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Australian Transport Safety Bureau

Engine shutdown and collision with terrain involving Beech Aircraft Corporation B200 VH-MVL

Moomba Airport, South Australia | 13 December 2016

Investigation

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Addendum

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Safety summary

What happened

On 13 December 2016, a Beech Aircraft Corporation B200, registered VH-MVL, conducted a visual approach to Moomba Airport, South Australia (SA), following a medical services flight from Innamincka, SA. As the aircraft turned onto the base leg of the approach, the pilot observed the left engine fire warning activate. The pilot shut down the left engine and continued the approach to the runway. The aircraft landed in the sand to the left of the runway threshold and after a short ground roll, spun to the left and came to rest. There were no injuries and the aircraft was substantially damaged.

What the ATSB found

The ATSB found that the pilot did not feather the left propeller (rotate the blades to an edge-on angle to the airflow) after the left engine was shut down, causing it to windmill, resulting in considerable drag. In addition, the aircraft was in a right turn, towards the engine developing power, with the landing gear extended and the flaps set to approach. This combination resulted in more thrust being required for continued safe flight than was available.

No engine fire damage was found and it was therefore concluded that the observed fire warning was almost certainly a false warning. The aircraft manufacturer had previously published a service bulletin for the optional replacement of the engine fire detection system with a system less susceptible to false warnings. However, the operator, who had limited experienced with false engine warnings in their fleet which were also considered as low risk, elected not to replace the fire detection system on the accident aircraft.

The accident pilot did not receive the operator's published syllabus of training for the B200 King Air. Instead, a tailored training program was delivered in consideration of the pilot's experience on the C90 King Air with another operator and advice the operator received from the Civil Aviation Safety Authority. This training did not cover all the elements required under the Civil Aviation Safety Regulations.

What's been done as a result

As a result of this occurrence, the Civil Aviation Safety Authority (CASA) intends to take steps to refresh industry and CASA officers' knowledge of particular terms and concepts within the flight crew licencing regulations to remove any doubt that might exist as to their interpretation and applicability.

The operator has undertaken to take safety actions in the areas of pilot recruitment, training and checking, aircraft and systems, safety and quality assurance, and communications.

Safety message

Following the accident, the pilot reported that their biggest lesson was not to hesitate during emergency procedures. They believed that their doubt in the veracity of the warning resulted in their hesitation while completing the four engine fire drill (memory) actions, resulting in them missing the step to feather the propeller.

This accident also highlights the need for organisations to consider all the relevant information available to them when making decisions, such as the process for reviewing non-mandatory service bulletins. Organisational decision-making should consider the potential consequences of human error when evaluating changes.

The occurrence

On 13 December 2016, a Beech Aircraft Corporation B200, registered VH-MVL, conducted a medical services flight from Innamincka, South Australia (SA) to Moomba, SA. On board the aircraft were the pilot and two passengers.

On arrival at Moomba at about 1250 Central Daylight-saving Time (CDT), the pilot configured the aircraft to join the circuit with flaps set to the approach setting and the propeller speed set at 1900 RPM.[1] They[2] positioned the aircraft at 150–160 kt airspeed to join the downwind leg of the circuit for runway 30, which is a right circuit.[3] The pilot lowered the landing gear on the downwind circuit leg. They reduced power (set 600-700 foot-pounds torque on both engines) to start the final descent on late downwind abeam the runway 30 threshold, in accordance with their standard operating procedures.

At about the turn point for the base leg of the circuit, the pilot observed the left engine fire warning activate. The pilot held the aircraft in the right base turn, but paused before conducting the engine fire checklist immediate actions in consideration of the fact that they were only a few minutes from landing and there were no secondary indications of an engine fire. After a momentary pause, the pilot decided to conduct the immediate actions. They retarded the left engine condition lever[4] to the fuel shut-off position, paused again to consider if there was any other evidence of fire, then closed the firewall shutoff valve, activated the fire extinguisher and doubled the right engine power[5] (about 1,400 foot-pounds torque).

The pilot continued to fly the aircraft in a continuous turn for the base leg towards the final approach path, but noticed it was getting increasingly difficult to maintain the right turn. They checked the engine instruments and confirmed the left engine was shut down. They adjusted the aileron and rudder trim to assist controlling the aircraft in the right turn. The aircraft became more difficult to control as the right turn and descent continued and the pilot focused on maintaining bank angle, airspeed (fluctuating 100–115 kt) and rate of descent.

