Havarikommissionen
Accident Investigation Board Denmark

# BULLETIN

## Serious incident

## 30-5-2019

## involving

## DE HAVILLAND CANADA DHC-8-202

## OY-GRJ

## FOREWORD

This bulletin reflects the opinion of the Danish Accident Investigation Board regarding the circumstances of the occurrence and its causes and consequences.

In accordance with the provisions of the Danish Air Navigation Act and pursuant to Annex 13 of the International Civil Aviation Convention, the safety investigation is of an exclusively technical and operational nature, and its objective is not the assignment of blame or liability.

The safety investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents and serious incidents.

Consequently, any use of this bulletin for purposes other than preventing future accidents and serious incidents may lead to erroneous or misleading interpretations.

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**BULLETIN**

## General

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|---|---|
| File number: | 2019-234 |
| UTC date: | 30-5-2019 |
| UTC time: | 14:58 |
| Occurrence class: | Serious incident |
| Location: | Nuuk (BGGH) |
| Injury level: | None |

## Aircraft

| | |
|---|---|
| Aircraft registration: | OY-GRJ |
| Aircraft make/model: | De Havilland DHC-8-202 |
| Current flight rules: | Instrument Flight Rules (IFR) |
| Operation type: | Scheduled |
| Flight phase: | Take off |
| Aircraft category: | Fixed wing |
| Last departure point: | Nuuk (BGGH) |
| Planned destination: | Kangerlussuaq (BGSF) |
| Aircraft damage: | None |
| Engine make/model: | Pratt & Whitney Canada, PW 123D |

## SYNOPSIS

## Notification

All times in this report are UTC.

The operator notified the Aviation Unit of the Danish Accident Investigation Board (AIB) of the serious incident on 30-5-2019 at 16:31 hrs.

The AIB notified the Danish Transport, Construction and Housing Authority (DTCHA), the Canadian Transportation Safety Board (TSB), the European Aviation Safety Agency (EASA), and the Directorate-General for Mobility and Transport (DG MOVE) on 3-6-2019.

The AIB notified the International Civil Aviation Organization (ICAO) on 27-6-2019.

The TSB accredited a non-travelling representative to the safety investigation.

## Summary

The serious incident occurred during the take-off roll on runway 05 in Nuuk (BGGH).

Pre-flight mass and balance calculations using standard masses on crew, passengers, and carry-on hand baggage documented a Center of Gravity (CG) within aircraft CG limitations.

Post-flight mass and balance calculations using actual masses on crew, passengers and carry-on hand baggage documented a CG forward of the operational aircraft CG limitation.

The actual loading of the aircraft beyond forward CG operational limitations reduced the aircraft rotation ability during the take-off roll resulting in an aborted take-off.

The serious incident occurred during daylight and under visual meteorological conditions (VMC).

## FACTUAL INFORMATION

### History of the flight

The serious incident flight was a commercial scheduled IFR domestic passenger flight from BGGH to Kangerlussuaq (BGSF).

Three crewmembers and 29 passengers were onboard the aircraft.

Before the flight and in order to mitigate a forward center of gravity issue, an off duty crewmember moved from the cockpit jump seat to a passenger seat.

Nuuk Aerodrome Flight Information Service (AFIS) reported runway 05 in use, wind conditions to be 330° and 5 knots, QNH 1014, and a temperature of 10° Celsius.

Runway conditions were dry, and the visibility was more than 10 kilometers (km).

There were no remarks to the aircraft pre-flight checks.

The commander was the pilot monitoring, and the first officer was the pilot flying.

Before engine start, the first officer made a departure briefing including information on aircraft take-off configuration (a flap setting of 15°), a $V_1$ (decision speed) equal to $V_R$ (rotation speed) of 88 knots, and a review of the aborted take-off procedure.

After engine start, Nuuk AFIS reported *no traffic on the runway* and the wind conditions to be 330° and 3 knots.

The aircraft taxied to take-off position on runway 05.

The flight crew completed the before take-off checklist (including a check of aircraft flight controls) without remarks.

The first officer initiated the take-off roll.

During the take-off roll, the commander called *Sixty* (airspeed), and the first officer confirmed.

At approximately 80 knots, the commander called *Vee-One-Rotate.*

The first officer applied normal backpressure to the elevator control but experienced no positive responsive feedback (aircraft rotation) and consequentially applied full aft backpressure to the elevator control.

The first officer received no positive responsive feedback (aircraft rotation), and considered the lack of aircraft rotation to be a result of a flight control failure and aborted the take-off by retarding the power levers to DISC position and applying maximum anti-skid braking.

The aircraft came to a full stop approximately 50 meters before the end of runway 05.

The flight crew discussed different scenarios and agreed that the sequence of events did not prevent them from making a safe taxi back to the apron.

While taxiing back to the apron, the flight crew requested an external visual inspection of potential hot wheel brakes, and the commander briefed the passengers.

## Injuries to persons

| *Injuries* | *Crew* | *Passengers* | *Others* |
|---|---|---|---|
| Fatal | | | |
| Serious | | | |
| None | 3 | 29 | |

## Damage to aircraft

None.

## Other damage

None.

## Personnel information

License and medical certificate

a. The commander

The commander - male, 57 years - was the holder of a valid Air Transport Pilot License (ATPL).

The rating DHC/IR was valid until 30-5-2020.

The medical certificate (class 1) was valid until 19-10-2019. The medical certificate held the limitation: *Wear multifocal spectacles and carry a spare set of spectacles (VML).*

b. The first officer

The first officer - male, 30 years - was the holder of a valid Commercial Pilot License (CPL).

The rating DHC/IR CO-PILOT was valid until 30-6-2020.

The medical certificate (class 1) was valid until 3-9-2019. The medical certificate held no limitations.

Flying experience

a. The commander

| | Last 24 hours | Last 90 days | Total |
|---|---|---|---|
| All types | 8:15 | 85:50 | 11144:00 |
| This type | 8:15 | 85:50 | 4339:00 |
| Landings this type | 4 | 75 | - |

b. The first officer

| | Last 24 hours | Last 90 days | Total |
|---|---|---|---|
| All types | - | 182:01 | 981:00 |
| This type | - | 182:01 | 771:00 |
| Landings this type | - | - | - |

Flight and duty time

Personal flight crew schedules from 23-5-2019 until 29-5-2019.

a. The commander

Block hours: 42:36
Duty hours: 17:34

The commander stated his latest rest period to be 15:00 hours.

b. The first officer

Block hours: 8:53

## Aircraft information

General information

| | |
|---|---|
| Manufacturer: | De Havilland Aircraft of Canada Limited |
| Type: | DHC-8-202 |
| Serial number: | 496 |
| Airworthiness review certificate: | Valid until 21-3-2020 |
| Engine manufacturer: | Pratt & Whitney Canada |
| Engine type: | PW123D |
| Maximum take-off mass: | 16466 kilos (kg) / 36300 pounds (lbs) |

The aircraft was a twin-engine turboprop with a maximum passenger capacity of 37 (9 rows).

The passengers were seated in the front part of the fuselage, and the cargo compartments were placed in the rear part of the fuselage.

The aircraft could be converted to a 29- or a 21-passenger version allowing a larger cargo compartment in the rear part of the fuselage.

