



Direction de l'Aviation civile

Annual Safety Review 2019

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1. Introduction

Safety is the highest priority in aviation. While each of the previous years saw a small number of accidents or serious incidents, in 2019 no accidents or serious incidents have been reported to DAC Luxembourg. This is a remarkable achievement that demonstrates a very high level of safety. However, it does not mean that all risks have been eliminated. There are still a few high risk situations that can provide useful lessons, as well as a significant number of occurrences of lower risk, where the statistical analysis can reveal positive or negative trends. Reporting of these events by front-line personnel helps to understand and mitigate the risks. This report, compiled by the DAC safety department, examines the safety performance of civil aviation in Luxembourg during 2019 and in a longer-term timeframe from January 2015 until February 2020.

This report helps to identify the priorities for the upcoming National Plan for Aviation Safety. The State Safety Program, which has been published in January 2020, describes the State's aviation oversight system, its legal base in the national and international context and the roles and responsibilities of the different actors. To establish from there the National Plan for Aviation Safety, which will describe the actions necessary to maintain and improve aviation safety in Luxembourg, an analysis of the current situation is required as a first step. This report provides that analysis based on the occurrences encountered and reported by pilots, air traffic controllers, maintenance engineers and other frontline personnel. The National Plan for Aviation Safety will also include the European safety priorities, as defined in the European Plan for Aviation Safety (EPAS).

2. Safety analysis 2019

a. Accidents, serious incidents and high-risk incidents

For the first time in many years, no accidents or serious incidents were reported in 2019, neither in Luxembourg nor worldwide by air operators from Luxembourg. This sets an excellent safety record for the year 2019.

The classification of an event as “accident” or “serious incident” is made by the Safety Investigation Authority of the State of occurrence (see Annex I). In addition, DAC is establishing a risk classification of all occurrences according the ARMS-ERC methodology (see Annex II). In this classification, two occurrences of 2019 have been assessed as high-risk events.

High-risk occurrences 2019				
Aircraft Type	Date	Location	Event	CICTT ¹ categories
B748	16.1.	Near Kuala Lumpur Malaysia	Fire/Smoke on flight deck during climb	F-NI ²
PC24	19.9.	Near Saanen Switzerland	Low-level airspace infringement of an active military shooting range	NAV ³

b. Latent conditions

In June 2019, the surveillance chain (radar and related data processing) at Luxembourg airport was upgraded. The upgrade introduced several issues that could not yet be fully solved. Among other issues, several occurrences of aircraft disappearing from radar screens, of ghost targets (aircraft shown where there is no aircraft) and of wrong correlations (aircraft shown, but with a wrong identity) have occurred since.

In normal operation, the data from 3 additional radars located in Belgium, France and Germany is used in addition to the TAR2 radar at Luxembourg airport. On 31.10.2019, the communications line carrying all this external data, as well as the data from a backup radar system, failed (failure located outside Luxembourg). For 4 days, the radar feed for Air Traffic Control was limited to TAR2 with its known issues, without backup. A separate line for the backup system was put in place in December 2019.

So far these shortcomings have not yet directly endangered an aircraft, but they constitute a latent condition that could lead to, or contribute to, safety-critical occurrences. DAC continues its supervision of the ongoing efforts to resolve this condition.

¹ CAST/ICAO Common Taxonomy Team

² F-NI: Fire or smoke in or on the aircraft, in flight or on the ground, which is not the result of impact.

³ NAV: Navigation errors - Occurrences involving the incorrect navigation of aircraft on the ground or in the air.

c. Reporting of occurrences

The DAC receives, classifies and analyses occurrence reports. The reports cover:

- Events in Luxembourg's airspace, at Luxembourg's airport and other landing sites
- Events occurring outside of the national territory reported by air operators from Luxembourg.

The number of reports per occurrence class is shown in the table below.

Occurrence class	2012	2013	2014	2015	2016	2017	2018	2019	Variation 2018-2019
Proactive report / Observation / Occ. with no flight intended	332	561	454	535	470	617	704	488	-31%
Occurrence Without Safety Effect	684	813	727	798	689	289	843	883	+5%
Incident	458	523	597	578	873	1229	1310	1473	+12%
Serious Incident	3	1	1	3	0	2	0	0	-
Accident	2	9	5	3	2	3	3	0	-
Total	1479	1907	1784	1917	2034	2140	2860	2844	-0.6%

In this table, two or more reports concerning the same event have been merged. Due to the fact that several reports can be filed for the same occurrence (by different reporters, and/or as initial and follow-up reports) the total number of reports treated by the DAC safety department is much higher than the numbers shown: approximately 6000 reports for 2019, similar to 2018.

The total number of reported occurrences is very close to the number reported in 2018. The relevant number of flights, for which the reporting obligations apply, has increased by approximately 1.7% between 2018 and 2019.

The decrease of 31% in the lowest class of occurrences (Proactive report / Observation / Occurrence with no flight intended) was expected. During the year, the reporting obligations were clarified between DAC and the Luxembourg Airport Operator, leading to the cessation of certain types of non-mandatory reports that have no safety effect (e.g.: FOD found on vehicle roads not accessible to aircraft). This decrease is almost compensated by an increase in the classes "occurrence without safety effect" and "incident". This is due to an increase in reporting by several air operators as well as the Air Navigation Service Provider of Luxembourg.

d. Occurrence categories

All occurrences have been attributed to one or more occurrence categories, as defined by the CICTT. The most frequent occurrence categories in 2019 are shown in Chart No.1.

