect a high normal acceleration in flight due to turbulence or a manoeuvre.
10B	Normal Acceleration Below 500 ft AGL	AS332L, S76	Air	Normal Acceleration, Radio Altitude	To detect a high normal acceleration at lower level flight conditions due to turbulence or a manoeuvre.
10C	Lateral Acceleration Above 500 ft AGL	AS332L, S76	Air	Lateral Acceleration, Radio Altitude	To detect a high lateral acceleration in flight due to turbulence or a manoeuvre.
10D	Lateral Acceleration Below 500 ft AGL	AS332L, S76	Air	Lateral Acceleration, Radio Altitude	To detect a high lateral acceleration at lower level flight conditions due to turbulence or a manoeuvre.
10E	Longitudinal Acceleration Above 500 ft AGL	AS332L, S76	Air	Longitudinal Acceleration, Radio Altitude	To detect a high longitudinal acceleration in flight due to turbulence or a manoeuvre.
10F	Longitudinal Acceleration Below 500 ft AGL	AS332L, S76	Air	Longitudinal Acceleration, Radio Altitude	To detect a high longitudinal acceleration at lower level flight conditions due to turbulence or a manoeuvre.
11A	Excessive Lateral Cyclic Control	AS332L, S76	Air	Lateral Cyclic Pitch	To detect movement of the lateral cyclic control to extreme left or right positions.

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
11B/C	Excessive Longitudinal Cyclic Control	AS332L, S76	Air	Longitudinal Cyclic Pitch	To detect movement of the longitudinal cyclic control to extreme forward or aft positions.
12A	Excessive Collective Pitch Control in Level Flight	AS332L	Air	Collective Pitch, Rate of Descent	To detect approaches to, or exceedences of, Flight Manual collective pitch limits for cruising flight.
12B	Excessive Collective Pitch Control	AS332L	Air	Collective Pitch	To detect exceedences of the absolute maximum Flight Manual collective pitch limit.
13A	Pilot Event Marker Pressed	AS332L, S76	Air		To detect when the FDR pilot event marker has been pressed.
14A	IAS Mode Engaged Below 60 knots IAS	AS332L	Air	Autopilot IAS Mode, Indicated Airspeed	To detect inappropriate engagement of autopilot airspeed hold at low airspeeds.
14B	ALT Mode Engaged Below 60 knots IAS	AS332L	Air	Autopilot ALT Mode, Indicated Airspeed	To detect inappropriate engagement of autopilot altitude hold at low airspeeds.
14C	HDG Mode Engaged Below 60 knots IAS	AS332L	Air	Autopilot HDG Mode, Indicated Airspeed	To detect inappropriate engagement of autopilot heading hold at low airspeeds.
15A	Gear Selected Up Below 100 ft AGL on Take-off	AS332L, S76	Take-Off	Gear Select, Radio Altitude	To detect early retraction of the landing gear during take-off.
15B	Gear Not Selected Down Below 300 ft AGL on Landing	AS332L, S76	Landing	Gear Select, Radio Altitude	To detect late lowering of the landing gear during landing.
16A	Excessive Time in Avoid Area				Not yet implemented (awaiting low airspeed algorithm)
17A/C	VNO Exceedence	AS332L	Air	VNO, Weight	To detect exceedance of the Flight Manual VNO limit (this is weight dependent).
17B/D	VNE Exceedence	AS332L, S76	Air	VNE, Weight	To detect exceedence of the Flight Manual VNE limit (this is weight dependent).
18A	No. 1 (LH) Fuel Contents Low	AS332L	Air	LH Fuel Contents	To detect if the total remaining fuel contents fall below the Operations Manual limit.

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
18B	No2. (RH) Fuel Contents Low	AS332L	Air	RH Fuel Contents	To detect if the total remaining fuel contents fall below the Operations Manual limit.
19A	Heater On During Take-Off	AS332L	Take-Off	Heater	To detect non-conformance with the Flight Manual requirement that the cabin heater should be off during take-off.
19B	Heater On During Landing	AS332L	Landing	Heater	To detect non-conformance with the Flight Manual requirement that the cabin heater should be off during landing.
20A	Early Turn on Offshore Take Off at Night	AS332L, S76	Rig Take-Off	Heading, Ground Speed, Day/Night	To detect an early turn after an offshore take-off at night.
21A	High Ground Speed Within 20 seconds of Rig Landing	AS332L, S76	Rig Landing	Ground Speed	To detect a high ground speed on the final approach to a helideck landing.
21B	High Ground Speed Within 10 seconds of Airport Landing	AS332L, S76	Airport Landing	Ground Speed	To detect a high ground speed on the final approach to an airport landing.
22A	High Airspeed Below 100 ft AGL	AS332L, S76	Air	Indicated Airspeed, Radio Altitude	To detect high speed flight at low level.
22B	High Airspeed Below 100 ft AGL and Gear Up	AS332L, S76	Air	Indicated Airspeed, Radio Altitude, Gear Select	To detect high speed flight at low level with the landing gear retracted.
22C	IAS Above 130 kt and Gear Down	S76	Air	Indicated Airspeed, Gear Select	To detect exceedence of the Flight Manual limit (to prevent overstressing of a landing gear strut).
23A	Downwind Flight Within 60 seconds of Take-Off	AS332L, S76	Take-Off	Indicated Airspeed, Ground Speed	To detect downwind flight shortly after take-off.
23B	Downwind Flight Within 60 seconds of Landing	AS332L, S76	Landing	Indicated Airspeed, Ground Speed	To detect downwind flight shortly before landing.
24A	Low Rotor Speed – Power On	AS332L, S76	Air	Rotor Speed, Total Torque	To detect excessively low rotor speed during power-on flight.
24B	High Rotor Speed – Power On	AS332L, S76	Air	Rotor Speed, Total Torque	To detect excessively high rotor speed during power-on flight.

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Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
24C	Low Rotor Speed - Power Off	AS332L, S76	Air	Rotor Speed, Total Torque	To detect exceedence of the Flight Manual minimum rotor speed limit for power-off flight.
24D	High Rotor Speed – Power Off	AS332L, S76	Air	Rotor Speed, Total Torque	To detect exceedence of the Flight Manual maximum rotor speed limit for power-off flight.
25A	Maximum Continuous Torque (2 Engines)	AS332L, S76	Air	Total Torque	To detect more than 5 minutes use of the Flight Manual takeoff rating torque limit
25B	Maximum Take-Off Torque (2 Engines)	AS332L, S76	Air	Total Torque	To detect exceedence of the Flight Manual absolute maximum torque limit.
25C/D	Maximum Continuous Torque – Engine 1/2	S76	Air	Engine 1/2 Torque	To detect exceedence of the Flight Manual single engine maximum continuous torque limit.
25E/F	Maximum Contingency Torque - Engine 1/2	S76	Air	Engine 1/2 Torque	To detect exceedence of the Flight Manual single engine maximum contingency torque limit.
25G	Maximum Combined Torque Over 200%	S76	Air	Total Torque	To detect exceedence of the Flight Manual 200% combined torque limit.
26A	Pilot Workload/Turbulence	AS332L, S76	Landing	Changes in Collective Pitch	To detect turbulence encountered during the final approach to a helideck landing.
27A	Pilot Workload	AS332L, S76	Landing	Collective, Lateral & Longitudinal Cyclic	Not yet implemented (awaiting outcome of CAA research project)
28A	Flight Though Hot Gas	AS332L, S76	Take-Off, Landing	Outside Air Temperature	To detect if the aircraft flies through the turbine efflux or flare plume during a helideck take-off or landing.
29A	High Pitch-Up Attitude on Ground	AS332L, S76	Ground	Pitch Attitude	To detect high aircraft pitch angles when on a vessel's helideck, or on sloping ground.
29B	High Pitch-Down Attitude on Ground	AS332L, S76	Ground	Pitch Attitude	To detect high aircraft pitch angles when on a vessel's helideck, or on sloping ground.
30A	High Roll Attitude on Ground	AS332L, S76	Ground	Roll Attitude	To detect high aircraft roll angles during taxiing, when on a vessel's helideck, or on sloping ground.
31A	High Normal Acceleration at Landing	AS332L, S76	Landing, Ground	Normal Acceleration	To detect a heavy landing.

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
32A	High Rotor Speed on Ground	AS332L, S76	Ground	Rotor Speed	To detect possible governor problems on the ground.
33A	Rotor Brake Applied at Greater Than 122 Rotor RPM	AS332L, S76	Ground	Rotor Brake, Rotor Speed	To detect application of the rotor brake above the Flight Manual limit for rotor speed.
34A	Excessive Long Cyclic Control with Insufficient Collective Pitch on Ground	AS332L, S76	Ground	Collective Pitch, Longitudinal Cyclic Pitch	To detect incorrect taxi technique likely to cause rotor head damage
34B	Excessive Rate of Movement of Longitudinal Cyclic on Ground	AS332L, S76	Ground	Longitudinal Cyclic Pitch Rate, Rotor Speed	To detect an excessive rate of movement of the longitudinal cyclic control when on the ground with rotors running.
34C	Excessive Rate of Movement of Lateral Cyclic on Ground	AS332L, S76	Ground	Lateral Cyclic Pitch Rate, Rotor Speed	To detect an excessive rate of movement of the lateral cyclic control when on the ground with rotors running.
35A/B	Excessive Movement of Deck	AS332L, S76	Helideck	Motion Severity Index	To detect excessive movement of a vessel's helideck when the helicopter is on the deck.
36A	High Lateral Acceleration (rapid cornering)	AS332L, S76	Ground	Lateral Acceleration	To detect excessive cornering accelerations/speeds when taxiing.
36B	High Longitudinal Acceleration (rapid braking)	AS332L, S76	Ground	Longitudinal Acceleration	To detect excessive deceleration due to braking when taxiing.
37A	High Ground Speed	AS332L, S76	Ground	Ground Speed	To detect excessive taxiing speeds.
38A	Taxi Limit (left gear lifts)	AS332L	Ground	Lateral Cyclic Pitch, Tail Rotor Pedal	To detect the risk of an aircraft roll over due to incorrect tail rotor pedal and lateral cyclic control positions when taxiing.
38B	Taxi Limit (right gear lifts)	AS332L	Ground	Lateral Cyclic Pitch, Tail Rotor Pedal	To detect the risk of an aircraft roll over due to incorrect tail rotor pedal and lateral cyclic control positions when taxiing.
39A	Single Engined flight	AS332L, S76	Air	No1 Eng Torque, No2 Eng Torque	To detect single engined flight.
40A	Torque Split in the Cruise	AS332L, S76	Cruise	No1 Eng Torque, No2 Eng Torque	To detect a possible engine problem, subsequently found to have been caused by module 2 stator vane rotation.

Event number	Title:	Applicable Aircraft Type	Applicable condition	Trigger parameters	Rationale
41A	Go Around	AS332L, S76	Cruise, Landing	Gear Select	To detect a go-around.
41B	Below Minimum Height on Go Around	AS332L, S76	Cruise, Landing	Gear Select, Radio Altitude	To detect a descent below the minimum height limit during a go around.
41C	Below Minimum Height on Go Around at Night	AS332L, S76	Cruise, Landing	Gear Select, Radio Altitude	To detect a descent below the minimum height limit during a go around at night.
42A	Autopilot Engaged On Ground Before Take-Off	AS332L, S76	Ground	Autopilot Status	To detect premature engagement of the autopilot prior to take-off which could result in unexpected control movements.
42B	Autopilot Engaged On Ground After Landing	AS332L, S76	Ground	Autopilot Status	To detect failure to disengage the autopilot after landing which could result in unexpected control movements.
43A/B	Maximum Continuous N1 - Engine 1/2	S76	Air	Engine 1/2 N1	To detect exceedence of the Flight Manual single engine maximum continuous N1 limit.
43C/D	Maximum Contingency N1 - Engine 1/2	S76	Air	Engine 1/2 N1	To detect exceedence of the Flight Manual single engine maximum contingency N1 limit.
44A/B	Maximum Continuous T5 - Engine 1/2	S76	Air	Engine 1/2 T5	To detect exceedence of the Flight Manual single engine maximum continuous T5 limit.
44C/D	Maximum Contingency T5 - Engine 1/2	S76	Air	Engine 1/2 T5	To detect exceedence of the Flight Manual single engine maximum contingency T5 limit.
45A	Low Height and Speed at Night	AS332L, S76	Air	Indicated Airspeed, Radio Altitude, Day/Night	To detect flight at low height and speed at night (e.g. due to an inadvertent descent).
45B/C	Low Height and Speed at Night (Take-Off/Landing)	AS332L, S76	Rig Take-Off/ Landing	Indicated Airspeed, Radio Altitude, Day/Night	To detect flight at low height and speed at night (e.g. due to an inadvertent descent).
46A	Inadvertent Lift Off	AS332L, S76	Ground	Weight-On-Wheels	To detect an inadvertent lift off (e.g. due to inadvertent application of collective instead of the parking brake).
47A/B	Yaw Turbulence (+ve/-ve Yaw Acceleration)	AS332L	Take-Off, Landing	Yaw Rate, Tail Rotor Pedal	To detect turbulence causing excessive aircraft yaw motion.

10 Annex 4 : Small helicopter HOMP triggers

LIST OF VIP TRIGGERS

Catégory	Code	Event name	Description	Flight phase	Score (1 à 3)	parameters	Values	Duration (sec)
Attitude	**01A**	High pitch up attitude below 500 Ft AGL	To detect excessive pitch up (>15°) below 500 Ft AGL	**Flight**	2	pitch height	>17° <= 500 Ft	2
Attitude	**01B**	High pitch up attitude above 500 Ft	pitch up above 20° in flight above 500 Ft	**Flight**	1	pitch height	>23° >500 Ft	2
Attitude	**02A**	High pitch down attitude below 500 Ft AGL	To detect excessive pitch down (<-15°) attitude below 500 FT and at Take Off	**Flight**	1	pitch height	<-17° H <= 500 Ft	2
Attitude	**02B**	High pitch **DOWN** attitude above 500 Ft AGL	To detect excessive pitch down (<-20°) attitude above 500 FT	**Flight**	2	pitch height	<-23° H >= 500 Ft	2
Attitude	**03A**	High speed at low alt	To prevent CFIT	**Flight**	2	Height IAS Vario	< 300 Ft >90 Kts = 0	1
Attitude	**06A**	Roll Attitude below 500 Ft on left turn	Roll attitude above 30° below 500 Ft	**Flight**	2	roll height IAS	<= - 33° (left turn) H< 500 Ft < 40 Kts	2

Attitude	**06B**	Roll Attitude below 500 Ft on right turn	Roll attitude above 30° below 500 Ft	**Flight**	2	roll height IAS	=> + 33° (right turn) H <500 Ft < 40 Kts	2
Attitude	**06C**	Roll Attitude above 500 FT on left turn	Roll attitude above 45° above 500 Ft	**Flight**	1	roll height IAS	<= - 48° (left turn) H >= 500 Ft <40 Kts	2
Attitude	**06D**	Roll Attitude above 500 FT on right turn	Roll attitude above 45° above 500 Ft	**Flight**	1	roll height IAS	>= +48° (right turn) H >= 500 Ft <40 Kts	2
Attitude	**08A**	High rate of descent on approach	To detect rate of descent above 500 ft/min on final approach or below 500 Ft AGL	**Flight**	1	Rate of descent height	<= - 700 ft/min <= 500 ft	2
Attitude	**08B**	High rate of descent	To detect rate of descent above 1500 ft/min	**Flight**	1	Rate of descent	<= - 1700 ft/min	2
Attitude	**08C**	**High rate of descent at low speed (VORTEX)**	To detect excessive rate of descent at low speed (entering in vortex ring state)	**Flight**	**3**	Rate of descent IAS	<= - 700 ft/min <= 30 kts	2
Attitude	**08D**	**High rate of descent at low speed by rear wind**	To prevent risk of Vortex during final aproach by rear wind	**Flight**	**3**	height Rate of descent IAS GS-IAS	<300 Ft <-500 Ft/min <30 Kts >14 Kts	2
Limitations	**10A**	Negative normal acceleration in flight	To detect normal excessive normal acceleration in flight	**Flight**	1	Z axis	xx<0,6 G	<1
Limitations	**10B**	Positive normal acceleration in flight	To detect normal excessive normal acceleration in flight	**Flight**	1	Z axis	xx >1,8 G	<1

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Limitations	**10C**	Left lateral acceleration in flight	To detect lateral acceleration in flight	**Flight**	1	Lat axis	xx<-0,5	<1
Limitations	**10D**	Right lateral acceleration in flight	To detect lateral acceleration in flight	**Flight**	1	Lat axis	xx>+0,5 G	<1
Limitations	**10E**	Front Longitudinal acceleration	To detect longitudinal acceleration in flight	**Flight**	1	Long axis	xx<-0,5G	<1
Limitations	**10F**	Aft longitudinal acceleration	To detect longitudinal acceleration in flight	**Flight**	1	Long axis	xx>0,5 G	<1
Limitations	**17A**	VNE exceedance Power ON	To detect VNE exceedance power ON	**Flight**	2	IAS TQ	>155 kt (sea level) >10%	2
Limitations	**17B**	VNE exceedence Power OFF	To detect VNE exceedance power OFF	**Flight**	2	IAS TQ	>125 kt (sea level) <10%	2
Limitations	**18A**	Low fuel	To detect low fuel contents	**Flight**	3	Low fuel	<48 Kg	2
Limitations	**24A**	Low rotor speed power **ON**	To detect Low rotor speed power ON	**Flight**	3	NR TQ TO switch	<=376 >10% =1	1
Limitations	**24B**	High rotor speed power **ON**	To detect High rotor speed power ON	**Flight**	3	NR TQ TO switch	=>404 >10% =1	1
Limitations	**24C**	Low rotor speed power **OFF**	To detect Low rotor speed power OFF	**Flight**	3	NR TQ TO switch	<=321 <10% =1	1
Limitations	**24D**	High rotor speed power **OFF**	To detect High rotor speed power OFF	**Flight**	3	NR TQ TO switch	=>429 <10% =1	1
Engine	**25A**	Max continuous torque	To detect max continuous torque in flight	**Flight**	3	TQ IAS	=>92,6% > 40 kt	1

Engine	**25B**	Max continuous torque at take off	To detect max continuous torque at take off	**Flight**	3	TQ IAS	103,9%<xx <= 40 kt	5
Attitude	**29A**	High pitch up attitude on ground	To detect high pitch up attitude engine Off on ground	**ground**	1	pitch	>10°	2
Attitude	**29B**	High pitch down attitude on ground	To detect high pitch down attitude engine Off on ground	**ground**	1	pitch	<-6°	2
Attitude	**29C**	High left bank angle on ground	To detect high bank attitude engine Off on ground	**ground**	1	Roll	< - 8°	2
Attitude	**29C**	High right bank angle on ground	To detect high bank attitude engine Off on ground	**ground**	2	Roll	> 8°	2
Limitations	**31A**	High acceleration on landing	To detect hard landing	**Flight**	2	Z axis Vario	xx>2 G <-390	<1
Limitations	**32A**	High rotor speed on ground	To detect High rotor speed on ground	**Ground**	2	NR	=>405	1
Engine	**43A**	Max NG transient rating	To detect max NG	**Flight**	3	NG TO switch	>102,2% =1	5
Engine	**44A**	Max T4 at start up		**Ground**	3	T4	>= 864°	10
Engine	**44B**	Max T4 at take off		**Flight**	3	T4 IAS	>= 914° <= 40 kt	1
Engine	**44C**	Max T4 in flight		**Flight**	3	T4 IAS	>= 848° > 40 kt	1
Engine	**48A**	NF max in flight	Free turbine	**Flight**	3	NF TO switch	>= 417 =1	1
Engine	**48B**	Max NF transient rating	Free turbine	**Flight**	3	NF TO switch	>= 449 =1	5
Engine	**48C**	NF mini in flight	Free turbine	**Flight**	3	NF TO switch	<350 =1	1
Engine	**49A**	Engine Oil temp		**Flight**	3	Oil temp	>= 114°	1

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Engine	**49B**	Mini engine Oil pressure		**Flight**	3	oil pressure	<= 1,2 bars	1
Engine	**49C**	Maxi engine Oil pressure		**Flight**	3	oil pressure	>= 9,7 bars	1