At the time of the serious incident, the aircraft was a 7-row 29-passenger version.

Aircraft version - see appendix 1.

Aircraft mass and CG

On 11-5-2016, the operator issued the below aircraft weighing form valid for the 29-passenger version.

| 29 Passenger version: | Weight [kg] | Weight [lb] | Moment [in lb] |
|---|---|---|---|
| BASIC EMPTY WEIGHT | 10089,6 | 22243,7 | 8806544 |
| STD. LOOSE EQUIP. (SLE) | 457,4 | 1008,4 | 430934 |
| COCKPIT CREW | 170,0 | 374,8 | 56967 |
| CABIN ATTENDANT | 75,0 | 165,3 | 37864 |
| DRY OPERATING WEIGHT (DOW) | 10792,0 | 23792,2 | 9332311 |

| | | |
|---|---|---|
| CENTER OF GRAVITY (C.G.) [in] | = | 392,24 |
| DRY OPERATING INDEX (DOI) | = | 81,54 |

Mass and balance and take-off data

a. Mass and balance software

For mass and balance calculations before the flight, the flight crew made use of an electronic software program.

The flight crew calculation contained use of crew and passenger standard masses (male/female/children) and a spread evenly free passenger seating.

The flight crew electronic presented mass and balance results - see appendix 2.

b. Loadsheet

The printed loadsheet - see appendix 3.

c. Take-off and landing speeds

The flight crew selected take-off speeds (relevant $V_R$ marked in yellow) - see appendix 4.

d. Route Performance Manual (extract)

Take-off performance data valid for BGGH - see appendix 5.

## Meteorological information

Terminal Aerodrome Forecast (TAF)

bggh 300813z 3009/3018 02008kt 0100 fg vv001 tempo 3009/3013 1500 bcfg bkn003 becmg 3013/3015 27005kt 8000 nsw sct008 tempo 3015/3018 2000 bcfg bkn004=

bggh 301114z 3012/3021 02008kt 0100 fg vv001 tempo 3012/3013 1500 bcfg bkn003 becmg 3013/3015 27005kt 8000 nsw sct008 tempo 3015/3021 2000 bcfg bkn004=

bggh 301412z 3015/3024 27006kt 9999 few004 prob40 3018/3022 2000 bcfg bkn004 becmg 3022/3024 0800 fg bkn002=

AMD bggh 301545z 3015/3024 27006kt 9999 few004 prob40 3017/3022 2000 bcfg bkn004 becmg 3022/3024 0800 fg bkn002=

Aviation Routine Weather Report (METAR)

bggh 301350z 02007kt 9999 vcfg few004 sct200 09/03 q1014=

bggh 301450z 32005kt 290v360 9999 few004 sct200 10/03 q1014=

bggh 301550z 28004kt 210v310 9999 few060 sct200 12/04 q1014=

bggh 301650z 18007kt 9999 sct200 13/04 q1014=

Runway conditions for runway 05

At the time of the serious incident, there were dry runway conditions.

## Communication

The flight crew were in radio contact with Nuuk AFIS (119.100 MHz).

The AIB obtained the involved AFIS voice recording.

The recordings were of good quality and useful to the AIB safety investigation.

## Aerodrome information

General information

| | |
|---|---|
| Aerodrome Reference Point: | 64 11 27.32N 051 40 41.03W |
| Elevation: | 283 feet |
| Runway directions: | 046.5° MAG / 226.5° MAG |
| Runway dimensions | 950 meter (m) x 30 m |
| Runway surface: | Asphalt |

ICAO aerodrome chart

See appendix 6.

## Flight recorders

The aircraft was fitted with a Flight Data Recorder (FDR), a Quick Access Recorder (QAR), and a Cockpit Voice Recorder (CVR).

The FDR data was recorded at 64 Words Per second (WPS), and was stored on the FDR and the QAR.

The AIB forwarded the QAR data file to the TSB. The TSB decoded the QAR file with a resolution of 1/64 of a second, with the exact observed times of each parameter plotted in a spreadsheet.

The AIB shipped the CVR to the TSB for a readout.

The CVR data contained five audio files in total.

Three of these CVR files were approximately 30 minutes in length and included the commander, the first officer and the observer channel. The serious incident was overwritten on these channels.

The remaining two CVR files were each approximately 2 hours in duration and included the Cockpit Area Microphone (CAM) channel and a mixed channel, which combined the 3 crew CVR channels.

The 2-hour CVR channels contained the serious incident.

The downloaded data was of good quality and useful to the AIB safety investigation.

The QAR and CVR data were synchronized using Very High Frequency (VHF) keying.

The VHF keying parameter was recorded with a resolution of 1 second.

Using multiple VHF communication events to determine the time of callouts, the CVR data was synchronized with the QAR data with an accuracy of close to 0.1 second.

With the addition of the CVR *Sixty* and *Vee-One-Rotate* callouts, the AIB generated a QAR data plot - see appendix 7.

## Organization and management information

General operator information

The operator was the largest air carrier in Greenland and constituted a major part of the Greenlandic traffic infrastructure.

The aircraft fleet consisted of helicopters, twin-engine turboprop aircraft, and one long-haul aircraft.

The area of operation (passengers, cargo and emergency medical service) was mainly the European and North Atlantic region. The long-haul aircraft was approved for worldwide operations.

The operator was the certificate holder of an approved maintenance organization.

The operator's Air Operator Certificate (AOC) held an approved Operations Manual (OM) system containing operational documentation and limitations, and Standard Operating Procedures (SOP).

Operations Manual Part A (extracts)

The AIB has removed the operator name.

The extracts from the Operations Manual Part A complied with Regulation (EU) 965/2012 on air operations.

*8.1.8.2 Procedures for preparation and acceptance of documents*

*The details for the respective mass and balance sheet will be presented in the Aircraft Flight Manual of the type concerned. Mass and balance calculations shall be prepared in accordance with those details in the Aircraft Flight Manual in order to allow the commander to determine that the load and its distribution is such that the mass and balance limits of the aircraft are not exceeded. Before all flights a load sheet containing a balance chart shall be completed by the traffic staff in accordance with the procedures contained in the Ground Handling Manual and in accordance with the OM-A and AFM for each aircraft. For take-offs from locations with no ground operations staff, the commander is responsible for the preparation of a load sheet and balance chart. However, the load sheet and balance chart may be dispensed with on charter flight when circumstances make it impracticable to do so.*

*The weight and balance sheet may be completed either in a "computerized" or "manual" form using the corresponding forms. The person responsible for the preparation will also confirm with his signature on the load sheet that the actual load distribution is according to the weight and balance sheet. This is also confirmed by the presentation to the Commander of both the loading checklist, signed by the traffic person responsible for the flight, and the loading instruction form, signed by the person who actually performed the loading of the aircraft.*

*The load sheet must be acceptable to and countersigned by the Commander (PIC). It is the responsibility of both the person preparing the weight and balance sheet and the Commander (PIC) that the correct load sheet form is used.*

*The load sheet and balance chart shall be distributed as follows:*

*1. One copy to the Commander*
*2. One copy with the signature of traffic staff and the Commander (PIC) to be filed electronic or at place of departure. (Remains in archives for 6 months).*

