THE GOVERNMENT
OF THE GRAND DUCHY OF LUXEMBOURG
Ministry of Mobility and Public Works

Directorate of Civil Aviation

Directorate of Civil Aviation

Annual Safety Review 2021

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Introduction

Despite all the sanitary and economic challenges affecting aviation in 2020, the sector managed to maintain aviation safety at a very high level. In 2021, with an improving economic situation, it was important to keep focused on safety despite the very dynamic environment and the changes carried over from the previous year. Worldwide, the aviation safety in 2021 remained at a very high level. This report presents the situation of aviation safety in Luxembourg for 2021.

First, the accidents and serious incidents of 2021 are reviewed. As the traffic situation was neither stable nor comparable to any previous years, it is necessary to look at the evolution of traffic before any safety analysis. Next, the main safety issues are presented, first for the Luxembourg aviation sector as a whole and operating worldwide, then specifically for the airspace and airport of Luxembourg. Two specific factors at Luxembourg airport are examined in more detail: the runway refurbishment works and surveillance chain (radar) issues.

The first National Plan for Aviation Safety (NPAS)[1] was issued by the Directorate of Civil Aviation at the beginning of 2022. It builds on previous annual safety reports, on the European Plan for Aviation Safety (EPAS)[2], and on the input of the national aviation stakeholders to define specific actions to further improve aviation safety. This report will serve as input for the yearly update of the NPAS in order to set the right priorities for safety actions.

[1] National Plan for Aviation Safety, Gouvernement.lu

[2] European Plan for Aviation Safety | EASA (europa.eu)

Accidents and serious incidents

One accident and three serious incidents affecting aircraft registered in Luxembourg were notified in 2021. One person suffered serious injuries in the only accident recorded in Luxembourg in 2021.

	Aircraft type	Date	Location	Event	Investigation
Accident	Cameron Z-105 (Hot Air Balloon)	14.8.	Consdorf	Balloon envelope caught fire after landing	AET
Serious incident	Boeing 747	22.3.	Dubai (UAE)	Smoke/fire from windshield heater	AAIS (UAE)
Serious incident	Boeing 747	28.7.	Zhengzhou (China)	Engine fire	(China)
Serious incident	Pilatus PC12	20.10	Brive-Souillac (F)	Loss of altitude and speed in an abrupt manual maneuver due to weather	BEA (France)

The accident involving a balloon and one serious incident occurred on General aviation flights, whereas two serious incidents took place during Commercial Air Transport operations.

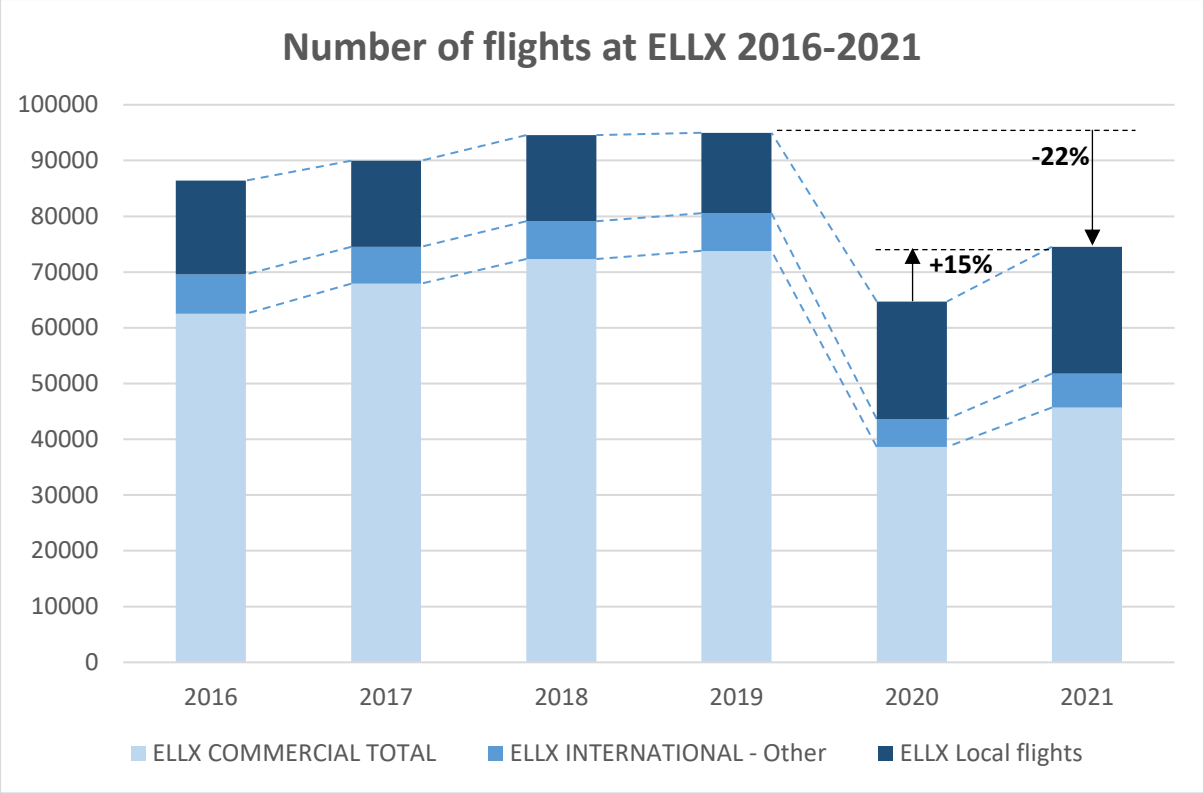
In addition to the above, the risk assessment for one incident was evaluated as high risk although the occurrence was not classified as "serious incident" according Regulation (EU) 996/2010.

