

Swiss Confederation

Summary report

A summary investigation was carried out in relation to this incident in accordance with the Ordinance on the Safety Investigation of Transport Incidents of 17 December 2014 (OSITI), status as of 1 February 2015 (SR 742.161). The sole purpose of an accident or serious incident investigation is the prevention of accidents or serious incidents. It is expressly not the purpose of the safety investigation and this report to determine fault or liability. If this report is used for purposes other than accident prevention, this fact shall be taken into account.

Aircraft type	Beech B200 Super K	ing Air	N7779V			
Operator	Private					
Owner	Aerospace Trust Management LLC Trustee, 1013 Centre Rd Ste 403A, Wilmington, DE 19805-1270, USA					
Pilot	Dutch citizen, born 1	962				
Licence	Commercial Pilot Lic Aviation Administration	ence Aeroplane on (FAA)	(CPL(A)) issued	by the Federal		
Flying hours	Total On type	13 200 hours 549 hours	Last 90 Last 90	days62 hoursdays22 hours		
Second pilot	Dutch citizen, born 1	981				
Licence	CPL(A) issued by the	e Civil Aviation A	uthority Netherla	inds		
Flying hours	Total	427 hours	Last 90	days 3 hours		
	On type	239 hours	Last 90	days 0 hours		
Location	12.2 NM north-east of	of Lausanne Airp	ort (LSGL)			
Coordinates	553 337/171 312 (Sv N 46° 41' 29"/E 006°	viss Grid 1903) 49' 43'' (WGS ¹	Altitude 84)	Flight level 155		
Date and time	23 February 2019, 14	4:54:18 UTC (LT	= UTC + 1 hour)		
Nature of flight	Private					
Flight rules	Instrument Flight Rul	es (IFR)				
Departure airport	Saanen (LSGK)					
Destination airport	Amsterdam (EHAM)					
Flight phase	Climb					
Nature of the serious incident	Total electrical failure)				
Injuries	Crew members	Pass	engers ⁻	Third parties		
Slightly injured	0		0	0		
Uninjured	2		0	0		
Damage to aircraft	Not damag	ed				
Third-party damage	None					

¹ WGS: World Geodetic System. The WGS 84 standard was adopted for aviation by a resolution of the International Civil Aviation Organization (ICAO) in 1989.

Factual information

General

The aircraft type Beech B200 Super King Air, involved in the present investigated serious incident, is certified for operation with only one pilot in the left seat. Neither a digital flight data recorder (DFDR) nor a cockpit voice recorder (CVR) was mandated or installed.

The following information was available for the investigation:

- Report of the pilot in command of the aircraft
- Owner's investigation report
- Air traffic control records

The pilot-in-command (PIC) was in the left cockpit seat during the serious incident. A pilot with a commercial pilot's licence but without authorisation for the aircraft type Beech B200 Super King Air was in the right-hand seat.

History of the flight

On 23 February 2019, the flight crew planned to undertake a private flight from Saanen (LSGK) to Amsterdam (EHAM) in the Beech B200 Super King twin-engine business aircraft, registration number N7779V. After the two engines had been started, the airport traffic control tower informed the flight crew that air traffic control in Geneva was currently unable to authorise their take-off. The flight crew then switched the two engines off again.

After around 30 minutes, the flight crew received clearance for their flight and restarted the engines. According to the Investigation Report mentioned above, the engines were started from memory, i.e. without using a corresponding checklist.

Take-off took place at 14:44 UTC under visual flight rules. The plan was to change to instrument flight rules (IFR) during the later stages of the climb. The flight crew reported to the air traffic controller (ATC) at 14:53:17 UTC and informed him that they were passing FL 150 to climb to FL 180. The ATC then cleared the flight crew for FL 240 and instructed them to take a direct course to the PENDU waypoint, which is located north of Besançon in France.

Shortly thereafter all the cockpit displays went blank, which the flight crew interpreted correctly as a total electrical failure. Only the emergency instrument (Standby Attitude Module – SAM, also called Electronic Standby Instrument System – ESIS) displays were still available (see Appendix 2). Due to the good weather conditions, the flight crew decided to re-route to Lausanne (LSGL), which could be approached as a non-towered airport under visual flight conditions.