LIST OF AERIAL WORK TRIGGERS

Catégory	**Code**	**Event name**	**Description**	**Flight phase**	**Score (1 à 3)**	**parameters**	**Values**	**Duration (sec)**
Attitude	**01A**	High pitch up attitude below 500 Ft AGL	To detect excessive pitch up (>25°) below 500 Ft AGL	**Flight**	2	pitch height	>28° <= 500 Ft	2
Attitude	**01B**	High pitch up attitude above 500 Ft	pitch up above 35° in flight above 500 Ft	**Flight**	1	pitch height	>38° >500 Ft	2
Attitude	**02A**	High pitch down attitude below 500 Ft AGL	To detect excessive pitch down (<-25°) attitude below 500 FT and at Take Off	**Flight**	1	pitch height	<-28° H <= 500 Ft	2
Attitude	**02B**	High pitch **DOWN** attitude above 500 Ft AGL	To detect excessive pitch down (<-30°) attitude above 500 FT	**Flight**	2	pitch height	<-33° H >= 500 Ft	2
Attitude	**03A**	High speed at low alt	To prevent CFIT	**Flight**	2	Height IAS Vario	< 300 Ft >90 Kts = 0	1
Attitude	**06A**	Roll Attitude below 500 Ft on left turn	Roll attitude above 45° below 500 Ft	**Flight**	2	roll height IAS	<= - 48° (left turn) H< 500 Ft < 40 Kts	2

Attitude	**06B**	Roll Attitude below 500 Ft on right turn	Roll attitude above 45° below 500 Ft	**Flight**	2	roll height IAS	=> + 48° (right turn) H <500 Ft < 40 Kts	2
Attitude	**06C**	Roll Attitude above 500 FT on left turn	Roll attitude above 45° above 500 Ft	**Flight**	1	roll height IAS	<= - 63° (left turn) H >= 500 Ft <40 Kts	2
Attitude	**06D**	Roll Attitude above 500 FT on right turn	Roll attitude above 45° above 500 Ft	**Flight**	1	roll height IAS	>= +63° (right turn) H >= 500 Ft <40 Kts	2
Attitude	**08A**	High rate of descent on approach	To detect rate of descent above 1000 ft/min on final approach or below 500 Ft AGL	**Flight**	1	Rate of descent height	<= - 1200 ft/min <= 500 ft	2
Attitude	**08B**	High rate of descent	To detect rate of descent above 3500 ft/min	**Flight**	1	Rate of descent	<= - 3700 ft/min	2
Attitude	**08C**	**High rate of descent at low speed (VORTEX)**	To detect excessive rate of descent at low speed (entering in vortex ring state)	**Flight**	**3**	Rate of descent IAS	<= - 700 ft/min <= 30 kts	2
Attitude	**08D**	**High rate of descent at low speed by rear wind**	To prevent risk of Vortex during final aproach by rear wind	**Flight**	**3**	height Rate of descent IAS GS-IAS	<300 Ft <-500 Ft/min <30 Kts >14 Kts	2
Limitations	**10A**	Negative normal acceleration in flight	To detect normal excessive normal acceleration in flight	**Flight**	1	Z axis	xx<0,6 G	<1

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Limitations	**10B**	Positive normal acceleration in flight	To detect normal excessive normal acceleration in flight	**Flight**	1	Z axis	xx >1,8 G	<1
Limitations	**10C**	Left lateral acceleration in flight	To detect lateral acceleration in flight	**Flight**	1	Lat axis	xx<-0,5	<1
Limitations	**10D**	Right lateral acceleration in flight	To detect lateral acceleration in flight	**Flight**	1	Lat axis	xx>+0,5 G	<1
Limitations	**10E**	Front Longitudinal acceleration	To detect longitudinal acceleration in flight	**Flight**	1	Long axis	xx<-0,5G	<1
Limitations	**10F**	Aft longitudinal acceleration	To detect longitudinal acceleration in flight	**Flight**	1	Long axis	xx>0,5 G	<1
Limitations	**17A**	VNE exceedance Power ON	To detect VNE exceedance power ON	**Flight**	2	IAS TQ	>155 kt (sea level) >10%	2
Limitations	**17B**	VNE exceedance Power OFF	To detect VNE exceedance power OFF	**Flight**	2	IAS TQ	>125 kt (sea level) <10%	2
Limitations	**18A**	Low fuel	To detect low fuel contents	**Flight**	3	Low fuel	<48 Kg	2
Limitations	**24A**	Low rotor speed power **ON**	To detect Low rotor speed power ON	**Flight**	3	NR TQ TO switch	<=376 >10% =1	1
Limitations	**24B**	High rotor speed power **ON**	To detect High rotor speed power ON	**Flight**	3	NR TQ TO switch	=>404 >10% =1	1
Limitations	**24C**	Low rotor speed power **OFF**	To detect Low rotor speed power OFF	**Flight**	3	NR TQ TO switch	<=321 <10% =1	1
Limitations	**24D**	High rotor speed power **OFF**	To detect High rotor speed power OFF	**Flight**	3	NR TQ TO switch	=>429 <10% =1	1
Engine	**25A**	Max continuous torque	To detect max continuous torque in flight	**Flight**	3	TQ IAS	=>92,6% > 40 kt	1

Engine	**25B**	Max continuous torque at take off	To detect max continuous torque at take off	**Flight**	3	TQ IAS	103,9%<xx <= 40 kt	5
Attitude	**29A**	High pitch up attitude on ground	To detect high pitch up attitude engine Off on ground	**ground**	1	pitch	>10°	2
Attitude	**29B**	High pitch down attitude on ground	To detect high pitch down attitude engine Off on ground	**ground**	1	pitch	<-6°	2
Attitude	**29C**	High left bank angle on ground	To detect high bank attitude engine Off on ground	**ground**	1	Roll	< - 8°	2
Attitude	**29C**	High right bank angle on ground	To detect high bank attitude engine Off on ground	**ground**	2	Roll	> 8°	2
Limitations	**31A**	High acceleration on landing	To detect hard landing	**Flight**	2	Z axis Vario	xx>2 G <-390	<1
Limitations	**32A**	High rotor speed on ground	To detect High rotor speed on ground	**Ground**	2	NR	=>405	1
Engine	**43A**	Max NG transient rating	To detect max NG	**Flight**	3	NG TO switch	>102,2% =1	5
Engine	**44A**	Max T4 at start up		**Ground**	3	T4	>= 864°	10
Engine	**44B**	Max T4 at take off		**Flight**	3	T4 IAS	>= 914° <= 40 kt	1
Engine	**44C**	Max T4 in flight		**Flight**	3	T4 IAS	>= 848° > 40 kt	1
Engine	**48A**	NF max in flight	Free turbine	**Flight**	3	NF TO switch	>= 417 =1	1
Engine	**48B**	Max NF transient rating	Free turbine	**Flight**	3	NF TO switch	>= 449 =1	5
Engine	**48C**	NF mini in flight	Free turbine	**Flight**	3	NF TO switch	<350 =1	1
Engine	**49A**	Engine Oil temp		**Flight**	3	Oil temp	>= 114°	1

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Engine	**49B**	Mini engine Oil pressure		**Flight**	3	oil pressure	<= 1,2 bars	1
Engine	**49C**	Maxi engine Oil pressure		**Flight**	3	oil pressure	>= 9,7 bars	1

List of Training triggers

Catégory	Code	Event name	Description	Flight phase	Score (1 à 3)	parameters	Values	Duration (sec)
Attitude	**01A**	High pitch up attitude below 500 Ft AGL	To detect excessive pitch up (>20°) below 500 Ft AGL	**Flight**	2	pitch height	>23° <= 500 Ft	2
Attitude	**01B**	High pitch up attitude above 500 Ft	pitch up above 35° in flight above 500 Ft	**Flight**	1	pitch height	>35° >500 Ft	2
Attitude	**01C**	**High pitch up attitude before landing**	**To detect high pitch up attitude before landing during autorotation training**	**Flight**	**1**	pitch height NG	**>10°** **<100 Ft** **<75%**	1
Attitude	**02A**	High pitch down attitude below 500 Ft AGL	To detect excessive pitch down (<-15°) attitude below 500 FT and at Take Off	**Flight**	1	pitch height	<-17° H <= 500 Ft	2
Attitude	**02B**	High pitch **DOWN** attitude above 500 Ft AGL	To detect excessive pitch down (<-20°) attitude above 500 FT	**Flight**	2	pitch height	<-23° H >= 500 Ft	2
Attitude	**03A**	High speed at low alt	To prevent CFIT	**Flight**	2	Height IAS Vario	< 300 Ft >90 Kts = 0	1
Attitude	**06A**	Roll Attitude below 500 Ft on left turn	Roll attitude above 30° below 500 Ft	**Flight**	2	roll height IAS	<= - 33° (left turn) H< 500 Ft < 40 Kts	2
Attitude	**06B**	Roll Attitude below 500 Ft on right turn	Roll attitude above 30° below 500 Ft	**Flight**	2	roll height IAS	=> + 33° (right turn) H <500 Ft < 40 Kts	2

Attitude	**06C**	Roll Attitude above 500 FT on left turn	Roll attitude above 60° above 500 Ft	**Flight**	1	roll height IAS	<= - 63° (left turn) H >= 500 Ft <40 Kts	2
Attitude	**06D**	Roll Attitude above 500 FT on right turn	Roll attitude above 60° above 500 Ft	**Flight**	1	roll height IAS	>= +63° (right turn) H >= 500 Ft <40 Kts	2
Attitude	**06E**	**Excessive left Roll Attitude before landing**	To detect excessive roll attitude before landing during autorotation training	**Flight**	**1**	roll height NG	<= - 5° (left turn) H< 100 Ft <75%	1
Attitude	**06F**	**Excessive Right Roll Attitude before landing**	To detect excessive roll attitude before landing during autorotation training	**Flight**	**1**	roll height NG	> 5° H< 100 Ft <75%	1
Attitude	**08A**	High rate of descent on approach	To detect rate of descent above 500 ft/min on final approach or below 500 Ft AGL	**Flight**	1	Rate of descent height	<= - 700 ft/min <= 500 ft	2
Attitude	**08B**	High rate of descent	To detect rate of descent above 1500 ft/min	**Flight**	1	Rate of descent	<= - 1700 ft/min	2
Attitude	**08C**	**High rate of descent at low speed (VORTEX)**	To detect excessive rate of descent at low speed (entering in vortex ring state)	**Flight**	**3**	Rate of descent IAS	<= - 700 ft/min <= 30 kts	2
Attitude	**08D**	**High rate of descent at low speed by rear wind**	To prevent risk of Vortex during final aproach by rear wind	**Flight**	**3**	height Rate of descent IAS GS-IAS	<300 Ft <-500 Ft/min <30 Kts >14 Kts	2

Attitude	**09A**	**Excessive slipping speed on ground**	To detect excessive slipping speed after landing during autorotation training	**Ground**	**1**	GS	>15 Kts	1
Limitations	**10A**	Negative normal acceleration in flight	To detect low normal acceleration in flight	**Flight**	1	Z axis	xx<0,6 G	<1
Limitations	**10B**	Positive normal acceleration in flight	To detect excessive normal acceleration in flight	**Flight**	1	Z axis	xx >2,3 G	<1
Limitations	**10C**	Left lateral acceleration in flight	To detect lateral acceleration in flight	**Flight**	1	Lat axis	xx<-0,5	<1
Limitations	**10D**	Right lateral acceleration in flight	To detect lateral acceleration in flight	**Flight**	1	Lat axis	xx>+0,5 G	<1
Limitations	**10E**	Front Longitudinal acceleration	To detect longitudinal acceleration in flight	**Flight**	1	Long axis	xx<-0,5G	<1
Limitations	**10F**	Aft longitudinal acceleration	To detect longitudinal acceleration in flight	**Flight**	1	Long axis	xx>0,5 G	<1
Limitations	**17A**	VNE exceedance Power ON	To detect VNE exceedance power ON	**Flight**	2	IAS TQ	>150 kt (sea level) >10%	2
Limitations	**17B**	VNE exceedance Power OFF	To detect VNE exceedance power OFF	**Flight**	2	IAS TQ	>120 kt (sea level) <10%	2
Limitations	**18A**	Low fuel	To detect low fuel contents	**Flight**	3	Low fuel	<30 Kg	2
Limitations	**24A**	Low rotor speed power **ON**	To detect Low rotor speed power ON	**Flight**	3	NR TQ TO switch	<=391 >10% =1	1
Limitations	**24B**	High rotor speed power **ON**	To detect High rotor speed power ON	**Flight**	3	NR TQ TO switch	=>414 >10% =1	1

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Limitations	**24C**	Low rotor speed power **OFF**	To detect Low rotor speed power OFF	**Flight**	3	NR TQ TO switch	<=341 <10% =1	1
Limitations	**24D**	High rotor speed power **OFF**	To detect High rotor speed power OFF	**Flight**	3	NR TQ TO switch	=>446 <10% =1	1
Limitations	**24E**	High rotor speed	To detect High rotor speed to check	**Flight**	3	NR TQ TO switch	=>456 <10% =1	1
Engine	**25A**	Max continuous torque	To detect max continuous torque in flight	**Flight**	3	TQ IAS	=>96,9% > 65 kt	1
Engine	**25B**	Max continuous torque at take off	To detect max continuous torque at take off	**Flight**	3	TQ IAS	105,9%<xx <= 65 kt	1
Engine	**25D**	Max continuous torque above 65 Kts	To detect max continuous torque in flight	**Flight**	3	TQ IAS	=>102,9% > 65 kt	1
Engine	**25E**	MAX TORQUE	Max torque in flight	**Flight**	3	TQ TO switch	=>109,9% = 1	1
Attitude	**29A**	High pitch up attitude on ground	To detect high pitch up attitude engine Off on ground	**Ground**	1	pitch	>10°	2
Attitude	**29B**	High pitch down attitude on ground	To detect high pitch up attitude engine Off on ground	**Ground**	1	pitch	<-6°	2
Attitude	**29C**	High left bank angle on ground	To detect high bank attitude engine Off on ground	**Ground**	1	Roll	<- 8°	2
Attitude	**29E**	High right bank angle on ground	To detect high bank attitude engine Off on ground	**Ground**	2	Roll	> 8°	2

Limitations	**31A**	High acceleration on landing	To detect hard landing	**Flight**	2	Z axis vario	xx>2 G <-390 FT/min	<1
Limitations	**32A**	High rotor speed on ground	To detect High rotor speed on ground	**Ground**	2	NR	>446	1
Engine	**43A**	Max NG transient rating	To detect max NG	**Flight**	3	NG TO switch	>103,5% =1	5
Engine	**44A**	Max T4 at start up		**Ground**	3	T4	>= 869°	10
Engine	**44B**	Max T4 at take off		**Flight**	3	T4 IAS	>= 869° <= 40 kt	1
Engine	**44C**	Max T4 in flight		**Flight**	3	T4 IAS	>= 829° > 40 kt	1
Engine	**48A**	NF max in flight	Free turbine	**Flight**	3	NF TO switch	>= 421 =1	1
Engine	**48B**	Max NF transient rating	Free turbine	**Flight**	3	NF TO switch	>= 446 =1	5
Engine	**48C**	NF mini in flight	Free turbine	**Flight**	3	NF TO switch	<366 =1	1
Engine	**49A**	Engine Oil temp		**Flight**	3	Oil temp	>= 109°	1
Engine	**49B**	Mini engine Oil pressure		**Flight**	3	oil pressure	<= 1,8 bars	1
Engine	**49C**	Maxi engine Oil pressure		**Flight**	3	oil pressure	>= 14,9 bars	1

LIST OF "SOLO" TRIGGERS

Catégory	Code	Event name	Description	Flight phase	Score (1 à 3)	parameters	Values	Duration (sec)
Attitude	**01A**	High pitch up attitude below 500 Ft AGL	To detect excessive pitch up (>15°) below 500 Ft AGL	**Flight**	2	pitch height	>17° <= 500 Ft	2
Attitude	**01B**	High pitch up attitude above 500 Ft	pitch up above 20° in flight above 500 Ft	**Flight**	1	pitch height	>23° >500 Ft	2
Attitude	**02A**	High pitch down attitude below 500 Ft AGL	To detect excessive pitch down (<-15°) attitude below 500 FT and at Take Off	**Flight**	1	pitch height	<-18° H <= 500 Ft	2
Attitude	**02B**	High pitch **DOWN** attitude above 500 Ft AGL	To detect excessive pitch down (<-20°) attitude above 500 FT	**Flight**	2	pitch height	<-23° H >= 500 Ft	2
Attitude	**03A**	High speed at low alt	To prevent CFIT	**Flight**	2	Height IAS Vario	< 300 Ft >90 Kts = 0	1
Attitude	**06A**	Roll Attitude below 500 Ft on left turn	Roll attitude above 30° below 500 Ft	**Flight**	2	roll height IAS	<= - 33° (left turn) H< 500 Ft < 40 Kts	2
Attitude	**06B**	Roll Attitude below 500 Ft on right turn	Roll attitude above 30° below 500 Ft	**Flight**	2	roll height IAS	=> + 33° (right turn) H <500 Ft < 40 Kts	2

Attitude	**06C**	Roll Attitude above 500 FT on left turn	Roll attitude above 45° above 500 Ft	**Flight**	1	roll height IAS	<= - 48° (left turn) H >= 500 Ft <40 Kts	2
Attitude	**06D**	Roll Attitude above 500 FT on right turn	Roll attitude above 45° above 500 Ft	**Flight**	1	roll height IAS	>= +48° (right turn) H >= 500 Ft <40 Kts	2
Attitude	**08A**	High rate of descent on approach	To detect rate of descent above 500 ft/min on final approach or below 500 Ft AGL	**Flight**	1	Rate of descent height	<= - 700 ft/min <= 500 ft	2
Attitude	**08B**	High rate of descent	To detect rate of descent above 1500 ft/min	**Flight**	1	Rate of descent	<= - 1700 ft/min	2
Attitude	**08C**	**High rate of descent at low speed (VORTEX)**	To detect excessive rate of descent at low speed (entering in vortex ring state)	**Flight**	**3**	Rate of descent IAS	<= - 700 ft/min <= 30 kts	2
Attitude	**08D**	**High rate of descent at low speed by rear wind**	To prevent risk of Vortex during final aproach by rear wind	**Flight**	**3**	height Rate of descent IAS GS-IAS	<300 Ft <-500 Ft/min <30 Kts >14 Kts	2
Limitations	**10A**	Negative normal acceleration in flight	To detect normal excessive normal acceleration in flight	**Flight**	1	Z axis	xx<0,6 G	<1
Limitations	**10B**	Positive normal acceleration in flight	To detect normal excessive normal acceleration in flight	**Flight**	1	Z axis	xx >2,3 G	<1
Limitations	**10C**	Left lateral acceleration in flight	To detect lateral acceleration in flight	**Flight**	1	Lat axis	xx<-0,5	<1
Limitations	**10D**	Right lateral acceleration in flight	To detect lateral acceleration in flight	**Flight**	1	Lat axis	xx>+0,5 G	<1

