



Direction de l'Aviation civile

Annual Safety Review 2017

1. Introduction

The mission of the Directorate of Civil Aviation Luxembourg (DAC) is to maintain or improve aviation safety, in compliance with national and international regulations.

The objective of this annual safety review is to summarise and analyse the current situation of aviation safety in Luxembourg.

In addition to the annual review for 2017, this report contains an analysis for the four years 2014 to 2017. Since 2014, DAC has consistently applied the ARMS methodology (cf Annex II) for the analysis of occurrence data. The reporting itself has seen significant changes during these four years, in particular due to the introduction of a new European regulation on occurrence reporting¹. Nevertheless, the bigger overall number of reports allows to draw some conclusions about safety issues which consistently show up over that timeframe.

¹ REGULATION (EU) No 376/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 3 April 2014 on the reporting, analysis and follow-up of occurrences in civil aviation, amending Regulation (EU) No 996/2010 of the European Parliament and of the Council and repealing Directive 2003/42/EC of the European Parliament and of the Council and Commission Regulations (EC) No 1321/2007 and (EC) No 1330/2007

2. Accidents and serious incidents

Two accidents involving foreign-registered non-commercial aircraft happened at Luxembourg airport. In addition, operators from Luxembourg were involved in one accident and two serious incidents outside of Luxembourg. No fatalities nor injuries were reported.

| A/C Type | Date | Location | Event | Outcome | Investigation | CICTT category |
|--------------------------|------|-------------------|----------------------------------------------------------------------------|-------------------------|---------------------|----------------|
| Accidents | | | | | | |
| R44 | 15/7 | LFSN Nancy | Hard landing – training flight | Helicopter destroyed | BEA (F), closed | ARC |
| PA24 | 29/8 | ELLX | Loss of electrical power, undetected emergency landing at airport | Substantial damage | AET, ongoing | ARC |
| BE9L | 7/12 | ELLX | Collision with parked aircraft | Substantial damage | AET, ongoing | GCOL |
| Serious incidents | | | | | | |
| B748 | 30/3 | EGPK Prestwick | Dangerous Goods - Fuel leak from cargo | Minor damage | AAIB (UK) closed | RAMP |
| C525 | 8/12 | LFLP Annecy | Lateral runway excursion | No damage | BEA (F), ongoing | RE |

Based on a summary investigation by STSB Switzerland published in 2018, an occurrence from 2016 has been reclassified from “incident” to “serious incident”.

| A/C Type | Date | Location | Event | Outcome | Investigation | CICTT category |
|----------|-----------|----------|--------------|-----------------|---------------------|----------------|
| RJ1H | 21/7/2016 | ELLX | Hard landing | Minor damage | STSB (CH) closed | ARC |

The definitions of accident, incident and serious incident are shown in Annex I.

3. 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, as well as any events outside of the national territory reported by air operators from Luxembourg.

| Occurrence class | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Variation 2016-2017 |
|----------------------------------|------|------|------|------|------|-------------|---------------------|
| Observation | 332 | 561 | 454 | 535 | 470 | 617 | +31% |
| Occurrence without safety effect | 684 | 813 | 727 | 798 | 689 | 289 | -58% |
| Incident | 458 | 523 | 597 | 578 | 873 | 1229 | +41% |
| Serious Incident | 3 | 1 | 1 | 3 | 1 | 2 | |
| Accident | 2 | 9 | 5 | 3 | 2 | 3 | |
| Total | 1479 | 1907 | 1784 | 1917 | 2035 | 2140 | +5% |

The overall number of occurrences has increased about 5%, which is approximately in line with the increase in traffic at Luxembourg airport as well as the increase in number of commercial flights by operators certified in Luxembourg. The table above shows the number of occurrences, in cases where two or more persons or organisations have reported the same event, the reports have been merged and are counted as only one event.

The number of "incidents" has increased significantly again. As was already noted for 2016, with the introduction of the reporting regulation Reg. (EU) 376/2015 the classification is now made by the reporting organisations whereas it was previously made by DAC. The significant increase in the number of occurrences classified as "incident", with a corresponding decrease in the class "occurrence without safety effect", was noted during the second half of 2016 and has stabilized throughout 2017.

In order to monitor the risk of crew fatigue at one operator, during 2017 DAC requested all its fatigue reports (which are not part of mandatory reporting except if the crew fatigue caused a reportable event). A significant number of specific fatigue reports was received and the vast

majority of them are classified as “observation”, which contributes to the increase in that occurrence class.

