Investigating how regulators and industry endeavour to address the risks of erroneous data entries

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The safety issue consisting of the use of erroneous parameters at take-off has been addressed these past years by a number of safety investigation authorities. This paper is based on an investigation that went beyond the human error to address systemic factors, and in particular, how regulators and industry have endeavoured to address these risks.

The investigation also analysed the handling of previous safety recommendations on the same issue. Such an approach, which takes into account State Safety Programs (SSP) and Safety Management Systems (SMS), also aims to provide more convincing safety recommendations, as laid out in the BEA strategic plan for 2018-2022.

1. The F-GUOC serious incident

This serious incident occurred during take-off from Paris Charles de Gaulle on 22 May 2015 and involved the Boeing 777-F registered F-GUOC, operated by Air France. The Captain (PM), the Co-pilot (PF) and two Relief Co-pilots were on board for this commercial air transport (CAT) operation (cargo) to Mexico.

The B777 took off at low speed and the tailstrike protection of the aeroplane was activated. The aeroplane did not gain altitude. The crew then applied full thrust (TOGA). The aircraft flew over the opposite threshold at a height of approximately 170 ft and continued to climb. During the climb, the crew discussed the causes of the incident and realized they had made a mistake of 100 tonnes in the weight used for the calculation of the take-off performance parameters. The crew continued the flight to destination without any further incident.

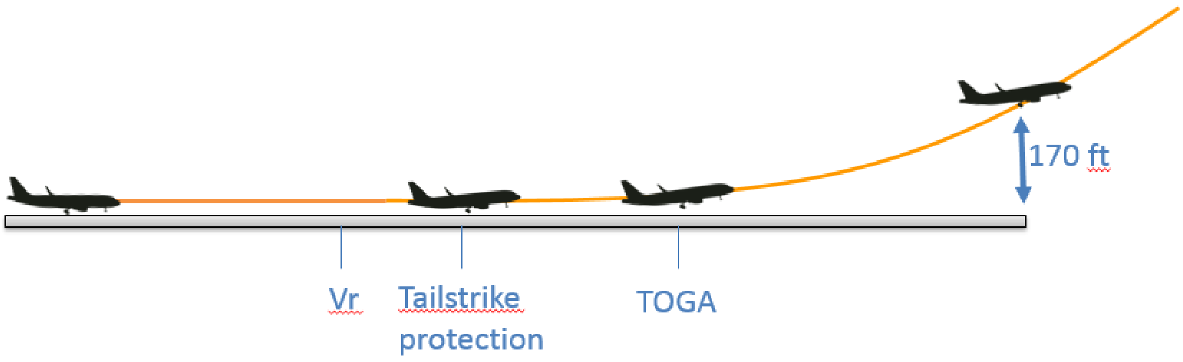

Figure 1

1.2 Erroneous data entry during flight preparation

After deciding on an extra fuel load, both the Captain (PM) and the Co-pilot (PF) tried to anticipate the new take-off weights and made some calculations. Both entered the same erroneous weight in their respective EFB performance tool, inferior by 100 tonnes to the correct weight.

As a result, they took off with highly incorrect take off speeds, configuration and thrust settings. A detailed description of the scenario will be available in the final report.

1.3 Effective barriers and associated limitations

Tail Strike Protection provides a timely elevator input to help avoid tail strikes on take-off. If the tail strike protection had not been activated during this take-off, Boeing estimated that there would have been runway contact about one second after the activation of the protection. This was an effective barrier against one of the possible outcomes associated with the use of erroneous parameters at take-off. However, it does not provide protection against other associated major outcomes such as collision with an obstacle, or high-speed runway excursion.

Moreover, eight seconds were necessary for the crew to opt for TOGA thrust and to apply it. This period seems consistent with the element of surprise, the unknown problem. The application of full thrust is not the sole and obvious solution. Indeed, it can be counterproductive (risk of tailstrike, some cases of engine failure) and therefore cannot be considered as a robust barrier.

