EUROPEAN OPERATORS FLIGHT DATA MONITORING FORUM
WORKING GROUP C

SAFETY PROMOTION
Good Practice document

‘BREAKING THE SILOS’

FULLY INTEGRATING FLIGHT DATA MONITORING

INTO THE SAFETY MANAGEMENT SYSTEM

December 2024

Revision 1 (unedited)

Contents

Note

This document was produced by Working Group C of the European Operators Flight Data Monitoring forum (EOFDM WG-C – Integration of an FDM programme into operator processes).

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Revision 1 of this document is the deliverable for the following action in the European Plan for Aviation Safety (EPAS) Volume II[1], 2024 Edition:

Safety Promotion Task SPT.0126	**Integrating the flight data monitoring (FDM) programme with safety risk management (SRM)**
Produce good practice for integrating the FDM programme with the operator's SRM, with a focus on risk assessment and on supporting flight crew training.	

If you would like to provide your comments or feedback on this document, please write to: fdm@easa.europa.eu.

Information on the EOFDM forum and other good practice documents produced by the EOFDM can be consulted on the EASA website at https://www.easa.europa.eu/en/domains/safety-management.

[1] The EPAS constitutes the regional aviation safety plan for EASA Member States, setting out the strategic priorities, the main risks that affect the European aviation system, and the necessary actions to mitigate those risks to further improve aviation safety. The EPAS is prepared by EASA together with the EASA Member States. EPAS Volume II contains the programmed actions for the coming 3-year period.

Log of revisions

REVISION NUMBER	DATE	SUMMARY OF MAIN CHANGES
Initial issue	June 2019	Not applicable
Revision 1	December 2024	A new section on integrating the FDM programme with the operators' safety risk management (SRM) process has been introduced in Chapter I. Three case studies have also been introduced in that chapter to provide examples of using FDM data to support the SRM process. The results of a survey carried out in 2018, which were presented in Chapters I and II, have been replaced with survey results from the year 2023. In Chapter III, a new methodology to define FDM events that support the objectives of the flight crew training programme has been introduced. This methodology was then applied to the minimum flight crew training syllabus specified for both aeroplane and helicopter pilots, and to a subset of the minimum evidence-based training (EBT) syllabus; the resulting examples are presented in a new appendix.

Introduction

1. Background

Flight data monitoring (FDM) was born in the 1970s to support safety assessment tasks. Several large European airlines identified at that time the potential benefit of FDM and pioneered this domain. With the progress in information technologies of the 1980s and 1990s allowing to record and process even greater amounts of digital data, FDM steadily gained momentum and recognition, resulting in the International Civil Aviation Organization (ICAO) introducing in Annex 6, a standard applicable to aeroplanes with a MCTOM in excess of 27 000 kg. The Joint Aviation Authorities (JAA) introduced a similar requirement in JAR-OPS 1, making FDM a necessary component of an operator's accident prevention and flight safety programme[2]. In parallel to that, other types of operators than large airlines (business jet operators, helicopter operators) decided to set up on a voluntary basis an FDM programme, and to adapt the concept of FDM to their particular organisations.

In the first decade after year 2000, the notions of quality system and of accident prevention and flight safety programmes defined by JAR-OPS 1 were superseded by the concept of safety management system (SMS). It eventually resulted in the creation of a dedicated ICAO Annex (Annex 19) in 2013. As a consequence of this conceptual change, the FDM programme was declared a part of the SMS and as such had to be integrated into SMS processes[3].

However, at the time this document was first written, an FDM programme was still perceived by some operators as a stand-alone process, separated from other safety data collection and analysis schemes. There was still little practical guidance available on integrating an FDM programme with the operator's SMS, and in particular on linking FDM with other data sources. This translated for some operators into maintaining non-integrated structures in their organisations (e.g. FDM team and SMS team being kept apart) or internal restrictive policies (such as forbidding any use of flight data for other purposes than the FDM programme).

In parallel, Regulation (EU) 2016/679[4] entered into force in 2018 to provide for an EU-wide framework for the protection of personal data. While that EU Regulation is driven by concerns with other industries than aviation, it impacted all processes whereby data related to an individual are collected, including the FDM programme. This did not only raise again questions about correct implementation of an FDM programme, but it also created an opportunity for operators to embrace a common approach for the collection and processing of safety-related data.

This document is meant to provide some practical advice for overcoming the issues related to the integration of an FDM programme with:

- other safety data collection processes,
- the operators' SMS, and in particular with their safety risk management (SRM) process, and
- the operators' flight crew training programme.

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[2] Refer to JAR-OPS 1 Section 1, 1.035 and 1.037.
[3] Refer to ICAO Annex 6 Part I, Chapter 3 Section 3.3, and to Regulation (EU) No 965/2012 point ORO.AOC.130.
[4] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (OJ L 119, 4.5.2016, p. 1).

Note 1:
While the EOFDM Working Group C was drafting Revision 1 to this document, amendments to the AMC and GM to the FDM requirements were being prepared under the EASA rulemaking task RMT.0392[5]. As these amendments were not finalised at the time Revision 1 to this document was adopted, it does not contain good practices to specifically implement these amendments.

Note 2:
This document sometimes refers to another EOFDM document titled 'Preparing a memorandum of understanding for an FDM programme'. This is because the two documents are considered complementary.

2. Definitions

According to Annex I (Definitions applicable to the rules for air operations) to Regulation (EU) No 965/2012, '**flight data monitoring (FDM)**' means the proactive and non-punitive use of digital flight data from routine operations to improve aviation safety.

According to Regulation (EU) No 376/2014, '**just culture**' means a culture in which front-line operators or other persons are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, but in which gross negligence, wilful violations and destructive acts are not tolerated.

Throughout this document:

'**flight data**' designates parametric data recorded on-board the aircraft by a system dedicated for this purpose (for instance, this system can be a flight data recorder or a quick access recorder).

Note: Flight data is the data necessary for running an FDM programme; however, it can also be used for other purposes.

'**FDM data**' designates flight data collected and analysed in the framework of the FDM programme. This includes raw flight data as well as processed flight data, such as FDM event triggers, FDM-based safety performance indicators and FDM statistics.

'**FDM event/Exceedance**' designates circumstances detected by an algorithm looking at flight data.

'**Safety culture**' designates the set of enduring values and attitudes regarding safety issues, shared by every member of every level of an organisation. Safety culture refers to the extent to which every individual and every group of the organisation is aware of the risks and unknown hazards induced by its activities; is continuously behaving so as to preserve and enhance safety; is willing and able to adapt itself when facing safety issues; is willing to communicate safety issues; and consistently evaluates safety-related behaviour.

[5] Refer to EASA Notice of Proposed Amendment (NPA) 2024-02 'Regular update of the air operations rules — Enhanced implementation of FDM programmes and miscellaneous amendments'.

I. Practicalities of integrating FDM into the Safety Management System

1. Enriching FDM with other data sources

A. THE LIMITATIONS OF FLIGHT DATA TAKEN ALONE

Flight data in isolation provides at best information as to 'What happened' and does not provide the 'Why it happened'. When additional data (such as contextual data) related to an incident, is combined with FDM, then it becomes easier to understand why an incident occurred. In addition, for some kinds of incidents, flight data is not even sufficient to understand what happened (e.g. in the case of an airprox). Moreover, detecting trends or improving operational procedures would be virtually impossible if FDM data were considered outside the actual circumstances.

See also examples in section I.4.

B. WHAT THE OPERATIONAL CONTEXT CAN BRING TO THE UNDERSTANDING OF FDM DATA

Several other types of factual (non-subjective) information available to the operator can be combined with FDM data to allow a more accurate analysis of occurrences and their findings ('contextual data'). For instance, weather, traffic data, and aircraft documentation are some of the types of data which can help FDM gain a more accurate assessment of occurrences.

Contextual data can be used in the framework of FDM for a dual purpose:

- Better analysis of individual FDM event triggers; and
- Context-enriched FDM statistics, which address practical questions regarding the safety trends and better support decision-making.

Table I.1 presents various contextual data which can be associated with FDM data.

Table I.1: Examples of contextual data that can be combined with FDM data

Type of contextual data	**What information does this data bring for FDM?**	**Possible data source(s)**
Aircraft publications	Knowledge of the applicable SOPs	Aircraft flight manual, aircraft operating manual
Operational flight data: aircraft tail number, flight number, departure point, arrival point, route, etc.	This enables the FDM data of a given flight to be associated with operational information, e.g. aircraft load and trim data, nature of flight delay if any	Records from the operational control over the flights (flight dispatching)
Weather: en-route weather, night/day and visibility conditions, local sunrise and sunset time	Identify adverse weather phenomenon (turbulence, storms, icing, wind shear)	Local weather stations (SIGMET, AIRMET, TAF, METAR) or national weather offices (satellite maps)
Available airfield infrastructure, Navigation	Constraints imposed by the departure/arrival airfield and	AIP, OFP

Type of contextual data	What information does this data bring for FDM?	Possible data source(s)
aids and departure/arrival procedures	departure/arrival procedures on the conduct of the flight	
Airfield and runway condition	Runway friction condition, closed runway and taxiways at the time of landing/take-off	NOTAM, runway condition report (RCR)
Computed performance data: computed weight and balance and other computed values, such as V1, V2, available runway. Also including performance data, and profiles of departure and arrival for helicopters	Identify any mismatch between the expected performance and the actual performance of the aircraft	EFB, FMS
Flight plan, delay in departing, and airspace restrictions	Contextual information to better reconstruct the history of the flight	Operator
Traffic data	Other traffic around (gives an indication of how busy ATC is and of the actual risk of airprox)	ATC surveillance data, ADS-B data from private suppliers
Training and experience of flight crew members	Example: to check whether the flight crew member was trained on a particular aspect	Operator training programme, consolidated/aggregated feedback from training records
Fatigue: flight activity of the flight crew members in the last 72 hours, fatigue risk index or alertness level	Level of fatigue of flight crew members (human factor)	FRMS, rostering system, rosters' robustness assessment result
Aircraft maintenance history	Whether a particular aircraft has been susceptible to repeated system failures	Aircraft technical logs, such as maintenance intervention, or defect and reliability reports, is Vehicle Health Monitoring data (or Health and Usage Monitoring System data in the case of a helicopter)
Terrain model	Constraints imposed by the surrounding terrain. Analysing approaches to airfield where there are frequent TAWS alerts. Identify local weather phenomena caused by terrain (e.g. mountain wave).	Geographical information system, terrain databases

Note:

This table is not meant to be exhaustive. More data sources may become available in the future.

Some contextual data would need to be obtained close to the time of the FDM event trigger or the FDM measurement (e.g. local weather conditions, landing runway condition, etc.).

Nevertheless, caution should be exercised when using FDM data combined with information that may lead to the disclosure of crew member identities, such as training records or tail/flight number and date (see subsection I.1.d. below). In these cases, adherence to the confidentiality principles and the just culture policy should be ensured.

C. WHAT AIR SAFETY REPORTS CAN ADD TO FDM

The narrative from an air safety report (ASR) associated with an event can provide information that is not recorded by flight data. Examples include actual weather conditions at the time of an event and ATC clearances. A report also provides information about flight crew perception and recollection of the flight, their intentions and a rationale for their actions.

In addition, if a report has been submitted and there is no corresponding FDM event trigger, then this may identify an issue with the event detection logic. In addition, ASRs can be used to identify the need for the implementation of new FDM events, and/or refine the detection logic of an FDM event.

For situations involving inadequate use of airborne systems, FDM and ASR data can be correlated to understand whether a repetitive issue is being reported by flight crews. The benefits of combining ASR with FDM statistics for this purpose could be to:

- define an FDM event in order to assess the actual extent of the issue;
- monitor the effectiveness of risk mitigation with FDM (not just counting ASRs);
- identify those categories of FDM events which are underreported and understand why they are not perceived as significant by the flight crews (or have flight crew members got used to experiencing the deviations tracked by the FDM events?);
- define an event risk score to be used for deciding on follow-up actions.

> Note: When facing a recurrent issue during the operation (such as a technical failure or an issue with the SOP), the natural human tendency is to not report it any more after a couple of occurrences. This is because one gets used to the issue or reporting is perceived as a waste of time when this issue is perceived as known. In that case, FDM may facilitate a quantitative assessment of the issue and of any related trend.

Conversely, the investigation of significative events raised by the ASR may often be supported by the analysis of the related FDM data.

For that matter, it would be highly efficient if the data from both sources (FDM and internal reporting system) could be collected, processed and analysed in a coordinated manner, so that one process can benefit from the data made available by the other.

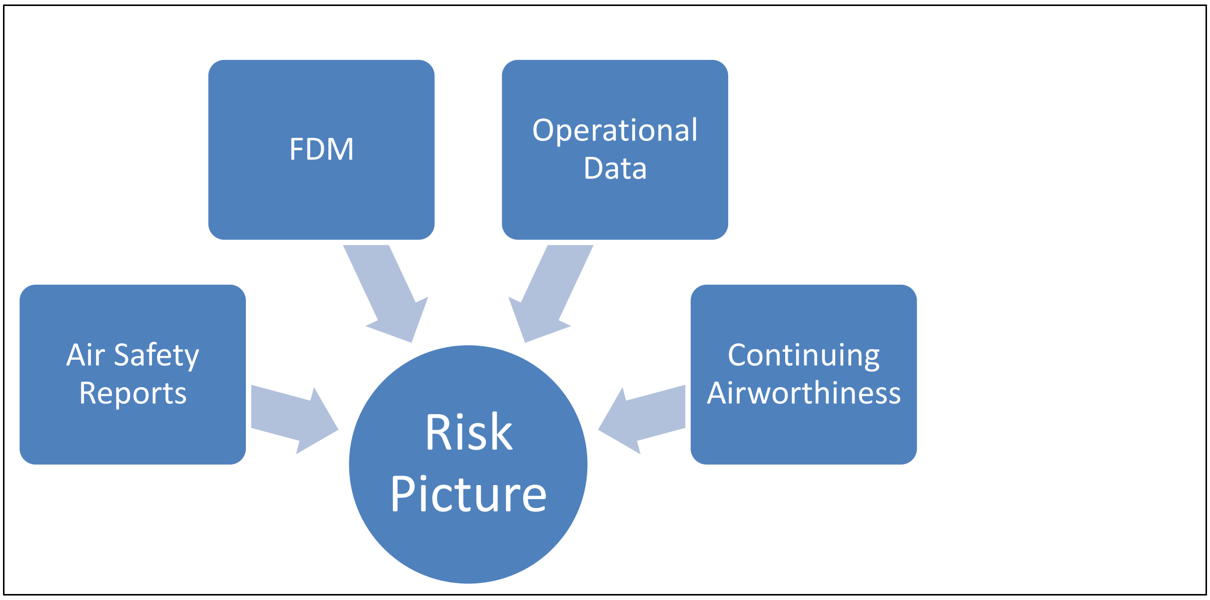
D. AUTOMATICALLY COMBINING FLIGHT DATA WITH OTHER DATA

A ‘common identification data point’ is necessary to combine the flight data with other data source. Examples include:

i. Flight number or tail number and departure date and time;
ii. Departure point and actual departure date and time; or
iii. Arrival point and actual arrival date and time.

Once a unique flight has been identified, it will then be possible to combine flight data related to this flight with other safety data (see Figure I.1). In order to facilitate the merging of all this data, the creation of a data repository is advisable. This usually requires setting up a dedicated IT project.

Figure I.1: Example of sources of safety data that can contribute to the risk picture



2. Integrating FDM into the SMS

A. PRACTICAL BENEFITS OF FDM INTEGRATION INTO THE SMS

FDM offers numerous benefits in the context of Safety Management System (SMS), the major ones being the the following:

- **Elevated safety awareness:** FDM increases safety awareness across all departments, including non-operational areas such as human resources or finance. By providing detailed flight data, it offers greater clarity on safety-related occurrences, leading to an enhancement of the safety culture across the organisation.
- **Enhancing operational standardisation:** FDM helps improve the standardisation of operations by providing aggregated or individual feedback to flight crews. Feedback can serve as a tool for flight crews to enhance their performance regarding compliance with the company's Standard Operating Procedures (SOPs).

- **Safety promotion and communication:** FDM enhances communication regarding safety risks and the dissemination of investigation outcomes, such as the findings from safety occurrences or lessons learnt. This might include specific operational trends observed or challenges faced at particular airports or with particular fleets.
- **Improved situational and operational awareness:** FDM provides clear situational and operational insights for upper management and key stakeholders. For instance, it can provide accurate data on operational issues specific to an airfield, a fleet, or even certain routes.
- **Increased transparency**: FDM promotes transparency and accuracy in safety and operational reporting, helping to foster trust and confidence in the organisation's safety management processes.
- **Effective change management:** FDM can play a crucial role in managing changes, such as monitoring the implementation of new SOPs, assessing operations during the introduction of new fleets, or tracking deviations when new pilots join the operator.
- **Risk management**: FDM provides objective data that supports the identification and evaluation of safety risks. It also helps monitor the effectiveness of existing and newly introduced risk-mitigation measures or SOPs.
- **Safety assurance**: FDM offers a transparent means of measuring operational compliance, such as tracking unstabilised approaches or high descent rates, thereby ensuring adherence to safety standards.
- **SMS audits**: FDM is a valuable data source for both reactive reporting (e.g. occurrence or hazard reporting) and proactive reporting (e.g. raising safety awareness). It forms part of the evidence required during internal and external audits to demonstrate that safety risks have been effectively managed and mitigated.
- **Safety Performance Indicators (SPIs):** Aggregated FDM data can be used to track SPIs linked to an operator's risk register, helping to identify trends and areas needing attention.

B. HOW CAN FDM BE USED AS PART OF THE SMS

Objectives

The objective should be to support the core processes of the SMS, in particular the identification and assessment of risks. The FDM programme may play an important role among SMS data sources because it has the potential to capture all flight operations, record every programmed measurement or deviation, and support the accurate reconstruction of incidents. Refer also to the EOFDM document 'Preparing a memorandum of understanding for an FDM programme'.

Risk management

The analysis of flight data allows the early identification of hazards and operational risks that potentially affect the safety of aircraft operations. By risk-assessing flight data, it is possible to identify the need to implement risk-mitigating actions to prevent accidents or incidents from occuring.

Risk monitoring

FDM-based indicators should be part of operational risk monitoring, whenever possible. FDM processes should be as transparent as possible, and FDM should provide up-to-date information to all management levels and flight crews.
These FDM-based indicators should provide up-to-date information and they should be fully integrated with the SMS SPIs.

Note: Using FDM for risk monitoring implies that a system is in place allowing the collection and analysis of flight data on a frequent basis.

C. FDM ORGANISATIONAL INTEGRATION

When addressing the organisational integration of FDM, the operator must revert to the 'Why' question, followed by the 'How' and finally 'What', in order to have a holistic and clear view of the possible ways to integrate the FDM programme:

- Why collecting flight data: Is it only for compliance with the rules or a customer agreement, or is it for enhancing operational safety (e.g. better monitoring a risk portfolio), or for improving operational efficiency (e.g. fuel, use of brakes, etc.)?
- How can the FDM programme be designed and integrated with the SMS so that the objectives in the previous question are met?
- What principles should be defined in the internal policy ruling the SMS and the FDM to ensure the efficient exchange of data?

A clear understanding of cultural aspects at the operator together with a correct safety culture analysis, are essential to define an optimal integration of FDM into an organisation. The level of safety and organisational awareness is driven by management and resource allocation. See also section III.5.

In practice, there are several organisation solutions, depending on factors such as whether FDM is performed by an in-house unit or a third party, whether the company has one or several AOCs, etc.

D. COMPETENCIES OF THE FDM AND THE SMS TEAMS

The skills of the FDM and SMS teams are key for successfully 'breaking data silos' between FDM and other data sources.

The competencies recommended for the FDM team are provided in the guidance material to the EU FDM requirement[6].

The FDM and the SMS teams should include staff members with a good competence in IT. Indeed, to this date the solutions on the market for combining FDM with other data sources have limited capabilities. Bridging the various sources of safety data in a smart way requires a good understanding of these data and how they will be used, as well as IT competence. Meaning in turn that someone with relevant IT competence is needed in the teams or the FDM service provider either to develop ad hoc solutions or to translate the FDM/SMS needs for external developers.

Not all competencies need to be in-house; however, in that case there should be some assurance that they are present at the service provider(s). Likewise, one individual might cover several competencies.

As important as selecting the right individuals for the FDM team is favouring the growth of competence. FDM competence growth is a rather slow process and a long-term investment. This implies proper allocation of time and human resources to go beyond just day-to-day jobs and superficial analyses, encouraging professional development for all team members and creating the incentives to stay in the FDM team.

[6] Refer to the guidance material for point ORO.AOC.130 of Annex III (Part-ORO) to Commission Regulation (EU) No 965/2012.

If too little is invested into the competence of the FDM and SMS teams, it is unlikely that they will be capable of developing a robust FDM system integrated with other data sources and with the SMS.

Note:

To demonstrate the need for human resources for the FDM programme, an internal ticketing service might be helpful. Such a ticketing service should capture the time spent for each request, including the time for debriefing with individual flight crew members. It should also track the time spent on R&D projects.

3. Integration of the FDM programme with the operator's safety risk management process

A. RISK IDENTIFICATION

Several data sources are nowadays available to operators, which will trigger the identification of a safety risk or the need to further investigate using FDM data and assess whether it is indeed a risk the operator is exposed to:

- Safety reports,
- Event with abnormal deviations identified in the FDM data,
- Crew notification of an abnormal situation,
- Event monitoring increasing trend,
- Event measurement increasing trend,
- Industry accident / serious incident/incident,
- Regulator Safety Notice / SIB / Communication,
- Safety Investigation report,
- Any other relevant safety information,
- Significant change requiring management, for example:
    - Starting of a new type of operation,
    - Introduction of a new aircraft type/variant,
    - Introduction of a new technology,
    - Organisational changes.

B. RISK ASSESSMENT

There are various risk assessment methodologies available, as indicated by the online survey conducted in 2023 (refer to section II.6). The data source used to identify risks does not restrict the use of a specific risk assessment methodology.

The ARMS/SIRA and classic risk matrix (5×5) are two examples of hazard risk assessment methodologies used by operators, either with FDM data only or with FDM data in conjunction with other data. Operators have the flexibility to adopt alternative risk assessment methodologies, provided they are approved and documented in the operators' internal processes.

ARMS\SIRA methodology guidance is available in Skybrary: https://skybrary.aero/bookshelf/arms-illustrated-how-risk-assess

The models behind the ARMS/SIRA and the classic risk matrix are illustrated in respectively, Figures I.2 and I.3.

Figure I.2: Overview of the ARMS/SIRA methodology (*source:* Skybrary)

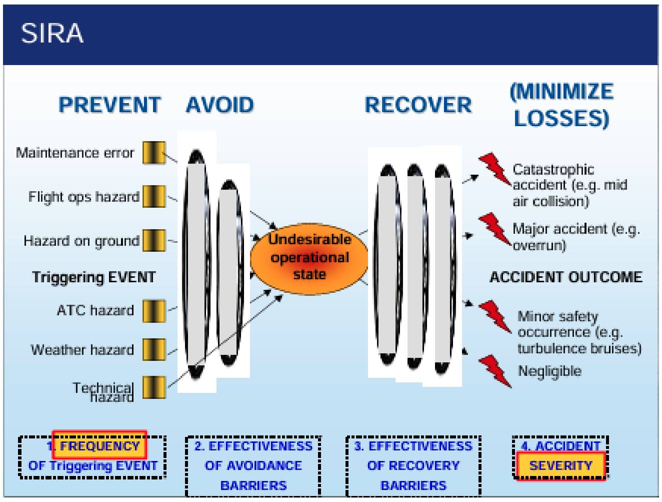


Figure I.3: Classic Risk Assessment Methodology guidance available in ICAO Annex 19 (example)

Safety Risk Probability	*Safety Risk Severity*				
	Catastrophic	Critical	Moderate	Minor	Negligible
Frequent	(dark red)	(red)	(red)	(orange)	(yellow)
Likely	(red)	(red)	(orange)	(yellow)	(yellow)
Occasional	(red)	(orange)	(yellow)	(yellow)	(green)
Seldom	(orange)	(yellow)	(yellow)	(green)	(green)
Improbable	(yellow)	(green)	(green)	(green)	(green)

The next step is to assign the subject-matter expert team members that will conduct the risk assessment and, if necessary, propose risk-mitigation measures. It is vital that this team include representatives from all risk areas being assessed. It is also important that the risk assessment is collegially performed between several experts to limit individual judgement bias.

Depending on the size and complexity of the operator, the Safety department may have various roles. It could actively contribute, provide support with FDM data, or participate in the risk-assessment process for validation before approval by the nominated person(s) who is (are) the risk owner(s). The ultimate responsibility for approving a risk assessment should always lie with the risk owner(s).

C. RISK MITIGATION

The final component of the risk-assessment methodology is the operator's tolerability criteria, which determine what level of risk is acceptable or unacceptable. An example of matrix showing risk-based tolerability criteria is provided in Figure I.4.

This leads to two possible scenarios that may prompt the need to implement risk-mitigation measures:

- When the risk score exceeds a tolerable level, resulting in either halting the operation or reducing the risk.
- When the risk score is within a tolerable range, but subject-matter experts believe it is feasible to further reduce the risk to as low as reasonably practicable.

Figure I.4: Example of risk-based tolerability criteria

<table>
<tr><th colspan="2">Output Risk Index</th><th>Action</th></tr>
<tr><td rowspan="2">Intolerable levels of risk</td><td>Stop</td><td>Intolerable under existing circumstances.

Operations should be discontinued immediately until an acceptable risk-reduction action has been implemented. The matter receives immediate senior management attention.

Issue has to be actioned by the stakeholder(s) at nominated person(s) level and risk monitored at the Safety Review Board.</td></tr>
<tr><td>High</td><td>Immediate action is necessary to mitigate the risk or stop the activity.

Risk-reduction action(s) need to be identified and introduced within agreed time frame by the nominated person(s). If risk reduction to acceptable level is not reached within an agreed time period, the nominated person(s) must take a decision regarding continuation of the concerned part of the operator's operation and risk monitored at the Safety Review Board.</td></tr>
<tr><td rowspan="3">Tolerable levels of risk</td><td>Medium High</td><td>Tolerable, if risk-reduction action(s) is (are) identified and introduced within agreed time frame. If risk reduction to acceptable level is not reached within an agreed time period, a decision must be taken at nominated person(s) level regarding continuation of the concerned part of the operator's operation.</td></tr>
<tr><td>Medium</td><td>Tolerable after review by the risk owner(s) at nominated person(s) level.

Data collection and trending for continuous improvement is required through the development of a risk-monitoring plan.</td></tr>
<tr><td>Low</td><td>Acceptable as is. No further safety risk mitigation required.

Data collection and trending for continuous improvement is required.</td></tr>
</table>

FDM data alone does not prescribe specific risk-mitigation actions but aids subject-matter experts in assessing potential risk-mitigation actions for implementation.

For example:

An operator identified a significant increase in the number of cases of non-compliance with low level-off operating requirements, which required aircraft to have a maximum vertical speed of 1500 ft/min at 1000 ft before reaching the required level.

A team of representatives from the Safety, Operations and Training teams was set up to further analyse the data, together with other data sources, such as safety reports about altitude deviations, crew member interviews, brainstorm with other operators concerning existing risk barriers to ensure compliance with the low level-off requirement. The operator implemented a call-out for the pilot monitoring (PM) at 2000 ft to level-off: '2 TO GO'.

D. RISK MONITORING

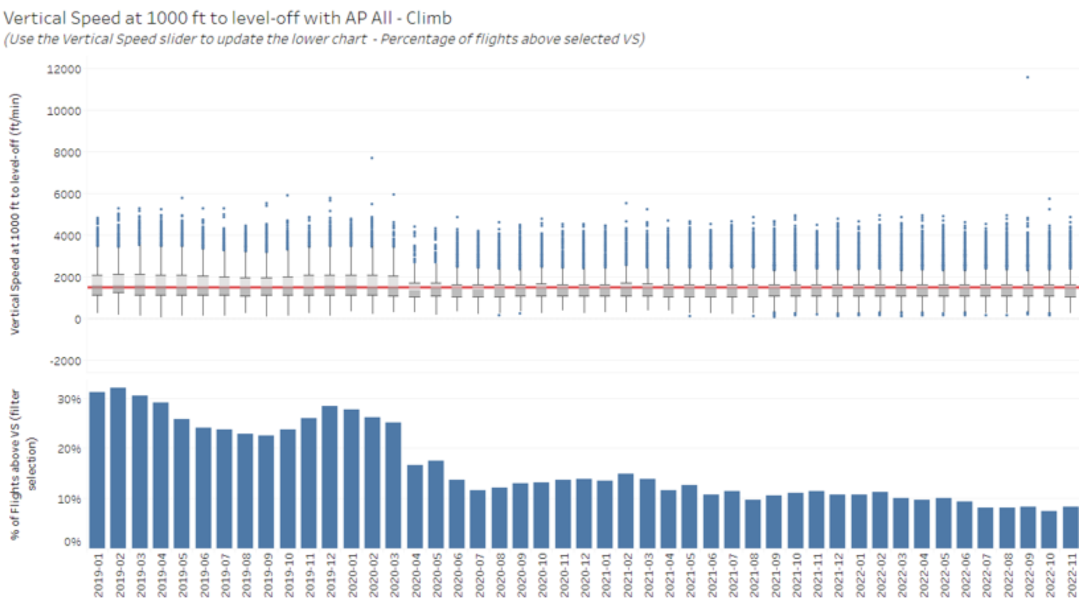
FDM is a valuable data source for monitoring the effectiveness of risk-mitigation measures as it provides factual data. This may involve developing new events/measurements or adjusting thresholds, as well as the development of Safety Performance Indicators.