DAC has also agreed with one operator to reduce reporting related to non-safety-related events in the passenger cabin. The related decrease in reporting provides an opposite trend to the increase from the additional fatigue reports, mostly in the “occurrence without safety effect” and “observation” classes.

4. Occurrence categories

All occurrences have been attributed to one or more occurrence categories, as defined by the CICTT². The most frequent occurrence categories in 2017 are shown in Chart No.1.

As in previous years, “Other” is the most frequent occurrence category. However, almost two thirds of the reports in this category are of the lowest severity (“observation”). The second-highest category “SCF-NP” (system or component failure, non-powerplant), has more “incidents” than “OTHR”. “NAV” (navigation error) is a new category that has been introduced during 2016. It includes errors in horizontal as well as vertical navigation, for example level busts. In its first full year of reporting it stands in 10th place.

2 CAST/ICAO Common Taxonomy Team

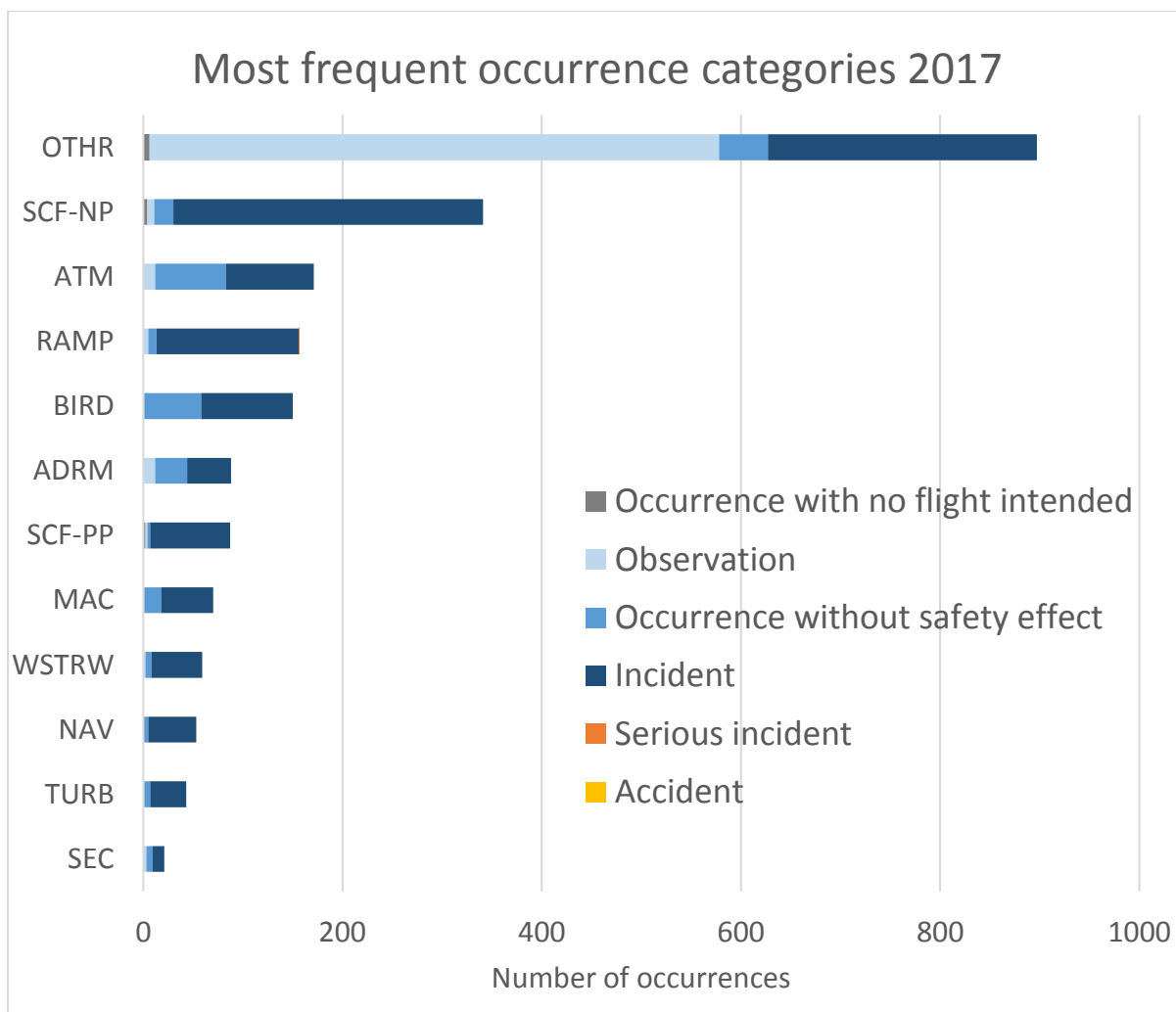


Chart No. 1: Most frequent occurrences of 2017, by CICTT category

Description of categories:

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

DAC has assigned an ERC Risk index according the ARMS methodology (cf Annex II) to all occurrences. Where the risk classification methods are compatible, the risk classification of the reporting organisation has been considered. As the ERC Risk index is expressed as a number, a relative comparison between the occurrence categories can be made by looking at the sum of the ERC Risk indexes of the related occurrences (chart No. 2). This comparison shows that the sum of the Risk indexes is often, but not always, in good relation to the number of occurrences. Exceptions with higher average ERC Risk index are the categories MAC (Risk of Mid-air collision) and NAV (navigation-related).

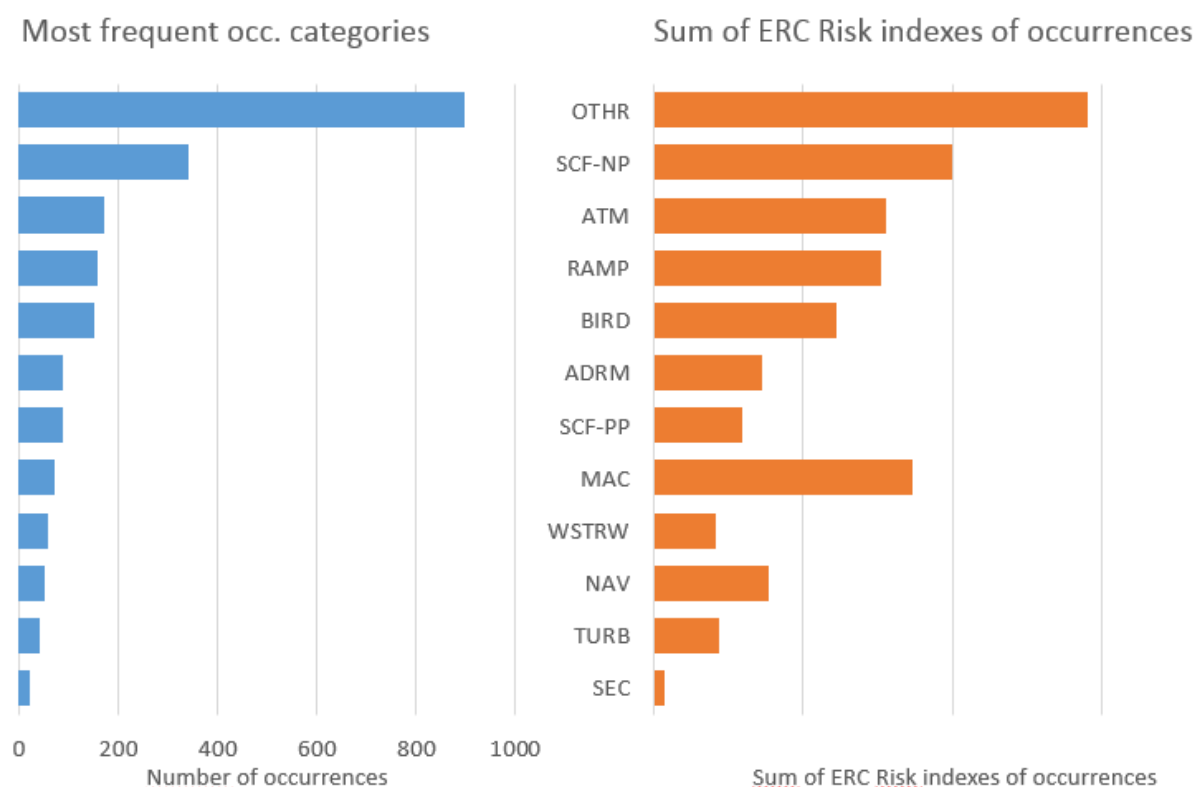


Chart No. 2: Comparison of number of occurrences and sum of ERC Risk indexes of the most frequent CICTT occurrence categories

Chart No. 3 represents the average of the Risk index per occurrence vs. the number of occurrences, for the 15 CICTT occurrence categories with the highest sum of ERC Risk indexes. Logarithmic scales have been used due to the large differences between the low and high ends on both scales. The chart shows that category OTHR has the highest overall risk but only due to its very high number of occurrences (horizontal scale), the average Risk index (vertical scale) being the lowest. On the other hand, some occurrence categories have very few occurrences, which carry a very high risk on average: ARC (Abnormal Runway Contact) and GCOL (Ground collision).