1.4 Specific improvements to be undertaken (operator/manufacturer)

Uniformity of weight data handled

The analysis pointed to the variety of weight data formats and denominations handled by the Air France crew during the flight preparation. Homogenization of the data between the media would make it possible to both facilitate simple equality checks and reduce the cognitive load. The goal is to give meaning to the numbers handled, to allow a better acquisition of the usual values and a more systematic use of orders of magnitude.

The BEA will address a safety recommendation in this sense to Air France.

Standard Operational Procedures (SOP)

Aware of the error-prone nature of the procedures associated with the calculation and entry of take-off parameters, Air France had initiated an internal working group concerning the use of the EFB performance tool. One of the main objectives of this group was to prevent the use of erroneous parameters at take-off. The work of this group was not carried through to completion. Following the serious incident, modifications were made, clarifying certain sequences and adding an overall consistency check between the weights of the three media (EFB, final loadsheet and FMS). These modifications in reaction to the event, while they introducebeneficial features, add further checks to already demanding procedures, the robustness of which must be assessed not only during implementation but also over time.

The BEA will address a safety recommendation that asks Air France to check, in operational conditions, the robustness of the procedures for calculating and entering take-off parameters in order to take into account the constraints inherent in the flight preparation phase.

Protections against entering erroneous speeds on B777

Following the serious incident, the DSB (Dutch Safety Board) contacted the BEA because they had to investigate two very similar serious incidents involving Boeing 777 where an error of 100 tonnes was made. Indeed, the F-GUOC serious incident is the third low-speed take-off on a Boeing 777 where flight crews did not detect or understand the “V SPEEDS UNAVAILABLE” FMS message, that is triggered when the FMS can no longer compute reference speeds. The message was not sufficiently salient and explicit and can be deleted directly by the crew. Boeing's operational documentation on the calculation of reference speeds and on the conditions in which the V SPEEDS UNAVAILABLE message is activated, is incomplete. It does not allow operators to assess the risks and develop robust procedures. The request from operators for Boeing to improve the FCOM documentation about this message was not followed up. In addition, the aircraft systems do not warn crews of the loss of protection preventing the entry of speeds below *V1min, VRmin* and *V2min* normally calculated by the FMS. In the F-GUOC event, as the system authorized the crew to enter the speed data, the crew thought that take off was possible.

The BEA will address two safety recommendations to Boeing to update documentation and to review its alerting systems.

2. Use of erroneous parameters at take-off: background overview

2.1 Previous safety investigations and safety studies

From 1999 to 2015, more than 30 accidents and serious incidents regarding the use of erroneous parameters for take-off led to safety investigations worldwide. In addition to these case-by-case safety investigations, the BEA (2008), the ATSB (2009) and the NASA (2012) published safety studies focusing on this issue.

One of the immediate findings of the safety studies was that these incidents and accidents have involved different aircraft manufacturers and different aircraft models operated by various operators around the world. They are equipped with different systems to process take-off parameters. Moreover, it was also observed that flight preparation is prone to errors at multiple points and that these errors are frequent but generally detected by the application of Standard Operational Procedures (SOP) or by individual techniques.

Previous safety investigations and safety studies mainly led to the identification of three areas of concern:

- operational procedures;
- knowledge of orders of magnitude;
- existing software user interface.

In the scope of these safety investigations and safety studies, Safety Investigation Authorities (SIA) addressed several safety recommendations to certification authorities worldwide; 13 have been listed in the F-GUOC safety investigation report (non-exhaustive list). The listed safety recommendations focused on the following systems:

- On-Board Weight and Balance Systems (OBWBS): 2 safety recommendations since 2005;
- Gross error detection/warning systems: 6 safety recommendations since 2006;
- Take-Off Performance Monitoring Systems (TOPMS): 3 safety recommendations since 2006;
- Electronic Flight Bags (EFB): 2 safety recommendations since 2011.