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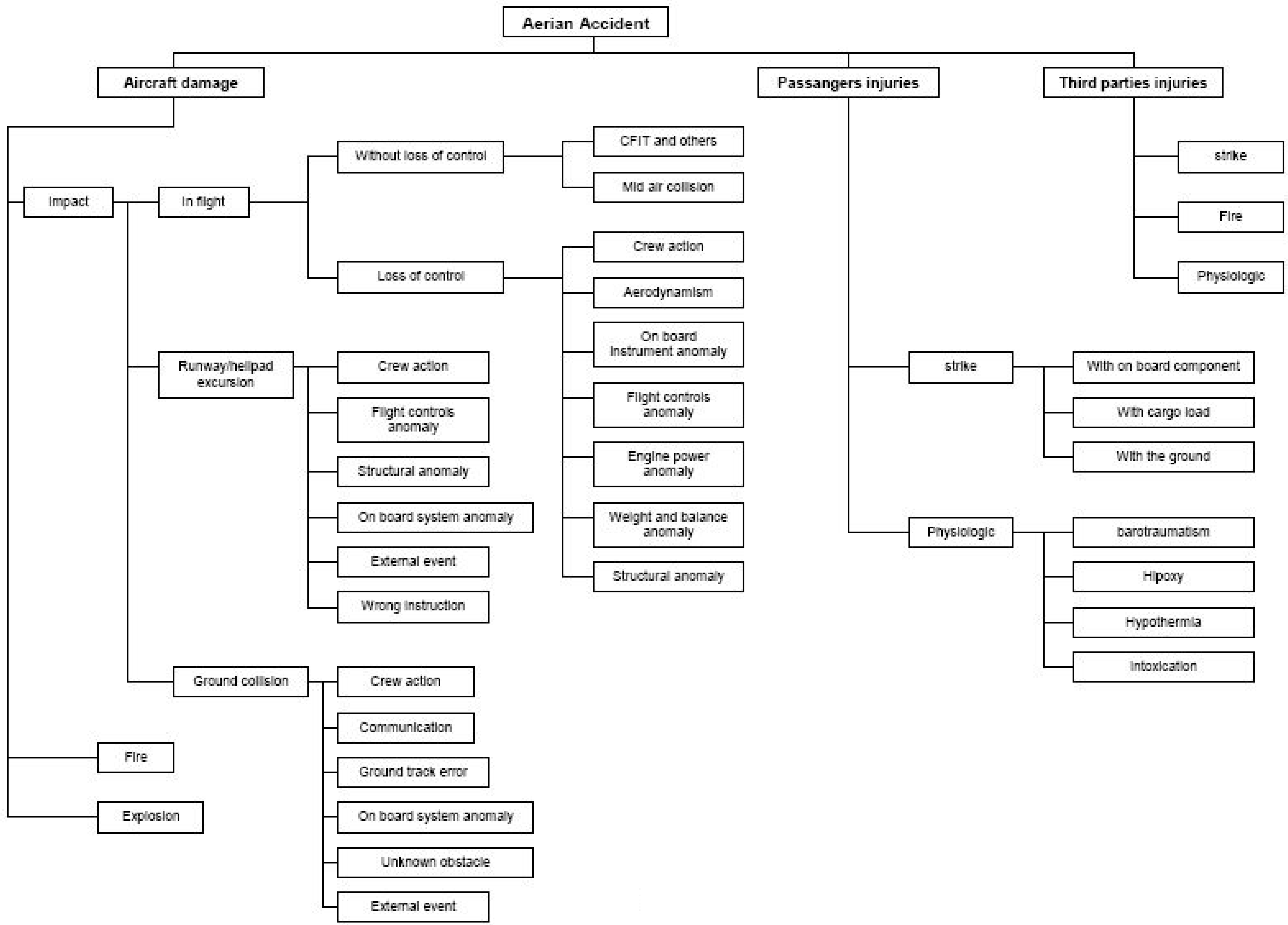
Limitations	**10E**	Front Longitudinal acceleration	To detect longitudinal acceleration in flight	**Flight**	1	Long axis	xx<-0,5G	<1
Limitations	**10F**	Aft longitudinal acceleration	To detect longitudinal acceleration in flight	**Flight**	1	Long axis	xx>0,5 G	<1
Limitations	**17A**	VNE exceedance Power ON	To detect VNE exceedance power ON	**Flight**	2	IAS TQ	>150 kt (sea level) >10%	2
Limitations	**17B**	VNE exceedance Power OFF	To detect VNE exceedance power OFF	**Flight**	2	IAS TQ	>120 kt (sea level) <10%	2
Limitations	**18A**	Low fuel	To detect low fuel contents	**Flight**	3	Low fuel	<30 Kg	2
Limitations	**24A**	Low rotor speed power **ON**	To detect Low rotor speed power ON	**Flight**	3	NR TQ TO switch	<=391 >10% =1	1
Limitations	**24B**	High rotor speed power **ON**	To detect High rotor speed power ON	**Flight**	3	NR TQ TO switch	=>414 >10% =1	1
Limitations	**24C**	Low rotor speed power **OFF**	To detect Low rotor speed power OFF	**Flight**	3	NR TQ TO switch	<=341 <10% =1	1
Limitations	**24D**	High rotor speed power **OFF**	To detect High rotor speed power OFF	**Flight**	3	NR TQ TO switch	=>446 <10% =1	1
Limitations	**24E**	High rotor speed	To detect High rotor speed to check	**Flight**	3	NR TQ TO switch	=>456 <10% =1	1
Engine	**25A**	Max continuous torque	To detect max continuous torque in flight	**Flight**	3	TQ IAS	=>96,9% > 65 kt	1

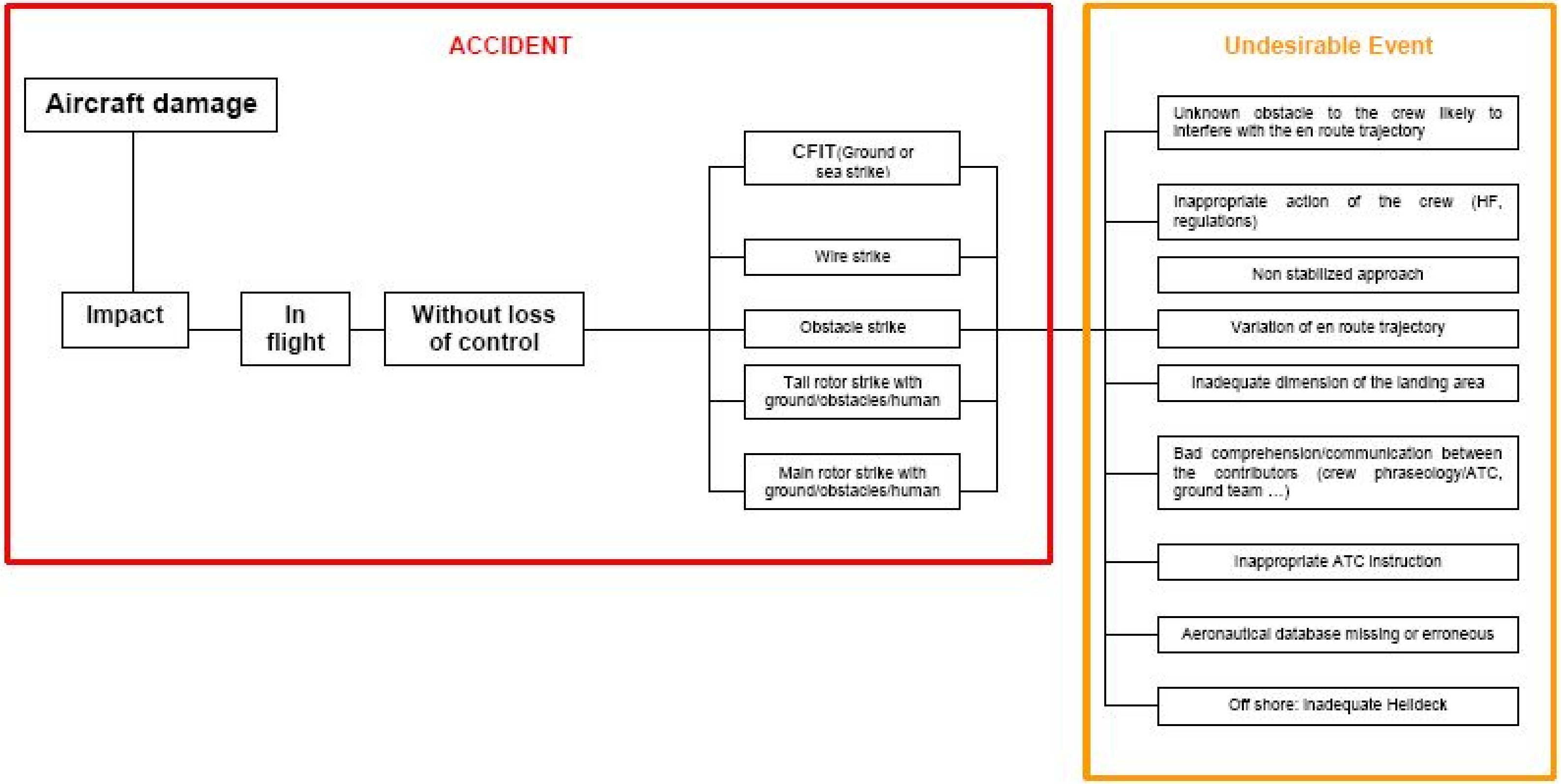
Engine	**25B**	Max continuous torque at take off	To detect max continuous torque at take off	**Flight**	3	TQ IAS	105,9%<xx <= 65 kt	1
Engine	**25D**	Max continuous torque above 65 Kts	To detect max continuous torque in flight	**Flight**	3	TQ IAS	=>102,9% > 65 kt	1
Engine	**25E**	MAX TORQUE	Max torque in flight	**Flight**	3	TQ TO switch	=>109,9% = 1	1
Attitude	**29A**	High pitch up attitude on ground	To detect high pitch up attitude engine Off on ground	**Ground**	1	pitch	>10°	2
Attitude	**29B**	High pitch down attitude on ground	To detect high pitch down attitude engine Off on ground	**Ground**	1	pitch	<-6°	2
Attitude	**29C**	High left bank angle on ground	To detect high bank attitude engine Off on ground	**Ground**	1	Roll	<- 8°	2
Attitude	**29E**	High right bank angle on ground	To detect high bank attitude engine Off on ground	**Ground**	2	Roll	> 8°	2
Limitations	**31A**	High acceleration on landing	To detect hard landing	**Flight**	2	Z axis vario	xx>2 G <-390 FT/min	<1
Limitations	**32A**	High rotor speed on ground	To detect High rotor speed on ground	**Ground**	2	NR	>446	1
Engine	**43A**	Max NG transient rating	To detect max NG	**Flight**	3	NG TO switch	>103,5% =1	5
Engine	**44A**	Max T4 at start up		**Ground**	3	T4	>= 869°	10
Engine	**44B**	Max T4 at take off		**Flight**	3	T4 IAS	>= 869° <= 40 kt	1
Engine	**44C**	Max T4 in flight		**Flight**	3	T4 IAS	>= 829° > 40 kt	1

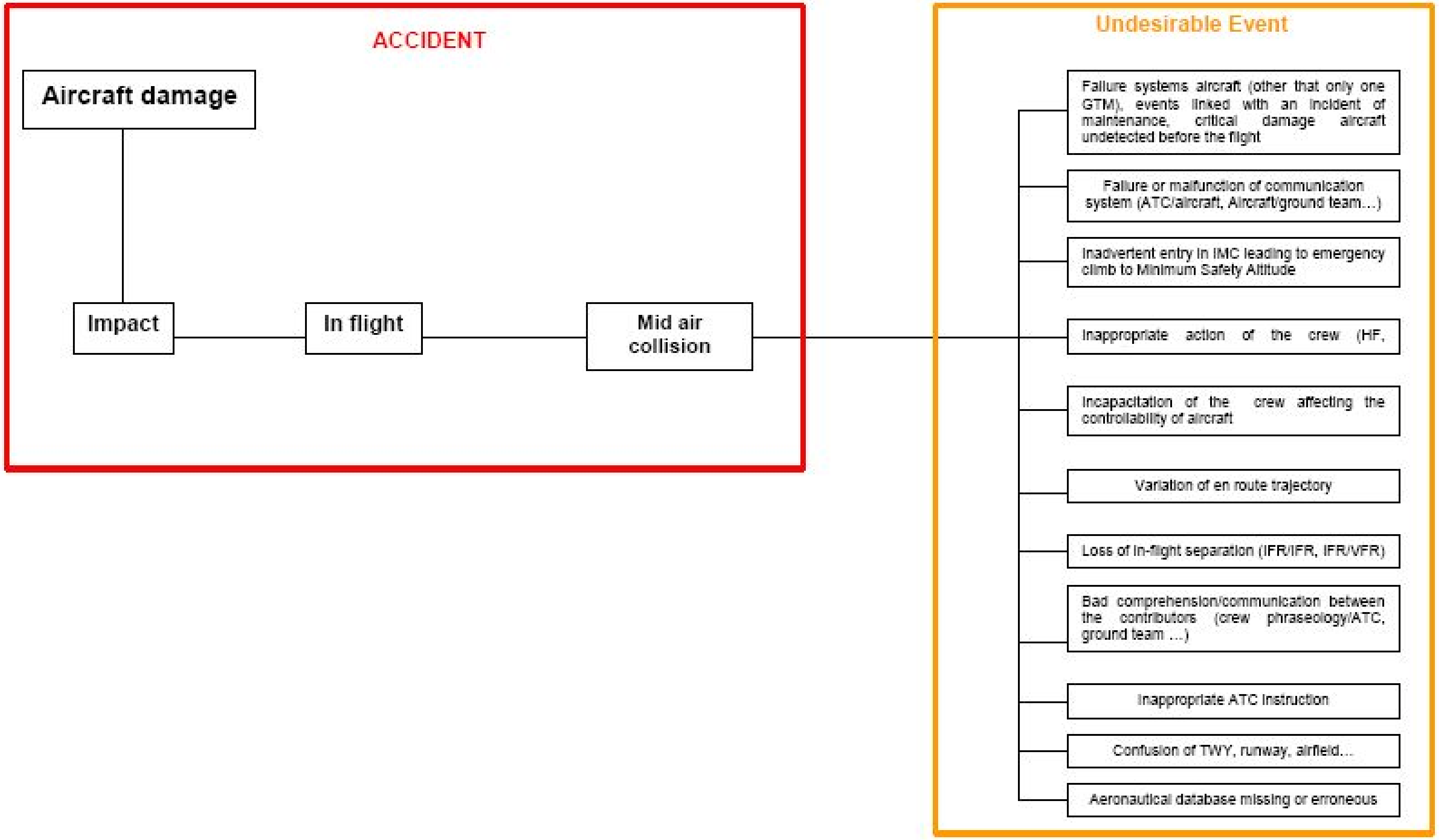
Engine	**48A**	NF max in flight	Free turbine	**Flight**	3	NF TO switch	>= 421 =1	1
Engine	**48B**	Max NF transient rating	Free turbine	**Flight**	3	NF TO switch	>= 446 =1	5
Engine	**48C**	NF mini in flight	Free turbine	**Flight**	3	NF TO switch	<366 =1	1
Engine	**49A**	Engine Oil temp		**Flight**	3	Oil temp	>= 109°	1
Engine	**49B**	Mini engine Oil pressure		**Flight**	3	oil pressure	<= 1,8 bars	1
Engine	**49C**	Maxi engine Oil pressure		**Flight**	3	oil pressure	>= 14,9 bars	1

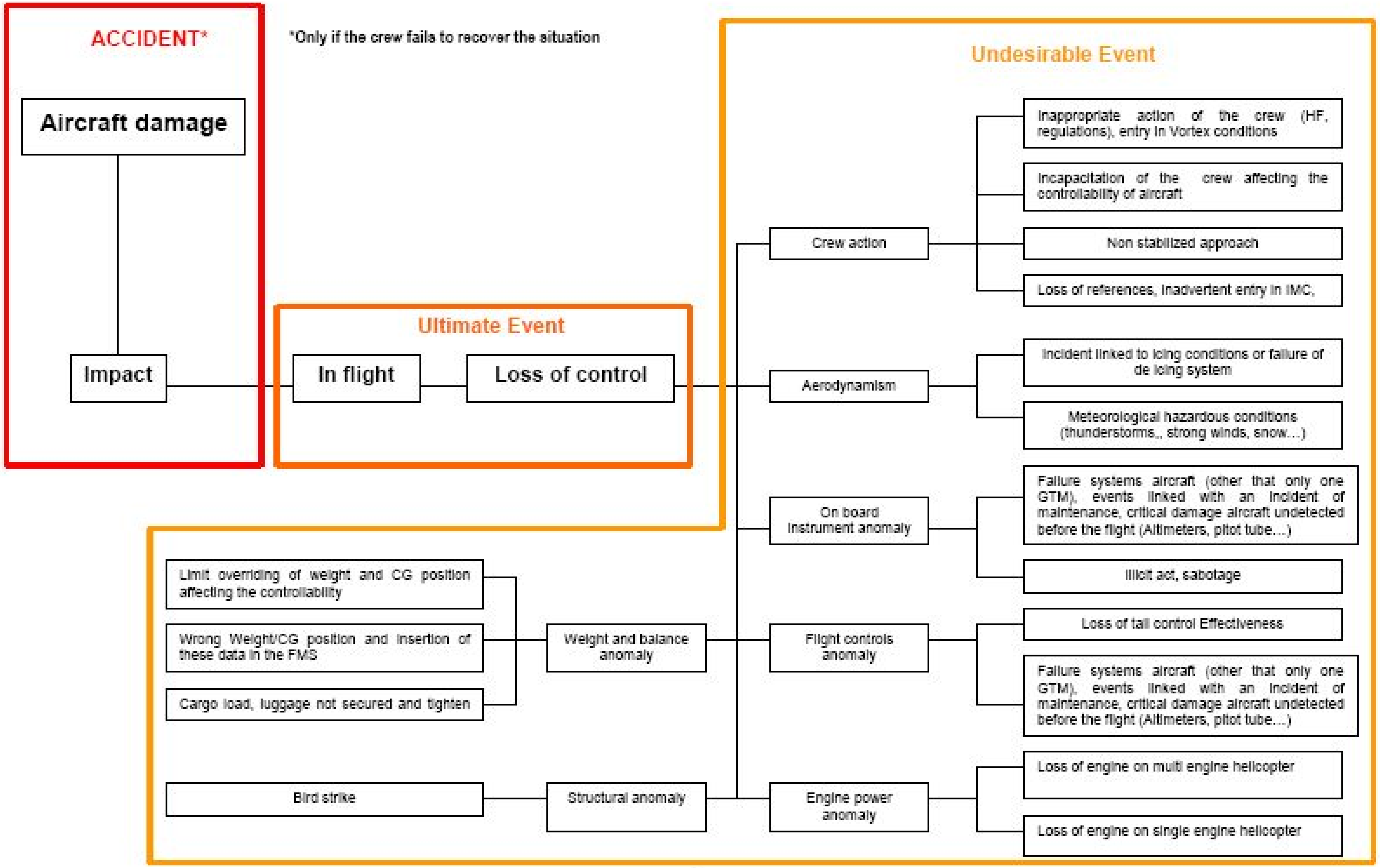
64/ 82

11 Annex 5 : Accident causal tree


Aerian Accident
Aircraft damage
Passangers injuries
Third parties injuries
Impact
In flight
Without loss of control
CFIT and others
Mid air collision
Loss of control
Crew action
Aerodynamism
On board instrument anomaly
Flight controls anomaly
Engine power anomaly
Weight and balance anomaly
Structural anomaly
Runway/helipad excursion
Crew action
Flight controls anomaly
Structural anomaly
On board system anomaly
External event
Wrong instruction
Ground collision
Crew action
Communication
Ground track error
On board system anomaly
Unknown obstacle
External event
Fire
Explosion
strike
With on board component
With cargo load
With the ground
Physiologic
barotraumatism
Hipoxy
Hypothermia
Intoxication
strike
Fire
Physiologic

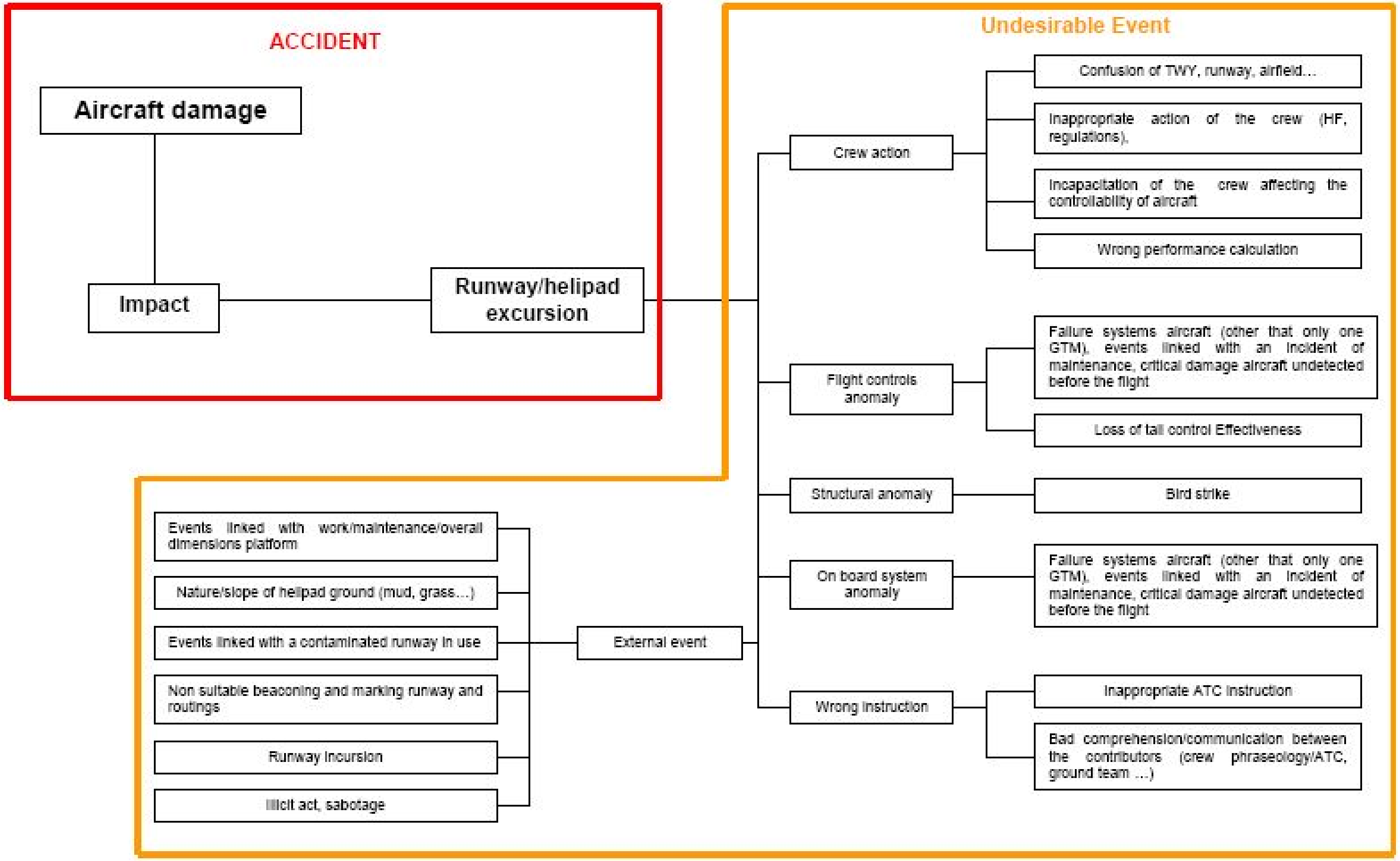

ACCIDENT
Aircraft damage
Impact
In flight
Without loss of control
CFIT(Ground or sea strike)
Wire strike
Obstacle strike
Tail rotor strike with ground/obstacles/human
Main rotor strike with ground/obstacles/human
Undesirable Event
Unknown obstacle to the crew likely to interfere with the en route trajectory
Inappropriate action of the crew (HF, regulations)
Non stabilized approach
Variation of en route trajectory
Inadequate dimension of the landing area
Bad comprehension/communication between the contributors (crew phraseology/ATC, ground team …)
Inappropriate ATC instruction
Aeronautical database missing or erroneous
Off shore: Inadequate Helideck

