RNSA

Rannsóknarnefnd samgönguslysa

Final report on aircraft accident

Case number: **M-01513/AIG-11**

Date: **5. August 2013**

Location: **At an automobile racetrack approximately 2.5 NM north-west of Akureyri Airport, Iceland**

Description: **The aircraft collided with the ground during a steep left turn**

CONTENTS

SYNOPSIS

On 5th of August 2013, a Beech King Air B200 with two flight crew members and a paramedic on board was heading back to its home base at Akureyri Airport (BIAR), after completing an ambulance flight from Höfn (BIHN) to Reykjavik Airport (BIRK).

When approaching the airfield, the flight crew requested to overfly the town of Akureyri before landing. The purpose of the detour was to fly over an automobile racetrack area that the commander was familiar with. As the aircraft approached the racetrack area, it entered a steep left turn and in line with the racetrack, collided with the ground. The commander and the paramedic were fatally injured and the co-pilot was seriously injured. The aircraft was destroyed.

A discussed flyby over the racetrack area was executed as a low-pass where a steep bank angle was needed in order to line up with the racetrack. The investigation revealed that the flyby/low-pass was insufficiently planned and outside the scope of operations manuals and handbooks. The pass was made at such a low altitude and steep bank that a loss of control occurred and a correction was not possible in due time and the aircraft collided with the racetrack.

The ITSB believes that human factor plays a major role in this accident. Inadequate collaboration and planning of the flyover amongst the flight crew indicates a failure of CRM. This caused the flight crew to be less able to make timely corrections.

Two safety recommendations were made and one safety action.

1. FACTUAL INFORMATION

Factual information	
Place:	At a racetrack, 2.5 NM north-west of Akureyri Airport (BIAR)
Date:	August 5th, 2013
Time[1]:	13:29
Aircraft:	
• **type:**	Beech King Air B200
• **registration:**	TF-MYX
• **year of manufacture:**	1983
• **serial number:**	BB-1136
• **engines:**	Two PT6A-42 turboprop
o **left S/N:**	93636
o **right S/N:**	93635
Type of flight:	Positioning flight
Persons on board:	2 flight crew members, 1 paramedic
Injuries:	2 fatally injured, 1 seriously injured
Nature of damage:	Aircraft was destroyed
Short description:	During approach to Akureyri Airport, the flight crew of an air ambulance flight requested to overfly the town of Akureyri before landing. The purpose of the detour was to fly over a racetrack. During a steep left turn, the aircraft collided with the racetrack.
Owner:	Glitnir fjármögnun
Operator:	Mýflug
Meteorological conditions:	Visual Meteorological Conditions (VMC)

[1] All times in the report are UTC

1.1. History of the flight

On 4th of August 2013 the air ambulance operator Mýflug, received a request for an ambulance flight from Höfn (BIHN) to Reykjavík Airport (BIRK). This was a F4[2] priority request and the operator, in co-operation with the emergency services, planned the flight the next morning. The plan was for the flight crew and the paramedic to meet at the airport at 09:30 AM on the 5th of August. A flight plan was filed from Akureyri (BIAR) to BIHN (positioning flight), then from BIHN to BIRK (ambulance flight) and from BIRK back to BIAR (positioning flight). The planned departure from BIAR was at 10:20, see the planned route in Figure 1.

The flight crew consisted of a commander and a co-pilot. In addition to the flight crew was a paramedic, who was listed as a passenger. Around 09:50 on the 5th of August, the flight crew and the paramedic met at the operator's home base at BIAR. The flight crew prepared the flight and performed a standard pre-flight inspection. There were no findings to the aircraft during the pre-flight inspection. The pre-flight inspection was finished at approximately 10:10.

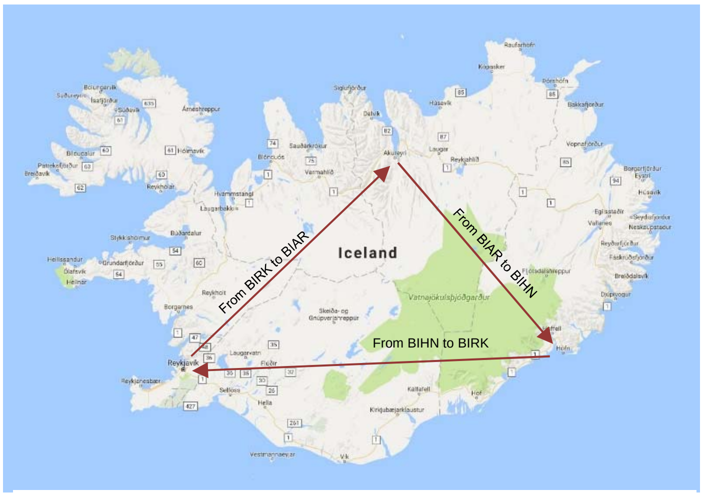

Figure 1: The flight route on the day of the accident

The departure from BIAR was at 10:21 and the flight to BIHN was uneventful. The aircraft landed at BIHN at 11:01. The commander was the pilot flying from BIAR to BIHN. The operator's common procedure is that the commander and the co-pilot switch every other flight, as the pilot flying. The co-pilot was the pilot flying from BIHN to BIRK and the commander was the pilot flying from BIRK to BIAR, i.e. during the accident flight.

The aircraft departed BIHN at 11:18, for the ambulance flight and landed at BIRK at 12:12. At BIRK the aircraft was re-fuelled and departed at 12:44. According to flight radar, the flight from BIRK to BIAR was flown at FL 170. Figure 4 shows the radar track of the aircraft as recorded by Reykjavík Control. There is no radar coverage by Reykjavík Control below 5000 feet, in the area around BIAR.

[2] Priority levels are F1 to F4, where F1 is the highest priority and F4 is the lowest priority

During cruise, the flight crew discussed the commander's wish to deviate from the planned route to BIAR, in order to fly over a racetrack area near the airport. At the racetrack, a race was about to start at that time. The commander had planned to visit the racetrack area after landing.

The aircraft approached BIAR from the south and at 10.5 DME the flight crew cancelled IFR. When passing KN locator (KRISTNES), see Figure 6, the flight crew made a request to BIAR tower to overfly the town of Akureyri, before landing. The request was approved by the tower and the flight crew was informed that a Fokker 50 was ready for departure on RWY 01. The flight crew of TF-MYX responded and informed that they would keep west of the airfield.

After passing KN, the altitude was approximately 800' (MSL)[3], according to the co-pilot's statement. The co-pilot mentioned to the commander that they were a bit low and recommended a higher altitude. The altitude was then momentarily increased to 1000'.

When approaching the racetrack area, the aircraft entered a steep left turn. During the turn, the altitude dropped until the aircraft hit the racetrack[4].

[3] All altitudes in the report are Mean Sea Level (MSL) unless otherwise stated

[4] The elevation of the racetrack is 468 feet MSL

1.2. Injuries to persons

The commander and the paramedic were fatally injured. The co-pilot was seriously injured.

Injuries	*Crew*	*Passengers*	*Total in the aircraft*	*Others*
Fatal	1	1	2	
Serious	1		1	
Minor				
None				
TOTAL	2	1	3	

1.3. Damage to aircraft

Both wings and the engines separated from the aircraft. The fuselage broke into three main pieces (cockpit, cabin and empennage). The aircraft was destroyed.

1.4. Other damages

Minor damage occurred to a few race cars and to some racetrack equipment.

1.5. Personnel information

The operator's "*Flight Crew Licence and Training Records*" revealed that both the commander and the co-pilot had passed initial training as well as annual technical training and recurrent flight training.

Commander	
Age:	Male - 46 years old
License:	IS/CPL/A Valid
Medical certificate:	Valid
Ratings:	• BE90/99/100/200 • IR(A)
Experience:	Total all types: ~ 2600 hours Total on type: ~ 1700 hours Last 90 days: 40 hours Last 24 hours: 1:24 hours
Previous rest period:	Well rested before the flight

When the commander was employed by the operator on 01.12.05, he had already received his Multi-Crew Conversion (MCC) and initial Crew Resource Management (CRM) training (16.07.04). According to the operators training records the commander's last annual CRM training was accomplished 21.05.13.

In recurrent line checks and proficiency checks, the commander passed with the remarks of a very good overall performance, good airmanship and good CRM.

Co-pilot	
Age:	33 years old
License:	IS/CPL/A Valid
Medical certificate:	Valid
Ratings:	• BE90/99/100/200 • IR(A)
Experience:	Total all types: ~ 2200 hours Total on type: ~ 1100 hours Last 90 days: 31 hours Last 24 hours: 1:24 hours
Previous rest period:	Well rested before the flight

The co-pilot was employed by the operator on 15.05.07. He received his Multi-Crew Conversion (MCC) on 06.06.07 and initial Crew Resource Management (CRM) on 19.06.07. According to the operators training records the commander's last annual CRM training was accomplished 21.05.13.

In recurrent line checks and proficiency checks, the co-pilot passed with the remarks of good handling of aircraft, overall good performance and good CRM.

Paramedic

The paramedic received initial training from the operator on 23.10.10 where CRM was a part of the training.

1.6. Aircraft Information

1.6.1 Aircraft general information	
Manufacturer:	Hawker Beechcraft
Type	Beech King Air B200
Build serial number	BB-1136
Year of manufacture	1983
Total airframe hours	15,247 hrs
Total cycles	18,574
Power plants	Two PT6A- 42 turboprop engines
Holder of certificate of Reg.	Mýflug hf.
Certificate of Registration:	TF-MYX
Date of issue	18 May 2006
Issuing Authority	Iceland CAA
Certificate of Airworthiness	Issued by the Iceland CAA on 19 May 2006

1.6.2. Aircraft description

The aircraft was a twin engine, turboprop, low wing and pressurized. The aircraft was modified for ambulance flights, equipped with four passenger seats and two stretchers and tools/equipment necessary for intensive care of patients. During the accident flight a commander, a co-pilot and a paramedic were on board. During the flight, the paramedic was seated in the second seat behind the commander. In Figure 2, the paramedic's seat is indicated by a circle.

According to the documents found at the accident site and the fuelling receipts, the aircraft was within its W&B[5] limits at the time of the accident.

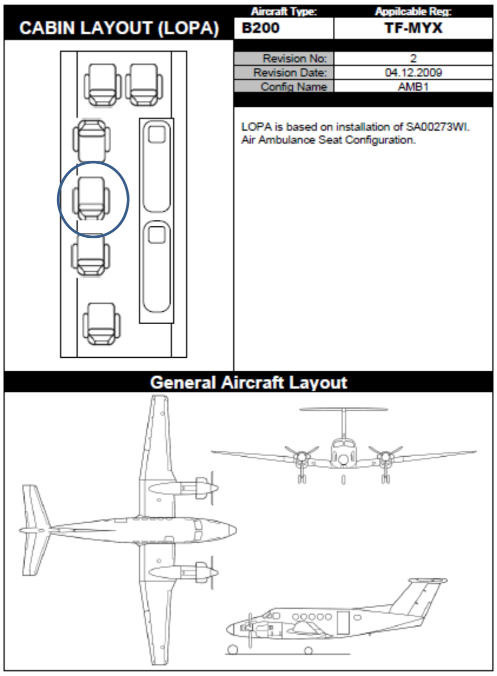

Figure 2: Layout of the aircraft

[5] Weight & Balance

1.6.3. Automatic device - Yaw damper system

The aircraft was fitted with a yaw damper system to provide aid with directional control and to increase ride comfort. The system could be used at any altitude and was required for flight above 17,000 feet. According to the Operation Manual[6] the YAW DAMP switch should be in the "OFF" position prior to landing (see Figure 3).