2.2 F-GUOC and historical areas of concerns: converging findings

Regarding the F-GUOC serious incident, the BEA concluded that the following elements may have contributed to the 100 t error not being detected and its propagation:

- the crew's handling of take-off weight data in numerous formats, on various media and with various denominations;
- the "*non-mobilisation*" of orders of magnitude partly related to the increasing use of performance optimization tools;
- the number of basic checks required, incompletely taking into account the operational context and how the crew works. These procedures are notably based on an independent double calculation, a simple verbalization undermining this independence. These procedures did not include a means of detecting gross errors or a simultaneous check of the three media using weight data (Final loadsheet, EFB performance tool and FMS).

These three elements are in line with the main areas of concern highlighted by previous safety investigations and studies. One of the F-GUOC investigation team members – a human factors specialist, who participated in the BEA study in 2008, confirmed this convergence. This is the reason why the decision was taken by the BEA to steer the focus of the investigation towards why the general situation seems not to have improved (cf. Investigating Safety Management Systems).

2.3 Risk management by Air France

The risk of an entry error has been the subject of several initiatives by Air France, either continuously or following a significant incident in 2004 on one of the airline's A340s. These initiatives took the form of ad hoc analyses, notably on the basis of incident reports collected via ASRs, the inclusion of the topic in the training program, the modification of certain operational media, requests for modifications addressed to manufacturers, or internal publications.

When EFB performance tools were introduced from 2009 on the airline's 777-F (cargo), Air France launched an internal working group and participated in the study conducted by the BEA. Nevertheless, the working group did not continue its reflections because Air France was beginning to use manufacturers’ documentation. Air France considered that these documentation changes were making this internal work less relevant.

Flight audits have limited effectiveness in this area due to the focus on compliance. The checks carried out by the Type Rating Examiners are not intended to assess the robustness of the reference frames but essentially the crews' performance within these reference frames.

Furthermore, before the F-GUOC serious incident, Air France had begun exploring two ways of detecting such events through its Flight Data Monitoring (FDM). While an incident such as that concerning F-GUOC was actually detectable, the system was still not considered effective enough to detect the various data entry errors that can be made. In this initiative, Air France reported not having received the expected assistance from manufacturers.

2.4 Systems developed by the aviation industry

The aviation industry is searching for systems to reduce the number of take-off related incidents and accidents. These systems are either intended to reduce manual entries, detect input and output errors by built-in crosschecks in take-off performance related aircraft systems or ultimately by monitoring the actual take-off performance.

BEA noticed that solutions developed by industry were very heterogeneous. At this time, it depends on the manufacturers’ philosophy. Some solutions are optional or provided by third parties which means that the choice can remain with the operator.

This range of approaches will be wider in the future and this also raises the issue of retrofit.

On-Board Weight and Balance Systems (OBWBS)
An autonomous OBWBS provides pilots with the actual weight and balance information. This information may serve as a crosscheck (secondary system) or as the source (primary system) for the weight and balance values used in the performance data process.

The two aircraft manufacturers Airbus and Boeing successfully developed OBWBS: Airbus certified it on A330/340 in 1993 and a system is currently in use on Boeing 747-8. However, it is available on a very limited number of aircraft models and leads to operational constraints and additional maintenance costs.

Airbus has no plans to develop any new OBWBS and privileges other systems.

Automated entries or checks related to aircraft take-off performance

Airbus developed a Take-Off Securing (TOS) function which detects inconsistencies in the parameters entered in the FMS. It includes, in particular, checks and dedicated warnings for the ZFW range, take off speed consistency with Take-off Weight, trim setting, aircraft position and take-off distance.

Boeing implemented different checks and associated alerts in the FMS. Some examples for the Boeing 777 are:
- V speed checks (minimum V speed protection, relative V speed check),
- configuration checks,
- an optional feature to uplink FMS data to the EFB, in order to reduce manual entries. A comparison feature can warn the crew if the difference between the FMS weight and EFB weight is too great.

