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SAFETY PROMOTION
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EUROPEAN AUTHORITIES COORDINATION GROUP ON FLIGHT DATA MONITORING (EAFDM)

DEVELOPING STANDARDISED FDM-BASED INDICATORS

FOCUS ON OPERATIONAL RISKS IDENTIFIED IN THE EUROPEAN PLAN FOR AVIATION SAFETY

Version 2 (December 2016)

Contents

General note

This document was produced by the members of the **European Authorities coordination group on FDM** (**EAFDM**). Information on the EAFDM can be consulted in EASA website.

The EAFDM is a voluntary partnership between the European Aviation Safety Agency (EASA) and National Aviation Authorities of EASA Member States, with the following objectives:

- to foster actions by National Aviation Authorities which lead to the improved implementation of FDM Programmes and increase their safety effectiveness,
- to contribute to enhancement of safety in Europe, and
- to assist in the provision of a more accurate overview of air transport operational safety in Europe.

The experts that contributed to the second edition of this document were delegated from the following authorities:

- Austro Control (Austria)
- BCAA (Belgium)
- DGAC (France)
- IAA (Ireland)
- ENAC (Italy)
- CAA (Latvia)
- ULC (Poland)
- AESA (Spain)
- CAA (United Kingdom)
- EASA

According to its terms of reference, the EAFDM is a voluntary and independent safety initiative. **Therefore this document should not be considered as an official guidance of any of the authorities represented at the EAFDM**.

This document is intended to be updated by the EAFDM when necessary. If you would like to give your comments on this document, please write to **fdm@easa.europa.eu**.

Executive Summary

This document offers standardised indicators based on Flight Data Monitoring data, for the monitoring of common operational risks identified at the European level.

Flight data monitoring (FDM) can be a powerful tool for an aircraft operator to improve and monitor its operational safety. National Aviation Authorities (NAAs) of EASA Member States are responsible for the oversight of their national operators including their FDM programmes.

Beyond this oversight function, NAAs should play a decisive role in coordinating a follow-up through operators' FDM programmes of significant operational risks identified at the national or European level. Ultimately, this would promote an enhanced monitoring of these risks by each operator, and this could contribute to the State Safety Programmes with information derived from FDM programmes.

In order to assist the NAAs in the achievement of this objective, the **European Authorities coordination group on FDM** (EAFDM) offers a set of **standardised FDM-based indicators** that an NAA can promote to its aeroplane operators. These FDM-indicators address four categories of aviation occurrences recognised as a high priority by the European Plan for Aviation Safety: runway excursions, controlled flight into terrain, loss of control in flight and mid-air collisions.

While standardised FDM-based indicators follow the same construction principles as any FDM event, they are not meant to replace the FDM events currently monitored by operators FDM programmes, or to provide for an acceptable means of compliance. Their function is only to capture known unsafe situations, and not to provide information on the causes, contributing factors or means of preventing unsafe situations. Their primary purpose is to offer guidance for monitoring operational risks in a more standardised manner.

Abbreviations and definitions

ACAS	Airborne collision avoidance system
AMAN	Abrupt manoeuvre: the intentional abrupt manoeuvring of the aircraft by the flight crew.
ARC	Abnormal Runway contact: any landing or take-off involving abnormal runway or landing surface contact.
Aviation occurrence category (CICTT)	Occurrence categories are used to classify occurrences (that is, accidents and incidents) at a high level to permit analysis of the data in support of safety initiatives.
CAST	Commercial Aviation Safety Team
CFIT	Controlled Flight into Terrain: In-flight collision or near collision with terrain, water, or obstacle without indication of loss of control.
CICTT	CAST/ICAO common taxonomy team
CTOL	Collision with obstacles during take-off or landing: Collision with obstacle(s) during take-off or landing while airborne
EAFDM	European Authorities Coordination Group on FDM
EPAS	European Plan for Aviation Safety
FDM	Flight Data Monitoring
FDM event	An occurrence or condition in which predetermined values of flight parameters are measured. Event detection is the traditional approach to FDM that looks for deviations from flight manual limits, standard operating procedures and good airmanship.
FDM data summary	Summary of the FDM programme activity of a given aircraft operator on a given period and of the number and severity of detections of selected FDM events.
ICAO	International Civil Aviation Organisation
ICE	Icing: Accumulation of snow, ice, freezing rain, or frost on aircraft surfaces that adversely affects aircraft control or performance.
LOC-I	Loss of control – in flight: loss of aircraft control while, or deviation from intended flight path, in flight.
MAC	Mid-air collision: Air proximity issues, TCAS/ACAS alerts, loss of separation as well as near collisions or collisions between aircraft in flight.
NAA	National Aviation Authority
Occurrence	Accident, serious incident or incident, as defined by ICAO Annex 13
RE	Runway Excursion: A veer off or overrun off the runway surface.
RI	Runway Incursion: Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and take-off of aircraft.
SCF-NP	System/ Component failure or malfunction (Non Powerplant): failure or malfunction of an aircraft system or component other than the powerplant
SCF-PP	System/ Component failure or malfunction (Powerplant): failure or malfunction of an aircraft system or component related to the powerplant

SMS	Safety Management System
SSP	State Safety Programme
Standardised FDM-based indicator	Indicator based on FDM data that is meant to capture a type of potentially unsafe situation common to many kinds of aircraft and operations. This definition is partially standardised, so that it can be implemented in a similar way by different aircraft operators while permitting adjustment to operational specificities. While indicators in this document follow the same construction principles as any FDM event, their intended function is only to capture known unsafe situations, and not to provide information on the causes, contributing factors or means of preventing unsafe situations.
TURB	Turbulence Encounter: In-flight turbulence encounter.
WSTRW	Wind shear or thunderstorm: Flight into wind shear or thunderstorm.

I. Explanatory note

1. Background

Flight Data Monitoring, a safety management tool

Flight Data Monitoring (FDM) is the pro-active use of digital flight data from routine operations in order to improve safety. In Europe, an FDM programme is mandatory for aeroplanes with a maximum certificated take-off mass (MCTOM) in excess of 27000 kg and operated for commercial air transport[1].

An FDM programme can be a powerful tool for an aircraft operator to monitor the safety of its operation. An FDM programme is destined to be integrated into the operator's Safety Management System (SMS), allowing to detect, confirm and assess safety issues and to check the effectiveness of corrective actions.

This guidance **pertains to FDM programmes of aeroplanes operators** and their focus on the broader perspective of safety issues identified at the European and national levels. Some aeroplane operators may not necessarily consider the safety issues that appear to be the most frequent and/or severe when considering national or European accident statistics, as a priority. However, no operator is immune to these safety issues; if they are not properly monitored it is just a question of time before they translate into a serious incident or an accident.

> Note:
> FDM programmes are mandatory for commercial offshore operations with helicopters required to carry a flight data recorder as of 01 January 2019[2], however helicopters operations are not addressed in this version of the document.

The European Plan for Aviation Safety

In Europe, the sharing of roles between the EU and the Member States, as described in EASA "Basic Regulation"[3], makes it necessary for the Member States to work together with EASA to fully implement their SSP. The **European Plan for Aviation Safety (EPAS)** identifies areas where coordinated action by European authorities (European Commission, EASA Member States, EASA) will make a difference in preventing accidents and incidents[4].

In particular, the EPAS has identified operational safety issues reflecting top safety concerns shared by EASA Member States. These operational safety issues and their precursors should be addressed by each individual operator of large aeroplanes in Europe. These operational safety issues are related to the following categories of occurrence[5]:

1. Runway Excursions (RE),
2. Mid-Air Collisions (MAC),
3. Controlled Flight Into Terrain (CFIT), and
4. Loss Of Control In Flight (LOC-I).