With data visualisation tools now widely accessible, continuous monitoring of data trends can be set up to evaluate the impact of risk-mitigation actions.

For example:

For monitoring flight crew adherence to the new call-out '2 TO GO' (introduced to prevent level-bust incidents and ensure a climb rate of 1500 ft/min at 1000 ft for level-off), an operator developed measurement monitoring using a data visualisation tool as shown in Figure I.5.

Figure I.5: Evolution over time of the vertical speed in climb at 1 000 ft below the target flight level (upper part) and evolution of the proportion of flights with vertical speed exceeding 1 500 ft/min at 1000 ft below the target flight level (lower part)



4. Practical application of FDM data

A. ANALYSING LONG-LANDING-DISTANCE EVENTS

A Long Landing Distance event is triggered in a specific FDM software based only on the distance measured from the runway threshold to the touchdown point.

The FDM event is triggered yellow when this distance exceeds 750 m, then amber beyond 900 m and finally red beyond 1050 m (see Figure I.6).

Figure I.6: Thresholds applicable to Long Landing Distance events

	DIST_TO_THR (at TD)
LOW	750 m
MEDIUM	900 m
HIGH	1050 m

Let's compare two events: a red one and an amber one.

The red FDM event is triggered with a distance from threshold to touchdown greater than 1050 m and the amber FDM event with this distance between 900 and 1050 m (see Figure I.7 for examples of actual FDM event triggers).

Figure I.7: Examples of FDM event triggers for Long Landing Distance events

	01/03/2009 08:10:33	1818	High	LAN	Distance to THR in meters	-1060.64	
	01/01/2009 09:02:31	1818	Medium	LAN	Distance to THR in meters	-1033.82	

Usually, most of the operators will focus on the red one and will probably consider the amber one as being less priority.

When looking at the first one we realise that this event occurred in Dubai Airport on a 4315 m runway giving a remaining distance available after touch down of 3255 m.

Checking the weather conditions, we observe the runway was dry, the wind favorable with a 10 kt ahead component and the calibrated airspeed was stable at Vapp. The aircraft status was without effect on the braking efficiency.

When looking at the amber one we observe that this event occurred at New Delhi on a runway with a landing distance available (LDA) of 2970 m (see Figure I.8). So, the remaining distance after touchdown is 2970–1033=1937 m which is a lot considering the normal landing distance on a dry runway.

But looking a bit deeper, we observe a tail wind at 11 kt, the gross weight at landing is closed to the maximum landing weight and the aircraft is 4 kt above the approach speed. Checking the performance we observe the factored landing distance, computed with the auto brake to low, is above the LDA. Fortunately, the non-factored landing distance remains within the LDA but with a stop margin of only 215 m. But because the actual flare was longer than assumed in the computation, this margin does not exist anymore and that's the reason why the flight crew had to revert to manual braking.

Looking at the weather conditions of the day, some rain showers have been reported changing the landing performance considerably. Here, if we consider more the 3 mm of water on the runway, which is not unrealistic in New Delhi in that period of time, even the autobrake medium setting would not allow at stopping the aircraft on the remaining runway following the long flare.

Only the aggregation of data from different sources (FDM, weather, performance, maintenance) gives reliable indication of the exposure to the risk.

But to go further, it would be necessary to have the feedback of the flight crew (air safety report).

Figure I.8: Landing performance data for a landing at New Delhi, assuming tailwind is 11 kt, dry runway and breaking mode set on Low

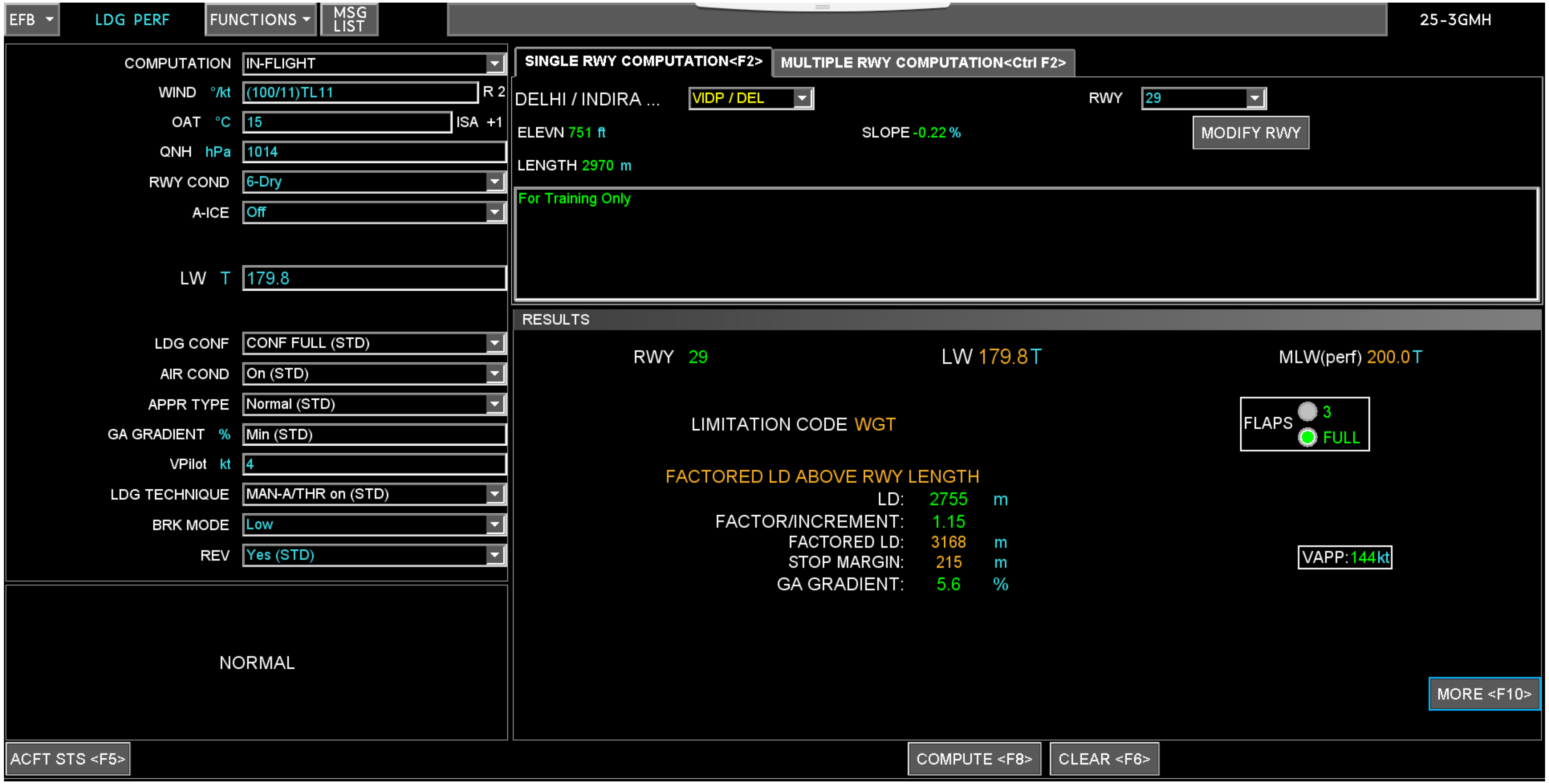


Figure I.9: Landing performance data for a landing at New Delhi, assuming tailwind is 11 kt, wet runway and breaking is manual

B. INDIVIDUAL FDM SUMMARY REPORTS

Airline 'A' has identified high energy approach / unstable approach prevention as part of its 3-year Corporate Safety Strategy. The purpose of the strategy is to reduce high energy approaches and unstable approaches to an acceptable level. The airline is providing all captains with a monthly FDM summary report which is specifically targeted on approach and configuration exceedances. AFM exceedances are provided as an addendum to the report along with a summary of the event flights and dates.

Information is collected from multiple data sources and merged to produce an individual FDM summary report. This report is, in this example, sent to the mobile devices of flight crew members on a fixed date every month and it includes 21 Key Performance Indicators (KPIs). Only those flight crew members and FDM programme trustees concerned have access to the data of an individual FDM summary report.

> Note:
>
> There is no information on the pilot dashboards that can be used to identify an individual flight crew member or a specific flight.

DATA SOURCES

Operational data – Flight number, destination, departure, times, tail number

Flight crew data – Flight crew members codes, experience levels of flight crew members (months with Airline 'A')

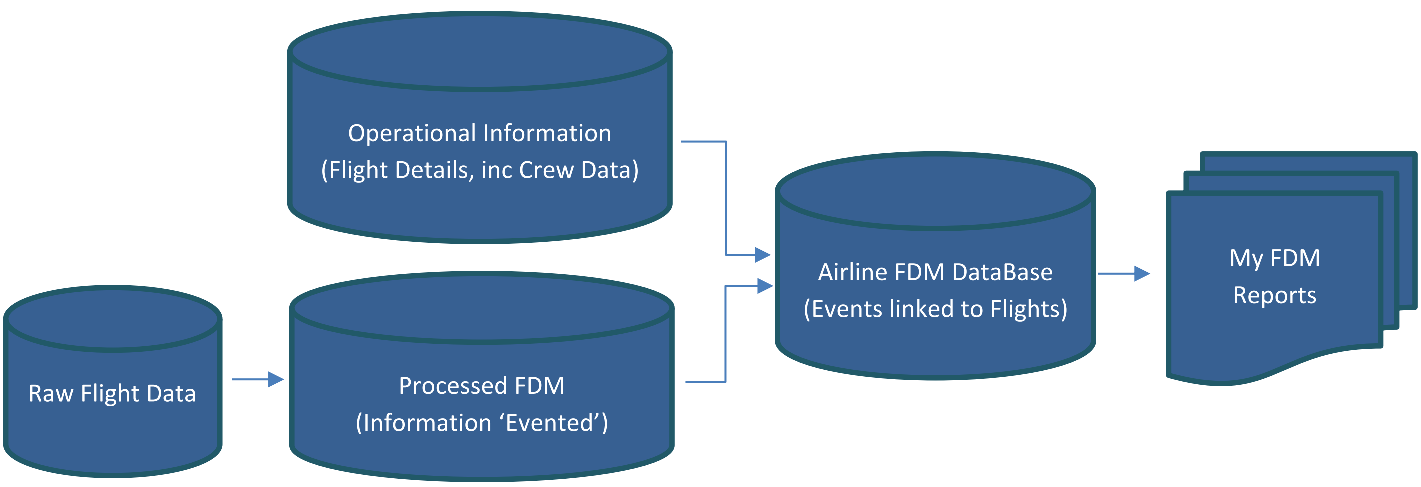
Flight data – Exceedance data, registration and time

Definitions of FDM events – Triggers, events, event classification, event name

DATA FLOW AND MERGE

The airline's IT department uses a system of ETL (extract, transfer and load) to merge and combine the data sources (see Figure I.10). The data is then exported to a dedicated data mart where the structured data is collated and prepared for reporting. There are two logical tables or data sets (1st: flights, 2nd: exceedance) with a link between the two tables. The date merge generates the report which is then automatically exported to the user.

Figure I.10: Data flow



Pilot Dashboard Page 1 – Approach Data

There are 21 approach KPIs that are split between Speed, Rate of Descent, Altitude and Configuration (see Figure I.11). The information is presented as a value in respect of all approaches conducted in the 1-month period. The pilot has comparable data for 'This Month', 'Last Month', and 'Year to Date', the number of approaches carried out by the pilot and an increase/decrease trend indication relative to the previous month.

Pilot Dashboard Page 2 – AFM Exceedance Data

There are 9 AFM limitations presented in respect of speed, altitude, G loading and weight exceedance (see Figure I.11). The information is presented as a value in respect of all approaches conducted in the 1-month period. The pilot has comparable data for 'This Month', 'Last Month', and 'Year to Date'.

Figure I.11: Example of presentation of key performance indicators (KPIs) related to the approach (pilot dashboard)

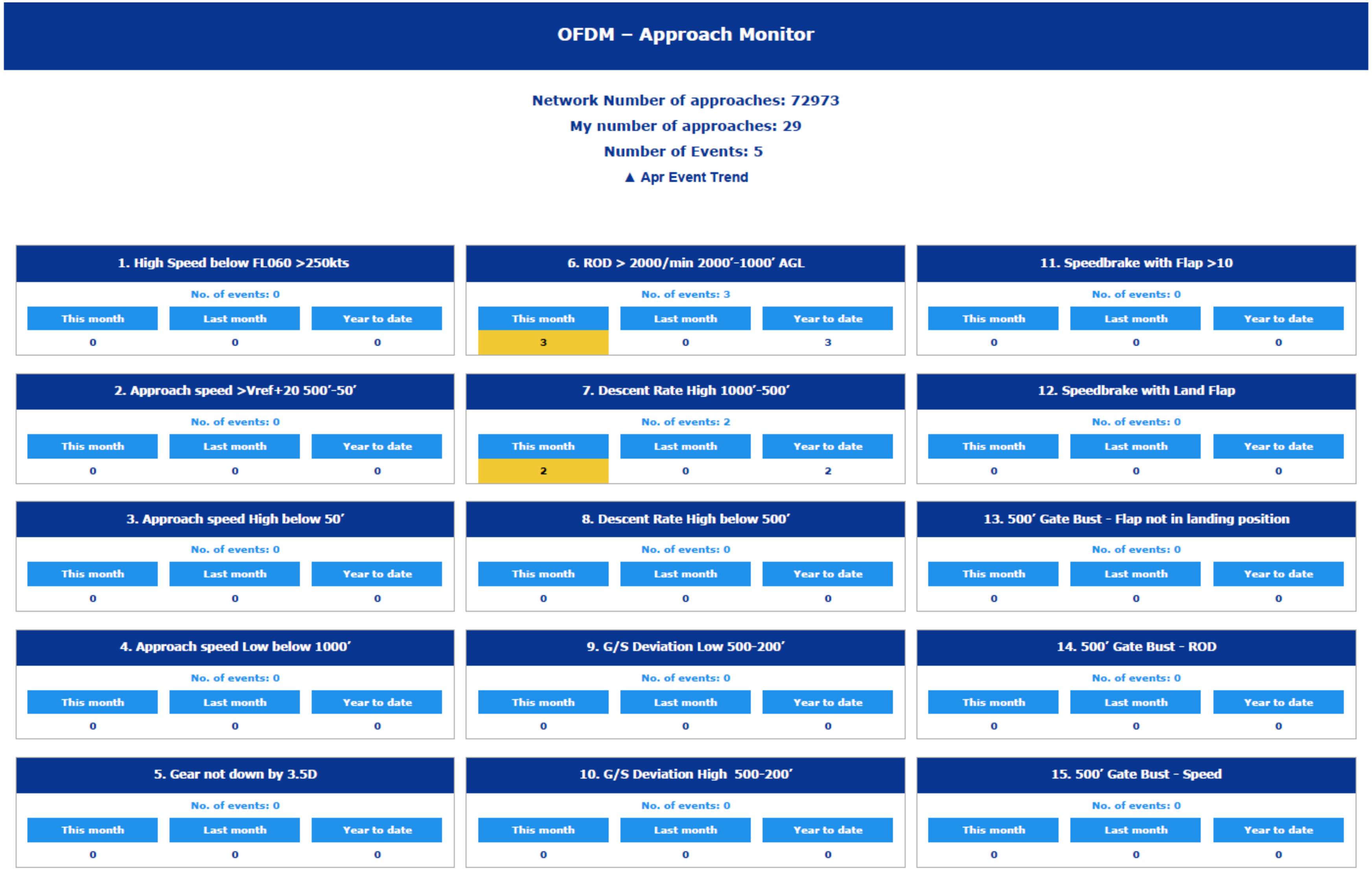
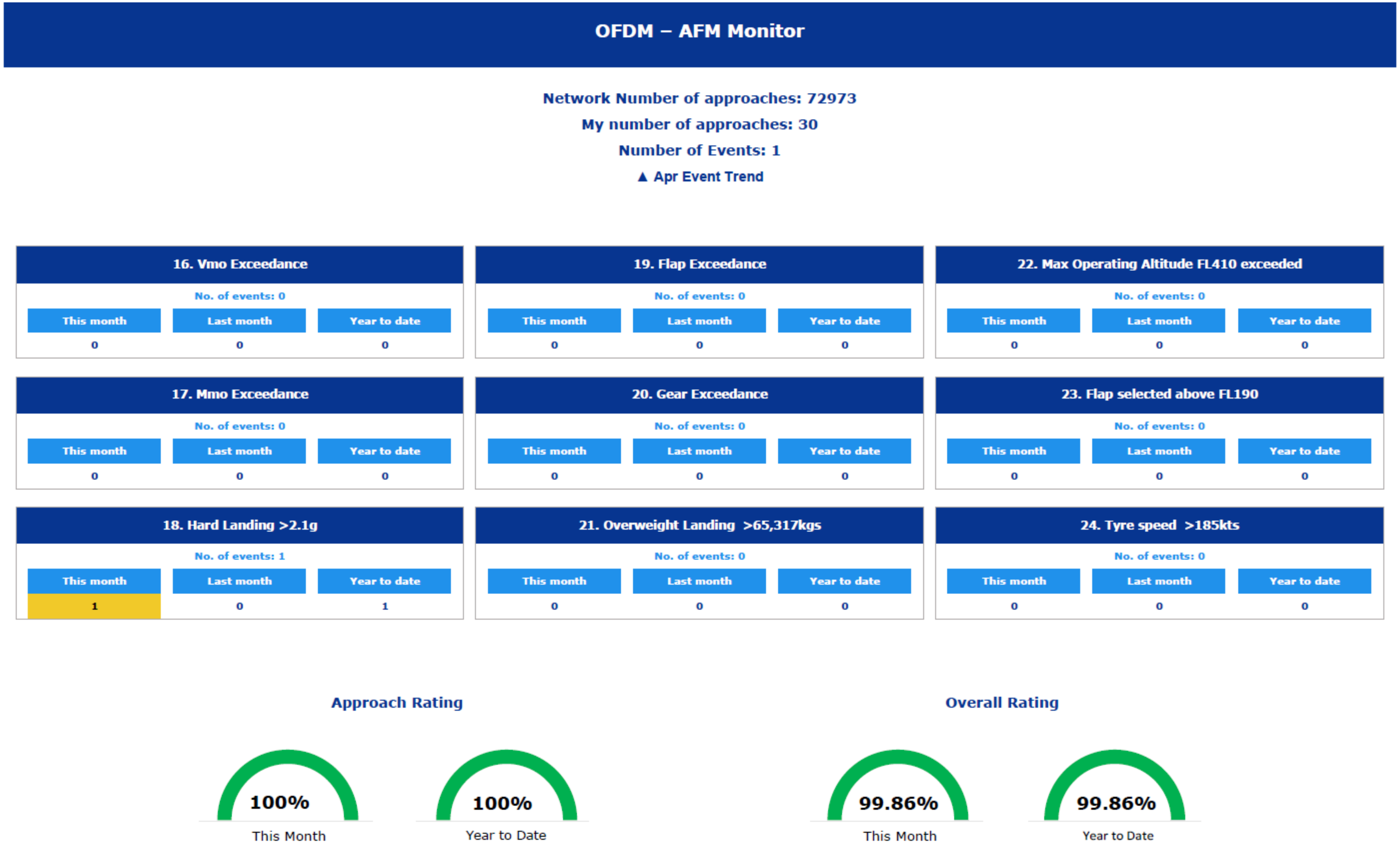


Figure I.12: Example of presentation of AFM exceedance data (pilot dashboard)



An approach performance and overall 'performance rating' is presented as an aggregate of all events that have occurred on all flights in the 'previous month' and also 'year to date'. The percentage is calculated by sectors flown minus number of events, divided by the number of sectors. Hence, when considering the rating corresponding to this month, if one event is triggered, and the pilot flew 50 sectors in the month, it would be 98%. 'Year to date' is simply the same calculation, but for the previous rolling 12 months.

The benefit with having these rating statistics is that they effectively factor the events taking into consideration the sectors flown.

Trustee Dashboards

The super users (trustees) can drill down using filters into features such as:

- Base / Captain / Arrival Airport / Month / Severity Class
- Detailed as well as high-level view of the data
- Geographical mapping of the data for ease of reference
- Month-on-Month comparisons

CONCLUSION

Such an initiative together with other awareness-raising or training activities can be very effective in highlighting areas of increased operational risk.

C. ENHANCING SELF-AWARENESS AND ENCOURAGING POSITIVE BEHAVIOUR

In traditional FDM programmes, the flight crews, despite being the source of data, have been little involved in the process that takes place after the data has been received, analysed and used for safety actions. In the most basic systems, the flight crew only knows this data through debriefings of incidents and accidents. Another typical use of flight data could be through statistics, usually containing data on exceedances, presented to a group of pilots. This kind of statistics could be helpful in identifying negative trends and possible safety risks within the operation.

Debriefs and statistical data based on exceedances are a small part of all data available in a FDM system, e.g. even if a pilot has never exceeded a flap extension speed limit, the system would have data from all their flights and the possibility to say their maximum, minimum, and average speed for selecting flaps.

Further development of the FDM system within the organisation could result in an increased self-awareness of own performance, thus enhancing further safety.

Excerpt from the ICAO Safety Management Manual, Doc 9859:

'A healthy safety culture actively seeks improvements, vigilantly remains aware of hazards and utilizes systems and tools for continuous monitoring, analysis and investigation.'

Pilot feedback could range from individual feedback on per event/ limit exceeded to more advanced reports. It could be beneficial to not only look at limits and exceedances, but also other underlying data that could indicate something about pilots' technique.

Presenting data of a pilot's performance should be accompanied with some guidance on what the intended range for that data is; this could be referenced from, e.g., training manuals or operations manuals.

EXAMPLE 1

Table I.2: Example of individual feedback (rotation rate)

AVERAGE ROTATION RATE DURING TAKE-OFF	
PILOT A	ALL PILOTS ON FLEET
1,8 DEG/S	2,2 DEG/S

Table I.2 will indicate to the pilot receiving this data that he/she is rotating at a slower rate than the recommendations set in the training manual. If considered beneficial, such information may be put into context with other data, such as the compliance rate of the fleet with the training manual guidance on rotation rate.

Had this data been presented for a pilot group or fleet-wide statistics and the average rotation rate value would have been within the limits set in the training manual, pilot A (from example 1) would most likely not be aware of his rotation technique being out of the guidance limits.

Note:

In this example, the average rotation rate value only provides partial information about compliance with the SOPs, as it does not show the shape of the distribution, its spread through time, etc. For more guidance on averaging and distributions, please refer to the EOFDM document 'FDM analysis techniques and principles'.

EXAMPLE 2

Table I.3: Example of individual feedback (average air speed at the time flap 1 is selected)

AVERAGE AIRSPEED AT FLAP 1 SELECTION	
PILOT A	SOP
230 KT	MAX 240, AIM FOR MNVR SPD FOR CURRENT FLAP.

Pilot A is on average 10 kt below the 240 kt limit that would typically be set as the trigger limit for an FDM event (see Table I.3).

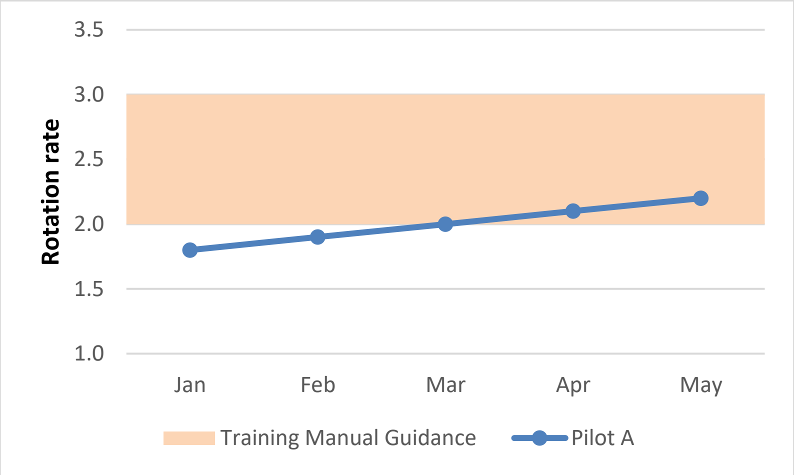
EXAMPLE 3

If pilot A has received the information from example 1, he/she will hopefully be trying to adjust his/her technique to be in line with the guidance limits. For the pilot to easily identify improvements over time, he/she should be presented with a possibility to view the development over time for the selected parameter (see Table I.4 and Figure I.13).

Table I.4: Example of individual feedback (evolution of average rotation rate during take-off over time)

AVERAGE ROTATION RATE DURING TAKE-OFF, PILOT A (DEG/S)			
JAN	FEB	MAR	APR
1,8	1,9	2,1	2,2

Figure I.13: Example of individual feedback (evolution of average rotation rate during take-off over time)



Note 1:

Providing flight crew members with their performance data should be done very carefully in order not to cause any unnecessary changes in flying technique/behaviour. In other words, the intention of providing performance data is not for pilots to fly the aircraft in order to have ‘good stats’ but rather a means of helping them monitor their own performance and raise self-awareness of any unwanted trends. The most important objective behind such reports remains compliance with the SOPs and the operations manual.

Note 2:

Any kind of flight-data-based visualisation (plots, animations, etc.) generated to provide feedback to the flight crews should not be made available without pre-validation and technical support to interpret the visualisation, and assistance from an honest broker / gatekeeper with operational experience. Indeed, systematically providing data without support and context is likely to be counterproductive.

D. CASE STUDY: ADOPTION OF A NEW AIRCRAFT TYPE

RISK UNDER ASSESSMENT

The risk under assessment was the potential for unsafe landing conditions with a newly introduced aircraft variant. Specifically, the risks included:

1. Hard landings and tail strikes,
2. Decreased pilot authority during the landing phase.

RISK IDENTIFICATION

The risk was initially identified through a combination of:

1. Pilot reports: Crews reported that the new variant 'seemed to fall from the sky in the last few feet, regardless of the inputs in pitch'.
2. Proactive FDM analysis: FDM data was used as a preventative measure to examine the handling qualities during the landing phase, especially the flare manoeuvre.

RISK ASSESSMENT

A comprehensive system safety analysis was performed by using the ARMS (ERC and SIRA methodologies), incorporating both qualitative (incident report) and quantitative (FDM data analysis) elements.

FDM: A Data-Driven Approach

The study compared the new aircraft variant, which were mainly located at a large European base at the time, with other variants of the same manufacturer.

FDM's Power to Uncover Hidden Risks

The gathered data gave a clear picture of the aircraft's performance in relation to manufacturer specifications and established norms. FDM allowed the airline to explore multiple important domains:

- **Pitch behaviour:** plotting the pitch evolution of both aircraft variant from 30 ft to touchdown, FDM data showed that, in comparison to other variants, the new one consistently approached and landed with a lower pitch attitude. In addition, a histogram showed the statistical distribution of pitch values for the two types of aircraft, emphasising the predominance of lower pitch angles in the new variant. See Figures I.14 and I.15.

Figure I.14: Pitch value plotted against radio-altitude, for the older variants (left-hand side) and for the new variant (right-hand side)

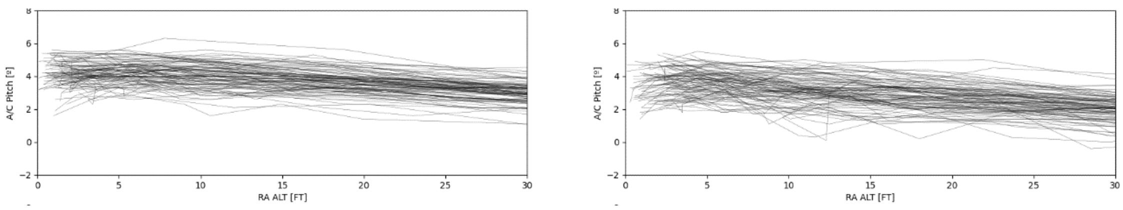
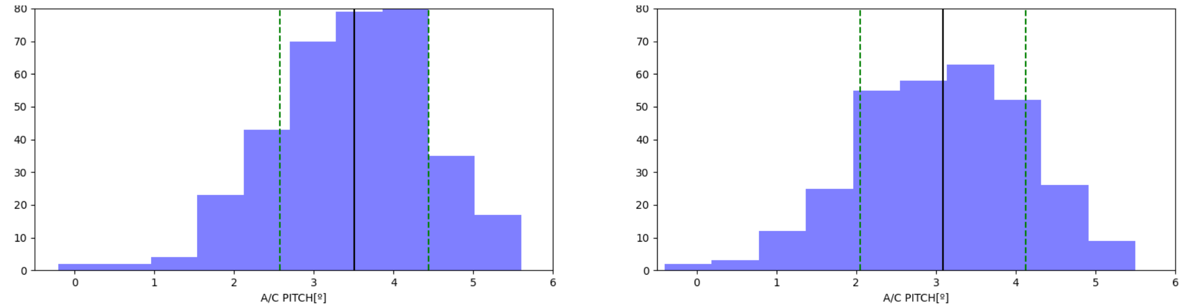
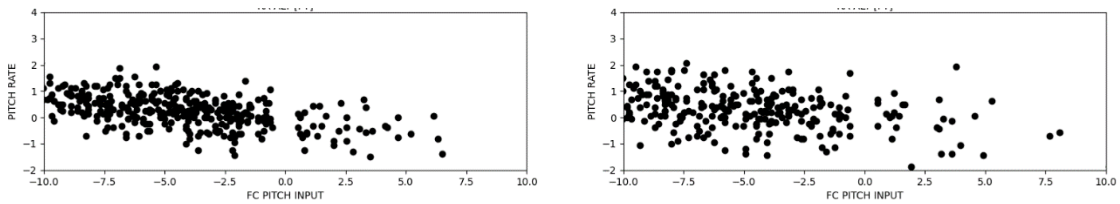


Figure I.15: Distribution of pitch values for two types of aircraft. The right-hand side plot shows the distribution for the new variant.