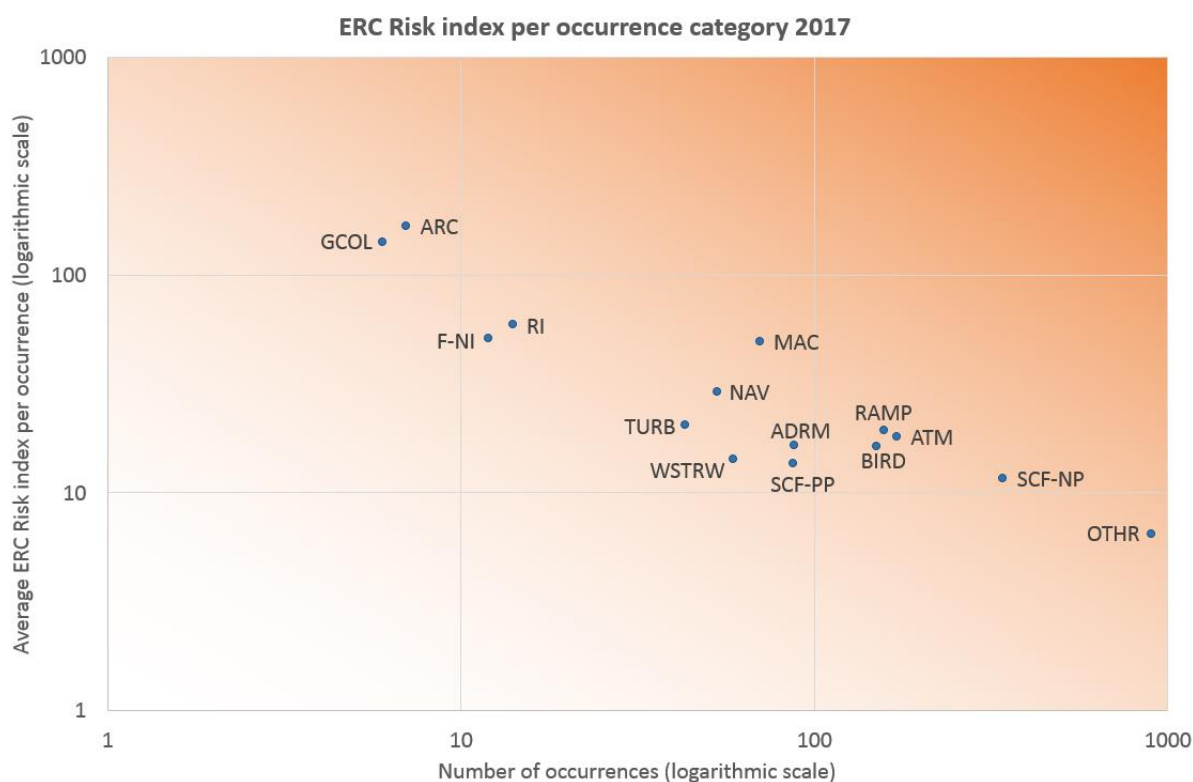


Chart No. 3: Number of occurrences and average Risk index per CICTT occurrence category

Description of categories (highest 15 categories, highest to lowest):

- OTHR: Any occurrence not covered under another category
- SCF-NP: Failure or malfunction of an aircraft system or component - other than the powerplant
- MAC: Airprox, ACAS alerts, loss of separation as well as near collisions or collisions between aircraft in flight
- ATM: Occurrences involving Air traffic management (ATM) or communications, navigation, or surveillance (CNS) service issues
- RAMP: Occurrences during (or as a result of) ground handling operations
- BIRD: Occurrences involving collisions / near collisions with bird(s)
- NAV: Navigation errors - Occurrences involving the incorrect navigation of aircraft on the ground or in the air
- ADRM: Occurrences involving aerodrome design, service, or functionality issues
- SCF-PP: Failure or malfunction of an aircraft system or component - related to the powerplant
- ARC: Any landing or takeoff involving abnormal runway or landing surface contact.
- TURB: In-flight turbulence encounter
- CGOL: Ground collision - collision while taxiing to or from a runway in use.
- WSTRW: Flight into windshear or thunderstorm
- RI: Runway incursion by a vehicle, aircraft or person
- F-NI: Fire or smoke in or on the aircraft, which is not the result of an accident impact