The EPAS has recognised the potential contribution of FDM programmes to addressing safety issues commonly shared at the European level. For these reasons, the EPAS contains Safety Actions aimed at enhancing the level of implementation of FDM programmes in Europe, in particular with regards to monitoring these common

1 Refer to Annex III to Commission Regulation (EU) 965/2012, paragraph ORO.AOC.130.
2 Refer to Annex V to Commission Regulation (EU) 965/2012, paragraph SPA.HOFO.145.
3 Regulation (EC) 216/2008.
4 More information on the EPAS can be consulted on EASA website.
5 The EPAS has identified a few other high priority issues for commercial air transport aeroplanes, such as Ground Collisions. This issue includes runway incursions and safety of ground operations. However, it was assessed that FDM data alone would probably not be sufficient to monitor the Ground Collisions risk, therefore it is not addressed in this document.

operational safety issues. EAFDM has supported the Agency and the Member States in addressing these Safety Actions.

A first version of this document was published in December 2013. However, EAFDM still considered that more experience on the practicalities and the safety benefits of standardised FDM-based indicators needed to be gathered. Therefore this second version was prepared.

2. Concept of Standardised FDM-based indicators

Objective

The objective is to foster the programming of FDM events that are meaningful for the monitoring of significant operational risks identified at the national or European level, in particular related to RE, MAC, CFIT and LOC-I.

The **standardised FDM-based indicators** are expected to bring several advantages:

- Bring all operators to monitor common operational risks[6] that they would otherwise not necessarily consider as priority;
- Ensure that for those common risks, operators have in place relevant FDM events;

  Note:
  The term "FDM event" has not been used to describe the FDM-based indicators in this document as FDM events are usually not only meant for capturing unsafe situations, but also monitoring SOPs, contributing factors, effectiveness of safety barriers, etc. Therefore, for the purposes of this document, the term "standardised FDM-based indicator" is used.

The objective of standardised FDM-based indicators is NOT to completely standardise the FDM programmes of aircraft operators. This is not desirable, as:

- The regulator cannot define an exhaustive list of FDM events, given the variety of aircraft models, types of operation and airfields. The definition of an appropriate FDM event set will vary according to the nature of the operation.
- The aircraft operator is responsible for managing its own SMS, including its safety data sources, such as the FDM programme; it is a general safety management principle that the data collection should be adapted to monitor particular risks identified. FDM programmes need to account for their own operational safety priorities.

Hence, standardised FDM-based indicators are foreseen to represent a subset of the FDM events that are relevant for the prevention of the categories of occurrence identified as priority by the EPAS. These standardised FDM-based indicators need to be programmed according to a common definition, as far as practicable.

Scope

The proposed standardised FDM-based indicators are only meant to capture potentially **unsafe situations** during aircraft operation. They are not designed for providing any insight on how the aircraft got into an unsafe situation or how the situation was recovered[7].

Hence, standardised FDM-based indicators are designed to help an operator to detect potentially unsafe situations and assess their severity and implement mitigating actions. However, **an effective FDM programme should not be reduced to monitoring only standardised FDM-based indicators**.

6 Those are common risks potentially affecting all operators.

7 This should be addressed by dedicated FDM events and/or in-depth analysis of the corresponding sequence in conjunction with other sources of information.

The CAST/ICAO Taxonomy Team (CICTT) has defined a taxonomy for **aviation occurrence categories**, i.e. the categories of occurrence that can take place during an accident or an incident[8]. The aviation occurrence categories:Runway Excursions (RE), Controlled Flight Into Terrain (CFIT), Mid-Air Collision (MAC), Loss of Control in Flight (LOC-I) are considered a common denominator among the various operational risks to be monitored by EASA Member States. Therefore standardised FDM-based indicators are defined in priority for these four aviation occurrence categories, however reference to other categories is made when applicable.

Figure 1 presents an overview of the standardised FDM-based indicators sorted by aviation occurrence category.

Fig. 1 - Standardised FDM-based indicators and aviation occurrence categories for which they are primarily relevant

RE	MAC	CFIT	LOC-I
› High speed rejected take-off › Take-off with abnormal configuration › Insufficient take-off performance › Unstable shortly before landing › Abnormal attitude or bounce at landing › Hard landing › A/C lateral deviations at high speed on the ground › Short rolling distance at landing	› TCAS/ACAS resolution advisory	› (E)GPWS/TAWS warning trigger	› Excessive roll attitude or roll rate › Stall protection trigger › Excessive speed / vertical speed / acceleration › Insufficient energy at high altitude › Low go-around or rejected landing › Reduced margin to manoeuvrability speed

Relationship with FDM events recommended in air operation rules

The air operation rules contain a requirement to implement an FDM programme for aeroplanes with an MCTOM of more than 27 000 kg and operated for commercial air transport: refer to Annex III to Commission Regulation (EU) 965/2012, paragraph ORO.AOC.130. AMC1 ORO.AOC.130 contains acceptable means of compliance for implementing ORO.AOC.130. AMC1 ORO.AOC.130 (c) recommends that a set of core events should be selected to cover the main areas of interest to the operator. A sample list is provided in Appendix 1 to AMC1 ORO.AOC.130." Appendix 1 to AMC1 ORO.AOC.130 contains a table of FDM events for illustration[9].

The FDM events table of Appendix 1 to AMC1 ORO.AOC.130 provides examples for implementing FDM events, while the standardised FDM-based indicators in this document are meant to track only those **unsafe** situations related to RE, CFIT, LOC-I or MAC. Therefore, standardised FDM-based indicators have a different purpose and a different scope; as such, they are not meant to replace or to complement the individual FDM events in the FDM event table of Appendix 1 to AMC1 ORO.AOC.130.

However, a **cross-reference** is offered in Table 1, as some standardised FDM-based indicators are related to FDM event groups identified in the FDM event table of Appendix 1 to AMC1 ORO.AOC.130. This cross-reference table illustrates this relationship.

8 This taxonomy is freely available on CICTT website : http://www.intlaviationstandards.org .
9 This table is an example and the events are "considered illustrative and not exhaustive", therefore it cannot be considered as definitive and for application by all aircraft operators.

Note:
The middle column of Table 1 indicates standardised FDM-based indicators related to an FDM event group, however these indicators may not necessarily cover the full scope of the corresponding FDM event group in the left-hand column because, the FDM event group is (partially) out of scope (i.e. not related or not exclusively related to RE or CFIT or LOC-I or MAC) or because the FDM event group is meant to detect events which are not desirable, but not necessarily unsafe per se.

Table 1 - cross-reference between FDM event groups in Appendix 1 to AMC1 ORO.AOC.130 and standardised FDM-based indicators

FDM Event Group in FDM event table of Appendix I to AMC1 ORO.AOC.130	Related standardised FDM-based indicators	Comments
Rejected take-off	• RE.1 - High speed rejected take-off	
Take-off pitch	• RE.2 - Take-off with abnormal configuration	
Unstick speeds	• RE.3 - Insufficient take-off performance	
Height loss in climb-out	• CFIT.1 - (E)GPWS/TAWS Warning Trigger	Mode 3 of the GPWS detects significant altitude loss after take-off.
Slow climb-out	• RE.3 - Insufficient take-off performance • CFIT.1 - (E)GPWS/TAWS Warning Trigger	If the terrain beneath is rising rapidly, this would already be captured by the indicator CFIT.1 - (E)GPWS/TAWS Warning Trigger (Mode 2A for excessive closure to terrain when climbing or Mode 4C for insufficient terrain clearance in climb or Enhanced terrain look-ahead alerting function).
Climb-out speeds	• LOC-I.3 - Excessive speed / vertical speed / accelerations • LOC-I.6 Reduced margin to manoeuvrability speed	A high climb-out speed would be captured by the indicator LOC-I.3. A low climb-out speed by the indicator LOC-I.6
High rate of descent	• LOC-I.3 - Excessive speed / vertical speed / accelerations • CFIT.1 - (E)GPWS/TAWS Warning Trigger	Mode 1 of the GPWS detects excessive descent rate below 2 500 ft AGL.
Missed approach	• LOC-I.5 - Low go-around or rejected landing	A missed approach is a safe maneuver when it is performed according to the procedures.
Low approach	• CFIT.1 - (E)GPWS/TAWS Warning Trigger	Mode 2B of the GPWS detects excessive closure rate to the terrain while on approach. Modes 4A and 4B capture insufficient radio-height during approach.
Glideslope	• CFIT.1 - (E)GPWS/TAWS Warning Trigger	Mode 5 of the GPWS detects deviations below glideslope.
Approach power	• RE.4 - Unstable shortly before landing	If the power is not sufficient during approach, it will translate into speed decay or high vertical speed. Both would be captured by the indicator RE.4.
Approach speeds	• RE.4 - Unstable shortly before landing • LOC-I.3 - Excessive speed / vertical speed / accelerations • LOC-I.6 Reduced margin to manoeuvrability speed	
Landing flap	• RE.4 - Unstable shortly before landing	
Landing pitch	• RE.5 - Abnormal attitude or bounce at landing	