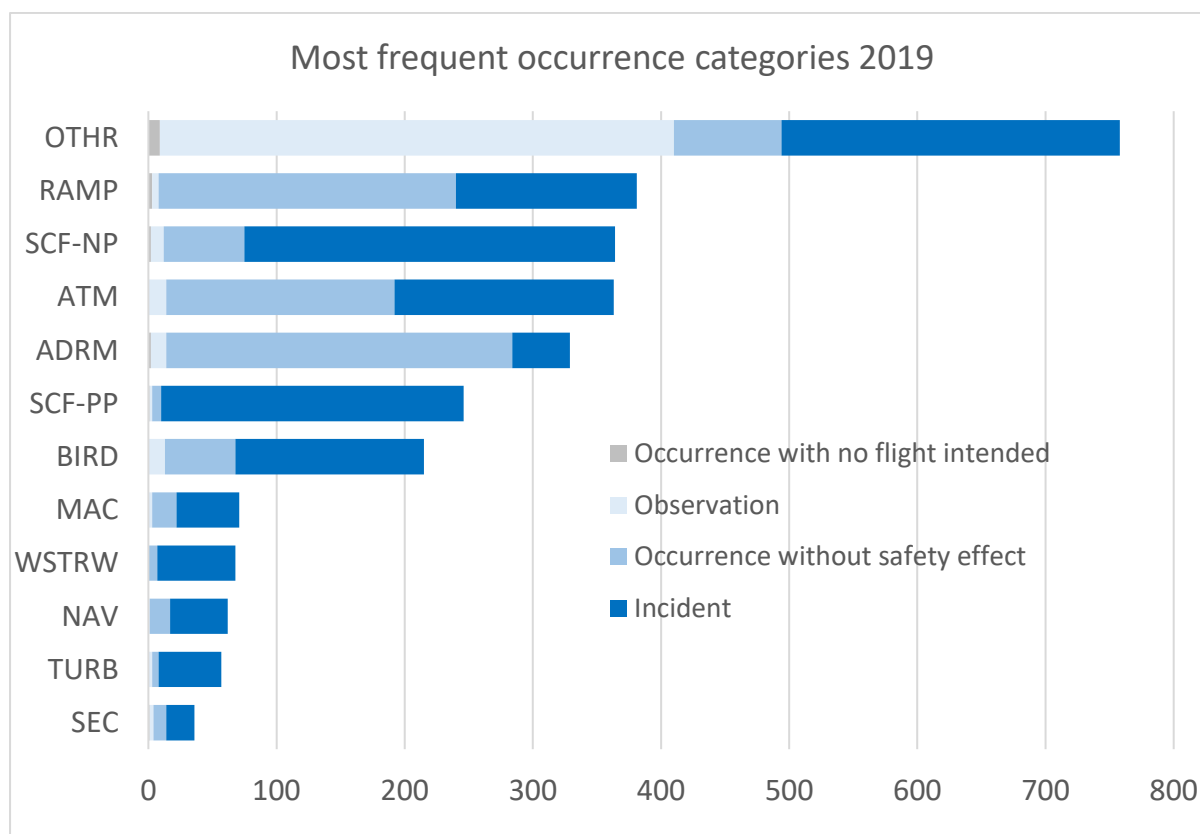


Chart No. 1: Most frequent occurrences of 2019, by CICTT category

Definition of categories:

OTHR:	<i>Any occurrence not covered under another category</i>
RAMP:	<i>Occurrences during (or as a result of) ground handling operations</i>
SCF-NP:	<i>Failure or malfunction of an aircraft system or component - other than the powerplant</i>
ATM:	<i>Occurrences involving Air traffic management (ATM) or communications, navigation, or surveillance (CNS) service issues</i>
ADRM:	<i>Occurrences involving aerodrome design, service, or functionality issues</i>
SCF-PP:	<i>Failure or malfunction of an aircraft system or component - related to the powerplant</i>
BIRD:	<i>Occurrences involving collisions / near collisions with bird(s)</i>
MAC:	<i>Airprox, ACAS alerts, loss of separation as well as near collisions or collisions between aircraft in flight</i>
WSTRW:	<i>Flight into windshear or thunderstorm</i>
NAV:	<i>Navigation errors - Occurrences involving the incorrect navigation of aircraft on the ground or in the air</i>
TURB:	<i>In-flight turbulence encounter</i>
SEC:	<i>Criminal/Security acts which result in accidents or incidents</i>

As in previous years, “OTHR” (other) is the most frequent occurrence category, but with a majority of occurrences at the lowest severity level (“observation”). The impact of the previously mentioned reporting arrangements with the Airport Operator is also seen here, in the decrease of the ADRM (Aerodrome-related) category, which was in second place in 2018. On the other hand the categories SCF-NP, ATM, SCF-PP and BIRD have seen an increase compared to 2018.

e. Top Ten Safety Issues 2019

In order to perform a detailed analysis of specific issues, DAC has defined and is monitoring more than 120 potential safety issues based on reported occurrences. All occurrences are assigned to one or more of these Safety Issues. This allows a customized and more detailed overview of specific issues. Notably, the very high number of occurrences in the CICTT category “OTHR”, which does not permit any further analysis, could be distributed to meaningful Safety Issues.

It is also desirable to take into account the severity of occurrences, to assess if an occurrence had a high risk or a low risk of resulting in an accident. DAC applies the ARMS methodology where an ERC Risk Index (Event Risk Classification, cf. Annex II) is assigned to each occurrence. As the ERC Risk Index is expressed as a number, a relative comparison between the Safety Issues can be made by looking at the sum of the ERC Risk indexes of the related occurrences. This will result in a better overall risk picture than counting only the number of occurrences related to a Safety Issue. Where the risk classification methodologies are compatible, the risk classification of the reporting organisation has been considered. Where the risk classification methodologies are not directly compatible, follow-up reports from the reporting organisations are crucial to enable DAC to understand the risks and to reproduce the operator’s own evaluation.