	Aircraft type	Date	Location	Event	Investigation
Incident	Boeing 747	22.11.	Luxembourg	Straps loose and cut on heavy cargo	internal

Aviation accidents leading to serious injuries or fatalities are very rare in Luxembourg. However, it is noticeable that over the last ten years, ballooning is the aviation sector most affected by such accidents (a serious injury in 2012, a fatal accident in 2013, and a serious injury in 2021). The other affected activities are parachuting and paragliding, with one serious injury each in 2018. Ballooning accidents typically occur during the landing phase and unlike the paragliding and parachuting accidents, tend to affect passengers rather than the pilot.

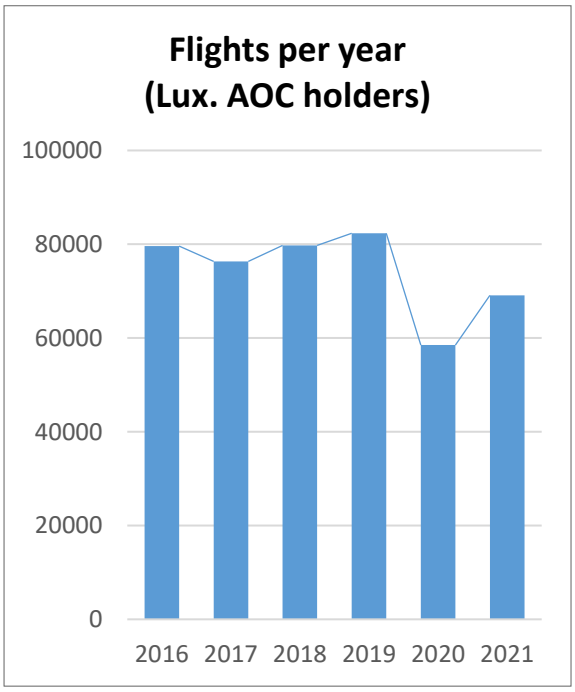
Evolution of traffic

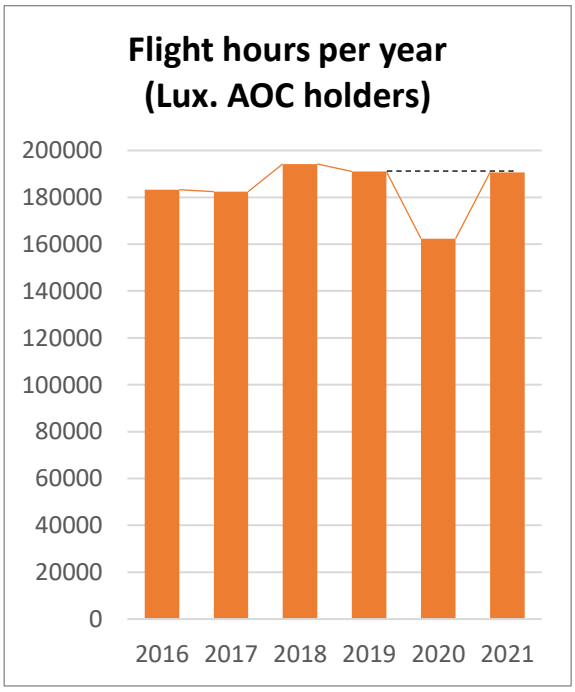
The overall traffic at Luxembourg airport followed the worldwide trend to a partial recovery in 2021, after the significant negative impact of the COVID-19 pandemic in 2020. Contrary to this trend, the local traffic at Luxembourg airport (ELLX) had increased in 2020. This increase was maintained in 2021, while the commercial and other international traffic recovered from the low of 2020 without reaching the levels from before the pandemic. Compared to 2019, a 22% drop in overall traffic at Luxembourg airport remained.



Source data: Administration de la Navigation aérienne