FDM Event Group in FDM event table of Appendix I to AMC1 ORO.AOC.130	Related standardised FDM-based indicators	Comments
Bank angles	• RE.5 - Abnormal attitude or bounce at landing • LOC-I.1 - Excessive roll attitude or roll rate • CFIT.1 - (E)GPWS/TAWS Warning Trigger • RE.4 - Unstable shortly before landing	Mode 6 of the GPWS detects excessive bank angle at low radio-height.
Normal acceleration	• RE.6 - Hard landing • LOC-I.1 - Excessive roll attitude or roll rate	The main risk represented by excessive accelerations along the normal axis of the aircraft is a structural failure, which does not belong to any of the occurrence categories RE, CFIT, LOC-I or MAC. However, some unsafe situations related to RE or LOC-I, such as a hard landing or an abrupt turn (excessive roll attitude) may well generate high values of normal acceleration.
Abnormal configuration	• RE.2 - Take-off with abnormal configuration • RE.4 - Unstable shortly before landing • LOC-I.5 - Low go-around or rejected landing	
Ground proximity warning	• CFIT.1 - (E)GPWS/TAWS Warning Trigger	
Airborne collision avoidance system (ACAS II) warning	• MAC.1 - TCAS/ACAS Resolution Advisory	
Margin to stall/buffet	• LOC-I.2 - Stall protection trigger • LOC-I.4 - Insufficient energy at high altitude • LOC-I.1 - Excessive roll attitude or roll rate • LOC-I.6 Reduced margin to manoeuvrability speed	
Aircraft flight manual limitations	• LOC-I.3 - Excessive speed / vertical speed / accelerations • LOC-I.4 - Insufficient energy at high altitude	The indicator LOC-I.3 would detect exceedance of VMO, VFE, VLE, MMO The indicator LOC-I.4 - Insufficient energy at high altitude would trigger on maximum operating altitude exceedance.

Flight parameter performance and FDM software limitation

It is essential to confirm and understand the relevant aircraft flight parameters' performance before commencing the process of programming and implementing any such standardised FDM-based indicators. Only valid, accurate and correctly sampled flight parameters can deliver a meaningful indicator.

In addition, some of the proposed standardised FDM-based indicators may not be achievable, because the needed flight parameters are not recorded with sufficient sampling rate, accuracy or recording resolution. It is acknowledged that less advanced or similar indicators may be implemented instead. However, it is recommended that whenever possible, the respective flight parameter performance appropriate for programming the most advanced indicators is communicated in advance to the aircraft manufacturer and to the FDM airborne system installer, so that those indicators may be computed on newly delivered aircraft.

Finally, the intrinsic design of the FDM software may make the programming of some standardised FDM-based indicators challenging. FDM software vendors might help in finding short-term solutions (alternative indicators) and long-term solutions (software change) to these limitations.

3. Definition of standardised FDM-based indicators

Composition

A standardised FDM-based indicator is composed of two elements:

1. A **trigger logic**, i.e. circumstances detected by an algorithm looking at flight data, and
2. An **indication of the severity** of what is detected by the trigger logic.

The fields

Note:
No field related to the flight phase was defined, because the definitions of flight phase are often complex and vary between taxonomies10. In addition the flight splitting logic is different from one FDM system to the other. Therefore, it was considered more helpful to include in the trigger logic, criteria that would help to capture a particular flight phase when necessary.

Title
This is the title or identifier of the standardised FDM-based indicator.

Description
A short text describing what potentially unsafe situation the indicator is designed to detect.

Applicable operational risk
This field contains information that:

1. Describes what risk information the standardised FDM-based indicator is meant to capture;
2. Identifies aviation occurrence categories[11] for which the standardised FDM-based indicator is relevant.

Trigger logic
This field contains information on the following:

1. The combination of conditions that triggers the detection. The description should be short and intuitive. This is meant to give a quick understanding of how the trigger logic works
2. List of data needed (flight parameters and other source of data); the flight parameters and the other data needed to perform the computation should be accurately defined (e.g. "CAS" instead of "speed", "EPR" instead of "engine power"). Where applicable, alternative parameters are proposed.(e.g. when ground speed is not recorded, use calibrated airspeed).

Suggested indications of severity
Examples of recommended indicators for assessing the severity of the situation. While there are several ways of quantifying severity, it would be necessary to elect one of them if results are to be compared or aggregated between several operators.

Useful contextual information
Information not captured by FDM data which is useful for the analysis of the trigger logic detection of a given standardised FDM-based indicator.

Getting contextual information is however not a precondition for programming the indicator, and it is expected that meaningful analysis of trigger logic detections will be possible even if only part of the contextual information recommended can be retrieved.

10 For reference, the CICTT defined a taxonomy for "Phases of Flight".

11 The aviation occurrence categories are based on CICTT taxonomy for aviation occurrence categories, definitions and usage notes

Examples: time, visibility conditions, local weather conditions, aircraft mass and balance, etc.

Effectiveness
This field contains considerations on the limitations of the trigger logic, and on how to use or assess some flight parameters.

A flexible and simple definition

A standardised FDM-based indicator needs to be applicable to all kinds of operation and all models of aeroplanes, therefore a single fully defined algorithm cannot be encompassed in its trigger logic. On the other hand, standardised FDM-based indicators can potentially facilitate the collection and comparison of data from various operators, which means that some level of standardisation is desirable to allow comparison and aggregation between various operators.

Therefore, a "**flexible definition**" is proposed here. The trigger logic is unique, but the values of variables in the trigger logic are not fixed, and have to be adjusted by the operator according to the aircraft model, the airport or the standard operating procedures. In particular, threshold values are not hard-coded but rather refer to commonly understood concepts (Example: "stall angle of attack" instead of 15°) or an indicative range of acceptable values for a threshold is provided (e.g. speed threshold in the range [50kts;80kts]). Similarly, suggestions are made for the indications of severity, but they purposely do not provide fixed thresholds values.

In addition, the definition of a standardised FDM-based indicator should ideally be easy to understand and implement. Therefore, as far as practicable, the definition should be univocal and **simple**, the flight parameters required should be commonly recorded on most aeroplanes, and the trigger logic should be easy to program with logic and arithmetic operators available in most FDM software.

It should be noted that the implementation of standardised FDM-based indicators will likely be an iterative process and it may be necessary for the operator to fine-tune these indicators in order for them to be effective.

Organisation

The standardised FDM-based indicators are presented by aviation occurrence category. When a standardised FDM-based indicator is also potentially related to categories of occurrence outside of the focus of this document, they are indicated as well in the field "Applicable operational risk".

II. Standardised FDM-based indicators

This chapter contains proposed definitions of standardised FDM-based indicators relevant for the prevention of categories of occurrence identified by the EPAS, namely Runway Excursion (RE), Controlled Flight Into Terrain (CFIT), Loss of Control In Flight (LOC-I), Mid-Air Collision (MAC).