- **Flight crew inputs and aircraft response:** FDM data was used to compare the aircraft pitch rate with flight crew pitch inputs (x and y axis respectively; see Figure I.16). The analysis revealed a distinct difference between the old and the new variants in terms of pilot–aircraft interaction. Pitch response and pilot input showed a strong correlation in the old variant; on the other hand, even with substantial pilot input for nose-up, the new variant's graph showed instances of negative pitch rate and a larger dispersion. This suggested that in order to achieve the appropriate pitch during landing, pilots had to put in more effort.

Figure I.16: Distribution of pitch rate versus flight crew pitch inputs. The left-side plot shows the distribution for an old variant, and the right-side plot the distribution for the new variant.



The evolution of the flight crew inputs during the last seconds of the flare (from 30 ft to touchdown) was also subjected to analysis (last 30 ft versus time).

For the old variant, it was observed that the amplitude of the inputs of the crew decreases as they get closer to the ground, while the pitch-down inputs almost completely disappear (positive values).

On the other hand, in the new variant there is still a lot of amplitude (pitch-up – pitch-down) and above all pitch-down values very close to the ground. It seems as if the flight crew member was fighting more with the aircraft to obtain the desired flare results during those final seconds before touchdown.

- **Engine spool-down:** Plotting engine data (N1 values) against time revealed a notable variation in the characteristics of the engine spool-down. While the new variant showed a much faster spool-down, the old one showed a more gradual decrease in N1 values. This quick spool-down of the engine on the new variant created more downward momentum, which might make pitch control more difficult during the landing flare.

RISK-MITIGATION ASSESSMENT

The need for new risk-mitigating actions was determined based on the FDM team's analysis, which revealed the following:

1. Lower landing pitch attitude of the new variant,
2. More frequent and substantial sidestick inputs necessary to attain the desired pitch,
3. Erratic reaction to pilot input for pitch control during the landing phase,
4. Faster engine spool-down, creating more downward momentum.

RISK-MITIGATION IDENTIFICATION

Based on the FDM analysis, the operator identified the following risk-mitigating actions:

1. Communicating findings to the manufacturer and other air operators,
2. Updating pilot training procedures and recommendations.

FDM data was instrumental in identifying these actions by providing concrete evidence of the new variants' unique handling characteristics and the potential risks they posed.

IMPLEMENTATION OF RISK-MITIGATION ACTIONS

FDM data was used to implement the new risk-mitigating actions in several ways:

1. Interaction with the manufacturer:
    - The operator communicated its FDM findings to the manufacturer, providing clear, data-driven evidence of the operational challenges.
2. Updates to pilot training:
    - The operator developed updated pilot training procedures and recommendations based on the FDM data.
    - The training included specific scenarios and techniques derived from the FDM analysis to address unique handling characteristics.

RISK MONITORING

FDM data continued to play a crucial role in monitoring the effectiveness of the new risk-mitigating actions:

1. Continued monitoring of landing data for the new fleet allowed the operator to track improvements in landing performance over time.
2. Comparison of pre- and post-intervention data demonstrated the effectiveness of the new training procedures.
3. Ongoing analysis of pilot inputs and aircraft responses helped in identifying any persistent issues or improvements in aircraft handling.
4. Monitoring of hard-landing occurrences and G-force data provided concrete metrics for assessing safety improvements.

E. CASE STUDY: ADOPTION OF A NEW AIRCRAFT

RISK UNDER ASSESSMENT

Stall warning / Stick shaker activation.

RISK IDENTIFICATION

Following the introduction of a new aircraft type into the turboprop fleet, during the first months of its operation, a few events were detected through FDM where stall warning was very briefly (less than a second) activated in combination with pilots' safety reports.

RISK ASSESSMENT

The risk-assessment methodology used was based on the Bowtie methodology. The ICAO 5×5 Risk Matrix was used for the evaluation of the risk score.

RISK-MITIGATION ASSESSMENT

All events were communicated to the aircraft manufacturer to assess their validity. In all cases, the aircraft systems operated as per design.

The stall-warning activation was triggered due to turbulent conditions and abrupt changes to the AoA. The analysis of the events through FDM showed that most of the events occurred during the take-off phase, below acceleration altitude in turbulent conditions, at a specific airport with special local topography. In comparison to the previous aircraft type, this aircraft variant, at the same airport, was flying to a lower altitude and was affected by turbulent conditions.

Even though the aircraft's state was not close to a genuine stall condition (in all cases, the aircraft had enough power energy and speed), the activation of the stall warning was something to be addressed.

All events were discussed and analysed with each pilot concerned to gather further information. On some occasions, due to the short duration of the phenomenon (less than 1 second activation), the warning was not perceived by the flight crew.

IDENTIFICATION OF RISK-MITIGATION IDENTIFICATION

Following the recommendation by the manufacturer, it was suggested to calculate the take-off performance with increased V2 equal to 1.25 Vs to reduce the possibility of stick shaker activation. This recommendation was communicated to the pilot community for implementation. Also, the characteristics of the events were gathered, and the simulator scenario was enhanced to include such conditions.

IMPLEMENTATION OF RISK-MITIGATION ACTIONS

The specifications of the events were gathered, and the simulator scenario was enhanced to include such conditions.

RISK MONITORING

Further to routine FDM analysis, all reported events for turbulent conditions were studied in combination with FDM to examine whether or not the provided information was implemented by the flight crews. The above risk-mitigation actions contributed to the reduction of the events to zero within 8 months of their introduction time. Also, a specific Safety Performance Indicator was created to periodically monitor these events.

F. CASE STUDY: CHANGES TO OPERATING PROCEDURES AND ASSESSMENT OF AN EMERGING RISK

RISK UNDER ASSESSMENT

The risk under assessment had the potential for sudden, uncontrolled yaw during high-speed deceleration on landing, which could lead to runway excursion. That risk was specifically related to the nose wheel steering (NWS) system.

RISK IDENTIFICATION

The risk was initially identified through a flight crew report following a routine flight. After landing at a main European airport, the flight crew experienced a pronounced right yaw at high speed during the deceleration roll. Although they managed to counteract this lateral movement, the event nearly resulted in a lateral runway excursion.

RISK ASSESSMENT

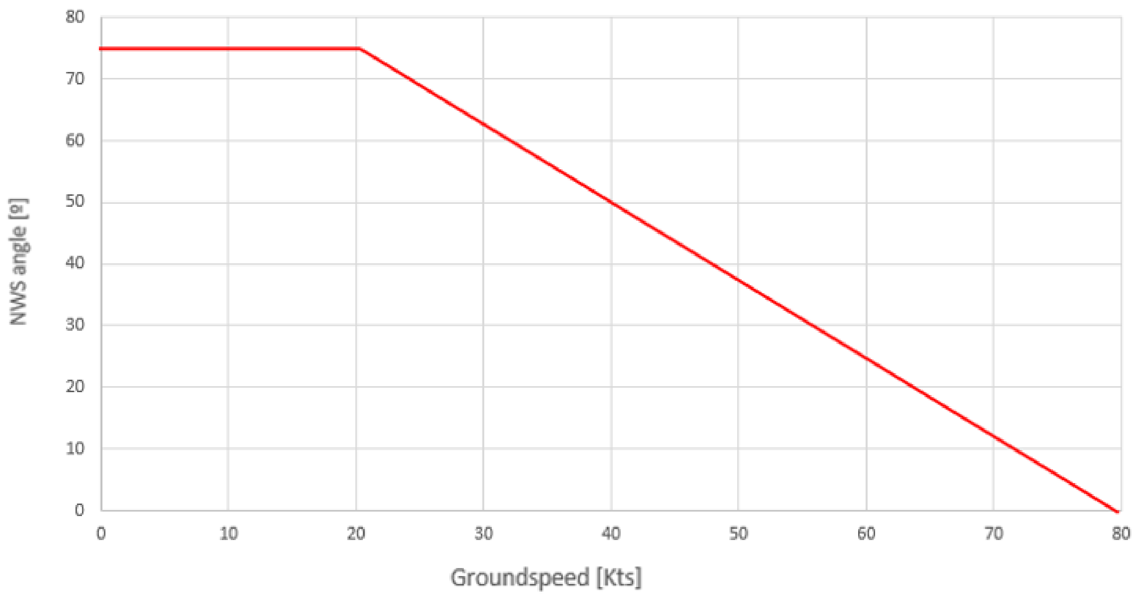
The risk was assessed using a combination of methods:

1. Initial incident report analysis
2. Flight data monitoring (FDM) team's detailed controllability analysis
3. Review of the manufacturer's manual specifications for the NWS system
4. Analysis of contributing factors, including:
    - Lack of angle reference for pilots during braking
    - Non-linear nature of the NWS tiller

A comprehensive system safety analysis was performed by using the ARMS (ERC and SIRA methodologies), incorporating both qualitative (incident report) and quantitative (FDM data analysis) elements.

The FDM team's analysis revealed a potential link to the aircraft's NWS system. The NWS system's high-speed protections can create an unsafe condition under specific circumstances. The aircraft manual specifies that the NWS system limits the nose-wheel turn angle at high speeds as shown in Figure I.17.

Figure I.17: Law limiting the maximum NWS angle depending on aircraft ground speed



The issue identified was that a rapid speed reduction during high-energy braking could result in an equally rapid increase in the nose-wheel angle permitted by the NWS system. This rapid change can create a situation where the nose wheel turns sharply, causing the aircraft to yaw suddenly, which the pilot might not be able to counteract in time.

Several factors contributed to this risk:

1. **Lack of angle reference**:
    - During braking, the pilot has no precise reference for the angle requested from the NWS system (except by directly looking at the tiller, which is not advisable as it diverts pilot attention from the runway).
    - There is no alert indicating that the pilot's input is being actively limited by the NWS system due to speed.
2. **Non-linear NWS tiller**:
    - The NWS tiller does not follow a linear scale; the requested input increases exponentially as the tiller is moved.

For these reasons, a pilot using the NWS tiller during the landing roll might feel that the hand movement is appropriate. However, during rapid deceleration, the angle permitted by the aircraft can increase suddenly, causing the nose wheel to turn sharply and potentially leading to a sudden high-speed turn.

The FDM team studied various flights and found conclusive results regarding the use of the NWS system at high speeds in the fleet. Until that time, the frequent use of NWS system during high-speed landings, constituting inappropriate practice and non-compliance with the manufacturer's recommendations in the aircraft manual, was unknown to the Safety department.

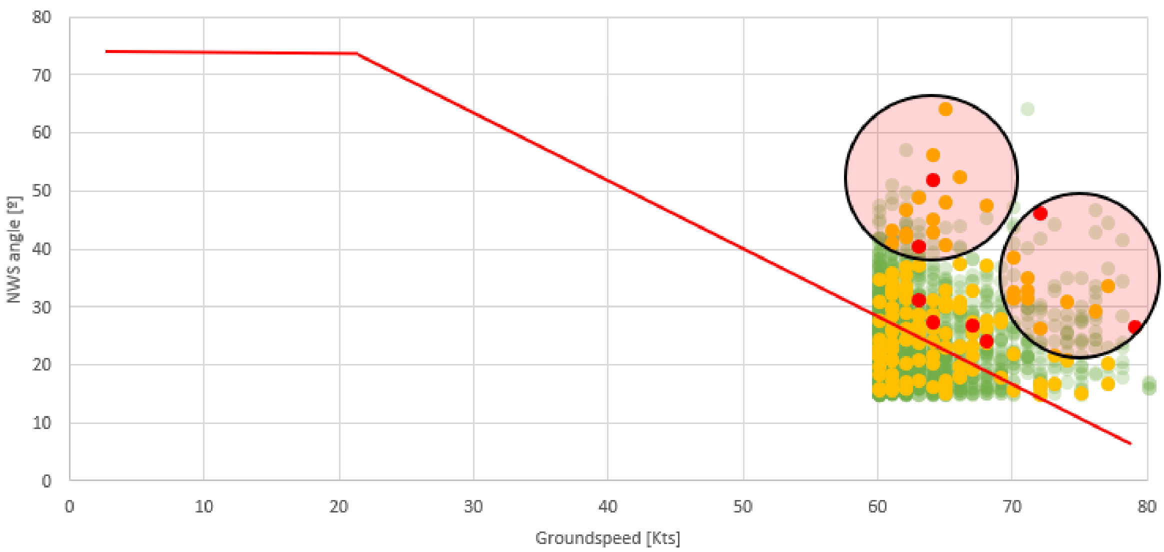
The analysis included data from flights conducted during a 2-month period, showing a significant number of pilots using the NWS system at speeds well above 60 kt. Many of these inputs were actively limited by the NWS system's protections.

Visualisation of Results

The data is visualised in Figure I.18. In this figure, the following colour codes are used:

- **Green dots**: Landings with smooth deceleration, giving the pilot enough response time to cope with a sudden change in the NWS-limited angle.
- **Yellow and red dots**: Landings where deceleration is equal to or greater than that normally provided by the aircraft's autobrake system, indicating strong deceleration that can cause an excessively rapid opening in the NWS-limited angle, making it difficult for the pilot to react in time.

Figure I.18: Distribution of NWS angle values against ground speed during the landing phase



RISK-MITIGATION ASSESSMENT

The need for new risk-mitigating actions was determined based on the FDM team's analysis of flight data. The analysis revealed the following:

1. A significant number of pilots were using the NWS system at speeds well above 60 kt, contrary to manufacturer recommendations.
2. Many of these inputs were actively limited by the NWS system's protections, indicating a potential safety issue.

FDM data was crucial in determining the above. The team analysed data from flights conducted during a 2-month period, visualising the results in a graph that categorised landings based on deceleration rates and NWS system use.

RISK-MITIGATION IDENTIFICATION

The risk-mitigating actions were identified based on the insights gained from the FDM data analysis. The actions included the following:

1. Notifying the aircraft manufacturer about the identified risk
2. Increasing pilot awareness through targeted communications
3. Updating pilot training programmes

FDM data was instrumental in identifying these actions by providing concrete evidence of the prevalence and nature of the issue across the fleet.

IMPLEMENTATION OF RISK-MITIGATION ACTIONS

FDM data was used to implement the new risk-mitigating actions in several ways:

1. The data analysis results were used to update the content of pilot communications and training programmes.
2. Specific examples from the FDM data were used in training material to illustrate the risk and the proper NWS system use.
3. The visualisations created from the FDM data (e.g. the graph categorising landings) were used in pilot briefings and training sessions.

RISK MONITORING

FDM data continued to play a crucial role in monitoring the effectiveness of the new risk-mitigating actions:

1. The ongoing analysis of NWS system use during landings allows the safety team to track changes in pilot behaviour over time.
2. The same metrics and visualisations used to identify the initial risk is used to monitor improvements.
3. Any incident or near-miss related to NWS system use is quickly identified and analysed using FDM data.
4. The effectiveness of training programmes is assessed by comparing the NWS system use patterns before and after implementation.

By continuously monitoring these metrics, the safety team assesses whether the risk-reduction strategies are effective and, if necessary, makes further adjustments.

5. Black and white versus grey – combining objective and subjective information

A. INTRODUCTION

Digital data from aircraft systems[7] are generated and recorded based on a clearly defined target, a threshold, or clearly defined criteria. Hence, if the defined condition is satisfied, the data is generated and recorded. The condition for its existence is clearly defined and, therefore, considered 'objective data'.

By definition, objective data is very consistent, and it will often tell us that something happened. However, it will not provide a complete picture of the context and, therefore, other data sources are necessary to provide a more accurate picture of what happened.

From a safety perspective, one source of complementary data can be a safety report submitted by a flight crew member. And while there are set requirements for what needs to be reported, the occurrence needs to be detected (or identified) by the flight crew member, interpreted as an occurrence which satisfies the reporting criteria and, finally, needs to be reported after-the-fact with details of the flight crew member's recollection of what happened. These various conditions need to be met for a safety report to be generated and submitted for analysis. Therefore, in comparison with objective data, such data sources which are largely subject to human interpretation and individual perception of risk, can be considered 'subjective data'.

[7] The Flight Data Recorder and Quick Access Recorder are just a few examples of data sources on the aircraft. Terrain Awareness and Warning System (TAWS), Airborne Collision Avoidance System (ACAS), Central Maintenance Computer (CMC) and Electronic Engine Controller (EEC) are other sources of digital data that could be retrieved for analysis purposes.

Note:

Recorded flight data has limitations, e.g. not all the information displayed to the flight crew is recorded, the source of recorded data may be different from the source used by a flight instrument, and the sampling rate or the recording resolution of a parameter may be insufficient to capture accurate information. Hence, objective data can be difficult to interpret or can even lead to wrong conclusions, especially when one does not know well the source and the limitations of this data.

B. SOME ORGANISATIONAL CHALLENGES OF COMBINING FLIGHT DATA WITH AIR SAFETY REPORTS

There are several challenges faced when objective data is combined with subjective data. Firstly, there is the technological challenge. Existing safety data management systems have come a long way to allow ease-of-use and practical management of safety data. However, without a system automatically linking the FDM software with air safety reports, it is necessary to access and interact with different sources of data separately to investigate an event.

Therefore, the task of combining data between several sources becomes a manual process, arduous and time consuming, which makes it impractical for an organisation to systematically engage in complementing air safety reports with FDM data.

Another challenge is flight crew perception. For any given event there may be several details which may go unnoticed by flight crew members, while they were picked up though FDM. Indeed, flight crew members may have a different recollection, may omit certain details or even, ultimately, fail to submit the report. Without FDM, this could lead to an event to go unnoticed. In addition, flight data can be used to add technical details to the event, get an enhanced reconstruction of the event or alert the flight crew for the need for a retrospective air safety report.

However, this may cause a sense of being watched and lectured even though the main purpose is to complement the information contained in the safety report, in the interest of creating a more accurate picture of what happened and therefore to identify and address hazards more precisely. Hence, such a practice needs to be considered very carefully and executed with great care in order not to cause any adverse perception or consequences among flight crew members. As expressed earlier, the organisation and flight crew members must evolve together in terms of safety culture to reach the stage where they are prepared and confident about using data from FDM for maximum safety benefit to the operation. In practical terms, the organisation can, again, establish a risk-classification criterion for when flight data is used to help analyse events reported through air safety reports.

Note:

To encourage reporting by staff members (flight crew members, but also technicians and ground staff), the reporting tools should be user-friendly and easily available. Removing redundant channels of reporting may as well be helpful.

6. The state of play in 2023

A. ONLINE SURVEY – INTEGRATION OF THE FDM PROGRAMME WITH THE SAFETY RISK MANAGEMENT PROCESSES

An aircraft operator survey was conducted in autumn 2023 with the aim to address the following topics:

- The use of FDM to support Safety Risk Management (SRM),
- How operators use FDM within their SRM processes,
- What risk assessment methodologies are being used.

The survey was made available online to aircraft operators. It was split into four main sections: operator information; FDM capability; use of FDM to support SRM; and how operators are looking for FDM within the SRM process. The survey included 17 questions in the form of single choice, multiple choice, slider as well as free-text fields to collect more specific input.

In total, 46 operators responded to the survey. The survey responses were treated in confidence and only figures and a de-identified summary of comments were shared.

B. SURVEY PARTICIPANTS

Information about the survey participants is presented in Figures I.19, I.20 and I.21.

Figure I.19: Distribution of the geographical location of participating operators

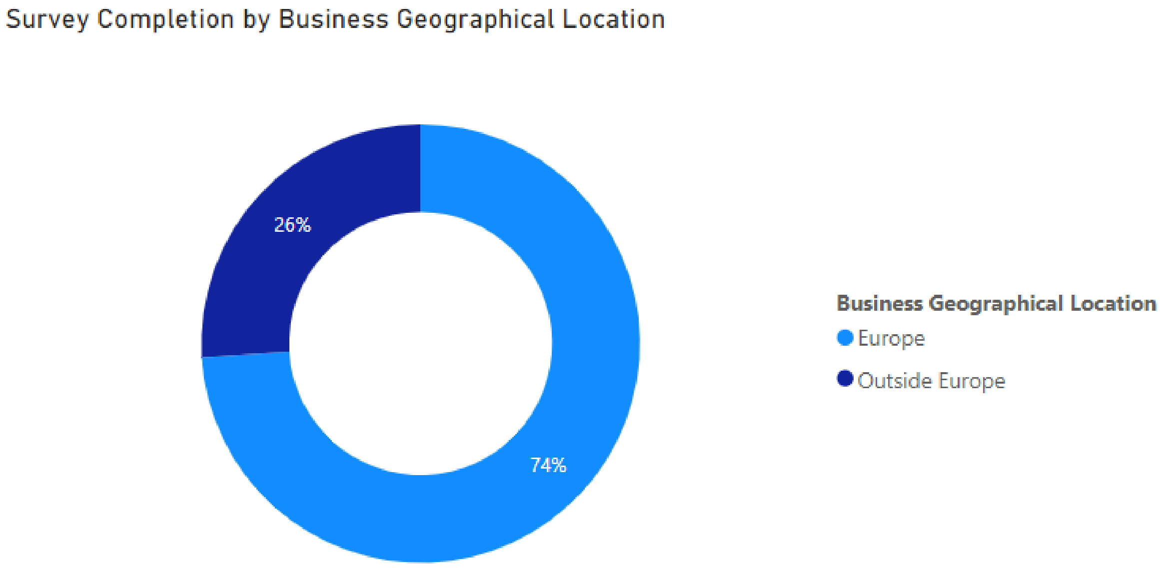


Figure I.20: Distribution of participating operators according to the category of operated aircraft

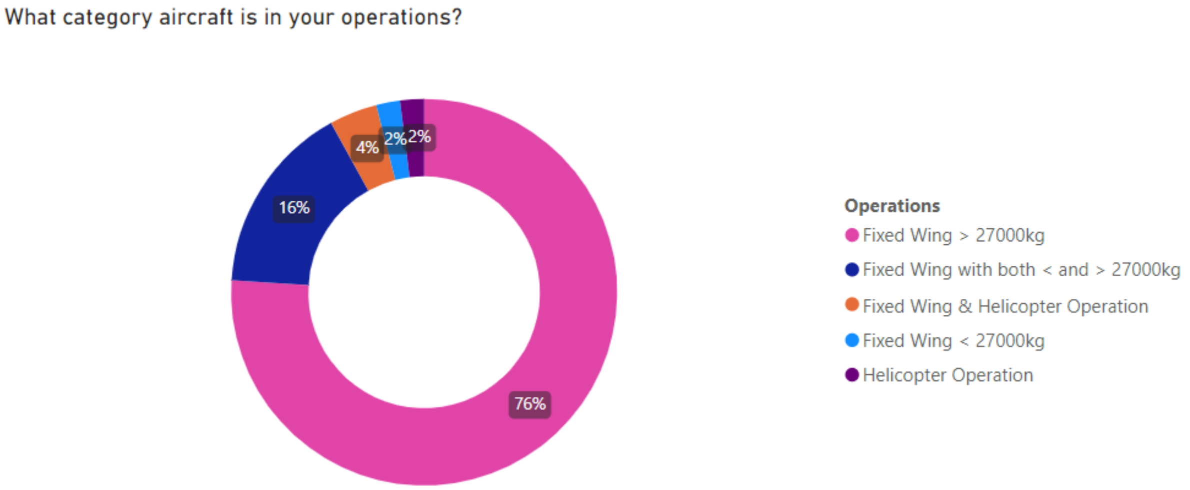
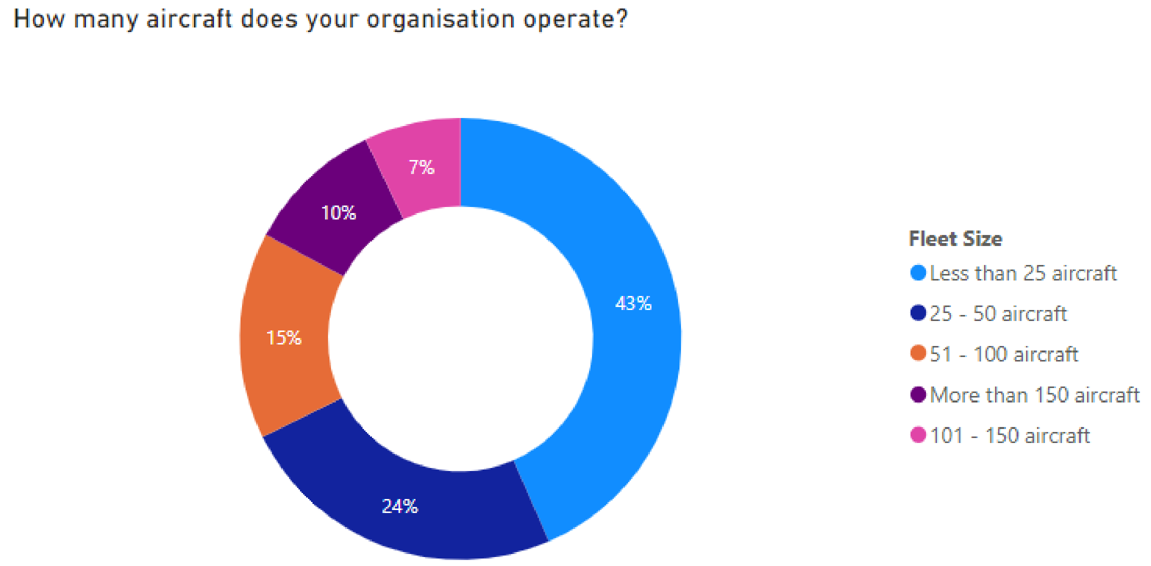


Figure I.21: Distribution of participating operators according to the size of their fleet



C. FDM CAPABILITIES OF PARTICIPATING OPERATORS

Information about the participating operators' FDM capability is presented in Figures I.22, I.23, I.24 and I.25, and is summarised in this section.