At 14:54:18 UTC, the aircraft label on the air traffic control radar screen changed to «lost on» because the N7779V's transponder had stopped transmitting a signal. Radio contact with the flight crew was interrupted at the same time. The ATC made several unsuccessful attempts to reach the flight crew on the emergency frequency. In coordination with various air traffic control centres, approach flights to Geneva (LSGG) were diverted to ensure that the airspace around the «lost on» label remained clear and no further take-offs were permitted from Geneva.

As the pilot was carrying a private radio, he was able to send a notification on the 121.5 MHz emergency frequency. Air traffic control confirmed that the pilot announced on the emergency frequency at 15:00:03 UTC that N7779V had suffered a total electrical failure and that he would divert the plane to Lausanne.

The flight crew also had three iPads, which meant that they had access to all relevant flight charts and also knew their current GPS position.

The flight crew continued their approach under visual conditions and extended their landing gear in accordance with the respective emergency-checklist. The approach was uneventful and the aircraft landed in Lausanne at 15:05 UTC.

Findings after the landing

After switching off the two engines, the pilot noticed that the left-hand IGNITION AND ENGINE START switch, that can be set in the three positions ON, OFF and STARTER ONLY, was still in the ON position (see Fig. 3), although it has to be returned to the OFF position after the engine has been started (see Appendix 4). He attributed the total electrical failure to this incorrect switch position and decided to recharge the battery with a ground power unit. Once the battery was charged, the flight crew started the left-hand engine. It started successfully and no anomalies were found. The right-hand engine was then started and again no anomalies were found and all systems and displays were functioning normally.

The flight crew concluded that there was no further defect. After another successful test on the following day, 24 February 2019, the aircraft took off from Lausanne (LSGL) at 09:15 UTC and landed in Amsterdam (EHAM) at 11:15 UTC following an uneventful flight.

Technical investigations

Technical investigations by a maintenance company revealed no anomalies in either the aircraft systems or the «Pro Line Fusion» avionics system. The battery no longer fulfilled the prescribed tests and was replaced.

Meteorological data

Switzerland was under the influence of a powerful high-pressure area that was centred over Poland. With a moderate breeze, which was strong at altitude, dry air was flowing into the Alpine region.

Lausanne Airport does not publish a Meteorological Aviation Routine Weather Report (ME-TAR). The following METAR was published for the time of the severe incident at the nearest Geneva Airport (LSGG):

«METAR LSGG 231450Z 04006KT 010V080 CAVOK 10/02 Q1030 NOSIG=»

This notification indicates that the following weather conditions had been observed shortly before its issuance at 14:50 UTC:

Wind From 040 degrees, variable between 10 and 80 degrees, 6 kt

Visibility, weather and clouds CAVOK (ceiling and visibility ok), which means:

visibility 10 km or more;
no clouds below 5000 ft or below the highest minimum sector altitude (MSA) if this is higher than 5000 ft (LSGG: 10 000 ft above ground level);
No cumulonimbus;
No significant weather phenomena.

Temperature/dew point10 °C/2 °CAir pressure (QNH)1030 hPa (pressure reduced to sea level, calculated using
the ICAO standard atmosphere values)OutlookNo significant change

Details of aircraft

General information

Only descriptions of those systems and functions of relevance to the serious incident are described below.

Electrical system

The electrical system has three power sources: the battery (BAT), the left generator (L GEN) and the right generator (R GEN). These three power sources supply various buses, which in turn power the different electrical components.

The direct current supply is provided by a 42 Ah sealed lead acid battery and two 250 A starter/generators connected in parallel. The two generators, driven directly by the two motors, are individually controlled by two voltage regulators, which ensure that the voltage remains constant at different motor speeds and system loads. The load on the generators is indicated in the cockpit overhead panel by voltage and load display instruments (see Fig. 1).

AC power is supplied by left and right inverters, which are directly fed from the corresponding generator buses. These inverters supply the aircraft with an AC voltage of 115 V and a frequency of 400 Hz. These two values are also displayed on the relevant instrument on the overhead panel (see Fig. 1).