The ten most important Safety Issues for 2019 have been identified by the highest sum of ERC Risk Index of the related occurrences. They are shown in the table on next page.

TOP 10 SAFETY ISSUES 2019			Potential accident outcome						
	Safety Issue	Accident Severity	CFIT	LOC-I	MAC	GCOL	RWY-EXC	Injury or damage in flight	Injury or damage on ground
1	Fatigue	Catastrophic	X	X		X	X	X	X
2	Risk of Mid-Air Collision	Catastrophic			X				
3	Engine failure or problems – multi-engine aircraft	Catastrophic	X	X			X	X	
4	FOD (Foreign object / debris)	Major							X
5	Dangerous goods handling	Catastrophic		X				X	
6	Windshear	Catastrophic		X			X	X	X
7	Bank angle - overbanked	Catastrophic		X			X		
8	Runway incursion by aircraft	Catastrophic				X			X
9	Level bust / Altitude bust	Catastrophic	X		X				
10	Aircraft released with incomplete maintenance tasks	Catastrophic		X			X	X	X

X : the Safety Issue can lead to the potential accident outcome

Note : the following cases have been excluded:

- Safety Issues linked to a “minor” accident severity
- Safety Issues with less than 3 related occurrences during the year

CFIT Controlled flight into terrain
 LOC-I Loss of control in flight
 MAC Mid-air collision
 GCOL Collision on the ground
 RWY-EXC Runway excursion

The Top Ten Safety issues fall into 2 distinct groups: for most of them (7 out of 10), their position in the Top Ten is the result of a limited number of occurrences with relatively high ERC Risk indexes. For the other 3, it is the result of a high number of occurrences with low ERC Risk indexes. These are: Fatigue, Engine failure or problems on multi-engine aircraft, and FOD (Foreign object / debris).

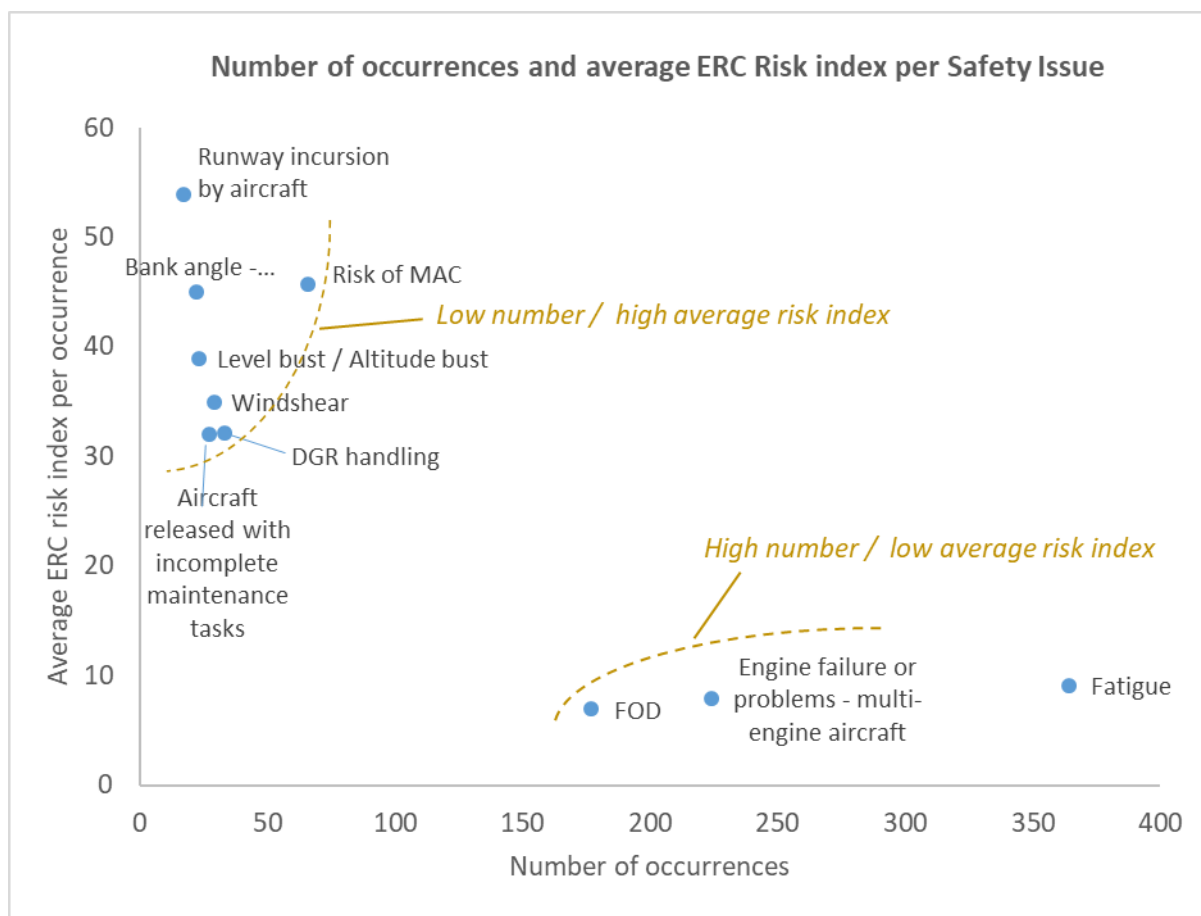


Chart No. 2: Average ERC Risk index vs. number of occurrences, related to the Top Ten Safety Issues for 2019

As explained in Annex II and shown in the Top Ten table, all Safety Issues have been associated with one or more potential accident outcome. The overall risk associated to each potential accident outcome can then be evaluated by adding the ERC Risk indexes of all related Safety Issues. This is shown in Chart No. 3, as percentage of the overall sum of the ERC Risk indexes of all Safety Issues. Chart No. 3 also shows the ranking in 2019 compared to the average of the previous years. The highest risk, for a potential “catastrophic” accident outcome, is still associated with the LOC-I category - Loss of control in flight. Compared to the average for 2015-2018, an increase for the accident outcome CFIT (Controlled flight into terrain) puts it in 2nd place during 2019, ahead of MAC (Midair-collision).