5. Top Ten Safety issues 2017

The CICTT categories presented in the previous paragraph are high-level categories. In order to perform a more detailed analysis of specific issues, DAC has defined and is monitoring more than 120 potential safety issues based on reported occurrences. All occurrences except some low risk occurrences are assigned to one or more of these safety issues. This also allows to distribute, and include in the analysis, the high number of occurrences that did not find their place in any meaningful CICTT category but could only be assigned to the “OTHR” basket.

It is possible to determine the most important safety issues by comparing, for each safety issue, the sum of the ERC Risk index numbers of the associated occurrences. The ten most important safety issues for 2017 are shown on the next page.

| TOP 10 SAFETY ISSUES 2017 | | | 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 | Risk of Mid-air collision | Catastrophic | | | X | | | | |
| 2 | Crew fatigue | Catastrophic | X | X | | X | X | X | X |
| 3 | Incorrect aircraft setup by crew | Catastrophic | X | | X | | X | | |
| 4 | Handling of Dangerous Goods | Catastrophic | | X | | | | X | |
| 5 | Technical - flight controls | Catastrophic | | X | | | X | X | X |
| 6 | Runway incursion by aircraft | Catastrophic | | | | X | | | X |
| 7 | Technical - Landing gear | Major | | | | | X | X | X |
| 8 | Airspace infringement | Catastrophic | | | X | | | | |
| 9 | Engine failure or problems - multi-engine aircraft | Catastrophic | X | X | | | | X | |
| 10 | FOD - Foreign Object Damage | Major | | | | | | | 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

CFIT Controlled flight into terrain

LOC-I Loss of control in flight

MAC Mid-air collision

GCOL Collision on ground

RWY-EXC Runway excursion

6. Top Ten Safety issues 2014-2017

Comparing the Top Ten Safety issues of 2017 to Top Ten of 2016, only two safety issues are in the Top Ten for both years: *Risk of Mid-air collision* and *Runway incursion by aircraft*. Since DAC has started the analysis according the ARMS methodology for the year 2014, the Top Ten Safety issues have not been stable, due to two main reasons.

First, there was a significant evolution in reporting due to the introduction of the occurrence reporting regulation Reg. (UE) 376/2014. The introduction of mandatory reportable events and of the requirement for organisations to classify and assess their reports, as well as different implementing timelines at different reporting organisations contribute to make year-to-year comparisons difficult.

Second, the analysis is based on a relatively small number of reports. On the other hand, with the selected methodology, there is a very large spread between the Risk index numbers that can be assigned to a single occurrence: 1 to 2500. As a result, one single high-risk event can have a significant impact on the ranking of the associated safety issue, up to pushing it into the Top Ten for the respective year. For this reason, safety issues with less than 3 occurrences per year have been excluded from the yearly Top Ten, but this restriction cannot completely eliminate this effect.

In conclusion, while year-to-year comparisons have to be treated with caution, it could be interesting to look at the reports of 4 years as one set of data and extract the Top Ten for the 4 years. The table on next page shows the ten safety issues with the highest sum of ERC Risk indexes over 4 years. It also shows during which years the safety issue appeared in the Top 20 Safety issues, as well as an indication of the trend over 4 years.

| | Top 10 Safety Issues 2014-2017 | In Top 20 ? | | | | Trend |
|----|--------------------------------------------------------|-------------|-------|-------|-------|-------|
| | | 2014 | 2015 | 2016 | 2017 | |
| 1 | Risk of Mid-air collision | No. 2 | No. 2 | No. 1 | No. 1 | |
| 2 | Cargo moving/shifting during flight | No. 1 | No. 1 | No. 2 | Y | |
| 3 | W&B issues due to wrong loading* | Y | Y | No. 3 | | |
| 4 | Airspace infringement | Y | Y | | Y | |
| 5 | Runway incursion by aircraft | Y | | Y | Y | |
| 6 | Handling of Dangerous Goods | Y | Y | | Y | |
| 7 | Technical - flight controls | Y | Y | Y | Y | |
| 8 | Incorrect aircraft setup by crew** | | Y | Y | No. 3 | |
| 9 | Loss of control during landing | No. 3 | | | Y | |
| 10 | Engine failure or problems - single engine aircraft | Y | Y | | | |