> Note:
> The indicators proposed in this document have been created on the presumption of a certain degree of flight parameter availability recorded on aircraft. It is acknowledged that some of these indicators may be difficult to compute: refer to I.2.

Every definition grid contains the following fields:

- Title,
- Description,
- Applicable operational risk,
- Trigger logic,
- Suggested indications of severity,
- Useful contextual information,
- Effectiveness.

The use of each field is described in I.3.

The acronyms in use in the definitions of standardised FDM-based indicators are provided below:

AOA	Angle of Attack
CAS	Calibrated air speed
EPR	Engine Pressure Ratio
IAS	Indicated air speed
N1	Fan RPM on a jet engine (in %)
Np	Propeller RPM on a turboprop engine
OAT	Outside air temperature
TAS	True air speed
V1	Take-off decision speed
TCAS	Traffic Collision Avoidance System
TLA	Thrust Lever Angle
PLA	Power Lever Angle
GS	Ground speed

1. Indicators relevant for the prevention of Runway Excursions

RE.1 - High speed rejected take-off

<table>
<tr><th>Title</th><td>High speed rejected take-off</td></tr>
<tr><th>Description</th><td>This indicator captures situations where the take-off roll was aborted while the aircraft speed was high.</td></tr>
<tr><th>Applicable operational risk</th><td>Risks addressed: runway overrun, runway veer-off (RE)
Other risks related to this indicator: RI</td></tr>
<tr><th>Trigger logic</th><td>Conditions that triggers the detection:
1. Aircraft on the ground or close to the ground, and engine thrust/power parameter in the take-off value range, and
2. Aircraft speed high (groundspeed or airspeed), and
3. Engine thrust/power parameter dropping from the take-off value range to a low value, or engine thrust/power control parameter reduced to idle or reverse thrust.

Alternative trigger logic (not using engine-related flight parameters):
1. Aircraft on the ground or close to the ground, and
2. Aircraft speed high (groundspeed or airspeed) and aircraft accelerating, then
3. Aircraft decelerating

Minimum set of flight parameters needed:
• Gears compressed (at least one gear)
• Radio-height
• Airspeed (CAS or IAS)
• Groundspeed
• Engine thrust/power parameter (EPR, N1, Np) or engine thrust/power control parameter (TLA, PLA)
• Longitudinal acceleration

Note: ‘close to the ground’ is meant to capture an extreme situation where the take-off is aborted while the aircraft is already airborne.
Note: An aircraft speed significantly above the normal taxi speed range (i.e. 40 kt above the upper boundary of the normal taxi range, or 80% of V1) could be considered high.</td></tr>
<tr><th>Suggested indications of severity</th><td>• Maximum airspeed attained during the acceleration, relative to V1 or VR
• Maximum groundspeed at the time of take-off rejection
• Available runway length remaining after coming back to normal taxi speed
• Acceleration necessary to stop the aircraft before the end of the runway (see the indicator RE.8 – Short rolling distance at landing)
• Actual Accelerate Stop Distance (ASD) relative to computed ASD
• Maximum longitudinal acceleration value</td></tr>
<tr><th>Useful contextual information</th><td>A/C mass and balance, weather conditions (OAT, Wind speed and direction, runway contamination, RVR, etc.), airfield and runway, UTC time, V1, take-off starting point (intersection)</td></tr>
<tr><th>Effectiveness</th><td>The aircraft situation can be considered unsafe only if the maximum airspeed attained is close to or greater than the decision speed (V1). The decision speed can usually not be directly computed from FDM data, therefore another callout speed may be preferred, or alternatively a speed value recommended by the aircraft manufacturer.
Notes:
• If there is no flight detection, a rejected take-off could go undetected. The FDM software logic for detecting the start of a flight should be checked to ensure that a rejected take-off would qualify as a flight.
• If needed, the normal taxi speed range can be determined based on recommendations from the aircraft manufacturers, SOPs, airport taxi speed regulation and taxi speeds observed in FDM data. Typically, normal taxi speed would vary between 5 kt and 30 kt.
• To assess reliably the remaining available runway length, a good accuracy of latitude and longitude parameters (3 angular seconds or better) and a good sampling rate (minimum 1Hz) of these parameters is needed.
• The actual accelerate stop distance can be computed by integrating the groundspeed over the rejected take-off phase.</td></tr>
</table>

RE.2 - Take-off with abnormal configuration

Title	Take-off with abnormal configuration
Description	This indicator captures situations where the take-off roll was initiated and • a warning related to the brakes/flap/slats/spoilers/thrust reverse configuration during the take-off roll was recorded, or • the take-off configuration or the autobrake setting was abnormal (slats/flaps/spoilers/pitch trim surface position). Note: a wrong thrust setting that is not corrected would be captured by the indicator RE.3 - Insufficient take-off performance.
Applicable operational risk	Risks addressed: runway overrun (RE) Other risks related to this indicator: loss of control at take-off or initial climb (LOC-I), CTOL
Trigger logic	Conditions that triggers the detection: 1. Take-off configuration warning triggered, or 2. Aircraft on the ground,accelerating and engine thrust/power parameter in the take-off value range and autobrake/flap/slats/spoiler/thrust reverser configuration is not usual. Note: in the case where take-off configuration warning (trigger logic 1) is not recorded, FDM events based on detecting unusual configurations (trigger logic 2) might generate nuisance alerts, for example when several configurations are permitted by SOPs. Minimum set of flight parameters needed: 1. Gears compressed (at least one gear) 2. Engine thrust/power parameter (EPR or N1 for a jet or Np for a turboprop) 3. Airspeed (TAS, or CAS or IAS) or groundspeed 4. Aircraft configuration (position of flaps, slats, spoiler) or position of aircraft configuration levers when the aircraft configuration is not recorded 5. (if available) Take-off warning, 6. Longitudinal acceleration 7. Autobrake setting
Suggested indications of severity	• Speed/time at which corrective action was performed (such as aborting take-off, correcting the aircraft configuration, correcting the thrust setting) • Duration of warning(s)
Useful contextual information	A/C mass and balance, weather conditions (OAT, Wind speed and direction, runway contamination, RVR, etc.), MEL (and maintenance logs), airfield and runway, UTC time
Effectiveness	Notes: • This indicator works in tandem with the indicator RE.3 - Insufficient take-off performance. This indicator captures unsafe situations resulting from the handling of the aircraft configuration, while RE.3 captures insufficient aircraft performance, whatever its cause may be.

RE.3 - Insufficient take-off performance

Title	Insufficient take-off performance
Description	This indicator captures situations where the aircraft performed a take-off with insufficient distance from the end of the runway.
Applicable operational risk	Risks addressed: runway overrun (RE) Other risks related to this indicator: LOC-I, CTOL
Trigger logic	Conditions that triggers the detection: 1. Aircraft on the ground, moving and accelerating and airspeed is equal to V1, and 2. The acceleration needed to stop the runway within the available runway length is high. Computation of the theoretical acceleration “a” needed to stop the aircraft within the remaining available runway length “d”: • If GS is the groundspeed (in meters per second), • If d is the remaining distance to the end of the runway (in meters), • If a is the theoretical acceleration needed to stop the aircraft at the end of the runway (in meters per square second), Then a=(GS*GS)/(2*d). Minimum set of flight parameters needed: • Gear compression (all main gears) • Ground speed or airspeed (TAS or CAS or IAS) • Engine thrust/power parameter (EPR or N1 for jet or Np for turboprop) • Latitude, Longitude • Longitudinal acceleration • Pitch rate (if VR is used instead of V1)
Suggested indications of severity	• Take-off roll distance (relative to the runway length) • Change of thrust setting during take-off roll • Thrust asymmetry (difference in N1%)
Useful contextual information	A/C mass and balance, weather conditions (OAT, Wind speed and direction, runway contamination, RVR, etc.), airfield and runway, UTC time
Effectiveness	This indicator requires a good accuracy of latitude and longitude parameters (3 angular seconds or better) and a good sampling rate (minimum 1Hz) of latitude, longitude, and gear compression parameters. In addition, accurate and up-to-date runway specifications should be imported into the FDM software. Further to that, this indicator requires knowledge of V1: either it is recorded or it can be easily computed. Notes: • If obtaining V1 is too difficult, the same computation may be performed at the time when the aircraft starts rotating (i.e. first time when the pitch rate is positive, when going backward into time from the time of lift-off). • This indicator works in tandem with the indicator RE.2 - Take-off with abnormal configuration. This indicator captures insufficient aircraft performance, whatever its cause may be. • The lift-off time can be determined using the gear compression parameter.

