NINTH MEETING OF THE ASIA PACIFIC ACCIDENT INVESTIGATION GROUP (APAC-AIG/9)

(27-28 October 2021 on Virtual Platform at 11.00 hrs. Bangkok Time UTC+7)

Agenda Item 4: Enhancing Accident Investigation Capabilities

EXTENSIVE SEARCHES IN GREENLAND LEADING TO DETERMINATION OF ROOT CAUSE OF AN A380 UNCONTAINED ENGINE FAILURE

(Presented by France)

SUMMARY

This information paper summarizes the extensive searches over Greenland which led to the determination of the root cause into this complex investigation.

1. INTRODUCTION

1.1 On Saturday, 30 September 2017, the Airbus A380-861 registered F-HPJE powered by Engine Alliance GP7270 engines, operated by Air France, was carrying out scheduled flight AF066 from Paris (France) to Los Angeles (USA). Approximately four hours after take-off, while the crew were changing en-route flight level to FL380, they heard an explosion and observed asymmetric thrust from the right side of the aeroplane, immediately followed by severe vibrations. The "ENG 4 STALL" and then the "ENG 4 FAIL" messages nearly simultaneously appeared on the ECAM. Pictures taken by passengers alerted the crew that they were facing an uncontained engine No 4 failure.

1.2 The engine performed an automatic shutdown and the crew confirmed the sequence by depressing the Engine 4 Master and Engine 4 fire pushbuttons a few seconds later. The crew started the incident processing method, FOR-DEC (Facts, Options, Risks & benefits, Decide, Execution, Check) taught by Air France and initiated decent initially to FL346. Observing that it was not possible to hold this flight level and maintain airspeed, due to the additional drag caused by the uncontained engine 4 failure, the crew continued descending level by level up to FL270 where the aircraft stabilized.

1.3 They diverted to Goose Bay airport (Canada) where they landed around two hours later without any further incidents.

1.4 The AIB DK (representing Greenland and Denmark) delegated the safety investigation to the BEA in accordance with the provisions of Regulation (EU) No 996/2010 and largely contributed to the search efforts in terms of both financial support and providing expertise.

1.5 A visual examination of engine No 4 found that the fan, first rotating assembly at the front of the engine, along with the air inlet and fan case, had separated in flight causing slight damage to the surrounding structure of the aircraft.

2. DISCUSSION

2.1 Two days after the event, the data contained in the flight data recorder (FDR) was used to determine the path and the precise position of the aircraft when the failure of engine No 4 occurred, in order to launch ballistic computation to define a search zone and locate the fragments which had separated from it. In addition, examination of the damage on the engine and simulations of the engine failure carried out by Engine Alliance made it possible to determine that the fan hub had most likely separated into at least three fragments and the size, weight and direction of ejection of the fragments were estimated.

2.2 Even though pieces of debris were recovered on the ice sheet of southwestern Greenland the days after the event, the key components were still missing. During the period when the conditions were not met to continue visual searches, and an extensive search campaign was being organised, the investigation team brainstormed on potential failure scenarios and associated immediate safety measures. The objective was to guarantee the airworthiness of the other engines in operation, preventing any further uncontained engine failure in this timeframe

Searches in Greenland

2.3 It was determined quite early on in the investigation that the recovery of the missing parts and in particular, the fragments of the fan hub, was essential to establish the circumstances and factors explaining this accident.

2.4 With the unstable weather conditions in Greenland, it soon became clear that a complementary search to the usual visual identification from a helicopter would be necessary. Searches in Greenland were made in several phases, that eventually led to the recovery of the missing fan hub parts.

Phase I

2.5 Search phase I consisted in initially determining, straight after the occurrence, a “rough zone” based on data from the FDR where debris was likely to be found and to recover the pieces.