*For further information regarding charter and special operations, refer to the applicable OM-B. Where "free seating" is used for xxx flights, the cabin crew must be briefed in advance on the planned placement of passengers to ensure that the seating planned on the load sheet is that achieved in practice. This briefing could be as simple as the Commander telling the cabin attendant prior to boarding that there will be "forward seating". If more detailed seating instructions are necessary, the*

*Commander should ensure that they are given to the cabin attendant in time to arrange the proper seating without undue delay of the flight's departure.*

*The number of persons on board an aircraft in flight shall not exceed the maximum number of people for which the aircraft is certified according to the certificate of airworthiness.*

*8.1.8.3 Policy for using either standard or actual masses*

*The weight of crewmembers, passengers and baggage shall be computed using either the actual weight of each person and the actual weight of baggage - or the standard weights specified in the tables below. It is xxx policy that the standard weights should be used. However, the Commander has the discretion to use the actual weights if, in his opinion, an operational benefit will accrue from the use of actual weights. If actual weights are used it must be ensured that passenger's personal belongings and hand baggage is included. Such weighing must be conducted immediately prior to boarding and at an adjacent location. A note explaining other than non-standard passenger weights must be placed on the weight and balance sheet.*

*In the event that a flight is identified by the sales office, traffic office, cabin crew or loading crew as carrying a significant number of passengers whose masses, including hand baggage, are expected to exceed the standard passenger masses, and/or groups of passengers carrying exceptionally heavy baggage (i.e. military or sports teams), the commander will be notified. In such an event, it is expected that a reweighing of the passengers and baggage will have to take place and the actual weights used in preparing the flight mass and balance documentation.*

*8.1.8.5.1 Standard weights crewmembers, incl. hand baggage*

| | |
|---|---|
| Flight Crew members | 85 kg (187 lbs) |
| Cabin crew members | 75 kg (165 lbs) |
| Technical Crew members | 85 kg (187 lbs) |

*8.1.8.5.2 Passenger standard weights, 20 pax seats or more*

| Passenger seats | 20 and more | | 30 and more all Adult |
|---|---|---|---|
| | Male | Female | |
| All flights except holiday charters | 88 kg (194 lbs) | 70 kg (154 lbs) | 84 kg (185 lbs) |
| Holiday charters | 83 kg (183 lbs) | 69 kg (152 lbs) | 76 kg (168 lbs) |
| Children | 35 kg (77 lbs) | 35 kg (77 lbs) | 35 kg (77 lbs) |

Operations Manual Part B (extracts)

The AIB has removed the operator name.

*2.1.6.2.2 Normal takeoff procedure*

| PF | PM |
|---|---|
| Once the aircraft is aligned with the runway, place one hand on the control column and the other on the power levers.<br>**Announce: "Takeoff."** | Release the control column (or tiller if the RP is PF) |
| Advance power levers to app. 60% TQ, check that autofeather arms and releasing the brakes while advancing power levers towards calculated takeoff power:<br>**Announce: "Autofeather armed." then**<br>**Announce: "Set power __%."** | Adjust power to calculated takeoff power.<br>**Announce: "Power set __%."** |
| Crosscheck speed<br>**Responds: "checked"** | Reaching 60 KIAS, **call "60"** |
| Place both hands on the control column and smoothly rotate the aircraft to FD bars<br><br>**Respond: "Gear up."**<br><br>**Respond: "Checked."** | **At $V_R$ call: "Vee-ONE - Rotate."**<br>In case of split between $V_1$ and $V_R$ **call "Vee-ONE" and "Rotate." upon passing $V_R$.**<br><br>When a positive rate of climb is indicated on the VSI and the altimeter:<br>**Announce: "Positive climb"**<br>Select the gear up and check that the gear retraction sequence initiates.<br>**Respond: "Gear up selected – in transit."**<br>When gear is up:<br>**Gear up checked."** |

*3.1.8.1 Malfunction during takeoff*

*3.1.8.1.1 General*

*In order to aid in reaching a quick and correct decision, should an abnormality occur, it is recommended that the Commander, prior to starting a takeoff, makes a mental review of the known or reported factors affecting that particular takeoff, e.g.:*

*a. gross weight;*
*b. available runway length (overrun) and runway conditions;*
*c. obstacles (beyond the threshold and in the climb-out area);*
*d. climb-out conditions (icing, wind conditions).*

*3.1.8.1.2 Critical Decision Point*

*If a serious failure is recognized during takeoff before reaching V1, the pilot recognizing the failure will call "Malfunction". The Commander will make the decision and call "Stop" or "Continue" and the PF will take action accordingly.*

*If the abnormality is seriously affecting the takeoff thrust, e. g. engine failure, the following basic rules apply:*

*a. if occurring at of after V1, normally continue.*
*b. if occurring before V1, normally discontinue.*

*After commander calls: "STOP". Thereafter,*
*If LP is PF:*

| LP | RP |
|---|---|
| All power levers DISC, Max braking | Informs ATC: " **XXX aborting – standby"**<br>Inform PF of situation |

| LP | RP |
|---|---|
| **Respond: "My controls."**All power levers DISC, max. anti-skid braking (full pedal deflection) is applied until the airplane is brought to a complete stop. | All power levers DISC, max braking. When approaching 60 KIAS **Announce: "Your controls."**<br><br>Informs ATC: " **XXX aborting – standby."** |

*3.1.9.2 Other Failures*

*When other abnormalities occur, their nature and time of occurrence must be taken into consideration.*

*When occurring at an early stage of the takeoff where no doubt exists as to a safe stopping on the runway, then discontinue.*

*If occurring at speeds close to reaching V1, the nature of the abnormality and its effect on the airworthiness of the aircraft in a continued flight must be judged verses the possibility of making a safe stop.*

*The following type of abnormalities may justify a continued takeoff:*

a. *engine fire warning when all engines develop normal thrust;*
b. *indication failure of instruments not absolutely required;*
c. *general electrical failures;*
d. *pilot incapacitation (body not blocking controls).*

*The following type of abnormalities may justify an aborted takeoff:*

a. *collision with foreign objects resulting in structural damage;*
b. *flight control failure or blocking of controls.*

*Note: A takeoff aborted at speeds above V1 on a minimum length runway is unprotected from a performance point of view.*

## AIB safety investigation

Technical safety investigation

The operator performed checks of the aircraft longitudinal control systems for defects and correct rigging in accordance with the Aircraft Maintenance Manual (AMM).

The operator checks only revealed few items to be slightly out of AMM stated limitations, and the operator check results led to minor rigging adjustments.

The operator performed a test for correct calibration of the pitot static system. The pitot static test revealed a 3 knot higher airspeed indication than the actual airspeed. This deviation on airspeed indication was within AMM limitations.

The Type Certificate (TC) holder determined that none of these technical deviations had a significant influence on the reduced rotation ability of the aircraft.

Operational safety investigation

a. Mass and balance

The AIB decided to launch the following operational safety investigations on mass and balance:

1. A reweighing of the aircraft.
2. A reweighing of the onboard baggage and cargo (cargo holds).
3. A comparison of mass and balance results, using standard masses, by use of the operator electronic software program versus an AIB manual mass and balance calculation using the aircraft *Weight and Balance Manual*.
4. An AIB survey among crew and passengers on actual crew and passenger masses, actual masses of carry-on hand baggage, actual masses of wardrobe baggage, and actual passenger seating.