The two generators are controlled by two switches marked GEN 1 and GEN 2. The Pilot's Operating Handbook (POH) notes the following in this regard: «In order to turn the generator ON, the generator control switch must first be held upward in the spring-loaded RESET position for a minimum of one second, then released to the ON position.marked»



Figure 1: The two instruments on the left-hand side show the loads of the left and right generators (0 to 100%) on their upper scales and, when the button is pressed, the voltage (0 to 30 V) on their lower scales. The third instrument indicates the load on the battery (-60 to +60 A) and the fourth instrument shows the AC frequency (380 to 420 Hz) on its upper scale and the voltage (100 to 130 V) on its lower scale.

If a generator is not connected, the annunciator panel will also display the warning L DC GEN for the left alternator or R DC GEN for the right alternator (see appendix 3).

Pro Line Fusion avionics system

The purpose of updating the cockpit with the Rockwell Collins' Pro Line Fusion avionics system is to make both the information required by the pilot and its processing more flexible and efficient. Instead of electromechanical instruments, three 14-inch touchscreen flight display screens are installed in the forward main panel. These make it possible to present and process all the information needed in a systematic manner (see Appendix 2). The size and layout of the information can be displayed with only a few taps. For example, it is possible to access weather information, traffic and map displays.

An important component of the update is the associated Flight Management System (FMS). The FMS provides centralised control over navigation, flight planning, radio support selection and fuel management.

An integral element of the update is the Standby Attitude Module (SAM), also known as the Electronic Standby Instrument System (ESIS). The SAM is an integrated emergency instrument that displays the pilot's course, attitude, flight level and speed on a colour liquid crystal display (LCD) (see Appendix 2). The SAM is normally powered by the aircraft's power supply. If this fails, as was the case in the serious incident under investigation in this report, an internal lithium-ion battery powers the SAM for a further 60 minutes.

Warnings and notifications

An optional add-on to the Pro Line Fusion avionics system allows the warnings and notifications to be displayed on the centre screen instead of the annunciator panel (see Fig. 2). This option had not been activated on the N7779V.



Figure 2: Left of the map display ($\mathbf{0}$) and below the displays to monitor the engines ($\mathbf{0}$), optional messages and warnings will be displayed ($\mathbf{0}$). This option had not been activated on the N7779V. (Picture edited by the SUST).

Procedural specifications

Starting the engines

The engine is started using the three-position IGNITION AND ENGINE START switch located on the lower left of the panel (see Fig. 3 and Appendix 2).



Figure 3: Three-position IGNITION AND ENGINE START switch; left switch in ON position, right switch in OFF position

When the switch is moved down to the STARTER ONLY position, the motor shaft rotates without engaging the ignition to remove any fuel residues. The switches are spring-loaded and return to the central position when released.

Moving the switch upwards to the ON position activates the starter and ignition and the corresponding IGNITION ON indicator on the annunciator panel glows green (see Appendix 3). The starter/generator powers the engine's compressor stage via the accessory gear box. It initially requires around 1100 A, which then rapidly decreases to approximately 300 A when the engine speed reaches 20% N1. Once the engine speed has accelerated to 50% N1 (or higher), the three-position switch must be switched back to the central OFF position.

This starting procedure was set out in the Pilot's Operating Handbook (POH) by the aircraft's manufacturer. This procedure was also taught at the Flight Safety International training centre where the pilot was trained (see Appendix 4).

Additional points must be observed or gone through before starting the engines of aircraft equipped with the Pro Line Fusion avionics system. These are detailed on an additional check-list for starting the engines, but do not apply when actually starting the engines as described in the checklists (see Appendix 4).

Checklist before taxi

Before taxiing the aircraft, the flight crew must work through the corresponding checklist (before taxi) (see Fig. 4). The first item in both the procedure issued by the manufacturer and the one issued by Flight Safety International explicitly requires checking the power supply to the generators. This is done via the displays of the electrical instruments (see Fig. 1).

	BEFORE TAXI
	NOTE
Item	s marked with an "*" may be omitted at pilot's etion after the first flight of the day.
1. Loadme	ersPARALLEL WITHIN 10%
2. Avionics	MasterON
3 Evternal	Lights AS REOLIIRED
Figure 4: Extract from the Fl	ght Safety International manuals before taxi checklist.

