Aircraft Accident Report No: 2/2018

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Report on the serious incident to
Boeing 737-86J, C-FWGH
Belfast International Airport
21 July 2017

Registered Owner and Operator:	Sunwing Airlines Inc.
Aircraft Type:	Boeing 737-86J
Nationality:	Canadian
Registration:	C-FWGH
Place of Serious Incident:	On takeoff from Belfast International Airport
Date and Time:	21 July 2017 at 1539 hrs (all times in this report are UTC unless stated otherwise)

Introduction

The Air Accidents Investigation Branch (AAIB) became aware of this serious incident during the morning of 24 July 2017. In exercise of his powers, the Chief Inspector of Air Accidents ordered an investigation to be carried out in accordance with the provisions of Regulation EU 996/2010 and the UK Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996 and, subsequently, 2018.

The sole objective of the investigation of an accident or incident under these Regulations is the prevention of accidents and incidents. It shall not be the purpose of such an investigation to apportion blame or liability.

In accordance with established international arrangements, both the National Transportation Safety Board (NTSB) of the USA, representing the State of Design and Manufacture of the aircraft, and the Transportation Safety Board (TSB) of Canada, representing the State of Registration and the Operator, appointed Accredited Representatives to the investigation. The aircraft operator, the aircraft manufacturer, the European Aviation Safety Agency (EASA), and the UK Civil Aviation Authority (CAA) also assisted the AAIB.

Summary

At 1539 hrs on 21 July 2017, a Boeing 737-800 took off from Belfast International Airport (BFS) with insufficient power to meet regulated performance requirements. The aircraft struck a supplementary runway approach light, which was 36 cm tall and 29 m beyond the end of the takeoff runway.

An outside air temperature (OAT) of -52°C had been entered into the Flight Management Computer (FMC) instead of the actual OAT of 16°C. This, together with the correctly calculated assumed temperature thrust reduction of 48°C[1], meant the aircraft engines were delivering only 60% of their maximum rated thrust. The low acceleration of the aircraft was not recognised by the crew until the aircraft was rapidly approaching the end of the runway. The aircraft rotated at the extreme end of the runway and climbed away at a very low rate. The crew did not apply full thrust until the aircraft was approximately 4 km from the end of the runway, at around 800 ft aal.

There was no damage to the aircraft, which continued its flight to Corfu, Greece without further incident. However, it was only the benign nature of the runway clearway and terrain elevation beyond, and the lack of obstacles in the climb-out path which allowed the aircraft to climb away without further collision after it struck the runway light. Had an engine failed at a critical moment during the takeoff, the consequences could have been catastrophic.

The investigation found the following causal factors for this serious incident:

1. An incorrect OAT was entered into the FMC, which caused the FMC to calculate an N_1[2] setting for takeoff which was significantly below that required for the aircraft weight and environmental conditions.

2. The incorrect OAT was not identified subsequently by the operating crew.

3. The abnormal acceleration during the takeoff run was not identified until the aircraft was rapidly approaching the end of the runway, and no action was taken to either reject the takeoff or increase engine thrust.

The investigation found the following contributory factors for this serious incident:

1. The aircraft's FMC did not have the capability to alert the flight crew to the fact that they had entered the incorrect OAT into the FMC, although this capability existed in a later FMC software standard available at the time.

2. The Electronic Flight Bags (EFB) did not display N_1 on their performance application (some applications do), which meant that the crew could not verify the FMC-calculated N_1 against an independently-calculated value.

3. The crew were unlikely to detect the abnormally low acceleration because of normal limitations in human performance.

The investigation identified other examples of accidents or serious incidents where there was a gross failure of an aircraft to achieve its expected takeoff performance, and found that technical solutions to address this serious safety issue are now feasible.

Footnote

1 See 1.1.3 for further information.
2 N_1: engine fan or low pressure compressor speed.

AAIB Special Bulletin S2/2017[3], published on 20 September 2017, provided initial information on the circumstances of this serious incident, clarification about the reporting of accidents and serious incidents, and made two safety recommendations related to FMC software updates. In this report, the AAIB makes four safety recommendations: one supersedes a recommendation made in Special Bulletin S2/2017; one concerns procedures to verify engine takeoff power settings; and two concern the development of Takeoff Acceleration Monitoring Systems.