Figure I.22: Participating operators' method to perform FDM data processing

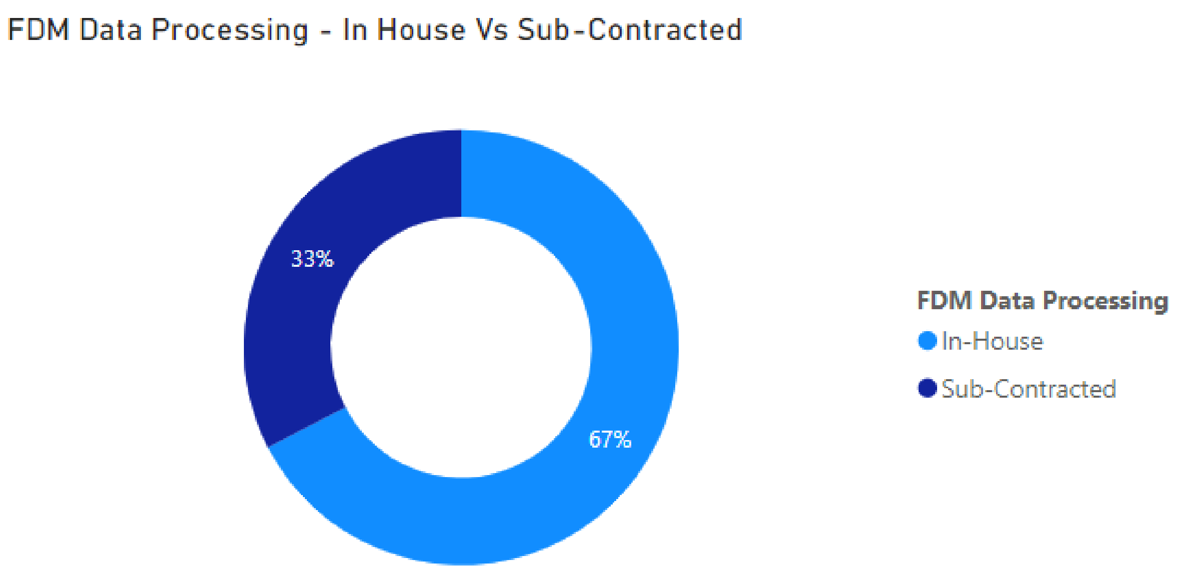


Figure I.23: Distribution of the operators' assessment of recorded flight parameters' reliability

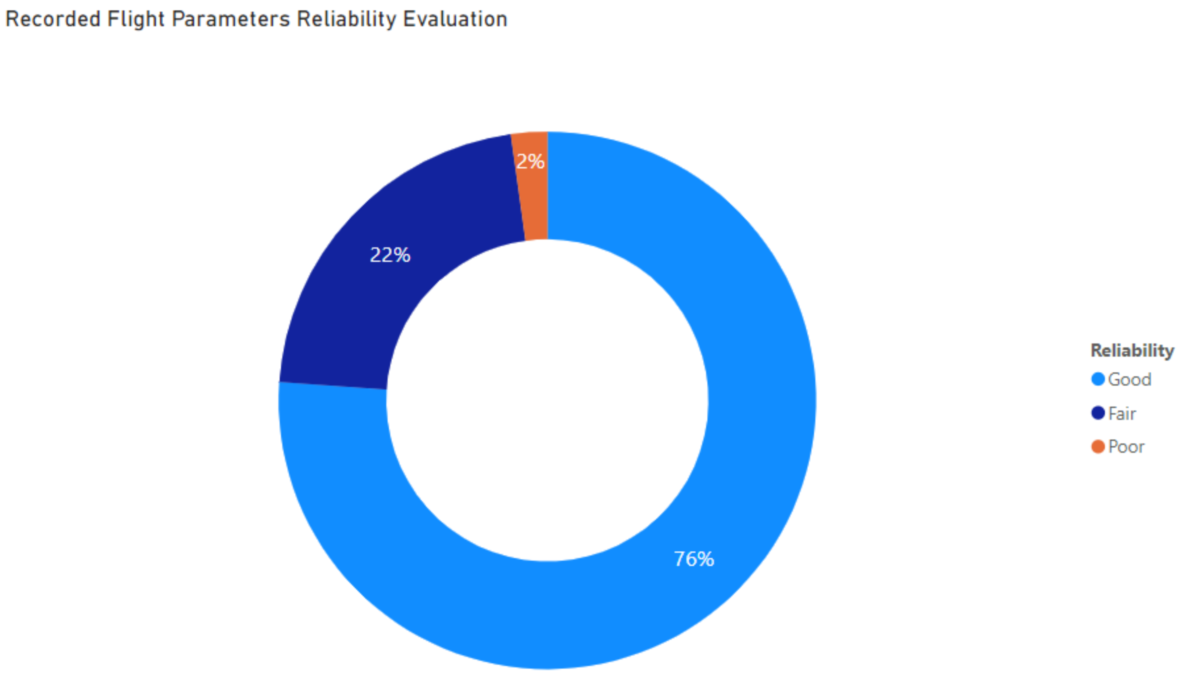


Figure I.24: Time required by operators between data collection to analysis being produced

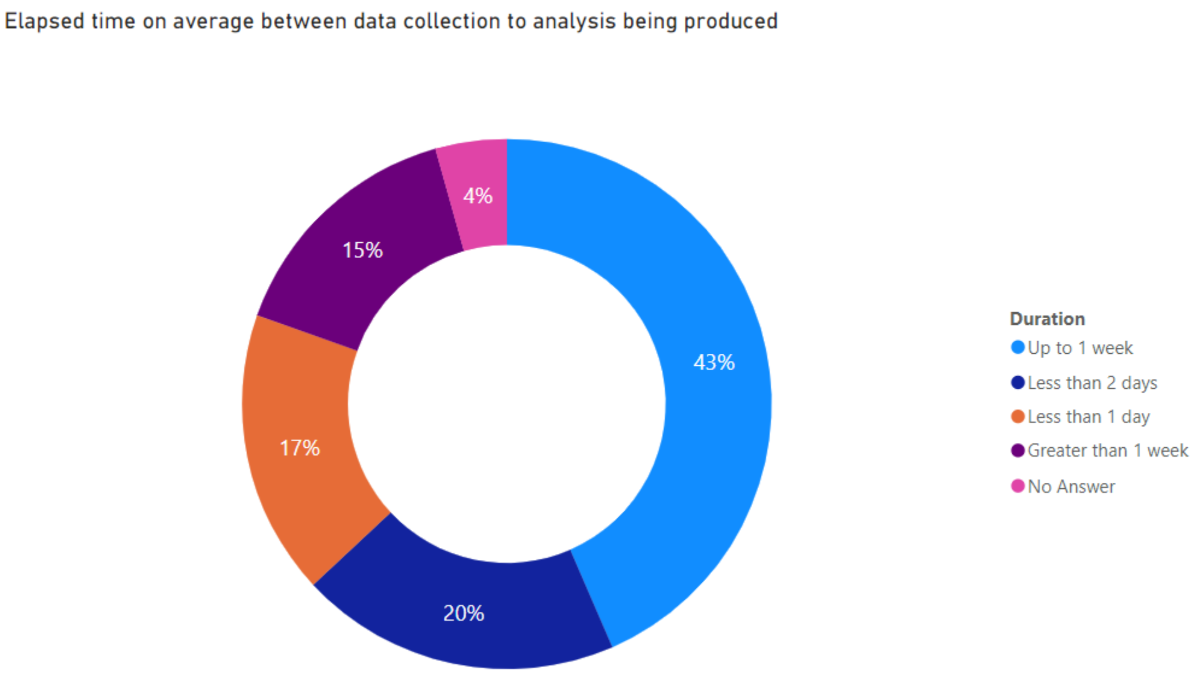
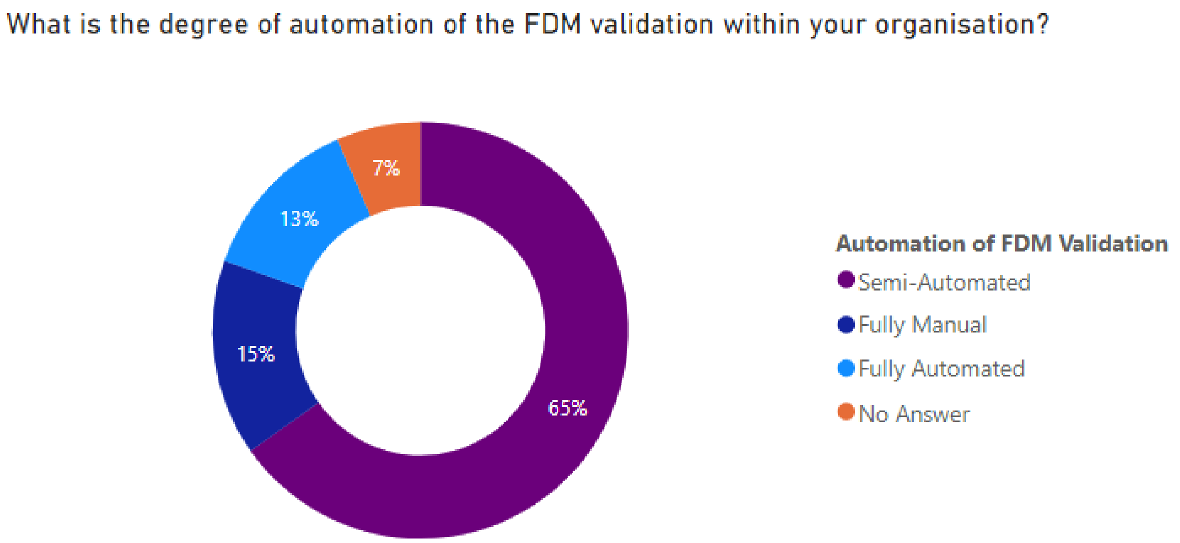


Figure I.25: Distribution of the operators' automation of FDM validation



The operators' FDM capability, as concluded from the survey results, is summarised below:

- 83% of the operators have full capability to perform FDM on their fleet, whilst 4% of the operators have only less than half of their fleet fitted with FDM capability.
- The data capture performance varies amongst the operators' FDM programme; however, 87% of the operators have achieved an average data capture rate of 90% and above. The survey found no operators with data capture rate below 60%.
- 67% of the operators process their FDM data in-house with only 33% using subcontracted services.
- 98% of the operators find the FDM data within their operations reliable; however, 2% of the operators reported their data lacks reliability. A few operators have reported unreliable geographical positioning data.
- The survey found that 57% of the operators believe that their data frame fully fulfils the objectives of their analysis while 43% feel that their objectives are only partially fulfilled.
- The time between data collection to analysis being produced varies amongst operators. 80% of the operators take between 1 to 7 days, while 15% of the operators take over 1 week to process this data.
- 65% of the operators use a semi-automated approach to perform FDM validations while 13% use a fully automated approach for FDM validations.

D. USE OF FDM WITHIN THE SRM PROCESS

Information about the participating operators' use of FDM within their SRM processes is presented in Figures I.26, I.27, I.28., I.29., I.30, I.31 and I.32, and is summarised in this section:

Figure I.26: Number of operators that use FDM to support each step of the SRM process

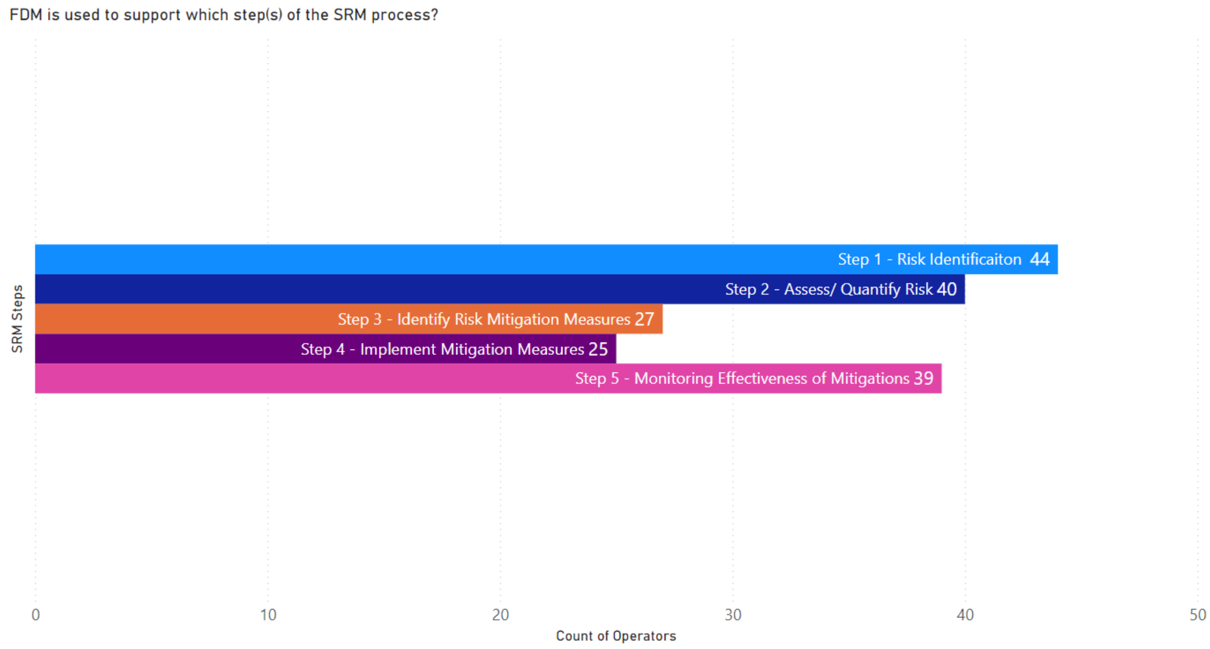


Figure I.27: How operators use FDM to support their SRM process

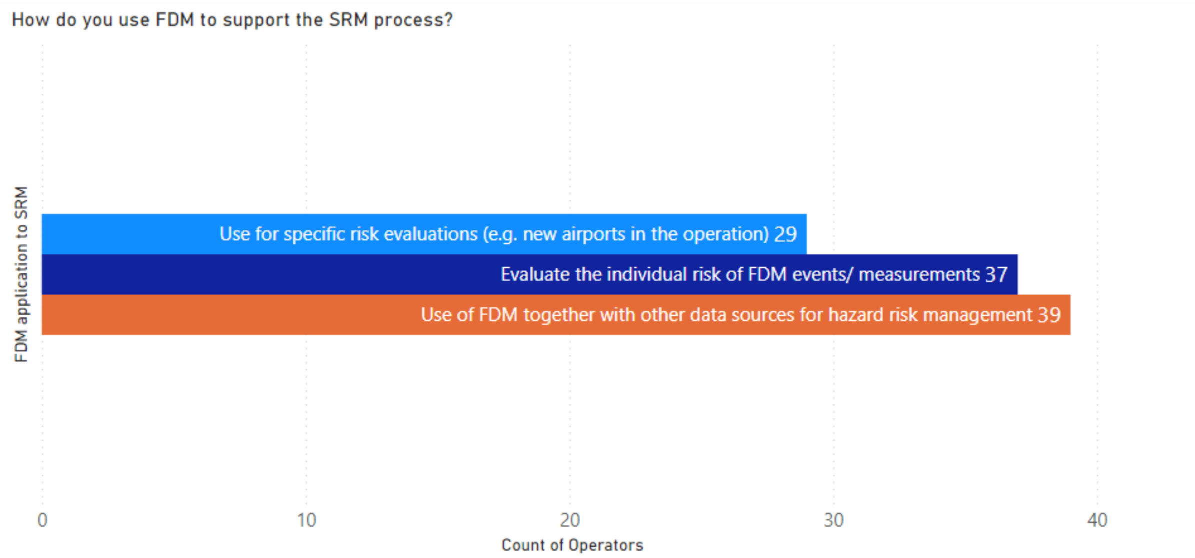


Figure I.28: How operators use FDM to evaluate individual risks

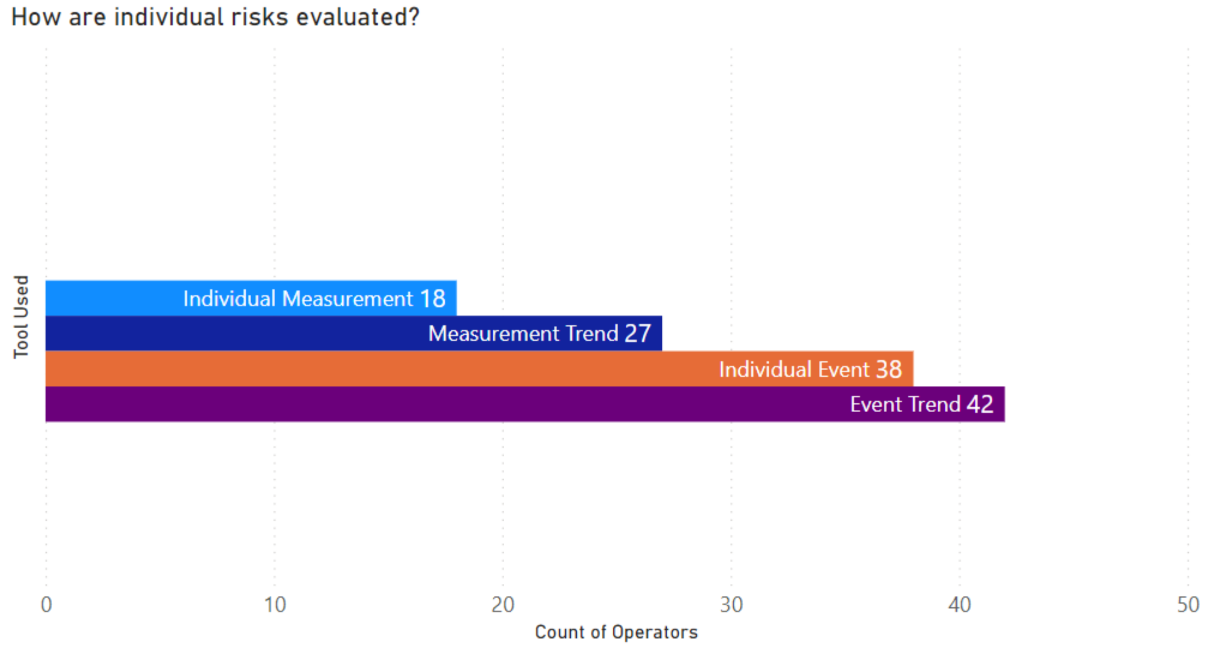


Figure I.29: Data sources used together with FDM to support the SRM process

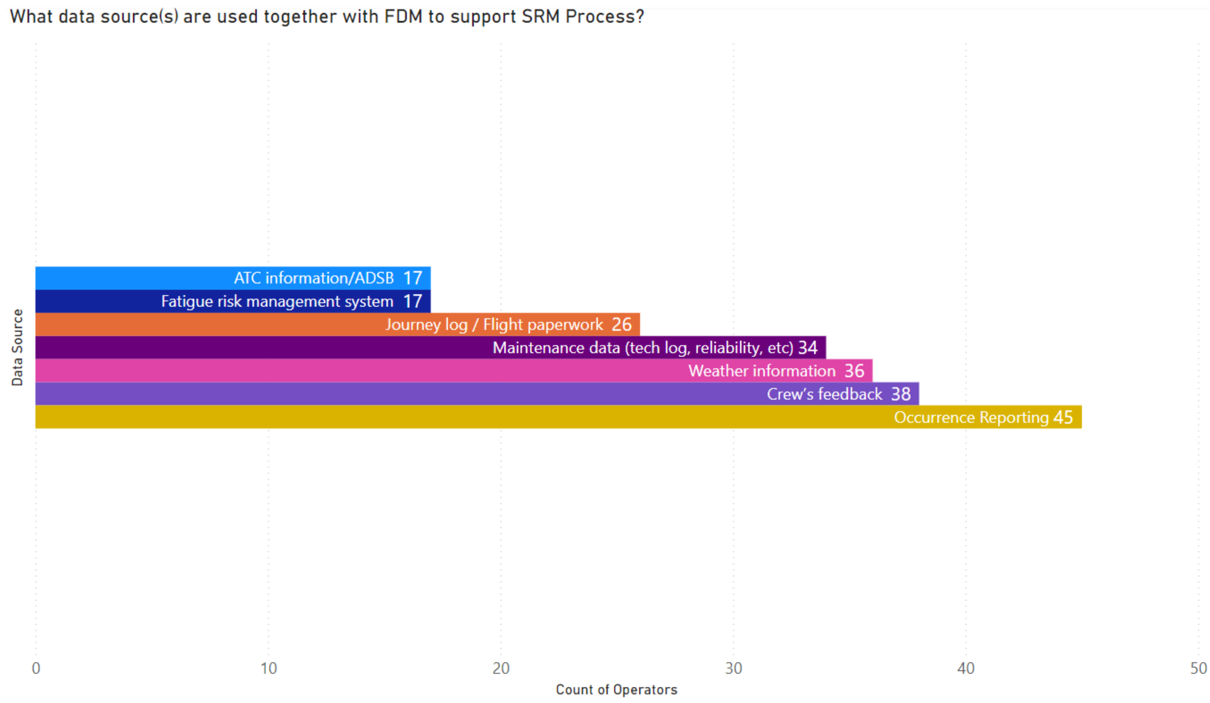


Figure I.30: How operators use FDM to support specific risk evaluations

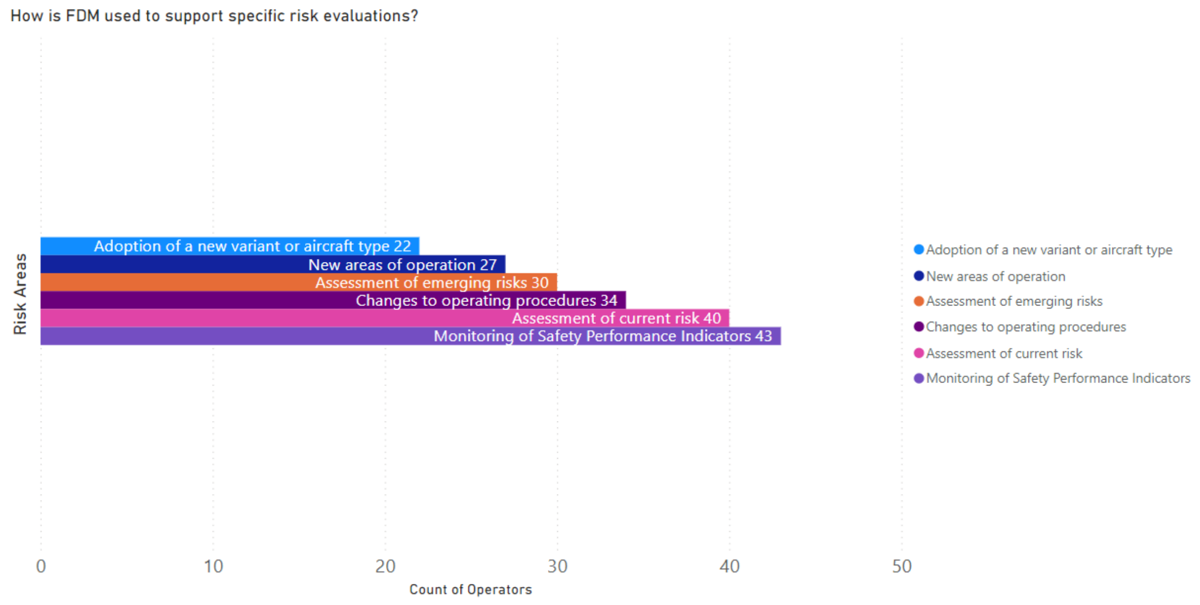


Figure I.31: Which operators' risk assessment methodologies are used

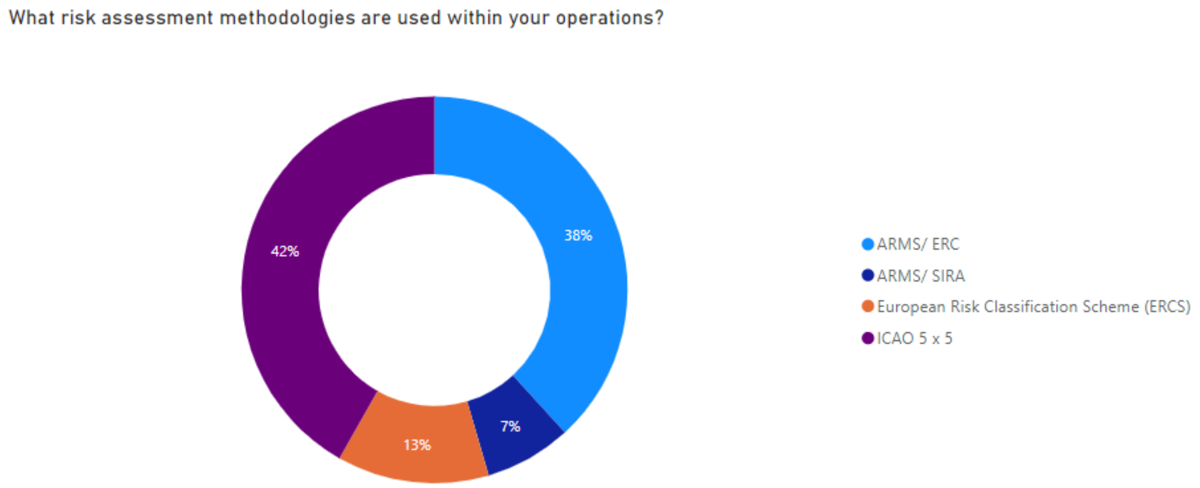
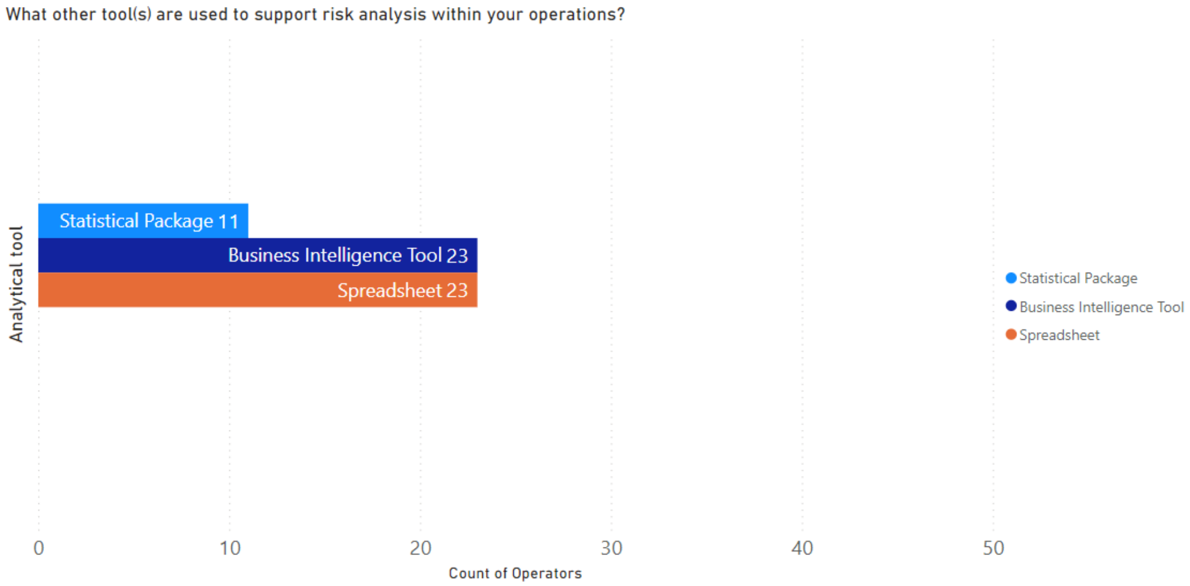


Figure I.32: Other data analytical tool(s) used to support risk analysis



Operators' use of FDM to support their SRM process is summarised below:

- The survey results showed that FDM data is mainly used to support three of the five steps of the SRM process. The majority of the operators use FDM data to identify risks, to assess/quantify risks, and to monitor the effectiveness of risk-mitigating measures.
- The survey results showed that 80% of the operators use FDM to evaluate individual risks from FDM events/measurements. 85% of the operators combine FDM data with other data sources to perform hazard risk management. It was found that only 63% of the operators currently use FDM to support specific risk evaluations (e.g. operating to new airports).
- It was found that most operators use individual FDM events or event trends for individual risk evaluation. However, only half of the operators use FDM measurements or measurement trends to assess their risk.
- The survey showed that 98% of the operators use FDM data together with occurrence-reporting data to support SRM. This is an interesting improvement since one of the main findings from a previous survey conducted in 2018 identified that time and resources were the main obstacles preventing operators from combining the two data sources. The latest survey also found that currently only 17% of the operators combine FDM data with their fatigue risk management system or traffic data.
- It was found that most operators use FDM data to assess current risks and monitor their safety performance. However, it was found that operators should put more focus on using FDM data to support risk assessment to new areas of operations and when adopting a new variant and aircraft type.
- The survey showed that ICAO 5×5 and ARMS/ERC are the two most popular risk assessment methodologies used by operators. The European Risk Classification Scheme (ERCS) and ARMS/SIRA are the least popular amongst operators.
- It was found that only 50% of the operators use either spreadsheets or business intelligence tools and only 24% of the operators use statistical packages in addition to their FDM tool to support their risk analysis.
  A few operators have also mentioned using Google Earth to support their risk analysis.

II. Confidentiality versus Safety – where to draw the line

1. Confidentiality requirements for FDM programmes and applicable EU legislation

Note: This section contains explanations and good practices about the relationships between FDM requirements and other rules. Like the rest of this document, it only presents the view of the EOFDM members, and it should not be confused with EASA official guidance.

A. THE AIR OPERATIONS REQUIREMENTS

The setup of an FDM programme is required by the EU air operations rules for large aeroplanes operated under an AOC (commercial air transport) and for helicopters operated for commercial air transport offshore helicopters[8].

Point ORO.AOC.130 of Annex III (Part-ORO) to Commission Regulation (EU) No 965/2012 contains the EU rule applicable to aeroplanes:

'ORO.AOC.130 Flight data monitoring — aeroplanes

(a) The operator shall establish and maintain a flight data monitoring system, which shall be integrated in its management system, for aeroplanes with a maximum certificated take-off mass of more than 27 000 kg.

(b) The flight data monitoring system shall be non-punitive and contain adequate safeguards to protect the source(s) of the data.'

Point SPA.HOFO.145 of Annex V (Part-SPA) to Commission Regulation (EU) No 965/2012 contains the EU rule applicable to helicopters:

'SPA.HOFO.145 Flight data monitoring (FDM) programme

(a) When conducting CAT operations with a helicopter equipped with a flight data recorder, the operator shall establish and maintain a FDM system, as part of its integrated management system, by 1 January 2019.

(b) The FDM system shall be non-punitive and contain adequate safeguards to protect the source(s) of the data.'

Hence, 'adequate safeguards to protect the source(s) of data' are required by the EU air operations rules. Therefore, the following is recommended to be checked by the oversight authority in the EAFDM document 'Good practice on the oversight of FDM programmes':

a. Statement on the general condition of use and protection of the flight data used in the framework of an FDM programme.
b. The flight crew members have access to the safety policy statement and the corresponding documents.

B. WHAT POLICY SHOULD BE IN PLACE?

The EU air operations rules are complemented by acceptable means of compliance (AMC) issued by EASA. AMC are non-binding standards which illustrate the means to establish compliance with a rule[9].

[8] See https://www.easa.europa.eu/document-library/general-publications/easy-access-rules-air-operations.

[9] The AMC issued by EASA are not of a legislative nature. They cannot create additional obligations on the regulated persons, who may decide to show compliance with the applicable requirements using other means. However, as the legislator wanted

Point (j) of AMC1 ORO.AOC.130 specifies that the FDM programme should have a data and security policy, and point (k) specifies the minimum content of the procedure to prevent disclosure of crew identity.

Note 1:

The provisions related to confidentiality and data protection contained in AMC1 SPA.HOFO.145 are the same as those contained in AMC1 ORO.AOC.130.

Note 2:

Refer to the EOFDM document 'Preparing a memorandum of understanding for an FDM programme', Chapter 2, for good practices on FDM data access and security policy.

C. WHO AT THE OPERATOR IS RESPONSIBLE FOR THE PROTECTION OF DATA?

Points ORO.AOC.130 and SPA.HOFO.145 state that the FDM programme 'shall be integrated in its management system' and so it refers to point ORO.GEN.200 Management system.

In addition, AMC1 ORO.GEN.200(a)(1) specifies the following:

'The management system of an operator should encompass safety by including a safety manager and a safety review board in the organisational structure.
(a) Safety manager
(1) The safety manager should act as the focal point and be responsible for the development, administration and maintenance of an effective safety management system.'

Further to that, AMC1 ORO.AOC.130 specifies that the safety manager, as defined under AMC1 ORO.GEN.200(a)(1), is responsible for the identification and assessment of issues and their transmission to the manager(s) responsible for the process(es) concerned.

The safety manager is designated by AMC1 ORO.AOC.130 as the responsible manager for the 'transmission' of issues, which means that he/she should be responsible for deciding what information needs to be transmitted and to which service. This also implies that the safety manager should be consulted in the establishment of the 'safeguards to protect the source(s) of the data'[10] required by points ORO.AOC.130 and SPA.HOFO.145, so that he/she can easily arbitrate the transmission of issues detected by the FDM programme. However, it does not mean that the safety manager himself/herself must ensure the protection of FDM data or is responsible for the FDM data security.