* Safety Issue changed from "Mismatch between calculated and actual CG" (2014-2015)

** Safety Issue merged with former SI "Aircraft not correctly configured for takeoff"

As explained in Annex II and shown in the Top Ten table for 2017, 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. 4, as percentage of the overall sum of the ERC Risk indexes of all safety issues. The distribution shows that the highest risk, for a potential "catastrophic" accident outcome, is associated with the LOC-I category - Loss of control in flight.

Risk associated with potential accident outcomes 2014-2017

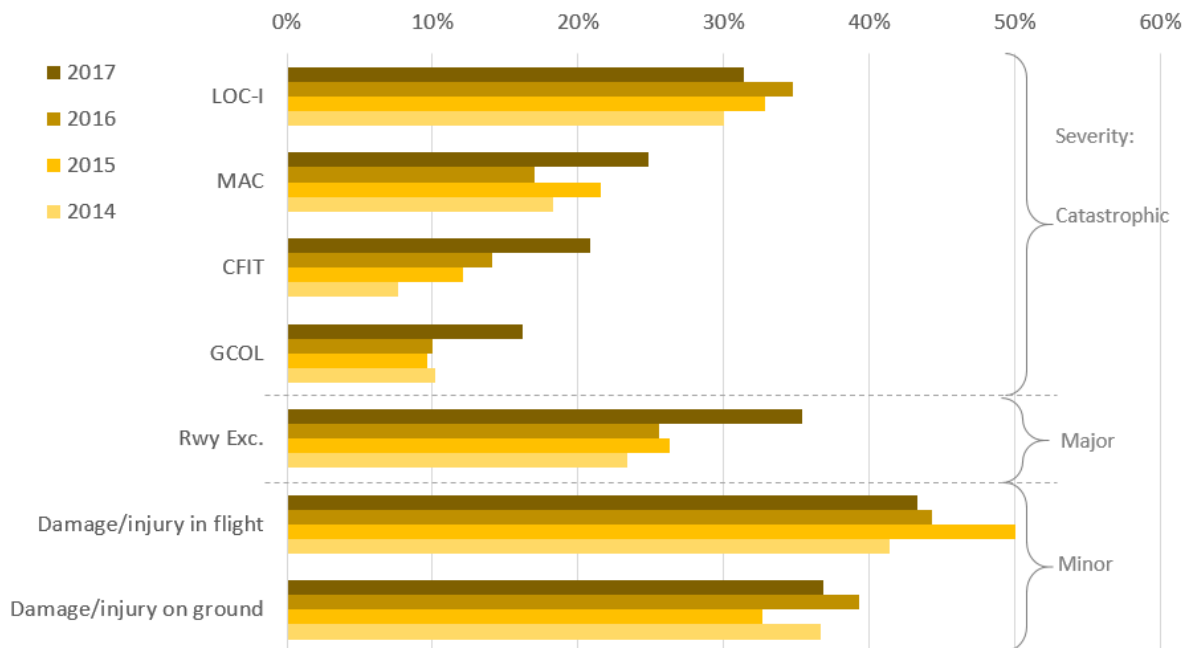


Chart No. 4: Risk associated with potential accident outcomes

- LOC-I* *Loss of control in flight*
- MAC* *Mid-air collision*
- CFIT* *Controlled flight into terrain*
- GCOL* *Collision on ground*
- Rwy Exc.* *Runway excursion*

Each safety issue is also associated with or one or more aviation domains, depending on the type of events that can trigger the safety issue. In the same way as for potential accident outcomes, the overall risk for each domain can be shown. Chart No. 5 shows that the highest risk is in the “operational” domain. A significant decrease can be detected for “Ground handling”. The pronounced downward trend of the Top Ten Safety issues “Cargo moving/shifting during flight” and “W&B issues due to wrong loading” are main contributors to this decrease.