The investigation revealed that the YAW DAMP switch was in the "ON" position during the accident. During the investigation, the possibility of the yaw damping system affecting the control of the aircraft in such attitude was taken into account and analysed.

According to the manufacturer, the pilot would note a resistance in the rudder pedals when the yaw damper was "ON". The accident flight was simulated in a flight simulator with the yaw damping system in both the "ON" and "OFF" positions.

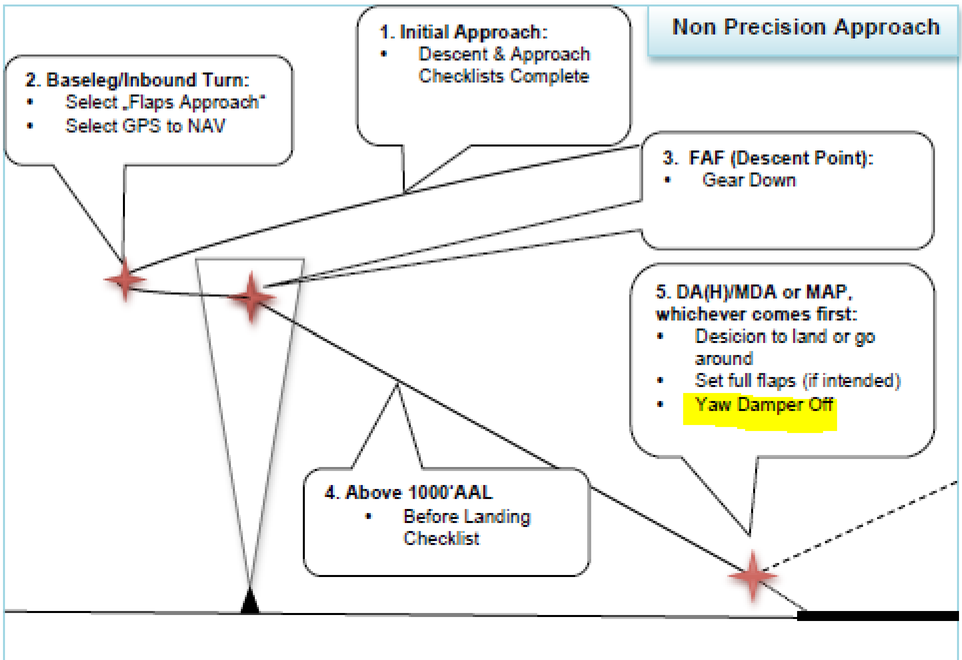

Figure 3: From the Operation Manual – Part B, Non Precision Approach

[6] Operations Manual – Part B, Rev 5, chapter 2.1 Standard Operating Procedure

1.7. Meteorological information

The METAR at BIAR prior to and after the accident was as follows:

BIAR 051300Z 35014KT 9999 FEW020 BKN067 09/03 Q1011
BIAR 051400Z 35013KT 9999 SCT048 BKN054 OVC062 09/03 Q1011

The racetrack heading is approximately 265°, magnetic. According to the METAR listed above, the wind direction was approximately 350° (true) at the time of the accident or 005° magnetic. The aircraft approached the racetrack area with a headwind and wind approximately 100° from the right, after the turn and during the impact. The cloud cover at 13:00 was few at 2,000’ and broken at 6,700’.

1.8. Aids to navigation

According to radar recordings, the flight from BIRK to BIAR was flown at FL170. When passing 5000’, on the approach to BIAR, the aircraft went below Reykjavík Control’s radar coverage. See Figure 4.

Figure 4: Radar plot for TF-MYX prior to the accident ends at 5000‘

When the aircraft was 10.5 NM from BIAR, the flight crew reported that they had the airfield in sight and cancelled IFR.

Based on the co-pilot’s and witness’ statements as well as camera recordings, the approximate track of the aircraft after KN can be seen on Figure 5. Furthermore according to the co-pilot’s statement, this phase of the flight was flown at 800’–1000’.

Figure 5: Approximate track of the aircraft after KN

1.9. Communications

During the entire flight, the communications between the crew and ATC[7] were normal.

According to the co-pilot, during the cruise to BIAR, the commander discussed with him and the paramedic that he would like to fly over the racetrack area prior to landing at BIAR, provided that the weather conditions at Akureyri would allow it.

When the aircraft was 10.5 NM from BIAR, the co-pilot informed Akureyri tower that they had the airfield in sight and cancelled IFR. The tower acknowledged and requested a notification on final approach. This was read back by the flight crew.

About 40 seconds later, the flight crew called the tower and requested to overfly the town of Akureyri. That was approved by the tower controller who also informed the flight crew that a F50 was taking off from RWY 01. The flight crew responded by informing that they would keep west of the airfield.

There were no further communications recorded regarding the request and ATC did not receive any distress call nor a declaration of an emergency before the accident.

1.10. Aerodrome information

The accident occurred 2.5 NM north-west of Akureyri airport (BIAR) after a deviation from an approach to RWY 01. BIAR airport has one runway, 01/19, and is located in a mountainous area. The aerodrome is in class D airspace with an operational control tower. Passing the KN NDB (see Figure 6), the aircraft was turned west of the airfield towards the racetrack area. A F50 (Fokker 50, domestic scheduled flight) was taking off from RWY 01 at the time when TF-MYX was passing the airfield, and flown approximately parallel to the runway, see blue arrow in Figure 6.

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[7] Air Traffic Control

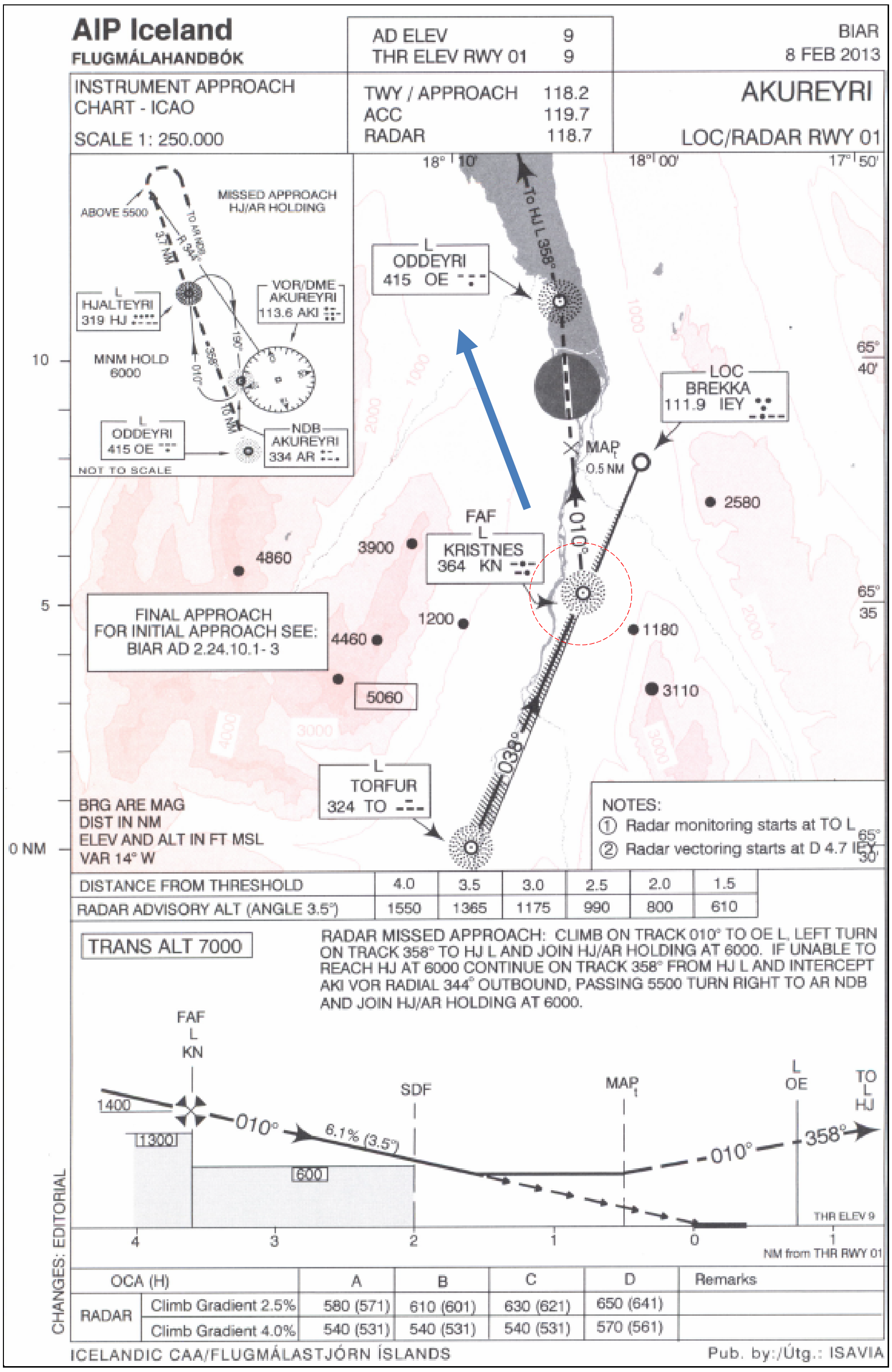

Figure 6: Instrument approach chart - blue arrow indicates the direction of deviation

1.11. Flight Recorders

There were no flight recorders or any other recording equipment fitted in the aircraft. There were two GPS receivers for navigation, Garmin GNS530 and GNS430, but these did not record useful data to the investigation.

1.12. Wreckage and Impact information

Initial mark of impact was found on the right side of the racetrack. The aircraft collided with the ground with the left wing impacting first. The aircraft rolled to the left and down the racetrack and the wings separated from the fuselage. The fuselage broke into three main parts. The empennage came to rest left of the racetrack but the cockpit and the cabin came to rest in a grass area beyond the end of the racetrack, slightly left of its centre. The engines separated from the wings.

The distance from where the airplane initially hit the ground, to the parts of the wreckage located furthest away was approximately 400 meters.

1.13. Medical and pathological information

Both the commander and the co-pilot carried a valid Class I medical certificate. Medical or pathological issues were not found to be a cause nor a contributing factor to the accident.

1.14. Fire

Indications of a post impact fire were found on the ground a few meters beyond the initial impact marks. Fuel was distributed over the racetrack and its surroundings, all along the accident site. Both engines were damaged, but still in a condition to be analysed. The tail and the fuselage did not catch fire. Both wings and other parts of the aircraft were severely damaged/burned.

Figure 7: Overview of the accident site, burn marks can be seen along the racetrack

1.15. Survival aspects

Due to the fact that this was a high energy impact with an immediate fire explosion, the possibilities of survival were considered at a minimum. The aircraft's initial impact with the ground was at its left side. Both wings and the engines separated from the aircraft. The fuselage broke into three main pieces (cockpit, cabin and empennage). The paramedic was seated in the cabin section close to where the cabin broke from the cockpit. The cockpit and the cabin rolled down the racetrack and impacted a grass ridge at the end of the racetrack and came to rest on top of the ridge. The cockpit section around the co-pilot, sitting in the right side of the cockpit, was found to have incurred significantly less deformation than the left side.

1.16. Test and research

Both engines were severely damaged as result of the impact. When the engines were analysed, the left engine was found fractured at the front reduction gearbox housing. The propeller shaft was fractured just aft of the accessories drive gear. The fracture surface exhibited features characteristic of an overload. External tubes and linkages were either severed or crushed from the impact. The fuel pump/fuel control assembly was broken off the engine. The remainder of the left engine suffered limited structural damage. Rotating components, such as compressor rotors, turbine disks and blades showed circular rubbing and scoring damage from contact with adjacent stationary components. The right engine showed similar impact damage to external components. The engine exhibited limited structural deformation. Rotating components such as compressor and turbine assemblies exhibited rubbing and scoring damage indicative of rotation at impact.