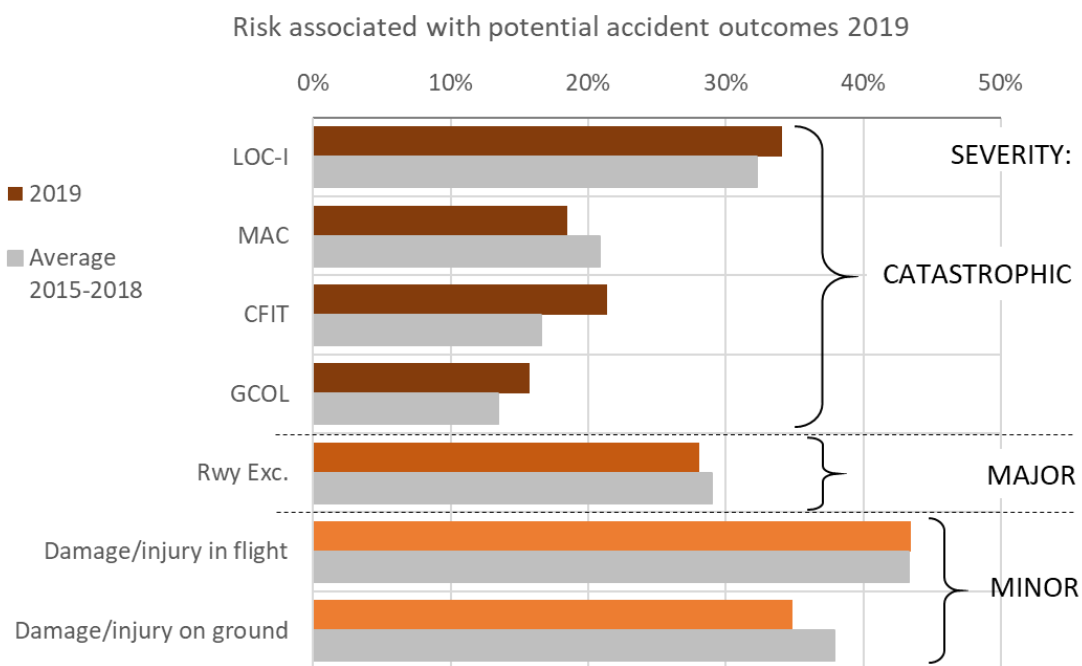


Chart No. 3: Risk associated with potential accident outcomes

As for the potential accident outcomes, the relative risk related to the different domains can be evaluated by the sum of the related Safety Issues. Chart No. 4 shows that Safety Issues with triggering events the “operational” domain carry the highest risk. The “technical” domain shows an increase due to a higher number of reported occurrences.

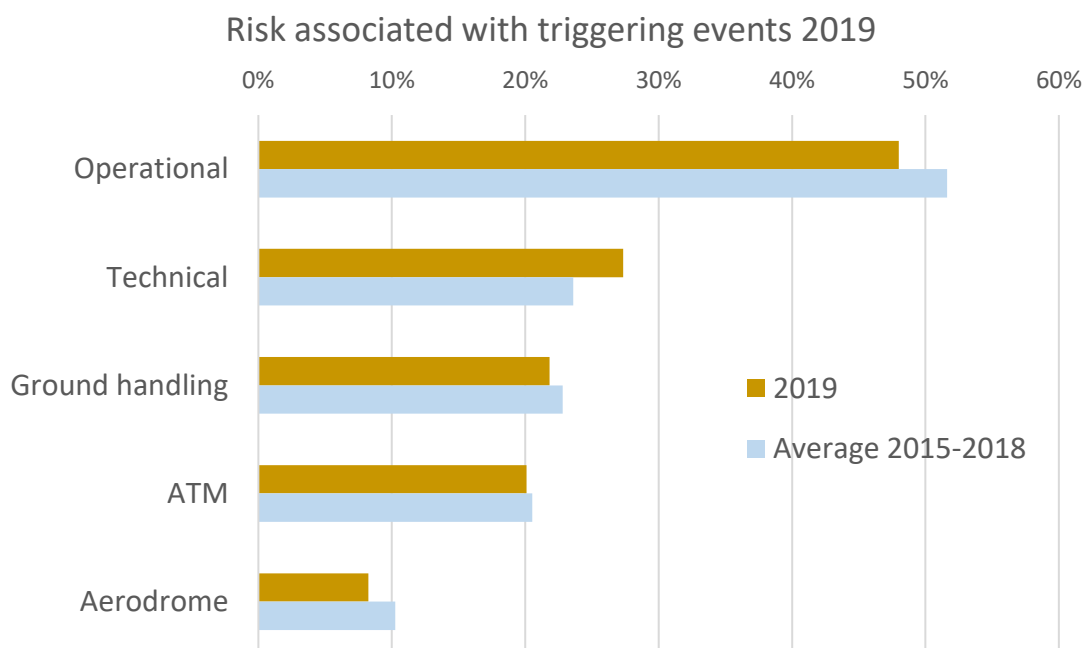


Chart No. 4: Risk associated with domains of triggering events

3. Safety analysis January 2015 – February 2020

a. Purpose

The occurrence database of DAC, like all other national databases of the European Union and the European Central Repository (ECR), is migrating to a new software at the beginning of 2021. A common risk classification scheme, to be used by all national authorities of the European Union, was foreseen at the same time but will be delayed: the ERCS – European Risk Classification Scheme. DAC will have to switch to ERCS from the current ARMS – ERC Risk Index underlying this analysis, creating a discontinuity in the analysis.