1. Reweighing of the aircraft

The reweighing of the aircraft revealed no significant differences or flaws to the weighing report in use at the time of the serious incident.

| **29 Passenger version:** | **Weight [kg]** | **Weight [lb]** | **Moment [in lb]** |
|---|---|---|---|
| BASIC EMPTY WEIGHT | 10123,9 | 22319,5 | 8835630 |
| STD. LOOSE EQUIP. (SLE) | 428,7 | 945,1 | 396854 |
| COCKPIT CREW | 170,0 | 374,8 | 56967 |
| CABIN ATTENDANT | 75,0 | 165,3 | 37864 |
| DRY OPERATING WEIGHT (DOW) | 10797,6 | 23804,7 | 9327316 |

| | | |
|---|---|---|
| CENTER OF GRAVITY (C.G.) [in] | = | 391,83 |

| | | |
|---|---|---|
| DRY OPERATING INDEX (DOI) | = | 80,54 |

2. Reweighing of the onboard baggage and cargo

The reweighing of the onboard baggage and cargo did not reveal inaccuracies.

3. Comparison of mass and balance results

The comparison of results between the operator electronic software program and the AIB manual mass and balance calculation only revealed insignificant differences.

The operator electronic software program did however not contain the possibility to include mass and balance of wardrobe baggage.

The flight crew electronic presented mass and balance result - see appendix 2.

The AIB manual mass and balance calculation using the aircraft *Weight and Balance Manual* - see appendix 8.

4. AIB crew and passenger survey

The AIB survey among crew and passengers featured three questions:

- Your actual mass.
- The actual mass of your carry-on hand baggage.
- Your actual seating.

The reply rate was 100% and useful to the AIB Safety investigation.

Based on obtained data (reweighing report, actual aircraft version, actual onboard baggage and cargo, and the AIB crew and passenger survey), the AIB prepared a mass and balance calculation - see appendix 9.

b. EASA survey of standard masses of passengers and baggage

In March 2008, EASA granted a private research company the service contract for the performance of a survey on standard masses of passengers and baggage.

The aim of the survey was to conduct a Pan-European survey of the current masses of passengers, carry-on luggage and checked baggage.

The conclusions and recommendations of the final report (EASA 2008.C.06/30800/R20090095/30800000/FBR/RLO) were:

*5.1.3 Conclusions on comparison of survey results with EUOPS*

*The 2008 - 2009 EASA survey on Standard Weights of Passengers and Baggage gives best estimates for the standard masses for the passenger categories 'male' and 'female' and all adults for the periods under consideration. It has been concluded in the survey that gender and ratio are the most important*

*factors in determining the standard masses of adult passengers.*
*It can be concluded that the standard masses of male and female passengers have increased, compared to current EU safety regulations. However, the increase of the standard mass for all adults on scheduled flights, is less than would have been expected. This is a result of the fact that the male/female ratio is changed (as a result of this survey).*

*Although the standard masses of checked baggage differs from the standard mass of the standard masses for route type in current EU safety regulations, it is recommended to disregard the factor 'route type', because it does not comply with the set criteria for appropriateness.*

*The following standard masses for updating EU safety regulations are recommended:*

| *Passenger seats:* | *20 and more* | | *30 and more* | |
|---|---|---|---|---|
| *Passengers* | *Male* | *Female* | *M/F ratio* | *All adult* |
| All flights | 94 kg | 75 kg | 70/30 | 88 kg |
| *Checked baggage* | | | | |
| All flights | 17 kg | 17 kg | n.a. | 17 kg |

*5.2 Recommendations on revisions of standard mass regulations*

*Revision of the regulations on standard masses for passengers, carry-on luggage and checked baggage is recommended. This is supported by two empirical issues:*

- *The outcomes of the survey indeed showed an increase in passenger mass and checked baggage mass as suggested in JAA SWWG report dated the 31st of October, 2006.*

- *The desk research in chapter 1 provides a summary of several studies in which the increase of body mass is also confirmed.*

*The findings from these studies are as follows:*

- *Recent worldwide research has revealed that passenger's body mass has increased and clothing is generally heavier in the Winter months. Research shows a clear upward trend, even in countries with traditionally lower rates of overweight and obesity.*
- *The increase of overweight amongst children and adolescents has accelerated in recent years. According to the most recent data on nationally representative samples from different countries in the European Region, the prevalence of obesity ranges from 5% to 20% in men and up to 30% in women.*

- *The increased consumption of more energy-dense, nutrient-poor foods with higher levels of sugar and saturated fats, combined with reduced physical activity (more sedentary lifestyle due to the rise in welfare), have led to overweight and obesity rates that have risen three-fold or more all over the world since 1980.*

*It is expected that the standard mass of the European population in the coming years will increase further based on the following:*

- *In 10 years time the current younger adult generation will represent the age class between 40 to 50 years and will show a further increase in body mass, based on the predictions of desk research.*
- *In case the survey is carried out in one year, the probability of measuring different standard masses is unlikely because of minor mass changes.*

*Based on this, a full new survey to update the dataset is recommended in 10 years time. As mentioned before, it is not recommended to use statistical extrapolation in order to determine future standard masses for passengers.*

*Due to the high accuracy outcome of the survey for children, it is not possible to determine a standard mass for children. In order to determine a new statistical standard mass for children, it is recommended to perform an additional survey with special focus on children.*

On 4-7-2019, the AIB asked EASA whether an updated survey existed.

With reference to the European Plan for Aviation Safety (EPAS 2019-2023) Rule Making Task (RMT) 0312, EASA replied that the task was de-prioritized.

**RMT.0312** **Review of standard weight**

Transposed task from the JAA to review the standard weights due to demographic changes. Review of IRs/AMC & GM based on the weight survey commissioned by EASA.

*This task is de-prioritised in accordance with criteria described in Chapter 3.*

| Owner | Affected stakeholders |
|---|---|
| EASA FS.2 | CAT and NCC operators |

| PIA | Proc | 3rdC | ToR | NPA | Opinion | Commission IR | Decision |
|---|---|---|---|---|---|---|---|
| B3 | ST | - | | | | | |

## ANALYSIS

General findings

The licenses and qualifications held by the flight crew and their duty time had, in the AIB's opinion, no influence on the sequence of events.

Actual runway conditions (runway 05) were dry, which had a positive effect on the aircraft accelerate-stop distance.

Aircraft take-off performance (performance data for runway 05) for the serious incident flight was not influential.

From a human performance point of view, the AIB considers the flight to be a routine operation. The pre-flight flight crew workload was equal to the expected pre-flight workload.

To the AIB, the technical status of the aircraft had no direct influence on the sequence of events.

When actual masses (crew, passengers and carry-on hand baggage) increased above standard masses, the architecture of this aircraft version made the aircraft vulnerable to CG movements.

Mass and balance

Before departure, the flight crew were aware of a forward CG issue leading to a repositioning of an off-duty crewmember from the cockpit to the cabin.

The mass and balance calculations, based on standard masses, prepared by the flight crew before the flight and subsequently by the AIB resulted in a CG within aircraft CG limitations.