Figure 8 and Figure 9 below, show the left and the right engines before they were disassembled.

Figure 8: Left engine

Figure 9: Right engine

The investigation of the engines did not reveal any evidence of pre-impact anomalies. Signatures found on the compressor and turbine sections of both engines where indicative of rotation under power at impact. The limited structural deformation observed on the engines prevented the assessment of the level of power the engines were producing at the time of impact.

The possibility of an un-commanded torque increase on one of the engines was investigated. Propeller blade angles, deformation and rotational signatures on both engines were compared and found to be very similar. This indicates that an un-commanded torque increase on either engine did not occur.

The engines are not considered a cause to the accident.

During the investigation process, a possible failure of the propellers was analysed, such as un-commanded feathering during the turn. The left propeller impacted before the right propeller, the propeller from left engine separated from the engine.

Figure 10: Left propeller

Figure 11: Right propeller

Figure 12: Left engine propeller blades

Figure 13: Right engine propeller blades

When analysing the propeller blades, the most damaged blade was found on the left propeller. All blades had moderate but distinct leading edge impact damage. All the blade tips were found fractured/torn, which is a strong indication of power and rotation during the impact.

In both of the propeller hubs, marks were found indicating that the propellers impacted under power. Both pitch change forks had damage on the aft tangs which supports a blade rotation from lower pitch towards higher pitch during the impact sequence.

Figure 14: Propeller blade, left propeller

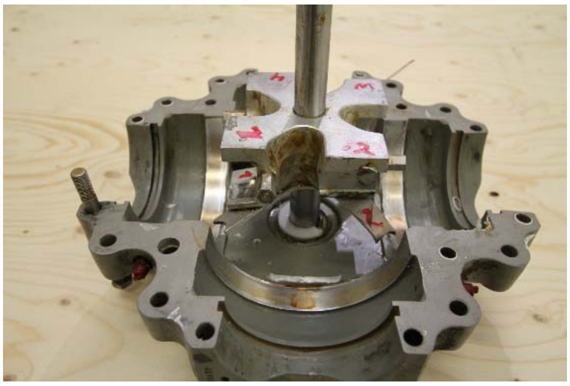

Figure 15: Left propeller hub opened

A fracture was found on the forward side of the bearing, which indicates that the impact forces occurred at a higher RPM setting. When analyzing the hub and the propeller blades no discrepancies that would prevent or degrade normal operation prior to impact were found.

No evidence was found that the propellers were in an abnormally high pitch or a feathered condition.

There were two sets of propeller strike marks found on the ground. The first set of marks was found approximately 70 meters, and the other set of marks at approximately 170 meters, after the initial impact of the aircraft.

Figure 16: Propeller strike marks approx. 70 meters after initial impact

Figure 17: Propeller strike marks approx. 170 meters after initial impact

Based on the aircraft impact angle (left turn), the marks 70 m after the initial impact were made by the left propeller and the marks 170 m after initial impact were made by the right propeller.

The investigation revealed that both propellers impacted under power and no evidence was found that indicated failure of the propellers.

1.17. Organizational and management information

The operator was established in 1984, as a sightseeing operator with one Cessna 206 aircraft. During the years 2001-2005, the operator was recovering from financial difficulties in its operation. In 2006, the operator started air ambulance flights as its core operation, based on a governmental contract. At this time, the operator emphasised on a safety culture within its operation and, in the following years, implemented a Safety Management System (SMS).

Approximately three months prior to the accident, at a crew training course, the operator emphasized that deviations from Standard Operating Procedures (SOP) were not acceptable.

The operator has an EU-OPS AOC[8] with applicable manuals in place, including four operating manuals, OM-A, OM-B, OM-C and OM-D. The following description can be found in the operating manuals:

OM-A

> *Part A of the Operations Manual complies with EU-OPS. It describes company policies and procedures for the execution of duties for all personnel, with guidelines and general information on the manner in which company operations are to be conducted. The manual also contains extracts from ICAO Annex 2, rules of the air with reference to Jeppesen Route Manuals Volume 1. The format of the manual is based on and complies with applicable requirements of EU OPS.*

In chapter 2.3 of OM-A, Accident prevention and flight safety program, the following statement can be found:

> *To maintain the highest standard of safety, strict adherence to Standard Operating Procedures and regulations is required. SOP's are provided for all aircraft operated by Myflug. Deviations from SOP are forbidden except in emergency situations.*

In chapter 8.1.1 of OM-A, Minimum Flight Altitudes, the following statement can be found:

> *Except when necessary for take-off or landing, airplanes shall not be operated below the minimum altitudes described in the following paragraphs for VFR and IFR flights.*

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[8] AOC no. IS-014

OM-B

Part B of the Operations manual deals with airplane type related matters. OM-B is, in addition to the company developed OM-B, the certification authority approved Aircraft Flight Manual for each aircraft operated by the company. It contains all relevant information regarding normal procedures, checklists, aircraft limitations, systems operation, and aircraft handling. It contains a description of emergency equipment and instructions for its use, as well as instructions relating to actions to be taken in emergencies. Part B contains chapter on "Normal Procedures". This chapter contains Standard Operating Procedures, developed for aircraft types to standardize normal flight operations. Normal Procedures do not override information contained in the approved AFM. Normal, non-normal and emergency checklists are developed from the procedures published by the manufacturer and EU OPS requirements for OM-B content. Company Checklists, when available, override checklists contained in the AFM.

In chapter 2.1.1.29.1 of OM-B, Descent Preparation, the following statement can be found:

PF will accomplish arrival and approach briefing prior to start of descent.

OM-C

OM-C is the Company Route Manual. The Route Manual includes all instructions and information needed to carry out operations along routes and to airports within allowed areas of operation. Along with part C of the OM, a separate Chart manual is carried on each flight, tailor made for the route to be flown and/or the mission to be accomplished. The chart manual is compiled from Jeppesen Airway Manual Service subscription and its content is defined in OM-C. Additionally the company subscribes to Iceland AIP.

In chapter 1.1.1 of OM-C, Minimum flight level/altitude, the following statement can be found:

Except when specifically authorised by the authority, cruising levels below the minimum flight altitudes, established by the State, shall not be accepted. Unless otherwise prescribed by the State, the lowest usable flight level is that which corresponds to, or is immediately above, the established minimum flight altitude". Minimum flight altitudes or flight levels are specified on enroute charts. Sector altitudes are specified on approach charts. Definitions for minimum flight altitudes can be found in OM-A 8.1.1.

OM-D

> *Flight Training manual complies with part requirements for OM part D of the EU-OPS, it describes training procedures and requirements for flight crew training. Type training programs are published in separate documents.*

In chapter 2.1.15 of OM-D, Continuous Descent Final Approach - CDFA, the following statement can be found:

> *Training should emphasise the need to establish and facilitate joint crew procedures and CRM to enable accurate descent path control and the requirement to establish the aeroplane in a stable condition as required by the operator's operational procedures. If barometric vertical navigation is used the crews should be trained in the errors associated with these systems. During training emphasis should be placed on the flight crew's need to:*
>
> *a. Maintain situational awareness at all times, in particular with reference to the required vertical and horizontal profile;*
> *b. Ensure good communication channels throughout the approach;*
> *c. Ensure accurate descent-path control particularly during any manually-flown descent phase. The non-flying pilot should facilitate good flight path control by:*
> *(i). Communicating any altitude/height crosschecks prior to the actual passing of the range/altitude or height crosscheck;*
> *(ii). Prompting, as appropriate, changes to the target ROD;*
> *(iii). Monitoring flight path control below DA/MDA.*
> *d. Understand the actions to be taken if the MAPt is reached prior to the MDA(H).*
> *e. Ensure that the decision to go around must, at the latest, have been taken upon reaching the DA(H) or MDA(H).*
> *f. Ensure that prompt go around action is taken immediately when reaching DA(H) if the required visual reference has not been obtained as there may be no obstacle protection if the go-around manoeuvre is delayed.*
> *g. Understand the significance of using the CDFA technique to a DA(H) with an associated MAPt and the implications of early go around manoeuvres.*
> *h. Understand the possible loss of the required visual reference (due to pitch change/climb) when not using the CDFA technique for aeroplane types/classes which require a late change of configuration and/or speed to ensure the aeroplane is in the appropriate landing configuration.*

The operator has four different types of operations: charter flights, sightseeing flights, air ambulance flights and other services such as calibration flights, air drops and aerial photography.

The operator has three locations defined as home base. The sightseeing flights are based at Mývatn, in northeast part of Iceland, the calibration flights at Reykjavik Airport and the air ambulance flights at Akureyri Airport. At the time of the accident, the operator was operating two King Air 200 airplanes, employing approximately 20 pilots. Some of the operator's pilots were also flying for another operator, located in Akureyri.

1.18. Additional information

The investigation revealed that during ambulance flights, if a patient was not being transported, some flight crews occasionally cancelled their IFR flight plan and proceeded visually for sightseeing. The investigation also revealed that the flight path flown over the racetrack area during the accident flight (i.e. steep turn) was something that had not occurred before.

According to Iceland AIP[9], the minimum safe altitude is listed as follow:

> *Aircraft shall not be flown below the minimum safe altitude except when necessary for take-off and landing. The minimum safe altitude is the altitude at which neither an unnecessary noise disturbance nor unnecessary hazards to persons and property in the event of an emergency landing are to be feared; however, over cities, other densely populated areas and assemblies of persons, this altitude shall be at least 1,000 ft (300 m) above the highest obstacle within a radius of 600 m, and elsewhere at least 500 ft (150 m) above ground or water. Gliders and balloons may be operated below an altitude of 500 ft (150 m) if necessary for the kind of operation and if danger to persons and property is not to be feared. Aircraft shall not be flown below bridges and similar constructions nor below overhead lines, and antennas. For flights conducted for special purposes, the local aeronautical authority may grant exemptions.*

[9] Aeronautical Information Publication, General rules and procedures, En-Route 1.1.2 minimum safe altitude

1.19. Useful or effective investigation technique

The investigation made use of three videos that captured the aircraft during its last phase of flight. One of the videos was from a CCTV camera located at a building near the accident site, which captured the aircraft prior to the left turn. The second video, from a personal video camera located on a race vehicle (facing back) at the racetrack, captured the aircraft in the left turn. The third video, from a personal camera located on the same race vehicle (facing forward) captured the aircraft during the last phase of the flight, as well as of the impact. In addition, the investigators were provided with a video taken from the racetrack's audience stand.

Following the video analysis, the investigation made use of King Air aircraft ''Full mission'' simulator to verify the results from the analysis.

1.19.1 Video analysis

The Transportation Safety Board of Canada (TSB Canada) supported the investigation by analysing these videos and visited the accident site in order to photograph and measure the landscape relatively to the captured videos. This data was then used to generate a 3D model of the aircraft positioning and orientation. Following is a summary from the report made by the TSB of Canada.

The following three videos were used for the analysis:

1. Closed-circuit television (CCTV) camera mounted on a building and pointed in a southern direction that showed the aircraft as it banked from the north to the west.

2. Rear-mounted camera on top of a vehicle at the end of the race track pointed in an easterly direction that showed the aircraft as it approached.

3. Forward-mounted camera on top of the same vehicle on the race track pointed in a westerly direction that showed the aircraft as it impacted with the terrain.

The CCTV camera (#1) was pointed in a southerly direction and showed the aircraft as it approached the race track, after passing the airport. The video showed the aircraft as it flew north and then turned west after passing over a ravine. The aircraft was only visible for about six seconds of video footage and then timestamp indicates just over 11 seconds of lost footage before the video resumed showing the smoke plume resulting from the post-crash fire (see Figure 18 to Figure 20).