Due to the pilot’s position in the left seat, they were initially unable to sight the runway when they started the right turn. The aircraft had flown through the extended runway centreline when the pilot sighted the runway to the right of the aircraft. The aircraft was low on the approach and the pilot realised that a sand dune between the aircraft and the runway was a potential obstacle. They increased the right engine power to climb power (2,230 foot-pounds torque) raised the landing gear and retracted the flap to reduce the rate of descent. The aircraft cleared the sand dune and the pilot lowered the landing gear and continued the approach to the runway from a position to the left of the runway centreline.

The aircraft landed in the sand to the left of the runway threshold and after a short ground roll spun to the left and came to rest (Figure 1). There were no injuries and the aircraft was substantially damaged.

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1 Two propeller levers are used to manage their respective engine propeller speed and for manual propeller feathering. The operating range is 1,600 to 2000 RPM. Full aft movement of a lever past a detent will feather an operating propeller.

2 Gender-free plural pronouns: may be used throughout the report to refer to an individual (i.e. they, them and their).

3 Right circuits are flown to runway 30 and left circuits are flown to runway 12 to avoid overflying the gas treatment plant located south of the airport.

4 Each engine has a condition lever with three positions: FUEL CUT-OFF, LOW IDLE and HIGH IDLE.

5 Each engine has a power lever which controls engine power by operation of the engine compressor (N1) governor in the respective engine fuel control unit.

Figure 1: VH-MVL accident site

Source: Airport operator

Context

Cockpit voice recorder key events

Table 1 is a list of key events from the accident flight cockpit voice recorder. Events marked with inverted commas (‘’) are automated voice from aircraft systems, such as the ground proximity warning system. Time is from the start of the recording in minutes and seconds.