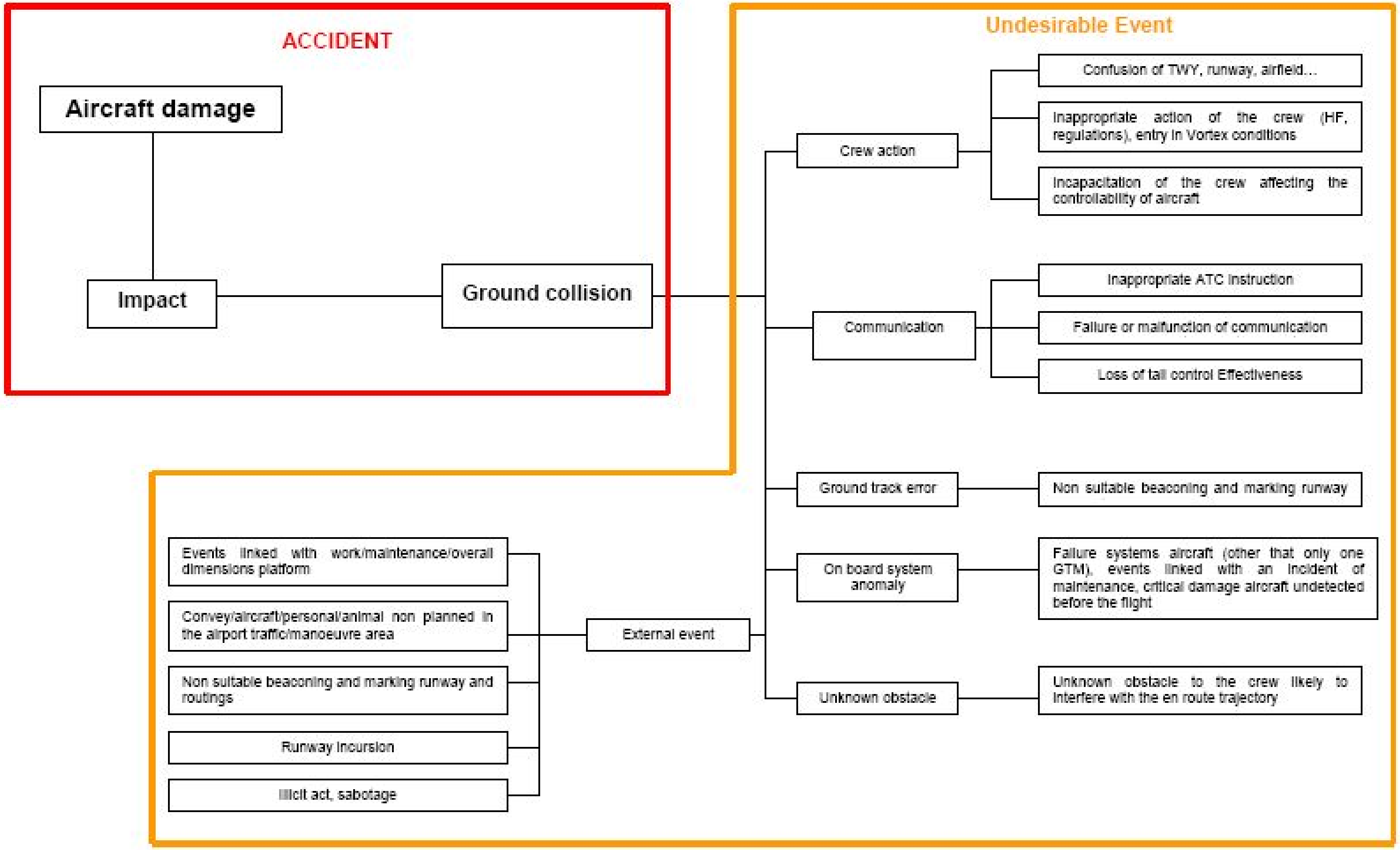

ACCIDENT
Aircraft damage
Impact
In flight
Mid air collision
Undesirable Event
Failure systems aircraft (other that only one GTM), events linked with an incident of maintenance, critical damage aircraft undetected before the flight
Failure or malfunction of communication system (ATC/aircraft, Aircraft/ground team…)
Inadvertent entry in IMC leading to emergency climb to Minimum Safety Altitude
Inappropriate action of the crew (HF,
Incapacitation of the crew affecting the controllability of aircraft
Variation of en route trajectory
Loss of in-flight separation (IFR/IFR, IFR/VFR)
Bad comprehension/communication between the contributors (crew phraseology/ATC, ground team …)
Inappropriate ATC instruction
Confusion of TWY, runway, airfield…
Aeronautical database missing or erroneous

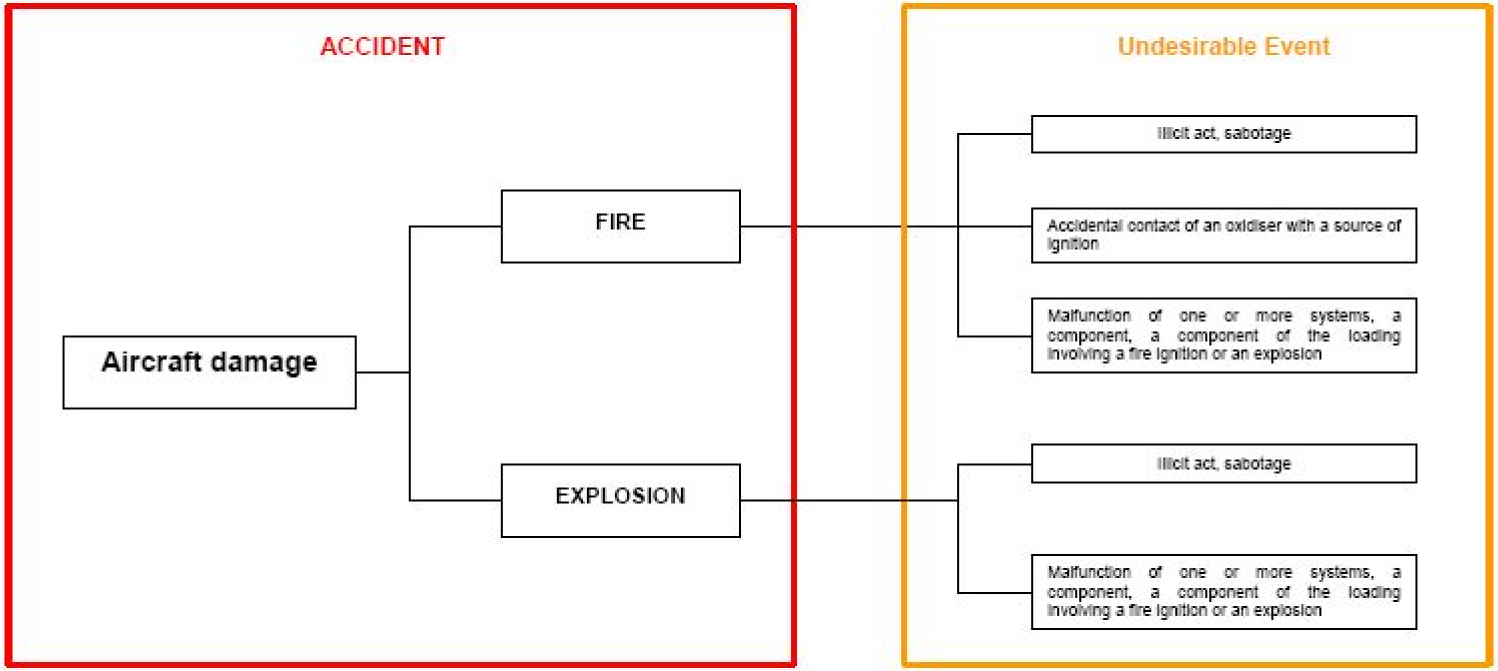


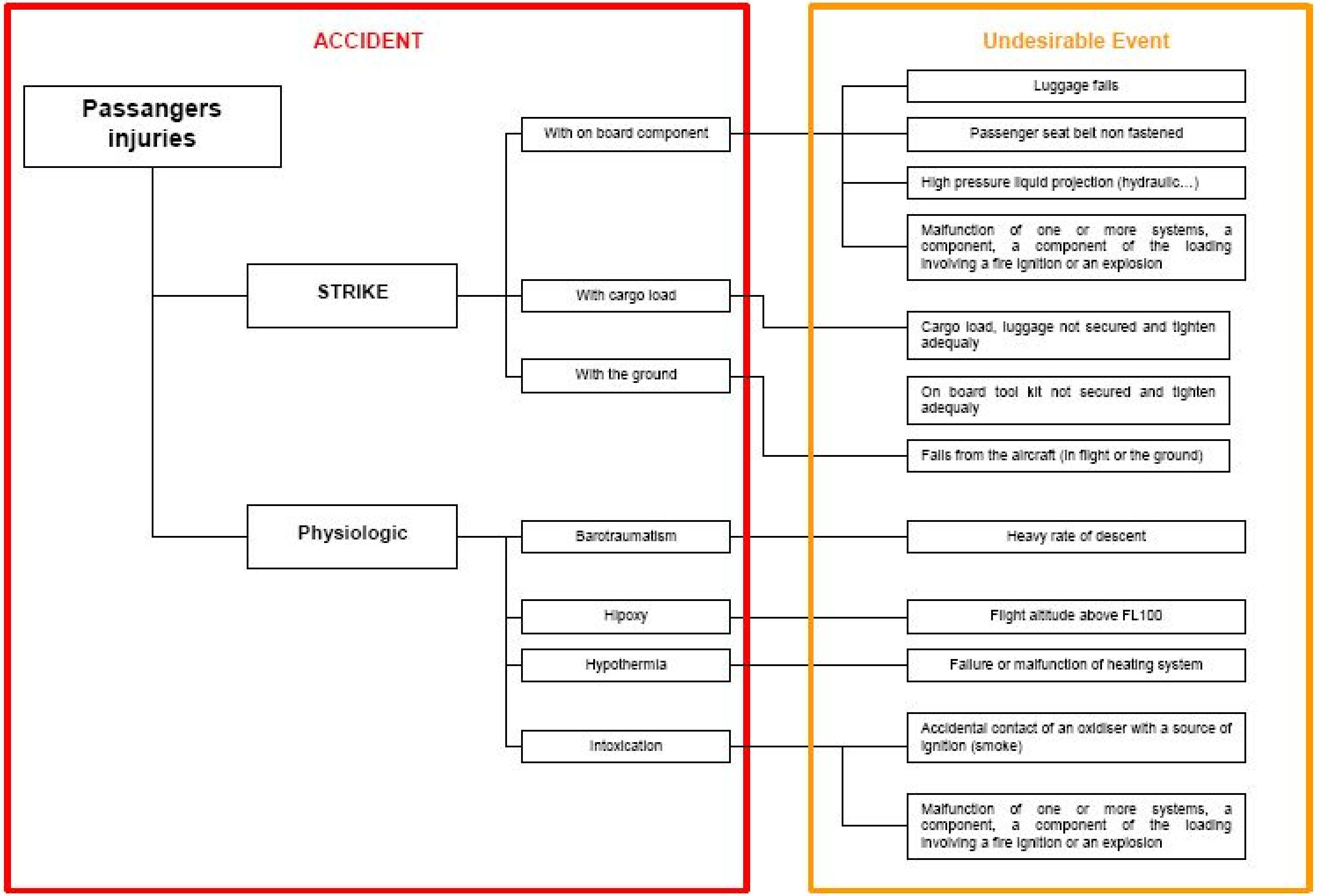
ACCIDENT*
*Only if the crew fails to recover the situation
Aircraft damage
Impact
Ultimate Event
In flight
Loss of control
Undesirable Event
Crew action
Inappropriate action of the crew (HF, regulations), entry in Vortex conditions
Incapacitation of the crew affecting the controllability of aircraft
Non stabilized approach
Loss of references, inadvertent entry in IMC,
Aerodynamism
Incident linked to icing conditions or failure of de icing system
Meteorological hazardous conditions (thunderstorms,, strong winds, snow…)
On board instrument anomaly
Failure systems aircraft (other that only one GTM), events linked with an incident of maintenance, critical damage aircraft undetected before the flight (Altimeters, pitot tube…)
Illicit act, sabotage
Flight controls anomaly
Loss of tail control Effectiveness
Failure systems aircraft (other that only one GTM), events linked with an incident of maintenance, critical damage aircraft undetected before the flight (Altimeters, pitot tube…)
Engine power anomaly
Loss of engine on multi engine helicopter
Loss of engine on single engine helicopter
Weight and balance anomaly
Limit overriding of weight and CG position affecting the controllability
Wrong Weight/CG position and insertion of these data in the FMS
Cargo load, luggage not secured and tighten
Structural anomaly
Bird strike

6

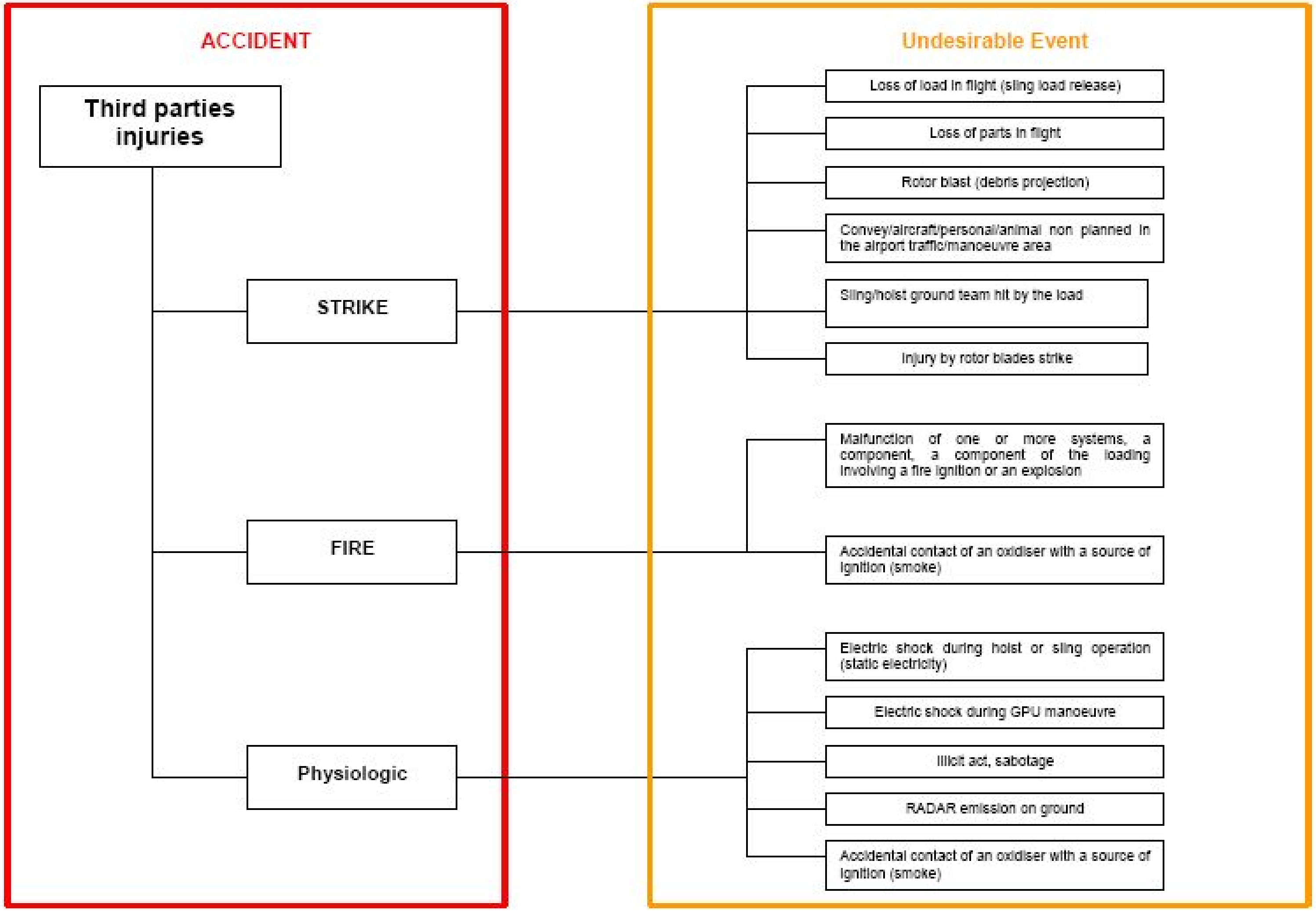

ACCIDENT
Aircraft damage
Impact
Runway/helipad excursion
Undesirable Event
Crew action
Confusion of TWY, runway, airfield…
Inappropriate action of the crew (HF, regulations),
Incapacitation of the crew affecting the controllability of aircraft
Wrong performance calculation
Flight controls anomaly
Failure systems aircraft (other that only one GTM), events linked with an incident of maintenance, critical damage aircraft undetected before the flight
Loss of tail control Effectiveness
Structural anomaly
Bird strike
On board system anomaly
Failure systems aircraft (other that only one GTM), events linked with an incident of maintenance, critical damage aircraft undetected before the flight
Wrong instruction
Inappropriate ATC instruction
Bad comprehension/communication between the contributors (crew phraseology/ATC, ground team …)
External event
Events linked with work/maintenance/overall dimensions platform
Nature/slope of helipad ground (mud, grass…)
Events linked with a contaminated runway in use
Non suitable beaconing and marking runway and routings
Runway incursion
Illicit act, sabotage


ACCIDENT
Aircraft damage
Impact
Ground collision
Undesirable Event
Crew action
Confusion of TWY, runway, airfield…
Inappropriate action of the crew (HF, regulations), entry in Vortex conditions
Incapacitation of the crew affecting the controllability of aircraft
Communication
Inappropriate ATC instruction
Failure or malfunction of communication
Loss of tail control Effectiveness
Ground track error
Non suitable beaconing and marking runway
On board system anomaly
Failure systems aircraft (other that only one GTM), events linked with an incident of maintenance, critical damage aircraft undetected before the flight
Unknown obstacle
Unknown obstacle to the crew likely to interfere with the en route trajectory
External event
Events linked with work/maintenance/overall dimensions platform
Convey/aircraft/personal/animal non planned in the airport traffic/manoeuvre area
Non suitable beaconing and marking runway and routings
Runway incursion
Illicit act, sabotage


ACCIDENT
Undesirable Event
Aircraft damage
FIRE
EXPLOSION
Illicit act, sabotage
Accidental contact of an oxidiser with a source of ignition
Malfunction of one or more systems, a component, a component of the loading involving a fire ignition or an explosion
Illicit act, sabotage
Malfunction of one or more systems, a component, a component of the loading involving a fire ignition or an explosion