The total number of flights by air operators certified in Luxembourg also shows a recovery, without reaching the same level as 2019: while a drop of 29% was noted in 2020, the gap was reduced to 16% in 2021. However, the total number of hours flown in 2021 is about equal to the hours flown in 2019. This is mainly due to the increase in cargo operations, where the flights typically have a much longer duration than passenger flights by Luxembourg AOC holders.





Reporting of occurrences

The Directorate of Civil Aviation (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 certified in Luxembourg and private pilots licensed in Luxembourg.

Both mandatory and voluntary reports (according Regulation (EU) 376/2014) are included in this analysis.

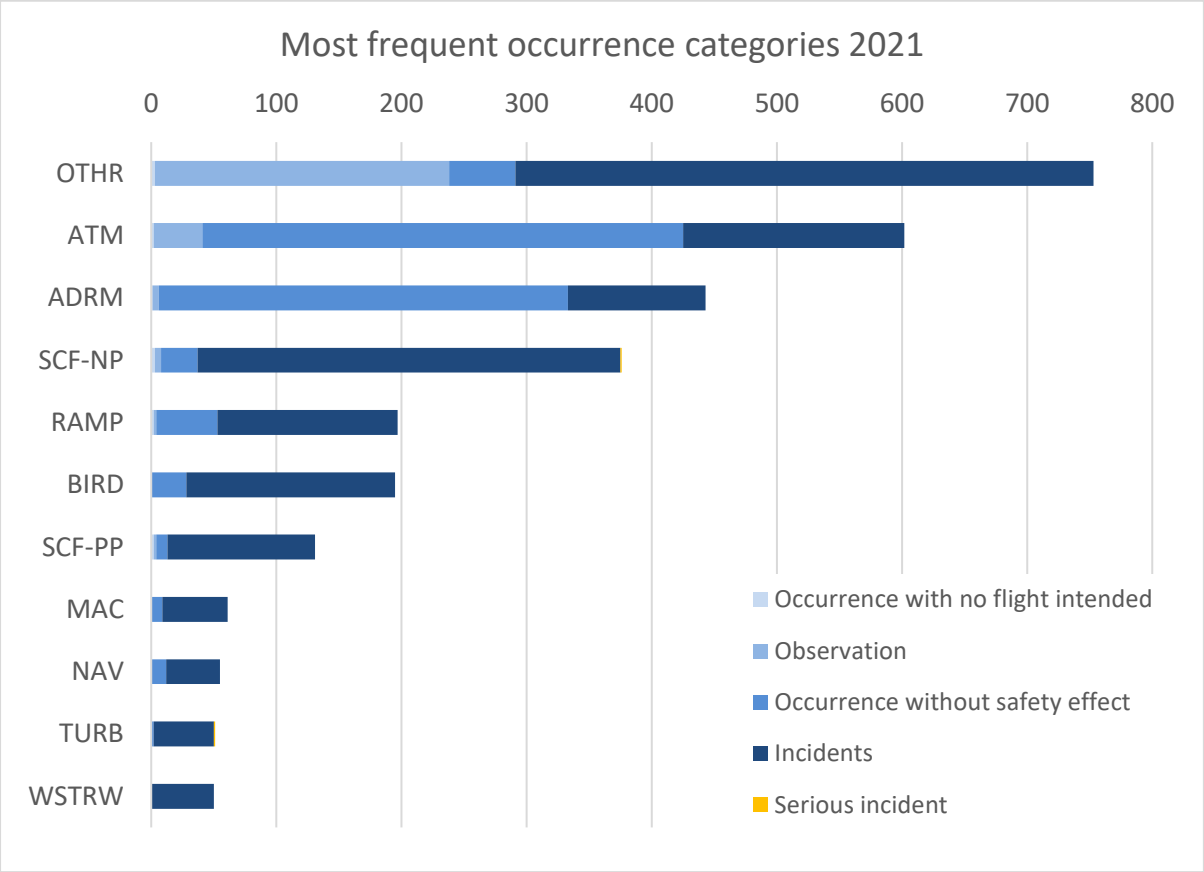
The number of reports per occurrence class is shown in the table below. In this table, two or more reports concerning the same event have been merged.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Variation 2020-2021
Proactive report / Observation / Occ. with no flight intended	332	561	454	535	470	617	704	488	232	**288**	+24%
Occurrence Without Safety Effect	684	813	727	798	689	289	843	883	563	**873**	+55%
Incident	458	523	597	578	873	1229	1310	1473	1256	**1699**	+35%
Serious Incident	3	1	1	3	0	2	0	0	2	**3**	-
Accident	2	9	5	3	2	3	3	0	1	**1**	-
Total	1479	1907	1784	1917	2034	2140	2860	2844	2054	**2864**	+39%