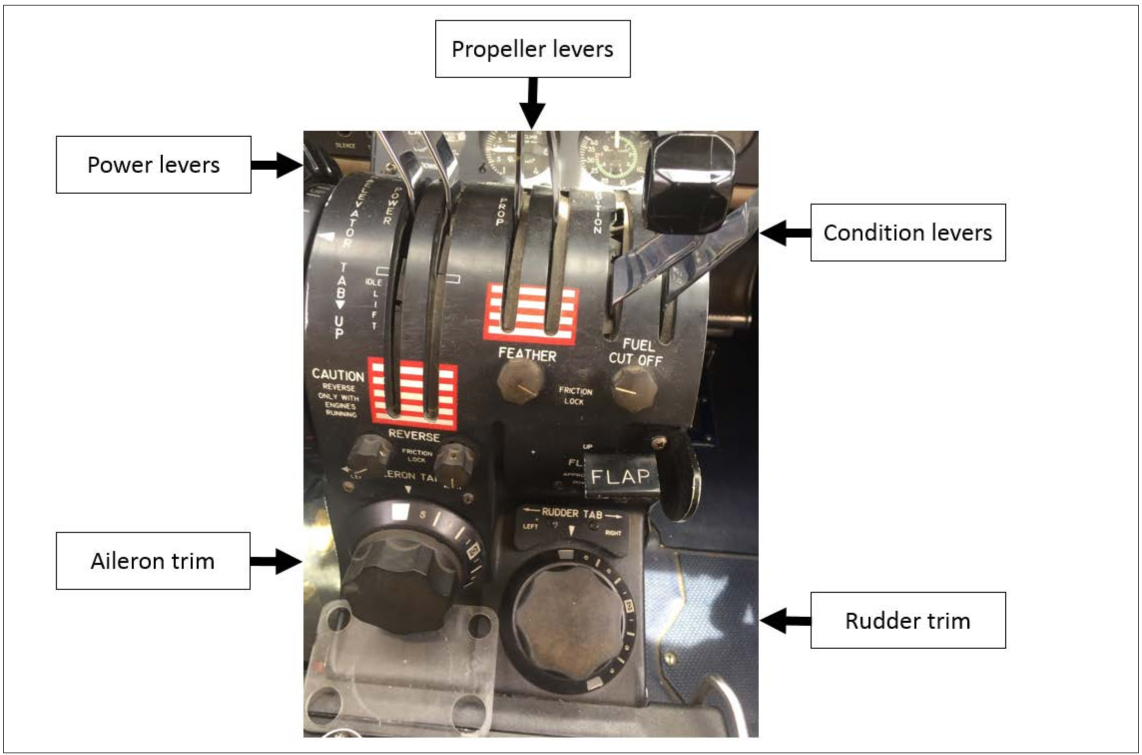
Table 1: Key events

Time from start	Event
26:10	Pilot reported joining downwind runway 30 Moomba
26:41-26:47	Sound of mechanical movement (consistent with pilot report of lowering landing gear)
27:32	Warning horn activation (consistent with master warning horn frequency, repetition rate and duty cycle) (consistent with pilot report of observing a left engine fire warning)
27:47-end	Propeller speeds separate – one maintains about 1,900 RPM and the other reduces to and then fluctuates around 1,650 RPM (consistent with pilot report of shutting down left engine)
28:17	Warning horn activation (consistent with master warning horn frequency, repetition rate and duty cycle) (consistent with the pilot report of observing activation of the left engine oil pressure and fuel pressure light after the left engine was shutdown)
28:20-28:26	Sound of mechanical movement (consistent with pilot report of raising the landing gear)
28:26	‘Five hundred, check gear, check gear, check gear’
28:48	‘Four hundred, check gear, check gear, check gear’
28:57	‘Three hundred, check gear, check gear, check gear’
29:07	‘Two hundred, check gear, check gear, check gear’
29:41	‘One hundred, check gear’
29:58-30:32	Intermittent warning horn activation (likely stall warning, but different frequency to the frequency supplied by the manufacturer (windmilling propeller is slowing down and flaps are retracted))
30:21-30:27	Sound of mechanical movement (consistent with pilot report of lowering the landing gear)
30:25	Sound of momentary impact
30:29-end	Subsequent sounds of impact

Post-accident aircraft information

Following the accident, an inspection of the left engine revealed the fire extinguisher bottle was discharged, but there were no physical indications of a fire. Damage to the left propeller was consistent with rotation of the propeller at impact and the propeller appeared to be in an unfeathered position (Figure 1). Both propeller control levers were at the 1900 RPM setting (Figure 2). The pilot reported that after the aircraft came to rest they shut off fuel and activated the firewall shutoff valve for the right engine, but were unsure of any other changes they made to switches and controls in the cockpit.

Figure 2: VH-MVL pedestal



Source: Operator, annotated by ATSB

Engine shutdown information

Engine fire emergency procedure

A left engine fire warning is annunciated by the aircraft master warning system, which activates the master warning horn, master warning light and L ENG FIRE light on the master warning panel. The operator's emergency checklist procedure applicable for an inflight engine fire was the 'emergency engine shutdown'. The procedure included boxed bold type immediate actions, which were performed from memory. The company procedure was to complete the immediate actions from memory and then reference the checklist to confirm immediate actions were completed before completing the remainder of the actions. The immediate actions for the emergency engine shutdown were:

1. Condition Lever… …FUEL CUT OFF
2. Prop Lever... …FEATHER
3. Firewall Shutoff Valve… …CLOSED
4. Fire Extinguisher… …ACTUATE (If required)

The pilot reported that their attention was drawn to the warning light in the top left corner of the master warning light panel (location of the left engine fire warning light).[6] They pulled the condition lever, then paused, then closed the firewall shutoff valve and pressed the extinguisher and confirmed it had discharged, all from memory, but there was no time to reference the checklist during the approach.

6 The pilot was wearing an active noise reduction headset and the aircraft warning horns are broadcast through a cockpit speaker, rather than the intercom system. Consequently it was the warning light, rather than the warning horn which captured the pilot's attention.

Propeller autofeathering system

The aircraft was fitted with an automatic feathering system of the propeller, which required the activation of two electrical interlocks for operation. The first interlock is achieved by setting the autofeather switch in the cockpit to ARM. The second interlock is achieved by advancing the power levers to a position which equates to about a 90 per cent N1[7] power setting. When both power levers are advanced to this position, a mechanical activator, connected to each power lever, will close its respective switch and complete the circuit to the high and low pressure switches mounted on each engine. This will activate the green AUOTFEATHER advisory lights for the left and right engine in the cockpit.