The mass and balance calculation, based on actual masses (an increase of masses compared to standard masses of approximately 13% on crew, wardrobe, passengers and carry-on hand baggage), prepared by the AIB resulted in a CG 2.4 inches forward of and outside aircraft operational CG limitations.

To the AIB, actual masses above standard masses resulted in the CG being forward of and outside aircraft operational CG limitations and was the root cause to reduced aircraft rotation ability.

Operating procedures, which complied with Regulation (EU) 965/2012 on air operations, stipulated ground handling and cabin crewmembers to notify the commander when observing significant number of passengers whose masses, including carry-on hand baggage, are expected to exceed the standard passenger masses.

The AIB questions the effectiveness and the strength of this operating procedure (risk control), because such observations to the AIB are affected by for instance culture, subjective perception, working experience, and individual training.

An EASA consultancy survey on masses of passengers and baggage back in year 2008 encouraged EASA to update the dataset within 10 years.

At this point, EASA has decided to deprioritize this task.

Taking the severity of this serious incident into consideration, the AIB encourages EASA to reconsider their task prioritization on this matter.

The take-off roll on runway 05

Prior to the take-off roll, the flight crew experienced no precursors of the upcoming sequence of events.

During the take-off roll and at approximately 80 knots, the commander called *Vee-One-Rotate* leading the first officer to apply backpressure to the elevator control.

The pitot static test revealed a 3 knot higher airspeed indication than the actual airspeed (however within AMM limitations).

The 3 knot higher airspeed indication in combination with the premature commander callout most likely prolonged the first officer's time perception of no positive responsive feedback resulting in a sooner decision on aborting the take-off roll. These findings might have been causal but were not the root cause.

Even though, the aircraft accelerated to an airspeed above $V_R$ (88 knots), and the first officer applied full backpressure to the elevator control, the control input only generated a minor increase in pitch attitude.

For that reason, the rationale behind the decision on aborting the take-off roll complied with the operating procedures and potentially prevented a more severe outcome.

## CONCLUSIONS

Actual masses above standard masses on crew, passengers and carry-on hand baggage led to a CG forward of the operational aircraft CG limitations causing reduced aircraft rotation ability during the take-off roll.

## PREVENTIVE ACTIONS

Since the time of the serious incident, the operator has launched the following safety initiatives:

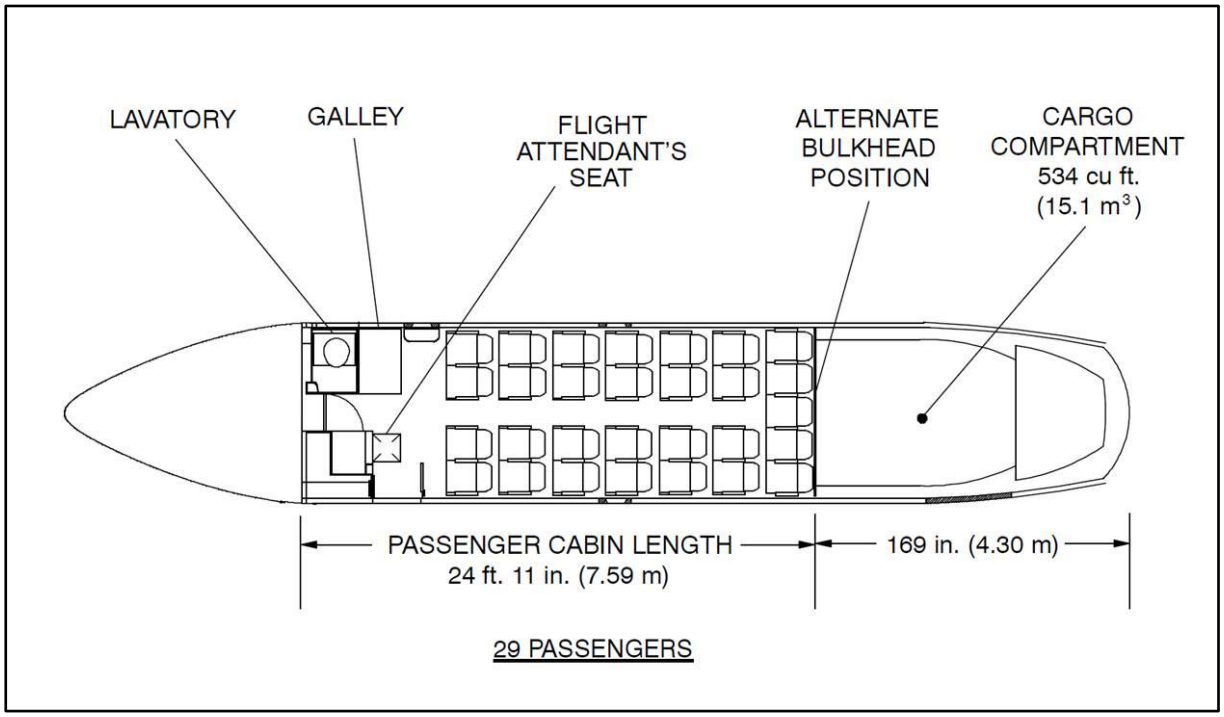
- Revision of the mass and balance CG envelope in order to cater for increased actual passenger masses according to AMC1 CAT.POL.MAB.100( a)(8).

- Implementation of zone distribution when *seating* the passengers in the mass and balance module of the Electronic Flight Bag, in order to assure more control of extreme forward and aft seating compared to the *spread evenly* technique.

- Inclusion of a set value for wardrobe contents (crew overnight bags etc.) of 25 kg.

## APPENDIX 1

Return to general information



## APPENDIX 2

Return to mass and balance and take-off data or return to AIB safety investigation


The Dry Operating Weight (DOW) included 64 kg of catering.

## APPENDIX 3

Return to mass and balance and take-off data

```
L O A D S H E E T           CHECKED                    APPROVED
ALL WEIGHTS IN KILOGRAMS
                            ON 30 MAY 2019 1451Z       ON 30 MAY 2019 1451Z
FROM/TO  FLIGHT     A/C REG  VARIATION         CONFIG     DATE         TIME
GOH  SFJ    BGGH     OYGRJ    M29               2/1        30 MAY 2019 1500Z
BGSF
                        WEIGHT           DISTRIBUTION
LOAD IN COMPARTMENTS    419    ||0|20|399|||
PASSENGER / CABIN BAG   2445   025/003/001/    TTL 29
TOTAL TRAFFIC LOAD      2864                    SOC
DRY OPERATING WEIGHT    10856
ZERO FUEL WEIGHT ACTUAL 13720  MAX 14696
TAKE OFF FUEL           1530
TAKE OFF WEIGHT  ACTUAL 15250  MAX 16466
TRIP FUEL               562
LANDING WEIGHT   ACTUAL 14688  MAX 15650
*****************************************************************************
BALANCE AND SEATING CONDITIONS
DOI                     79.15548
LIZFW                   85.27 MACZFW                  20.37
LITOW                   88.04 MACTOW                  21.88
LILW                    87.02 MACLW                   21.36
FWD AND AFT INDEX LIMITS
TO:  0.0 I-----------I 0.0
LD:  0.0 I-----------I 0.0
ZF:  0.0 I-----------I 0.0
THS
PAX DISTRIBUTION
UNDERLOAD BEFORE LMC    962
*****************************************************************************
NOTOC                   NO
```

Note. The AIB has removed the operator name and flight crew data.