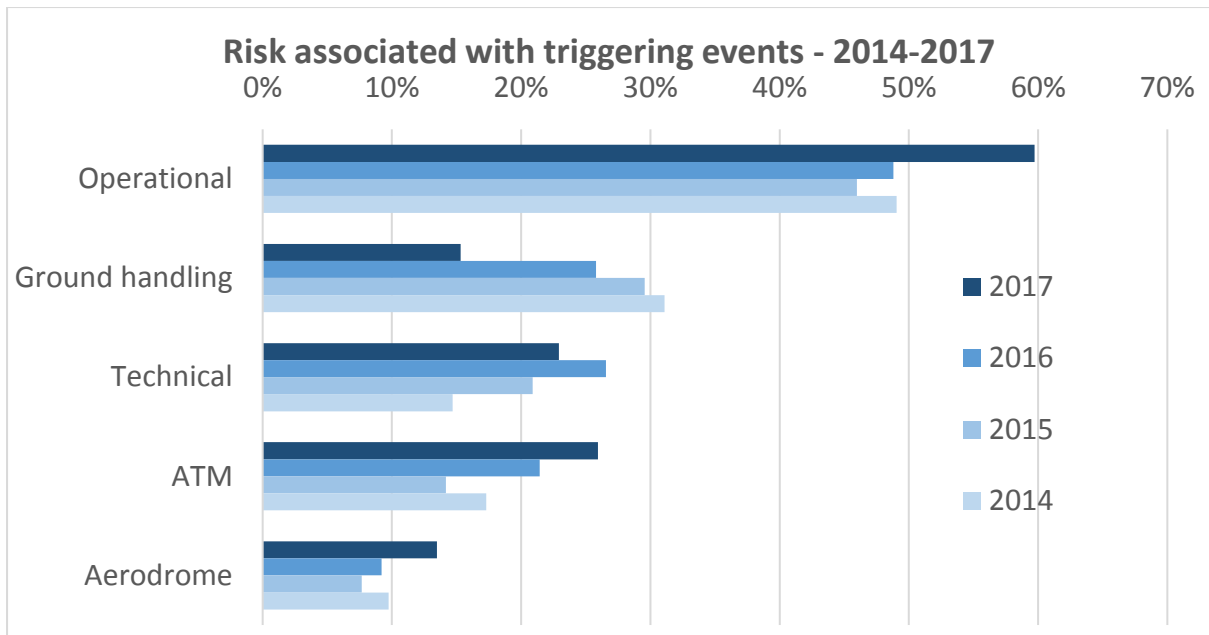


Chart No. 5: Risk associated with triggering events 2014- 2017

7. Conclusions

Taking into account the trends as well as the numbers, the safety issues in the following table can be considered the most relevant for the future. The table is structured according the aviation domains.

| ATM | OPS | Technical | Ground handling | ADRM | Safety issue |
|-----|-----|-----------|-----------------|------|----------------------------------|
| X | X | | | | Risk of Mid-air collision |
| X | X | | | | Runway incursion by aircraft |
| | X | | | | Airspace infringement |
| | X | | | | Incorrect aircraft setup by crew |
| | X | | | | Crew fatigue |
| | | X | | | Technical - flight controls |
| | | | X | | Handling of Dangerous Goods |
| | | | | X | FOD - Foreign Object Damage |

Risk of Mid-air collision

Recent evolution (2016-2017) shows a 50% increase in the number of occurrences, while the average Risk index stays approximately the same.

Runway incursion by aircraft

The majority of runway incursions are caused by single-engine piston aircraft (At Luxembourg airport: 5 out of 6 in 2017).

Airspace infringement

While the number of reported airspace infringements is low and shows a decreasing trend, a distinction should be made between airspace infringements caused by transponder-equipped aircraft and airspace infringements caused by other airspace users, mainly paragliders and paramotors. For the first category, all infringements are likely to be detected and reported, for the second category they are only reported if the paraglider or paramotor is seen in controlled airspace by the crew of another aircraft. This type of airspace infringement is likely underreported but carries a high risk. Two such cases were reported in Luxembourg airspace in 2017.

FOD – Foreign object damage

The risk of FOD should be considered in the context of the planned major construction works on the runway of Luxembourg airport. In 2017, while no specific construction works were undertaken, a significant percentage of the foreign objects found were tools, including several found on the runway.