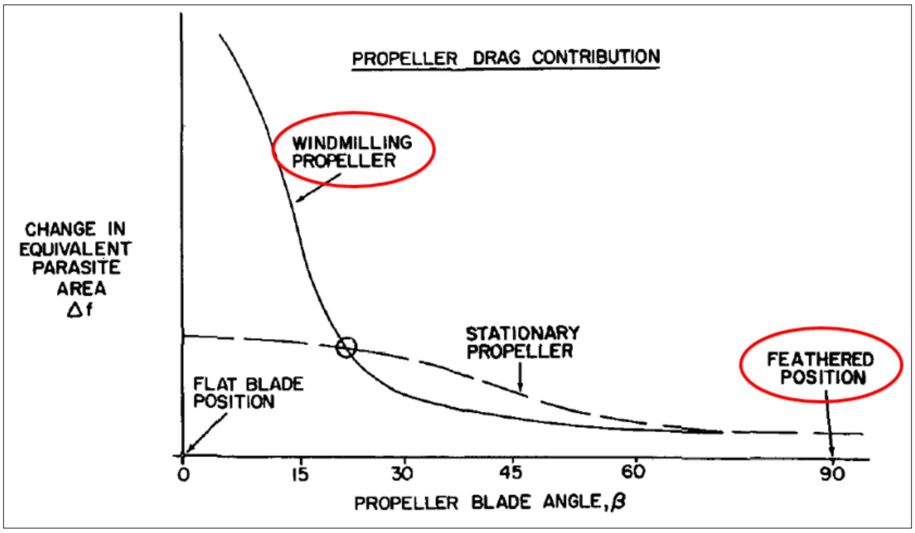
The autofeather switch is required to be set to ARM in the approach checks. However, the engine fire warning activated after the pilot had set their descent power of about 600–700 foot-pounds torque[8] (about 75–80 per cent N1) and the left engine was shut down from this power setting. This was below the setting which would activate autofeather when the system is armed.

One engine inoperative performance

The B200 aeroplane flight manual (AFM) recommended procedure to obtain best performance[9] with one engine inoperative is to bank the aircraft 3° to 5° into the operating engine while maintaining a constant heading. The AFM one engine inoperative best rate of climb speed was 121 kt.

Acceleration and climb performance is a function of the excess thrust and power. Therefore, any increase in drag will reduce the aircraft performance. A windmilling propeller can produce a significant amount of drag, which is estimated to be comparable to a parachute canopy of the same area as the propeller disc area (Figure 3).[10]

Figure 3: Windmilling propeller drag



Source: Aerodynamics for naval aviators, annotated by ATSB

The pilot reported that, from their simulator experience, the aircraft performed well with one engine shut down. If an engine was shut down for an approach, then doubling the power on the other engine was sufficient to maintain the correct profile. In the accident flight they initially set about 1,400 foot-pounds torque on the right engine, but then increased the power to the climb power setting of about 2,230 foot-pounds torque. Based on the ground proximity warning height

7 N1: Engine compressor speed.

8 Normal operating ranges is 400–2,230 foot-pounds torque.

9 Performance refers to the general flight dynamics of the aircraft with respect to airspeed, rate of climb or descent etc., and is the result of the combination of the configuration and attitude of the aircraft.