## APPENDIX 4

Return to mass and balance and take-off data

| DHC8-202/202S<br>Issue 5 – 16.08.2015 | | | | |
|---|---|---|---|---|
| | **15.650** | | | |
| **TAKE OFF** | | | | |
| FLAPS | **35°** | **15°** | **5°** | **0°** |
| $V_R$ | | 88 | 94 | |
| $V_2$ ▶ | | 94 | 103 | |
| $V_{FRI}$ | | 99 | 109 | |
| $V_{FTO}$ ▷ | 118 flap 0° | | (ICE +15 kts) | |
| | | | | |
| **LANDING** | | | | |
| $V_{REF}$ ▶ | 92 | 102 | 111 | 123 |
| $V_{ICE}$ | 97 | 112 | 126 | 138 |

Note. The AIB has removed the operator name.

## APPENDIX 5

Return to mass and balance and take-off data

| | | |
|---|---|---|
| | **DHC-8-202S / PW 123D**<br>Route Performance Manual | Sheet : BGGHgrl-05.DHC<br>Date : Oct 10 2017 |
| TORA 950 m<br>ASDA 950 m<br>TODA 950 m<br>LDA 950 m | **NUUK/GODTHAB**<br>Slope 0.32% Uphill<br>AD Elev 283 ft **BGGH/GOH 05.DHC** | **Opt.Flaps**<br>Bleeds . . . . . OFF<br>Anti-skid . . . . OPER<br>**Static TO** |

Climb STRAIGHT ahead. At D2.0 "GN" DME turn LEFT (max 125 KTAS) DIRECT "KU" NDB. At "KU" NDB, join holding.

**TAKEOFF - Dry runway - Max structural mass: 16466 kg**

| OAT / TRQ | WIND T 5 kt | Calm | H 5 kt | H 10 kt | H 15 kt | H 20 kt | H 25 kt |
|---|---|---|---|---|---|---|---|
| 30°C 99.5% | **14038**(8) F [15] 82/82/90 | **15210**(9) F [15] 88/88/93 | **15507**(10) F [15] 89/89/94 | **15809**(10) F [15] 90/90/95 | **16132**(10) F [15] 91/91/96 | **16508**(11) F [15] [93/93/97] | **16874**(10) F [15] [94/94/98] |
| 25°C 99.5% | **14194**(9) F [15] 83/83/90 | **15382**(10) F [15] 88/88/94 | **15684**(10) F [15] 90/90/95 | **15993**(10) F [15] 91/91/96 | **16340**(11) F [15] 92/92/97 | **16721**(12) F [15] [93/94/98] | **16874**(5) F [15] [94/94/98] |
| 20°C 99.5% | **14341**(9) F [15] 84/84/91 | **15544**(10) F [15] 89/89/94 | **15849**(10) F [15] 90/90/95 | **16166**(11) F [15] 91/91/96 | **16534**(12) F [15] [93/93/97] | **16874**(11) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] |
| 15°C 99.5% | **14487**(9) F [15] 84/84/91 | **15705**(10) F [15] 89/89/95 | **16012**(10) F [15] 91/91/96 | **16338**(10) F [15] 92/92/96 | **16715**(11) F [15] [94/94/98] | **16874**(5) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] |
| 10°C 99.5% | **14641**(9) F [15] 85/85/92 | **15875**(9) F [15] 90/90/95 | **16186**(10) F [15] 91/91/96 | **16520**(10) F [15] [93/93/97] | **16874**(10) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] |
| 8°C 99.5% | **14708**(9) F [15] 85/85/92 | **15950**(10) F [15] 90/90/95 | **16263**(10) F [15] 92/92/96 | **16602**(10) F [15] [93/93/97] | **16874**(7) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] |
| 6°C 99.5% | **14786**(9) F [15] 85/85/92 | **16041**(10) F [15] 91/91/96 | **16361**(10) F [15] 92/92/97 | **16707**(11) F [15] [93/93/98] | **16874**(5) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] |
| 4°C 99.5% | **14864**(9) F [15] 85/85/92 | **16131**(11) F [15] 91/91/96 | **16458**(11) F [15] 92/92/97 | **16811**(12) F [15] [94/94/98] | **16874**(3) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(11) F [5] [101/101/108] |
| 2°C 99.5% | **14942**(10) F [15] 86/86/92 | **16222**(11) F [15] 91/91/96 | **16555**(12) F [15] [93/93/97] | **16874**(12) F [15] [94/94/98] | **16874**(1) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(8) F [5] [101/101/108] |
| 0°C 99.5% | **15021**(10) F [15] 86/86/93 | **16312**(12) F [15] 92/92/96 | **16652**(13) F [15] [93/93/97] | **16874**(9) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(6) F [5] [101/101/108] |
| -2°C 99.5% | **15099**(10) F [15] 86/86/93 | **16403**(12) F [15] 92/92/97 | **16750**(13) F [15] [93/93/98] | **16874**(7) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(3) F [5] [101/101/108] |
| -4°C 99.5% | **15177**(10) F [15] 87/87/93 | **16493**(12) F [15] [92/92/97] | **16847**(13) F [15] [94/94/98] | **16874**(4) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(9) F [5] [101/101/108] | **16874**(0) F [5] [101/101/108] |
| -6°C 99.5% | **15255**(10) F [15] 87/87/93 | **16584**(12) F [15] [93/93/97] | **16874**(11) F [15] [94/94/98] | **16874**(1) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(6) F [5] [101/101/108] | **16874**(0) F [5] [101/101/108] |
| -8°C 99.5% | **15333**(10) F [15] 87/87/94 | **16675**(12) F [15] [93/93/97] | **16874**(8) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(4) F [5] [101/101/108] | **16874**(0) F [5] [101/101/108] |
| -10°C 99.5% | **15412**(10) F [15] 88/88/94 | **16765**(12) F [15] [93/93/98] | **16874**(5) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(1) F [5] [101/101/108] | **16874**(0) F [5] [101/101/108] |
| -15°C 99.5% | **15607**(10) F [15] 88/88/94 | **16874**(8) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(6) F [5] [101/101/108] | **16874**(0) F [5] [101/101/108] | **16874**(0) F [5] [101/101/108] |
| -20°C 99.5% | **15803**(10) F [15] 89/89/95 | **16874**(2) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(1) F [5] [101/101/108] | **16874**(0) F [5] [101/101/108] | **16874**(0) F [5] [101/101/108] |
| -25°C 99.5% | **15998**(10) F [15] 90/90/96 | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(5) F [5] [100/100/108] | **16874**(0) F [5] [100/100/108] | **16874**(0) F [5] [100/100/108] | **16874**(0) F [5] [100/100/108] |
| -30°C 99.5% | **16194**(9) F [15] 91/91/96 | **16874**(0) F [15] [94/94/98] | **16874**(0) F [15] [94/94/98] | **16874**(0) F [5] [100/100/108] | **16874**(0) F [5] [100/100/108] | **16874**(0) F [5] [100/100/108] | **16874**(0) F [5] [100/100/108] |

Limit code: F=Field, Fb=Brakes, Fv=V1min, O=Obstacle, Oz=5 min Takeoff thrust time and C=Climb.