Findings

1. The crew were properly licensed and qualified to perform the flight.

2. The pilots independently calculated the correct takeoff performance using their EFBs based on the airfield ATIS and the load instruction form.

3. During pre-flight programming of the FMC an incorrect figure (-47°C) was entered into the OAT field of the N1 LIMIT page.

4. The correct figure for the assumed temperature derate (47°C) was entered into the SEL field on the N1 LIMIT page.

5. Following an operational delay and an updated performance calculation, the correct value for the new assumed temperature (48°C) was entered into the FMC, but another incorrect figure (-52°C) was entered into the OAT field of the N1 LIMIT page.

6. Although the commander felt well rested, it was possible that he was suffering from jet lag, which might have had an adverse affect on his performance when programming the FMC.

7. The incorrect value of OAT, when combined with the correct value for the assumed temperature, meant that the FMC calculated a value of N_1 for takeoff which was significantly below the value required for the aircraft weight and environmental conditions.

8. The risk controls in place did not prevent the aircraft from beginning its takeoff run with insufficient power for the aircraft weight and environmental conditions:

    a. Pre-flight performance calculations were performed correctly twice on the EFB.

    b. The FMC was programmed incorrectly twice but a crew crosscheck, if carried out, did not highlight the incorrect value of OAT or the abnormally low value of N_1.

Footnote

[3] https://assets.publishing.service.gov.uk/media/59c2302140f0b60d848fd9ad/AAIB_S2-2017_C-FWGH.pdf [accessed September 2018].

9. The FMC software on C-FWGH was at revision U10.8A, which did not include an automated crosscheck of a manually-entered OAT against the OAT sensed by the aircraft.

10. Two manufacturer's service bulletins were available which installed FMC software revision U12.0 and which introduced an OAT crosscheck that would have alerted the crew to their erroneous OAT entry. Service bulletins are not mandatory, but Boeing recommends compliance with these bulletins by January 2019.

11. The risk of this type of error leading to a serious incident or accident would be reduced if the N_1 calculated by the FMC was crosschecked with the N_1 produced by an independently-assured source, such as a performance application on an EFB.

12. There is no requirement for EFB performance applications to display N_1 on the performance calculation output page (EFBs are not regulated), and not all operators use EFBs.

13. The low takeoff thrust meant that the takeoff was abnormal in terms of:

    a. Low acceleration.

    b. Distance along the runway to achieve V_1 and V_R.

    c. Low rotation rate.

    d. Low climb rate.

    e. Marginal ability of the aircraft to stop during an RTO from V_1.

    f. Inability of the aircraft to continue the takeoff following an engine failure at V_1 without increased thrust.

14. Once the aircraft began its takeoff run with insufficient thrust, the risk controls in place did not alert the crew to act to recover the situation because, in general:

    a. Pilots are unlikely to recognise that actual acceleration is below a threshold value for a particular runway.

    b. The use of autothrust de-couples pilots from the thrust levers.

    c. Pilots are disposed only to reduce thrust to idle during takeoff (in case of RTO).

    d. Pilots remove their hands from the thrust levers at V_1.

    e. Pilots do not have to increase thrust during a takeoff in the event of an engine failure.

15. The takeoff run was significantly longer than expected and the aircraft lifted off at the extreme end of Runway 07.

16. The aircraft struck a Runway 25 supplementary approach light which was in the stopway, 29 m beyond the end of the Runway 07.

17. Thrust was not increased until the aircraft was approximately 4 km from the end of the runway and 800 ft aal.

18. Once the thrust was increased the aircraft climbed away normally and the flight proceeded to CFU without further incident.

19. There was no damage to the aircraft.

20. There were no injuries.

21. The investigation found no faults with the aircraft which could have contributed to this serious incident.

22. Had the crew of C-FWGH been alerted to the abnormally low acceleration while still at low speed, the takeoff could have been rejected and the aircraft brought to a halt well before the end of the runway.

23. Previous attempts to develop technical specifications for TOPMS have failed because the work tended to focus on the more sophisticated options, which were complex in nature.

24. TAMS reduces the complexity of the problem by only considering acceleration during the early stages of a takeoff, and the solution is data-driven.

25. The TAMS trialled in this investigation would have alerted the crew to the abnormally low acceleration during this takeoff.