The overall number of reported safety occurrences in 2021 is back to the same level as in 2018 and 2019. As noted previously, the number of flights was still lower than in 2019 but the number of hours flown by operators from Luxembourg was almost the same. For calculating rates of reporting, neither the rate of reports per 1000 flights nor the rate of reports per 1000 flight hours are perfect indicators: some types of occurrences are expected to be proportional to the number of flights while others are more related to flights hours. Overall, the number of reports in 2021 meets expectations in relation to the traffic situation.

Occurrence categories

All occurrences have been attributed to one or more occurrence categories, as defined by the CICTT[3]. The most frequent occurrence categories in 2021 are shown in the chart below.



Definition of categories:

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

[3] CAST/ICAO Common Taxonomy Team

The categories “OTHR” (other) and “ATM” (Air traffic management (ATM) or communications, navigation, or surveillance (CNS) service issues) maintained the two highest positions, both with a significant increase in numbers, although in the context of increased traffic when compared to 2020. “ADRM” moves up to third place. The increasing number of reports in the “ATM” and “ADRM” categories is specific to Luxembourg airport and will be analyzed in the “Main Safety Issues – Luxembourg” section of this report.

Main Safety Issues

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.

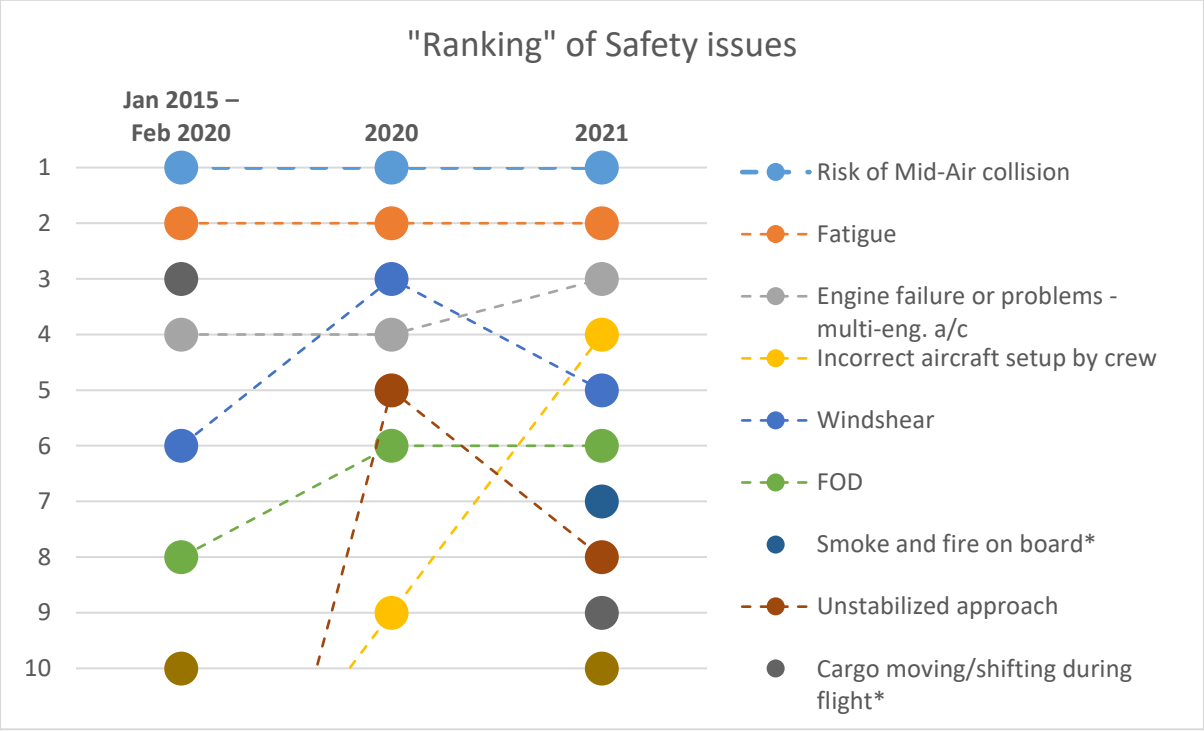
It is also desirable to take into account the severity of occurrences, to assess if an occurrence had a high risk or a low risk of resulting in an accident. DAC applies the ARMS methodology where an ERC Risk Index (Event Risk Classification, cf. Annex II) is assigned to each occurrence. As the ERC Risk 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 organization has been considered. Where the risk classification methodologies are not directly compatible, follow-up reports from the reporting organization are crucial to enable DAC to understand the risks and to reproduce the operator’s own evaluation.

The ten most important Safety Issues for 2021 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 2021
1	Risk of Mid-Air Collision
2	Fatigue
3	Engine failure or problems - multi-engine aircraft
4	Incorrect aircraft setup by crew
5	Wind shear
6	Foreign Object Debris (FOD)
7	Smoke and fire on board
8	Unstabilized approach
9	Cargo moving/shifting during flight
10	Technical - flight controls

Evolution of the main Safety issues

The chart below shows the evolution of the "ranking" of the main Safety Issues: the first column shows the ranking over a long, relatively stable period before the COVID-19 pandemic: From January 2015 to February 2020. The second and third columns show the ranking for the years 2020 and 2021 respectively.