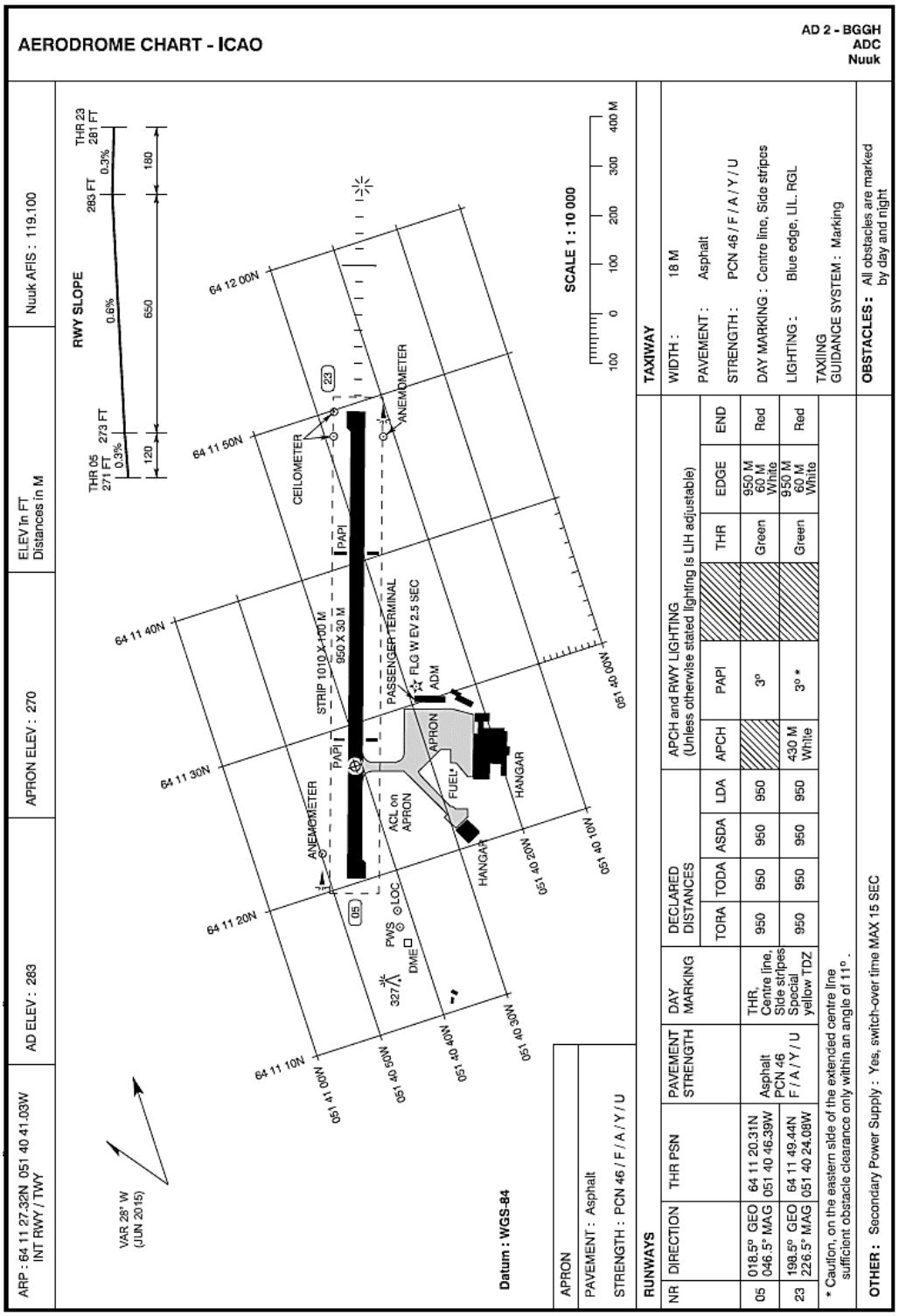
**EASA-OPS line-up with 180 degr turnaround**

Obstacles included in calculation: (Height above runway end / Distance from brake release point)
No obstacles.

Note. The AIB has removed the operator name.