RE.4 - Unstable shortly before landing

<table>
<tr><th>Title</th><td>Unstable shortly before landing</td></tr>
<tr><th>Description</th><td>This indicator captures cases where the approach is still not stabilised or destabilised shortly before landing. It will not capture most cases of unstabilised approach, which are to be detected in an earlier phase of the approach.</td></tr>
<tr><th>Applicable operational risk</th><td>Risks addressed: RE
Other risks related to this indicator: CTOL</td></tr>
<tr><th>Trigger logic</th><td>Conditions that triggers the detection:
Pressure altitude is decreasing (aircraft descending), the aircraft height in relation to runway elevation is between predefined values H1 and H2 and any of the following conditions is met:
Aircraft not in landing configuration (landing gear, flaps, slats), or
More than X° difference between magnetic heading and QFU, or
Airspeed too high or too low relative to approach reference speed (as defined by SOP), or
Vertical speed higher than V ft/min, or
Absolute value of the Roll attitude exceeding R°.
Minimum set of flight parameters needed:
Pressure altitude
Landing gear extension
Flaps and slats extension
Vertical speed (or if not recorded, pressure altitude)
Airspeed (CAS or IAS)
Roll attitude
Power Lever Angle or Thrust Lever Angle
Localizer deviation
Recommended threshold values:
H1 should be higher than the height at which the flare is normally initiated. For example, H1 could be 50 ft.
H2 should be set well below the decision height or decision altitude, but it should be no less than 150 ft. (150 ft corresponds to roughly 10 seconds before crossing the runway threshold at 50 ft AGL, when considering a vertical speed of 600 ft per min).
The deviation threshold from the SOP approach reference speed is as defined by SOP.
A vertical speed threshold of 1 000 ft/min is usually adequate for a typical 3° approach path. The vertical speed threshold would need to be higher for a steep approach airport.
The roll attitude threshold could be typically 7° or 10°.</td></tr>
<tr><th>Suggested indications of severity</th><td>Maximum deviation of either Localizer indication, airspeed, vertical speed, pitch attitude or roll attitude between H1 and H2
Maximum durations of the deviations</td></tr>
<tr><th>Useful contextual information</th><td>Approach type and category, Weather conditions (OAT, wind speed and direction, RVR), UTC time airfield and runway.</td></tr>
<tr><th>Effectiveness</th><td>This indicator does not aim at capturing all unstable approaches, but still not stabilised or destabilised in the last 10 or 20 seconds before landing.
Notes:
This indicator works in tandem with the indicator named Low go-around (LOC-I.5). This indicator captures unstable approaches indistinctively if they are followed by a landing or by a go-around, while the low go-around captures all kinds of low go-around and rejected landings, whatever could be the reason (runway incursion, sudden loss of visibility, deep landing, etc.)
If the vertical speed is not a recorded flight parameters, deriving it using two successive readings of the pressure altitude generates a high level of noise. In that case, the vertical speed could be averaged on several seconds.However this time interval should not be too long in order to also detect short periods with an excessive vertical speed. The duration of this time interval is recommended to be in the range [3 sec;10 sec].
The glideslope signal does not provide for a constant slope under 200 feet radio-height, so that glideslope deviation is not relevant for detecting deviations from the intended flight path angle at low height., and it does not appear in the trigger logic of this indicator. If needed, the flight path angle may be assessed using the groundspeed and the vertical speed.</td></tr>
</table>

RE.5 - Abnormal attitude or bounce at landing

Title	Abnormal attitude or bounce at landing
Description	This indicator captures an abnormal attitude at the time of ground contact (excessive roll, landing in a crab, negative pitch) or a bounced landing). Note: the indicator RE.6 - Hard landing, captures landings with hard contact to the ground.
Applicable operational risk	Risks addressed: LOC-G leading to a runway veer-off (RE) Other risks related to this indicator: low margins to wing-tip strikes or stress on the airframe due to the abnormal landing attitude (ARC)
Trigger logic	Conditions that triggers the detection: Any of the conditions below is met: 1. Roll attitude takes excessive values between 20 ft AGL and the time where all gears are compressed; or 2. Time difference between compression of LH and RH landing gear is excessive, or 3. Pitch attitude takes negative values between 20 ft AGL and the time where all gears are compressed; or 4. Pitch attitude is high when main gears are compressed, or 5. The angle between aircraft magnetic heading and runway QFU takes excessive values between 20 ft AGL and the time where all gears are compressed; or 6. There is a gear compression followed by an airborne phase (bounced landing). Minimum set of flight parameters needed: • Gears compressed (at least nose gear and one main landing gear) • Radio-height • Pitch attitude • Roll attitude • Magnetic heading (or true heading corrected from magnetic declination) Note: See also indicator RE.7 with regards to lateral acceleration limits set by the aircraft manufacturer.
Suggested indications of severity	• Maximum roll attitude value reached (absolute or relative to the pitch attitude) from 20 ft AGL and until all gears are and remain compressed (no further bounce) or until go-around is initiated. • Minimum and maximum pitch attitude values from 20 ft AGL and until all gears are and remain compressed (no further bounce) or until go-around is initiated. • Maximum angle between aircraft magnetic heading and runway QFU from 20 ft AGL and until all gears are and remain compressed (no further bounce) or until go-around is initiated. • Duration of the airborne phase after the bounce, until main gears are compressed again (and remain compressed) or until go-around is initiated.
Useful contextual information	Flap setting, A/C mass and balance, weather conditions (OAT, Wind speed and direction, runway contamination, RVR, etc.), airfield and runway, UTC time
Effectiveness	Notes: • The sampling rate of gear compression should be at least 1 Hz to determine accurately the time of ground contact. • To assess the clearance to the various extremities of the aircraft, a combination of pitch and roll attitude in a 2D-space can be monitored. • If during the ground contact phase, the roll attitude value is significant, then the aircraft situation is not safe (a roll attitude of only a few degrees is not an issue). • If during the ground contact phase, there is a bounce lasting several seconds, then the detection should be analysed in depth. A very short bounce is not desirable, but it does not represent a high risk either. • This indicator works in tandem with the indicator RE.6 - Hard landing. This indicator is designed for capturing an abnormal touchdown sequence, while indicator RE.6 should capture touchdown were the attitude or the sequence of gears contact are normal, but the energy of the aircraft is excessive.