D. WHAT DOES THE REGULATION ON OCCURRENCE REPORTING MEAN FOR FDM PROGRAMMES?

Regulation (EU) No 376/2014 on the reporting, analysis and follow-up of occurrences in civil aviation is applicable to (see Article 3(1)):

such material to provide for legal certainty and to contribute to uniform implementation, it provided the AMC adopted by EASA with a presumption of compliance with the rules, so that it commits competent authorities to recognise regulated persons complying with the EASA AMC as complying with the corresponding rules.

[10] The data protection officer should also be consulted; see Part E of this section.

- 'occurrences' i.e. any safety-related event which endangers or which, if not corrected or addressed, could endanger an aircraft, its occupants or any other person; occurrences include accidents and serious incidents; and
- other safety-related information in that context.

The European Commission also published Guidance Material for Regulation (EU) No 376/2014 and Commission Implementing Regulation (EU) 2015/1018[11].

This official guidance material states:

'It is understood that Regulation 376/2014 does not apply to automatic sources of safety information such as the Flight Data Monitoring programmes in air operators or radar track analysis calculations in Air Navigation Service Providers.' This means that an FDM event trigger is not considered as an occurrence under Regulation (EU) No 376/2014.

However, an FDM event trigger could reveal an occurrence. In that case, this official guidance states:

'In some cases an individual may be made aware of an occurrence through the automatic reporting systems of his/her organisation (e.g. Flight Data Monitoring programme, post processing of radar tracks etc) and not during the actual operation. In those cases, the 72 hours period [for reporting an occurrence] starts when the potential reporter is made aware of this occurrence.'

E. WHAT DOES THE REGULATION ON PERSONAL DATA PROTECTION MEAN FOR AN FDM PROGRAMME?

DEFINITIONS

Regulation (EU) 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, defines the following (Article 4):

- *'personal data' means any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person.*

- *'processing' means any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction;*

- *'controller' means the natural or legal person, public authority, agency or other body which, alone or jointly with others, determines the purposes and means of the processing of personal data; (…)*

According to these definitions, raw flight data may be considered 'personal data' (as it can be associated to flight crew members), and Regulation (EU) 2016/679 should be considered when collecting raw flight data. However, if all information allowing direct or indirect identification of a flight crew member is removed from flight data, then it does not need to be considered 'personal data'.

[11] See https://ec.europa.eu/transport/sites/transport/files/modes/air/safety/doc/guidancematerial376.pdf.

In addition, recital (26) of Regulation (EU) 2016/679 contains the following explanations:

'The principles of data protection should apply to any information concerning an identified or identifiable natural person. Personal data which have undergone pseudonymisation, which could be attributed to a natural person by the use of additional information should be considered to be information on an identifiable natural person. To determine whether a natural person is identifiable, account should be taken of all the means reasonably likely to be used, such as singling out, either by the controller or by another person to identify the natural person directly or indirectly. To ascertain whether means are reasonably likely to be used to identify the natural person, account should be taken of all objective factors, such as the costs of and the amount of time required for identification, taking into consideration the available technology at the time of the processing and technological developments. The principles of data protection should therefore not apply to anonymous information, namely information which does not relate to an identified or identifiable natural person or to personal data rendered anonymous in such a manner that the data subject is not or no longer identifiable. This regulation does not therefore concern the processing of such anonymous information, including for statistical or research purposes.'

DATA PROTECTION OFFICER

The tasks of the data protection officer are defined in Article 39 of Regulation (EU) 2016/679. They mainly consist in informing and advising, monitoring compliance raising awareness and training the staff. However, the responsibility of protecting the data remains with the data controller (i.e. for FDM, the operator).

DATA PROCESSING

Regulation (EU) 2016/679 establishes the following:

Article 5 – Principles relating to the processing of personal data

'1. Personal data shall be:

> *(a) processed lawfully, fairly and in a transparent manner in relation to the data subject ('lawfulness, fairness and transparency');*
>
> *(b) collected for specified, explicit and legitimate purposes (…); further processing for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes shall, in accordance with Article 89(1), not be considered to be incompatible with the initial purposes ('purpose limitation');*
>
> *(c) adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed ('data minimisation');*
>
> *(d) accurate and, where necessary, kept up to date; every reasonable step must be taken to ensure that personal data that are inaccurate, having regard to the purposes for which they are processed, are erased or rectified without delay ('accuracy');*
>
> *(e) kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed; personal data may be stored for longer periods insofar as the personal data will be processed solely for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes in accordance with Article 89(1) subject to implementation of the appropriate technical and organisational measures required by this Regulation in order to safeguard the rights and freedoms of the data subject ('storage limitation');*
>
> *(f) processed in a manner that ensures appropriate security of the personal data, including protection against unauthorised or unlawful processing and against accidental loss, destruction or damage, using appropriate technical or organisational measures ('integrity and confidentiality').'*

While points ORO.AOC.130 and SPA.HOFO.145 and their AMC cover points (a), (b) and (c) of Article 5, attention should be paid to points (d), (e) and (f). These aspects should also be addressed in the policies addressing the FDM programme.

> Note 1:

The 'fairness' principle mentioned in point (a) of Article 5 is addressed in recitals (60) and (61) of Regulation (EU) 2016/679. In short, fairness means handling personal data in ways that people would reasonably expect and not use it in ways that have unjustified adverse effects on them. The fairness principle is considered in AMC1 ORO.AOC.130. Indeed, point (b) of AMC1 ORO.AOC.130 describes what the FDM programme should allow the operator to do (identify areas of operational risk, quantify risks, put in place procedures for remedial action, confirm the effectiveness of remedial actions), and point (k) specifies that the procedure to prevent disclosure of crew identity should be written in a document which should be signed by all parties (including flight crew member representatives). However, when flight data is used for purposes other than an FDM programme (e.g. for operating efficiency) or combined with other protected data, the issue of fairness should be addressed.

Note 2:

The EOFDM document 'Preparing a memorandum of understanding for an FDM programme' provides advice regarding data retention.

Article 6 – Lawfulness of processing

'1. Processing shall be lawful only if and to the extent that at least one of the following applies:

(a) the data subject has given consent to the processing of his or her personal data for one or more specific purposes;

(b) …;

(c) processing is necessary for compliance with a legal obligation to which the controller is subject;

(d) …;

(e) …;

(f) processing is necessary for the purposes of the legitimate interests pursued by the controller or by a third party, except where such interests are overridden by the interests or fundamental rights and freedoms of the data subject which require protection of personal data, in particular where the data subject is a child.'

Hence the use of flight data for an FDM programme can be considered lawful under Article 6(1)(c): the processing is necessary for compliance with the EU air operations rules.

However, when an FDM programme is implemented at the initiative of the operator (not required by the EU air operations rules) or if the flight data are used for purposes other than operational safety (e.g. for airworthiness or maintenance purposes, fuel efficiency, etc.), then the operator should identify the conditions for ensuring that these other uses are lawful.

Example: The readout of specific parameters can be requested by the maintenance manual as a necessary step in the troubleshooting procedure to restore the airworthiness of an aircraft.

Note 1:

If de-identified information stemming from flight data is provided to airworthiness or maintenance purposes, then the general data protection regulation does not apply to that data. In addition, improving operational safety, continuing airworthiness or limiting the environmental impact of operations might be considered as 'legitimate interests' of the operator.

Note 2:

Regulation (EU) 2016/679 defines 'consent' as follows (refer to Article 4):

'Consent' of the data subject means any freely given, specific, informed and unambiguous indication of the data subject's wishes by which he or she, by a statement or by a clear affirmative action, signifies agreement to the processing of personal data relating to him or her;

In the case of an employer–employee relationship between the data controller and the data subject (like between the operator and flight crew members), the consent of the employee might be considered as not 'freely given'.

Note 3:

When flight data is combined with other data, the technical protection of the combined data should follow the highest standard among technical protection standards applicable among the data sources for this combined data. In practice it is advised that the combined data is securely stored and that it is encrypted.

RIGHTS OF THE DATA SUBJECT

Regulation (EU) 2016/679 defines the rights of the data subject in its Chapter III. The operator should be aware of these provisions and check that they are taken into account in the internal policies regulating the FDM programme.

In particular:

Article 13 – Information to be provided where personal data are collected from the data subject

Article 15 – Right of access by data subject

'1. The data subject shall have the right to obtain from the controller confirmation as to whether or not personal data concerning him are being processed.'

Article 15 provides a list of information the data subject has the right to obtain. However, Article 15(4) states: *'The right to obtain a copy [of personal data] shall not adversely affect the rights and freedoms of others.'*

In the case where the aircraft is piloted by two flight crew members, the flight data is not related to one flight crew member, but to both.

Article 16 – Right to rectification

'The data subject shall have the right to obtain from the controller without undue delay the rectification of inaccurate personal data concerning him or her. (…)'

Where FDM data is considered personal (because it is associated to identified FDM members), a flight crew member might require correction of errors in that data. Hence, validation of FDM event triggers is important to avoid that undesired (i.e. non-relevant) FDM event triggers are used for following up the performance of individual flight crew members or initiate flight crew contact. An event detection can be undesired for several reasons, which are explained in the EOFDM document titled 'Key performance indicators for a flight data monitoring programme'.

Article 17 – Right to erasure ('right to be forgotten')

'1. The data subject shall have the right to obtain from the controller the erasure of personal data concerning him or her without undue delay and the controller shall have the obligation to erase personal data without undue delay where one of the following grounds applies:

(a) the personal data are no longer necessary in relation to the purposes for which they were collected or otherwise processed;

(b) the data subject withdraws consent on which the processing is based according to point (a) of Article 6(1), or point (a) of Article 9(2), and where there is no other legal ground for the processing;

(…)'

Note: Regulation (EU) 2016/679 also defines the general obligations of the data controller and processor in its Chapter IV 'Controller and processor'.

F. WHAT HAPPENS WHEN AN OFFICIAL SAFETY INVESTIGATION IS LAUNCHED?

GENERAL PRINCIPLES

According to ICAO Annex 13 on Accident and Incident Investigations, the authority's investigator-in-charge is entitled to access all data and evidence that are relevant for the investigation. In Europe, these principles were transposed into Regulation (EU) No 996/2010. This Regulation applies, among others, to official investigations of accidents and serious incidents which have occurred in Europe, or where an EASA Member State is involved as State of the Operator (see Article 3).

Article 11:

> *'2. Notwithstanding any confidentiality obligations under the legal acts of the Union or national law, the investigator-in-charge shall in particular be entitled to:*
>
> *(…)*
>
> *(c) have immediate access to and control over the flight recorders, their contents and any other relevant recordings;*
>
> *(…)*
>
> *(g) have free access to any relevant information or records held by the owner, (…) the operator or the manufacturer of the aircraft, (...)'*

Article 13:

> *'3. Any person involved shall take all necessary steps to preserve documents, material and recordings in relation to the event (…)'*

Article 15:

> *'1. The staff of the safety investigation authority in charge, or any other person called upon to participate in or contribute to the safety investigation shall be bound by applicable rules of professional secrecy.'*

Therefore, it is advised that the flight data files pertaining to an accident or a serious incident are integrally preserved and made available on request by the official safety investigation authority.

Care should also be taken of the confidentiality of the official safety investigation.

CASE WHERE FDR DATA IS USED FOR THE FDM PROGRAMME

In the case where the flight data recorder (FDR) is used for the FDM programme, AMC1 ORO.AOC.130 specifies that accident and incident data requirements specified in point CAT.GEN.MPA.195 take precedence over the requirements of an FDM programme.

Point CAT.GEN.MPA.195 (Handling of flight recorder recordings: preservation, production, protection and use) states:

'(a) Following an accident, a serious incident or an occurrence identified by the investigating authority, the operator of an aircraft shall preserve the original recorded data for a period of 60 days or until otherwise directed by the investigating authority.'

2. The potential conflict between confidentiality and the broader use of FDM for safety

A. A NON-PUNITIVE FDM PROGRAMME IN A JUST CULTURE ENVIRONMENT

FDM was introduced with the sole objective of enhancing safety.

Because a direct monitoring of individual crew members is possible with an FDM program, there is a need to reconcile the non-punitive character of FDM on one hand and the identification of unacceptable behaviour on the other hand.

According to EU requirements applicable to FDM, the safety manager should be responsible for the identification and assessment of safety issues (see also section II.1).

In addition, the EOFDM document 'Preparing a memorandum of understanding for an FDM programme' recommends among others:

- That FDM be embedded in a just culture environment that basically promotes a non-punitive, open and transparent reporting culture while at the same time recognising that unacceptable behaviour such as gross negligence is not tolerated. With the introduction of Regulation (EU) No 376/2014, a definition of what 'gross negligence' in aviation should be, found its way into European legislation for the first time.
- To define a clear framework for contacting the flight crew after FDM findings where follow-up is required. One possible solution is based on a gate keeper who can contact the crew to collect information after a significant FDM event trigger.
- To balance the need for confidentiality versus accountability once potentially unacceptable behaviour was detected.

B. FINDING THE OPTIMAL LEVEL OF PROTECTION FOR FLIGHT DATA

Protecting flight data while making it available for wider use to enhance operational safety can be difficult.

- An FDM programme with a stronger tendency towards confidentiality can cause flight crew members to be more honest and forthcoming with information during the analysis of the events by the FDM team (say with a peer pilot). However, the subsequent use and benefit of that information within the organisation's risk management process are hindered due to confidentiality restrictions. Indeed, information provided without the support of accurate data such as provided by FDM may have less force and be less convincing for decision makers.
- An FDM programme that is more open may not obtain as much honest and open information from the crew compared to a more restrictive model. However, it may be more effective from a risk management perspective and achieve greater safety gains.

  Note 1:

  The principles for removing confidentiality should be defined in procedures and be clear to everybody. In addition, such procedure should clearly identify who is responsible for what action (interview, debrief, training, etc.).

  Note 2:

  It is recommended to consider the 'who-needs-to-know-what' principle in the sharing of safety data inside the operator. The principle is to share with each internal stakeholder what they need to know for their duty and not more.

C. FURTHER DEVELOPMENTS

With the larger amount of data recorded on new aircraft models, insight into aircraft performance beyond mere flight envelope and SOP monitoring is easily possible. The following list describes several areas of interest:

PERFORMANCE MONITORING

This is one of the most prominent fields of interest for an operator as it may very quickly yield results in many areas ranging from safety to economic and environmental benefits.

> Note:
> Some of the areas may span over safety and other areas. For example, single-engine taxi could be analysed for safety purposes or other performance purposes.

Safety performance monitoring

It consists in providing to flight crew members a means where they can see their performance against several safety performance indicators. For example, a safety performance indicator provides the number of triggers for a particular FDM event over the last 30 calendar days. An example is provided in II.4.

Operational performance monitoring

In an ever-competitive economic environment where costs such as fuel, staffing and maintenance attribute to a significant proportion to the overall operating costs of an airline, flight data can be used to assess the effectiveness of company procedures with regard to operating efficiency.
For example:

- percentage of flights completing single engine taxi;
- adherence to procedures, such as engine cool-down and warm-up times, thrust limits, etc., being observed;
- route analysis: compare different routes i.e. oceanic routing versus domestic, shorter routing with restrictions (i.e. level caps) versus longer unrestricted routes. Bringing together comparison data for fuel burn, A/C and engine hours / maintenance requirements, staffing (i.e. pilot costs) could allow an airline to efficiently create its flight plans.

FLIGHT ANIMATIONS AND TRAINING

Developments in this area fall into a number of closely related categories:

- The appearance of sophisticated data analysis and processing software as well as user-friendly hardware facilitates replay of own flights at user level. Most importantly the approach and landing phase. Some operators are already making this available to their crews.
- A logical continuation of flight animations is the possibility to create an individual performance report. Operators define certain criteria (such as (vertical) speed limits or stabilisation on final) and provide an overview of how an individual pilot performed compared to the rest of his/her group (see section I.4).
- Another development would be to make good use of the acquired individual performance data and develop training of individual deficits during recurrent simulator lessons. This is already in some operators' training processes. Pilots could be encouraged to bring their personal results to the next planned simulator event and the instructor would take care of the individual deficits as far as possible.

D. EMERGING ISSUES

PERFORMANCE MONITORING

The use of individual performance reports may easily lead to the unwanted situation that crews rather 'fly the recorder' than the aircraft. In other words, they worry more about limits than about good airmanship. As a result, unwanted situations could occur because a crew's primary focus was not on proper decision making as is recognised in ICAO Doc 10000:

‘2.4.5 A proper value should be programmed for trigger and exceedance and designed to include an acceptable buffer that will disregard minor deviation, spurious events, as well as introduce an adequate operational margin to fly the aeroplane through SOPs, instead of leading the flight crew to focus on FDA parameters in order to avoid deviations.’

The EOFDM document ‘Key performance indicators for a flight data monitoring programme’ also refers to these risks:

‘An event detection can be undesired for several reasons, such as:

- *Corrupt data or faulty data due to an on-board sensor(s) failure (see note 1);*
- *A shortcoming in the measurement algorithm, detection logic or other FDM software configuration;*
- *It’s the result of a necessary, intentional and expected action from the crew – meaning it’s detection is correct, but the event is not applicable in the context of the flight (see note 2).’*

The effect of improperly set individual performance reports is potentiated when performance (of the individual) could be used as a basis for management decisions or even for disciplinary actions, especially when no seniority systems are in place or contract details are negotiated individually. It is imperative that individual performance reports are fine-tuned to include margins so that they do not put unnecessary emphasis on a ‘perfect’ flight profile.

Note:

Individual performance reports show little about how an individual pilot will ‘perform’ in an exceptional situation. Hence, being focussed on individual performance reports (or other kinds of SPIs) might create a false feeling of being safe while it just shows a high level of compliance with SOPs.

The balance between safety, efficiency and environmental factors is a delicate one. For example, linking fuel monitoring to disciplinary supervision is unacceptable. Crews need to be free in their decision regarding the fuel quantity carried for each flight. These decisions must be based on the circumstances of the respective flight. Any pressure because of economic considerations will eventually compromise safety. Even the mere comparison of ‘fuel performance’ between crews may result in a competition to take less and less fuel with negative safety consequences.

FLIGHT ANIMATIONS AND TRAINING

Flight animations are prone to significant limitations:

- Data integrity should be checked before the replay to ensure their correctness (data validation). Missing data or a spike in data could lead to significant deviations between the flight path shown in the animation and the flight path that was actually flown and/or instrument indications.
- Some of the parameters shown in an animation are not actually measured and recorded but calculated or derived from one or more other parameters. For example, altitude values shown may or may not be corrected for QNH regardless of what value is displayed in the altimeter setting window. Also, Flight Mode Annunciations are usually derived from a complex algorithm using multiple parameters. The resulted value may not be correct.

Obviously, the above-mentioned limitations must be considered. All data needs to be carefully screened before it can be used in a visualisation. Also, crew members themselves should be made aware of the limits of such a visualisation and using it for unsupported ‘self-briefing’ is unadvisable.

COMBINING FDM WITH OTHER DATA SOURCES

Once de-identified personal data is available, the potential for misuse increases when a link can be made with related data. For example, combining an FDM exceedance with meteorological data could lead to a flight date and subsequent crew identification when a significant meteorological event was involved at a particular location.

The subsequent potential effect of 'naming and shaming' of individual crew members and/or companies would have a disastrous effect on just culture and should be avoided at all costs. Therefore, there is a need to define a 'circle of confidence' (refer to section II.4).

E. JUST CULTURE

A broader use of FDM as described above will bring clear safety benefits when a functioning just culture is in place.

To achieve this, unambiguous protocols, should be in place. Any crew member should be convinced that increasing personal excellence and company safety is the only driver behind the FDM programme. Trustful agreements will result in a win-win situation for both parties: the company provides programmes to improve or strengthen individual abilities which pay off by having better performing pilots. On the other hand, everybody needs to accept human factors and associated shortcomings, and show the willingness to address them.

For a functioning just culture, much more is required than a simple statement of intent and a definition. Just culture principles must pervade the organisation every day in all its activities.

The EOFDM document 'Preparing a memorandum of understanding for an FDM programme' provides recommendations with regard to just culture and the participation of flight crew representatives.

3. Circle of confidence – The boundaries of confidentiality

A. THE CIRCLE OF CONFIDENCE – WHO IS THAT?

The circle of confidence means those people who have access to identified data.

The simple fact of compiling data does not mean that this data is useful. The analysis of the compiled data, done by the right person and the use of the resulting information by the right team will make it meaningful. This normally requires the involvement of persons with the necessary expertise to understand safety issues.

Essential trust is defined as the trust established between management and flight crew and is considered the foundation of a successful FDM programme. This can be facilitated by the operator strictly limiting data access to selected individuals, as explained in GM1.ORO.AOC.130.

During the investigation of an incident, the safety analyst will use data obtained from air safety reports (ASRs) or any other reports in conjunction with the operational information related to the flight. This process, when we talk about incidents and not about accidents, is carried out by the company's safety staff. In this context, the less restricted their access to flight data is, the more accurate the investigation outcomes will be.

In some cases, when a pilot fills in an ASR, the possibility of omitting important information exists. Recorded flight data is useful in adding to the impressions and information recalled by the flight crew. It also provides an accurate indication of aircraft systems status and performance, which may help in determining cause and effect relationships.

However, someone should be able to decide which FDM event triggers are relevant to include in the analysis of the ASR (only FDM event triggers corresponding to the reported occurrence, other detections in the same flight not directly related to the occurrence, similar FDM event triggers from previous flights with the same aircraft?). This choice is only possible when the access of the safety analyst to FDM data is not restricted. Conversely, for the safety analyst to be able to perform an informed analysis of the FDM event triggers, his/her access to the related ASRs should be facilitated. One can usually not preclude the information sufficient for a given safety analysis. This shows that the safety analysts (including the safety manager) may need to access identified data for their job.

B. BREAK A SILO, NOT THE CONFIDENTIALITY

To ensure the confidentiality of the flight data, and in order to guarantee control over the communication and identification, the staff inside the circle of confidence should commit to confidentiality terms of the FDM programme.

However, the data may be shared, de-identified, with other departments within the organisation (such as the Training department) to correct operational drifts, engineering, etc.

Unless justified and addressed by established processes, access to flight data by departments other than the Safety department should be limited to de-identified data and statistics.

The level of confidentiality depends on the level of information shared, so, in some manner, different circles may coexist with different levels of information and different levels of confidentiality.

Considering that just culture is the basis of the SMS, any persons with the authority to impose sanctions against the pilot (e.g. training, flight operations, etc.), or to influence career progress, should remain outside the circle of confidence, and not have any access to identifiable flight data. Disclosure for purposes other than promoting or improving safety of flight operations can compromise the engagement of all persons involved, including flight crews.

Clearly defined processes have to be designed and agreed before the implementation of any FDM programme with regard to identified and de-identified data, and monitored for compliance once implemented. These processes will be specific to an operator depending on such things as existing structures/departments, size of the organisation and roles and responsibilities within, and maturity of the safety culture in the organisation.

> Example 1:
>
> An adverse safety trend is highlighted across the pilot staff of airline X within FDM that could be addressed via recurrent training, then de-identified data can be passed on to the Training department highlighting this trend, thus allowing the adverse safety trend to be addressed in the 3-year recurrent simulation training programme.
>
> Example 2:
>
> If after analysis of an FDM event trigger, or a series of FDM event triggers, that involve a single flight crew member it is concluded that ad hoc / remedial training is required, then detailed information would need to be passed on to the Training department to allow specific training to be delivered. The

process for doing this would need to be detailed and adhered to[12]. In this case a 'trustee' from within the Training department is given the detailed information, who can then develop an individual training plan. The training plan does not need the actual event details. Once the plan is complete, it can then be passed (without original flight data) on to any 'non-trustee' (i.e. a TRI/TRE) who can deliver the training.

Example 3:

At airline Y, a complementary training process has been established which allows remedial training requests to be instigated by the Safety department or the Flight Operations department and implemented by the Training department. The complementary training delivered to the crew member(s) may either be in accordance with the standard procedures documented in the Operations Manual or developed in the form of a tailored training package. If the request for complementary training was made by the Safety department based on confidential data sources (for example, FDM or confidential safety report), then the result of the training will be kept as a separate record by the Safety department. In all other cases, the results of the remedial training will be stored in the crew member's (members') training file.

These are just examples of a defined process, which could involve various departments across an organisation. The larger an organisation is, the more processes and lines of communication must be defined. The larger the organisation, the more the trustees, simply due to the roles and responsibilities being divided in such an organisation — no one person in a large organisation could be responsible and manage the processes end-to-end.

4. The safety culture and the need for confidentiality – a dynamic relationship

Every organisation will have a different setup for FDM. Set within the regulations, there will be differences depending on the size and structure of the organisation, the human resources invested in the FDM programme, the degree of participation from unions and, most importantly, the level of maturity of the organisation's safety culture. And within that, specifically, the implementation and perception of just culture. For example, within an organisation with a non-mature safety culture, the FDM programme, at inception, will have to be much more protective of the data to ensure confidentiality. This FDM model comes about as a consequence of the organisational environment and the expectations of crew with respect to data protection. In a sense, one could consider that this FDM model, although far from ideal, may in fact be adequate for the needs of that organisation, at that point in time, with respect to the prevalent level of safety culture. In contrast, at an organisation where there is a more advanced level of maturity in terms of safety culture, FDM would have a more integrated role in the Management System of the operator. Whilst confidentiality would still be maintained to a degree, the data may be used more liberally to better support safety critical decision within the organisation. Likewise, this FDM model is designed to respond to the safety needs of such an organisation. It is important to recognise that none of these FDM models are wrong. The cultural context of the organisation determines what type of an FDM model is created. And more importantly, as the organisation evolves over time and, with it, there is a more mature level of safety culture, so too should the FDM programme keep pace with this progress to ensure that it adequately meets the safety needs of the organisation.

[12] According to the principle of transparency established by Regulation (EU) 2016/679, the processes for passing the necessary information from the FDM programme on to the Training department should be transparent for the flight crew members (refer to section II.1).

Note:

Indications of a mature safety culture are provided in ICAO Doc 10000, Manual on Flight Data Analysis Programmes (FDAP). To get an assessment of the company's safety culture, an analysis performed by an independent consultant might be useful. In that case, the analysis should not just rely on an opinion survey but include an active investigation of how safety information is protected and how safety lessons are disseminated internally. Another approach may consist in comparing the internal implementation with industry best practice. In any case, soft skills such as human factors, psychology, etc., are advisable for a relevant analysis.

Whatever the level of maturity of the operator's safety culture, external threats such as those caused by a judicial investigation or the press, or lawsuits for breaching Regulation (EU) 2016/679 (General Data Protection Regulation) still exist. Therefore, operators should also consider these risks when defining their data protection and retention strategies. To address such threats, it is advised to set up clear and complete procedures to guide the assessment of significant security and compliance issues and to document each individual assessment. These procedures should take into account the personal data protection regulation applicable to the operator (in the case of EU-based operators, it is Regulation (EU) 2016/679; see section II.1)

Example 1: Following an accident where several passengers were severely injured, the justice administration seized all flight data and ASR records retained at the operator. They tasked independent experts to analyse this data.

Example 2: FDM trends are leaked to investigative journalists, which use them to picture the operator as being unsafe and complacent with safety risk.

Example 3: A pilot files a complaint against an airline for using personal data without consent (where only legitimate interest prevails) and the airline is fined at the maximum penalty of 4% of annual turnover as stated by Regulation (EU) 2016/679.

III. Going beyond the conventional use of FDM

1. Serving internal and external customers

To fulfil its purpose as an integral component of the Safety Management System, FDM needs to support several internal and external 'customers' in discharging their safety duties.

Operators are very diverse (large or small, operating helicopters or aeroplanes), and implementing FDM in each organisation is unique.

FDM needs to be utilised in a company's holistic vision, and to be supported by optimal and efficient data flows, to extract, communicate, service and deliver essential information to all departments. Many operators have realised this to stay competitive.

All departments within an operator could potentially benefit from more data-driven knowledge because it would elevate the respective departments' awareness in either safety matters or optimal efficiency, or even both.

To achieve this, the needs of these internal customers need to be thoroughly understood and, likewise, they may need to be informed about the worth of flight data and the importance of safeguards to protect flight data.

> Note:
>
> There can be limitations to this approach. For example, one limitation is the number of recorded flight parameters: on older aircraft, there are too few flight parameters available for implementing some of the ideas exposed here. Other limitations may be the size of the fleet, or the diversity of missions which makes comparisons and meaningful statistics difficult.

A. INTERNAL CUSTOMERS

Beyond the traditional contact with crew to debrief them of occurrences or exceedances, FDM can provide information which can help crew proactively improve their performance and prevent occurrences or exceedances in the first place. A good example of this is providing monthly reports to crew members with their own performance regarding stable approaches or touchdown distances; see section I.4.

There is also potential for closer collaboration with flight operations at management level. Sharing aggregated data in the form of safety metrics / statistics can help flight operations management monitor the operation and act where necessary to halt the development of any adverse trends or behaviours. Working with Fleet Management, specific fleet metrics can help the Chief Pilot monitor normal operations or target a particular concern. In addition to sharing aggregate data, FDM can also support flight operations ad hoc requests and projects.

FDM and flight operations can also collaborate and combine their technical expertise to create flight animations which can aid crews to gain better familiarity of category B and C aerodromes or to understand aircraft/system behaviours. Specifically, such flight animations are useful to raise crew awareness of the correct track whilst executing visual or VPT approaches[13] to adhere to stable approach requirements. These flight animations can help mitigate unstable approaches at hotspots identified through FDM. An example of where this can be useful is Nice runway 22, in order to help crew to initiate the turn at the correct point or Le Bourget runway 25 to avoid infringement of Charles de Gaulle airspace. The flight animations can also help enhance familiarity with the local terrain and obstacle features near airports, such as Bolzano, Pantellaria, Annecy, Cannes, Lugano and Buochs.