Highest risks for General aviation

The overall number of occurrence reports from General aviation remains very low. The two main safety issues for General aviation, from the reports received between 2014 and 2017 are:

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

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 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? | | Typical accident scenarios |
|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Catastrophic Accident | Loss of aircraft or multiple fatalities (3 or more) | Loss of control, mid air collision, uncontrollable fire on board, explosions, total structural failure of the aircraft, collision with terrain |
| Major Accident | 1 or 2 fatalities, multiple serious injuries, major damage to the aircraft | High speed taxiway collision, major turbulence injuries |
| Minor Injuries or damage | Minor injuries, minor damage to aircraft | Pushback accident, minor weather damage |
| No accident outcome | No potential damage or injury could occur | 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”, except for the least severe (ERC Risk index 10 or less) that do not fit with any existing 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:

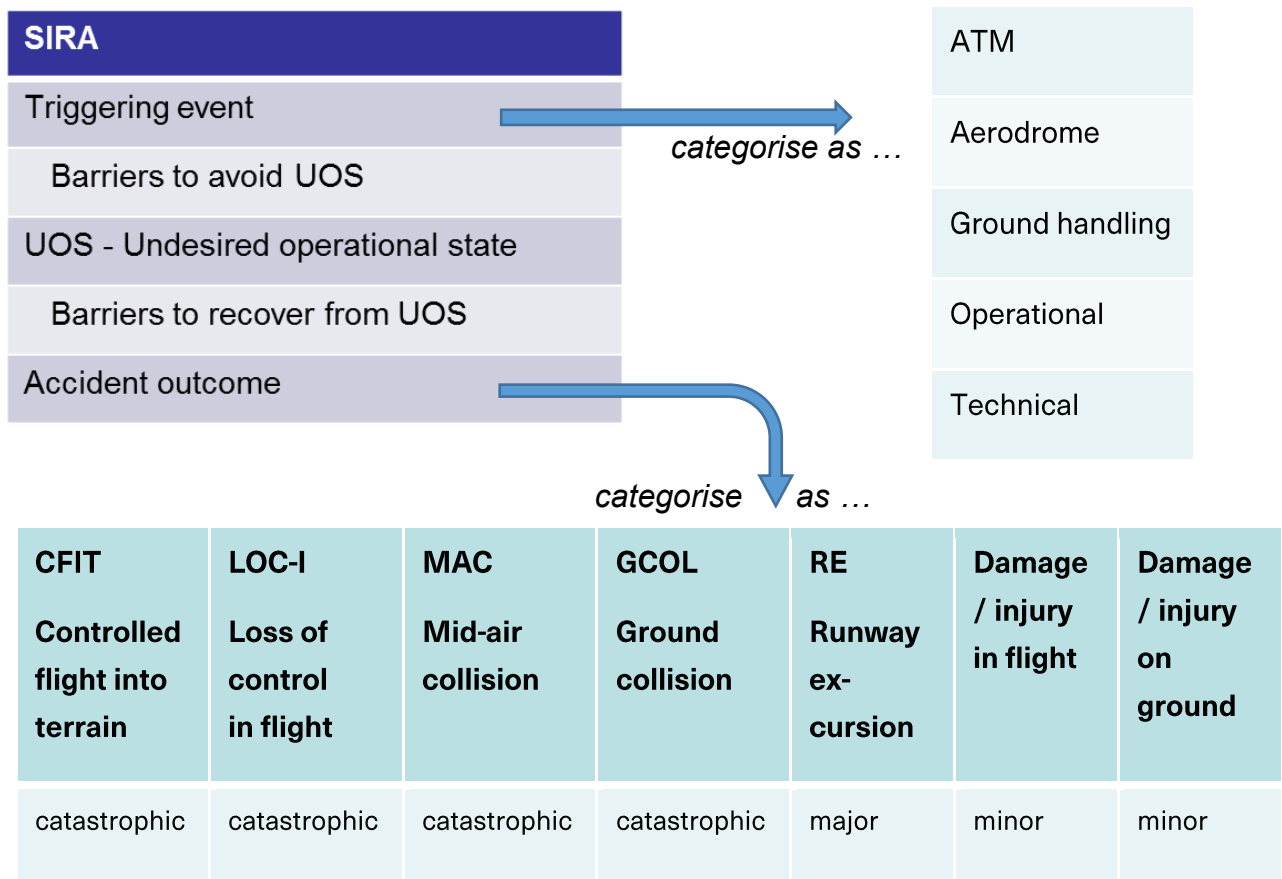
- the triggering event(s)
- the Undesired Operational state UOS

- 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:
 - o ATM (Air traffic management)
 - o Aerodrome
 - o Ground handling
 - o Operational
 - o 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 France³.



³ “Strategic action plan to improve aviation safety – the 2018 agenda”, DGAC France