26. There is currently no technical specification or certification standard for either TOPMS or TAMS.

27. Safety margins built into TODR calculations, which cater for normal variations in operational performance, are rendered unreliable or ineffective when there is a data entry error because of the random (and possibly gross) nature of the effect.

28. It was the benign nature of the runway clearway and terrain elevation beyond, and the lack of obstacles in the climb-out path, which allowed the aircraft to climb away without further collision after it struck the runway light.

29. Staff at BFS ATC attempted to contact the crew through the watch manager at ScACC. The crew were finally contacted by the operator when the aircraft was on the ground in CFU.

30. Although BFS ATC filed an MOR, neither the commander, aircraft operator, nor tour operator informed the AAIB directly as they were required to do for a serious incident of this nature.

Safety Recommendations and Actions

Safety Recommendations

Two Safety Recommendations were made in Special Bulletin S2/2017, published in September 2017, which are reproduced below along with the response from the addressee:

> **Safety Recommendation 2017-016**
>
> It is recommended that the Federal Aviation Administration mandate the use of Flight Management Computer software revision U12.0, or later revision incorporating the outside air temperature crosscheck, for operators of Boeing 737 Next Generation aircraft.

The FAA, in its initial response to this recommendation, stated that there might be hardware and fleet compatibility issues and cost implications for some operators which it would need to understand before responding substantively. It undertook to provide an updated response by December 2018.

The AAIB classified this response as: Superceded.

> **Safety Recommendation 2017-017**
>
> It is recommended that The Boeing Company promulgates to all 737 operators the information contained within this Special Bulletin and reminds them of previous similar occurrences reported in the Boeing 737 Flight Crew Operations Manual Bulletin dated December 2014.

On 13 July 2018, Boeing issued a Multi Operator Message which described the potential for FMC OAT entry errors referring to this, and other serious incidents. The message also reminded operators of the associated service bulletins recommending the installation of revision U12.0 of the FMS OPS software and BP15 update of the CDS[4]. The message reminded operators that the final compliance date for the recommended action was 10 January 2019.

The AAIB classified this response as: Adequate – Closed.

Footnote

[4] See 1.16.3.2.

The following Safety Recommendation is made in this report, which supersedes Safety Recommendation 2017-016:

Safety Recommendation 2018-012

It is recommended that the Federal Aviation Administration mandate the use of Flight Management Computer OPS software revision U12.0, or later, and the Common Display System Block Point 15 update where this is required, to enable the outside air temperature crosscheck on all applicable Boeing 737 aircraft.

The following additional Safety Recommendations are made in this report:

Safety Recommendation 2018-013

It is recommended that Boeing Commercial Airplanes give guidance to operators of Boeing 737 aircraft on how they might verify the FMC-calculated value of N_1 against an independentlycalculated value.

Safety Recommendation 2018-014

It is recommended that the European Aviation Safety Agency, in conjunction with the Federal Aviation Administration, sponsor the development of technical specifications and, subsequently, develop certification standards for a Takeoff Acceleration Monitoring System which will alert the crew of an aircraft to abnormally low acceleration during takeoff.

Safety Recommendation 2018-015

It is recommended that the International Civil Aviation Organization note the conclusions of this report and introduce provisions addressing Takeoff Acceleration Monitoring Systems.

Safety Action

This report presents the following safety action:

Safety Action by the aircraft operator

As a result of the initial findings of this investigation into this serious incident the aircraft operator began a programme of upgrading their fleet of B737s to FMC Update 13 and CDU BP15 in order that the OAT alerting function would be available. They also updated their EFB software to display N_1 and included a crosscheck of this figure in their SOPs.

Safety Action by the UK CAA

After this serious incident, the CAA amended MATS Part 1 such that the senior controllers at ATSUs providing air traffic services at an aerodrome are required to notify the AAIB by telephone as part of their initial reporting actions following an aircraft accident or serious incident.

The CAA also amended CAP 797, *Flight Information Service Officer Manual,* to require air traffic services personnel to notify the AAIB by telephone as part of their initial reporting actions following an aircraft accident or serious incident.

In addition to the action above, a link to Regulation (EU) 996/2010 was put into MATS Part 1 and CAP 797 pointing to typical examples of what are likely to be classified as serious incidents.