[13] Visual approach with prescribed track

Unexpected aircraft/system behaviours can also be the subject of flight animations, to raise crew awareness and complement other sources of mitigating action, such as operational procedures, training, etc. In most cases, add-on modules are required to allow the FDM team to take full advantage of the data and create flight animations, using the actual flight displays or accurate terrain features. Some software programs allow to simulate weather phenomena (clouds, fog, snow, etc.) and different light conditions (dusk, night, etc.).

Advanced means of replaying the data can also have a significant benefit from a training perspective. A future application of FDM may be in the form of monitoring compliance of training with the syllabus, by integrating into the FDM programme data recorded by the simulator. Such an activity could provide a more objective view of what was trained, how it was trained, the crew member's response to the training and, thus, serve as a reference to baseline reference to monitoring day-to-day operations. The so-called SOQA (simulator operational quality assurance) is still at its infancy, but it offers interesting prospects.

FDM can also help monitor serviceability of parameters required to be recorded by the FDR[14], and help troubleshoot technical events. Indeed, through FDM, flight data is available over long periods of time, which can help engineering teams to carry out reliability assessments and better support the investigation of technical events.

B. EXTERNAL CUSTOMERS

There are a few external customers which will benefit from the access to some of the flight data collected for the FDM programme. The first example is the OEMs, which can use routinely collected flight data to support troubleshooting and investigation of technical issues, or to seek improvements in terms of reliability at component or system level. Indeed, some OEMs will have their own means (airborne systems) which will collect flight data independently from the operator's FDM programme, to carry out health monitoring/management. In other cases, they may rely on the operator for the data.

Civil aviation regulatory authorities and airline associations may also seek FDM programme output of operators in order to conduct predictive analyses of the aviation system, and some have set up large data exchange programmes for that purpose. Examples of such data exchange programmes are EASA's Data4Safety programme, the FAA's ASIAS programme, and IATA's pioneering STEADES programme. STEADES participants also benefit from contributing their data because they can access the database and use the de-identified data for their own analysis and benchmarking.

Operators may choose to share data from their FDM programmes among each other, for benchmarking purposes, although this needs to be done very carefully to obtain meaningful results. There needs to be sufficient similarity in place to allow any meaningful comparison between two operators. There is greater potential for achieving this, for example, between operators within the same group company, where normally there is both scope for data sharing and commonality in terms of SOPs and operation of the same aircraft types.

In addition, the intrinsic design of the FDM software may result in different results for the same FDM event definition. This can make the comparison of FDM events between operators that use different FDM software challenging.

> Example: In the case of recurrent failure of an aircraft system, flight data can be used to support a discussion with the (supplemental) type-certificate holder.

[14] Refer to AMC1 CAT.GEN.MPA.195(b): under certain conditions, an FDM programme can be used to get a relief from mandatory inspection of FDR recording.

C. SUPPORTING OPERATIONS – DAY-TO-DAY USE OF FLIGHT DATA

The following activities may be supported by the use of flight data, but should not be considered an exhaustive list.

PART-M

- Aircraft maintenance (e.g. for engine condition monitoring)
- Serviceability of the FDR (to fulfil the requirement to inspect the FDR recording)

PART-145

- Preventive monitoring concerning rises in temperature, pressure, etc.
- Support maintenance troubleshooting

OPERATIONS MANUAL PART D (TRAINING)

- Evidence-based training (OPC & PC)
- Line training
- Introduction to FDM (to improve transparency and get the buy-in of flight crew members)

TRAINING ORGANISATIONS

- Evidence-based training (lesson plans)
- Replay of scenarios based on findings made in flight data for pre- and post-simulator session briefings

For more details, see section III.2.

FLIGHT OPERATIONS AND GROUND OPERATIONS

Flight operations:

- Annual, quarterly and monthly performance indicators in reference to FM, OM-B, etc.
- Key performance indicators, such as:
    - Fuelling procedure versus flight plan
    - Taxi in respect to times, speed, etc.
    - On-time performance
    - Starting procedure: ground power unit versus aircraft battery
    - Use of brakes versus thrust reverse

Ground operations:

- Key performance indicators related to the fuelling procedure and the aircraft weight: Monitor the fuel actually burnt (fuel conservation), the actual time taken by the refuelling procedure, and the margin to structural weight limits

- Key performance indicators related to the shutdown cooling procedure

OTHER APPLICATIONS

- Annual audit, e.g. by customers
- Fuel conservation programme
- Block-to-block (B2B) run times

2. Enhancements to training and operational policies through the use of FDM

A robust line operation requires the implementation of a relevant and effective training programme. Flight data provides an additional source of information separate from training records.

In addition, the algorithms implemented in the FDM programme can support the objectives of flight crew training in various manners:

- They can help assess the actual exposure of operations to events reflected in training scenarios (e.g. what is the proportion of flights with a predictive or a reactive wind shear warning).
- They can help assess the actual exposure of operations to events that are precursors of the training scenario (e.g. abnormal engine vibration levels as a precursor of an in-flight engine failure).
- They can help monitor common problems with the piloting or management of the aircraft that may make the recommended procedure for a given training scenario ineffective (e.g. monitor low-energy approaches, as the loss of thrust of one engine during approach — training scenario — may be very difficult to recover if it occurs during a low-energy approach).
- They can help monitor the correct management of the aircraft engines or the aircraft safety-critical systems (e.g. on helicopters, monitor airspeed with undercarriage extended).
- They can help identify and address cases of repetitive false alerts, as they might lead a flight crew to not respond to a genuine alert expected in a training scenario (e.g. excessive rate of nuisance TAWS warnings on the approach to a given runway, resulting in flight crews continuing approaches even when the approach path is too low and clearance to terrain is insufficient).

To implement FDM events that output relevant information for the training programme, a detailed analysis of the training scenarios in the flight crew training syllabus is first needed. This analysis should determine which training scenarios and associated SOP deviations are relevant to monitor with FDM. For this purpose, a methodology is detailed in subsection A. This approach is not only beneficial in the case of an Alternative Training Qualification Programme (ATQP) or an Evidence-Based Training (EBT) programme, but also for other training programmes.

Besides using the FDM programme to support the objectives of individual training scenarios in the flight crew training syllabus, FDM can also be used to identify training needs associated with environmental hazards, or specific airfields and heliports with challenging take-off, landing or approach conditions, or specific fleets; refer to subsections B, C and D.

In order to maximise the benefits of using the findings of FDM in training, it is important to have an unobstructed line of communication from the FDM programme into the Training department. Each commercial operator will have a 3-year recurrent simulator training (RST) programme. Formal procedures should exist in Operations Manual Part D (Training) to ensure communication between FDM and the Training department management for the identification of trends, the effectiveness of new procedures and the development of appropriate content for the RST programme and the FDM programme. This communication can be achieved through routine review meetings where operational feedback is assessed to establish the effectiveness of training programmes and compliance with standard operating procedures. See also section II.4, subsection B.

A. SUPPORTING THE OBJECTIVES OF FLIGHT CREW TRAINING WITH FDM

This subsection describes an approach to align the FDM programme with the flight crew training syllabus (hereafter called 'syllabus').

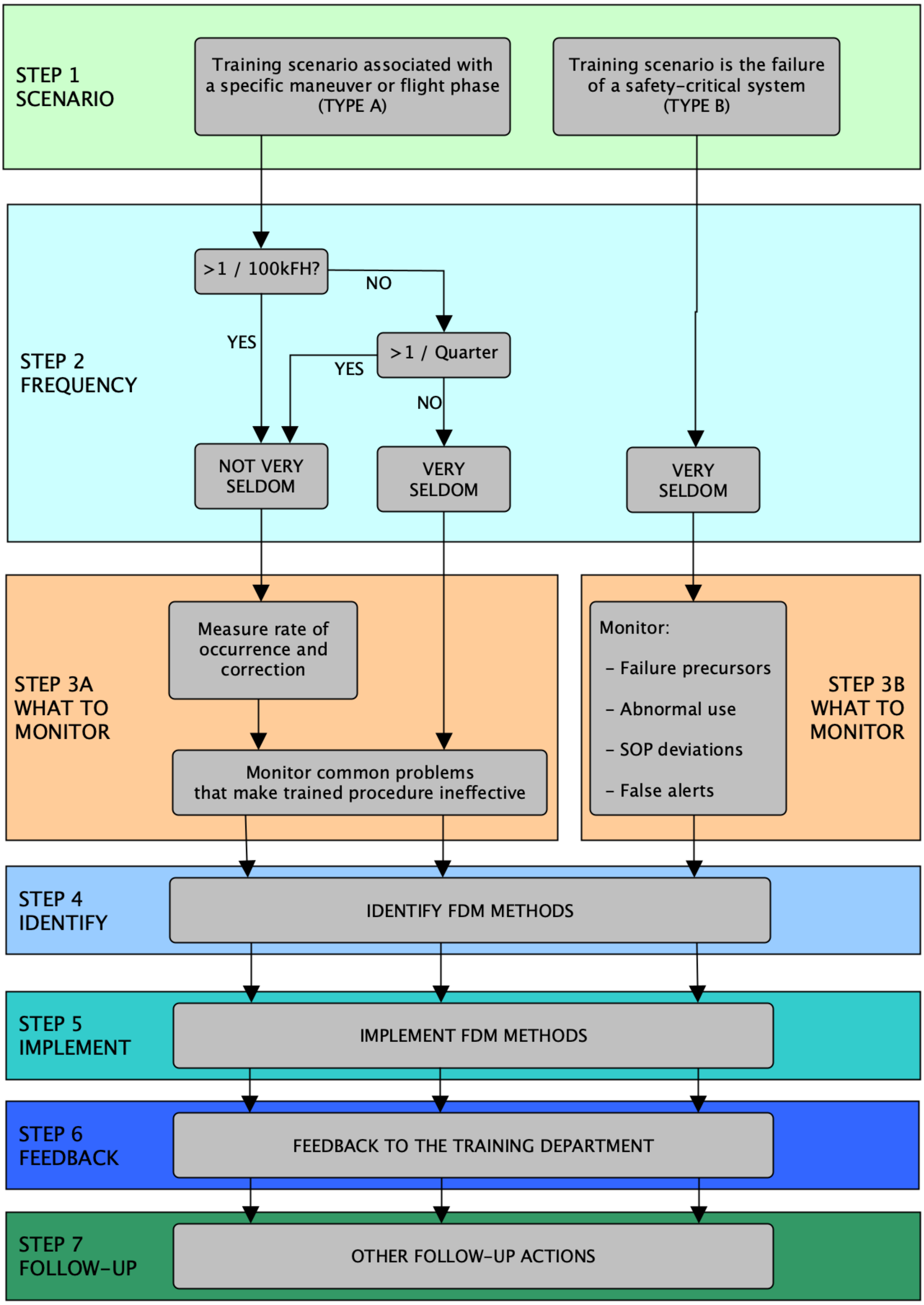
This approach includes a methodology with 7 steps to define FDM events that are relevant to support the objectives of the syllabus. The methodology is based on a systematic analysis of the training scenarios in the syllabus (steps 1 to 4): for each training scenario, the analysis determines whether and which FDM event(s) would be relevant to monitor. Once the relevant FDM event(s) is (are) identified (step 4) and implemented (step 5), its (their) output should be provided in a manner and format that are useful and practicable for managing the flight crew training programme (step 6), while ensuring confidentiality where needed (refer to section II.4). The last step (step 7) is related to follow-up actions beyond training. Figure III.1 provides an overview of the methodology.

For demonstration purposes, the methodology has been applied to:

- the minimum set of proficiency check items that is specified for aeroplane pilots in the EU air operations rules (in AMC1 ORO.FC.230 Recurrent training and checking). Each proficiency check item corresponds to a training scenario that has been analysed. The analysis results are presented in Table A.1 of Appendix A; and
- example training scenarios related to adverse weather, automation management, go-around management and other topics, which are part of the minimum syllabus of an evidence-based training programme according to the EU air operations rules (refer to AMC2 ORO.FC.232 EBT programme assessment and training topics). The analysis results are presented in Tables A.2.1 and A.2.2 of Appendix A;
- the minimum set of proficiency check items that is specified for helicopter pilots in the EU air operations rules (in AMC1 ORO.FC.220 Operator conversion training and checking). Each proficiency check item corresponds to a training scenario that has been analysed. The analysis results are presented in Table A.3 of Appendix A.

Note: The methodology is applicable to any specific syllabus.

Figure III.1: Flowchart showing the main steps of the methodology



STEP 1 – DETERMINE THE TYPE OF TRAINING SCENARIO

Two types of training scenarios are defined in the methodology:

A. **Training scenario associated with a specific manoeuvre or flight phase (Type A).** For example, the training scenario 'take-off with engine failure between V1 and V2' is associated with the take-off manoeuvre; the training scenario '3D approach operation to minima with, in the case of multi-engine aeroplanes, one-engine-inoperative' is associated with the final approach phase.
B. **Training scenario to manage the failure of an engine or another safety-critical system**, and for which no manoeuvre or flight phase is specified **(Type B)**. For example, the training scenario 'hydraulic failure' does not specify a manoeuvre or flight phase during which the hydraulic failure occurs.

STEP 2 – DETERMINE WHETHER THE TRAINING SCENARIO CAN BE CONSIDERED VERY SELDOM

If the training scenario is not very seldom encountered (e.g. 'TCAS RA'), then it is worth implementing FDM events to detect occurrence of such scenario and check the correct execution of the trained procedure.

If the training scenario is very seldom encountered, i.e. it is a 'worst-case scenario' (e.g. 'take-off with engine failure between V1 and V2'): apart from very large FDM programmes (FDM programmes that typically encompass several hundreds of aircraft), an FDM event algorithm would capture very few occurrences in the flight data. In that case, it does not seem relevant to implement and maintain FDM events to detect occurrence of such a scenario.

It is recommended that **scenarios likely to occur on average more than once per quarter** given the volume of operations of the operator, **and scenarios that are deemed to occur on average more frequently than once per 100 000 flight hours** when considering the commercial air transport sector, **should not be considered 'very seldom'**[15].

It is assumed that **safety-critical system failures are very seldom**, 'worst-case scenarios'. Apart from very large FDM programmes, an FDM event algorithm would capture very few occurrences of failure of a given safety-critical system in the flight data. As a consequence, it does not seem relevant to implement and maintain FDM events to detect such failures (training scenarios of type B).

*Example 1: For a large operator X with a fleet of 300 aircraft, each being operated on average 20 hours per day, the total volume of operations per quarter is 300*20*365/4 = 547 500 flight hours.*

- *Scenario A is deemed to occur on average every 50 000 flight hours when considering the commercial air transport sector. As this is more frequent than once per 100 000 flight hours, scenario A should be considered 'not very seldom' for operator X.*
- *Scenario B is deemed to occur on average every 200 000 flight hours when considering the commercial air transport sector. As the volume of operations per quarter of operator X is significantly more than 200 000 flight hours, scenario B is likely to occur more than once per quarter for operator X and, therefore, it should be considered 'not very seldom' for operator X.*
- *Scenario C is deemed to occur on average every 1 000 000 flight hours when considering the commercial air transport sector. As the volume of operations per quarter of operator X is significantly less than 1 000 000 flight hours, scenario C is not likely to occur more than once per quarter. In addition, scenario C is deemed to be less frequent than once per 100 000 flight hours. As a consequence, scenario C could be considered 'very seldom' for operator X.*

[15] Note: When the operator's safety statistics are based on number of events per flights, then the criteria related to the frequency of occurrence of a scenario per 100 000 flight hours may be translated into a frequency per 100 000 flights, based on an estimate of the average duration of the operator's flights.

*Example 2: For a small operator Y with a fleet of 3 aircraft, each being operated on average 20 hours per day, the total volume of operations per quarter is 3*20*365/4 = 5 475 flight hours.*

- *Scenario A is deemed to occur on average every 50 000 flight hours when considering the commercial air transport sector. As this is more frequent than once per 100 000 flight hours, scenario A should be considered 'not very seldom' for operator Y.*
- *Scenario B is deemed to occur on average every 200 000 flight hours when considering the commercial air transport sector. As the volume of operations per quarter of operator Y is less than 200 000 flight hours, scenario B is not likely to occur more than once per quarter. In addition, scenario B is deemed to be less frequent than once per 100 000 flight hours. As a consequence, scenario B could be considered 'very seldom' for operator Y.*

STEP 3 – IDENTIFY AREAS OF INTEREST DEPENDING ON THE TYPE OF TRAINING SCENARIO

STEP 3A – CASE OF A TRAINING SCENARIO ASSOCIATED WITH A MANOEUVRE OR FLIGHT PHASE (TYPE A)

(See Table III.1)

a. If the training scenario is not considered 'very seldom', monitor its rate of occurrence and the correct execution of the trained procedure.
b. Whether the training scenario is very seldom or not, monitor common problems that could make the trained procedure ineffective. These are common problems that may bear significant safety risks: problems occurring during the execution of the manoeuvre or during the flight phase, and problems adversely changing the initial conditions at the start of the execution of the manoeuvre or at the start of the flight phase. The purpose is to ensure that, should the training scenario occur during operation, there is assurance that implementing the trained response to that scenario will ensure a safe outcome. Very improbable combinations of events should not be considered when identifying the common problems (for instance, simultaneous loss of an engine and wind shear during approach is very improbable).

> *Example of common problem that could make the trained procedure ineffective:*
>
> *A common problem with the take-off phase is when actual take-off performance is lower than expected, usually resulting in take-off distance significantly longer than planned and reduced clearance with obstacles during initial climb. While this is likely to have no adverse consequence during a take-off with all engines operative, an abnormally long take-off distance followed by failure of one engine between V1 and V2 may not be recoverable with the trained procedure, leading to runway excursion or collision with terrain.*

STEP 3B – CASE OF A TRAINING SCENARIO DESCRIBING THE FAILURE OF A SAFETY-CRITICAL SYSTEM (TYPE B)

In case of a training scenario of type B, four areas relevant to monitor were identified; refer to Table III.2.

Table III.1: Areas that are relevant to monitor with FDM for a training scenario that is associated with a specific manoeuvre or flight phase

What to monitor with FDM?	For what purpose?	Examples
Monitor the rate of occurrence of the training scenario in actual operations (when this training scenario is not very seldom), and the correct execution of the trained procedure.	Measure the actual exposure to the training scenario in operations. Detect issues with the implementation of the trained procedure to address the scenario.	Monitor the rate of approaches not stabilised under 500 ft AAL, whether they are followed by a go-around and the correct execution of the go-around.
Monitor common problems that may make the trained procedure ineffective to safely address the training scenario (applicable whether the training scenario is very seldom or not).	Prevent the risk that the trained procedure is made ineffective (even if correctly implemented) because of other issues with the management of the aircraft/flight.	Training scenario of landing with one-engine-inoperative: monitor the rate of final approaches with low aircraft energy (below the glide slope or glide path and/or aircraft is too slow) as in the case of a loss of thrust on one engine during a low-energy approach, it may be more difficult for the flight crew to avoid a collision with terrain or with obstacles, or to perform a short landing.

Table III.2: Areas that are relevant to monitor with the FDM programme for a training scenario of type B (failure of a safety-critical aircraft system)

What to monitor with FDM?	For what purpose?	Examples
Monitor precursors to the failure of the safety-critical system.	Prevent failure of the safety-critical system.	For an engine, for example, precursors could be higher EGT or higher level of vibration, or HUMS alert, or recurrent caution alerts.
Monitor the use of the system that may increase the probability of a failure (either incorrect use of the system or use that is different from the assumptions).	Prevent failure of the safety-critical system.	Excessive speed with undercarriage or landing gear extended (VLE/VLO).
Monitor deviations from SOPs other than the trained failure management procedure, which may add significant risks in case of failure of the safety-critical system.	Prevent the risk that the trained failure management procedure is made ineffective because of other issues with the management of the aircraft/flight.	Issues that may make the trained engine relight procedure ineffective. Example for helicopter operations: high airspeed and low-altitude cruise flights (less time to manage a loss of thrust on one engine).
Monitor false alerts regarding failure of the safety-critical system. Use other flight parameters and/or flight crew reports to determine whether an alert was spurious or genuine.	Prevent a situation whereby repetitive false alerts lead the flight crew to not timely implementing the failure management procedure that was trained in case of a genuine alert.	Excessive frequency of TAWS or HTAWS alerts on a given approach.

STEP 4 – IDENTIFY RELEVANT DEFINITIONS FOR FDM EVENTS

Look for FDM event definitions offered in FDM guidance or other sources, which are relevant to monitor the training scenarios, deviations from SOPs, precursors or false alerts identified at step 3.

Examples of published guidance for aeroplane operations include:

- Guidance material to point ORO.AOC.130 'Flight data monitoring – aeroplanes' of the EU rules for air operations;
- EOFDM document 'Guidance for the Implementation of Flight Data Monitoring Precursors' for aeroplanes.

Examples of published guidance for offshore operations include:

- Guidance material to point SPA.HOFO.145 Flight data monitoring (FDM) programme, of the EU rules for air operations;
- Helicopter Flight Data Monitoring (HFDM), HeliOffshore.

If no FDM method can be found in available guidance, an FDM method may need to be developed.

STEP 5 – IMPLEMENT THE FDM EVENT DEFINITIONS

Detailed guidance on testing and validating an FDM algorithm is provided in Chapter II of the EOFDM document 'FDM analysis techniques and principles'.

STEP 6 – FEEDBACK TO THE TRAINING PROGRAMME

According to the EU rules for air operations, the FDM programme is part of the operator's SMS and the safety manager should be responsible for the identification and assessment of safety issues and their transmission to the managers of other processes (see also section II.1).

Therefore, as for any FDM-based information provided to other units within the operator, the framework for transmitting FDM outputs to the Training department should be approved by the safety manager.

Note 1: General guidance on building indicators based on FDM events, studying distributions and trends, and on presenting them, can be found in the EOFDM document 'FDM analysis techniques and principles'.

Note 2: The operator should keep in mind that it is difficult to accurately replicate the actual environmental conditions at the time of occurrence of an event (e.g. actual visibility conditions) in the flight simulator.

a. How could the Training department use FDM-based information?

- Identify the competencies that need to be reinforced through training.
- Know the frequency at which the training scenarios have been encountered in actual operations to understand how much practical experience flight crew members have with the training scenario.
- Assess the effectiveness of the syllabus: identify the training scenarios for which the implementation of the trained procedure in actual operations is unsatisfactory.
- Identify problems with the management of the aircraft, which reduce the effectiveness of some trained procedures, so as to address these problems in training as well.
    - These could include the identification of trends even before they trigger detection of SOP deviations (example: progressive increase of the average speed on approach over the fleet).
- Identify those approaches or airfields with a higher number of SOP deviations due to the characteristics of the approach or local conditions, which may require specific training or reinforced training (example 1: steeper approach path, short runway, or high-elevation airport; example 2: training to perform RNP-AR on some challenging approaches such as Madeira, Innsbrück, Calvi).

- Adapt the training scenarios in the syllabus to make them better reflect frequent operational conditions experienced by pilots (e.g. crosswinds frequently encountered on the approach to a given runway). Note: Simulator capabilities do not always allow to accurately reproduce actual operational conditions.
- Confirm that a change to the syllabus is effective, i.e. a reduction of the SOP deviations addressed by this syllabus change can be observed in data from actual operations.
- Support the analysis of individual events, together with other sources of data (flight crew reports) to identify the techniques or procedures that would benefit from training reinforcement.

b. Examples of useful information for the Training department staff to help them adapt the syllabus:
   - How often are flight crew members exposed to situations represented in the training scenarios of the syllabus?
   - What is the rate of correct execution of the trained procedure when a situation represented in a training scenario occurs?
     - What is the trend over the last few months?
     - Provide information allowing to narrow down where there may be more frequent incorrect execution of a trained procedure: distribution of deviations per fleet, per airport, phase of flight, etc.
   - Common problems with the piloting or the management of the aircraft:
     - Which of these problems have a non-negligible rate of occurrence and what are their trends over time? Which one contributed to more serious events? It should include reference to the training scenario(s) potentially affected by these common problems.
     - Include information on their distribution per fleet, per airport, phase of flight, etc.
   - Cases of inadequate management of the engines or of other safety-critical systems:
     - What is the rate of occurrence of such cases, and what are their trends over time?
     - What is the distribution per fleet, airport, phase of flight, etc.

c. How to ensure that the information provided to the Training department is usable, used as agreed, and is effective?

Note: There needs to be consistent use of the FDM information among the instructors to assess the effectiveness of the changes made to the training. For example, should this information be used in briefings to the trainees, or in introducing the event in the flight simulator? Should there be a startle effect or not?

- Collect feedback of the training programme manager on the usefulness of the provided information: Does it address their questions? Does it provide sufficient information to understand what changes are needed to the training programme?
- Check whether the information on the most concerning FDM event rates or trends has triggered changes to the syllabus, such as new training scenarios, changes to existing training scenarios, etc.
- Survey, in coordination with the Training department, the pilots on the new or modified training scenarios: Did they find the new training scenarios to be closer to actual operations? Did they find them useful?

Close the loop: the new training content should ideally lead to a decrease in FDM event rates and trends.

STEP 7 – OTHER FOLLOW-UP ACTIONS

Some of the FDM programme output provided to the flight crew training programme may also trigger other follow-up actions:

- The safety risk register[16] of the operator may have to be updated. For example, the ranking of some safety topics may need to be reassessed in view of the rates or trends shown by the FDM-based indicators.
- Excessive rate of false alerts with some systems: follow-up actions should be taken to address false alerts that are too frequent.
- Inadequate management of the engines or of other safety-critical systems in some flights: this may require targeted checks or inspection of the affected systems. Inform the manufacturer of design flaws with some interfaces, or with the aircraft documentation. For example, clarifying information in the AFM or making the QRH more practical in emergency situations.
- Rewriting some of the SOPs may be needed, for example, when analysis of FDM events shows that they are not clear or are challenging to implement under certain conditions.

B. DETECTING AND LOCATING ENVIRONMENTAL HAZARDS

Safety performance in abnormal weather events (e.g. high winds, severe clear-air turbulence) or local challenging conditions (e.g. platform environment in the case of offshore operations) should be examined to ensure ongoing effectiveness of procedures and limitations. De-identified FDM event triggers indicating at abnormal weather events should be publicised as fast as possible to make all flight crew members aware.

C. IDENTIFYING CHALLENGING TAKE-OFF AND LANDING LOCATIONS AND NOISE-ABATEMENT PROCEDURES

Repeatedly triggered FDM events associated with a particular location or compliance with noise-abatement procedures should be publicised to flight crews by way of crew safety bulletins, safety documentation or specific airfield briefs. Where an FDM event trigger can be traced to a specific procedure or location, details of the operation should be reviewed to ensure that standard operating procedures remain fit for purpose or require modification in order to reduce exposure to the particular FDM event, i.e. steep approach, offset approach, circling approach. Any associated change of procedure must be included in pilot theoretical or RST programmes as deemed appropriate by the nominated persons for flight operations and training.

D. IDENTIFYING ISSUES WITH THE PILOTING OF A SPECIFIC FLEET

Undesirable trends associated with a particular aircraft tail number, or fleet, should be communicated to the Engineering post holder. Where it is established that crew management of a specific failure or malfunction is prone to mishandling or misinterpretation as evidenced by FDM, the procedure should be reviewed and mitigation considered to reduce exposure to recurrence of such incidents.

[16] A safety risk register is a tool to manage safety risks. How to establish a safety risk register is outside the scope of this document. Refer to ICAO Doc 9859, Section 2.5.

APPENDIX A – FDM EVENT DEFINITIONS THAT SUPPORT THE OBJECTIVES OF FLIGHT CREW TRAINING – EXAMPLES

Tables A.1, A.2.1, A.2.2 and A.3 contain examples of the application of the methodology described in section III.2 of this document. The examples are illustrative, and the tables are not exhaustive.

In all four tables, questions Q1 to Q8 should be understood as follows:

- Q1. Is the training scenario associated with a manoeuvre or a flight phase?
- Q2. Does the training scenario include the failure of a safety-critical system?
- Q3. Can the training scenario be considered ‘very seldom’?
- Q4. If Q3 value is ‘No’: briefly describe FDM event definitions to detect occurrence of the training scenario in actual operation or provide reference to FDM event definitions described in publicly available documentation.
- Q5. If Q1 value is ‘Yes’: what are the common problems with the execution of the manoeuvre or flight phase, which may make the trained recovery procedure ineffective?
- Q6. Briefly describe FDM event definitions for monitoring the common problems identified in Q5 or provide reference to FDM event definitions described in publicly available documentation.
- Q7. If Q2 value is ‘Yes’: could FDM be used to detect 1/ Precursors of a failure of the system, 2/ Abnormal system use by flight crew members, 3/ SOP deviations that could make the system failure procedure ineffective, 4/ False system failure alerts?
- Q8. Briefly describe FDM event definitions for monitoring the points identified in Q7 or provide reference to FDM event definitions described in publicly available documentation.

In all four tables, ‘TS’ stands for ‘training scenario’.

TABLE A.1: MINIMUM PROFICIENCY CHECK ITEMS SPECIFIED FOR AEROPLANE PILOTS

In Table A.1, the methodology described in section III.2 of this document was applied to the minimum proficiency check items specified for aeroplane pilots to identify relevant FDM event definitions. The proficiency checks are listed in point (b)(1)(i) of AMC1 ORO.FC.230 (Recurrent training and checking) of the EU rules for air operations.