Deal with warnings

Warnings are displayed on the annunciator panel. Amber warnings require the pilot to take action, while green indicators are to inform the pilot and do not necessarily require action. The various displays and their significance are described in the POH. The displays relevant to the present investigation (see Appendix 3) serve as an example. The aircraft manufacturer goes on to describe in the POH the following: *«An illuminated caution annunciator on the caution/ad-visory annunciator panel will remain illuminated until the fault condition is corrected, at which time it will extinguish.»*

The following procedure is specified by the aircraft manufacturer for the warning L DC GEN, which was displayed in the serious incident:

Section 3A Abnormal Procedures ELECTRICAL SYSTEM	Hawker Beechcraft Corporation Model B200GT/B200CGT
SINGLE GENERATOR FAILUR	E [L DC GEN] OR [R DC GEN]
1. Loadmeter	VERIFY GENERATOR IS OFF (0% LOAD)
2. Generator	RESET, THEN ON
If Generator Will Not Reset:	
3. Generator	OFF
4. Loadmeter DO NO	T EXCEED 100% (88% above 31,000 feet)
In the event of a single generator failur reduce the electrical load below 100%	re, the following systems may be shut off to :
Furnishing Systems	Cabin Lights
Tail Flood Lights	Cockpit/Cabin Blowers (Low Speed)
Prop Sync	
Copilot Windshield Anti-Ice	
Strobe Lights	

Figure 5: Checklist for the warning L DC GEN (copied from the POH)

Analysis

Technical aspects

The left three-position IGNITION AND ENGINE START switch was left in the ON position (see Fig. 3). This meant that the left engine's starter generator² was still being powered, incurring a high consumption of electricity, and that the electrical system was only being supplied by the right generator and the battery. The high-power consumption of this combination of circumstances exceeded the capacity of the right generator, which is why the battery was discharged. Ten minutes into the flight, the battery voltage dropped below 16 V, which caused the avionics system to fail.

As the Standby Attitude Module (SAM) is powered by its own independent battery in such a case, the pilots still had the corresponding displays.

Operational aspects

After starting the left motor, the three-position IGNITION AND ENGINE START switch was incorrectly left in the ON position. Since the start procedure was not performed as per the checklist, this error went unnoticed by both pilots. The flight crew again failed to spot the error by not following the next step of the «before taxi» procedure, whose very first item is the check-ing of the electrical system (see Fig. 4).

As a result, it also meant that three different indications of the error remained unnoticed. All three were only visible away from the three screens of the Pro Line Fusion avionics system: the differing generator load indicators and the display on the battery discharge indicator (see Fig. 1), the differing positions of the two three-position IGNITION AND ENGINE START switches (see Fig. 3), and the indicators on the annunciator panel (see Appendix 3). It is reasonable to assume that the pilots were strongly focused on the three screens.

It is also possible that the annunciator panel displays were dimmed and therefore difficult to see in the prevailing lighting conditions. The optional displays of notifications and warnings on the centre screen of the Pro Line Fusion avionics system (see Fig. 2) overcome these problems.

The flight crew interpreted the failure of the three screens correctly as a total electrical failure. They reacted immediately by deciding to make a visual approach to the nearest airport and leaving the controlled airspace. This is an understandable reaction. The fact that the pilot was carrying a portable radio was very helpful, as it enabled him to contact air traffic control on the emergency frequency, significantly reducing the potential severity of the situation.

Conclusions

Ten minutes into the flight, all three cockpit displays failed. The flight crew immediately undertook a visual approach to the nearest airport. This was successful, whereby the emergency instruments that were powered independently of the aircraft's electrical system, the backup navigation on the iPads, the pilot's handheld radio, the good weather conditions and the fact that air traffic control kept the airspace clear were contributing factors.

The investigation showed that this failure was not due to a technical defect. After starting the left engine, the three-position switch IGNITION AND ENGINE START was erroneously left in the ON position, which caused the battery to discharge. This error went unnoticed by both pilots, because they did not work their way consistently through the procedural specifications and failed to notice the corresponding warnings and displays.

² A starter generator combines the functions of a starter and a generator in a single electrical device.

As it seems unlikely that any further investigative actions would produce useful findings, the Swiss Safety Investigation Office is concluding the investigation of the serious incident in question with a summary report in accordance with Art. 45 (1) of the Ordinance on the Safety Investigation of Transport Incidents (OSITI).