Unfortunately the COVID-19 pandemic created an unprecedented drop in air traffic, starting in March 2020. With levels of traffic that are not comparable to previous years, it is reasonable to compare data and evaluate trends only up to February 2020. The period chosen for a longer-term analysis is from January 2015 to February 2020, during which timeframe occurrences were consistently linked to Safety Issues, according the ARMS methodology (Aviation Risk Management Solutions, cf. Annex II). Even if some changes affected reporting during this timeframe, the bigger overall number of reports allows drawing some conclusions about Safety Issues that show up consistently. In summary, this analysis is the final analysis to provide trends based on the DAC ERC Risk index, evaluating a total of more than 12000 occurrences.

The relevant number of flights, for which the reporting obligations apply, has increased continuously by approximately 3% every year between 2015 and 2019.

b. Top Ten Safety Issues

As for the year 2019, the ten most important Safety Issues for January 2015 - February 2020 have been identified by the highest sum of ERC Risk Index of the related occurrences.

Safety Issue	
1	Risk of Mid-Air Collision
2	Fatigue
3	Cargo moving/shifting during flight
4	Engine failure or problems - multi-engine aircraft
5	Dangerous Goods handling (DGR)
6	Windshear
7	Runway incursion by aircraft
8	FOD (Foreign object / debris)
9	Technical - flight controls
10	Weight & Balance issues due to wrong loading

Note : the following cases have been excluded:

- *Safety Issues linked to a “minor” accident severity*
- *Safety Issues labeled “Other” (by domain). These do not provide any added value for analysis at Safety Issue Level. They were introduced for analysis at aviation domain level. “Other – ground handling” and “Other – operational” would show up in the Top Ten.*

Unlike the Top Ten for 2019, the distribution between Safety Issues with low number of occurrences and high average Risk Index vs. high numbers and low average Risk index is more even. Only the “fatigue” safety issue has a very high number of reports with very low average risk index.

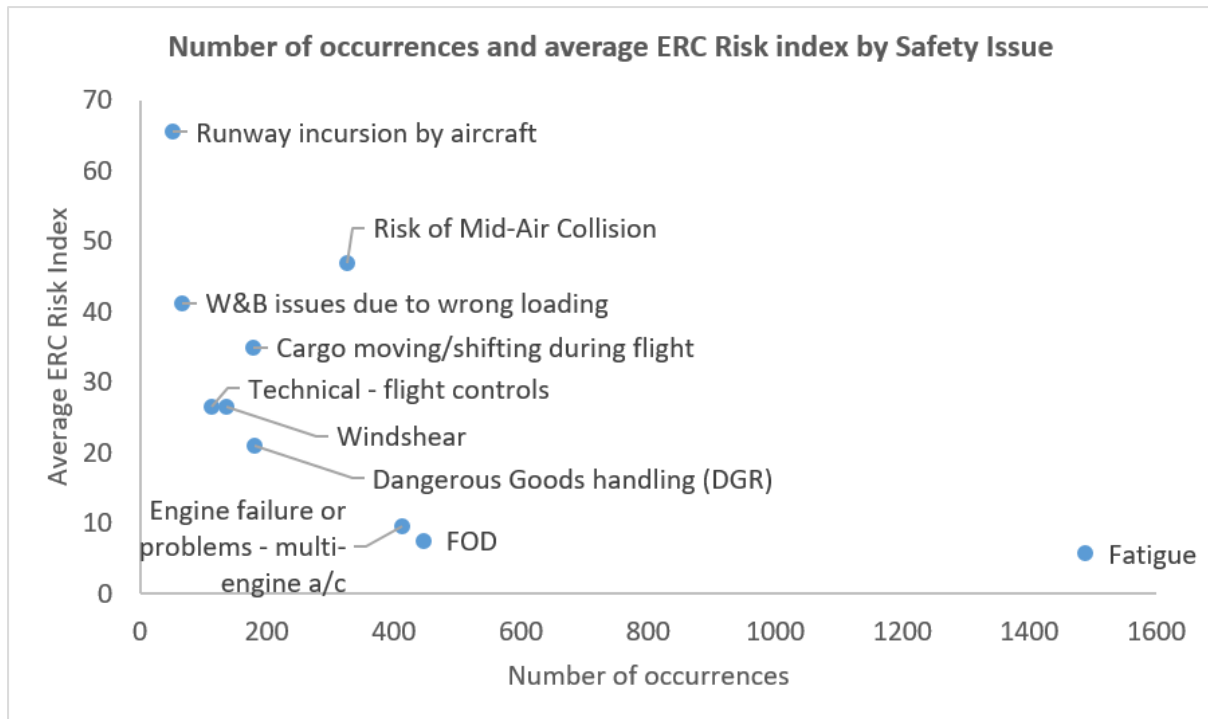


Chart No. 4: Average ERC Risk index vs. number of occurrences, related to the Top Ten Safety Issues for Jan. 2015 – Feb. 2020

- **Risk of Mid-Air collision**

This Safety issue represents the highest risk overall, by a significant margin. Over 5 years, it is consistently at the very top of the list or in second position. The number of occurrences is variable but with a slight increase in the spring and summer months, which would be consistent with the increase in traffic (commercial and general aviation) during summer.

- **Fatigue**

This safety issue presents the highest number of occurrences among all monitored safety issues. The very high number is due to a specific cause: the request by DAC to one operator to provide all fatigue reports, which would typically not fall under the mandatory reporting obligation. The number of reports has decreased in 2019 compared to 2018, but a higher average Risk index has compensated this trend.