RE.6 - Hard landing

Title	Hard landing
Description	This indicator captures landings with hard contact to the ground. This indicator is not a continued airworthiness tool, it is only meant to detect adverse trends before they result into a landing causing loads on the aircraft such that action is recommended by the aircraft manufacturer. This indicator works in tandem with the indicator RE.5 - Abnormal attitude or bounce at landing.
Applicable operational risk	Risks addressed: damage to the gears leading to a runway veer-off (RE) Other risks related to this indicator: other type of damage to the airframe (ARC).
Trigger logic	Conditions that triggers the detection: The trigger logic often relies on criteria such as values of the normal acceleration or of vertical speed at the time of touchdown, and when available, the aircraft computed weight. The trigger logic can be built using the following method: 1. use the criteria recommended by the aircraft manufacturer for detecting hard landings for continued airworthiness purposes (refer to aircraft flight manual or maintenance manual); 2. instead of using the threshold values recommended by the aircraft manufacturer (which correspond to events for which immediate action is required such as inspecting the aircraft), set lower threshold values in order to detect events with a lower severity. Measurements could be used to determine “normal” values at touchdown and infer threshold values which effectively capture outliers.
Suggested indications of severity	• Margin to the thresholds set by the aircraft manufacturer for hard/heavy landings.
Useful contextual information	A/C mass and balance, weather conditions (OAT, Wind speed and direction, runway contamination, RVR, etc.), airfield and runway, UTC time
Effectiveness	• This indicator may be useful for detecting inadequate flaring techniques with a particular aircraft model or a higher proportion of hard landing at a particular airfield (e.g. due to the approach profile). It can also allow identification of repetitive hard landings affecting a given individual aircraft of the fleet, which may cause an earlier aging or failure of the landing gear. • To be effective, this indicator requires adequate sampling rate of the flight parameters used in the trigger logic. For example based on the experience of safety investigations authorities, EUROCAE Document 112A recommends to record the accelerations at 16 Hz, the vertical speed at 4 Hz and each gear compression at 4 Hz. • If the vertical speed is not recorded, an accurate assessment is difficult; simply deriving the pressure altitude generates noise, and smoothing the signal (or averaging it on several seconds) to get rid of the noise is not appropriate for a dynamic flight phase such as a landing. The vertical speed changes rapidly during the flare and the first gear compression. • If not recorded, the aircraft mass can be computed from the take-off mass and integrating the fuel flow over time since the take-off. However, even the take-off mass is usually not measured, it is an estimate made by the flight crew during the flight preparation. • The stress on the landing gear or airframe could be excessive despite normal landing energy (refer to RE.5). In addition, the lateral accelerations during landing may be worth monitoring if the aircraft manufacturer has prescribed limits.

RE.7 - Aircraft lateral deviations at high speed on the ground

Title	Aircraft lateral deviations at high speed on the ground
Description	This indicator captures a problem with the lateral control of the aircraft trajectory when on the ground at high speed (end of take-off roll or beginning of landing roll).
Applicable operational risk	Risks addressed: runway veer-off (RE) Other risks related to this indicator: LOC-G
Trigger logic	Conditions that triggers the detection: 1. The aircraft is on the ground (at least one gear on the ground) with high speed; and 2. Any of the following condition is met: – The lateral acceleration takes excessive values (negative or positive); or – The difference between aircraft magnetic heading and runway QFU takes excessive values (negative or positive). Minimum set of flight parameters needed: • Landing gears compressed (at least one gear) • Ground speed, or if not available, airspeed (TAS, IAS or CAS) • Lateral acceleration • Magnetic heading (or true heading corrected from magnetic declination)
Suggested indications of severity	• (absolute value of the lateral acceleration) × speed • (absolute value of the difference between the aircraft magnetic heading and the runway QFU))× speed • (yaw rate) × speed • Duration of deviation
Useful contextual information	Weather conditions (OAT, Wind speed and direction, runway contamination, RVR, etc.), airfield and runway, UTC time
Effectiveness	This indicator is relevant only when the aircraft is moving on the ground at high speed. Also the speed at which the lateral deviation occur are essential for assessing the potential severity. An aircraft speed significantly above the normal taxi speed range (i.e. 40 kt above the upper boundary of the normal taxi range, or 80% of V1) could be considered a high speed. Note: • See note on normal taxi speed in the indicator RE.1 - High speed rejected take-off. • The lateral acceleration parameter may be offset, in which case an offset correction is needed. • In case one reverse is inoperative, lateral deviations may occur.

RE.8 - Short rolling distance at landing

<table>
<tr><th>Title</th><td>Short rolling distance at landing</td></tr>
<tr><th>Description</th><td>This indicator captures situations where the combination (remaining runway length & speed) after landing touchdown is not safe and requires the immediate and full application of all deceleration means to stop the aircraft before the end of the runway.</td></tr>
<tr><th>Applicable operational risk</th><td>Risks addressed: runway overrun (RE).</td></tr>
<tr><th>Trigger logic</th><td>Conditions that triggers the detection:
The acceleration that needs to be applied to stop the aircraft within the remaining available runway length is high:
1. At gears compression (touchdown), and
2. When the ground speed is X kts (X above the normal taxi speed range).

Minimum set of flight parameters needed:
• Gears compressed (at least one gear)
• Groundspeed (or if not available, airspeed: TAS, CAS, IAS)
• Latitude and Longitude (to compute the distance to the end of runway)

Computation of the theoretical acceleration needed to stop the aircraft within the remaining available runway length:
• If GS is the groundspeed (in meters per second),
• If d is the remaining distance to the end of the runway (in meters),
• If a is the theoretical acceleration needed to stop the aircraft at the end of the runway (in meters per square second),
Then a=(GS*GS)/(2*d).
Note:
To determine X, see note on the normal taxi speed range in the indicator RE.1 - High-speed rejected take-off.</td></tr>
<tr><th>Suggested indications of severity</th><td>• Value of the theoretical acceleration needed to stop the aircraft within the remaining available runway length, compared with the statistical distribution of this value
• Delay in applying deceleration means
• Maximum brake temperature/pressure during landing roll
• Margin between the distance required to stop from touchdown for the average deceleration and the runway remaining after touchdown.</td></tr>
<tr><th>Useful contextual information</th><td>A/C mass and balance, weather conditions (OAT, Wind speed and direction, runway contamination, RVR, etc.), airfield and runway, UTC time</td></tr>
<tr><th>Effectiveness</th><td>This indicator needs to be computed at two times:
1. At gear compression: indicates if it is a deep landing, and
2. At X kts (X above the normal taxi speed range): captures cases where the landing was not deep but the braking was not sufficient or delayed or runway was contaminated (insufficient or late deceleration).

This indicator requires a good accuracy of latitude and longitude parameters (3 angular seconds or better) and a good sampling rate (minimum 1Hz) of latitude, longitude, groundspeed and gears compressed parameters. In addition, accurate and up-to-date runway specifications should be imported into the FDM software.
Note:
• See note on the normal taxi speed range in the indicator RE.1 - High-speed rejected take-off.
• In order to determine the severity, a statistical distribution may need to be established.</td></tr>
</table>

2. Indicators relevant for the prevention of Controlled Flight Into Terrain

CFIT.1 - (E)GPWS/TAWS Warning Trigger

Title	(E)GPWS/TAWS Warning Trigger
Description	This indicator captures (E)GPWS/TAWS warnings
Applicable operational risk	Risks addressed: CFIT Other risks related to this indicator: windshear (WSTRW), excessive bank angle or excessive vertical speed (LOC-I)
Trigger logic	Conditions that triggers the detection: • The discrete coding (E)GPWS/TAWS warnings indicates a hard warning, or • The discrete coding (E)GPWS/TAWS warnings indicates several soft warnings within a few minutes or a prolonged soft warning (lasting several seconds). Minimum set of flight parameters needed: • (E)GPWS/TAWS warnings (can be a binary parameter or a more elaborate discrete parameter that codes several modes of the (E)GPWS/TAWS)
Suggested indications of severity	• Maximum duration of GPWS/TAWS soft warning during the last X minutes • Cumulated duration of GPWS/TAWS soft warnings during the last X minutes • At least one genuine GPWS/TAWS hard warning
Useful contextual information	Weather conditions (OAT, Wind speed and direction RVR, etc.), airfield and runway, UTC time, type of approach (Visual or instruments-based)
Effectiveness	Notes: • The carriage of a (E)GPWS/TAWS is required by European air operation rules for all turbine powered aeroplanes with a MCTOM in excess of 5 700 kg or a maximum approved passenger seating configuration of more than nine (see Annex IV to Commission Regulation 965/2012, paragraph CAT.IDE.A.150). The recording of a corresponding parameter is required for all aeroplanes of a MCTOM in excess of 27 000 kg and first issued with an individual CofA on or after 01. April 1998 (refer to the acceptable means of compliance to paragraph CAT.IDE.A.190). Therefore, it is expected that at least a discrete coding (E)GPWS/TAWS warnings is recorded, however information on the (E)GPWS/TAWS mode that was triggered may not be recorded. • The (E)GPWS/TAWS hard warning is the last automatic safety defence before collision with the ground, therefore every recorded hard warning value should be considered genuine a priori and carefully analysed. The causes of recurrent non-genuine hard warnings should be analysed, and if possible, eliminated. Occurrence reports could help identifying spurious GPWS warnings. • (E)GPWS/TAWS soft warnings that are prolonged and/or repetitive should be analysed.