Table A.1

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
(A) rejected take-off when an FSTD is available to represent that specific aeroplane, otherwise touch drills only;	Yes	No	No	EOFDM: RE10 — Rejected Take-off (RTO)	Too late execution of the rejected take-off (risk of runway overrun)	EOFDM: RE11 — Runway Remaining After Rejected Take-off	N/A	N/A	
					Insufficient deceleration during the rejected take-off (risk of runway overrun)	EOFDM: RE12 — Inadequate Use of Stopping Devices RE13 — Insufficient Deceleration			
					Asymmetry during the take-off roll or rejected take-off (thrust or brakes' asymmetry, crosswind, or reverser) (Risk of lateral excursion)	EOFDM: RE16 (Aircraft handling) to RE22 (Braking asymmetry)			
					Warning and caution alerts during the take-off roll (might trigger improper reaction, i.e. rejecting the take-off when not needed or continuing the take-off while it should be rejected). (Risk of runway overrun)	Monitor all warning alerts during take-off roll, and that they are not followed by a rejected take-off. Monitor all caution alerts during the take-off roll.			

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
(B) take-off with engine failure between V1 and V2 (take-off safety speed) or, if carried out in an aeroplane, at a safe speed above V2;	Yes	Yes	Yes	N/A	The actual take-off and climb performance of the aircraft is lower than expected (risk of runway overrun or of terrain collision).	EOFDM: RE01 — Incorrect Performance Calculation RE05 — Slow Acceleration RE09 — No Lift-off RE14 — Engine Power Increase RE15 — Runway Remaining at Lift-off CFIT15 — Low climb gradient	1/ Precursors of system failure (engine failure): high EGT, high vibration levels, low thrust indication, engine-related caution alerts.	EOFDM: LOC23 — Engine failure	
					Taking off with excessive take-off weight in case of a loss of one engine (risk of terrain collision or aircraft upset).	EOFDM: LOC11 — Overweight take-off	2/ Abnormal use of the system (engine) increasing the risk of failure. Insufficient engine warm-up time (especially during single-engine taxi), late stowing of reversers at the end of landing roll.	EOFDM: LOC09 — Abnormal operations	
					Inadequate aircraft configuration or inappropriate use of aircraft controls and brakes during take-off roll or take-off (risk of runway overrun or of terrain collision). Control wheel inputs to counter crosswind that may trigger spoiler extension, 'into-wind aileron' (the usual recommendation is to use the control wheel to counter crosswind during take-off roll).	EOFDM: RE02 — Inappropriate Aircraft Configuration RE16 — Aircraft Handling	3/ Deviations from the SOPs that may make the trained failure management procedure ineffective. Already covered by Q5.	Already covered by Q6	

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
					NOTAM not taken into account. Examples: 1/ Insufficient vertical separation with obstacle on the climb path. 2/ Part of the runway is, or taxiways are, closed; start from an intersection and subsequently the take-off distance is shortened.	(No simple FDM method identified so far.)	4/ False alerts False engine warnings (for instance, false engine fire warnings).	EOFDM: LOC23 — Engine failure	
(C) 3D approach operation to minima with, in the case of multi-engine aeroplanes, one-engine-inoperative	Yes	Yes	Yes	N/A	Unstable approach during the final approach phase, before one of the engines becomes inoperative.	EOFDM: RE26 — Unstable approach CFIT03 — Flight below minimum sector altitude (MSA) (implementation is complex) Data4Safety: Guidance for the identification of unstable approaches	Already addressed in TS (B).	Already addressed in TS (B).	There are different tolerances in terms of heading, track, etc., with regard to approach and go-around with all engines operative and with one engine inoperative. There is no easy way to determine with FDM which approach was flown. The information about the flown approach could be contained in the EFB.
					Capturing a secondary lobe of the glide, resulting in incorrect approach slope/gradient.	EOFDM: RE34 — Erroneous guidance			

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
(D) 2D approach operation to minima	Yes	No	No	1/ Analysis windows start where the aeroplane is at a lower altitude and in the vicinity of a known airport, from which it has not taken off in the last 5 minutes. Include in analysis windows ends of flights preceding touchdown, to capture landings at unknown airports. An analysis window ends when the aeroplane is not anymore at low altitude and in the vicinity of a known airport (case of a diversion), or	GNSS: loss of signal or degraded position accuracy (risk of terrain collision). Note: Discrepancies between GNSS position and other position sources (ADIRS, VOR/DME) should be handled by the FMC.	Monitor the difference between FMC position and RNP procedures on the chart. If actual navigation performance (ANP) parameter is recorded, compare ANP value to a generic RNP (example: 0.3 for approach) or the recorded RNP.	N/A	N/A	The described method for the detection of a final approach phase has been implemented in Data4Safety. Often, the final approach phase is automatically identified through a flight phase splitting function of the FDM software. There is no easy way to determine with FDM which approach was flown. The information about the flown approach could be contained in the EFB.
					Incorrect altimeter setting resulting in erroneous vertical guidance (risk of terrain collision).	EOFDM: CFIT02 — Wrong altimeter settings			

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
				there is a confirmed touchdown. 2/ A final approach phase always starts at a time in an analysis window. It starts when the aeroplane height above the airport is less than X feet (for instance, X=2000 ft) and the aircraft is descending. It ends when there is touchdown, or the analysis window ends (case of a diversion), or the aeroplane height above the airport is more than X feet and the aeroplane is climbing (missed approach).	Incorrect approach slope/gradient (risk of terrain collision).	Approach gradient at the end of the final approach to be compared with the approach slope in the approach procedure.			
					The selected vertical mode during approach is not compliant with the FCOM or the SOPs; for example, not permitted during the approach (risk of terrain collision).	EOFDM: CFIT06 — Inadequate vertical mode selections of the aircraft flight control system (AFCS)			
					Unstable approach during the final approach phase.	EOFDM: RE26 — Unstable approach CFIT03 — Flight below minimum sector altitude (MSA) (implementation is complex) Data4Safety: Guidance for the identification of unstable approaches			

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
(E) At least one of the 3D or 2D approach operations should be an RNP APCH or RNP AR APCH operation	Yes	No	No	See TS (D).	See TS (C) and (D).		N/A	N/A	
(F) missed approach on instruments from minima with, in the case of multi-engined aeroplanes, one-engine-inoperative	Yes	Yes	Yes	N/A	Incorrect thrust setting or no thrust adjustment during the execution of the go-around, leading to performance degradation, e.g. speed decay, loss of altitude (risk of terrain collision or of aircraft upset).	Monitor the application of thrust in compliance with the go-around SOP (full TOGA thrust or soft/reduced TOGA thrust). EOFDM: CFIT09 — Inadequate missed approach and go-around flight path	Already addressed in TS (B).	Already addressed in TS (B).	
					Inappropriate configuration change (including no configuration change) and/or inappropriate pitch attitude, leading to performance degradation (risk of terrain collision or of aircraft upset).	Monitor that the change in configuration and the aircraft pitch attitude follow the go-around SOP (retract flaps, landing gear) and in a time sequence as indicated in the SOP. EOFDM: LOC32 — Incorrect Aircraft Configuration			

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
(G) landing with one-engine-inoperative. For single-engine aeroplanes, a practice forced landing is required.	Yes	Yes	Yes	N/A	Insufficient deceleration during the landing roll (risk of runway overrun). Note: Many aircraft types require a lower flap setting for operation with one engine, resulting in a higher approach speed.	EOFDM: RE13 — Insufficient deceleration	Already addressed in TS (B)	Already addressed in TS (B)	With one-engine-inoperative, there is less control over the aircraft energy than with two engines, and the approach speed is higher.
					Short landing, low aircraft energy during approach (risk of terrain collision). Deep landing (risk of runway overrun).	EOFDM: RE28 — Long flare RE29 — Deep landing CFIT11 — Low-energy state during approach / unstable approach			
					Bounced landing (risk of runway overrun) and landing in a crab, tail or wingtip strikes (risk of runway overrun or of lateral excursion).	EOFDM: RE30 — Abnormal runway contact (ARC)			

TABLES A.2.1 AND A.2.2: TRAINING SCENARIOS SPECIFIED FOR EVIDENCE-BASED TRAINING (EBT) PROGRAMMES

In Tables A.2.1 and A.2.2, the methodology described in section III.2 of this document was applied to EBT scenarios to identify relevant FDM event definitions. These training scenarios were extracted from AMC2 ORO.FC.232 (EBT programme assessment and training topics) of the EU rules for air operations.

AMC2 ORO.FC.232 (EBT programme assessment and training topics) is applicable to the so-called 'Generation 4 (jet) aeroplanes' (manufactured as of 1988; EFIS cockpit — FMS equipped; FADEC; fly-by-wire control systems; advanced flight envelope protection; integrated auto-flight control system — navigation performance, and terrain avoidance systems).

Table A.2.1 covers Section 1 of AMC2 ORO.FC.232 (Skill retention. Manoeuvres training phase). In Table A.2.1, the following training topics are covered:

- emergency descent, and
- go-around.

Table A.2.2 covers Section 4 of AMC2 ORO.FC.232 (Training topics with frequency A. Evaluation phase or scenario-based training phase). In Table A.2.2, the following training topics are covered:

- adverse weather,
- automation management,
- fuel management,
- go-around management.

In both tables, only the training scenarios appear that fulfil both conditions below:

- The training scenario is not covered by Table A.1, and
- The training scenario addresses at least one of these three EBT competencies: application of procedures and compliance with regulations (PRO); aeroplane flight path management — automation (FPA); or aeroplane flight path management — manual control (FPM).

Table A.2.1

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Initiation of emergency descent from normal cruise altitude.	Yes	No	Yes	N/A (Scenario is considered very seldom.)	Flying in airspace which is restricted or where there is a security concern (e.g. should not fly under a given flight level — usually, emergency descent is down to FL 100) or flying over severe convective weather. The airspeed is not well controlled.	For airspeed control, refer to EOFDM LOC12 — Envelope protection systems, and LOC09 — Abnormal operations. Regarding flight over restricted areas, there is a need for other sources of data: merge FDM with maps of restricted airspace or need to merge FDM with weather maps.			Possible reasons for emergency descent: loss of cabin pressure, smoke or fumes in the cabin, engine fire. Possible common problems which cannot be monitored with FDM because the information is not recorded or because the problems are too seldom: flight crew members do not get supplemental oxygen and are incapacitated (risk of aircraft upset), either because the supplemental oxygen system is not functioning correctly or because flight crew members do not use the oxygen masks. Regarding oxygen supply: monitoring its condition is a maintenance topic, not for FDM. There is a loss of separation with traffic below (risk of airborne collision). (more difficult to establish communication between flight crew members with the masks)

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Go-around, all engines operative High energy, initiation during the approach at 150 to 300 m (500 to 1 000 ft) below the missed approach level-off altitude	Yes	No	No	EOFDM: RE31 — Go-around	Incorrect application of go-around thrust. Incorrect configuration. Excessive vertical speed (risk of level bust). Excessive speed (risk of overspeed). Excessive pitch attitude. Confusion of automatic modes (if automation is used). Deviation from the go-around procedure.	EOFDM: LOC12 — Envelope protection systems LOC14 — Inadequate aircraft attitude LOC29 — Mismanagement of automation LOC32 — Incorrect aircraft configuration MAC04 — High rate of climb/descent			Possible causes for a go-around: Loss of separation, Runway is occupied, Approach is unstable or destabilised, Failure of an essential navigation aid, Weather limits are exceeded (e.g. excessive crosswind), System failure (e.g. autopilot, radio height probe).
Initiation of a go-around from DA followed by visual circuit and landing	Yes	No	No	EOFDM: RE31 — Go-around	Same as previous	Same as previous			
Go-around, all engines operative, during flare/rejected landing	Yes	No	No	EOFDM: RE31 — Go-around	Too long flare, or no flare, or too high flare (piloting technique). Gust, excessive tailwind pushing the aircraft beyond the touchdown zone. Abnormal runway contact (hard landing, bouncing) bringing the aircraft outside the touchdown zone. Incorrect application of go-around thrust. Incorrect configuration during the go-around. Excessive pitch attitude during the go-around.	EOFDM: RE24 — Tailwind RE27 — High energy over the threshold RE28 — Long flare RE29 — Deep landing LOC14 — Inadequate aircraft attitude LOC32 — Incorrect aircraft configuration			

Table A.2.2

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Predictive wind shear warning before take-off, as applicable	Yes	No	Yes	EOFDM: LOC19 — Wind shear	Predictive wind shear warning system not activated or otherwise disabled				Before initiating take-off roll: wait and delay take-off. The issue is rather how long to wait, and when you decide to take off. Predictive wind shear warning is a function of the weather radar. The weather radar and the predictive windshear warning system may not be independent on some aircraft types.
Wind shear encounter during take-off, not predictive	Yes	No	Yes	EOFDM: LOC19 — Wind shear CFIT12 — Inadequate response to wind shear warnings	Insufficient take-off performance, e.g. too slow at take-off (reduced margin to Vstall), insufficient climb rate, excessive pitch attitude, etc., or incorrect aircraft configuration at take-off	EOFDM: LOC10 — Incorrect performance calculation LOC14 — Inadequate aircraft attitude LOC11 — Overweight take-off LOC12 — Envelope protection systems LOC13 — Inadequate aircraft energy LOC32 — Incorrect aircraft configuration			Refer to the CICTT definition of the take-off flight phase. Skybrary: 'Before V1: The take-off should be rejected if unacceptable airspeed variations occur (not exceeding the target V1) and if there is sufficient runway remaining to stop the airplane; After V1: Disconnect the autothrottles (A/THR), if available, and maintain or set the throttle levers to maximum take-off thrust; Rotate normally at Vr; and follow the FD pitch command if the FD provides wind shear recovery guidance, or set the required pitch attitude (as recommended in the aircraft operating manual (AOM)/quick reference handbook (QRH)); During initial climb: Disconnect the A/THR, if available, and maintain or set the throttle levers to maximum takeoff thrust; If the autopilot (AP) is engaged and if the FD provides wind shear recovery guidance, keep the AP engaged; '

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Predictive wind shear warning during take-off	Yes	No	Yes	EOFDM: LOC19 — Wind shear	Same as previous	Same as previous			If the warning occurs during the take-off roll, the procedure is to reject the take-off. If there is a predictive wind shear warning after V1, either avoid the wind shear (if information on the location of the wind shear is provided) or perform a wind shear escape manoeuvre. The procedure depends also on the operator. Note: Often, the predictive wind shear warning is inhibited above about 80 kt.
Crosswinds with or without strong gusts on take-off	Yes	No	No	EOFDM: LOC09 — Abnormal operations RE20 — Lateral deviation	Control over lateral trajectory not accurate during the take-off roll. Excessive inputs on lateral controls during the take-off phase.				Guidance from a manufacturer: 'Significant lateral control should be avoided during the take-off run in order to prevent extension of spoilers which will have a detrimental effect on performance and may induce some directional disturbance. With strong crosswinds there will be a natural tendency for the aircraft to roll away from the wind at lift-off and this can be compensated for by a smooth lateral input as the aircraft becomes airborne.'
Turbulence that increases to severe turbulence	Yes	No	No	EOFDM: LOC20 — Severe turbulence LOC29 — Mismanagement of automation	Flying at the boundary of the flight envelope, with a risk that severe turbulence or flight crew response to severe turbulence leads to stall or overspeed. Excessive flight control inputs.	EOFDM: LOC12 — Envelope protection systems LOC30 — Abnormal flight control inputs			For some aircraft models, the autopilot should remain on but the autothrust may need to be disconnected in case of severe turbulence.
Wind shear encounter scenario during cruise	Yes	No	Yes	EOFDM: LOC19 — Wind shear	Same as previous	EOFDM: LOC12 — Envelope protection systems LOC30 — Abnormal flight control inputs LOC13 — Inadequate aircraft energy			Possible situations leading to that scenario: Entering or leaving a jet stream (CAT), thunderstorm, mountain wave, wake turbulence. For several aircraft models, wind shear warnings during cruise are only reactive.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Reactive wind shear warning during approach or go-around	Yes	No	No	EOFDM: LOC19 — Wind shear	Too low on approach Too slow on approach (reduced margin to Vs) Insufficient thrust Changing the configuration during the wind shear recovery	EOFDM: CFIT04 — Deviation below the glideslope LOC13 — Inadequate aircraft energy CFIT12 — Inadequate response to wind shear warnings RE26 — Unstable approach Data4Safety guidance on unstable approach detection with FDM			Skybrary: 'If wind shear is encountered during the approach or landing, the following recovery actions should be taken without delay: Select the take-off/go-around (Take-off / Go-around (TO/GA) Mode) mode and set and maintain maximum go-around thrust Follow the Flight Director pitch command (if the FD provides wind shear recovery guidance) or set the pitch-attitude target recommended in the AOM/QRH If the AP is engaged and if the FD provides wind shear recovery guidance, keep the AP engaged; otherwise, disconnect the AP and set and maintain the recommended pitch attitude Do not change the flap configuration or landing-gear configuration until out of the wind shear Level the wings to maximize climb gradient, unless a turn is required for obstacle clearance Allow airspeed to decrease to stick-shaker onset (intermittent stick-shaker activation) while monitoring airspeed trend Closely monitor airspeed, airspeed trend and flight path angle (if flight-path vector is available and displayed for the PNF) and, When out of the wind shear, retract the landing gear, flaps and slats, then increase the airspeed when a positive climb is confirmed and establish a normal climb profile.'

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Predictive wind shear warning during approach or go-around	Yes	No	No	EOFDM: LOC19 — Wind shear	Ignoring wind shear warnings Weather radar inoperative or predictive wind shear warning inoperative				
Increasing tailwind on final approach (not reported)	Yes	No	No	EOFDM: RE24 — Tailwind	Late or no landing configuration Too high or too fast on approach Pitch too low on approach Flares are too long, landings too deep	EOFDM: RE02 — Inappropriate aircraft configuration RE25 — Excessive engine power RE27 — High energy over the threshold RE28 — Long flare RE29 — Deep landing			A variation in wind direction and speed may compromise the previously factored landing distance, especially if it's a tailwind. Crews may be alerted of strong tailwind by ATC, other pilots' reports (PIREPS) or their own aircraft instruments (calculated by air data computers). Tailwind shall be factored at 150 % (increase in landing distance versus a 'no wind' situation). Tailwind may cause a 'long flare'; therefore, in case of excessive tailwind value before the flare, a go-around should be performed. Skybrary: 'During take-off and landing, tailwinds reduce the airflow. Consequently, the necessary lift is achieved later and at higher speeds (the wind speed is added to the aircraft speed). Therefore, longer runways are required to perform a safe take-off or landing. Another factor to be considered is that in case of rejected take off, the speed of the aircraft will generally be higher, so it will need more distance to decelerate. Take offs and landings with tailwind component exceeding certain value (usually 10 kts) are avoided.'

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Non-precision approach in cold-temperature conditions, requiring altitude compensation for temperature, as applicable to the type	Yes	No	No	Not proposed	Incorrect temperature correction of the altimeter, or no correction at all	EOFDM: CFIT02 — Wrong altimeter settings			When temperature is lower than ISA, an aircraft will actually be lower than the altimeter reading. According to ICAO PANS OPS (Doc 8168), 'The calculated minimum safe altitudes/heights must be adjusted when the ambient temperature on the surface is much lower than that predicted by the standard atmosphere. In such conditions, an approximate correction is 4 per cent height increase for every 10°C below standard temperature as measured at the altimeter setting source. This is safe for all altimeter setting source altitudes for temperatures above –15°C. For colder temperatures, a more accurate correction should be obtained according to the guidance provided in section 4.3 "Temperature corrections"'.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Crosswinds with or without strong gusts on approach, final approach and landing (within and beyond limits)	Yes	No	No	EOFDM: RE17 — Crosswind LOC09 — Abnormal operations	Significant deviation from the localiser when starting the final approach. Insufficient control of the lateral deviations during the approach. Incorrect execution of the technique to land with crosswind, possibly resulting in heading changes, lateral accelerations.	EOFDM: RE20 — Lateral deviation RE26 — Unstable approach RE30 — Abnormal runway contact (ARC)			An 'out of limits' crosswind situation may exist due to three main reasons: 1) airport / runway / wind direction and speed limitation, 2) SOP limitation by the operator, 3) aeroplane manufacturer wind limitations. Airport/runway limitations are the most conservative because they are not aircraft specific. It's a general limitation for everyone, considering the characteristics of the airport environment. Operators may also establish wind limits for all the airports they operate at, not being airport/runway specific.The aeroplane manufacturer's wind limitations establish the maximum head/tail/crosswind speeds at which the aircraft may be safely operated. Above these limits, full deflection of the flight control surfaces (rudder, ailerons) may no longer be enough to control the aircraft's path upon landing. Guidance from an aeroplane manufacturer: 'The aircraft may be landed with a residual drift / crab angle (maximum 5°) to prevent an excessive bank (maximum 5°). Consequently, combination of the partial decrab and wing down techniques may be required.' 'The higher the wheel/tire braking force, the lower the tire-cornering force; therefore, if the aircraft tends to skid sideways, releasing the brakes (i.e., by taking over from the autobrake) increases the tire-cornering and contributes to maintaining or regaining directional control. Selecting reverse idle cancels the effects of reverse thrust (i.e., the side force and rudder airflow disruption) and, thus, further assists in regaining directional control. After directional control has been recovered and the runway centerline has been regained: • Pedal braking can be applied (autobrake was previously disarmed when taking over) in a symmetrical or differential manner, as required, and • Reverse thrust can be reselected.'

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
In approach, unexpected braking action 'good to medium' reported by the preceding aircraft	Yes	No	Yes		Too high or too fast on approach. Flares are too long (incorrect flare technique), landing too deep. Inadequate use of stopping devices during the landing roll (thrust reversers, airbrakes, brakes) or inadequate configuration (e.g. spoilers not armed).	EOFDM: RE27 — High energy over the threshold RE25 — Excessive engine power RE32 — Excessive energy at touchdown RE28 — Long flare RE29 — Deep landing RE12 — Inadequate use of stopping devices			
Moderate to severe icing conditions during approach effecting aircraft performance	Yes	No	Yes	EOFDM: LOC21 — Icing conditions	Insufficient margin to the stall speed during approach. Insufficient thrust during approach. Incorrect or ineffective use of the de-icing or anti-icing systems. Unmonitored automatic excessive pitch trim setting.	EOFDM: LOC13 — Inadequate aircraft energy LOC15 — Loss of lift LOC22 — De-icing system failure			Icing essentially increases drag and decreases lift. It may also add some weight. The pilot should increase the thrust and the approach speed. (Example of accident to look at: Logan Air)

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
ACAS warning (resolution advisory), recovery and subsequent engagement of automation	Yes	No	No	EOFDM: MAC08 — Airborne collision avoidance system (ACAS) alerts	Late reaction to the TCAS RA (to climb, descend, or level off). Corrective action by the flight crew is not consistent with the TCAS RA (e.g. increasing descent rate while the RA is only to maintain vertical speed). Excessive reactions (excessive pitch rate, excessive normal acceleration, excessive vertical speed). Inappropriate TCAS settings, so that it does not generate RAs.	EOFDM: MAC08 — Airborne collision avoidance system (ACAS) alerts MAC09 — Inappropriate airborne collision avoidance system (ACAS) settings			MAC08 addresses both the detection of RAs and their management by the flight crew.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Recoveries from terrain avoidance warning systems (TAWS), management of energy state to restore automated flight	Yes	No	No	EOFDM: RE31 — Go-around (following TAWS activation)	Go-around flight path significantly deviating from the missed approach procedure (reduced separation with other traffic, reduced distance to terrain). Go-around climb rate is too low, or climb angle is too shallow (especially an issue when terrain is climbing). Inadequate thrust setting, resulting in speed decay during the climb (reduced margin to stall). Too rushed execution of the go-around procedure, or actions not performed in the right time sequence (risk of stall) (case of turboprops). Inadequate power management setting (risk of engine overtorque). Excessive pitch rate during the go-around. Aircraft configuration change not in	EOFDM: CFIT08 — Inadequate terrain awareness and warning system (TAWS) MAC02 — Lateral deviation LOC14 — Inadequate aircraft attitude LOC12 — Envelope protection systems			Note: An aircraft operator studied what is an appropriate time sequence for go-around actions (best practice), after an accident. This was established empirically and then communicated to pilots during recurrent training.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
					accordance with the SOPs. Excessive climb rate (risk of level bust).				

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Amendments to ATC cleared levels during altitude capture modes to force mode awareness and intervention	Yes	No	No	No FDM method proposed	Inadequate action to enter the new target FL.	EOFDM: LOC29 — Mismanagement of automation MAC03 — Flight level bust			Assuming that the training scenario is a last-minute change to cleared FL, leading to interrupt the FL capture and to continue descent or climb. The vertical modes and their transitions are type specific. A flight crew might inadvertently revert to another vertical mode when addressing a last-minute change to cleared FL.
ACAS warning (resolution advisory to level off) during climb or descent; for example, close to the cleared level when the capture mode has already been activated.	Yes	No	No	EOFDM: MAC08 — Airborne collision avoidance system (ACAS) alerts	See TS 'ACAS warning (resolution advisory), recovery and subsequent engagement of automation'. Plus excessive rate of climb or descent when approaching the target FL or incorrect selection of the FL capture mode (e.g. vertical speed selection instead of full open descent).				This typically happens in a scenario where the target FL is approached quickly (high vertical rate). Apply the TCAS RA SOP (may mean to take over and fly manually or just monitor the AP). It depends on the ACAS warning: could be to maintain vertical speed (level-off must be interrupted) or do not climb or do not descend (level-off can be continued).
Engine-out special terrain procedures	Yes	Yes	Yes		Too low climb rate before the engine failure. Excessive bank angle during the turn.	EOFDM: LOC14 — Inadequate aircraft attitude CFIT15 — Low climb gradient			An engine-out procedure (EOP) for the climb phase is a custom-designed, lateral flight path 'escape route' to provide a climb departure designed to minimise obstacle and terrain constraints. It is designed to be used only in cases where an engine fails during the take-off and the aircraft is not able to comply with the SID. This is typically prepared by the aircraft operator on airfields with obstacles or terrain; it is not provided by the ATC.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Forcing autopilot disconnect followed by re-engagement, recovery from low- or high-speed events in cruise	Yes	No	No	EOFDM: LOC09 — Abnormal operations LOC12 — Envelope protection systems LOC29 — Mismanagement of automation	Attempting to re-engage the autopilot while the speed is too low or too high, or the pitch and roll attitudes are not stabilised (e.g. turbulence encounter) or excessive (e.g. after speed decay). Inappropriate thrust setting.	EOFDM: LOC13 — Inadequate aircraft energy LOC29 — Mismanagement of automation			The following two situations are considered: 1/ In a high-speed situation, it is not advisable to disconnect the AP, as it helps keeping the aircraft stable. Rather reduce the thrust setting and/or the descent rate. 2/ In a low-speed situation, it might be necessary to disconnect the AP to quickly change the aircraft attitude and increase the thrust to prevent stall (faster than the AP can do). In addition, nose-up and nose-down situations have different recovery techniques. Note: Slight high-speed exceedances are not very seldom, but most of the time they are without any consequence on the aircraft structure. Low-speed situations are very seldom and usually hazardous.
Engine failure in cruise to onset of descent using automation	Yes	Yes	Yes	EOFDM: LOC23 — Engine Failure LOC13 — Inadequate aircraft energy	Delayed application of procedure (selection of maximum continuous thrust (MCT), initiation of descent) potentially resulting in airspeed decay and approach to stall.	EOFDM: LOC29 — Mismanagement of automation LOC12 — Envelope protection systems LOC14 — Inadequate aircraft attitude LOC15 — Loss of lift			
Emergency descent	Yes	No	Yes	EOFDM: LOC05 — High Cabin Altitude	(Not identified)	N/A			Typically caused by a loss of cabin pressure, or smoke or fume in the cockpit.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Managing high-energy descent, capturing descent path from above (correlation with unstable approach training)	Yes	No	No	EOFDM: LOC13 — Inadequate Aircraft Energy	Descent is not steep enough, leading to level-off to the ILS platform altitude without intercepting the glide (above the glide). Going back into climb mode (inadequate selection of flight mode). Not arming the approach mode and going through the glide path (not capturing the glide path) (refer to CFIT04 — Deviation below the glideslope).	EOFDM: LOC29 — Mismanagement of automation RE26 — Unstable approach			Possible causes: steep descent flight path caused by ATC clearance, or aircraft configuration that is not adequate for a steeper approach without accelerating.
No ATC clearance received prior to commencement of the approach or final descent	Yes	No	Yes		Crossing the runway external centre line, which can result in a loss of separation in parallel approaches (in case of ATC vectoring to a localiser). Steep, high-energy approach from above the glideslope without ATC clearance to a lower altitude, instead of discontinuing the approach.	EOFDM: MAC02 — Lateral deviation MAC08 — Airborne collision avoidance system (ACAS) alerts RE26 — Unstable approach			Approach charts may include a note about the considerations that must be made in case that ATC does not clear an aircraft for the approach due to a loss of communications, busy environment, etc. Approach charts also include a point to go on holding pattern if not cleared for descent. Most airports have a point called 'clearance limit'. If no clearance is received until that point, the aircraft should go on hold and ATC notified of the hold. In case of communication failure, SSR transponder code 7600 to be used and the aircraft is given priority to land.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Gear malfunction during an approach planned with autoland (including autobrake)	Yes	Yes	Yes	Gravity extension switch or procedure carried out (if parameters are recorded) and\or autoland carried out with no autoland-dependent system malfunction	Unstable approach that is continued (no go-around)	EOFDM: RE26 — Unstable approach			Not knowing whether a landing gear is locked or not, the flight crew should land manually, e.g. to have first runway contact with the landing gear that is fully operative. — Individual components such as the autoland status of the aircraft or the procedures employed for gravity extension of the gear may be reviewed, if parameters are recorded by data frame. — If the flight crew knew in advance about the failure, a time duration from gear gravity extension to start of approach may be used as learning opportunity for the flight crew (workload management as a competency). — If autobrake setting\level is recorded, it may be used to ascertain whether the correct autobrake level was set or not, depending on manufacturer recommendation for landing with gear malfunction. — If a go-around manoeuvre was expected, was the go-around performed in accordance with the SOPs? In conclusion: an event has many variables that may not be measurable by FDM. Note: Autoland is part of a proficiency item, whereas gear malfunction may not be.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
ATC clearances to waypoints beyond the programmed descent point for a coded final descent point during an approach utilising a final descent that is commanded by the flight management system	Yes	No	Yes	Aircraft height versus distance to touchdown point, selection of gear and flap in the correct time sequence. Selected vertical speed or selected means of descent (vertical mode) utilisation of drag devices (speed brake).	Incorrect gear and flap selection before manoeuvre starts, hence aircraft speed increases and crew don't meet stabilisation criteria at the company's gate. Incorrect selection of automation modes that may lead to LOC-I scenario, e.g. forget to arm ILS approach and then descend through glidepath with high rate of descent.	EOFDM: LOC29 — Mismanagement of automation			Working on the assumption that this TS would leave the aircraft above the vertical profile for the approach, it would be more challenging for the crew to regain the vertical profile and meet all stabilisation criteria needed for a stabilised approach (at 1000 ft AAL or 500 ft AAL depending on conditions\operator SOPs). — Manufacturers may provide guidance on the 'interception from above' procedure to be applied; this may also vary depending on the type of approach being flown, e.g. ILS or VNAV mode. — FDM may be utilised to measure prominent airports where it is prevalent for aircraft to be kept high. — FDM may be utilised to review procedures employed by the crew to perform 'intercept from above' procedures. — If it is confirmed that such a scenario has occurred, when was the first time that aircraft met all stabilised approach criteria? The last time the aircraft did not meet the stabilised approach criteria? — FDM-based statistics may be provided to flight crews to make them aware of challenging airfields and approaches.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Diversion with low remaining fuel or increased fuel flow due to system malfunction	Yes	Yes	Yes	EOFDM: LOC31 — Fuel exhaustion	Late decision to divert (e.g. at the time the flight is diverted, the remaining fuel does not provide sufficient safety margins). Engine thrust setting leading to excessive fuel consumption during the diversion leg. Inadequate aircraft configuration during the diversion (flaps, slats, landing gear), leading to increased drag and to increased fuel consumption.	EOFDM: LOC31 — Fuel exhaustion LOC32 — Incorrect aircraft configuration			A fuel-related diversion may be caused by an abnormal increase in the fuel flow (e.g. flight at lower altitude after an emergency descent, landing gear cannot be retracted, or by a fuel leak in a tank) or by an issue at the destination (e.g. severe convective storm, flooded runway, airport is closed). This becomes an emergency only when the final fuel reserve is being used.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Adverse-weather scenario, e.g. thunderstorm activity, heavy precipitation or icing forcing decision at or close to DA/MDA	Yes	No	No	EOFDM: LOC20 — Severe turbulence LOC19 — Wind shear LOC21 — Icing conditions	Go-around flight path significantly deviating from the missed approach procedure. Speed low/high in climb after go-around. Go-around climb rate is too low, or climb angle is too shallow (risk of CFIT). Inadequate thrust setting (during the go-around). No change to the go-around mode when go-around is initiated. Excessive HDG/bank corrections. Incorrect selection of speed during adverse weather (in case of headwind or icing or low-visibility approaches). Flying close to stall/overspeed limits. Incorrect use of weather radar (not correctly used to help confirming the weather around the airport). Incorrect aircraft configuration before and during	EOFDM: LOC13 — Inadequate aircraft energy LOC15 — Loss of lift MAC02 — Lateral deviation CFIT12 — Inadequate response to wind shear warnings RE02 — Inappropriate aircraft configuration LOC12 — Envelope protection systems			Three possible cases: icing, thunderstorms, reduced visibility (fog, hail, etc). — Reduced visibility -> perform go-around if visibility is insufficient, no later than DA/MDA. — Icing: all modern aircraft are certified for all-weather operations and should be able to cope with even severe icing, except in case of anti-icing system failure. — Thunderstorms and heavy rain: this is an indication of a risk of a low-level wind shear. If wind shear is suspected, it may be safer to not even start the final approach.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
					the execution of the go-around.				