** Safety issue affected in 2021 by a very small number of high risk events*

Risk of Mid-air collision

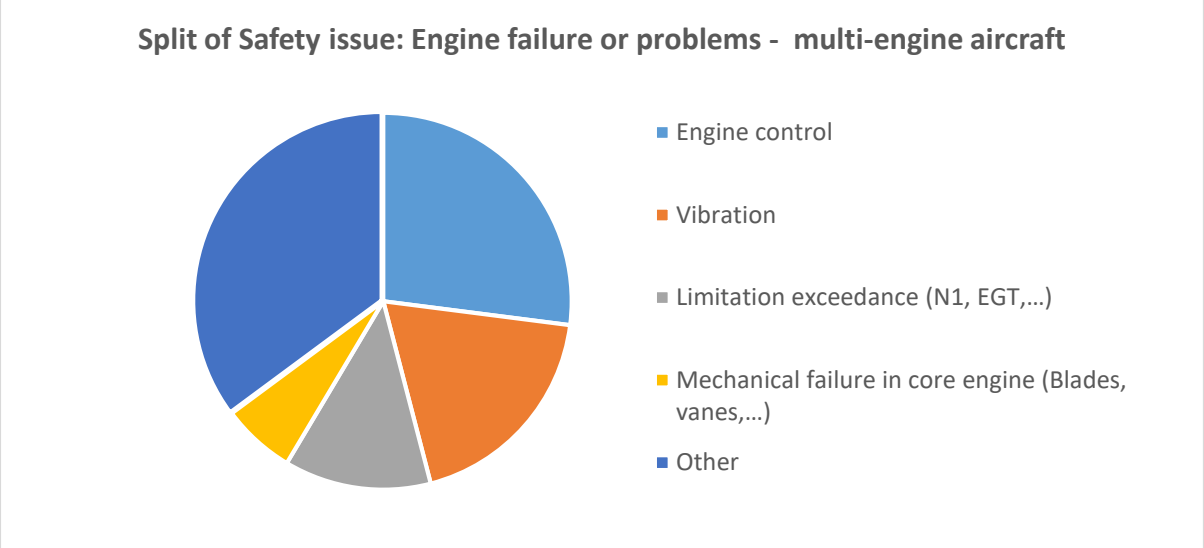
Like the previous years, this Safety issue remains in the highest position. Its evolution follows the evolution of the number of flights: there are more occurrences, with a higher overall risk, than in 2020, but less than in 2019 and the previous years. According the methodology used for risk assessment, the risk score of a safety issue depends on the frequency and severity of related occurrences. Consequently, a high-risk score can be the result of a high number of relatively low risk events, or of a low number of relatively high-risk events. The risk of mid-air collision follows the latter scheme because the potential outcome is always assessed as "catastrophic".

Fatigue

The risk of crew fatigue results from a relatively high number of reported occurrences of low average risk. For 2020, the number of reports showed a significant reduction compared to 2019, even when adjusted for the reduction in traffic. In 2021, the number of fatigue reports is only slightly higher than in 2020 but still significantly lower than in 2019. This confirms the continuing positive trend.

Engine failure or problems – multi-engine aircraft

This Safety issue also follows the pattern of a relatively high number of occurrences with on average a low risk. The reports mainly fall into the categories of engine control, vibration and exceedances and only very rarely lead to a significant issue in flight.



Skill, experience or knowledge-related Safety issues

Even if the main impact of the COVID-19 pandemic on the aviation sector had passed, 2021 was not a normal year. The return to normal operations after the prolonged period of much less flying (for most operators) possibly had an impact on safety. During the COVID-19 pandemic, EASA defined a portfolio of potential Safety issues related to the pandemic[4]. One expected Safety issue was described as "Skill and knowledge degradation due to lack of recent practice". There are two Safety issues in the Top Ten

[4] "Review of Aviation Safety Issues Arising from the COVID-19 Pandemic", EASA

that could potentially be related to this: “Incorrect aircraft setup by crew” and “Unstabilized approach”.

The number of occurrences assigned to the Safety issue “Incorrect aircraft setup by crew” doubled from 2019 to 2020, and then almost doubled again between 2020 and 2021. The increase cannot be assigned with certainty to any effect of the ramp-up after the COVID-19 pandemic. For “Unstabilized approach”, although it dropped in the ranking when compared to other Safety issues, its number and overall risk index in 2021 increased when compared to 2020. However, the increase is approximately proportional to the increased number of flights.

Main Safety Issues - Luxembourg

The occurrences reported to DAC Luxembourg can be split in two groups: those that happen worldwide to operators certified in Luxembourg or to pilots licensed in Luxembourg, and those that happen in Luxembourg airspace or at Luxembourg airport. This means that a specific ranking of the Safety Issues for the airspace and airport of Luxembourg can be established. It includes some Safety issues that are also found in the overall Top Ten, but also some very specific items. In the table below, the Safety issues that are common with the overall Top Ten are highlighted in green.