Solutions are not limited to aircraft manufacturers. For example, LINTOP (Lufthansa systems) is an on the ground remote performance calculation system that can compare the weight entered in the ACARS page by the crew with the weight used during the flight preparation. If the deviation is too high, and if the weight entered is lower, the crew is warned (in % of difference).

Take Off Performance Monitoring Systems (TOPMS)

A Take-Off Performance Monitoring System monitors the acceleration of the aircraft during take-off by comparison with the performance data entered. The system makes it possible to detect an erroneous Take-Off Weight (TOW), a degraded aircraft performance or an abnormal contamination on the runway. It provides pilots with associated warnings.

A Take-Off Monitoring System was evoked by Airbus in 2015 and certified on A380 in February 2018. A retrofit on other programmes is planned.

To the BEA’s knowledge, Boeing did not develop any TOM systems.

3. Investigating safety management systems

3.1 Early analysis and decision

On starting the investigation into this new serious incident, the BEA assessed the situation as follows:

- Use of erroneous parameters at take-off still occurs frequently;
- Outcomes are still potentially catastrophic;
- Safety barriers still consist mainly of SOPs and of the appropriate detection and reaction by crewmembers.

In this context, the BEA had in mind its own input in this safety issue, as well as the inputs from its counterparts worldwide:

- Previous findings have shown that operational safety barriers are of importance; however, numerous events and studies have shown that there are occasions where they are not effective;
- For 15 years, SIAs issued safety recommendations regarding the introduction of technology to prevent and/or detect erroneous parameters.

Based on this initial analysis and on the apparent *status quo*, the BEA gave thought to the appropriate scope for this new investigation. Carrying out an in-depth analysis of operational deficiencies, assuming that sufficient data is available in the absence of CVR data, could contribute once again to the experience feedback. However, what would be the benefits with regard to the global state of knowledge and to this *status quo*? Therefore, what would be the actual benefit in terms of risk management?

Naturally, the decision was to focus on "risk-based approaches", in particular at the level of aviation authorities. In the scope of this paper, the term designates:

- Risk management as part of continued airworthiness, especially from the certification authorities point of view, as they were the addressees of various safety recommendations;
- Safety management as defined by ICAO in Annex 19; in the context of this investigation, it refers to Safety Management Systems (SMS) to be implemented by operators and to State Safety Programs (SSP) to be implemented by authorities.

Through new Protocol Questions (PQs) recently included in its audit program related to Annex 19, ICAO invites SIAs to analyse SMS and SSP in the scope of their investigations.

3.2 Investigation principles

Like other organisations and authorities, SIAs have limited resources. It is their responsibility[1] to define the scope of their investigation, taking into account this constraint and the lessons that can be drawn for the improvement of aviation safety.

In this context, SSP and SMS are one possible line of investigation. The BEA does not systematically explore this line but assesses on a case-by-case basis the relevance of investigating the safety management processes. Detailed criteria for this do not exist. Nevertheless, there are situations that raise questions. This is the case, for instance:

- When the type of event is recurrent, potentially catastrophic and when the remaining safety barriers, if they exist, have a robustness that raises questions;
- When the type of event is potentially catastrophic and, during the investigation, the organizations involved do not seem to demonstrate their ability to manage the risk effectively.

[1] Regulation (EU) 996/2010 (Recital 13) and ICAO DOC9756 (Part2 paragraph 2.1)

The BEA's overall investigation methodology aims at identifying and analysing safety principles that are intended to:

- prevent an unsafe situation from appearing;
- ensure recovery from this unsafe situation; or
- mitigate the consequences of the possible subsequent accident.

In this respect, the investigation of SMS is consistent with the BEA's methodology.