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
DA with visual reference in heavy precipitation with doubt about the runway surface braking capability	Yes	No	No	No FDM method proposed	See TS 'Adverse-weather scenario, e.g. thunderstorm activity, heavy precipitation or icing forcing decision at or close to DA/MDA'	See TS 'Adverse-weather scenario, e.g. thunderstorm activity, heavy precipitation or icing forcing decision at or close to DA/MDA'			Braking action is factored when performing landing distance calculations. It is provided by ATC or Meteo information (ATIS or VOLMET). It may vary between Good, Medium, or Poor, or a combination of these (e.g.: Medium/Poor). But flight crews must be ready for changes for the worse, and that may happen very late on the approach. If the surface state of the runway is 'Unknown', the 'Friction Coefficient' of the runway may be a lot worse than according to in-flight calculations. If in doubt, a 'missed approach' must be performed. Some operators establish in their SOPs a 'minimum' braking action, e.g. 'Medium'. Otherwise, the flight crew shall not land. But new calculations must always be performed, to be sure of the 'corrected' landing distance, according to the landing weight, landing flaps, and wind speeds. Not doing this may lead to a runway overrun; therefore, in case of doubt, a go-around should be performed.
Adverse-wind scenario resulting in increasing tailwind below DA (not reported)	Yes	No	No	See TS 'Increasing tailwind on final approach (not reported)'	See TS 'Increasing tailwind on final approach (not reported)'	See TS 'Increasing tailwind on final approach (not reported)'			A variation in wind direction and speed may compromise the previously factored landing distance, especially if it's a tailwind. Crews may be alerted of strong tailwind by ATC, other pilots' reports (PIREPS) or their own aircraft instruments (calculated by air data computers). Tailwind shall be factored at 150 % (increase in landing distance versus a 'no wind' situation). Tailwind may cause a 'long flare'; therefore, in case of excessive tailwind value before the flare, a go-around should be performed.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Adverse-wind scenario including strong gusts and/or crosswind out of limits below 15 m (50 ft) (not reported)	Yes	No	No	EOFDM: RE17 – Crosswind LOC09 – Abnormal operations LOC13 – Inadequate aircraft energy RE20 – Lateral deviation RE24 – Tailwind RE26 – Unstable approach RE27 – High energy over the threshold RE28 – Long flare RE29 – Deep landing RE32 – Excessive energy at touchdown	Destabilised approach. Abnormal flight control inputs (excessive inputs or dual inputs) during approach that can worsen the effect of crosswind and gust. Incorrect flaring technique (wind could bring the aircraft landing off side of the runway, or make the flare even longer, with a risk of runway overrun).	EOFDM: LOC30 — Abnormal flight control inputs RE26 — Unstable approach RE28 — Long flare RE32 — Excessive energy at touchdown			
Loss or difficult communications resulting in no approach clearance prior to commencement of approach or final descent	Yes	No	Yes	EOFDM: CFIT10 — Loss of communication	No 7600 squawking -> CFIT10 Not following the national rules and regulations (CRAR) or airport-specific COM FAIL procedures	No FDM method proposed			
Birds: large flocks of birds below DA once visual reference has been established	Yes	No	Yes	EOFDM: LOC01 (Specific for engine fire) LOC23 — Engine failure LOC26 — Loss of thrust LOC16 —	Destabilised approach, approach with low energy Incorrect go-around technique	EOFDM: RE26 — Unstable approach CFIT11 — Low-energy state during approach / unstable approach			

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
				Foreign object damage (FOD)					

TABLE A.3: MINIMUM PROFICIENCY CHECK ITEMS SPECIFIED FOR HELICOPTER PILOTS

In Table A.3, the methodology described in section III.2 of this document was applied to the minimum proficiency check items specified for helicopter pilots to identify relevant FDM event definitions. The proficiency checks are listed in point (e) of AMC1 ORO.FC.220 (Operator conversion training and checking) of the EU rules for air operations.

Table A.3

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
(A) Abnormal/emergency procedures									
Engine fire	No	Yes	Yes	N/A	N/A	N/A	1/ Precursors to engine fire or malfunction? Excessive ITT, overtorque, or torque difference between engines during acceleration.	Monitor ITT exceedance, torque limit exceedance, and torque value difference between engines.	ITT = interstage turbine temperature Torque = main rotor torque Today, HUMS alerts are often not recorded by the airborne FDM system. HUMS data is usually analysed by the CAMO.
							2/ Incorrect or abnormal use of engine that might increase the risk of engine fire? Too frequent use of the quick start engine procedure (can have a detrimental effect on engine temperature).	Detect engine values approaching the maximum allowed according to the RFM. It is useful to set the FDM event trigger at the maximum continuous or maximum take-off power threshold, and then set the severity of the event according to the duration of the exceedance above those limits to have an idea of how often the engine transient range (being on NG, ITT or Torque) is used by crews, and if there are some helipads / operating sites	NG = compressor rotation speed

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
								with a greater frequency of transient use. During engine start, the following items can be monitored: 1) Simultaneous start of engine 1 and engine 2 (quick start procedure). 2) On some fleets, activation of the engine controller position caution during start as this may point out that an incorrect starting procedure is performed. 3) Monitor that the generator of engine 1 that was started (or alternatively EXT POWER) was correctly activated before starting engine 2, as this might lead to higher than normal ITT.	
							3/ Issues that may make the trained engine fire procedure ineffective: a) High-airspeed, low-altitude cruise flights (less time to manage an engine fire). b) High airspeed and/or high rate of descent on approach outside CAT A RFM requirements, identifying whether the approach is clear area (airport) or not to correctly compare detected	1) High airspeed (> Vy + margin) below a certain radio height threshold set according to operator's SOPs. 2) Monitoring of the rate of descent below a certain height above airfield (HAA) threshold during approach (HAA and vertical speed values to be set according to helicopter's RFM CAT A profiles). 3) Monitoring of the	VTOSS = minimum speed at which the helicopter can maintain a climb if it's most critical engine fails. To determine whether the helicopter was operating from an airport or a helipad, programming a 'captured parameter' based on a geographical zone algorithm set to return if the helicopter is within a set distance (e.g. 1 NM) from an airport (comparing latitude/ longitude from the FDM

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
							parameters with applicable RFM indications. c) High airspeed and low height during departure, outside CAT A profiles. d) High pitch up and, therefore, speed reduction after reaching vertical take-off safety speed (VTOSS) beyond CAT A RFM requirements (risk of not being able to maintain altitude).	ground speed below a certain height above airfield threshold (usually 150 ft) during approach (HAA and vertical speed values to be set according to helicopter's RFM CAT A profiles; a filter on distance to touchdown, e.g. < 0.5 NM, is useful to ensure valid events). 4) Monitoring of the maximum pitch-up angle within the first 0.5 NM after take-off and after IAS is above the VTOSS value of the helicopter type. If the maximum pitch angle exceeds the recommended angle from the helicopter's CAT A take-off profile, an event is triggered.	data with a database of airport positions) is useful. This contextual evaluation is important to know the correct V/S and RH values of the applicable approach profile.
							4/ Monitor false engine fire alerts? Monitor caution alerts and warning alerts and use other flight parameters and/or flight crew reports to assess whether alerts were spurious or genuine.	An event could be set to detect activation of engine fire warning alerts. Analysis needed to determine whether these warnings were genuine.	
Interior helicopter fire or smoke	No	Yes	Yes	N/A	N/A	N/A	1/ Precursors to fuselage fire? (No FDM method proposed)	(No FDM method proposed)	
							2/ Incorrect or abnormal use of the helicopter such that it may significantly increase the risk of fuselage fire? (No FDM method proposed)	(No FDM method proposed)	

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
							3/ Issues that may make the trained procedure to deal with a fuselage fire ineffective? (No FDM method proposed)	(No FDM method proposed)	
							4/ Monitor false alerts related to fuselage fire? Monitoring of bag fire / cabin fire (through smoke detector) warnings and battery fire (through overheat detector) warnings being triggered during normal operation.	An event could be set to detect activation of fuselage fire warning alerts. Analysis needed to determine whether these warnings were genuine.	Should also be reported by flight crews.
Emergency operation of undercarriage	No	Yes	No	Detect landing gear caution alerts and landing gear position indicator	N/A	N/A	1/ Precursors to failure of the undercarriage extension/retraction system? Duration of extension and/or retraction, when it is commanded.		Most models used for offshore operations and large helicopters have retractable undercarriage. Failure to extend the lower landing gear is not a high severity event for a helicopter as it can be managed with minor damage to the helicopter following a belly landing. Failure to retract the undercarriage is not high severity either; it would probably cause increased fuel consumption and speed limitation. Some fleets (e.g. older AW139) do not record landing gear up/down parameters but only record activation of the 'landing gear' caution that triggers at 150 ft radio height when gear is not down.
							2/ Incorrect or abnormal use of the helicopter such	Hard landing: monitor the normal acceleration value	

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
							that it may significantly increase the risk of failure of undercarriage extension/retraction system? Hard landings. Excessive speed with undercarriage extended.	at touchdown. Excessive speed: monitor the airspeed value at touchdown.	
							3/ Issues that may make the trained procedure to deal with a failure of undercarriage extension/retraction system ineffective? (No FDM method proposed)	1) During approach: detect when undercarriage is not down below a certain height above airfield (HAA) threshold or below a certain IAS. 2) During departure: detect when undercarriage is retracted too early (below a certain HAA). RFMs usually recommend retracting the landing gear only above a specified height (e.g. 200 ft) during CAT A profile take-off.	
							4/ Monitor false alerts related to undercarriage extension/retraction system? 'Gear too low' warning typically triggered under 300 ft above terrain. Captures a non-extension or delayed extension before landing. Another possibility is collecting landings with gear-up or entire flights with gear-down.	Monitor whether the 'landing gear' caution has been triggered.	
Hydraulic failure	No	Yes	Yes	N/A	N/A	N/A	1/ Precursors to hydraulic failure? Hydraulic oil pressure or	Monitor the hydraulic oil temperature.	The event is, however, not commonly used in FDM as it would be seldom.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
							temperature can be monitored to remain within the RFM limits. Various cautions related to the hydraulic system such as: — low pressure, — high pressure, — pump malfunction.	Hydraulic leak detection warning.	Typical consequences of a hydraulic failure on a helicopter: restriction to use flight controls, land as soon as possible (do not continue flight longer than necessary) or as soon as practicable (nearest aviation location or a safe landing site), implement procedure for extending the landing gear — no extensive procedure to be performed to specifically address the hydraulic failure. The failure of a hydraulic system does not significantly affect the controllability of the helicopter for most models.
							2/ Incorrect or abnormal use of the helicopter such that it may increase the risk of hydraulic failure? (No FDM method proposed)	(No FDM method proposed)	
							3/ Issues that may make the trained hydraulic failure procedure ineffective? (No FDM method proposed)	(No FDM method proposed)	
							4/ Monitor false hydraulic failure alerts? Monitor caution alerts and warning alerts and use other flight parameters and/or flight crew reports to assess whether the alerts were spurious or genuine.	(No FDM method proposed)	

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Electrical failure	No	Yes	Yes	N/A	N/A	N/A	1/ Precursors to electrical failure? GEN1 and GEN2 loads outside the RFM limits. GEN1/GEN2 caution alerts, fault reports.	Monitor generator load and trigger according to the RFM limits or detect activation of caution alerts related to the generator.	Such events are not commonly used as they would be seldom. Typical consequences of electrical failure: The failure of a generator usually does not affect the systems (backed-up) or affects only a few non-essential systems. The failure of two generators or of the electrical bus causes the loss of displays, APs (SAS), and communications. The helicopter is still controllable and standby instruments can be used.
							2/ Incorrect or abnormal use of the helicopter such that it may increase the risk of electric failure? (No FDM method proposed)	(No FDM method proposed)	
							3/ Issues that may make the trained electrical failure procedure ineffective? (No FDM method proposed)	(No FDM method proposed)	
							4/ Monitor false electrical failure alerts? Monitor caution alerts and warning alerts and use other flight parameters and/or flight crew reports to assess whether the alerts were spurious or genuine.	Monitor the generator load and set trigger according to the RFM limits, or detect activation of caution alerts related to the generator.	Such events are not commonly used as they would be seldom.
Engine failure and relight	No	Yes	Yes	N/A	N/A	N/A	1/ Precursors to engine failure? Same as TS ‘Engine fire’.		

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
							2/ Incorrect or abnormal use of the engine such that it might increase the risk of engine failure? Same as TS 'Engine fire' plus engine overspeed.		
							3/ Issues that may make the trained engine relight procedure ineffective? Same as TS 'Engine fire'.		
							4/ Monitor false engine failure alerts? Same as TS 'Engine fire'.		
Engine failure during take-off before decision point (for multi-engine helicopters)	Yes	Yes	Yes	N/A	The rotation height is too low, before reaching the decision height, which increases the risk of hitting the take-off surface in case of a loss of one engine (not really applicable to HEMS due to high variability of landing sites and various obstacles).	Event to detect when rotation height is below or above the prescribed radio height value by the applicable RFM CAT A profile of the specific type.	Refer to TS 'Engine failure and relight'.	High torque values or high ITT/T4 during take-off (compared to RFM transient limit): the frequency of such events can help to detect locations or fleets for which a higher power for take-off is required, creating more stress on the gearbox.	T4 = exhaust gas temperature
Engine failure during take-off after decision point (for multi-engine helicopters)	Yes	Yes	Yes	N/A	Deviations from the specified pitch attitude and/or airspeed at TDP and after TDP. Incorrect NR value setting before take-off. High airspeed (> Vy) low height during departure (compared to RFM CAT A requirements).	1/ Event to detect when the pitch-down angle reached during rotation (increase of pitch-down during take-off, detectable by the rate of change of pitch) is below or above the pitch-down attitude value prescribed by the applicable RFM CAT A profile of the specific type. 2/ Monitoring of	Refer to TS 'Engine failure and relight'.		To determine whether the helicopter was operating from an airport or a helipad, programming a 'captured parameter' based on a geographical zone algorithm set to return if the helicopter is within a set distance (e.g. 1 NM) from an airport (comparing latitude and longitude from the FDM data with a database of airport positions) is useful.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
					High-climb rate and pitch attitude during take-off when IAS>VTOSS+margin and below 300 ft AHE (example: AW139 pitch up > 8° and climb rate > 1000 fpm during take-off when IAS>VTOSS (low severity threshold). Monitor the pitch attitude at TDP and then during the acceleration phase and during the climb-out.	maximum pitch-up angle within the first 0.5 NM after take-off and after IAS is above the VTOSS value of the specific helicopter type. If the maximum pitch angle exceeds the recommended angle from the helicopter CAT A take-off profile, an event is triggered. 3/ Monitor the IAS at a certain height above airfield during departure to detect when acceleration above Vy speed has been performed too early (too low) during the take-off. For IAS/height values, refer to the RFM CAT A departure profiles. 4/ Compare the NR value during take-off before a specified speed, with the NR recommended setting for take-off.			This contextual evaluation is important to know the correct V/S and RH values of the applicable approach profile.
Engine failure during landing before decision point (for multi-engine helicopters)	Yes	Yes	Yes	N/A	High radio height and low IAS to detect too early reduction of speed during rig landing leading to a prolonged time in HOGE (hover out of ground effect) hover. Low height (above touchdown point altitude) during the approach.	Use radio height, IAS and GS to detect when both IAS and GS reduce below a certain value (e.g. 30 kt IAS, 10 kt GS) when the helicopter is not yet above the landing pad (when radio height is still > 50 ft, for example). Severity based on the duration of the event (how long the helicopter is below the speed threshold and	Refer to TS 'engine failure and relight'		The failure of an engine before DP may result in excessive power demand on the remaining engine. For some helicopter models, the NR is automatically set, meaning that an NR deviation from the normal setting is probably due to a failure, and not a deviation from the SOP.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
					High rate of descent below 500 ft AHE during rig landing. Offshore operation: downwind flight shortly before landing (GS–IAS difference). Incorrect NR value setting before landing.	above the radio height threshold), because when the helicopter is at low speed out-of-ground effect, the effect of an engine failure is more hazardous. Compare the NR value during landing with the NR recommended setting for landing.			
Engine failure during landing after decision point (for multi-engine helicopters)	Yes	Yes	Yes	N/A	Non-adherence to RFM performance class 1 landing speed and pitch attitude to ensure that a forced landing is possible in case of failure of an engine. Examples: High ground speed at LDP height. High pitch angle on approach. High rate of descent at LDP height. Incorrect NR value setting before landing.	Monitor: 1/ Maximum pitch-up angle reached during final approach. 2/ Ground speed at a predefined height above airfield and distance to touchdown value. 3/ Rate of descent below a height above airfield value. Note: Specific values to be defined according to the operator's SOPs and RFM CAT A landing profiles of the specific helicopter type.	Refer to TS 'Engine failure and relight'.		In HEMS operations, monitoring the 'door open' parameter is important to detect off-field versus helipad landings to correlate severity of event.
Flight and engine control system malfunctions	No	Yes	Yes	N/A	N/A	N/A	1/ Precursors to the malfunction? Torque split or engine showing significantly different settings may indicate a system malfunction. NR over- or under-speed.	1) Detect excessive torque / NG / ITT split between the 2 engines. 2) Detect when NR approaches the cautionary range (high or low values of NR defined in the RFM).	This corresponds to the failure of the stability augmentation system or the engine electronic control. Caution: It is useful to introduce a filter to exclude instances where the helicopter engine-out

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
									training mode was being used for training purposes, as the use of this mode allows NR values that are outside the range of values for all-engines-operative.
							2/ Incorrect or abnormal use of the helicopter such that it may significantly increase the risk of malfunction? Disconnection of the AP (SAS) in flight might reveal an error by the pilot (e.g. pressing the wrong switch) or a malfunction of the system.	Detect when one autopilot or both autopilots are disconnected in flight. This is often an anomalous occurrence in most helicopters since disconnecting the autopilots deactivates the stability augmentation system, something not usually done in normal operations.	Note: Just relying on FDM data, it is not always possible to determine whether an AP disconnection was commanded. Caution: Events that occurred during training flights where SAS disconnection may be on purpose should not be included.
							3/ Issues that may make the trained procedure to deal with a malfunction ineffective? (No FDM method proposed)	(No FDM method proposed)	
							4/ Monitor false alerts related to malfunction? EEC failure warnings. FADEC failure warnings, if recorded. High rotor rpm false indications.	Monitor the activation of rotor low / rotor high warning, EEC transition from AUTO to MANUAL mode, and other caution / warnings related to flight and engine controls.	
Recovery from unusual attitudes	Yes	No	No	Detect excessive pitch, roll or yaw angles or rates.	Upper modes still engaged (risk of contradictory commands between pilot and autopilot upper modes). Incorrect use of upper modes. SAS disengagement.				The trained procedure is usually to level the aircraft.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Landing with one or more engines inoperative	Yes	Yes	Yes	N/A	Refer to TS 'Engine failure during landing before DP'.		Refer to TS 'Engine failure and relight'.		
Instrument meteorological conditions (IMC) autorotation techniques	Yes	No	Yes	N/A	Not addressed as this is already a worst-case scenario.	(No FDM method proposed)			Very seldom occurrence, usually encountered only during training, requiring specific manoeuvring techniques used only for autorotation and not used during normal flight operations. Note: Information on flight data is usually insufficient to determine whether the flight was operated in IMC and, therefore, the crew had to comply with IFR flight procedures, or the flight was operated in VMC and, therefore, less stringent VFR procedures were used. Note 1: This TS is very seldom for offshore and HEMS operations, as they are performed with multiple-engine helicopters (check the air operations rules). Note 2: For some helicopter models, it is not permitted to practise autorotation during the flight; it may only be trained in the simulator. (No FDM method proposed)

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
Autorotation to a designated area	Yes	No	Yes	Monitor collective position and the main rotor rpm. Monitor high rate of descent.	Development of an excessively high rate of descent. IAS not within the autorotation IAS specified by the RFM. NR not controlled within the specified range within the minimum and maximum value.		Refer to TS 'IMC autorotation techniques'.		Specific for HEMS operations: detect high rate of descent with torque values close to 0; may be indicative of on-purpose autorotation.
Pilot incapacitation	No	No	Yes	N/A	N/A	N/A			Advanced FDM algorithm could look at flight control movements but the relevance to detect signs or precursors of pilot incapacitation remains to be demonstrated.
Directional control failures and malfunctions	No	Yes	Yes	N/A	N/A	N/A	1/ Precursors to the malfunction? Tail rotor's insufficient effectiveness, such as revealed by the maximum deflection of the yaw pedals. High yaw rate, or lack of response to yaw inputs.	FDM event to detect high yaw rate, differentiating when at low IAS hovering or during horizontal flight (IAS above 30 kt). FDM event detecting when tail-rotor pedals are deflected close to their limit, correlating if there is a change of yaw rate according to the pilot tail-rotor input or if the yaw rate is opposite to the pilot tail-rotor input (possible occurrence of a loss of tail-rotor effectiveness).	
							2/ Incorrect or abnormal use of the helicopter such that it may significantly	Detect pedal position offset from neutral position for more than X	

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
							increase the risk of malfunction? Monitor prolonged periods with offset pedal positions on the ground (might cause overtemperature of bearing in the tail).	minutes, when on ground.	
							3/ Issues that may make the trained procedure to deal with the malfunctions ineffective? Too slow on approach, as this would require more power, more torque created by the main rotor and, therefore, failure of the tail rotor would be more hazardous.	FDM event based on radio height, IAS and GS to detect when both IAS and GS reduce below a certain value (e.g. 30 kt IAS, 10 kt GS) when the helicopter is not yet above the landing pad (when radio height is still > 50 ft, for example). Severity based on the duration of the event (duration of period when the helicopter is below the speed threshold and above the radio height threshold), because when the helicopter is at low speed out-of-ground effect, the effect of a loss of tail rotor is more hazardous.	
							4/ Monitor false alerts related to malfunction? No specific alert to directional control failure was identified. (No FDM method proposed)	(No FDM method proposed)	Most helicopters are not fly-by-wire.
(B) Applicable to pilots required to engage in IFR operations									
3D approach operation to minima (if relevant, at least one of the	Yes	No	No	Detection of approach phase	Misuse of automation, meaning use against the operator's SOP.	Active collective mode during the approach. HTAWS warnings during approach.			The large variety of approach types makes it difficult to detect deviations from the approach flight profile.

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
3D or 2D approach operations should be an RNP APCH or RNP AR APCH operation) (in the case of multi-engine helicopters, a simulated failure of one engine to be included in either the 3D or the 2D approach operation to minima)					For instance, the level of automation selected is not appropriate (e.g. collective is still manually controlled, flying 2-Cue instead of 3-Cue). Frequent HTAWS warnings, hinting at lack of or wrong information on obstacles. HTAWS too early inhibited during approach. Significant deviation from the approach path.				
Go-around on instruments	Yes	Yes	Yes	N/A	Failure to achieve the best climb speed. A high climb rate is important to avoid obstacles around the platform (e.g. vessels). No change of heading during the go- around to avoid obstacles (good practice is to change the heading by about 30° to 45° to avoid obstacles at an offshore platform). Gear not retracted. Too late / too low initiation of go-around.	Monitor the climb rate after the initiation of go-around. After an FDM event detects a go-around, the FDM analyst can analyse the flight path to detect if the change in heading (offset) was correctly performed, if the speed was above Vy and if the correct power (torque) was applied, and the radio height at which the event was initiated.	Refer to TS 'Engine failure and relight'.		

Training scenario (TS)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Notes
2D approach operation to minima (if relevant, at least one of the 3D or 2D approach operations should be an RNP APCH or RNP AR APCH operation)	Yes	No	No	Detection of approach phase	Refer to TS '3D approach operation to minima' plus incorrect altimeter setting, leading to a risk of collision with obstacles or the sea.	Refer to TS '3D approach operation to minima' plus incorrect altimeter setting, leading to a risk of collision with obstacles or the sea.			
Landing with a simulated failure of one or more engines	Yes	Yes	Yes	N/A					Already covered by the items 'engine failure during landing before decision point' and 'engine failure during landing after decision point'.
Where appropriate to the helicopter type, approach with flight control system / flight director system malfunctions, flight instrument and navigation equipment failures	Yes	Yes	No	Flight control system failure alert, AP failure alert, instrument failure alerts.	Misuse of automation, meaning use against the operator's SOPs. Incorrect use of upper modes.	Refer to TS '3D approach operation to minima' plus incorrect altimeter setting, leading to a risk of collision with obstacles or the sea.	1/ Precursors to the malfunction (No FDM method proposed)		Note: This TS encompasses several types of failures and malfunctions. Autopilot failures are not very seldom.
							2/ Incorrect or abnormal use of the helicopter such that it may significantly increase the risk of malfunction? (No FDM method proposed)		
							3/ Issues that may make the trained procedure to deal with the malfunctions ineffective? Addressed by Q5.		
							4/ Monitor false alerts related to malfunction? False alerts related to the flight control system, the AP, or instruments and navigation equipment.	False alerts related to the flight control system, the AP, or instruments and navigation equipment. Detect difference in barometric settings between left side and right side.	Difference in barometric settings between left and right side of the cockpit can lead to autoflight behaviour that is not expected by the flight crew.