2.6 This zone proved to be a deserted terrain covered with ice, situated approximately 100 km northwest of Narsarsuaq, in the southwestern part of Greenland. During this ten-day phase, three helicopter flights were carried out and around 30 pieces of debris were recovered: fan blade fragments, fan containment case, front cone fragments, the air inlet and parts of the nacelle. No fan hub fragment was found at this time. Snowfalls and the wind covered the parts still present in the zone with snow after a couple of days, preventing further visual detections.

Phase II

2.7 Search phase II consisted in assessing detection means to locate the hub fragments on the Greenland ice sheet as well as preparing and carrying out the search operations which took place in April and May 2018. The detection means had to be compatible with the harsh environmental conditions in the zone where the debris had fallen and with all the associated operational constraints. For these reasons, the spring of 2018 was the closest period after the accident which could be considered for search and recovery operations. Two consecutive operations were set up:

– an aerial campaign, consisting in the use of synthetic aperture radars operated by the ONERA[1] from an aeroplane, to try to detect and locate the missing parts under the layer of snow ;

– a ground campaign led by the GEUS[2], consisting in the recovery of the parts previously located during the aerial campaign, or in a systematic search with the help of ground penetrating radars if the aerial phase was unsuccessful.

2.8 Despite the efforts made in the operations described above, the fan hub fragments were not detected at the end of June 2018.

2.9 ONERA's technology, SETHI, is experimental and its deployment over the ice sheet to detect parts buried under the snow was new. Due to both the higher-than-expected background scatter noise and the less-than-expected radar penetration, no target with a sufficient confidence level was detected in the relatively short time before the ground campaign carried out by GEUS started. ONERA finally indicated six moderate-confidence targets to GEUS for its ground campaign. The GEUS ground campaign first focused on the targets detected in ONERA's aerial campaign. Once the six targets that had been provided had been explored without any debris being found, the ground campaign extended to a systematic search campaign. The GPR towed on the ice behind a snowmobile proved to be a sub-optimal sensor for a wide-area search. In all, 430 km of radar measurements were analysed without being able to certify that if the part had been located under these swaths, it would have been identified. Despite the search zones being given priorities following the more accurate ballistic calculations carried out by Airbus and the NTSB, no debris was found before this second search campaign came to an end.

2.10 The confidence of the ONERA experts that it was possible to improve the processing of the radar data to identify high-confidence targets led the BEA to envisage continuing the work. The ONERA team continued processing the radar data acquired during the aerial campaign after the team's return to France. New specific algorithms led to promising results. In conjunction with this work, the investigation team thought that it was necessary to test new ground sensors with a wider swath and a more reliable signal return before initiating a new search phase in 2019.

Phase III

2.11 The engine manufacturer carried out engine failure simulations considering a fan hub "bore to rim" fracture, the results of which were used to update the ballistic computations and refine the search zone. At the end of 2018, the HydroGeophysics Group (HGG) of Aarhus University (Denmark) offered help to the investigation when it modified its electromagnetic detection system so as to be able to detect a titanium part at a distance of five to six metres under the snow. In parallel, ONERA completed its post-processing of the radar data acquired during phase II. ONERA sent the coordinates of one high-probability target and of two less obvious targets to the investigation team. The decision to carry out a new expedition was taken at the end of February 2019 for a departure in May 2019. The expedition kick-off was delayed due to weather, which shortened the mission duration. At the very end of the campaign, at the most promising spot indicated by ONERA, an unambiguous signal was recorded. Its position was close to the spot where the GPR had already made a detection, indicative of buried metal. The detection was situated one metre north of a four-metre-wide crevasse which had a six-metre thick bridge. The presence of the crevasse meant that it was not possible for the team to dig and retrieve the fragments at that time. An excavation campaign was organized in June 2019, which was able to carefully extract a fan hub fragment (Figure 1) and transport it to an examination lab.

[1] French Aerospace Lab
[2] Geological Survey of Denmark and Greenland

Figure 1: extraction of fan hub fragment (source: Austin Lines)

3. ACTION BY THE MEETING

3.1 The Meeting is invited to note the methods used to conduct search operations and to find titanium fan hub fragment under ice.

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