ACCIDENT
Passangers injuries
STRIKE
Physiologic
With on board component
With cargo load
With the ground
Barotraumatism
Hipoxy
Hypothermia
Intoxication
Undesirable Event
Luggage falls
Passenger seat belt non fastened
High pressure liquid projection (hydraulic…)
Malfunction of one or more systems, a component, a component of the loading involving a fire ignition or an explosion
Cargo load, luggage not secured and tighten adequaly
On board tool kit not secured and tighten adequaly
Falls from the aircraft (in flight or the ground)
Heavy rate of descent
Flight altitude above FL100
Failure or malfunction of heating system
Accidental contact of an oxidiser with a source of ignition (smoke)
Malfunction of one or more systems, a component, a component of the loading involving a fire ignition or an explosion


ACCIDENT
Third parties injuries
STRIKE
FIRE
Physiologic
Undesirable Event
Loss of load in flight (sling load release)
Loss of parts in flight
Rotor blast (debris projection)
Convey/aircraft/personal/animal non planned in the airport traffic/manoeuvre area
Sling/hoist ground team hit by the load
Injury by rotor blades strike
Malfunction of one or more systems, a component, a component of the loading involving a fire ignition or an explosion
Accidental contact of an oxidiser with a source of ignition (smoke)
Electric shock during hoist or sling operation (static electricity)
Electric shock during GPU manoeuvre
Illicit act, sabotage
RADAR emission on ground
Accidental contact of an oxidiser with a source of ignition (smoke)

12 Annex 6 : Undesirable Events list

Air crew behaviour		
Undesirable Event	**Related Trigger code**	**Comments**
Unknown obstacle to the crew likely to interfere with the en route trajectory	Not applicable	The hazard can be identified and report to the other pilots by using trajectory replay
Inappropriate action of the crew (HF, regulations), entry in Vortex conditions	**01A to 18A**	
Incapacitation of the crew affecting the controllability of aircraft	Not applicable	
Non stabilized approach	**01A, 02A, 06A, 06B, 08A, 08D**	
Variation of en route trajectory	**01B, 02B, 06C, 06D, 08B**	***Could be improved with heading information***
Passanger seat belt non fastened	Not applicable	
Mission preparation operations		
Undesirable Event	**Related Trigger code**	**Comments**
Wrong performance calculation	Not applicable	
Limit overriding of weight and CG position affecting the controllability	Not applicable	
Wrong Weight/CG position and insertion of these data in the FMS	Not applicable	
Aeronautical database missing or erroneous	Not applicable	**The hazard can be identified in flight and reported to the other crews by using trajectory replay**
Luggage falls	Not applicable	
Cargo load, luggage not secured and tighten adequately	Not applicable	
On board tool kit not secured and tighten adequately	Not applicable	
Aircraft state		
Undesirable Event	**Related Trigger code**	**Comments**
Failure or malfunction of communication system (ATC/aircraft, Aircraft/ground team…)	Not applicable	

Failure systems aircraft (other that only one GTM), events linked with an incident of maintenance, critical damage aircraft undetected before the flight (Altimeters, pitot tube…)	**17A to 24D, 31A, 32A**	
Incident linked to icing conditions or failure of de icing system	Not applicable	
Loss of tail control Effectiveness	Not applicable	***Could be detected with Yaw sensor indications***
Loss of engine on multi engine helicopter	Not applicable	***Due to the fact that none multi engine aircraft were used for the study***
Loss of engine on single engine helicopter	**25A, 25B, 43A to 49C**	
Failure or malfunction of heating system	Not applicable	
In flight operations		
Undesirable Event	**Related Trigger code**	**Comments**
Inadequate dimension of the landing area	Not applicable	
Nature/slope of helipad ground (mud, grass…)	**29A to 29D**	Excessive slope of helipad
Off shore: inadequate Helideck	Not applicable	
Bad comprehension/communication between the contributors (crew phraseology/ATC, ground team …)	Not applicable	
Inappropriate ATC instruction	Not applicable	
Inadvertent entry in IMC leading to emergency climb to Minimum Safety Altitude	Not applicable	The trajectory mode can be used after the flight to investigate the incident
Loss of in-flight separation (IFR/IFR, IFR/VFR)	Not applicable	The trajectory mode can be used after the flight to investigate the incident
Confusion of TWY, runway, airfield…	Not applicable	
Meteorological hazardous conditions (thunderstorms,, strong winds, snow…)	Not applicable	The trajectory mode can be used after the flight to investigate the incident ***An indication of flight controls position could detect how it was difficult for the crew to control the helicopter***
Falls from the aircraft (in flight or the ground)	Not applicable	
Heavy rate of descent	**08B**	
Flight altitude above FL100	***Applicable but according to the company operation, not defined for the study***	
Loss of load in flight (sling load release)	Not applicable	The trajectory mode can be used after the flight to investigate the incident

Sling/hoist ground team hitted by the load	Not applicable	
Electric shock during hoist or sling operation (static electricity)	Not applicable	
Loss of parts in flight	Not applicable	The trajectory mode can be used after the flight to investigate the incident
Bird strike	Not applicable	**The study of engine curves can be used after the flight to investigate the incident (in case of engine damage)**
On ground		
Undesirable Event	**Related Trigger code**	**Comments**
Events linked with work/maintenance/overall dimensions platform	Not applicable	
Convey/aircraft/personal/animal non planned in the airport traffic/manoeuvre area	Not applicable	
Events linked with a contaminated runway in use	Not applicable	
Runway incursion	Not applicable	
Nonsuitable beaconing and marking runway	Not applicable	
Electric shock during GPU manoeuvre	Not applicable	
RADAR emission on ground	Not applicable	
Others		
Undesirable Event	**Related Trigger code**	**Comments**
Malfunction of one or more systems, a component, a component of the loading involving a fire ignition or an explosion	Not applicable	
High pressure liquid projection (hydraulic…)	Not applicable	
Rotor blast (debris projection)	Not applicable	***The trajectory mode could be used after the flight to investigate the incident***
Injury by rotor blades strike	Not applicable	***The trajectory mode can be used after the flight to investigate the incident***

13 Annex 7 : List of acronyms

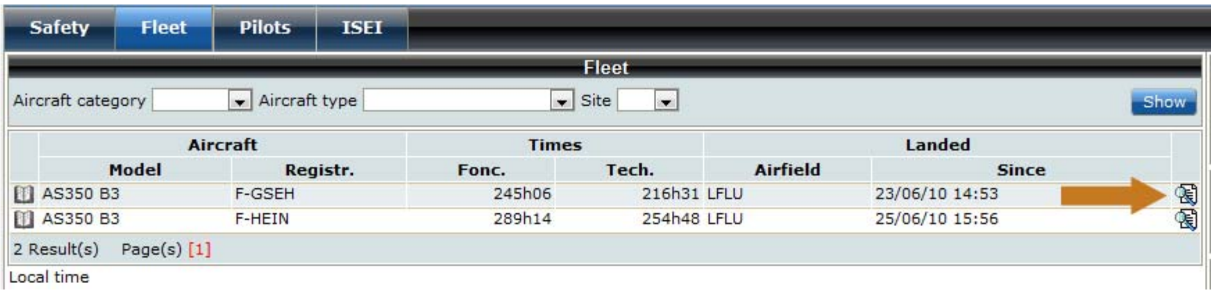
AW	Aerial Work
ARINC	Aeronautical Radio INCorporated
CFIT	Control Flight Into Terrain
COTS	Commercial Off The Shelf
EALAT	Ecole d'Application de l'Armée de Terre
FDM	Flight Data Monitoring
FH	Flight Hours
GPS	Global Positionning System
GPRS	General Packet Radio Service
GSM	Global Systems Mobile
H/C	Helicopter
HOMP	Helicopter Operational Monitoring Program
HUMS	Health and Usage Monitoring System
NF	Free Power Turbine
NG	Gas Generator Speed
NR	Main Rotor Speed
OEM	Original Equipment Manufacturer
SOP	Standard Operating Procedure
T4	Turbine exhausted gas temperature (or TOT)
VEMD	Vehicule & Engine Monitoring Display
VIP	Very Important Person

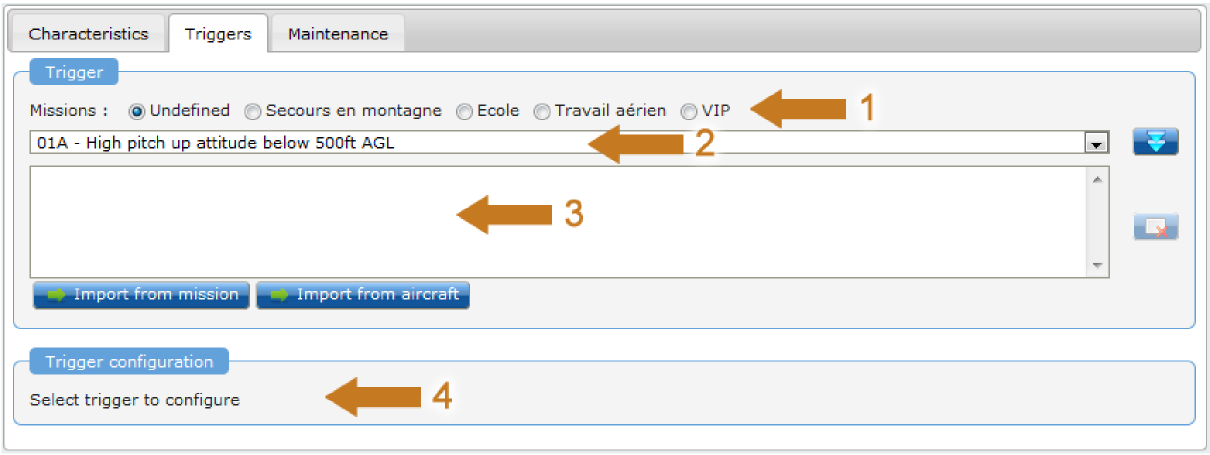
14 Annex 8 : Safetyplane ground station screenshots

Trigger management function

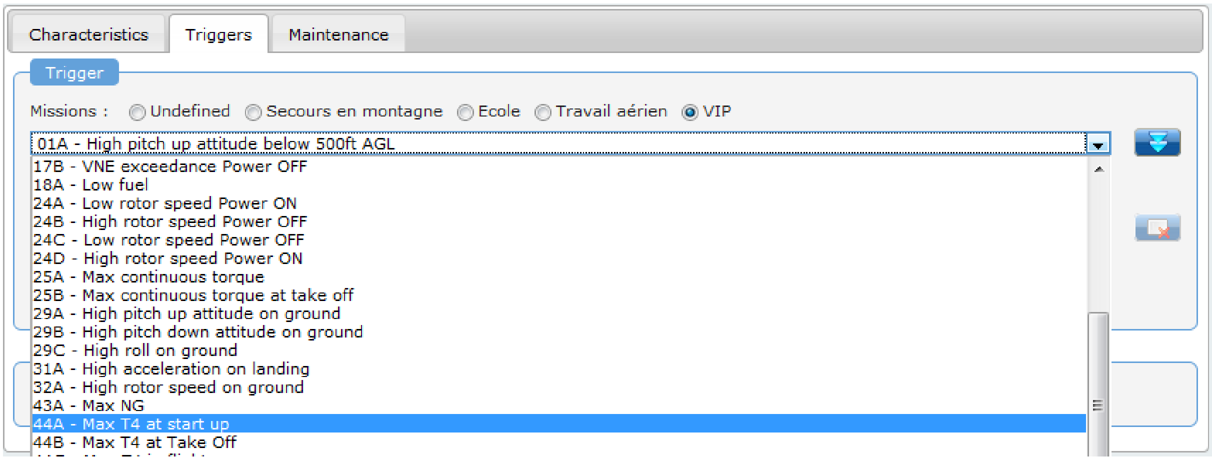
<u>Trigger definition</u>

Access is provided from the fleet page, per aircraft as shown below.

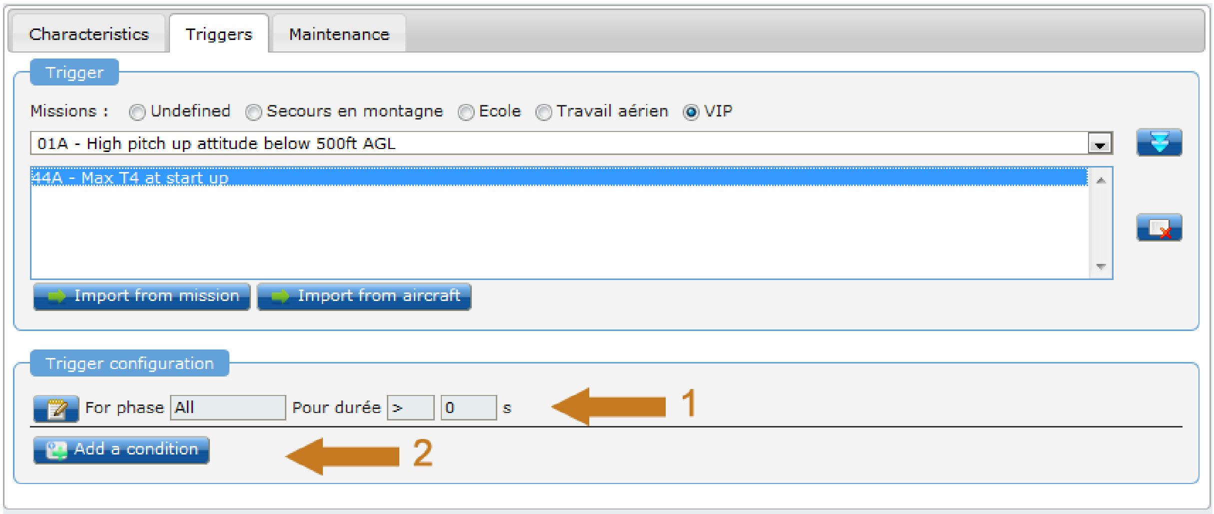




The VIP mission will be used here as an example as well as T4 monitoring at start-up (trigger 44A).

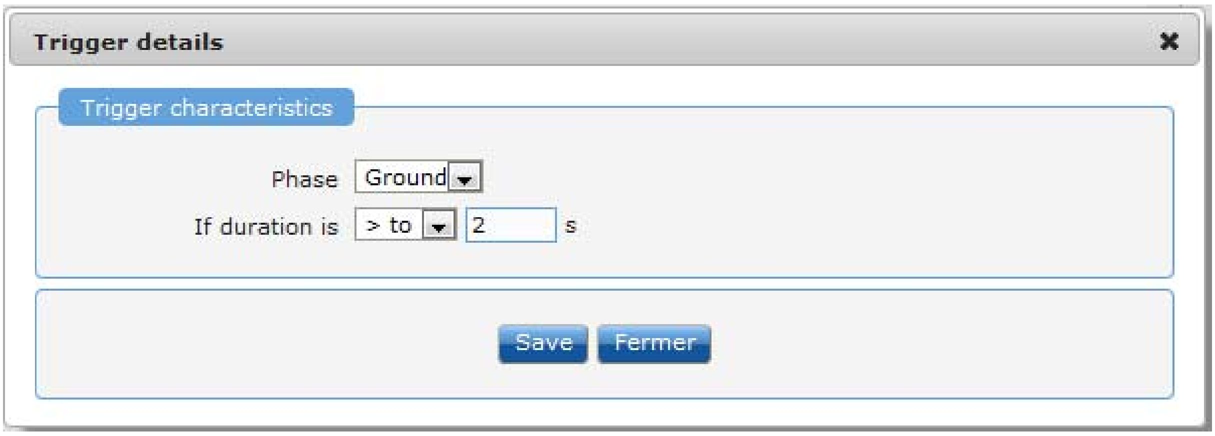


To include the trigger in list 3, the  buttons hall be used.
The trigger need then to be configured.

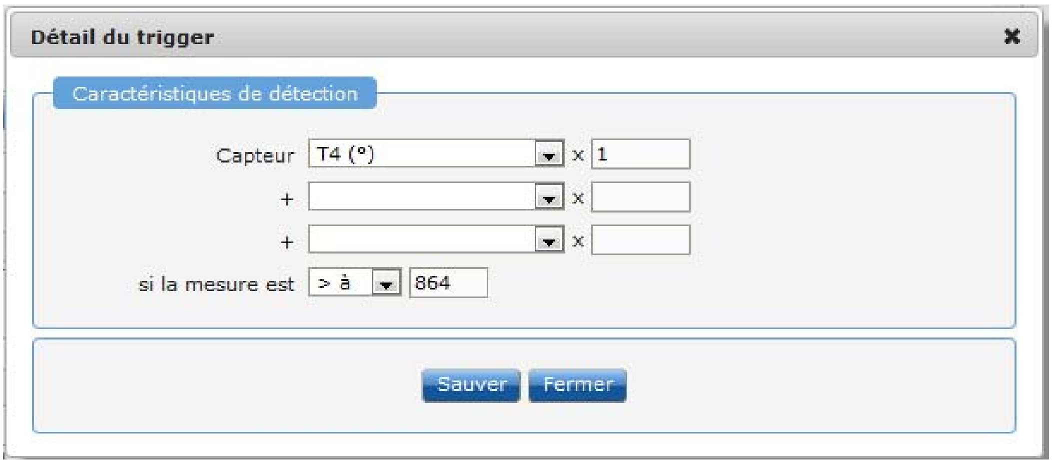


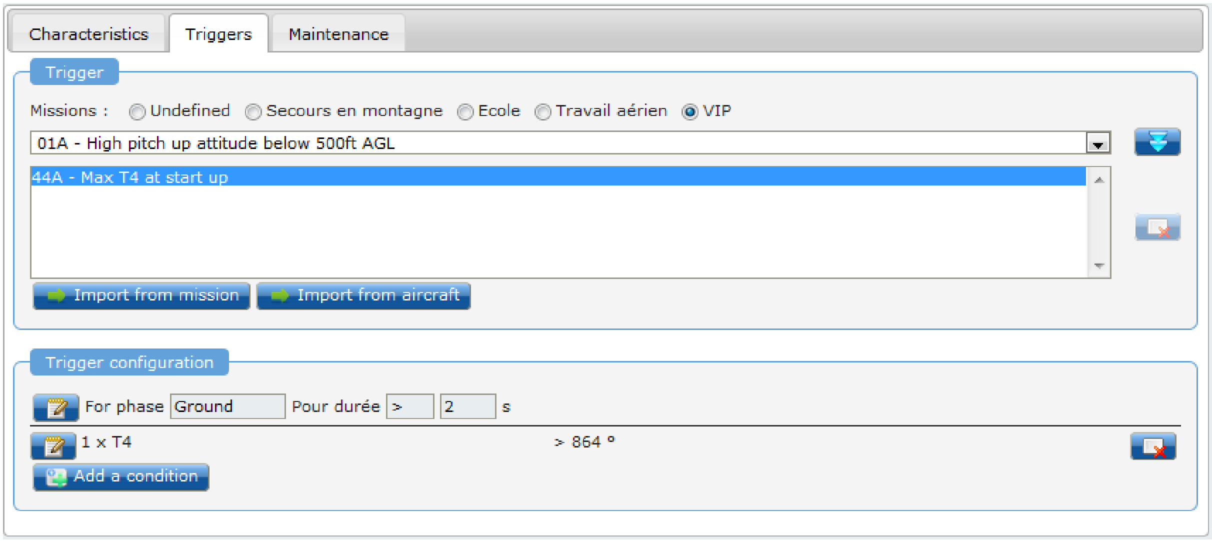
In area 1, the flight phase need to be defined as well as the time during which the data need to match the conditions.

The  button opens the configuration window.



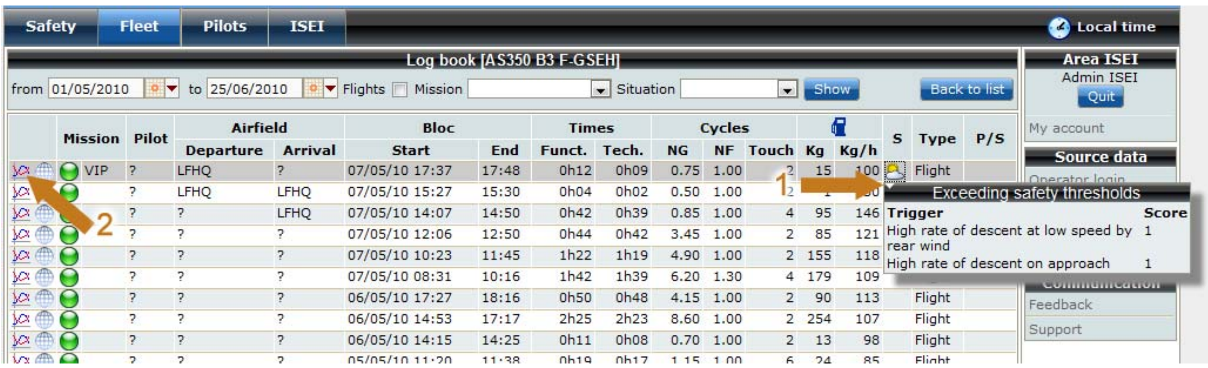
Add condition button opens the trigger configuration window.