There were two race vehicles located at the start line of the racetrack, ready to start a race. There were two mounted cameras on one of the race vehicles, one facing forward (#3), and the other facing rear (#2). The rear-facing camera was pointed in an eastward direction and showed the aircraft as it approached the race track. The forward-facing camera (#3) was pointed in a westward direction and showed the aircraft from behind, once it passed over the vehicle and impacted with the terrain of the race track (see Figure 21 and Figure 22). There were no specifications for the vehicle mounted cameras.

In order to solve for the aircraft location and orientation throughout each video it was necessary to solve the location and orientation of each camera. This required surveying the site and taking photographs for the purpose of photogrammetric analysis.

Post-processing was conducted on the survey data to improve the accuracy of the data in real world coordinates. The relative accuracy is typically 5 mm horizontally and 10 mm vertically. The absolute accuracy of the entire survey data can vary substantially over time but is improved once post-processing is performed.

Photography was also performed at various positions around the crash site using a calibrated camera. Taking photographs at various angles around specific locations and using photogrammetry allowed measurements to be taken of points that were difficult to measure (power poles, buildings, etc.).

Referencing the points in multiple photographs at different angles and using the survey data as a control system provided 3-dimensional (3D) coordinates of each point relative to the survey data and real-world coordinates (see Figure 24 and Figure 25).

The three video camera positions were solved by performing an inverse-camera solution on each of the unknown cameras using a photogrammetry software application called PhotoModeler. The software combines referenced points from the calibrated cameras with the control points from the survey data to solve the position and orientation of each unknown camera relative to the surveyed data. Each camera required a self-calibration to determine each camera's parameters and reduce the amount of error produced. The position and orientation of each camera is listed in Table 1.

Video Camera	Camera #	Latitude	Longitude	Mean Sea Level Elevation
CCTV on Building	1	65° 40' 37.7454" N	18° 08' 44.8207" W	124.0 m
Rear-Facing Vehicle Mounted	2	65° 40' 31.8356" N	18° 08' 57.5824" W	137.0 m
Forward-Facing Vehicle Mounted	3	65° 40' 31.8118" N	18° 08' 57.6453" W	135.7 m

Table 1: Solved camera numbers and locations

Each solved camera provided the position, orientation and camera lens properties that could be exported from PhotoModeler into a 3D Computer-Aided Design (CAD) software application called 3D Studio Max. Each imported camera location contained an image plane and focal point for each solved camera. After importing a scale CAD model of the Beech 200 and positioning the aircraft in the scene, lines could be constructed from the focal point of each camera location for the purpose of aligning the aircraft as it appeared in each image. The lines were drawn through aircraft features in the image plane (nose, wing tips, stabilizers, etc.) and then extruded out past the image plane into 3D space. The aircraft was then placed in a position and oriented so the lines all intersected through the same aircraft features as those in the image plane. The best approach for orienting the CAD model was to align the aircraft nose along the line that intersected the nose feature in the image plane to a position along the line where the vertical and horizontal stabilizers matched their respective intersects. This placed the CAD model in a location along the lines that best matched the dimensions of the aircraft. The other feature lines for the wing tips and engines could be used to align the bank angle of the aircraft (see Figure 26 and Figure 27).

The process of generating CAD model positions and orientations for the aircraft was repeated for a series of image frames extracted from the video footage for each camera. Each image frame was corrected within PhotoModeler for lens distortions based upon the camera calibrations determined for each camera that warped the image, so it could be used in a 3D CAD environment. This was repeated at an interval of approximately 1 image frame every 0.3 seconds.

The three different videos were not synchronized. So although the timing between the frames in each video was accurate, they did not correlate with each other. However, since the time intervals between the image frames was small (~0.3 seconds) it could be assumed that there would be little change in aircraft speed for calculated positions close by. It is unlikely that the aircraft would incur any significant changes in position within such a small time interval.

The timing could then be extrapolated based on distance travelled and the speed of the aircraft from adjacent frames to synchronize the timing of all 3 videos, to that of the security footage from the CCTV (camera #1). Although the timestamp in the CCTV footage may not be synchronized with world time it does provide a good approximation as to when the aircraft impacted with the terrain.

Once the timing was synchronized for all three camera locations, the information could be combined for a flight track of the aircraft providing the time, position and orientation at each solved location (Appendix 1). Furthermore, the points could be used to construct an interpolated flight path to smooth the flight path (see Figure 28 and Figure 29).

Assessing the level of accuracy for photogrammetry is difficult; one of the best indicators for project quality is the marking residual. A large marking residual means that the 3D location of the point differs from the marked location of the point. A significant number of points with high residuals can indicate a camera calibration problem or that one or more of the camera stations are not oriented correctly. Marking residuals is one of the best indicators of the project quality.

This project produced a good marking residual for each of the solved cameras. The highest residual value was 2.3 when solving for unknown cameras; a good solution would have residuals below 3 with known and calibrated cameras.

One solution involved the CCTV camera (#1) and the rear-facing vehicle mounted camera (#2) while a separate solution was used for the forward-facing vehicle mounted camera (#3). Errors do exist when merging the two projects since they are solved independently. Some of the error does present itself when comparing the two positions of the vehicle mounted cameras. The two positions are approximately 1 m apart horizontally with a difference of approximately 1.3 m in elevation. The two cameras may have been offset by this amount given that one was mounted at the front of the cab and the other possibly elevated at the rear, however, it was not possible to determine precisely how the cameras were mounted.

Solving for the position and orientation of each image/aircraft location is a “best-fit” case to try and fit the aircraft within the constraints of the intersect lines from each image frame.

A 1 degree rotation in the aircraft pitch, bank or yaw can result in a translational shift of about 0.5 m giving rise to positional errors of close to plus or minus 1 m.

Aircraft positions and orientations were calculated from image frames captured out of the 3 videos where discernible aircraft features (nose, wingtips, stabilizers, etc.) could be identified (Appendix 1). A flight track was constructed using interpolated positions from the solved aircraft locations in the photogrammetric analysis.

Figure 18: CCTV view of aircraft approaching from the south at 1328:42.3[10]

Figure 19: CCTV view of aircraft heading west towards drag strip at 1328:44.9

[10] Time referred to in a hhmm:ss.sss format.

Figure 20: CCTV view of smoke plume after aircraft impacted terrain at 1328:55.9

Figure 21: View towards east from rear facing camera mounted on vehicle.

Figure 22: View towards west from forward facing camera mounted on vehicle.