	Top Ten Safety issues - LUXEMBOURG
1	FOD (Foreign object - Debris)
2	Risk of Mid-air collision
3	FDP Issues at ELLX
4	Radar issues at ELLX
5	Smoke and fire on board
6	Engine failure or problems - multi-engine aircraft
7	Incorrect aircraft setup by crew
8	Risk of collision with drone
9	Technical - Landing gear
10	Fatigue

Two factors specific to Luxembourg had an impact on safety in 2021.

First, significant runway refurbishment works were undertaken during nights during the summer of 2021 at Luxembourg airport. Second, the surveillance chain issues at Luxembourg airport, already identified in 2019, are still present. The related number of reports has even increased.

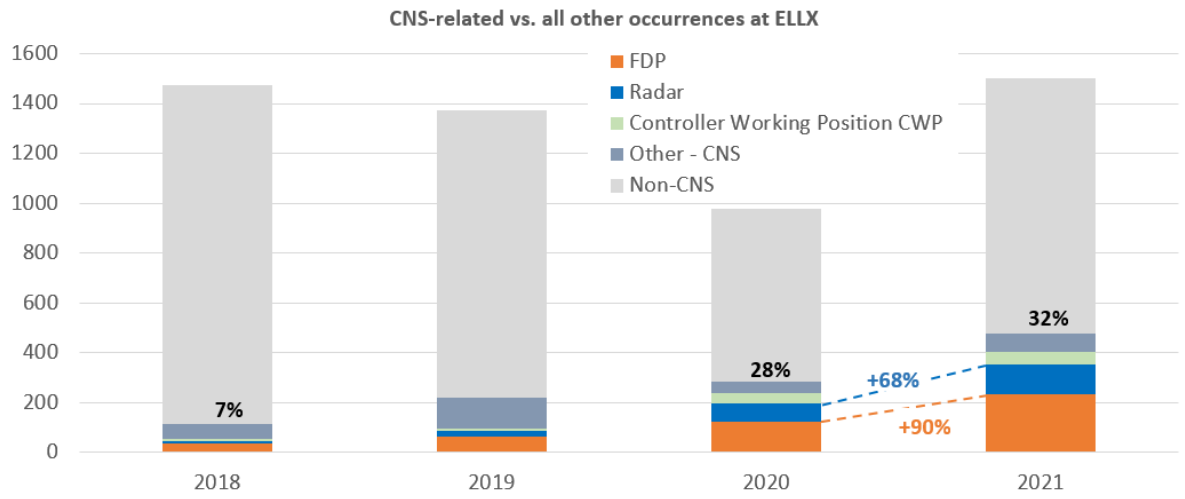
Runway refurbishment at Luxembourg airport

The first phase of the runway refurbishment at Luxembourg airport took place during nights from May to September, with air operations during the day. Related safety events like FOD (Foreign object – debris) and Runway incursions be vehicles were expected and mitigation measures were put in place. Overall, a very high number of FOD were reported; usually by patrols and inspections conducted for this purpose. The inspections acted as an effective safety barrier, so that a very low Risk index could be assigned to almost all FOD reports. They were effective in avoiding the undesirable outcome of damage to aircraft. Nevertheless, their high number pushed this safety issue into the overall Top Ten and to first place in the specific Top Ten for Luxembourg.

Several runway incursions by vehicles were also recorded in the context of the runway works, but in low numbers. In only two cases, aircraft were operating on or near the airport at the time of the incursion, without immediate risk of collision. It can therefore be concluded that the safety measures put in place to prevent runway incursions by work vehicles were effective.

Surveillance chain issues at ELLX

As reported in the DAC Annual Safety Reviews of 2019 and 2020, a technical upgrade of the surveillance chain at Luxembourg airport in June 2019 created several issues that could not be resolved during the reporting period. The number and proportion of reported occurrences related to these issues even increased significantly in 2021. The affected systems are mostly, but not exclusively, related to the Radar (including its data processing) and to Flight Data Processing (FDP). While the number of FDP-related reports is even higher than the number of radar-related reports, they generally involve a lower risk. The number of reported Radar-related issues increased by 68% over 2020, the number of FDP-related issues even by 90%. Even taking the increased traffic into account, this represents a higher proportion of all occurrences reported at or near Luxembourg airport. Before the technical upgrade in June 2019, 8% of all occurrences reported in Luxembourg were related to issues on ground equipment for Communication, navigation and surveillance. During 2020, this proportion reached 28%. In 2021, with more traffic than 2020, it even increased to 32%. A more detailed analysis reveals that the increase in 2021 is partially due to a real increase in events, partially due to an improved reporting culture among some of the concerned personnel after intervention of DAC. DAC will continue to monitor the risks involved and the efforts to resolve these issues.