3. Indicators relevant for the prevention of Loss of Control In Flight

LOC-I.1 - Excessive roll attitude or roll rate

Title	Excessive roll attitude or roll rate
Description	This indicator captures excessive roll attitude values and excessive roll rate values.
Applicable operational risk	Risks addressed: stall, spin (LOC-I) Other risks related to this indicator: wake vortex encounter (TURB), AMAN
Trigger logic	Conditions that triggers the detection: • Roll attitude exceeds Y° or the roll rate exceeds X°/sec (if a roll rate is recorded or can be computed). Recommended thresholds values: • Y should be within the range 40° and above (may be adjusted on the aircraft type and operation) • X should be within the range 20°/sec and above (may be adjusted on the aircraft type) Minimum set of flight parameters needed: • Roll attitude
Suggested indications of severity	• Cumulated duration of roll attitude exceedance over the flight phase • Maximum roll attitude value • Maximum roll rate • Maximum normal acceleration • Radio height
Useful contextual information	Weather conditions (OAT, Wind speed and direction, visibility), UTC time, clearance (visual approach or IFR)
Effectiveness	This indicator is useful when no corresponding alert of the GPWS/TAWS is recorded ("Excessive Bank Angle Callout" for the GPWS). Note: • When the roll attitude parameter comes from an inertial reference system, it is an accurate flight parameter and only the recording resolution of this parameter is limiting its accuracy. In that case a reliable roll rate may be computed based on the difference of successive roll attitude values. In the absence of information on the accuracy of the roll attitude, this computation technique should not be used.

LOC-I.2 - Stall protection trigger

Title	Stall protection trigger
Description	This indicator captures triggers of angle of attack protections
Applicable operational risk	Risks addressed: stall (LOC-I)
Trigger logic	Conditions that triggers the detection: • Activation of a high AOA protection (stall warning, alpha floor, stick shaker, stick pusher, etc.) Minimum set of flight parameters needed: • Discrete coding the trigger of AOA protection
Suggested indications of severity	• Cumulated duration of high AOA protection triggers over the last X minutes • Loss of altitude • Pressure altitude (when the aircraft is at pressure altitude corresponding to cruise levels, the margin to stall is significantly reduced) • Radio-height (proximity to ground)
Useful contextual information	Weather conditions (OAT, Wind speed and direction, visibility), UTC time, airfield and runway (if applicable), AFM, Operations manual, Pitch.
Effectiveness	Notes: • Every recorded high AOA protection trigger should be considered as genuine and carefully analysed. The causes of recurrent non-genuine triggers should be analysed, and if possible, eliminated. • Some AOA protections are not fully effective in some parts of the flight envelope (e.g. at high altitude and high speed), therefore an indicator defined in this manner may not trigger when it should (false negative event).

LOC-I.3 – Excessive speed / vertical speed / accelerations

Title	Excessive speed / vertical speed / accelerations
Description	This indicator captures high values of airspeed, Mach, vertical speed or accelerations when the aircraft is airborne
Applicable operational risk	Risks addressed: LOC-I Other risks related to this indicator: AMAN, CFIT, MAC High vertical speed values, high speed values or high acceleration values can indicate that the aircraft trajectory is not fully under control or a loss of situation awareness (CFIT). High vertical speed values could also increase the risk of a mid-air collision.
Trigger logic	Conditions that triggers the detection: Aircraft is airborne (no gear compressed) and: • Vertical speed out of the normal vertical speed range, or CAS exceeding the Maximum operating limit speed VMO, or • Mach exceeding the Maximum operating limit Mach MMO. • Excessive lateral or longitudinal acceleration • Excessive normal acceleration or normal acceleration value significantly less than 1 g Minimum set of flight parameters needed • Landing gear compressed • Vertical speed (or if not available, pressure altitude) • CAS (or IAS) • Mach • Flaps position • Landing gear extension • Normal, lateral and longitudinal accelerations
Suggested indications of severity	• Maximum vertical speed • Cumulated duration of vertical speed exceedance • Maximum CAS or Mach • Cumulated duration of CAS or Mach exceedance • Maximum deviation of lateral or longitudinal acceleration from 0 g • Maximum deviation of normal acceleration from 1 g • Cumulated duration of accelerations exceedance • Radio-height at the time of exceedance
Useful contextual information	Weather conditions (OAT, Wind speed and direction, visibility), UTC time, airfield and runway (if applicable)
Effectiveness	Notes: • GPWS/TAWS warnings detect excessive vertical speed (refer to GPWS mode 1) or excessive closure rate to terrain (refer to GPWS mode 2) at low height (typically below 2500 ft radio-height), while this trigger logic aims at capturing excessive vertical speed irrespective of the height. • Deriving the vertical speed using two successive readings of the pressure altitude generates a high level of noise. It is advised to compute the average vertical speed on a time interval longer than 1 second to reduce the noise (for instance, using a moving average). However this time interval should not be too long in order to also detect short periods with an excessive vertical speed. The duration of this time interval is recommended to be in the range [3 sec;10 sec]. • High vertical speed can lead to a a (near) mid-air collision: see the dedicated indicator.

LOC-I.4 - Insufficient energy at high altitude

Title	Insufficient energy at high altitude
Description	This indicator triggers when the aircraft is operating at high altitude and there are indications that either the airspeed or the altitude cannot be maintained.
Applicable operational risk	Risks addressed: stall or loss of control at high altitude (LOC-I) Other risks related to this indicator: strong turbulences (TURB)
Trigger logic	Conditions that triggers the detection: Aircraft at high altitude, and any of the following conditions is met: • Airspeed is decreasing while the aircraft is flying at a given flight level and there is no pilot input on pitch controls or on thrust/power control, or • Pressure altitude loss after climb or level flight, without any pilot input on pitch controls or on thrust/power control. Recommended thresholds values: • An airspeed decrease of more than N kt (N within [10 kt; 30 kt]) • A pressure altitude decrease of more than X feet (X within 100 to 300 feet) Minimum set of flight parameters needed: • Pressure altitude • EPR or N1 (for jet engines) or Np (for turboprop engines) • Control column or side stick (pitch control) • Airspeed (TAS, CAS or IAS)
Suggested indications of severity	• Pressure altitude loss • Airspeed lossPressure altitude loss • Time to corrective action
Useful contextual information	Weather conditions (OAT, Wind speed and direction, visibility, turbulence, storm), UTC time, aircraft take-off weight.
Effectiveness	The automatic protections against stall may not always effectively protect against high altitude stall or overspeed, so that the indicator LOC-I.2 - Stall protection trigger is not always sufficient. Therefore this additional indicator is proposed. Notes: • The high altitude range for an aircraft model could be defined as all altitude values that are above the maximum operating altitude when the aircraft mass is equal to the MCTOM, the deviation from International Standard Atmosphere of ISA+20°C and all bleed air and anti-ice systems are on. Above this altitude, there may be restriction to the operation of the aircraft caused by its weight, air temperature or activation of airborne systems. • The flight envelope depends on the aircraft mass, the OAT, the activation of bleed air and anti-icing systems. Hence determining accurately the aircraft situation with regards to the flight envelope can be very difficult. The aim of identifying insufficient energy as described is to capture situations where the aircraft AOA or airspeed are abnormal for the altitude, which is an indirect indication that the aircraft is close to the border or even outside the flight envelope (which usually translates into a speed decay or a non-controlled deviation from the vertical flight profile). • Strong turbulences may as well cause the speed and/or pressure altitude to decrease, even if the aircraft is well within its flight envelope.