Display of trigger results

The Safety button (1) displays a list of all flights where triggers matched.
The weather icon (2) provides the matching triggers (3).



The fleet page provides access to the same data (1).
Trigger analysis data can be accessed from icon (2).

15 Annex 9 : Part 1 of Small helicopter HOMP trial

PART 1 REPORT

TENDER N° EASA.2008.OP.33

“SMALL HELICOPTER HOMP TRIAL”

TABLE OF CONTENTS

1. Introduction

The present document provides the results of phase 1 of the Light Helicopter HOMP trial study contracted by EASA to EUROCOPTER, IXAIR and ISEI.

Phase 1 covers the following work-packages:

- 1.1 : Review of small helicopter accidents
- 1.2 : Review of FDM technologies on small helicopters
- 1.3 : Review of other works
- 1.4 : Analysis of costs and benefits
- 1.5 : Recommendations

2. Reference documents

- SERVICE CONTRACT No. EASA.2008.C50 "Small Helicopter Operational Monitoring Programme (HOMP) Trial CONTRACT NUMBER – EASA.2008.C50
- EHOMP CONSORTIUM TECHNICAL PROPOSAL EASA.2008.OP.33 "SMALL HELICOPTER HOMP TRIAL" – ETFR 08.11.20

3. Review of small helicopter accidents

3.1. Initial accident database list

Main regional AAIB (Accident Air Investigation Board) database available on each official web Site.

- Accident Investigation Branch (United Kingdom)
- Australian Transport Safety Bureau (Australia)
- Transportation Safety Board of Canada
- ECCAIRS (French BEA Accident Database)
- National Transport Safety Board of United States of America

Available private accident database:

- Eurocopter DB (Only Eurocopter helicopters around the world)
- Griffin helicopter Web Site (linked with main DB's)

Non public database (Limited access):

- EASA secured EHSAT DB

3.2. Retained Accident database

The EHSAT Database contains accident data related to several types of helicopters (piston and turbine) covering most of the European countries.

The structure of this DB provides also a quick overview of the accidents analysis in order to determine if an FDM process could have prevented them.

The other candidate DBs do not provide sufficient details/coverage for the intended analysis.

For these reasons, the EHSAT DB has been retained and used.

3.3. Accident analysis methodology and results

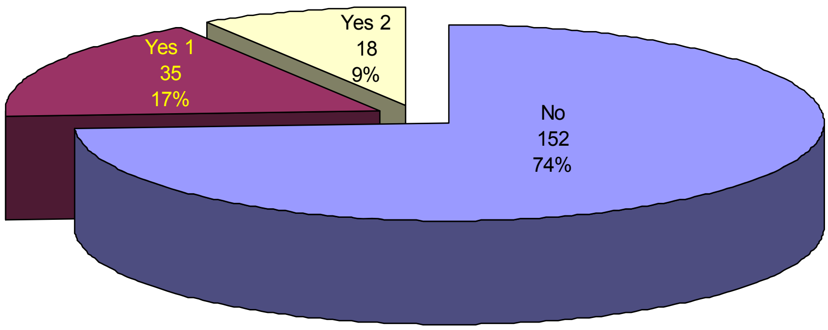
EC and IXAIR experts reviewed all the FAR27 helicopter accidents from the EHEST database (nearly 200 accidents, 98 (50%) for General Aviation flights). For each accident, the team read the event description and the contributing factors of the accident as well as the associated Standard Problem Statement.

Then, the team analyzed the accident in the following way: "if the customer has had an FDM program in his company, would this accident have been avoided?" The answer to this question could be: No, Yes 1 or Yes 2 (decided after an agreement between the IXAIR and EC experts).

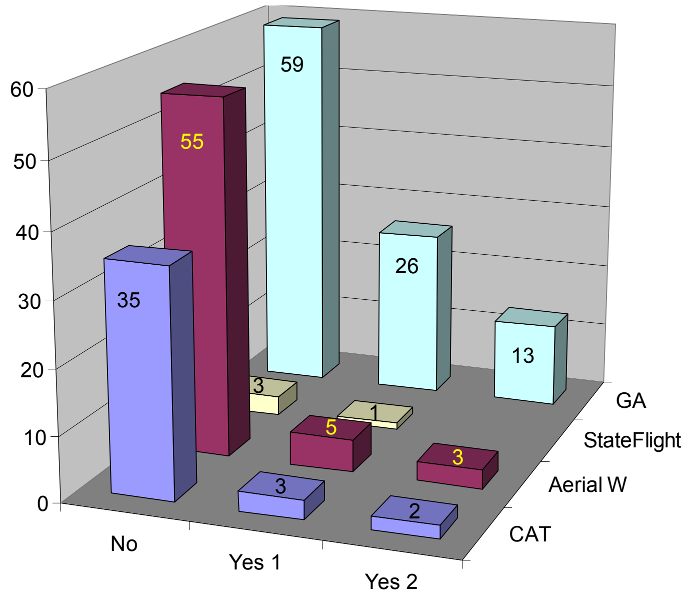
- No: self explanatory (example: breakdown of a blade in flight which leads to a loss of control of the helicopter);
- Yes 1: possible (example: the accident shows a general behaviour of the pilot which is not safe like a flight at low altitude without any reason for the mission which leads to a wire strike. With an FDM program monitoring the height cruise, the FDM manager could have detected this behaviour and the pilot would have been recalled to fly above 500ft/ground which is the minimum height regulation in case of day flight);
- Yes 2: probable (example: the accident shows clearly that there was a problem of piloting quality like an excessive pitch attitude near the ground during landing phases which leads to a tail boom strike). With an appropriate Flight Data Monitoring program, this behaviour would have been detected and the pilot would have had an appropriate training for this specific flight phase).

The result of the analysis is the following:

Spreading by type of operation	HOMP			
	No	Yes 1	Yes 2	Total
CAT - Air Taxi	3			3
CAT - Ferry/Positioning	5			5
CAT - HEMS	3	1		4
CAT - NonSched - Pax	17	1		18
CAT - Other	2	1		3
CAT - Sched - Pax			1	1
CAT - Sightseeing	1			1
CAT - Training	4		1	5
S/TOTAL CAT	**35**	**3**	**2**	**40**
AerialW - Comm - Fire Fighting	7		1	8
AerialW - Comm - Other	29	3	2	34
AerialW - Comm - Sling/External load	14	2		16
AerialW - NonComm - Other	3			3
AerialW - NonComm - SAR	1			1
AerialW - NonComm - Sling/External load	1			1
S/TOTAL AerialW	**55**	**5**	**3**	**63**
State Flight - Military		1		1
State Flight - Other	1			1
State Flight - Police	2			2
S/TOTAL State Flight	**3**	**1**		**4**
GA - Business	4	1		5
GA - Other	9	4	1	14
GA - Pleasure	34	15	8	57
GA - Training	12	6	4	22
S/TOTAL GA	**59**	**26**	**13**	**98**
TOTAL	**152**	**35**	**18**	**205**
Rate	**74%**	**17%**	**9%**	**100%**



This result shows that 26% of the analyzed accidents have a probability to be avoided using an FDM system. .



Accidents in General Aviation Flights represents around 50% of the total (98 accidents among 205).

This histogram shows that FDM would be more effective for General Aviation (approximately 40% potential for reduction of accidents).

3.4. Link with proposed Flight trials and FDR parameters

The above results assume that a potential FDR system would have made available all the parameters defined in paragraph 6 (list 1,2 & 3).

Flight trials: the two selected operators do not perform all the missions identified in the above tables. For missions who have a significant safety improvement potential and are not covered by flight trials (eg GA pleasure flights), the phase 2 report shall identify, among the events defined during flight trials, those applicable to these missions and propose a way to implement.

4. Review of FDM technologies on small helicopters

The Flight Data Monitoring (FDM) is increasingly becoming an integral part of the safety and operational management.

Currently no regulation or guide-line exists for this kind of product.

This Work Package aims at presenting a global view of the FDR products. The benchmark has been performed comparing:

- The available functions,
- The physical characteristics; such as the weight, the dimensions, …
- And the data exploitation possibilities.

4.1. FDM Manufacturer list

The analysis is based on documentations and/or information received from 16 manufacturers in February 2009. We did not work with an exhaustive list of FDR manufacturer. The results are based on the comparison of “on-the-shelf” products.

This study deals with the data acquisition as well as the data transmission and analysis. In the study, also the manufacturers proposing only services based on data analysis has been taken into account.

Following, the list of studied manufacturers:

- **ISEI** Safety plane
- **ECT** Brite Saver
- **Appareo** Vision 1000, ALERTS

- **IAero** Apibox
- **ETEP** Nano
- **Teledyne** MFDAU, GroundLink system
- **Honeywell** Ground Support Equipment
- **SAGEM** Analysis Ground Station
- **THALES** EQAR
- **L-3 Com** Micro QAR & Aerobytes software
- **Meggit Avionics** Card QAR
- **SES** S3DR-C
- **PI Search** Data monitoring (for car, boat or aircraft)
- **Alyzair** FDM Services
- **Avionica** Mini QAR MkII, MkIII
- **CTS** SSQAR et PGS

4.2. Available functions

The FDM can be used in many different cases according to the customer's user needs. The functions can be divided in four categories:

- Safety-related functions
- Accident investigation capabilities
- Data Analysis functions
- Miscellaneous

4.2.1. Safety-related functions

The main purpose of the safety functions is to help aircrews to identify the occurrence of potential safety events. Some identified functions are:

- Detection of thresholds overruns
- Detection of unsafe aircrew behaviour using event triggers
- Capability to generate new event triggers following incident investigation

The above functions use data analysis features described hereafter.

4.2.2. Accident investigation capabilities

These capabilities include both hardware features (such as ruggedization) and data analysis features as defined in next paragraph.

4.2.3. Data analysis functions

The main purpose of these functions is to have the best knowledge of flights.
List of functions proposed by the suppliers:

- Fleet management (localization, …),
- Flight path and parameter display (aeronautical map, satellite map or road map...), 3D flight replay,
- Cockpit video and audio replay,
- Fleet statistics analysis.

4.2.4. Miscellaneous

Additional functions or capabilities:

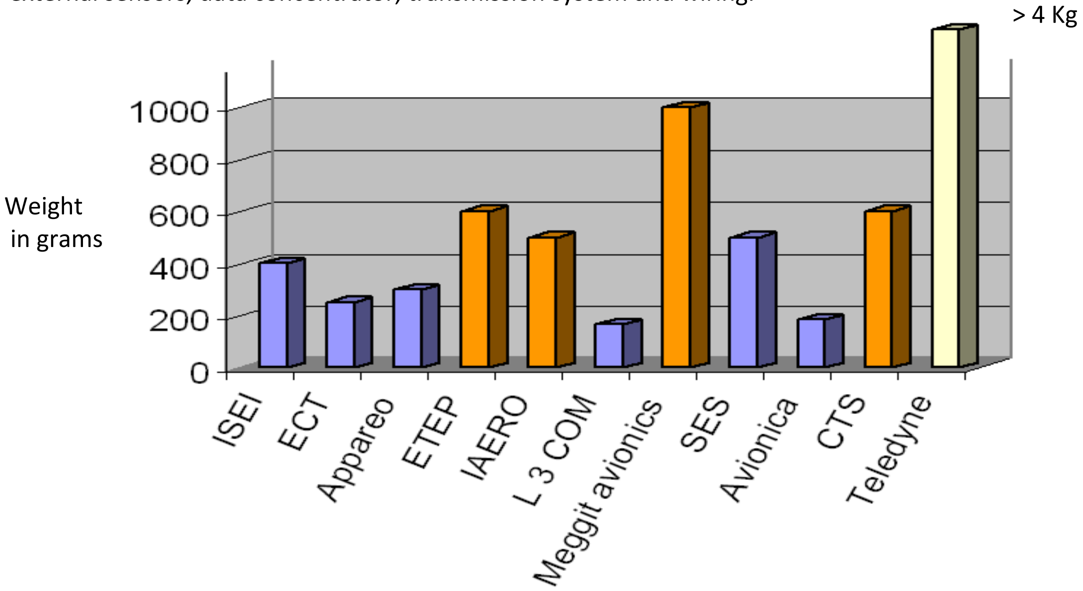
- HUMS Usage functions,
- Aircrew Identification
- Pilot and Aircraft Logbook Management
- Maintenance schedule

- Mission debriefing
- Web-based management of aircraft booking
- Management of Aircraft access (check of pilot license update status)
- Real-time invoicing based on effective use of the aircraft (fuel, flight time, taxes additional charges in case of overruns, …)
- Identification of flight phases

4.3. Weight & Dimensions

4.3.1. Weight

The following graph presents the product weights. The weight includes the FDR equipment, excluding external sensors, data concentrator, transmission system and wiring.



Most of FDM recorder solutions have a weight less than 1 Kg; one out of two weights less than 500 g.

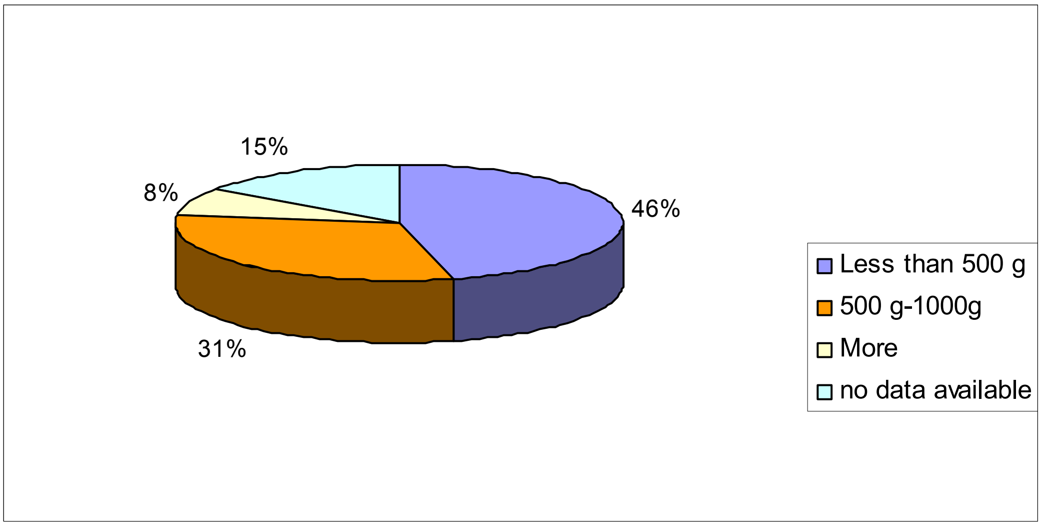
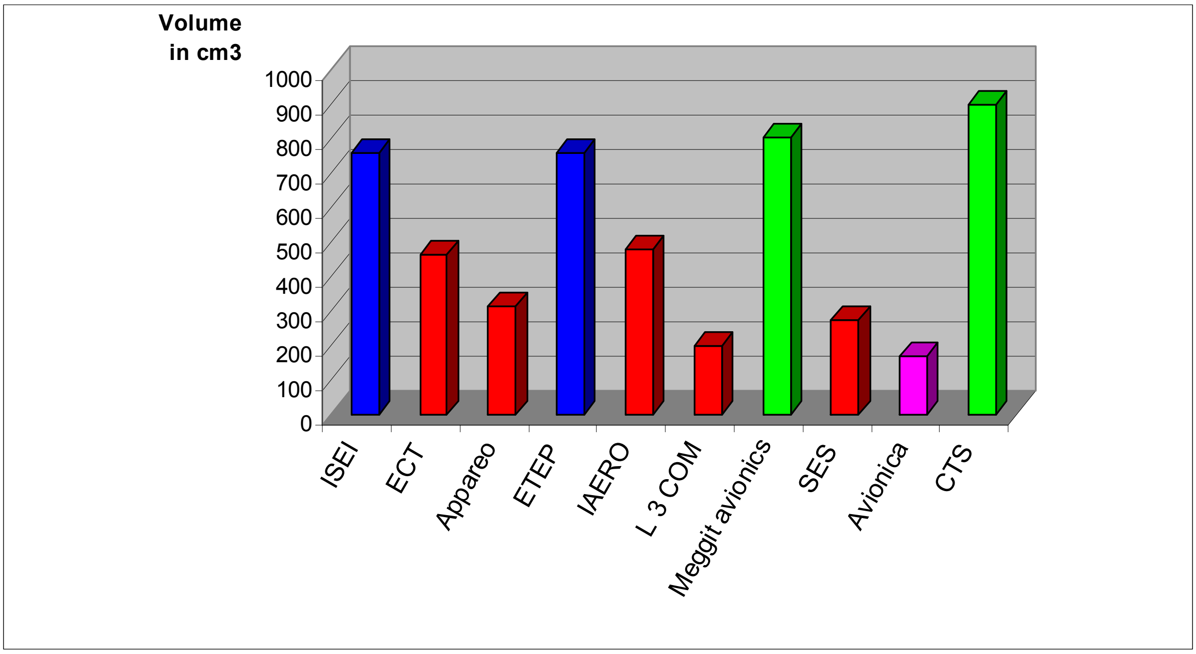


Figure 1: product weight.

4.3.2. Volume

All studied recorders have different dimensions and shape. To compare them their volumes have been studied.



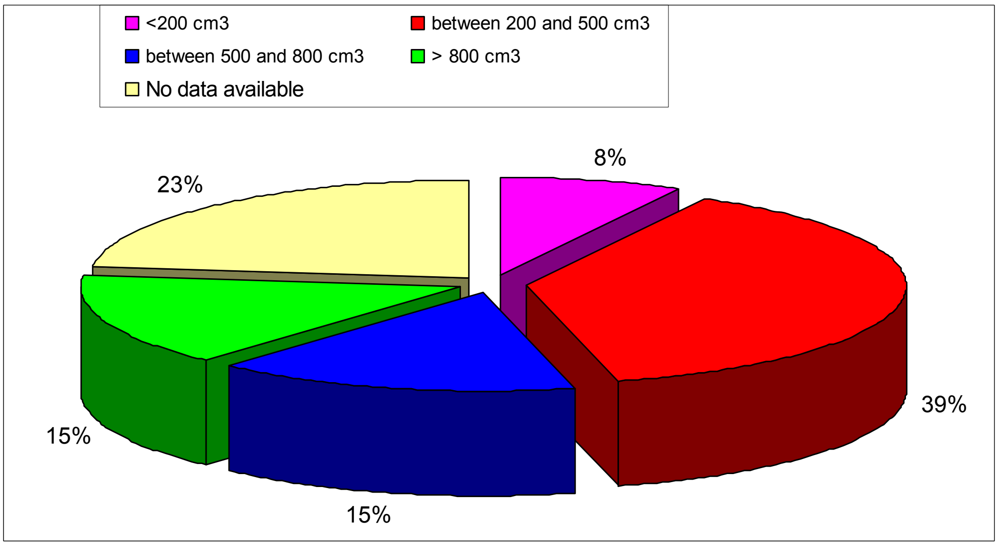


Figure 2: product volume (12 products).

The majority of the products have a volume included between 200 and 800 cm^3.

4.3.3. Dimensions

The table hereafter presents the recorder (alone, without any others sensors, data concentrator or transmission system).

Manufacturers	Size (in mm)
ISEI	160x28x120
ECT	105x35x126
Appareo	54x63x92
PISearch	No data available
ETEP	68x112x100
IAERO	160x30x100
THALES	No data available
L3COM	56x69x52
Meggit avionics	146x38x145
SES	115x85x28
Avionica	55x45x66
CTS	146x38x146
Teledyne	No data available

4.4. Aircraft integration

The table hereafter presents the location of the FDR systems:

Manufacturers	Integration in the aircraft
ISEI	Cockpit
ECT	Cockpit
Appareo	Ceiling next to the cockpit (for video recording)
PISearch	No data available
ETEP	no installation requirement
IAERO	Cockpit
THALES	No data available
L3COM	Cockpit or electrical bay
Meggit avionics	No data available
SES	Cockpit
CTS	Cockpit
Avionica	cockpit, near the data concentrator
Teledyne	No data available

The majority of the recorders are usually installed in the cockpit in order to facilitate the access to the equipment. But according to the manufacturers there is no important installation constraint for the equipment.