- **Cargo moving/shifting during flight**

The number of occurrences dropped in summer 2016. At the same time, an even more significant drop in average Risk index was noted. Starting at that time, follow-up reports became available more regularly, enabling a more accurate risk classification. The data indicates a possible second drop in summer 2019.

- **Engine failure or problems – multi-engine aircraft**

The number of reported occurrences was increasing steadily, then accelerating in 2019. At the same time, the average Risk index is decreasing significantly, indicating better reporting, in particular of low severity events like engine vibration.

- **Dangerous Goods handling**

The high overall Risk index is due to very few high-risk incidents. The overall number of occurrences is relatively low, as is the Risk index of most occurrences.

- **Windshear**

In general, there is no seasonal (summer/winter) pattern, with the exception of rare peaks when very high winds or storms affect Luxembourg airport. These exceptional events have so far mostly occurred from January to March.

- **Runway incursions by aircraft**

Overall the number of runway incursions is low, but the average risk index is high. Runway incursions are tracked as three separate Safety Issues, to enable better risk assessment and analysis of each: runway incursions by aircraft / by vehicles / by persons. The outcome shows that runway incursions by aircraft are about 6 times more frequent than runway incursions by vehicles, with an almost identical, high risk index for both. The high average risk index puts runway incursions by aircraft in the Top Ten Safety Issues.

Runway incursions by persons are very infrequent but high risk.

c. Other Safety Issues with significant trends

The following Safety Issues, while not in the Top Ten, show a negative trend:

- **Level bust / altitude bust**

The number of reports increased over 2 consecutive years 2018 and 2019.

- **Aircraft release with incomplete maintenance tasks**

An increase in the number of reports was noted in 2017 and 2018. In 2019, a decrease in number of reports was more than compensated by a significant increase of the average Risk Index.

- **Jet blast / propeller hazard**

The overall number of reports is low but generally increasing, with a high proportion of medium to high risk occurrences.

- **Aircraft deviation from ATC clearance**

The number of reports is increasing through 2018 and 2019.

One new Safety Issue was introduced in 2019 to enable monitoring of a type of event that is becoming more frequent: GPS jamming, usually encountered near conflict zones.

While the main object of this report is to point out the main problem areas, it is also worth looking at the most significant improvements. For Safety Issues that are not in the Top Ten, the following two are notable for their improvement:

- **Aircraft damage during loading/unloading**

The number of related reports, already decreasing very slowly the previous years, dropped significantly during 2019.

- **Laser interference**

The number of reports about interference by laser pointers dropped by half in 2016 compared to 2015, and has stabilized at that level since then.

d. Safety Issues by domain

Each Safety Issue is also associated with one or more aviation domains, depending on the type of events that can cause the Safety Issue. For example, the risk of mid-air collision can have as triggering event either an issue in Air Traffic Management (ATM) or a flight operations issue, related to the conduct of the flight.

Each Safety Issue has been associated in this way to one, or more, of the five domains: ATM (Air Traffic management), Air Operations, Ground handling, Aerodrome, Technical. The five most important Safety Issue per domain have been determined over the same period of January 2015 to February 2020. They are shown in the tables below.

Air Traffic Management
Risk of Mid-Air Collision
Runway incursion by aircraft
Level bust / Altitude bust
Loss of communication
Wake turbulence

Air Operations
Risk of Mid-Air Collision
Fatigue
Windshear
Runway incursion by aircraft
Risk of collision with drone

Ground handling
Cargo moving/shifting during flight
Dangerous Goods handling
FOD (Foreign object / debris)
Weight & Balance issues due to wrong loading
Jet blast / Prop hazard

Aerodrome
FOD (Foreign object / debris)
Runway excursion
Runway incursion by a vehicle
Runway or taxiway incursion by vehicle at Luxembourg airport
Vehicles cutting off aircraft entering/exiting apron at Luxembourg

Technical
Engine failure or problems - multi-engine aircraft
Technical - flight controls
Aircraft released with incomplete maintenance tasks
Technical - landing gear
Technical - pressurisation system

For General Aviation, the overall number of occurrence reports remains very low. The two main Safety Issues for General aviation remain the same as for last year's analysis:

- Loss of control during landing
- Engine failure or problems - single engine aircraft

4. Safety analysis Jan. 2015 – Feb. 2020 – Luxembourg

The previous part summarizes an analysis of all reports received by DAC Luxembourg. This includes reports from all organisations, as well as private pilots, under DAC supervision regardless of the place of occurrence. This section provides a summary analysis of occurrences that happened in Luxembourg and were reported to DAC.

Reporting obligations exist for pilots, maintenance personnel, air traffic controllers, technical personnel working on air navigation facilities, etc. Obviously almost all occurrences reported to DAC by airport personnel or air navigation services personnel happened in Luxembourg, so that the types of events reported by these persons are better represented in this analysis. So it should be expected that the main safety issues are not identical to those of the previous paragraph.

Safety Issues State of occurrence: Luxembourg	
1	Risk of Mid-Air Collision
2	FOD (Foreign object / debris)
3	Airspace infringement
4	Runway incursion by aircraft
5	Risk of collision with drone
6	Jet blast / Prop hazard
7	Fuel leak on ground - technical issues (risk of fire)
8	Windshear
9	Aircraft released with incomplete maintenance tasks
10	Aircraft deviation from ATC instruction

With the exception of FOD, most safety issues of the Top Ten for Luxembourg have a relatively low number of occurrences but an average to high risk index. The lowest number of occurrences, with the highest average risk index, is for the risk of collision with drones.