LOC-I.5 - Low go-around or rejected landing

Title	Low go-around or rejected landing
Description	This indicator captures go-arounds taking place at low height (including go-arounds performed after touch-down)
Applicable operational risk	Risks addressed: stall due to inappropriate configuration or energy (LOC-I) Other risks related to this indicator: CTOL, CFIT, RI. A late decision to interrupt the landing is often the response to an unexpected hazard (sudden variation of wind, sudden loss of visibility, etc.). It can also be a late decision to interrupt a non-stabilised approach. When performed hastily and/or with insufficient clearance to the ground, a low go-around can bring the aircraft in an unsafe situation.
Trigger logic	Conditions that triggers the detection: Go-around in the air: • Pressure altitude trend reversal (increasing after a decrease) at time T, and • Minimum radio-height at time T is less than H ft. Rejected landing: • Gears compressed for N sec, • Followed by aircraft being airborne (no gear compressed) and climbing (pressure altitude increasing). Recommended threshold values: • H should be no less than 150 ft, but it could be higher. • N should be small enough to exclude normal ground cycles (for example N<30 sec). If the aircraft has been on the ground for more than N seconds, this is a take-off, not a go-around. Minimum set of flight parameters needed: • Gear compressed (at least one gear) • Pressure altitude • Radio-height
Suggested indications of severity	• Minimum radio-height during the initial climb following the go-around • GPWS (Mode 2A) warning during the initial climb following the go-around • Stall protection triggers during the climb following the go-around • Pitch close to or beyond tail clearance pitch when gears are compressed • Inadequate pitch angle during initial climb • Spoiler deployment (in the case of a rejected landing) • Inadequate flaps/slats/landing gear configuration during initial climb • Inadequate pitch trim setting during initial climb • Climbing with thrust or power values not in the TO/GA value range
Useful contextual information	Weather conditions (OAT, Wind speed and direction, RVR), UTC time, airfield and runway (if applicable)
Effectiveness	Notes: • The decision height varies according to a number of factors. However FDM-based indicators in this document are not meant for capturing violations of procedures, but an actual unsafe situations. Here the unsafe situation is characterised by an aircraft too low or even on the ground when the landing is rejected. Therefore, no modulation of the H according to the category of approach is proposed here. • H should be at least 150 ft, since it corresponds to roughly 10 seconds before crossing the runway threshold at 50 ft AGL, when considering a vertical speed of 600 ft per min (it is less than 10 seconds if the approach is performed at a higher vertical speed). • H could be set at a higher value than 150 ft if the airfield, the runway or the category of approach can be determined.

LOC-I.6 – Reduced margin to manoeuvrability speed

Title	Reduced margin to manoeuvrability speed
Description	It covers situations where the airspeed is close to or below manoeuvrability speed for the configuration (Vmc or Vmcl).
Applicable operational risk	Risks addressed: stall due to inappropriate energy that is not recoverable because close to the ground (LOC-I). This indicator captures situations where if one engine becomes suddenly inoperative, the aircraft would not be controllable anymore.
Trigger logic	Conditions that triggers the detection: • The aircraft is airborne and descending (pressure altitude decreasing) and close to the terrain (low radio-height) and the CAS is low for the aircraft's configuration (reduced margin to VMCL or below VMCL), or • The aircraft is airborne and not descending (pressure altitude steady or increasing) and close to the terrain (low radio-height) and the CAS is low for the aircraft's configuration (reduced margin to VMC or below VMC) Minimum set of flight parameters needed: • Pressure altitude • Radio-height • CAS • Flaps position • Landing gear extension Note: according to CS 25.149: • VMC is the calibrated airspeed, at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the aeroplane with that engine still inoperative, and maintain straight flight with an angle of bank of not more than 5º. • VMCL, the minimum control speed during approach and landing with all engines operating, is the calibrated airspeed at which, when the critical engine is suddenly made inoperative, it is possible to maintain control of the aeroplane with that engine still inoperative, and maintain straight flight with an angle of bank of not more than 5º.
Suggested indications of severity	• CAS below VMC (If the aircraft is not descending) or VMCL (if the aircraft is descending) • Bank angle at the time of trigger • Aircraft weight at the time of trigger
Useful contextual information	Weather conditions (OAT, Wind speed and direction, RVR), UTC time, airfield and runway (if applicable)
Effectiveness	

4. Indicators relevant for the prevention of Mid-Air collisions

MAC.1 - TCAS/ACAS Resolution Advisory

Title	TCAS/ACAS Resolution Advisory
Description	This indicator captures a non-transient Resolution Advisory of the aircraft TCAS/ACAS system
Applicable operational risk	Risks addressed: MAC Other risks related to this indicator: AMAN
Trigger logic	Condition that triggers the detection: A non-transient RA (confirmed by at least two successive samples) is recorded. Minimum set of flight parameters needed: • TCAS/ACAS binary parameter that codes the trigger of a RA (with or without distinction of the type of RA triggered)
Suggested indications of severity	• Duration of the TCAS/ACAS RA • Cumulated durations of TCAS RA in the x minutes that follow the first TCAS RA (example: x = 5) • A TCAS mode reversal (e.g. descend RA immediately followed by a climb RA)
Useful contextual information	(if applicable) Airfield and runway or ATM area (terminal area, FIR, UIR), UTC time.
Effectiveness	The RA of the TCAS/ACAS is the last automatic safety defence before in flight collision, therefore every non-transient RA should be considered genuine a priori and carefully analysed. The causes of recurrent non-genuine TCAS/ACAS RA should be analysed, and if possible, eliminated.

Annex A: FDM data summaries

Principle of FDM data summaries

The primary purpose of this document is that a number of aircraft operators monitor key common operational safety issues identified in the EPAS through their FDM programmes in a consistent manner.

An **FDM data summary** is, for a given aircraft operator and a given time period, defined as a summary of the FDM programme activity and of the number and severity of detections of selected FDM events.

An FDM data summary including FDM events corresponding to the standardised FDM-based indicators is one possible way for an operator to verify how it monitors the operational risks identified by the EPAS (RE, LOC-I, CFIT, MAC).

Time frame and reference period

In general, a quarterly time frame better captures seasonal variations, while an annual time frame allow for comparison between successive years.

Examples:

- In the case of a quarterly time frame, the common winter reference period could be from January to March, or from winter solstice to spring equinox.
- In the case of an annual time frame, the common reference period could be from 01 January to 31 December.

General activity information

General activity information allows putting the results into perspective with the operator's activity monitored by the FDM programme.

Table A.1 provides examples of activity information.

Table A.1 – examples of activity information useful for an FDM data summary

TITLE	DETAIL OF INFORMATION NEEDED	RECOMMENDATIONS AND COMMENTS
Overall FDM activity	Number of aircraft covered by the FDM programme, per aircraft fleet	This gives an indication of overall FDM activity of the operator and of distribution of FDM activity on its fleet.
FDM activity per aircraft fleet	1. Number of scanned flights per aircraft fleet. 2. Number of flown flights	Allow for the computation of rates per flight and aircraft fleet and relating detections made by other aircraft operators for a given aircraft fleet. As a minimum the aircraft fleet should correspond to the aircraft master model, as defined by CICTT taxonomy for aircraft make, model and series[12]. A finer granularity, based on the aircraft model, the aircraft master series or the aircraft series may be appropriate.
FDM activity per airfield	Number of scanned flights per airfield (departing)	Allows operators to relate their results for a given airfield. Use ICAO code instead of city name or airport name.

12 This taxonomy is freely available on CICTT website.

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