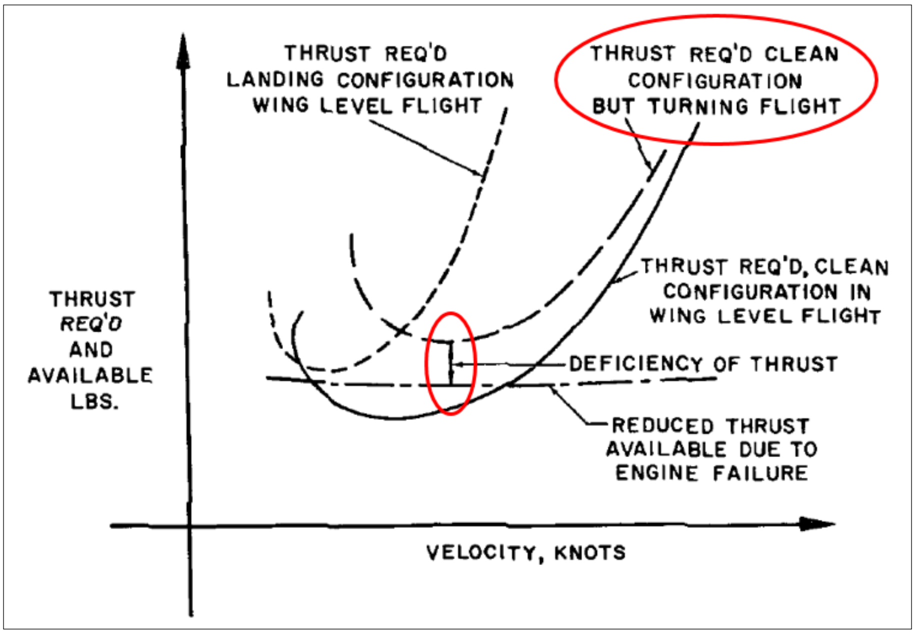
10 H. H. Hurt, Jr., Aerodynamics for naval aviators, NAVAIR 00-80T-80, University of Southern California, USA, 1965.

annunciations, the rate of descent from 1,000 ft to 700 ft was about 1,000 ft/min, which then reduced to about 440 ft/min from 500 ft to 200 ft.

In this configuration,[11] there would be a yawing moment to the left produced by asymmetric thrust, (which would be exacerbated by a windmilling left propeller), and a rolling moment to the left from the right propeller slipstream over the right wing. This results in asymmetric lift. The left engine is the critical engine for asymmetric flight.[12] Consequently, full right rudder trim and full right aileron trim were applied by the pilot during the (right) base leg turn.

A right turn flown against these forces will produce more drag than a left turn, which will produce more drag than maintaining a constant heading (Figure 4). The extension of landing gear and flap will also increase drag. The combination of factors which increase drag can lead to a critical condition where the thrust required to maintain the planned flight path exceeds the thrust available.

Figure 4: Thrust required for asymmetric turning flight



Source: Aerodynamics for naval aviators, annotated by ATSB

The Raisbeck Engineering[13] flight manual supplement for the B200 indicated that the minimum control speed - air (V_{MCA}) is 88 kt (indicated airspeed) with the flaps in the approach setting and 91 kt with the flaps retracted.[14] However, there is a flight manual supplement caution that 'with one-engine either at idle or inoperative, flaps up and propeller windmilling, V_{MCA} may be as high as 108 kt.' This was inside the approach airspeed range reported by the pilot (100-115 kt).

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11 Configuration, as used in this report, refers to how the pilot has set-up the aircraft with respect to airframe (such as landing gear and flap settings) and power-plant controls (such as engine power and propeller settings).

12 The critical engine is the power unit, which if failed, would have the most adverse effect on the performance characteristics of an aeroplane.

13 The Raisbeck Engineering Company provides a modification kit for B200 model aircraft, which was fitted to VH-MVL. Pilots operating a Raisbeck Engineering modified B200 must comply with the flight manual supplement.

14 The flight manual supplement describes V_{MCA} as the lowest airspeed at which the airplane is directionally controllable when one engine suddenly becomes inoperative and the other engine is at take-off power. V_{MCA} was determined with a 5° bank into the operating engine and the propeller feathered on the inoperative engine.

Training and checking

Pilot's training

The pilot joined the operator in early 2015. The operator noted that the pilot had a licence for multi-engine aeroplane with endorsements for gas turbine engine and pressurisation, and had flown the Beechcraft C90.[15]

In February 2015, the operator provided the pilot with 26.1 hours of line training on the B200 aircraft, which started on 10 February. They were also provided with two simulator training sessions of 3.7 hours, which included instrument approaches and asymmetric flight exercises. On completion of the second simulator session, the trainer reported that the pilot had 'very good asymmetric control of aircraft' and could progress to the instrument proficiency check (IPC). They progressed to a third simulator session of 1.9 hours, which was their IPC on 22 February. During the IPC, the pilot was exposed to an engine fire in the cruise and engine failure after take-off. The testing officer reported that the IPC was 'completed to a very good standard.' The pilot's line check was conducted on a medical flight on 27 February. They were assessed as 'all ok' and cleared to line for clinic operations only.