The BEA has not developed a formal method to explore risk-based approaches. In any case, an investigation has to adapt to the specific processes implemented by stakeholders. Bearing in mind the usual steps of a safety management process, the only principle followed by the BEA is to explore the consistency between:

- the data available to the safety manager/analyst;
- their implicit reasoning (processing of data);
- their explicit arguments;
- their decisions; and
- their actions.

In doing so, the BEA pays particular attention to avoid the following two biases:

- To limit its analysis to the observation that risk management failed. Even if the assertion is exact, it could be considered as the expression of a retrospective bias.
- To express a disagreement with a managerial decision based on a value judgement only (e.g. regarding the acceptability and hierarchy of risks, choice of mitigation measures, etc.). SIAs should understand and accept that decisions are under the responsibility of safety managers (within competent authorities, operators, etc.). Inputs from SIAs are limited to risk analysis.

3.3 Management of this safety issue (use of erroneous parameters at take-off) by aviation authorities until the F-GUOC serious incident in 2015

As mentioned above, in the scope of previous safety investigations and safety studies, SIAs addressed several safety recommendations to certification authorities worldwide. Among the listed safety recommendations, two concerned OBWBS, six concerned gross error detection/warning systems, three concerned TOPMS and two concerned EFB.

EFB

EASA's work on EFB resulted in the publication of AMC 20-25 in 2014, providing guidance material (risk assessment, main principles regarding the interface design or SOPs, testing program, etc.) to operators for their use prior to their implementation or any changes. At the date of the F-GUOC serious incident, Air France had not had the opportunity to refer to AMC 20-25 for its B777's fleet, since no change was scheduled or being conducted regarding the use of EFBs.

Even if relevant with regard to the failures highlighted by the F-GUOC serious incident, AMC 20-25 puts the ball in the operator's court. Previous safety investigations and studies have already demonstrated that because of organisational and operational contingencies, operators cannot completely manage the risk alone. Incomplete and ineffective initiatives by Air France before the serious incident are one example. This meant that the BEA had to pay particular attention to what had been undertaken (designed, developed, certified, standardized or implemented) with respect to aircraft systems.

OBWBS

A working group was initiated in 2010 by EASA under the auspices of EUROCAE. Past initiatives by manufacturers were reviewed in the scope of this group. In 2013, the working group stated that it was in favour of a standardization of such a system. It was only at the end of 2015, after the serious incident involving F-GUOC, that the group was reactivated with the new mandate to define Minimum Operational Performance Standards (MOPS). In the meantime, EASA left the chairmanship of the group to the industry, thus accepting that they would be less able to control actions and timelines.

Gross error detection/warning systems

In 2009, in response to some safety recommendations from the NTSB, the FAA released acceptable means of compliance applicable to new airworthiness approvals of FMS, including warning systems intended to detect grossly erroneous parameters. However, the FAA decided not to extend them to existing FMS, considering that operators’ policies (e.g. including normal crosscheck procedures) were sufficient barriers. For its part, EASA did not conduct a review of these systems as the agency had suggested it would do in 2011, following BEA's recommendation issued in 2008. However, gradually, various aircraft and equipment manufacturers, based on different approaches, have developed systems to deal with gross errors. As with the serious incidents involving the F-GUOC and two similar incidents identified by the DSB, several accidents and serious incidents among those identified by EASA resulted from entering clearly erroneous parameters in the FMS, which such systems could have detected and brought more clearly to the attention of the crews.

TOPMS

From 2006 onwards, Transport Canada (TC), in response to a safety recommendation issued by the Transport Safety Board (TSB), has indicated that there was not any suitable system to monitor take-off performance. It has also stated that the industry was the best placed to take the lead in developing a take-off performance monitoring system. The research project established by TC in 2007 came to a standstill in 2009 due to the lack of appropriate funding. In 2012, in response to a safety recommendation issued by the BEA, EASA initiated a dedicated working group under the auspices of EUROCAE. The group concluded in 2015 that the standardisation was not possible. Despite that conclusion, it should be noted that in parallel, Airbus started to develop its own system (TOM) which meets certain TOPMS criteria.