4.5. Other technical features

Other performances have been compared, such as:

- The recorded parameters, and
- The external interfaces.

4.5.1. Recorded parameters

FDM recorders can be divided in two categories:

- Recorders, with supplier-predefined list of parameters[1];
- Recorders, not providing a pre-defined list of parameter; the customer can choose the parameters to record.

Note: in addition, some suppliers propose (according with customer's request) to customize their product.
The following chart presents the percentage of manufacturers providing a basic list of recorded parameters.

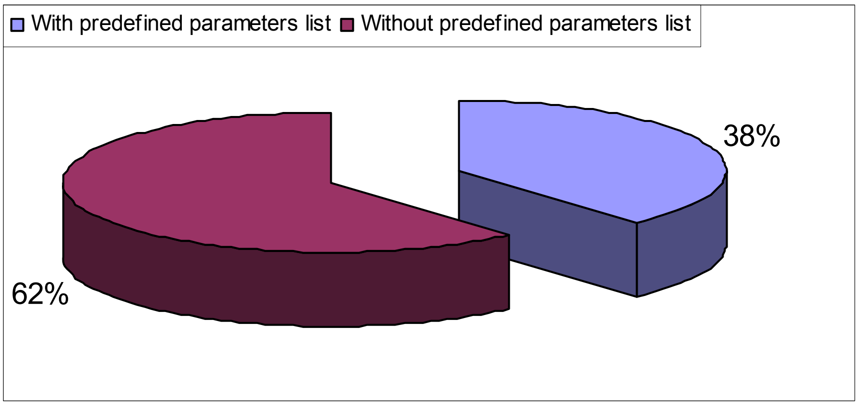


Figure 3: customizable parameter list.

The majority of manufacturers allow the customer to choose the parameters to record.
The manufacturers with a pre-defined parameters list are ISEI, ECT, Appareo, CTS and iAero.

4.5.2. Parameters list

The parameters recorded have been split in 5 categories:

- Engine
- Attitude
- Localization
- Environment
- Other

The next table shows the parameters list for each category (√=Recorded).

[1] some products with pre-defined parameters list can be upgraded and proposed optionally to acquire additional parameters.

7

	ISEI		ECT		APPAREO		IAERO		CTS	
Product name	Safety Plane		Brite Saver		Vision1000		Apibox		SSQAR	
ENGINE		Freq		Freq		Freq		Freq		Freq
NG (engine gas generator speed) or pow	√		√							
NF (free power turbine speed)	√		√							
NR (main rotor speed)	√		√							
T4 (engine exhausted gas temperature)	√		√							
Torque	√	1 or 5 Hz	√	1 Hz		4 Hz	√	1 or 10 HZ		
Oil temperature	√		√				√			
Oil pressure	√						√			
Electric detection of particles	√									
Fuel level	√						Optional			
Fuel rate	√						Optional			
ATTITUDE		Freq		Freq		Freq		Freq		Freq
Heading	√				√		√		√	
Roll	√				√				√	
Pitch	√		√		√				√	
Yaw rate	√				√				√	
Roll rate	√				√				√	
Pitch rate	√	1 or 5 Hz		1 HZ	√	4 Hz		1 or 10 HZ	√	1 to 1000 Hz
Collective pitch							√			
Cyclic pitch							√			
Tail rotor pedal							√			
Vertical acceleration	√				√		√		√	
Lateral acceleration	√				√		√		√	
Longitudinal acceleration	√				√		√		√	
GPS LOCALIZATION		Freq		Freq		Freq		Freq		Freq
GPS Time	√				√		√		√	
GPS Altitude	√		√		√		√		√	
Ground height										
Longitude	√	1 or 5 Hz		1 HZ	√	4 Hz	√	1 or 10 HZ	√	4 Hz
Latitude	√				√		√		√	
Trajectory / route	√				√		√		√	
Vertical speed GPS	√				√					
Ground speed	√				√		√		√	
ENVIRONMENT		Freq		Freq		Freq		Freq		Freq
Outside Air Temperature	√		√				√			
Static pressure	√						√		√	
Total pressure	√	1 or 5 Hz		1 HZ		4 Hz		1 or 10 HZ		1 Hz
Indicated Air Speed	√						√			
Vertical Speed Anemometer										
OTHER				Freq		Freq		Freq		Freq
Internal clock (or cycles counting)	√		√		√					
Pad of take-off contact	√									
Battery operating time	√		√							
Engine operating time	√	1 or 5 Hz	√	1 HZ		4 Hz		1 or 10 HZ		
Vibration analysis			√							
Audio recording			Optional		√					
Video recording			Optional		√					

Figure 4: parameters list.

The following diagram presents the comparison among 4 manufacturers with pre-defined parameter list.

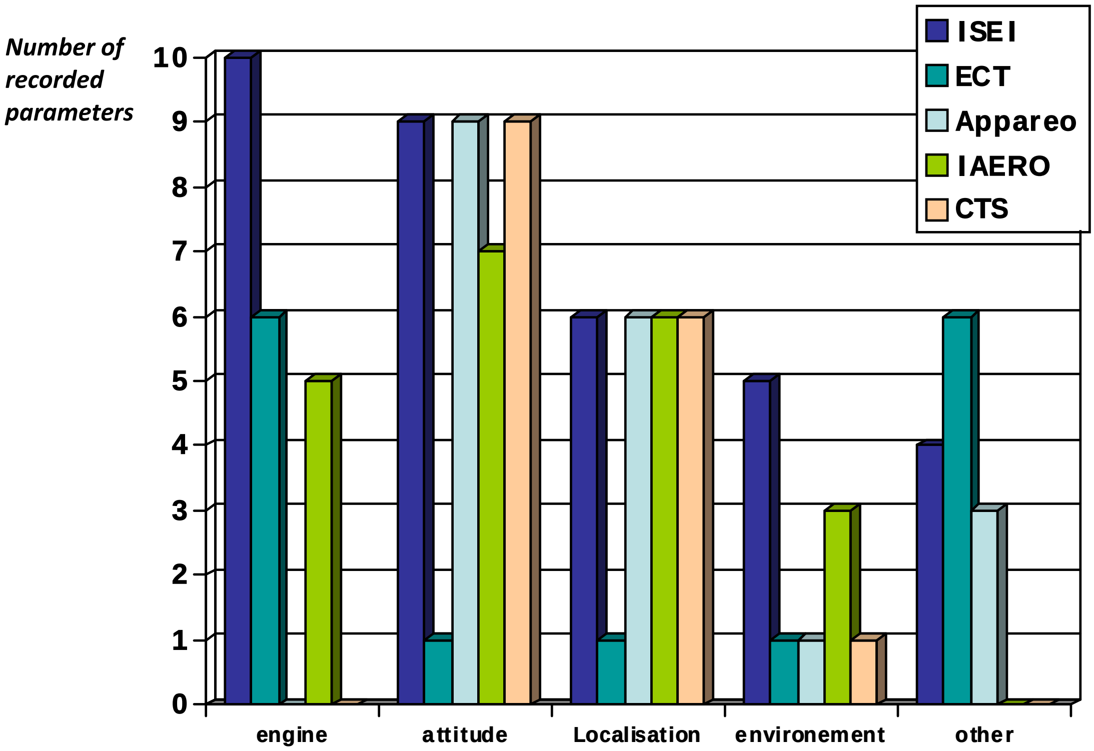


Figure 5: recorded parameter.

4.5.3. Recording capacity

The following table summarizes the recording capacity for each recorder (on the removable memory).

Manufacturers	Recording capacity (hours)
ISEI	2000 (1hz)
ECT	900 (1 Hz)
Appareo	2 (4 Hz) including video
PISearch	No data available
ETEP	Between 2 and 6 h
IAERO	100 (1HZ)
THALES	No data available
L3COM	320 (256 12 bits-words/s)
Meggit avionics	Between 25 to 200
SES	Depend on parameter list
Avionica	Depend on parameter list
CTS	Between 740 an 5900 h
Teledyne	No data available

These capacities depend on the parameters list and on recording frequencies.

4.5.4. Crash-resistant memory

No manufacturer proposes a full crash-resistant memory. But some of them have an internal ruggedized memory (no reference to associated standard).

4.5.5. External interfaces

Different types of inputs are available on recorders. The following table provides the mapping of the different inputs for each manufacturer. Some inputs are optional and added on costumer request.

	CAN	A429	A717 A573	1553	Analog	Discrete	RS485	RS232	RS422	Ethernet	Stand-alone
ISEI	✓	✓	✓		✓	✓	✓	✓	✓		
ECT		✓		✓	✓						
Appareo											✓
PISearch	✓				✓					✓	
ETEP		✓		✓	✓	✓		✓	✓		
IAERO		✓	✓		✓			✓			
THALES			✓						✓		
L3COM			✓								
Meggit avionics			✓	✓				✓	✓		
SES	✓	✓			✓	✓	✓	✓			
Avionica		✓	✓								
CTS		✓	✓			✓			✓		✓
Teledyne		✓	✓		✓	✓					

Figure 6: external input interfaces.

Note: Arinc 717 is the standard used for interface specifications of FDR (Flight Data Recorder) and its environment.

Vision1000 (Appareo) and SSQAR (CTS) are stand-alone equipments. Vision 1000 is the only recorder including cockpit video recording.

4.6. Data download and analysis

4.6.1. Data Download

Three kinds of solutions are available to download recorded data:

- Removable memory device,
- Wireless,
- Wired.

4.6.2. Removable memory

83 % of benchmarked manufacturers are using this solution. The following chart presents the different memory technologies.

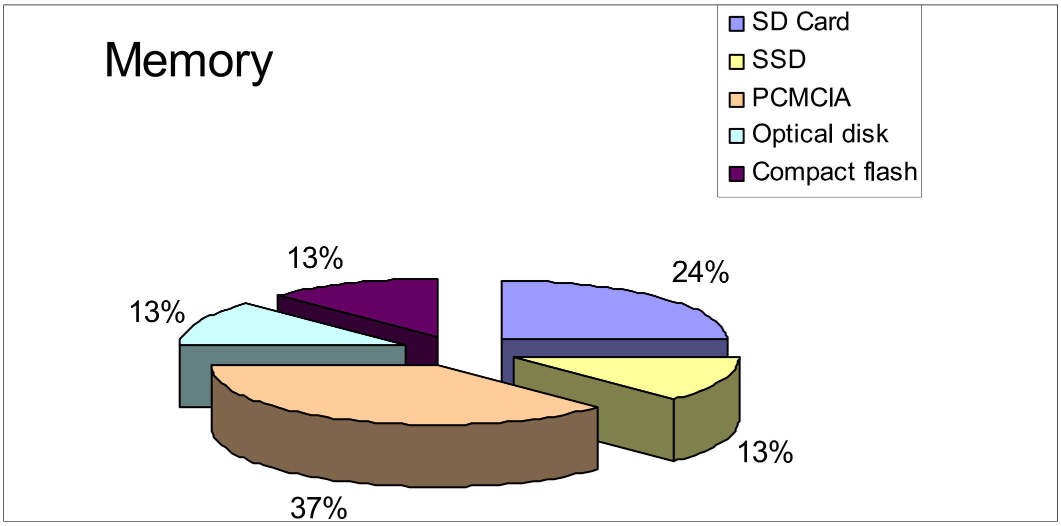


Figure 7: memory types.

- SD: Secure Digital (flash memory)
- SSD: Solid State Drive (flash memory)
- PCMCIA: Personal Computer Card International Association (flash memory)
- CF: Compact Flash (flash memory)
- Optical Disk (eg. CD-ROM).

Except the products using optical technology, all the products are using flash memory technology.

4.6.3. Wireless

The following diagram provides the proportion of products using wireless download.

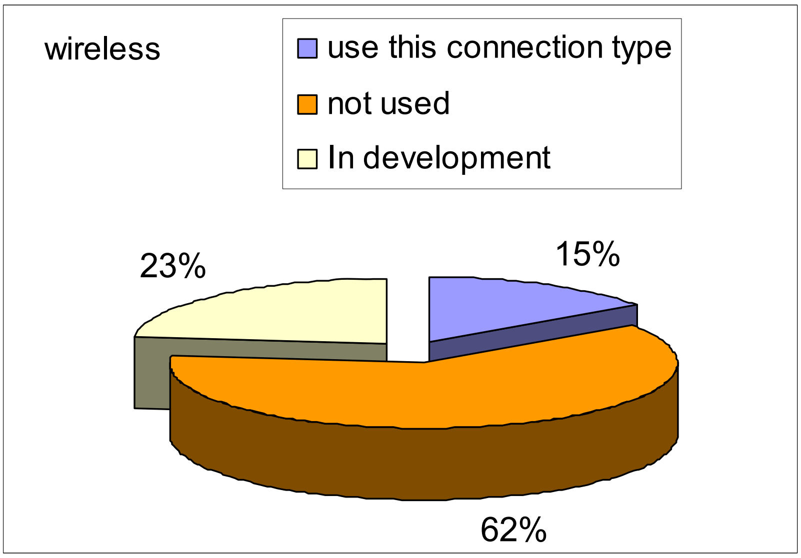


Figure 8: wireless technology.

The two products using wireless data download are using GSM/GPRS technology. The data are provided to the ground station via GSM provider.

No SAT communication solution has been used in the benchmarked products.

4.6.4. Wired

More than half of the recorders propose a wired downloading solution.

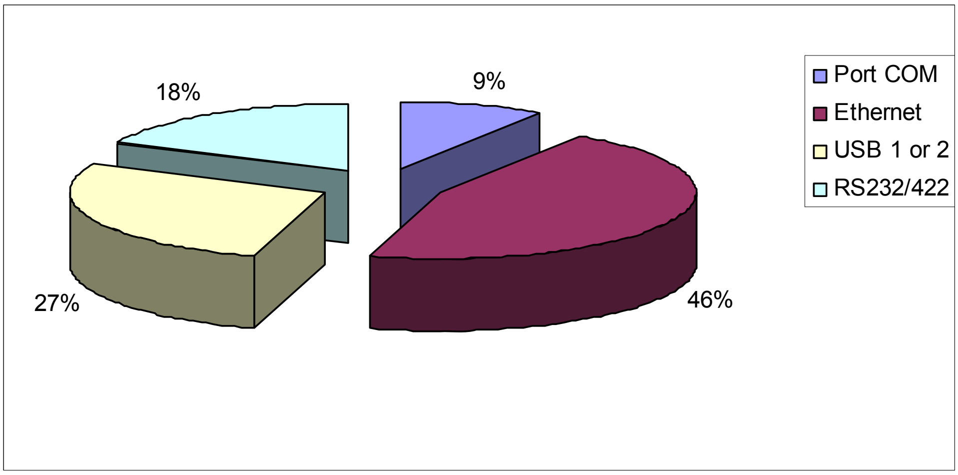


Figure 9: wired technologies.

4.6.5. Summary of Data transfer technologies

	Removable memory	SD Card	SSD	PCMCIA	Optical Disk	Compact Flash	Wired	USB	Port COM	Ethernet	RS 232 RS422	Wireless
ISEI	√	√					√	√				√
ECT	√	√					√		√			
Appareo	√	√										
PISearch							√			√		
ETEP	√		√				√			√		In development
IAERO	√	√					√				√	In development
THALES	√				√							
L3COM	√					√	√	√				
Meggit Avionics	√			√								
SES	√			√								
Avionica							√	√		√	√	In development
CTS	√			√			√			√		
Teledyne	√			√	√		√					√

Figure 10: data transfer technologies.

4.6.6. Data format

The data protection during download has not been clearly identified by the manufacturers. Three types of solutions are available:

- No data protection
- Light data protection using a proprietary format or password-protected file,
- Data encryption, not identified in the benchmark.

4.6.7. Data analysis

There are two possibilities to analyze the recorded data:

- Standalone ground station or device
- Web-Based services

ISEI		√	
ECT	√		
Appareo	√	√	
ETEP	√		
Iaero	√		
Honeywell	√		
Sagem	√		
Thales	√		
L-3 Com	√		√
Meggit Avionics	√		
SES	√		√
French flight safety		√	
Teledyne		√	
CTS	√		
Alysair		√	
Avionica	√	√	
	stand-alone	Web-based	Other (PDA,..)

Figure 11 : Analysis tools solutions

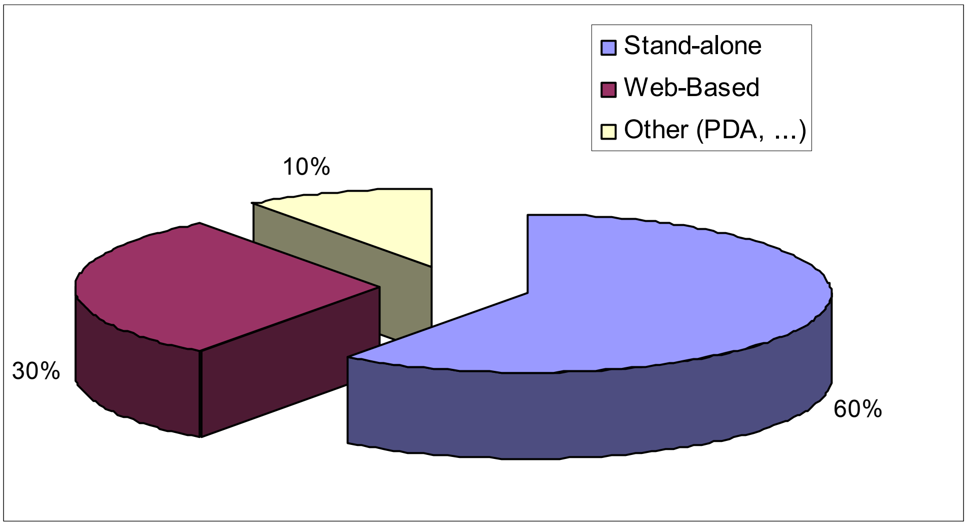


Figure 12: data analysis

4.6.8. Analysis tools capabilities

The ground station functions are divided in three categories: Playback capabilities, Events triggers detection and others capabilities (as commercial or management functions).

Playback:

Almost all of the manufacturers who answered propose to playback the acquired parameters in time curves or table forms. But some of them propose additional functions in order to facilitate the replay of the flight.
The following table describes these functions.

ISEI	✓	✓		
ECT	✓		✓	
Appareo	✓	✓	✓	
ETEP			✓	
Iaero	✓	✓		
Honeywell	No data available			
Sagem	✓	✓	✓	
Thales	No data available			
L-3 Com	✓	✓	✓	✓
Meggit Avionics	No data available			
SES	No data available			
French flight safety	✓	✓	✓	
Teledyne	✓	✓	✓	
CTS	✓	✓	✓	✓
Alysair	✓	✓	✓	No data available
Avionica	No data available			
	Flight trace available on 3D view	Aircraft attitudes displayed in the flight trace	Display of flight instruments	The user can create his own flight instruments

Figure 13: Ground station playback functions

Event capabilities:

The event trigger detection is a basic FDM function. But manufacturers can be distinguished by the available capabilities to manage these events.

The basic event detection capabilities are described hereafter.

ISEI	✓	✓	✓
ECT	✓	✓	✓
Appareo	✓	✓	✓
ETEP	No data availaible		
Iaero	✓		
Honeywell	✓		✓
Sagem	✓	✓	✓
Thales	No data availaible		
L-3 Com	✓	✓	✓
Meggit Avionics	No data availaible		
SES	No data availaible		
French flight safety	✓	✓	
Teledyne	✓	✓	✓
CTS	✓	✓	✓
Alysair	No data availaible		
Avionica	✓	✓	✓
	Event detection	Events can be modifyed by user	Detected event can be correlated with flight replay

Figure 14: Ground station event functions

Others capabilities:

Some manufacturers propose additional functions on their analysis tools. Some of these functions are described in the following table.

ISEI	✓	✓	✓	✓	✓
ECT				✓	
Appareo			✓		TBC
ETEP		✓			
Iaero					
Honeywell			No data available		No data available
Sagem		✓	✓	No data available	✓
Thales	No data available				
L-3 Com			✓		
Meggit Avionics	No data available				
SES	No data available				
French flight safety			✓		
Teledyne			✓	✓	✓
CTS					✓
Alysair	No data available				
Avionica	No data available				
	Billing management (according to fuel cumption, overruns…)	Management of aircraft log book	Automatic send report on defined events	Alert at the apporach of the maintenance visit	Fleet localisation and trace (after data downloading)

In addition the data access protection (passwords and rights according to each user) is proposed by all of the manufacturers .