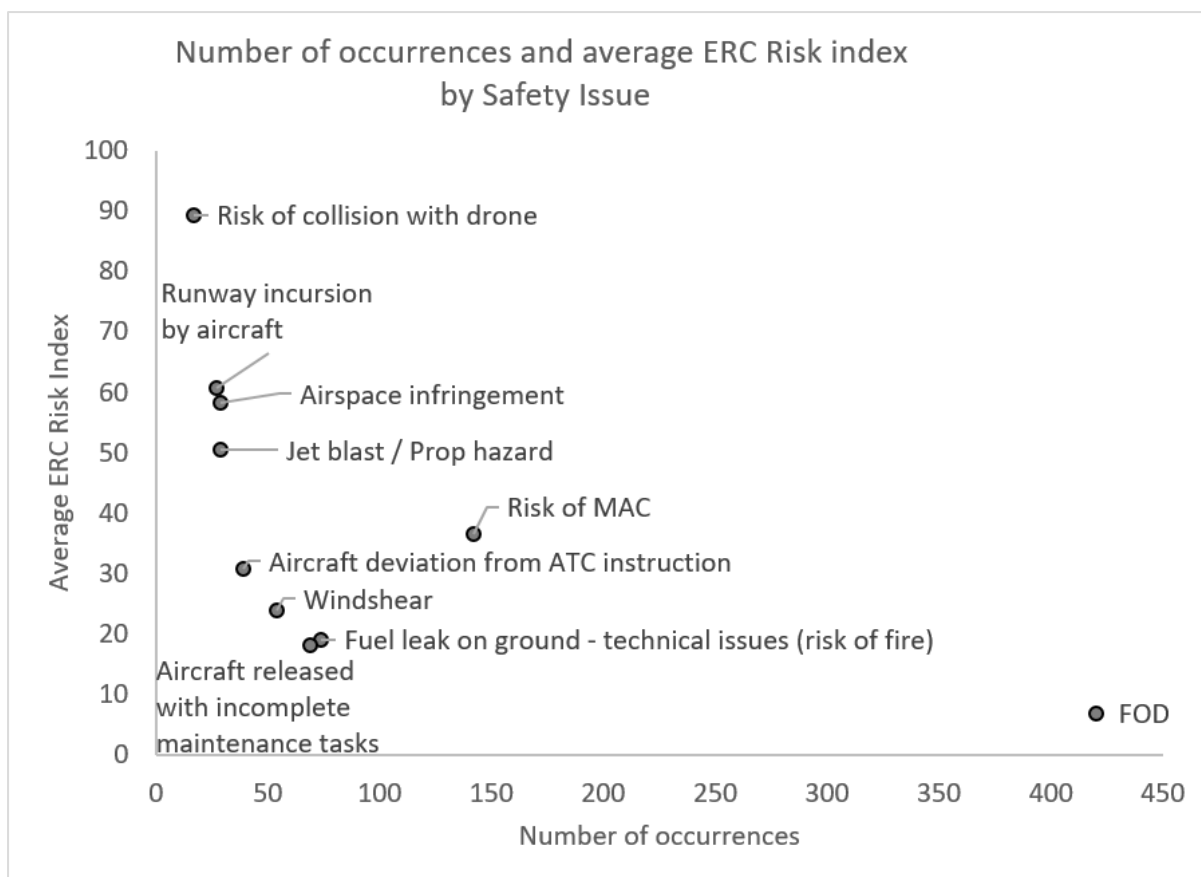


Chart No. 5: Average ERC Risk index vs. number of occurrences, related to the Top Ten Safety Issues for Jan. 2015 – Feb. 2020, in Luxembourg

Note : This analysis is mainly based on the « ERC Risk Index » values assigned by DAC to each occurrence. This allows a more detailed analysis than a simple counting of the number of occurrences, but is dependent to a large extent on the information content of the occurrence reports and a simplified evaluation of that content. As a result, an overestimation or underestimation of some safety issues cannot be excluded.

ANNEX I: Definitions

Source:

Regulation (EU) No.996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC

- **Accident** means an occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time it comes to rest at the end of the flight and the primary propulsion system is shut down, in which:
 - (a) a person is fatally or seriously injured as a result of:
 - being in the aircraft, or,
 - direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or,
 - direct exposure to jet blast,except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or
 - (b) the aircraft sustains damage or structural failure which adversely affects the structural strength, performance or flight characteristics of the aircraft, and would normally require major repair or replacement of the affected component, except for engine failure or damage, when the damage is limited to a single engine, (including its cowlings or accessories), to propellers, wing tips, antennas, probes, vanes, tires, brakes, wheels, fairings, panels, landing gear doors, windscreens, the aircraft skin (such as small dents or puncture holes) or minor damages to main rotor blades, tail rotor blades, landing gear, and those resulting from hail or bird strike, (including holes in the radome); or
 - (c) the aircraft is missing or is completely inaccessible.
- **Incident** means an occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.
- **Serious incident** means an incident involving circumstances indicating that there was a high probability of an accident and is associated with the operation of an aircraft, which in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time it comes to rest at the end of the flight and the primary propulsion system is shut down.

ANNEX II: ARMS Methodology

DAC has adopted the ARMS – Aviation Risk Management Solutions methodology for the assessment of risks related to reported safety occurrences. The ARMS methodology was developed by a voluntary collaboration of aviation authorities, operators and air navigation service providers. It consists of two parts:

a. Risk classification of occurrences

A risk classification (“ERC- Event Risk classification”) has been applied to each occurrence, according to the ARMS methodology. The “ERC Risk Index” is expressed as a number from 1 to 2500, with associated green (1-10), yellow (20-102) and red bands (≥500).