Summary of the management of this safety issue by certification authorities until the F-GUOC serious incident

The overall approach of the civil aviation authorities regarding the above mentioned systems has been to let the industry both decide on the development and certification of advanced systems, and to decide whether to standardize or not. The authorities did not closely monitor the progress made by the industry regarding design features to better protect against risks associated with erroneous take off parameters. This did not allow these authorities:

- to influence the timing of the standardisation activity, as evidenced by the recent postponements of the conclusions regarding the possibility to standardise OBWBS;
- to encourage the introduction of the most effective features, in particular the retrofit of aircraft systems (e.g. to make the improved warning of the Boeing 787 available to the Boeing 777);
- to detect that the state of the art had become favourable to the development of new relevant systems (e.g. sufficiently mastered technology enabling Airbus to communicate on TOM system in 2015).

Work conducted by the major aviation authorities, particularly through their handling of safety recommendations did not lead to the F-GUOC being equipped with sufficiently reliable systems to prevent the use of erroneous parameters at take-off. The industry had progressively developed more effective systems than those equipping F-GUOC, but authorities either seemed to ignore these developments or did not consider how their use could be extended and what could be their own role in this respect.

3.4 Since 2015: safety management by EASA related to erroneous data entry

Authorities in charge of rulemaking, certification and continued airworthiness, as well as safety oversight in other domains, have started implementing ICAO Annex 19 requirements regarding safety management, in particular those related to State Safety Programs (SSP). In particular, EASA has recently designed and implemented a new process called Safety Risk Management (SRM). EASA also restructured itself to organize its activities (certification and operational standards) on this risk-based approach.

The use of erroneous parameters at take-off was one of the first safety issues processed through the SRM process; analysis started two months before the serious incident. EASA continued its work in parallel with the investigation performed by the BEA. Some of the documents were provided to the BEA during the investigation. EASA issued specific cautions regarding their reading, in particular:

- the documents provided to the BEA are draft versions; there were not shared with the advisory bodies, and for this reason could not be considered as officially validated;
- the SRM process is an on-going process; findings should not be considered as definitive;
- the whole process is still in its development phase. As an example, data sources for risk monitoring and assessment are not consolidated. Therefore, quantitative results have to be considered carefully.

Nevertheless, the conclusions and findings of this work were directly used to define the EASA action plan on this topic.

The SRM process designed by the EASA includes five steps: risk identification, risk assessment, determination of safety actions, implementation of safety actions and risk monitoring.

Safety analysis report

In March 2015, EASA initiated a review and assessment of the safety issue relating to the use of erroneous parameters at take-off. In this respect, it considered 31 investigation reports and several safety studies issued since 1999. Among the 31 events during CAT operations that were listed in this review, there were three fatal accidents (outside the EASA member States).

Based on these occurrences, EASA stated that the risk level associated with this safety issue was "*secure*" (level 6 out of 10), which corresponded to the following definition according to the ARMS methodology[2]: "*the risk level and its trend needs to be monitored continuously […] in order to prevent escalation to unacceptable level. Reinforcement of existing measures should be discussed at the next convenient opportunity […] and taking further reduction measures should be considered*".

Moreover, the fact that serious incidents and accidents continue to occur almost every year means, according to EASA, that the current risk barriers are inadequate and insufficient.

However, the largest number (five) of new actions listed by the EASA concerned barriers to be managed by operators. Regarding aircraft systems, the list includes the continuation of work on OBWBS on one hand, and the acknowledgement that work on TOPMS had come to a standstill on the other hand. EASA also suggests that manufacturers should improve their FMS to make them more sensitive to erroneous parameters inputs and calculated data, compared to current gross error checks.