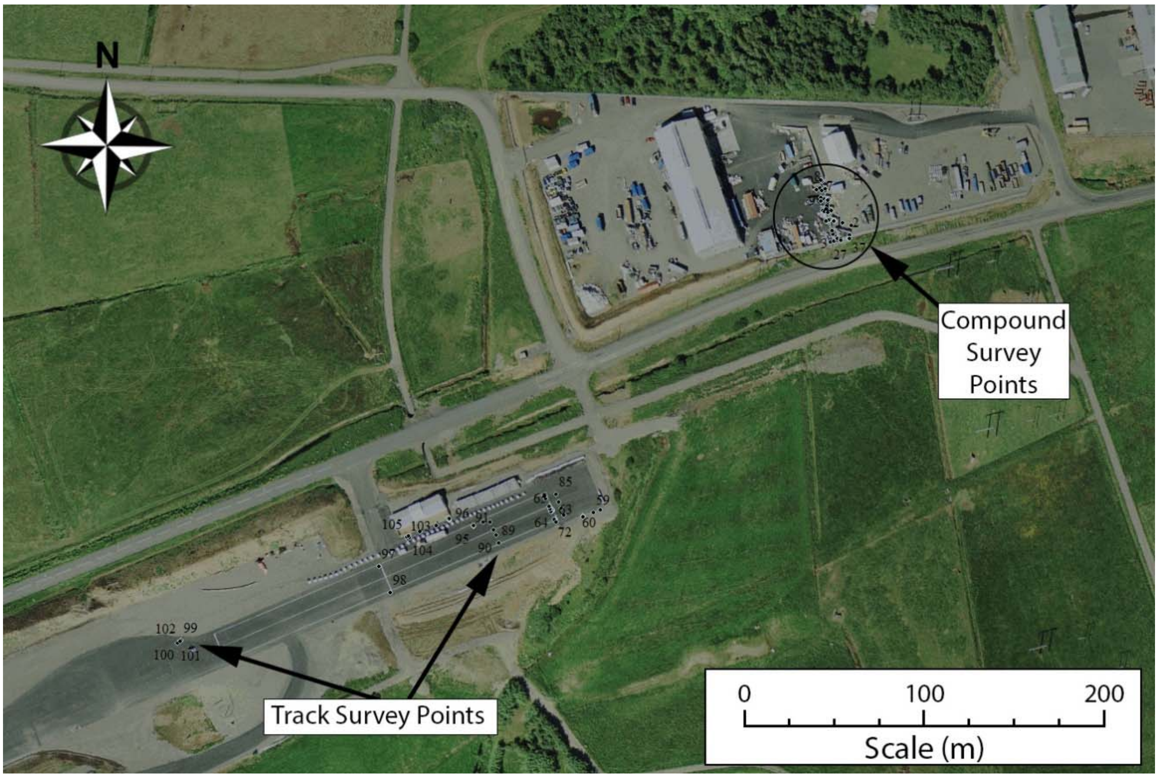

Figure 23: Survey locations of the CCTV compound and race track

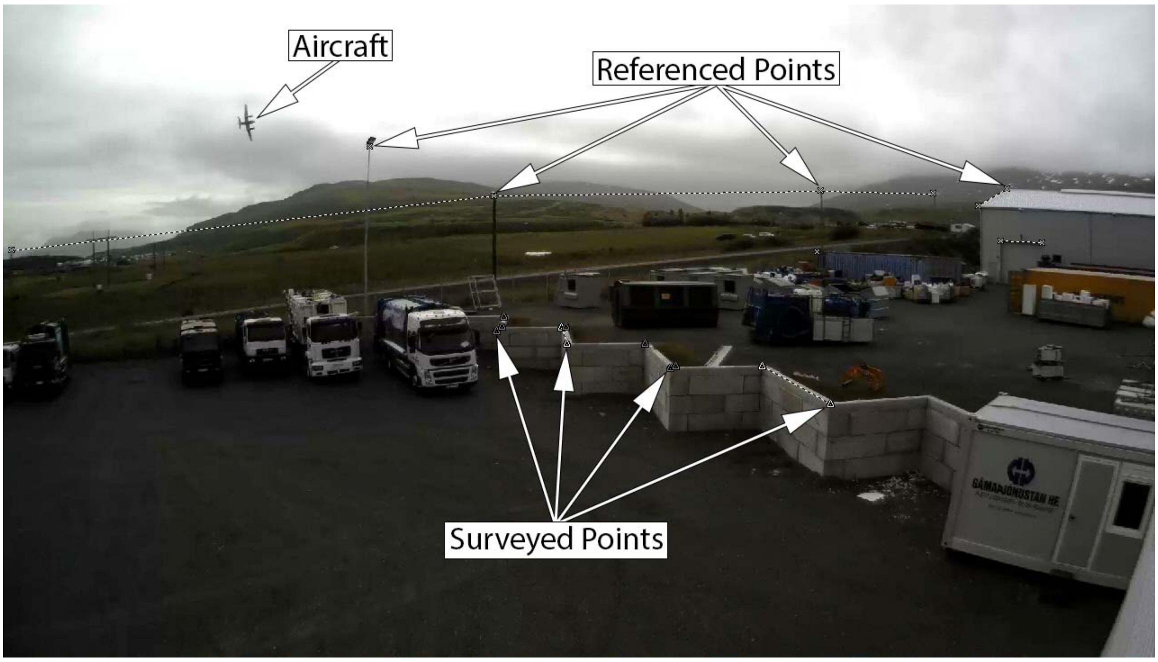

Figure 24: CCTV image showing control points

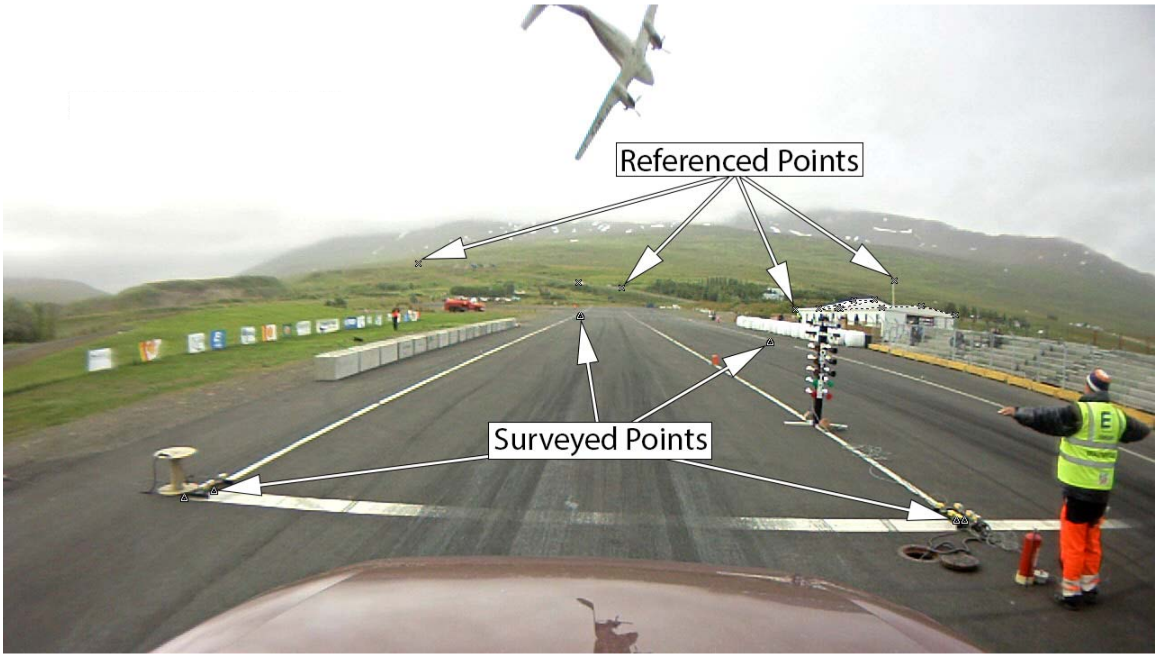

Figure 25: Forward facing race vehicle image showing control points

Figure 26: Corrected CCTV image at 1328:44.9 showing intersect lines from camera principal point with aircraft features

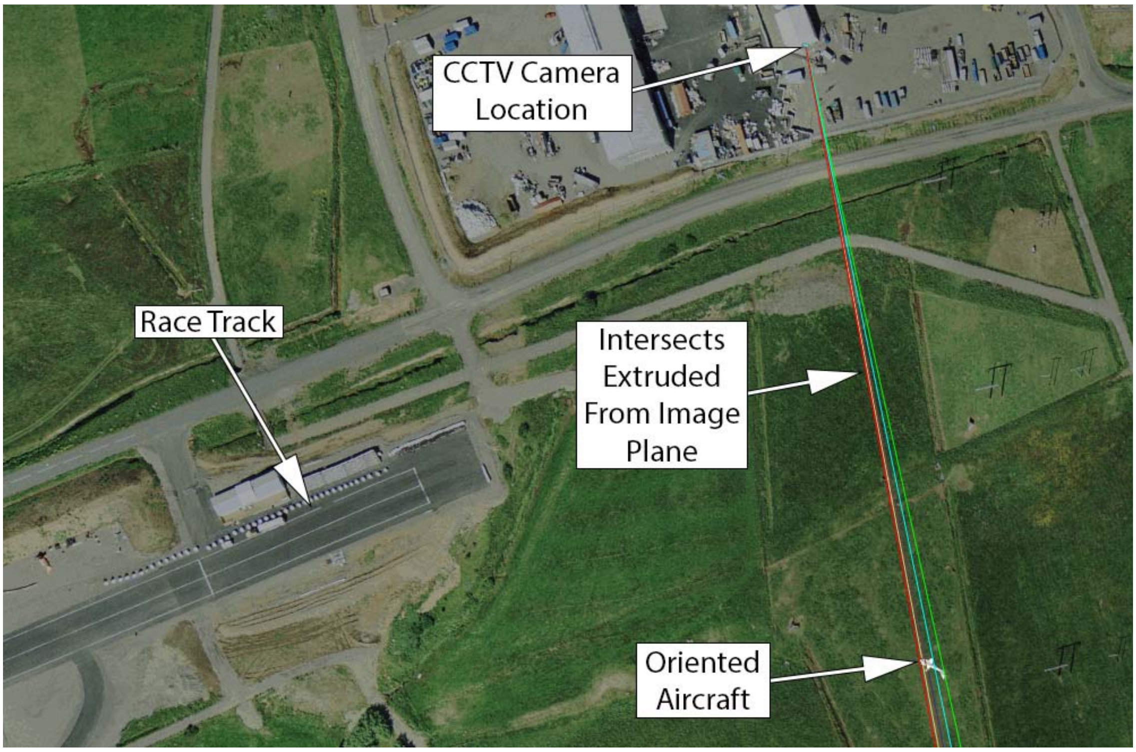

Figure 27: Aircraft oriented to fit intersect lines extruded from image plane for CCTV camera at 1328:44.9

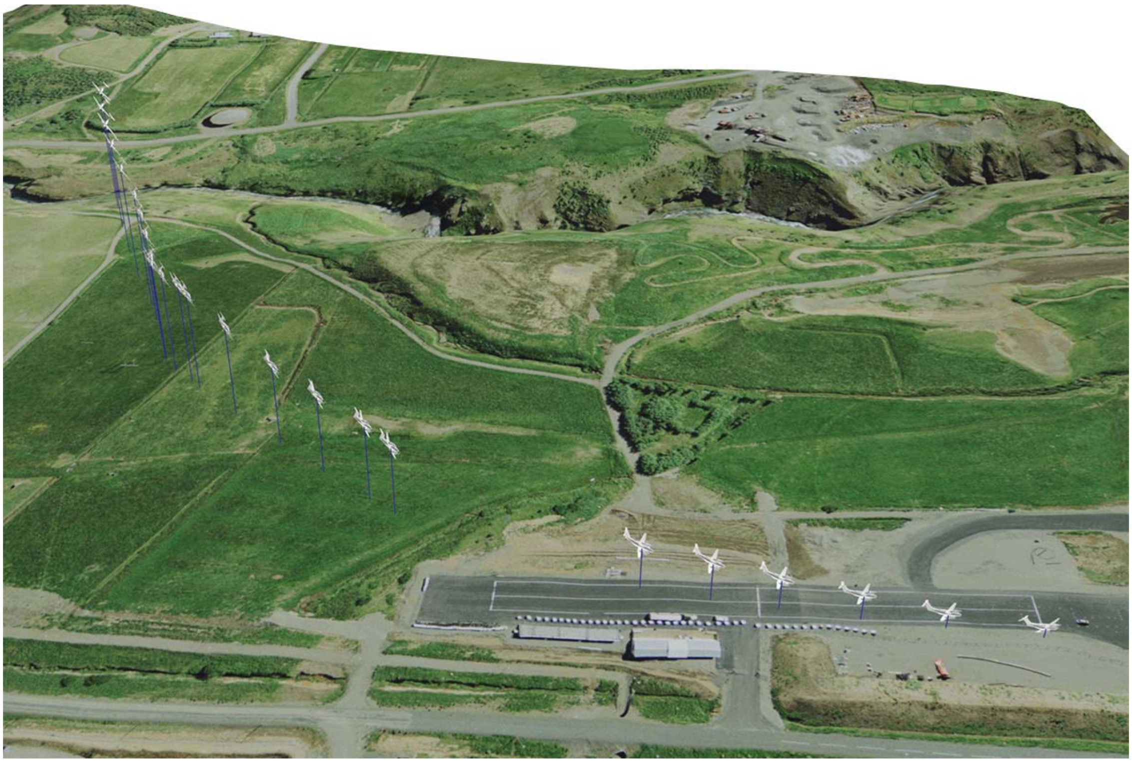

Figure 28: Oblique view looking southward showing calculated aircraft positions and orientations

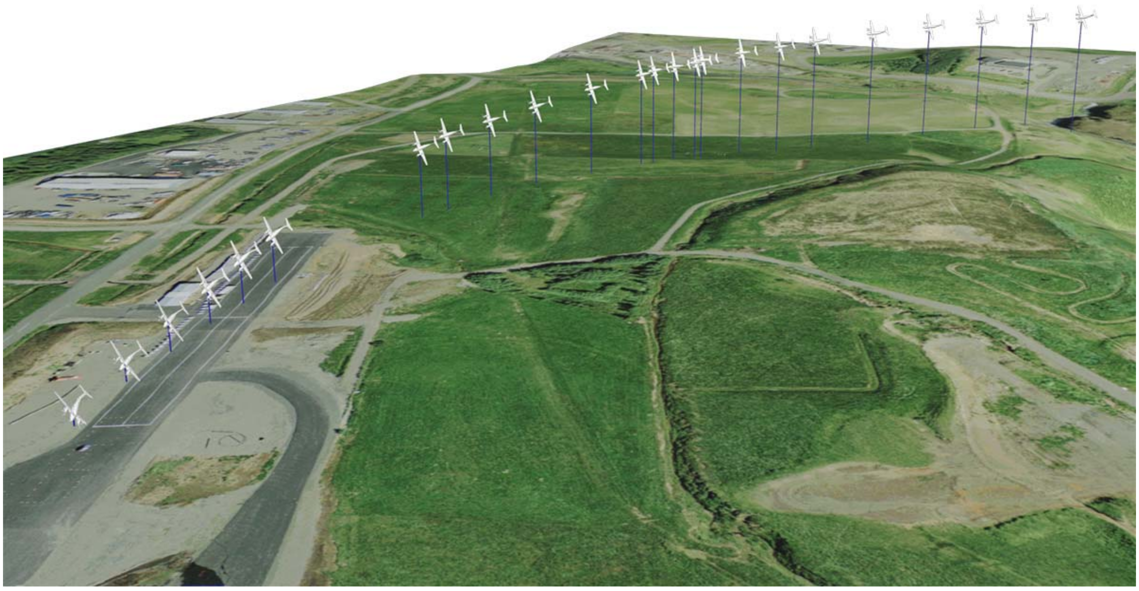

Figure 29: Oblique view looking eastward showing calculated aircraft positions and orientations

By calculating the speed from the photogrammetric analysis, the aircraft was at 240-260 knots (GS[11]) during the turn and close to 275 knots (GS) at the time of impact. The bank angle increases from 54.2° and up to 72.9° at the midpoint of the flight path (see Appendix 1 for more details).

1.19.2 Simulator flight

Based on the information from the investigation, as well as the results from the photogrammetric analysis, the flight from the point of deviation was simulated in a King Air flight simulator located in Farnborough (UK).

The simulator was configured according to the facts known from the accident, as determined by the investigation, and the power settings were as they would have been for a flight passing by the airfield.