5. Review of other works

5.1. Private initiatives

H/C type	Customer	Supplier (airborne)	Supplier (on ground SW)	Location	Sources: Press Release & more	Potential links with the expected recommendations issued from HOMP EASA for light h/c project
AS350 / A119[2]	ERA	IAC / Honeywell	SAGEM	USA	([3]) E-FOQA, as it is known at Era, is the first FOQA program approved for FAR (Federal Aviation Regulations) Part 135 operations. ([4]) Era Helicopters is the only helicopter operator with an FAA approved FOQA (Flight Operations Quality Assurance) program and the IAC 1134 is an integral part of this new program. The IAC 1134 has a fully programmable flight data recording capability resulting in an extremely light weight and affordable solution for light helicopters. IAC products and technology add value for our customers by applying easy-to-understand advanced technology solutions to complex problems that increase machinery availability, reduce operating costs, and improve safety. ([5]) Sagem Avionics, Inc. is pleased to announce that Era has selected the AGS (Analysis Ground Station) in-house software for their E-FOQA (Era – Flight Operational Quality Assurance) program. Sagem's proven results and return on investments (ROI) for helicopter operations made the AGS a clear choice for Era's E-FOQA program. Within one year of implementing the AGS with an offshore helicopter operation in Brazil, Sagem has	none

[2] Agusta
[3] (2007-08-14) http://www.erahelicopters.com/content/e8/e177/
[4] (2007-09-04) http://web.iac-nline.com/Headlines/headline_detail.asp?news_id=54
[5] (2007-01-01) http://www.sagemavionics.com/Press%20and%20Events/CurrentNews.aspx?pressId=13

H/C type	Customer	Supplier (airborne)	Supplier (on ground SW)	Location	Sources: Press Release & more	Potential links with the expected recommendations issued from HOMP EASA for light h/c project
					demonstrated more meaningful results than any other H-FOQA (Helicopter – Flight Operational Quality Assurance) program in the previous 10 years.	
EC120 / R22 / R44	IXAIR	ISEI	ISEI	FR	Installation of Safetyplane product on IXAIR H/Cs First feedback from installed systems on light H/C Mainly used for monitoring of H/C rental	Lessons learned directly reused in the frame of Light HOMP trial
BELL206 / BELL 407	Air Logistics	Appareo	Appareo	USA	([6]) APPAREO ALERTS GAU 2000 • Autonomous Inertial Measurement and GPS System • FAA STC for AS350 and EC130 since March 2009	Appareo & Air Logistics presentation to EC and American Eurocopter in Feb 2008

[6] (2009-03-23): draft EC presentation HOMP CHC Summit 09-04-01.ppt (CHC Safety seminary)

5.2. *Initiatives linked to Organizations*

- **EUROCAE ED1555: MOPS requirements document for light H/C recorders**

  This document defines the minimum specification to be met for aircraft required to carry lightweight flight recording systems which may record aircraft data, cockpit audio, airborne images or data-link messages; in a robust recording medium primarily for the purposes of the investigation of an occurrence (accident or incident). It is applicable to robust on-board recording systems, ancillary equipment and their installation in aircraft.
  This document can also be used to give guidance to manufacturers intending to develop or install lightweight flight recording systems which maybe used for or other purposes such as flight training, flight data monitoring…
  This document responds to a need for improved recording of vital information on small aircraft needed for aviation safety investigations. This document defines recording functions (aircraft data, cockpit audio, airborne images and data-link) as individual Parts along with a common section, applicable to all Parts. Parts may be revised independently of each other and independently of the main body of this document.
  Today, this document is yet in draft version (WG77 is closed after the last meeting of March 2009), but it will be released by the middle of 2009 (June).

- **Final Report on the Helicopter Operations Monitoring Programme (HOMP) Trial – CAA paper 2004/12 (not specific to light h/c)**

  This report presents the results of the CAA-funded follow-on activities to the Helicopter Operations Monitoring Programme (HOMP) trial that completed in late 2001. The CAA published the final report on this work (CAA Paper 2002/02) in September 2002. As a result of the success of the trial, UKOOA committed its members to fund the implementation of HOMP on all FDR-equipped UK public transport helicopters operating over the UK Continental Shelf. With UKOOA's help, Bristow Helicopters Limited (BHL) has now fully implemented HOMP on the whole of its North Sea helicopter fleet, located at four different operating bases.
  To help to facilitate this wider implementation of HOMP, the CAA funded a follow-on programme of work with the two primary objectives of:

  - Transferring the HOMP to a second UK operator, CHC Scotia Limited (Scotia),
  - Developing the HOMP for a second helicopter type, BHL's S76.

  A secondary objective was to continue to develop and refine HOMP data analysis capabilities using the new experience gained. This report presents the results of the CAA-funded work and also contains additional experience from BHL's on-going AS332L programme, as this provides useful complementary information.
  Study results: The follow-on programme resulted in a successful trial of HOMP within Scotia on two AS332Ls and also a successful HOMP implementation on BHL's S76s. The results obtained provide further evidence of the safety benefits of HOMP. Both BHL and Scotia identified significant safety issues as a result of their programmes and were able to take corrective measures to address them [..] They have been able to demonstrate a reduction in operational risk as a result of the actions taken. [..]
  The HOMP events continued to be developed, with two new types of event being implemented as a result of pilot-reported occurrences. In addition, the event severity allocation guidelines developed by BHL in the main HOMP trial were evaluated by both BHL and Scotia in the follow-on work. The results showed that the guidelines provide a good basis for severity allocation, but there is a need for guidance material to achieve greater standardisation of the process. The flight data measurements continued to be refined and were used to demonstrate a capability to 'map the helideck environment', to characterise problems of both structure induced turbulence and hot turbine exhaust plumes on offshore platforms.

- **CAA Safety Regulation Group CAP 739 Flight Data Monitoring 2003/08/29 (not specific to light h/c)**

  This document outlines good practice relating to first establishing and then obtaining worthwhile safety benefits from an Operator's Flight Data Monitoring (FDM) programme. It will be regularly reviewed and revised by CAA and the Industry to reflect the wider use of FDM and developing technologies and methodologies. The objectives of the document are to:

- Give guidance on the policy, preparation and introduction of FDM within an operator,
- Outline the CAA's view on how FDM may be embodied within an operator's Safety Management System,
- Describe the principles that should underpin a FDM system acceptable to the CAA.

The flight data analysis performed for a FDM programme includes event detection and the taking of routine flight data measurements. These are described in CAP 739 as follows:

- Event (or Exceedance) Detection: is the traditional approach to FDM that looks for deviations from flight manual limits, standard operating procedures and good airmanship. There are normally a set of core events that cover the main areas of interest that are fairly standard across operators.
- Routine Data Measurements. Increasingly, data is retained from all flights and not just the significant ones producing events. The reason for this is to monitor the more subtle trends and tendencies before the trigger levels are reached. A selection of measures is retained that are sufficient to characterize each flight and allow comparative analysis of a wide range of aspects of operational variability.

5.3. *Eurocopter's Experience & Initiatives for medium and heavy helicopters*

H/C type	Customer	Supplier (airborne)	Supplier (on ground SW)	Location	Sources: Press Release & more	Potential links with the expected recommendations issued from HOMP EASA for light h/c project
EC225 EC155 EC135 EC145	Oil & Gaz	SAGEM (MFDAU-QAR) CTS (QAR EC155)	CTS (PGS SW)	-	([7]) EC proposal based on FLIGHT DATA VISION product "PGS suite" to offer Turn Key Solution to customers: • Data frame list integration in Ground software package • Minimum Events baseline to start HFDM program immediately • Training session & help desk support • Already deployed: DANCOPTER, HU (in progress)	Contribution to Events definition

[7] (2009-03-23) draft EC presentation HOMP CHC Summit 09-04-01.ppt (CHC Safety seminary)

6. Analysis of costs and expected benefits

6.1. Expected benefits

The expected and identified benefits have been analysed following the various existing or planned use cases of Safetyplane at IXAIR and other similar systems, as well as potential benefits for the Helicopter manufacturer and Aviation Authorities.

Benefits for training school:

The overall FDM contribution is to provide an enhanced support for training debriefing sessions.
The added value is provided by the following capabilities:

- Potential reduction of accident/incident rate
- Follow-up of trajectories, speed, attitudes
- Validation of training programs
- Analysis of trainee's behavior during solo flights (eg Flight replay)
- Analysis of trainee's behavior during dedicated phases (eg start-up procedure)
- Analysis of flight incidents
- Awareness of pilots with respect to maintenance actions linked to exceedances

Benefits for helicopter operations:

- Potential reduction of accident/incident rate
- Monitoring of trajectories, speed, attitudes
- Compliance to Standard Operating Procedures (SOP) and adjustment of SOPs
- Availability of flight hours after each flight for maintenance purposes
- Availability of helicopter positions after each mission
- Management of pilot flight hours
- Fleet planning and booking
- Management of invoicing and payment
- Visibility on dry-rental flight conditions
- Support for OPS3 requirements (section 515 & following): Exposure Time-flights in hostile environments
- Potential reduction of insurance fees
- Fuel savings (adherence to SOPs)
- Analysis of flight incidents (not a primary goal of HOMP systems)

Benefits for maintenance activities:

- Reliable and accurate identification and storage of limitations exceedance
- Reliable identification and storage of red & amber warnings
- Support for planning of maintenance activities
- Support for failure diagnostic based on selected data
- Detection of events requiring maintenance actions (eg hard landing)
- Helicopter localization when landing after failure
- Forecast of Spare orders based on status provided by the system
- Engine power check (ground based)

Benefits for the helicopter manufacturer:

- Potential reduction of accident/incident rate
- Support to accident/incident analysis
- Better knowledge of fleet status(flight hours/product and mission)
- Support to "By The Hour" contracts
- Support to Spares forecast
- Contribution to product and training improvement
- Support to Training Need Analysis

- Comparing the performance of dedicated H/C with the fleet average
- Early support to Manufacturer technical support activities
- Decision aid in the frame of deviation requests (TBO, SLL, …)

Benefits for Aviation Authorities

- Potential reduction of accident/incident rate
- Support to accident/incident analysis

6.2. FDM Cost analysis

The following costs are based on available commercial data from ISEI or other FDM suppliers.
The values need to be considered as orders of magnitude.

6.2.1. Identification of Non-Recurring Costs

Procurement	Airborne HW	Procurement cost: 5-15 k€ / HC
	Ground Station HW	Procurement cost: 0 (existing PC)–10 k€ / Ground Station (GS)
	Ground Station SW	Procurement cost : 0 (cost per flight hour)–10 k€ (depending on commercial policy) per Ground Station
Installation	Documents	STC cost : depending on the amortization logic
	Airborne HW & sensors	Installation Kit: 1 k€ / HC
	Workload	By authorized organization: 0.5–2 k€ / GS
	Ground station HW	Installation cost: 0 (existing PC)–0.5 k€ / GS
	Ground Station SW	Installation cost: 0–0.5 k€ / GS
Training	Ground Station	User training: 1 k€ / user

Total NRC :

- Total H/C-related NRC : 7 – 16 k€ per H/C
- Total GS-related NRC : 1 – 23 k€ per GS

6.2.2. Identification of Recurring Costs

Operations	Data transfer (H/C-GS)	GSM monthly costs: 15–20 € Manual transfer effort: 400 € / month / HC
	Ground segment software/services	License/service costs: 2 000 € / HC / year
	Data analysis	Effort spend: 1 day / HC / month (350 €)
Maintenance	Ground station	Maintenance contract of HW & SW 15–20 % of NRC
	Airborne equipment	Maintenance contract of HW: 0–10 % of NRC depending on commercial policy (per year)

Total RC:

- Total HC-related RC : 9 600 € / year + HW Maintenance contract value / year
- Total GS-related RC : GS Maintenance contract value (where applicable)

6.2.3. Estimated savings

The implementation of an FDM program will increase the overall fleet safety, reduce incidents/accidents occurrence and therefore reduce the risk of associated consequences:

- Fatalities
- Unavailability of aircraft
- Loss of business
- Investigation/expertise

- Repair costs.

Other benefits have been identified / assessed:

- Invoicing and payment: the saving is estimated between 5 and 10 € per invoice
- Capture of Flight hours: the manual capture is estimated to be 15-20 min per Flight
- Savings in maintenance activities: To be assessed in phase 2
- Fleet planning and booking: To be assessed in phase 2
- Pilot electronic log book: To be assessed in phase 2
- Potential Insurance reduction: To be assessed in phase 2.

7. Recommendation of small helicopter FDM and HOMP configuration and specifications

- **Weight**

  The recommended target weight for the FDR Airborne equipment(s) shall be in the range 500g-1000g.
  The target weight shall include the equipment(s), the potential mounting rack, the battery if included.
  The target weight does not include any cockpit camera (maximum weight 300 g).
  The equipments considered shall cover the recommended functions (see below).
  Cables and equipment-external sensors are excluded.

- **Size/volume**

  Single equipment solution is recommended to ease H/C integration, although Multiple-equipment solutions may be needed to provide extension capabilities.
  Current products range between 200 cm^3 and 800 cm^3 which is considered acceptable (camera excluded).
  Recommended maximum camera volume: 200 cm^3
  The equipment form factor should be compliant with NFL65-211/212 or equivalent for equipment which needs to be installed in inter-seat console.
  No specific recommendation is provided for equipment to be installed outside of the cockpit.

- **Compliance to DO160F**

  Recommendations provided in ED155 (chapter I-3) should be used.

- **Compliance to DO178**

  No compliance requirement to DO178 levels A-B-C-D is recommended due to cost constraints as recommended in ED155.

- **Recording capacity**

  Video recording capacity should be minimum 2 hours.
  Parameter recording capacity should allow recording at least all flights during 1-2 days for HOMP processing and 100 h minimum for other purposes.

- **Memory robustness**

  Recommendations provided in ED155 (chapter I-3) should be considered if the equipment has to be used also for crash investigation.

- **Download**

  Automatic transmission after each flight is recommended.
  Transfer of data triggered by a crew member can lead to miss flight data for two main reasons:

  - **The memory card is missing in the equipment,**
  - **The crew forget (voluntarily or not) to download the data.**

  Wireless transfer is the preferred solution.
  Due to current bandwidth limitations of wireless technology, the video download needs to be performed using a memory media or a wired link.

- **Parameters**

  For FDM functions, 3 lists of parameters have been identified:

  - Minimum list of parameters which are considered mandatory to analyze the basic trajectory issues
  - Recommended list of parameters allowing:

- A refined analysis of trajectory using aerodynamic data,
- An additional analysis based on engine parameters (monitoring of limitations),

In addition to the above list, the cockpit video recording is recommended to :

- Have access to parameters not recorded,
- Analyze the crew behaviour,
- Analyze any incident,
- Contribute to training debriefing.

o Complementary list of parameters allowing to extend the scope of the FDM program; the proposed list includes :
  - The ground height: this parameter is a key safety one and would be part of list 1, if the helicopter was fitted with a radar-altimeter. However, the sensor is expensive and rarely fitted on light helicopters,
  - Helicopter red and amber available warnings,
  - Any other relevant parameters could be recorded depending on the helicopter type, configuration or on the specific need.

The parameter recording rate should be comprised between 1 Hz and 5 Hz depending on the dynamic of the parameter. The video recording rate should be 4 Hz and the image resolution should be at least 2 Mpixels.

List 1 parameters	
ATTITUDE	
	Heading
	Roll
	Pitch
	Yaw rate
	Roll rate
	Pitch rate
	Vertical acceleration
	Lateral acceleration
	Longitudinal acceleration
GPS LOCALIZATION	
	GPS Time
	GPS Altitude
	Longitude
	Latitude
	Trajectory / route
	Vertical speed GPS
	Ground speed

List 2 parameters	
AERODYNAMIC	
	Outside Air Temperature
	Static pressure
	Total pressure
	Indicated Air Speed
	Vertical Speed anemometer
ENGINE	
	NG (engine gas generator speed)
	NF (free power turbine speed)
	NR (main rotor speed)
	T4 (engine exhausted gas temperature)
	Torque
	Fuel level
OTHER	
	Video recording

List 3 parameters	
	Ground height (if available)
	Warnings (if available)
	Other

- **Data protection**

  A proprietary format for data transfer between FDR and Ground segment is recommended to prevent access from unauthorized personnel.

- **Functions**

  The main functions of FDM should be:

  o For each flight:
    - Automatic detection of event triggers
    - Event analysis through 3D replay, parameter replay …
    - Analysis of all occurred incidents.

  o For periodic analysis: all kinds of statistics needed.

Proposal for HOMP Events

	List 1 Parameters															
Level 1 events	Date	GMT time	Ground Speed	GPS altitude	Longitude	latitude	Vertical Speed	Heading	Roll	Roll rate	Pitch	Pitch Rate	Yaw Rate	Normal Acceler.	Longitudinal Acceler.	Lateral Acceler.
Fast hover (sea level)	X	X	X	X	X	X										
Excessive pitch down on take off (sea level)	X	X		X	X	X					X					
Premature departure turn (sea level)	X	X	X	X	X	X	X	X								
Excessive climb	X	X	X	X	X	X	X									
Low cruise (no safety)	X	X	X	X	X	X	X									
Settling with power	X	X	X		X	X	X									
Excessive bank	X	X			X	X			X	X						
Excessive pitch	X	X			X	X					X	X				
Excessive yaw	X	X			X	X							X			
High normal acceleration	X	X			X	X								X		
High longitudinal acceleration	X	X			X	X									X	
High Lateral acceleration	X	X			X	X										X

Excessive descent	**X**	**X**	**X**		**X**	**X**	**X**									
Low turn to final approach (sea level)	**X**	**X**			**X**	**X**										
Excessive pitch up on landing or before hover	**X**	**X**	**X**	**X**	**X**	**X**					**X**					
	List 2 Parameters															
Level 2 events	**NG**	**T4**	**Torque**	**Engine Oil Press**	**Engine Oil Temp**	**NR**	**OAT**	**Static Pressure**	**Total Pressure**	**Take-Off Detection**	**Fuel Level**	**Fuel Rate**	**Particles Detection**	**Other?**		
Limitation exceedances and new possible events	**X**	**X**	**X**	**X**	**X**	**X**										
Improvement of level 1 defined events by using air data							**IAS, TAS, Vz, Zi, Zp**									
Improvement of level 1 defined events depending on avionic system fitted										**X**	**X**	**X**	**X**	**X**		
	List 3 parameters															
Level 3 events	**Radio altitude**															

Improvement of level 1 defined events with ground height parameters	**X**													

The above proposal is an input to phase 2 activities and will be further analyzed and refined.

- **Price**

  The target price for such FDR device (including harness and image recording) for standard parameters should be less than 10 000 €.
  Other costs should be taken into account: ground station acquisition, fees for the software licences and/or web access.
  Target price for ground segment: 3000 € – 4000 € per year.

- **Data Analysis**

  Some companies are providing HOMP services addressing various levels of flight data analysis. Those services can be helpful in dedicated situations.
  As a general recommendation, the corrective actions resulting from Flight data analysis process shall be performed by the organization operating the helicopters.
  In order to limit the HOMP overhead, the process for flight data download, analysis and feedback to the HOMP responsible has to be automated as much as possible. This has been confirmed by feedback from operational use of systems using a manual data download process.

7.1. Summary of recommendations

In addition to the above technical and economical recommendations, the successful implementation of a HOMP program for light helicopters requires additional organizational features.

- A minimum safety culture (non-punitive) providing the needed transparency (consistent with Safety Management System basics),
- The involvement of the company top management (consistent with Safety Management System basics),
- An assessment of the organization related processes,
- The set-up of the HOMP program processes.

The combinations of safety and other operational benefits should allow the current FDM technologies to be affordable for small a medium size light helicopter operators.

Acronyms

AerialW	Aerial Work
ARINC	Aeronautical Radio INCorporated
CAT	Commercial Air Transport
CF	Compact Flash
Comm	Commercial
FDM	Flight Data Monitoring
FDR	Flight Data Recorder
FOGA	Flight Operations Quality Assurance
GA	General Aviation
GPRS	General Packet Radio Service
GSM	Global Systems Mobile
HEMS	Helicopter Emergency Medical Service
HOMP	Helicopter Operational Monitoring Program
HUMS	Health and Usage Monitoring System
NF	Free Power Turbine
NG	Gas Generator Speed
NonComm	Non Commercial
NR	Main Rotor Speed
PCMCIA	Personal Computer Card International Association
PDA	Personal Digital Assistant
SAR	Search And Rescue
SD	Secure Digital
SSD	Solid State Drive
T4	Turbine exhausted gas temperature (or TOT)
UMS	Usage Monitoring System
USB	Universal Serial Bus
w/s	Words per second