Preliminary Impact Assessment (PIA)

Preliminary Impact Assessments (PIA) are new activities, which consist in evaluating the impact of the actions envisaged by EASA in terms of cost-efficiency and implementation time criteria. The PIA carried out by EASA in 2016 regarding the use of erroneous parameters at take-off was the first one that they had ever conducted. It was in line with the safety analysis conducted in 2015. The updated version provided to the BEA in 2018 was still in draft form.

The objective claimed by the agency at the beginning of the document was to reduce the severity level of the risk from "secure" to "monitor" ("*monitor throughout the routine database analysis*" according to ARMS methodology).

Three actions were listed:

- action 1: publication of a Safety Information Bulletin (SIB) on the "Use of erroneous parameters at take-off";
- action 2: OBWBS EUROCAE WG-88 – On Board Weight and Balance System;
- action 3: RMT.0601 Improve the use of EFB with the updated provisions of AMC20-25.

[2] http://skybrary.aero/bookshelf/books/1141.pdf

To assess the safety benefit of the SIB (Action 1), a survey was conducted by EASA between October and December 2015. Eighty-six operators answered this survey, reporting 128 occurrences over the 2010-2014 period. These operators were divided into 3 categories:

- category 1: operators without FDM;
- category 2: operators with FDM but without criteria related to this issue;
- category 3: operators with FDM and adapted criteria to this issue.

Based on the comparison between operators in categories 2 and 3, EASA concluded that an operator could reduce the number of incidents of this nature by at least 70% with an adequate FDM system. Data collected through this first survey was considered not sufficiently reliable by EASA to complete the comparison. The BEA agrees with EASA on the difficulty of estimating safety benefits based on such a data set. However, it is of BEA's opinion that this incomplete reasoning may have led to an overestimation of the overall safety benefit of the SIB. Indeed, the data collected through the survey indicates that many operators estimate they already have an adequate FDM system and that their contribution to the total number of commercial flights is 80%. As a result, based on this data, the overall benefit for the SIB would be 14%. Even if not accurate, this is an order of magnitude that questions the impact of measures to be implemented by operators, and EASA should take this into account.

In comparison, EASA estimated the safety benefit of the OBWBS at 50%.

Cost for the publication of the SIB was assessed at 3 based on a scale from 0 (low) to 10 (very high) and the implementation time was assessed to be 2 years. EASA could not assess the cost and the time for the implementation of OBWBS because these parameters depend on the results of the EUROCAE working group, still preparing the specifications at the date of publishing the investigation report. The timing of the associated EASA RuleMaking Task (RMT.0116) has been revised (postponed) several times in the recent years.

The 3rd action (EFB) was not assessed in the first versions of the PIA.

EASA has temporarily concluded that the SIB to alert operators and flight crew of operational mitigation measures would be the most cost-effective measure. In the event that it does not lead to the expected outcome (following a monitoring assessment), the regulatory action on the development of specifications for the OBWBS could be the second preferred option, once the EUROCAE working group has confirmed the feasibility of such specifications.

Based on this action plan, EASA estimated that the remaining risk would be at the "Monitor" level.

EASA published the SIB "Use of erroneous parameters at take-off" on 16 February 2016[3]. The objective of the SIB was to increase the awareness of operators and competent authorities with respect to the safety issue of using erroneous parameters at take-off and to manage this safety issue. EASA recalled that among the risk mitigation measures that can be implemented are systems

[3] SIB 2016-02: http://ad.easa.europa.eu/ad/2016-02

such as OBWBS or systems to detect gross errors in the values entered. It has to be noted that the development and the availability of these systems is not the responsibility of the operators to which the SIB is addressed. Nevertheless, this is a first step to promote technology and it would benefit from more details about products available for each type of aircraft.