The flight was flown both from the point of deviation from BIAR and to the race track area, as well as arbitrarily at an altitude of 5.000´. The test results were similar to the calculation from the photogrammetric analysis, i.e. when the bank angle increased beyond 60°, the simulated flight started to descend and lost its altitude rapidly. Furthermore, the airspeed increased similarly to the findings calculated from the photogrammetric analysis. If the simulator was set to approximately 73° bank, the airspeed increased up to 270 knots, the altitude decreased dramatically and the aircraft started to spiral down. It was difficult for an experienced pilot to immediately recover from this attitude. It should be taken into consideration that the “G” load factor could not be simulated.

This was tested with Yaw damp in ON and OFF position which had no effect on the outcome.

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[11] Ground Speed

2. ANALYSIS

2.1. General

The accident occurred outside the planned flight route from Reykjavik Airport to Akureyri Airport. The crew decided to deviate from the flight route and to fly over a racetrack area near the airport prior to landing.

The deviation from the normal procedures was analysed in order to understand how and why the decision was made not to go directly to the airport and how and why the deviation was performed in such way.

The last part of the deviated flight path was captured by three video recorders:

1. CCTV video recorder, located on a building near the accident side (Camera 1)
2. Video recorder located on a race car at the racetrack facing backward (Camera 2)
3. Video recorder located on a race car at the racetrack facing forward (Camera 3)

The flight path of the aircraft in a left turn, prior to the impact, was analysed based on these three recordings.

2.2. Flight operation

2.2.1. Flight crew qualification

According to the operator’s documents, both the commander and the co-pilot were qualified for the flight. The training records revealed that they were both current and had passed required training and skill tests.

The investigation revealed that the execution of the accident flight, when it deviated from the planned flight route, was an unusual practice for both of the crew members.

The investigation revealed that the commander was known for good airmanship while flying, as well as good preparation before each flight. This was stated by his colleagues as well as the operator’s management. Furthermore the investigation revealed that the commander had made a flyby over the racetrack area once before, but from the opposite direction, i.e. approaching from the southwest. This was without steep turns and with a minor deviation from the approach to the airfield.

On the operator's ambulance flights the paramedic is always listed as a passenger. According to the EC regulation no 965/2012 (Annex 1, para (11)), a cabin crew member is defined as:

> *An appropriately qualified crew member, other than a flight crew or technical crew member, who is assigned by an operator to perform duties related to the safety of passengers and flight during operations.*

2.2.2. Operational procedures

According to the operator's manuals[12], an aircraft shall adhere to the current flight plan or the applicable portion of the current flight plan submitted for a controlled flight unless a request for a change has been made and clearance obtained from the appropriate air traffic control unit, or unless an emergency situation arises which necessitates immediate action by the aircraft. The investigation revealed that some flight crews occasionally cancelled their IFR flight plan and proceeded visually for sightseeing, while not transporting a patient, especially in good weather conditions and when there was no time pressure on the flight. This practice is within the scope of the operator's manuals.

2.2.3. Weather

The weather information, recorded by the Icelandic Meteorological Office, revealed that the wind was from 005° at 13-14 knots and the direction of the racetrack is 265°[13]. According to the BIAR METAR at 13:00, the cloud cover was: Few at 2,000' and broken at 6,700' and at 14:00 the METAR listed the cloud cover as scattered at 4.800' and overcast at 6.200'.

The weather is not considered to be a factor in this accident.

2.2.4. Air traffic control

The air traffic controller at BIAR received a request from the aircraft to fly over the town of Akureyri. The air traffic controller approved the request.

When TF-MYX approached the airfield, another aircraft was ready for departure and was cleared for take-off. The crew of TF-MYX was informed of this aircraft by ATC to which

[12] OM-A 12.8.1.2 Adherence to a flight plan

[13] Both wind and racetrack direction are magnetic

they replied that they would keep their flight path west of the airfield. ATC did not receive a distress call nor a declaration of an emergency.

Video recordings from the accident site show the other traffic on its initial climb to the north a few seconds prior to the accident. The ITSB believes that the knowledge of the departing traffic might have influenced the commander’s decision on how far west of the airfield he chose to fly which gave him less space for the turn to line up with the racetrack.

2.2.5. Communication

During the cruise from BIRK to BIAR, the flight crew discussed the possibilities of flying over the racetrack prior to landing at BIAR. According to the co-pilot’s statement a brief discussion was made about the flyover, i.e. to fly over the area, heading north, turn back and land. After passing KN the altitude was approximately 800’ (MSL). The co-pilot recommended that they would increase the altitude as he was uncomfortable with the low altitude. Following that, the altitude was increased momentarily from 800’ to 1000’ by the commander.

According to the co-pilot, during the approach to the racetrack, he expressed his concern regarding the number of spectators at the race track area and that he did not want to fly low over the area.

After KN, there was no communication with ATC.

2.2.6. Accident area

The racetrack is located in the foothills of a mountain, where the land slopes down against the flight path, i.e. after the left turn. Figure 30 is taken with a drone at the first calculated position from the video recordings and at the approximate altitude of the aircraft prior to the left turn. This figure therefore approximately portrays the view from the cockpit, prior to the accident.

Figure 30: View, approaching the accident site

The racetrack is similar in shape to a runway. However with the racetrack being narrower, shorter and sloping upwards, it might have provided the pilot with the visual illusion of the aircraft being at a greater altitude and distance from the racetrack.

2.2.7. Aerodrome

N/A.

2.3. Aircraft

2.3.1. Aircraft maintenance

The aircraft was properly maintained and there were no findings during the pre-flight inspection, or during the flights prior to the accident. According to the co-pilot, there were no discrepancies or failures indicated during the flight, or past flights. Furthermore, the investigation revealed no abnormalities with regards to maintenance or the technical condition of the aircraft.

2.3.2. Aircraft performance

Using the analysis performed by TSB Canada, 22 out of 24 calculated points revealed that the bank angle in the turn was found to range from 60.4° to 72.9°[14]. When the aircraft is flown at a steeper bank angle than 60°, it is considered to be an acrobatic manoeuver by the manufacturer.

According to the co-pilot's statement, the aircraft was flown at approximately 200-220 knots, IAS[15] when approaching the racetrack area. By calculating the speed from the photogrammetric analysis, the first calculated aircraft speed was 217 knots (GS[16]), increased to 240-260 knots during the turn and was close to 275 knots at the time of impact.

Figure 31 and Figure 32 were created by analysing the videos captured by the three cameras (1, 2 & 3). The figures show the calculated flight path, prior to and during the turn, prior to the impact. At approximately 150' above the race track elevation, the bank angle increases from 54.2° and up to 72.9° (red circle on figure 31) resulting in the aircraft losing altitude.

To stop an aircraft from losing altitude in such attitude the correct action is to level the wings and then pull back on the controls. Otherwise, the harder the pilot pulls, the faster the aircraft loses altitude.

The investigation revealed that prior to impact, the bank angle was decreasing from the maximum bank angle (72.9°) to 57.6° and the commander was most probably trying to correct the high sink rate and the steep bank, but given the low altitude the correction was initiated too late.

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[14] The aircraft's bank angle was calculated at 24 points. At the first point the bank angle was 54.2° (when entering the turn) and at the last one it was 57.6° (during the impact). At other points the bank angles were calculated to be more than 60°.
[15] Indicated Air Speed
[16] Ground Speed

Figure 31: Computer generated view of the aircraft flight path during left turn (seen from behind)

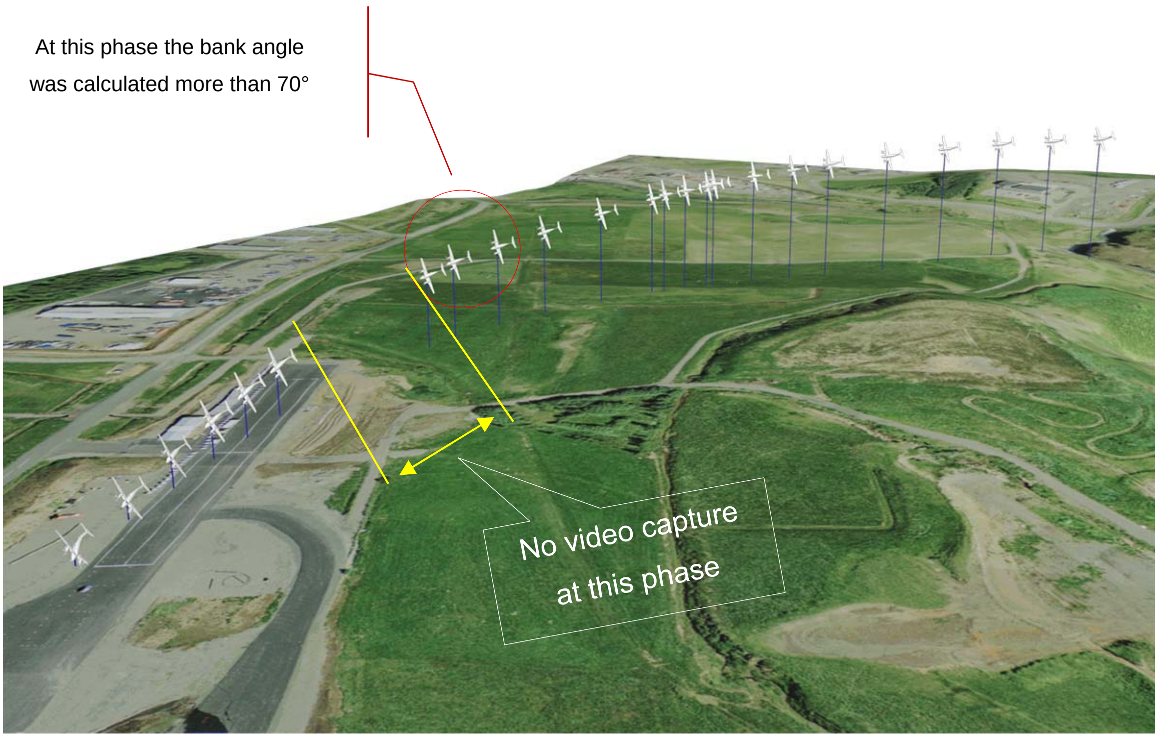


Figure 32: Computer generated view of the aircraft flight path during left turn (seen from front)

2.3.3. Load factor

The acceleration pushing the pilot into the seat is known as G load. This is equal and opposite of lift, and the wings must support it. Therefore, in level flight this acceleration is normally 1 G, where the load factor is 1.

The following formula can be used to estimate the G load on the aircraft where ϕ is the bank angle and N is the load factor.

$$N = \frac{1}{\text{Cos } \phi}$$

During the turn, there were four places measured were the bank angle was above 70° (from 70.4 – 72.9):

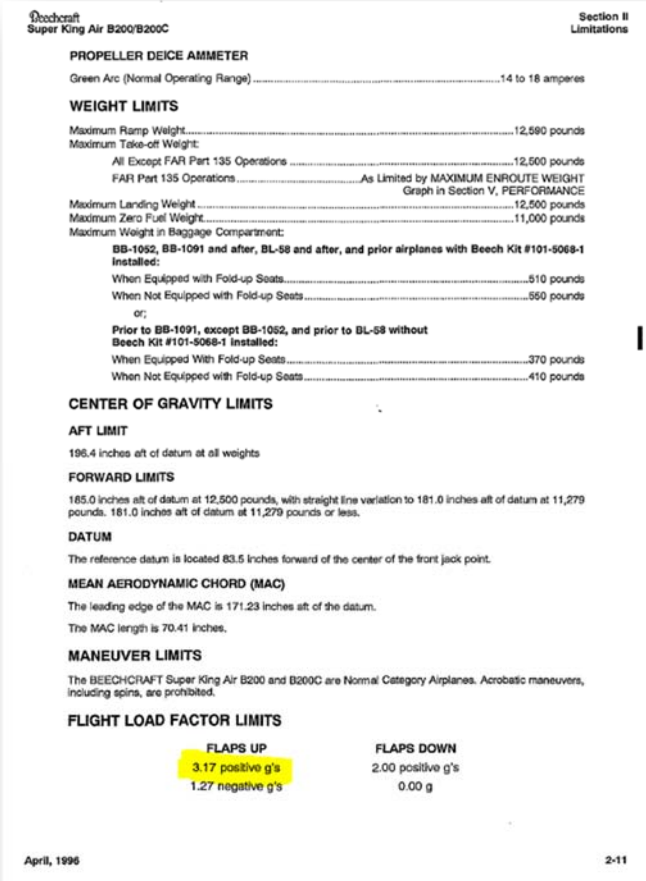
$$3 = \frac{1}{\text{Cos } 70.4} \qquad 3{,}4 = \frac{1}{\text{Cos } 72.9}$$

Assuming that the turn was coordinated, the highest calculated G-load to the aircraft would be 3.4 G. This however shall be seen only as an estimate due to the fact that it is not known if the turn was coordinated.