Conclusion

The first National Plan for Aviation Safety[5] (NPAS) has been published by DAC at the beginning of 2022, after consultation of the stakeholders during summer and autumn of 2021. It contains specific actions to improve aviation safety. The relevance of these actions has been assured by using the previous DAC Annual Safety Reports as input and by targeting safety actions on the identified shortcomings. Likewise, this report will serve as input for the first update of the NPAS.

A ballooning accident with one serious injury during 2021 highlights that, while very rare, injuries to passengers during ballooning activities deserve further scrutiny and action.

Commercial aviation activities have recovered to a certain degree, but not completely, after suffering a major decline in 2020.

The safety measures put in place around the runway refurbishment project at Luxembourg airport were generally effective. The biggest related issue, FOD – foreign objects related to the works left on the runway or taxiway, was mitigated by effective inspections. However, the number and risk index of reports related to issues with the ground radar at Luxembourg and the flight data processing software deteriorated further in 2021.

[5] National Plan for Aviation Safety, Gouvernement.lu

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 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 Organizations. 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.

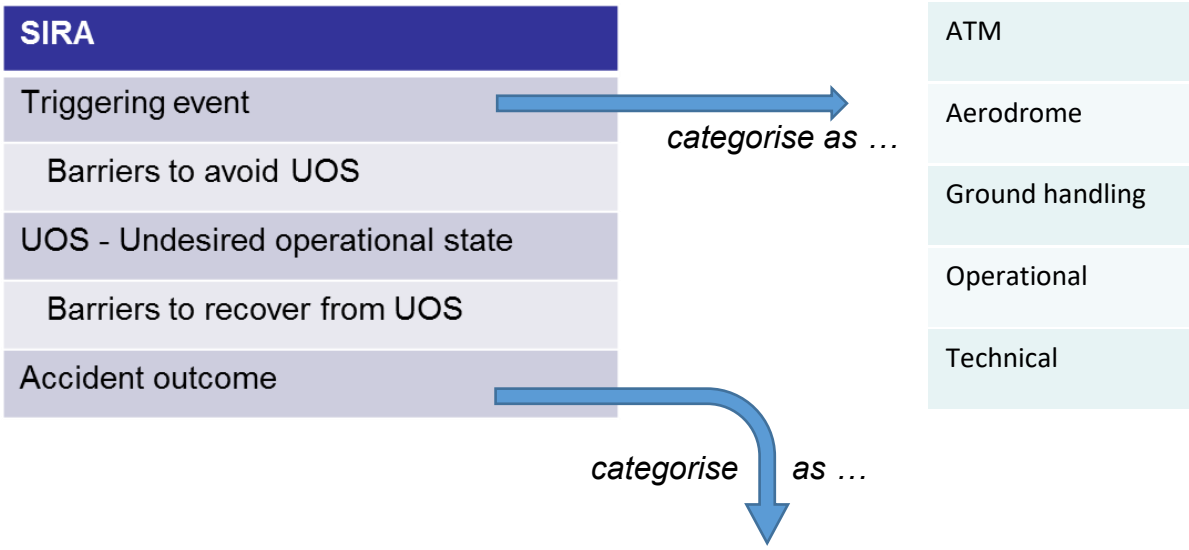
The risk assessment ("SIRA – Safety Issue Risk Assessment") according to the ARMS methodology, allows to identify:

- 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 France[6].



CFIT Controlled flight into terrain	LOC-I Loss of control in flight	MAC Mid-air collision	GCOL Ground collision	RE Runway excursion	Damage/ injury in flight	Damage/ injury on ground
catastrophic	catastrophic	catastrophic	catastrophic	major	minor	minor

[6] "Strategic action plan to improve aviation safety – the 2018 agenda", DGAC France