The pilot completed three further flight checks within the operator's cyclic training and proficiency program (CTPP) between their conversion and the accident flight. In 2015, the pilot conducted two checks in the simulator. In 2016, the pilot conducted their March check in the aircraft and their August check in the simulator.

The simulator field of view for the pilot is less than what is available in the aircraft. Due to the restricted field of view to the sides, the operator assessed it as inappropriate to initiate emergencies in the simulator from a circuit base leg position. Therefore critical situation emergencies, such as an engine fire indication on approach, were generally initiated on the final approach of an instrument approach. This provided a critical decision-making scenario for the pilot, in which they could initiate the immediate actions while in the final stages of an approach, or alternatively land the aircraft before initiating the immediate actions.

The pilot was exposed to engine fire indications in the cruise and on instrument approach during the CTPP. No knowledge deficiencies were noted with their immediate actions and the four CTPP checks were assessed as completed to the required standard.

Development of the pilot's training program

The pilot started training with the operator about five months after the introduction of the then new flight crew licencing regulation, Civil Aviation Safety Regulation (CASR) Part 61. Under the previous regulation for flight crew licencing (Civil Aviation Regulation (CAR) 5), the C90 and B200 aircraft were separate class endorsements (BE-90 and BE-200, respectively). However, with the introduction of CASR Part 61, both aircraft types were included in the 'multi-engine aeroplane (MEA) class rating' and did not require type specific ratings.[16]

In January 2015, the Civil Aviation Safety Authority (CASA) published edition 1 of legislative instrument 'Prescribed aircraft, ratings and variants for CASR Part 61 Instrument 2014'. Paragraph 25 and Schedule 13 of the instrument identified the Beechcraft King Air 90 series and King Air 200/250 series as aircraft *types*, for which each required initial type-specific training. The training required was in accordance with all the units of competency published in the Part 61 Manual of Standards[17] for the class rating that are relevant for the aircraft type. Although both

[15] The B200 and C90 are part of the Beechcraft 'King Air' family of twin-engine turboprop aircraft.

[16] A rating or endorsement is type specific and applies only to the aircraft type that is specified on the rating or endorsement.

[17] The Part 61 Manual of Standards was written to support the Part 61 licencing regulations, which came into effect on 1 September 2014. It contains the aeronautical knowledge and practical competency standards for all Part 61 licences, ratings and endorsements. It also contains flight test, proficiency check and flight review standards.

aircraft may be referred to as King Air series aircraft, they have different Type Acceptance Certificates and therefore are different aircraft types.

The explanatory statement associated with the legislative instrument indicated that the aircraft listed in Schedule 13 were ‘identified as being sufficiently complex or have performance or handling characteristics[18] that warrant initial type-specific training and a flight review in the specific type’. However, the operator was not aware of this instrument or associated explanatory statement at the time of the pilot’s employment. The pilot started training about one month after the publication of the legislative instrument and the operator developed their training program before the pilot started their training.

The operator tailored the pilot’s training program in consideration of the fact that the pilot was trained on the C90 King Air with a previous operator. Consequently, the pilot did not receive the operator’s B200 syllabus of training, as published in their training and checking manual, which included five simulator training sessions (excluding IPC). The operator’s training and checking manual permitted this for a pilot with previous King Air series experience.[19] This was the operator’s understanding of CASR Part 61 after consultation with their respective CASA Flying Operations Inspector.

During the course of the investigation, the ATSB received several responses from different positions within CASA that ‘differences training’[20] was an acceptable approach to transition a pilot from the C90 to the B200. This included the CASA Flying Operations Inspector assigned to the operator and the CASA Flight Standards Branch. On review of the pilot’s training records, the ATSB could not find evidence that the pilot received training in stalling or upper air asymmetric handling in accordance with the operator’s B200 syllabus.

Civil Aviation Safety Regulation 61.747

The relevant regulation to transition a pilot onto a new aircraft within the multi-engine aeroplane class rating system was CASR 61.747 ‘Limitations on exercise of privileges of class ratings in certain aircraft-flight review’. Regulation 61.747 was a competency based training regime, which required pilots to be trained in all the units of competency in the Part 61 Manual of Standards relevant for the aircraft type, followed by a flight review. Competency based training allows an operator to consider the pilot’s previous qualifications and experience in developing their training and assessment program to demonstrate all the relevant units of competency.