In addition this does not take into account that the aircraft's pitch angle is also varying, which affects the G-load. If the airplane is pitched up during the turn, the G-loading is increased further, while if the aircraft is pitched down the G-loading decreases. At the highest bank (72.9) the pitch angle was calculated 12.5° down. This point still showed the largest calculated G-loading of 3.3, when taking the pitch angle into account.

The Beechcraft Super King Air B200 aircraft are normal category aircraft. According to the Pilot Operation Handbook (POH), shown in Figure 33, it is stated that acrobatic maneuvers are prohibited. It is also stated that the flight load factor limit with the flaps up is 3.17 g's.

The three cameras that captured the aircraft in the turn did not capture a section of the flight after the point where the bank angle was calculated 70.5°. The next point captured by the cameras was when the aircraft was already over the racetrack, where the bank angle was calculated 69.8°.


Beechcraft
Super King Air B200/B200C

Section II
Limitations

PROPELLER DEICE AMMETER

Green Arc (Normal Operating Range) .... 14 to 18 amperes

WEIGHT LIMITS

Maximum Ramp Weight .... 12,590 pounds
Maximum Take-off Weight:
All Except FAR Part 135 Operations .... 12,500 pounds
FAR Part 135 Operations .... As Limited by MAXIMUM ENROUTE WEIGHT Graph in Section V, PERFORMANCE
Maximum Landing Weight .... 12,500 pounds
Maximum Zero Fuel Weight .... 11,000 pounds
Maximum Weight in Baggage Compartment:

BB-1052, BB-1091 and after, BL-58 and after, and prior airplanes with Beech Kit #101-5068-1 installed:

When Equipped with Fold-up Seats .... 510 pounds
When Not Equipped with Fold-up Seats .... 550 pounds

or;

Prior to BB-1091, except BB-1052, and prior to BL-58 without Beech Kit #101-5068-1 installed:

When Equipped With Fold-up Seats .... 370 pounds
When Not Equipped with Fold-up Seats .... 410 pounds

CENTER OF GRAVITY LIMITS

AFT LIMIT

196.4 inches aft of datum at all weights

FORWARD LIMITS

185.0 inches aft of datum at 12,500 pounds, with straight line variation to 181.0 inches aft of datum at 11,279 pounds. 181.0 inches aft of datum at 11,279 pounds or less.

DATUM

The reference datum is located 83.5 inches forward of the center of the front jack point.

MEAN AERODYNAMIC CHORD (MAC)

The leading edge of the MAC is 171.23 inches aft of the datum.

The MAC length is 70.41 inches.

MANEUVER LIMITS

The BEECHCRAFT Super King Air B200 and B200C are Normal Category Airplanes. Acrobatic maneuvers, including spins, are prohibited.

FLIGHT LOAD FACTOR LIMITS

FLAPS UP	FLAPS DOWN
3.17 positive g's	2.00 positive g's
1.27 negative g's	0.00 g

April, 1996

2-11

Figure 33: Maneuver and flight load factor limit listed in the POH

2.3.4. Mass and balance

The aircraft was fuelled with 738 litres of fuel before the flight from BIRK to BIAR. According to the load sheet, the aircraft ramp weight was 11,858 lbs, before the departure. The landing weight was calculated as 11,280 lbs. and the center of gravity was calculated as 187.5 inch. The mass and balance was within limits at the time of the accident.

2.3.5. Aircraft instrumentation

N/A.

2.3.6. Aircraft systems

The stall warning system consists of a transducer, a lift computer, a warning horn, and a test switch. Angle of attack is sensed by aerodynamic pressure on the lift transducer vane located on the left wing leading edge. When a stall is imminent, the output of the transducer activates a stall warning horn. The system has pre-flight test capability by the use of a switch placarded STALL WARN - TEST - OFF on the co-pilot's left subpanel. Holding this switch in the TEST position activates the warning horn. There was no indication of a failure in the stall warning system.

The co-pilot does not recall any stall warning prior to the impact.

The aircraft was fitted with a yaw damper system, to provide aid to maintain directional control and to increase ride comfort. The system could be used at any altitude and was required for flight above 17,000 feet. According to the operators SOP the YAW DAMP switch should be in "OFF" position prior to landing. The investigation revealed that the YAW DAMP switch was in the "ON" position during the accident. Given the phase of flight prior to the accident (not landing), this was the proper position.

2.4. Human factors

2.4.1. Crew Resource Management (CRM)

Crew Resource Management (CRM) is the effective use of all available resources for flight crew personnel to assure a safe and efficient operation, reducing error, avoiding stress and increasing efficiency. CRM aims to ensure that crews respond appropriately to situations in which they find themselves and refers to factors that include communication, coordination, planning, and teamwork.

According to the Human Factors Analysis and Classification System ineffective CRM can be a precondition for unsafe acts such as decision errors, skill based errors and perception errors.

Decision errors may occur in situations where there is not a procedure to rely on and flight crews find themselves required to make a choice among multiple response options, under conditions when there is insufficient experience, insufficient time or external pressures.

There are indications that communication, planning and teamwork of the flight crew was not effective and that decision errors were made.

According to the co-pilot’s statements, the communication between the commander and the co-pilot regarding the flyover was limited to a brief discussion that included the co-pilot mentioning at one time to the commander that they were a bit low and recommended a higher altitude. The commander increased the altitude momentarily to 1000’ MSL.

Based on the final heading of the aircraft, before it collided with the racetrack, the ITSB believes that the commander intended to fly over and along the racetrack instead of flying a semi perpendicular track over the racetrack. The decision to bring their flight path further west of the airport, in response to the departing traffic from BIAR, placed the commander in a situation that in order to line up with the racetrack an excessive bank angle would be required that exceeded the manufacturer's limitations.

2.4.2. Spatial orientation/disorientation

Spatial orientation is a subset of the pilot’s situational awareness and can be defined as a correct understanding of the aircraft's position, such as movement and attitude in relation to the ground. The spatial orientation consists of information from vision, muscles and the vestibular system and of the information from the flight instruments. Under spatial disorientation, one is unable to determine the aircraft's position, movement and/or attitude in relation to the ground or another aircraft. If a pilot only relies on his senses, the risks of spatial disorientation increases, especially if the visual cues from ground, water, horizon and cloud formations are not clear. A high G-load may also contribute to spatial disorientation.

A disoriented pilot with little or no acrobatic experience would have tendencies to pull back on the controls as the aircraft starts to lose altitude during a steep turn. That leads to the aircraft pitching down and further increase in bank angle as well as the sink rate.
Prior to the steep turn, the aircraft was flown in an area where the landscape slopes downhill along the flightpath. The focus of the commander was most probably on the racetrack area where the racetrack itself has a similar shape to an airport runway, but is smaller in size. After the steep turn the mountain area slopes against the flight path.
This could lead to spatial disorientation for the commander such as giving the impression of being at a higher altitude than the actual altitude of the aircraft.

2.4.3. Monitoring limitations - Attention and Distraction

Attention is the behavioral and cognitive process of selectively concentrating on a discrete aspect of information while ignoring other perceivable information. Therefore, if attention is targeted at a particular area, then it is likely to be at the expense of the other areas. Therefore, it is impossible to provide full attention to all areas at the same time.

Distraction acts to shift attention from where a person was intending to focus their attention to another point. Warning systems (alarms) can be used to provide a distraction in order to shift attention to new and critical information. However when a distraction is caused by an irrelevant information, then attention is shifted away from the intended task.

The investigation revealed that the commander had a personal connection with the race club, was familiar with club members on the ground and also intended to volunteer at the event after landing. The commander had been active in the race club for number of years and had an active role in planning and organizing the race event.

The ITSB believes that the commander’s association with the race club was a key motivator for the commander‘s decision to fly over the race track. If not for this personal connection to the activities and persons on the racetrack, the reason to execute the flyby would not have existed to the same extent.

The ITSB also believes that due to the aforementioned personal association it likely was a source of distraction that shifted the commander‘s attention away from a safe execution of the flight. This made him less able to perceive and detect information that contradicted the advisability to perform the maneuver he intended to do.

The fact that the aircraft was in a descent, during the turn, while under high G-load, indicates that the commander’s attention was likely primarily focused out the cockpit’s windows and not on the aircraft’s instruments.

2.4.5. Effects of acceleration/G-load

Acceleration due to changing speed and/or direction of flight may produce considerable physiological effects upon the occupants of an aircraft. Under rapid onset of acceleration forces, the average human tolerance is about 3-4 G[17]. Acceleration forces will cause blood pooling in peripheral limbs and depending on the onset rate, exposure time and magnitude may cause greying out of vision and ultimately unconsciousness. It should be taken into account that acceleration tolerance for each individual may vary from day to day.

According to the co-pilot, the G-load he experienced was such that he felt pinned to his seat and could not lift his arms.

Under these circumstances it is assessed that the G-load likely wouldn't have been of such force that it prevented the pilot, already with his hand(s) on the controls, to operate the ailerons. However with minimum or no experience of acrobatic flying, delayed reaction is likely in such circumstances. As mentioned in chapter 2.3.3, the maximum bank angle during the turn was calculated 72.9° resulting in a G-load of approximately 3.4. According to the aircraft manufacturer, bank angle beyond 60° is considered to be an acrobatic flight. The investigation revealed that the commander did not have any background or training in acrobatic flight.

The calculated time from the first point of the video capture and until the time of impact was 5.6 seconds. Analysis of the video recordings revealed that a correction was initiated about 1.5 seconds prior to the impact. However the altitude was insufficient for the correction to be completed.

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[17] James E. Whinnery Ph.D., M.D. Aeromedical Research Division, Civil Aerospace Medical Institute.

2.4.6. Planning and situational awareness

A good plan generally increases safety in the implementation of flight. Planning is therefore critical for the conduction of safe flight. It plays a very important role in supporting crew's situational awareness, to enable the crew to identify, discuss and plan how to handle risks.

The investigation revealed that the flightpath prior to the racetrack flyby was most probably unplanned in details. This, most likely, made the crew improvise and focus on the relevant tasks (flyby) which would have a negative effect on their situation awareness and their ability to maintain a common goal (how to perform the flyby).

The area of the accident was the hometown of the commander and he was familiar with it. The commander had flown over the racetrack before, but from a different direction (from southwest with no steep turn). In order to implement a safe flight, regardless of the commander being familiar with the area, it would have been necessary to conduct a more detailed planning of a deviation such as the flyby.