The German version of this report is the original and therefore decisive.

Bern, 11 February 2022

Swiss Transportation Safety Investigation Board

Measures taken since the serious incident

The measures of which STSB is aware are listed below without comment.

The owner of the aircraft made the following recommendations in his investigation report and noted *«The report is intended for the aircraft's owner, the flight crew and the Part 145 mainte-nance organisation»*:

- (1) As this investigation report is initially intended for use by the owner and the crew, it is recommended to inform both Raytheon Aircraft Company and Collins Aerospace about the incident.
- (2) As the owner and commander require the single-pilot certified aircraft to be operated by two pilots, it is recommended to give both co-pilots a proper training. A type rating on the aircraft increases their added value and contribution to the safety and efficiency of the operation.
- (3) As the aircraft is operated in a multi-pilot setting, is recommended to also train in a multicrew concept, to enhance effective crew coordination and checklist handling. This can be done by arranging a crew resource management (CRM) training for the commander and both co-pilots.
- (4) Annual training and checking on the aircraft, with the instructor/examiner in the right-hand seat has limited added value as most abnormal and emergency situations cannot be realistically simulated. Therefore, it is recommended to extend the training on the aircraft – which is completed by the commander only – to annual training sessions in a suitable Flight Training Device (FTD-2). The simulator should be used for training in the correct completion of normal, abnormal and emergency procedures and in applying CRM-practices in a multi-crew concept. It is therefore also recommended to include both co-pilots in the training and checking programme.
- (5) When operating the aircraft by a single pilot, strict adherence to the normal, abnormal and emergency checklist is required. This requires self-discipline and time but is essential to prevent errors or to timely identify and correct them. It also aids in preventing negative effects on the flight operation due to distractions, time- pressure and complacency.
- (6) As the engine start is done by memory, it is recommended to add the following item to the Normal Checklist, section Before Taxi checklist: "Ignition/start switches ... OFF". Some operators include an "Engine Start" checklist in their Normal Checklist. An example of such a checklist is depicted in Appendix B.
- (7) It is recommended to rephrase the Normal Checklist, section Before Taxi checklist, item "Electrical System ... CHECKED" into "DC Volts and Load ... CHECKED". This will require both crew members to check the actual output of the generators and the correct functioning of the electrical system. Refer to Appendix B for an example.
- (8) To the aircraft manufacturer, it is recommended to(a) add a "Low Battery" amber annunciator light.
- (9) To the manufacture, it is also recommended to add a simple load shedding logic, which prevents a failure of all avionics at approximately the same time. In many aircraft, the copilot's side fails first before in a later stage all avionics fail. This provides a clear indication to the crew and gives them adequate time to react."

Appendices

Appendix 1: Radar recording of the flight path (green) of N7779V and flight crew's communications with the air traffic controller



Lege	Legend					
	UTC	Flight level	Radio communication			
0	14:20:00		Take off from Saanen (LSGK)			
0	14:53:17	152	Pilot reports that he is climbing to FL 180, FL 150. The air traffic controller then gives clearance to the PENDU waypoint and FL 240.			
₿	14:54:18	155	Radio contact is lost and the «lost on» label is displayed			
4	15:00:03	Not known	The pilot reports on the 121.5 MHz emergency frequency that the aircraft is suffering a total electrical failure and that they plan to land in Lausanne.			
6	15:05:00		Landing in Lausanne (LSGL)			

Appendix 2: Cockpit layout

Cockpit layout before the update (copied from the POH):



Cockpit layout with Pro Line Fusion avionics system (standard Rockwell Collins image):



Legend 1 Three-position switch for starting the engines (see procedural specifications section) 2 Annunciator panel, no changes resulting from the upgrade to Pro Line Fusion 3 Standby Attitude Module (SAM), also known as Electronic Standby Instrument System (ESIS)

Power source switch
 The MASTER SWITCH DOWN cover allows all three power sources (BAT, L GEN + R GEN) to be switched off simultaneously



Appendix 3: Annunciator panel

Possible displays in the annunciator panel (copied from the POH):