Civil Aviation Advisory Publication 5.23-2(0)

In July 2007, CASA published Civil Aviation Advisory Publication (CAAP) 5.23-2(0) ‘Multi-engine aeroplane operations and training’. CAAP 5.23-2(0) was the second CAAP written on this subject and has been superseded by CAAP 5.23-1(2), published September 2015. The CAAP was written following ‘a number of multi-engine aeroplane accidents caused by aircraft systems mis-management and loss of control by pilots.’ The CAAP indicated that during training, ‘pilots should be shown all the flight characteristics[21] of the aircraft, and be given adequate time and practice to consolidate their skills.’

The V_{MCA} (minimum control speed – air) demonstration sequence was identified in the CAAP as one of the ‘more important in asymmetric training.’ The instructor should ‘point out the yaw, wing

18 Handling characteristics refers to the manner in which the aircraft responds with respect to rate and magnitude of pilot initiated control inputs to the primary flight control surfaces.

19 In accordance with Civil Aviation Order 82.1, appendix 2, paragraph 4.1, each operator must provide a training and checking manual acceptable to CASA which may be a section of an operations manual or a separate document. The manual must include course outlines, syllabuses and completion standards for each flight or simulator training program currently in use.

20 Differences training for a variant of an aircraft type covered by the rating means training in all the units of competency mentioned in the Part 61 Manual of Standards for the rating that are necessary to ensure that the pilot is able to exercise the privileges of the rating as safely as if the pilot had undertaken the flight training for the rating in the variant.

21 Flight characteristics are handling characteristics or performance characteristics perceivable by a pilot.

drop and change to attitude.'[22] When a trainee pilot conducts the V_{MCA} exercise, the instructor should ask them to 'identify when the aircraft starts to yaw and roll' to determine if they are 'recognising these conditions early enough.' The CAAP also discussed the technique to recover from a critical asymmetric situation, with low airspeed near the ground and a windmilling propeller. The risks associated with V_{MCA} training are explained in the CAAP. The operator had managed the risks associated with V_{MCA} training by moving their syllabus of training for the B200 from the aircraft to the simulator.

The CAAP highlighted that it was important for the pilot to recognise and avoid a stall in any aircraft and that instructors must conduct this exercise in multi-engine aeroplanes. Instructors should 'stress the characteristics and devices that warn the pilot of the stall' and allow the trainee pilot to 'experiment with these characteristics and practice them in different configurations and flight situations.'

The references to CAAP 5.23-2(0), published July 2007, were consistent with the guidance in CAAP 5.23-1(2), which was the current CAAP on the subject at the time of the accident.

Flight review

The pilot successfully completed an instrument proficiency check during their initial B200 training, which the operator believed fulfilled the requirements for a flight review. However, CASR 61.747 required the pilot to demonstrate competency in all the units of competency prescribed for the multi-engine aeroplane class rating. A flight review means an assessment of the competency of a flight crew member to perform an activity authorised by the rating. Following advice from CASA Flight Crew Licencing, an instrument proficiency check could fulfil the flight review requirements of CASR 61.747 provided the check included all the units of competency for the multi-engine aeroplane class rating. If units of competency are missed, then the flight review does not comply with the intent of the CASR 61.747 flight review.

Fire detection system

Beech service bulletin 2596

In 1995, Beech Aircraft Corporation[23] issued a service bulletin, SB 2596, which announced the availability of a 'continuous loop fire and overheat detection system' as a replacement for the aircraft engine optical fire detection system. This was the most recent design incorporated into production aircraft to improve reliability and maintainability of the engine fire detection system.

The operator reviewed SB 2596 and the decision was made not to incorporate the modification on 15 July 2003 due to cost considerations. An earlier service bulletin, SB 2005, which relocated one of the fire detectors to an area less susceptible to external light and added an additional light shield to the system, was already incorporated in the aircraft from manufacture.

Civil Aviation Safety Authority airworthiness bulletin 26-005

On 10 April 2013, CASA issued an airworthiness bulletin (AWB 26-005) for the Beech B200 Series engine fire detection systems. The purpose of AWB 26-005 was to 'provide information to operators and maintainers regarding improved engine fire detection systems to avoid false in-flight engine fire indications'.