2.4.7. Safety culture

According to the operator, deviations from its Operating Manual are not accepted except in emergency situations. The extent of the deviation of this particular flight, i.e. low-pass over an area with group of people, would not have been accepted by the operator.

The investigation revealed that deviations from normal procedures had been practiced previously, such as low pass and sightseeing on the way back from an ambulance flight, and was seen as acceptable by some flight crews. Flight crews often begin their careers with the operator by flying sightseeing tours and then making a transition to flying ambulance flights. Deviations from normal procedures were not acceptable to the operator.

2.5. Survivability

2.5.1. Rescue fire service response

The fuselage broke into three main pieces (cockpit, cabin and empennage). The paramedic was seated in the cabin section close to where the cabin broke from the cockpit. The empennage came to rest left of the racetrack but the cockpit and the cabin came to rest in a grass area beyond the end of the racetrack.

Due to the race event, some rescue personnel were present when the accident occurred. Further assistance arrived only few minutes later at the accident site. Both the commander and the paramedic sustained fatal injuries due to high energy impact and the co-pilot sustained serious injuries. As this was a high energy impact the survivability aspects are considered to be low. Fire did not affect the survivability.

3. CONCLUSION

3.1 Findings

1. The flight crew was licensed and qualified to conduct the flight.
2. The flight crew was well rested.
3. The aircraft was certified, equipped and maintained in accordance with existing regulations and approved procedures.
4. No abnormalities were found with regards to the engines nor the propellers.
5. No abnormalities were found with regards to the flight controls.
6. The yaw damper system was likely in the “ON” position during the accident.
7. ATC received no distress call from the crew.
8. The last phase of the flight was outside the operator’s normal procedures.
9. A flyby was discussed between the pilots but not planned in details.
10. The discussed flyby was executed as a low pass.
11. The flight crew reacted to the departing traffic from BIAR by bringing their flight path further west of the airport.
12. The approach to the low pass was misjudged.
13. A steep bank angle was needed to line up with the racetrack.
14. The maximum calculated bank angle during last phase of flight was 72.9°, which is outside the aircraft manoeuvring limit.
15. In general and according to the manufacturer, a bank angle beyond 60° is considered to be an acrobatic manoeuver.
16. A loss of control occurred during the steep turn.
17. A correction to the bank angle was initiated about 1.5 seconds prior to the impact.
18. Given the low altitude the correction was initiated too late.
19. The flight test in Beech King Air B200 flight simulator revealed that the aircraft was unable to maintain altitude during such a steep bank angle.
20. The steep turn was most probably made due to the commander’s intention to line up with the race track.
21. Survivability was considered to be low.
22. The commander’s attention to the activity at the race club area, and his association with the club was most probably a source of distraction for him and most likely motivated him to execute the low-pass.
23. A breakdown in CRM occurred.
24. The variability of the mountain area as well as the size/shape of the racetrack (smaller than a RWY) may have caused the commander to misjudge the altitude.

25. The investigation revealed that the safety management system of the operator was being implemented in accordance with regulations.
26. Deviations from normal procedures were seen to be acceptable by some flight crews.
27. Deviations from normal procedures were not seen as acceptable by the operator's management.

3.2 Causes

The commander was familiar with the racetrack where a race event was going on and he wanted to perform a flyby over the area. The flyby was made at a low altitude. When approaching the racetrack area, the aircraft's calculated track indicated that the commander's intention of the flyby was to line up with the racetrack. In order to do that, the commander turned the aircraft to such a bank angle that it was not possible for the aircraft to maintain altitude.

The ITSB believes that during the turn, the commander most probably pulled back on the controls instead of levelling the wings. This caused the aircraft to enter a spiral down and increased the loss of altitude.

The investigation revealed that the manoeuvre was insufficiently planned and outside the scope of the operator manuals and handbooks.

The low-pass was made at such a low altitude and steep bank that a correction was not possible in due time and the aircraft collided with the racetrack.

The ITSB believes that human factor played a major role in this accident. Inadequate collaboration and planning of the flyover amongst the flight crew indicates a failure of CRM. This made the flight crew less able to make timely corrections.

The commander's focus was most likely on lining up with the racetrack, resulting in misjudging the approach for the low pass and performing an overly steep turn. The overly steep turn caused the aircraft to lose altitude and collide with the ground.

The co-pilot was unable to effectively monitor the flyover/low-pass and react because of failure in CRM i.e. insufficient planning and communication.

A contributing factor is considered to be that the flight path of the aircraft was made further west of the airfield, due to traffic, resulting in a steeper turn.

The investigation revealed that flight crews were known to deviate occasionally from flight plans.

Causal factors:

- A breakdown in CRM occurred.
- A steep bank angle was needed to line up with the racetrack.
- The discussed flyby was executed as a low pass.
- The maximum calculated bank angle during last phase of flight was 72.9°, which is outside the aircraft manoeuvring limit.
- ITSB believes that the commander's focus on a flyby that he had not planned thoroughly resulted in a low-pass with a steep bank, causing the aircraft to lose altitude and collide with the ground.

Contributory factors:

- The commander's attention to the activity at the race club area, and his association with the club was most probably a source of distraction for him and most likely motivated him to execute an unsafe manoeuver.
- Deviations from normal procedures were seen to be acceptable by some flight crews.
- A flyby was discussed between the pilots but not planned in details.
- The flight crew reacted to the departing traffic from BIAR by bringing their flight path further west of the airport.
- The approach to the low pass was misjudged.
- The steep turn was most probably made due to the commander's intention to line up with the race track.

Company changes following the accident

Following the accident, the operator started an internal investigation and took the following actions:

- Standard operating procedures, including normal, abnormal and emergency procedures (chapter 2 and 3 of OM-B) was reviewed and revised.
- Standardization was emphasized in training, both ground training and simulator.
- Clearly communicate by management that individuality in procedural adherence is not acceptable.
- Relationship between flight standardization, professionalism and safety should be included in all upcoming training.
- Other measures to strengthened procedural compliance.
- The operator updated its Aerial Work & VFR IFR Policy.

4. SAFETY RECOMMENDATIONS AND SAFETY ACTIONS

Safety recommendations:

M-01513 T01

It is recommended to the operator to re-evaluate its CRM training.

M-01513 T02

It is recommended to the Icelandic transport authority (ICETRA) to consider that a paramedic in an ambulance flight should be defined as a crew member.

Safety actions:

ITSB would like to emphasize the following safety actions to operators and crew members:

CRM shall be maintained and practiced during unplanned operations as well as during planned operations.

The following ITSB board members approved the report:

- Geirþrúður Alfreðsdóttir
- Bryndís Lára Torfadóttir
- Gestur Gunnarsson
- Hörður Vignir Arilíusson
- Tómas Davíð Þorsteinsson

Reykjavík, 12. June, 2017

On behalf of the Icelandic Transportation Safety Board

Þorkell Ágústsson – IIC

5. APPENDIX 1 - SOLVED AIRCRAFT LOCATIONS

Time (hhmm:ss.sss)	X (m)	Y (m)	Z (m)	LATITUDE	LONGITUDE	Pitch (deg) (+ve Nose Down)	Bank (deg) (+ve Right Up)	True Heading (deg) (+ve Nose Down)	Mean Sea Level Elevation (m)	Above Ground Level Elevation (m)	Speed GS KN	Speed IAS KN
1328:42.316	348.573	-359.463	188.211	65° 40' 22.3924" N	18° 08' 22.5452" W	11.3	54.2	315.7	188.211	78.284	-	
1328:42.656	320.480	-332.325	188.788	65° 40' 23.3091" N	18° 08' 24.6460" W	5.5	60.4	321.4	188.788	71.081	217	230
1328:43.003	288.426	-305.098	189.493	65° 40' 24.2345" N	18° 08' 27.0563" W	12.9	62.5	316.7	189.493	70.063	-	
1328:43.338	255.853	-278.120	189.298	65° 40' 25.1526" N	18° 08' 29.5082" W	6.3	64.6	311.4	189.298	70.347	-	
1328:43.678	221.335	-251.162	188.038	65° 40' 26.0729" N	18° 08' 32.1123" W	3.5	62.8	309.4	188.038	68.601	238	248
1328:44.023	185.698	-225.501	186.767	65° 40' 26.9530" N	18° 08' 34.8087" W	4.1	67.1	303.6	186.767	65.308	-	
1328:44.188	166.269	-209.784	185.009	65° 40' 27.4885" N	18° 08' 36.2726" W	2.2	66.9	300.2	185.009	62.964	-	
1328:44.361	143.594	-191.167	182.807	65° 40' 28.1223" N	18° 08' 37.9801" W	-0.3	67.1	308.8	182.807	59.918	-	
1328:44.531	126.642	-175.460	180.638	65° 40' 28.6538" N	18° 08' 39.2503" W	-1.2	66.6	307.9	180.638	56.691	-	
1328:44.564	125.251	-173.860	179.591	65° 40' 28.7075" N	18° 08' 39.3534" W	-1.3	66.7	307.5	179.591	55.668	-	
1328:44.703	111.127	-166.394	178.924	65° 40' 28.9691" N	18° 08' 40.4317" W	-2.5	68.1	305.7	178.924	53.662	-	
1328:44.871	94.875	-160.735	178.791	65° 40' 29.1754" N	18° 08' 41.6829" W	-2.4	68.0	294.9	178.791	52.130	-	

Time (hhmm:ss.sss)	X (m)	Y (m)	Z (m)	LATITUDE	LONGITUDE	Pitch (deg) (+ve Nose Down)	Bank (deg) (+ve Right Up)	True Heading (deg) (+ve Nose Down)	Mean Sea Level Elevation (m)	Above Ground Level Elevation (m)	Speed GS KN	Speed IAS KN
1328:44.897	86.446	-157.117	177.608	65° 40' 29.3045" N	18° 08' 42.3294" W	6.4	69.0	287.2	177.608	50.607	-	
1328:45.231	51.037	-143.486	174.802	65° 40' 29.7961" N	18° 08' 45.0509" W	10.9	69.4	284.2	174.802	45.751	-	
1328:45.564	13.321	-130.195	171.044	65° 40' 30.2801" N	18° 08' 47.9540" W	19.3	70.4	270.8	171.044	40.454	250	252
1328:45.897	-17.683	-121.401	169.036	65° 40' 30.6092" N	18° 08' 50.3481" W	12.5	72.9	275.4	169.036	38.009	-	
1328:46.231	-47.056	-114.622	167.061	65° 40' 30.8710" N	18° 08' 52.6218" W	18.3	72.4	265.9	167.061	36.522	-	
1328:46.364	-62.912	-110.310	163.670	65° 40' 31.0333" N	18° 08' 53.8468" W	19.4	70.5	263.6	163.670	33.087	-	
1328:47.054	-173.153	-112.531	152.428	65° 40' 31.1230" N	18° 09' 02.4786" W	39.8	69.1	227.0	152.428	19.146	-	
1328:47.220	-199.148	-118.348	150.847	65° 40' 30.9734" N	18° 09' 04.5327" W	35.6	68.2	228.5	150.847	17.095	-	
1328:47.387	-223.555	-123.993	148.639	65° 40' 30.8270" N	18° 09' 06.4620" W	24.4	66.3	236.4	148.639	13.24	-	
1328:47.554	-251.665	-131.550	147.003	65° 40' 30.6243" N	18° 09' 08.6878" W	10.2	64.7	237.3	147.003	10.757	-	
1328:47.720	-279.911	-139.677	144.111	65° 40' 30.4034" N	18° 09' 10.9262" W	10.4	62.5	236.8	144.111	6.089	-	
1328:47.887	-311.336	-150.379	142.751	65° 40' 30.1041" N	18° 09' 13.4224" W	18.8	57.6	217.5	142.751	4.309	276	266