Question 2

What was the effectiveness of the remaining barriers between this event and the most credible accident scenario?			
Effective	Limited	Minimal	Not effective
50	102	502	2500
10	21	101	500
2	4	20	100
1			

Question 1

If this event had escalated into an accident outcome, what would have been the most credible outcome?	
Catastrophic Accident	Loss of aircraft or multiple fatalities (3 or more)
Major Accident	1 or 2 fatalities, multiple serious injuries, major damage to the aircraft
Minor Injuries or damage	Minor injuries, minor damage to aircraft
No accident outcome	No potential damage or injury could occur

Typical accident scenarios
Loss of control, mid air collision, uncontrollable fire on board, explosions, total structural failure of the aircraft, collision with terrain
High speed taxiway collision, major turbulence injuries
Pushback accident, minor weather damage
Any event which could not escalate into an accident, even if it may have operational consequences (e.g. diversion, delay, individual sickness)

ERC – Event risk classification (ERC) according ARMS.

Source: *The ARMS Methodology for Operational Risk Assessment in Aviation Organisations.*

Developed by the ARMS Working Group, 2007-2010

b. Safety issues

Every occurrence reported to DAC is linked to a “potential safety issue”. If an occurrence with an ERC risk index higher than 10 (i.e. in the yellow or red band) does not fit with any existing “potential safety issue”, a new potential safety issue is created, in order to be able to identify future recurring events.

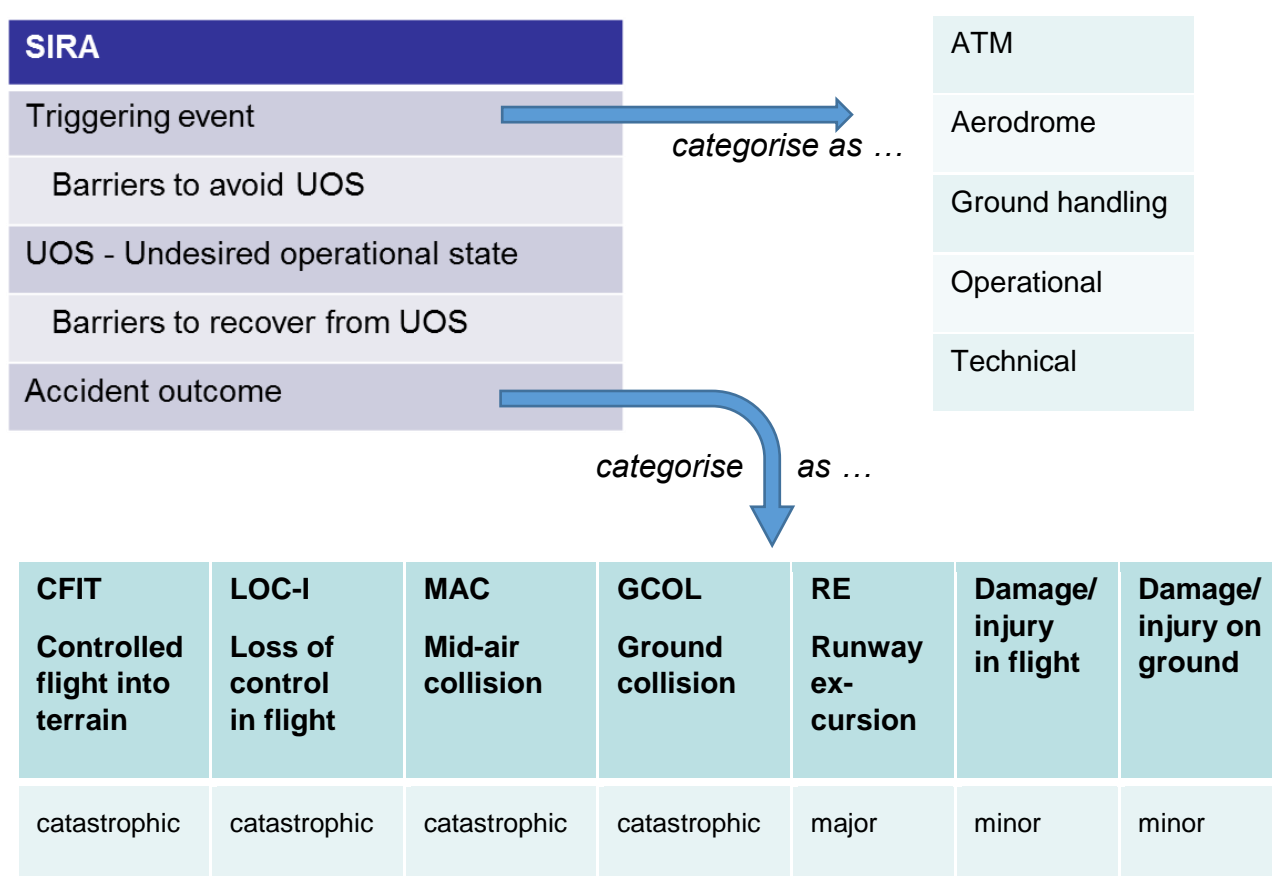
The risk assessment (“SIRA – Safety Issue Risk Assessment”) according to the ARMS methodology, allows to identify:

- the triggering event(s)
- the Undesired Operational State UOS
- the potential accident outcome(s)
- the safety barriers to avoid the UOS as well as the safety barriers to recover from the UOS.

In total, DAC is currently tracking more than 120 potential safety issues. To maintain an overview it is necessary to apply a classification. Two criteria have been applied by DAC:

- the domain of the triggering event:
 - ATM (Air traffic management)
 - Aerodrome
 - Ground handling
 - Operational
 - Airworthiness (technical)
- The type of potential accident outcome:

7 types of potential accident outcome have been defined, corresponding to the “feared consequences” of the risk portfolio of DGAC France¹.



¹ “Strategic action plan to improve aviation safety – the 2018 agenda”, DGAC France