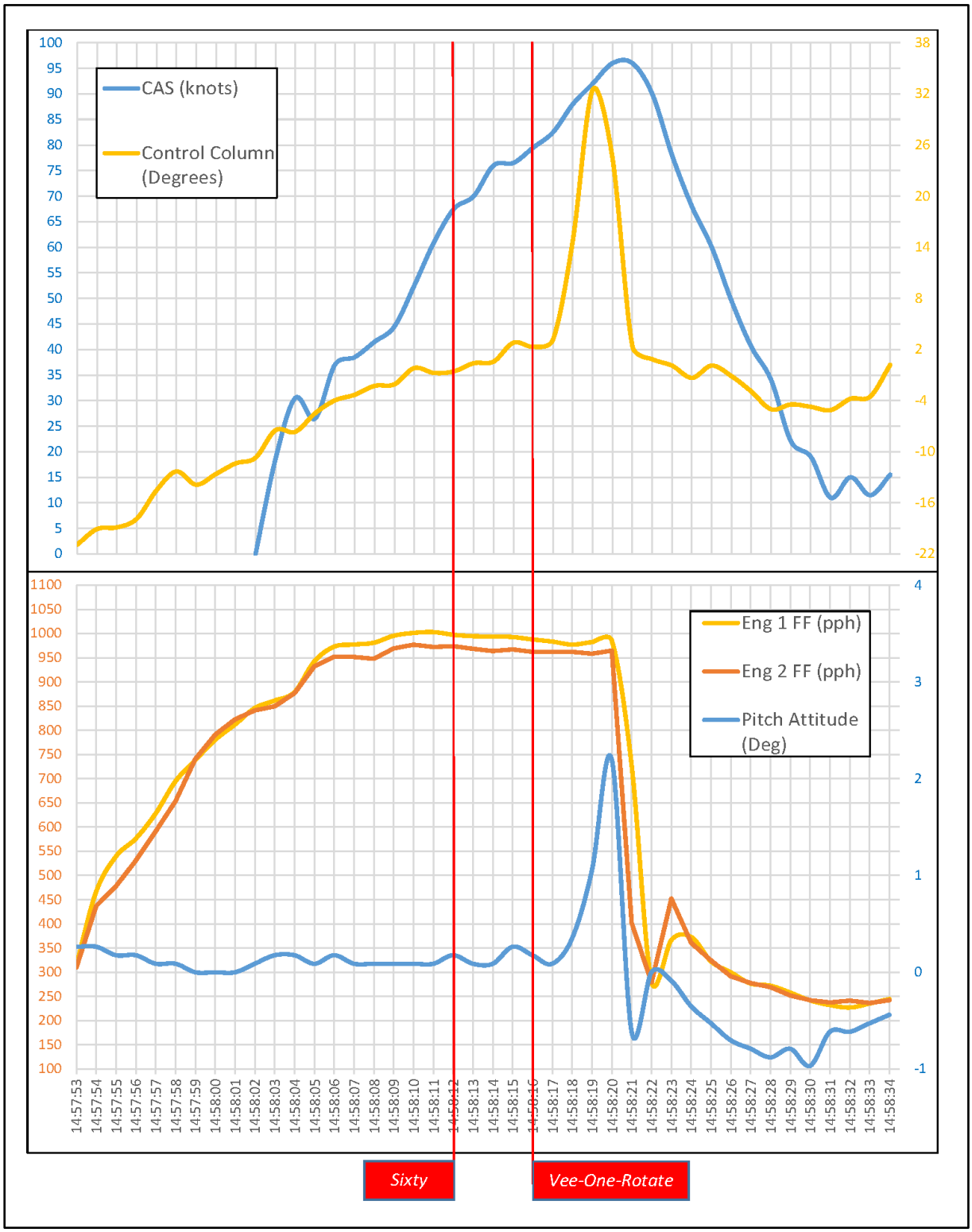
## APPENDIX 6

Return to aerodrome information



## APPENDIX 7

Return to flight recorders




Note. The elevator position attained was sufficient to rotate an aircraft loaded within the operational CG envelope (elevator position not presented in this plot).

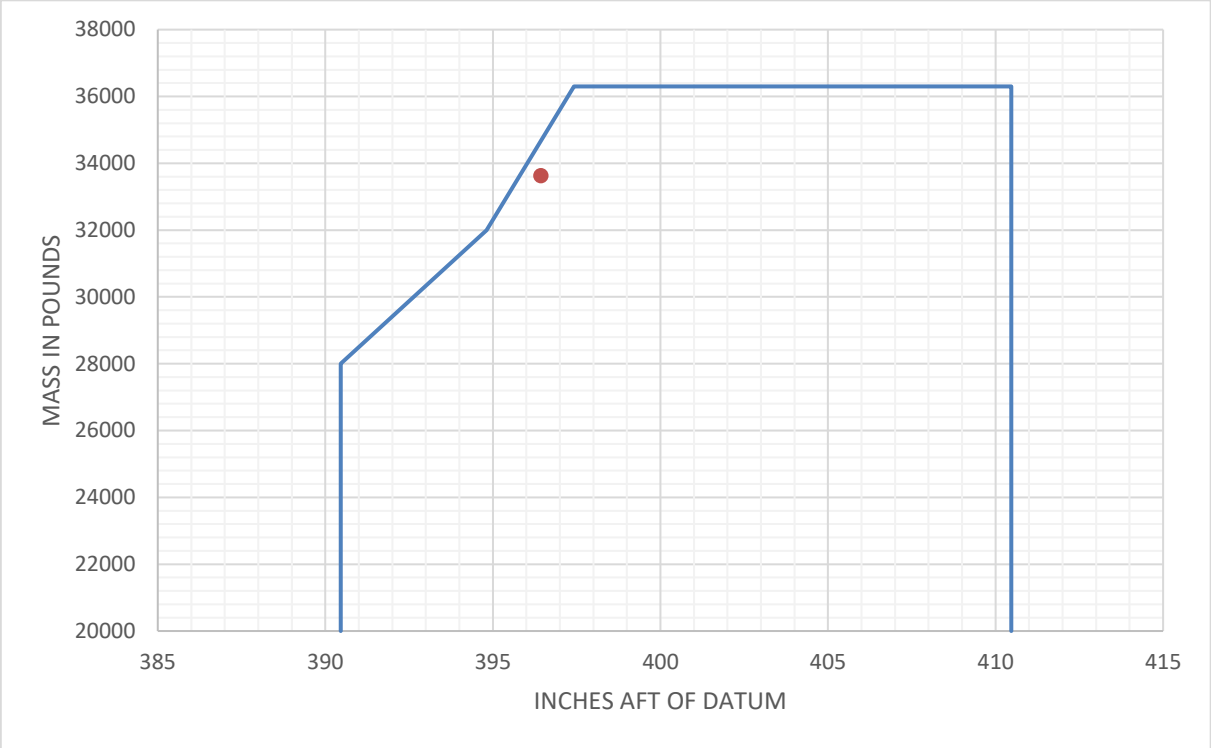
## APPENDIX 8

Return to AIB safety investigation

Mass and balance calculation

| Description | Mass (Lbs) | Arm (In) | Moment (InLbs) |
|---|---|---|---|
| Basic empty mass | 22.243,70 | 395,91 | 8.806.544,00 |
| Standard loose equipment | 1.008,40 | 427,34 | 430.934,00 |
| Pilots | 374,79 | 152,00 | 56.967,38 |
| Observer | 0,00 | 185,00 | 0,00 |
| Wardrobe | 0,00 | 210,00 | 0,00 |
| CA | 165,35 | 229,00 | 37.864,35 |
| Catering | 141,10 | 230,00 | 32.452,01 |
| Row 1 | 743,49 | 276,00 | 205.202,99 |
| Row 2 | 743,49 | 307,00 | 228.251,15 |
| Row 3 | 743,49 | 338,00 | 251.299,31 |
| Row 4 | 743,49 | 371,00 | 275.834,45 |
| Row 5 | 743,49 | 402,00 | 298.882,61 |
| Row 6 | 743,49 | 433,00 | 321.930,78 |
| Row 7 | 929,36 | 464,00 | 431.223,67 |
| Cargo Compartment A | 0,00 | 514,40 | 0,00 |
| Cargo Compartment 1 | 44,09 | 571,00 | 25.176,76 |
| Cargo Compartment 2 | 879,64 | 624,00 | 548.897,47 |
| Fuel | 3.373,07 | 408,20 | 1.376.886,60 |
| Total | 33.620,43 | 396,44 | 13.328.347,53 |

Mass and balance diagram



## APPENDIX 9

Return to AIB safety investigation

Mass and balance calculation

| Description | Mass (Lbs) | Arm (In) | Moment (InLbs) |
|---|---|---|---|
| Basic empty mass | 22.319,50 | 395,87 | 8.835.630,00 |
| Standard loose equipment | 945,10 | 419,90 | 396.854,00 |
| Pilots | 443,13 | 152,00 | 67.355,55 |
| Observer | 0,00 | 185,00 | 0,00 |
| Wardrobe | 46,30 | 210,00 | 9.722,37 |
| CA | 178,57 | 229,00 | 40.893,50 |
| Catering | 141,10 | 230,00 | 32.452,01 |
| Row 1 | 903,89 | 276,00 | 249.474,80 |
| Row 2 | 908,30 | 307,00 | 278.849,16 |
| Row 3 | 967,83 | 338,00 | 327.125,92 |
| Row 4 | 890,67 | 371,00 | 330.437,26 |
| Row 5 | 670,20 | 402,00 | 269.422,20 |
| Row 6 | 824,53 | 433,00 | 357.020,57 |
| Row 7 | 877,44 | 464,00 | 407.131,58 |
| Cargo Compartment A | 0,00 | 514,40 | 0,00 |
| Cargo Compartment 1 | 44,09 | 571,00 | 25.176,76 |
| Cargo Compartment 2 | 879,64 | 624,00 | 548.897,47 |
| Fuel | 3.373,07 | 408,20 | 1.376.886,60 |
| Total | 34.413,36 | 393,84 | 13.553.329,76 |

Mass and balance diagram