European Risk Classification Scheme (ERCS)

More recently[4], this safety issue (use of erroneous parameters at take-off) was assessed by EASA through the European Risk Classification Scheme (ERCS). According to this work, the "entry of aircraft performance data" is not a priority as it is ranked as the 23rd safety issue. It is not up to the BEA to challenge the prioritization of risks. However, the BEA in its safety study released in 2008, other safety investigation authorities and the EASA itself have already pointed out the fragility of operational barriers against errors that occur frequently and that could have catastrophic outcomes. The F-GUOC serious incident is an additional confirmation. The ERCS score is based on these three criteria. In the future, in order to convince aviation stakeholders, EASA could describe its methodology, both to assess individual occurrences and to aggregate each occurrence assessment to arrive at a global score for a safety issue.

Certification of the Airbus-designed Take-Off Monitoring (TOM) system for A380

The TOM system, which was developed by Airbus, was certified by EASA for the A380 in February 2018. Regarding this improvement, EASA explained that:

- since the risk level does not reflect an "unsafe condition" as defined in AMC 21.A.3B(b) related to Regulation (EU) No 748/2012, such a system could not be made mandatory (i.e. by an airworthiness directive);
- to call for a standardization directly based on this existing product is impossible since it would create a competitive advantage to one manufacturer detrimental to the market;
- to organize the promotion of this newly certified system had not yet been considered.

This tricky situation highlights the need for aviation authorities to closely monitor the early progress made by industry so that they preserve the maximum number of possible levers. As a last recourse, the promotion of aircraft systems related to identified safety issues has to be systematized.

Summary of post-serious incident safety management by EASA

The BEA fully understands that aviation authorities and the industry set priorities, even and especially when it comes to dealing with safety issues. In this, all the above observations must be considered with reference to the priority level of this particular safety (No 23 in the CAT Airlines Portfolio).

However, overestimating the capacity of operators and crews to preclude gross parameter errors by relying only on procedural barriers could compromise the assessment of the priority level of this risk,

[4] EASA aviation safety review 2018:
https://www.easa.europa.eu/sites/default/files/dfu/218639_EASA_ASR_MAIN_REPORT_2018.pdf

the intended safety benefit for the SIB and, therefore, the consistency of the action plan. For these reasons, it could be reasonable not to wait for the SIB performance monitoring and for the unknown future conclusions of the EUROCAE working group regarding OBWBS prior to drawing up a wider action plan. In this respect, it would be necessary to assess the potential benefits of the different technologies among those available or to come. Then an informed decision could be taken in coordination with each type certificate holder regarding the most appropriate technology(ies) for the types of aircraft. In this respect, the BEA will address several safety recommendations to EASA (to be coordinated appropriately with the FAA and other certification authorities).

4. Conclusion

By focusing and investigating on the safety management performed by the aviation authorities, the intention of the BEA was not to lead to a situation where there was less commitment from crews and operators – the immediate conclusions of the investigation refer to the human errors and to the poor effectiveness of the operator's SOPs. New systems (standardized or not) should be considered as complementary safety barriers only, meaning that efforts have to be made locally to improve safety. However, the F-GUOC serious incident again highlights that flight preparation is prone to errors at multiple points and that the operators should not be considered as able to manage the risk completely, alone.

The objective of this systemic investigation was to encourage EASA and other certification authorities to consider the big picture of this safety issue. It includes the risk description based on the lessons learned already provided by several SIAs, the exhaustive list of technical features developed by manufacturers and the levers available to them to extend their use (i.e. promotion, certification, standardization or mandatory implementation). In this sense, the objectives of the BEA investigation seem to be consistent with the recent transition to an overall risk management.

Of course, it is too early to evaluate the impact of this investigation but we can say that it has already been the occasion to agree on the following point. The mitigating actions put in place by EASA, while addressing technical solutions, have mostly targeted the reinforcement of the procedural barriers to be set up by Competent Authorities, operators, and training organisations. Although it was intended that these would be supplemented by additional safety benefits arising from inputs of the industry, the recurrence of this kind of event should lead aviation authorities to reconsider the prioritization of potential benefits achievable through the implementation of available and proven technical solutions.