Section 7 Hawker Beechcraft Corporation Systems Description Model B200/B200 CAUTION/ADVISORY PANEL ILLUSTRATION					rporation B200/B200C
L DC GEN		HYD FLUID LOW	RVS NOT READY		R DC GEN
L CHIP DETECT			DUCT OVERTEMP		R CHIP DETECT
L ENG ICE FAIL	L PITOT HEAT	ELEC HEAT ON	EXT PWR	R PITOT HEAT	R ENG ICE FAIL
L AUTO- FEATHER			AIR CND N1 LOW		R AUTO- FEATHER
L ENG ANTI-ICE	*BRAKE DEICE ON	LDG/TAXI LIGHT	PASS OXY ON		R ENG ANTI-ICE
L IGNITION ON	L BL AIR OFF		FUEL CROSSFEED	R BL AIR OFF	R IGNITION ON

* Optional Equipment

Significance of the displays in the serious incident situation (copied from the POH):

NOMENCLATURE	COLOR	CAUSE FOR ILLUMINATION
L DC GEN	Amber	Left generator off the line.
L IGNITION ON	Green	Left ignition and engine start switch is ON or left auto ignition system is armed and left engine torque is below 400 ft-lbs.

Displays in the N7779V aircraft (displays in the serious incident situation):

-	L DC GEN			
				ľ
-				3
	L IGNITION ON			

Appendix 4: Checklist for starting the engines

Checklist as published in the POH:

Sect Norr	ion 4 Hawker Beechcraft Corporation nal Procedures Model B200/B200C
ENC	GINE STARTING (BATTERY)
1.	Right Ignition and Engine Start ON
	[R IGNITION ON] - ILLUMINATED
0	[R FUEL PRESS] - EXTINGUISHED
2.	Right Condition Lever (12% N1 or above) LOW IDLE
3.	Right II I and N1 MONITOR (1000°C maximum)
	CAUTION
	If no ITT rise is observed within 10 seconds after moving the condition lever to LOW IDLE, move the condition lever to FUEL CUTOFF. Allow 60 seconds for fuel to drain and starter to cool, then follow ENGINE CLEARING Proce- dures.
4.	Right Oil Pressure CHECK
5.	Right Ignition and Engine Start (50% N1 or above)OFF
6.	Right Condition Lever HIGH IDLE
7.	Right Generator RESET, THEN ON
8.	BatteryCHARGE
0	(until loadmeter reads approximately 50% or less.)
9.	
	[L FUEL PRESS] - EXTINGUISHED
10.	Left Condition Lever (12% N1 or above) LOW IDLE
11.	Left ITT and N1 MONITOR (1000°C maximum)
12.	Left Oil Pressure
13.	Left Ignition and Engine Start (50% N1 or above)OFF
14.	D.C. Volt/Loadmeters PRESS TO CHECK VOLTAGE (27.5 - 29.0 volts)
15.	Left Generator RESET, THEN ON
16.	Right Condition Lever REDUCE TO LOW IDLE

Checklist as per the Flight Safety Training Centre:

Raytheon Aircraft Company

FlightSafety

ENGINE STARTING (BATTERY)

1.	Right Ignition and Engine StartON [R IGNITION ON] - ILLUMINATED [R FUEL PRESS] - EXTINGUISHED
2.	Right Condition Lever (12% N1 or above)LOW IDLE
З.	Right ITT and N ₁ MONITOR (1000°C maximum)
4.	Right Oil PressureCHECK
5.	Right Ignition and Engine Start (50% N1 or above)OFF
6.	Right Condition LeverHIGH IDLE
7.	Right GeneratorRESET, THEN ON
8.	BatteryCHARGE (until loadmeter reads approximately 50% or less.)
9.	Left Ignition and Engine StartON [L IGNITION ON] - ILLUMINATED [L FUEL PRESS] - EXTINGUISHED
10.	Left Condition Lever (12% N1 or above)LOW IDLE
11.	Left ITT and N ₁ MONITOR (1000°C maximum)
12.	Left Oil PressureCHECK
13.	Left Ignition and Engine Start (50% N1 or above)OFF
14.	D.C. Volt/LoadmetersPRESS TO CHECK VOLTAGE (27.5-29.0 volts)
15.	Left GeneratorRESET, THEN ON
16.	Right Condition Lever