AWB 26-005 indicated that operators using the optical flame detectors continue to experience false indications of engine fire warnings and that the continuous loop and overheat detection system kits introduced in 1995, through SB 2596, have proven reliable and eliminated false

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[22] Attitude refers to the orientation of the aircraft longitudinal, lateral and normal axes to an outside reference system, such as the local horizon.

[23] Beech Aircraft Corporation, also known as Beechcraft, was the aircraft manufacturer. At the time of SB 2596 Beechcraft was owned by the Raytheon Company, and at the time of drafting the accident investigation report Beechcraft was owned by Textron Aviation.

indications. CASA strongly recommended operators install the continuous loop engine fire detection systems to avoid false in-flight fire warnings.

The operator reviewed AWB 26-005 on 12 April 2013, but elected not to incorporate the modification, based on their prior review and decision on SB 2596.

Previous false engine fire warnings

The operator identified four previous reports of false in-flight engine fire warnings recorded in their database for their B200 aircraft fleet, three incidents in 2003 and one in 2005.

- A left engine fire warning, which extinguished after about 30 seconds (13 March 2003).
- A left engine fire warning, which extinguished after about 30 seconds. A fire detection probe was replaced (22 March 2003).
- A left engine fire warning. The pilot conducted the immediate actions. The response recorded in the report was to check the fire detection probes for serviceability (24 April 2003).
- A left engine fire warning which activated momentarily on approach. After landing, the warning activated and remained illuminated. The pilot conducted the immediate actions. There was no evidence of fire found and a fire detector was replaced. The warning light activated three times on the return flight. A fault in the wiring harness connector was recorded as the reason (10 July 2005).

The pilot commented that they were aware that the fire detection system was susceptible to false indications due to sunlight entering the engine compartment, but had not previously experienced such an incident. The operator acquired VH-MVL in 1997 and had no prior reported incidents of false fire warnings for that particular aircraft prior to the accident.

Safety analysis

Fire warning

The pilot reported there was a left engine fire warning, which resulted in them performing an emergency engine shutdown and activating the fire extinguisher. On inspection by the operator, the left engine fire bottle was found to be discharged, but there was no evidence of fire damage. The activation of the master warning followed by the separation of the propeller speeds, as detected by the cockpit voice recorder, were consistent with the pilot's report of a fire warning and left engine shutdown. Therefore, the ATSB concludes that the pilot likely experienced a fire warning, which was almost certainly a false indication.

The ATSB did not establish what initiated the fire indication. However, it was noted that the optical fire detection system fitted to the aircraft was susceptible to false indications. In 1995, Beechcraft issued a service bulletin (SB 2596) for a continuous loop fire and overheat detection system to 'improve reliability and maintainability.' In July 2003, after three reports of false engine fire indications earlier that same year, the operator reviewed the bulletin but elected not to incorporate the modification. The operator also decided not to incorporate the modification after a Civil Aviation Safety Authority (CASA) airworthiness bulletin in 2013 recommended incorporating the manufacturer's modification. Neither review made reference to the flight risk of false engine fire indications. However, the operator's previous false engine fire warning reports recorded them as low risk and their last report was in 2005.

The earliest safety management manual the operator was able to provide the investigation was dated 2006, some three years after the operator's review of SB 2596. Therefore the operator's risk assessment process, as it applied to the earlier false engine fire warnings and review of SB 2596 was not investigated any further.

In consideration of CASA's findings of the effectiveness of SB 2596 to eliminate false fire indications, it is apparent that the incorporation of the manufacturer's modification would have reduced the risk of a false fire warning occurring.

One engine inoperative performance

The pilot reported that, following their observation of an engine fire indication, they completed three of the four immediate memory actions, but omitted to manually feather the left propeller. They then experienced considerable difficulty handling the aircraft in the right turn and were unable to reach the runway, despite applying climb power to the right engine.

Although the aircraft was fitted with an autofeathering system for the propellers, the system was only operative at high power settings. As the pilot had reduced power for descent by the time of the engine fire indication, the autofeathering system was inoperative, as per design, when the engine was shutdown.

As a result, the approach was flown with the left propeller unfeathered and windmilling. When combined with the drag from the landing gear, flap and right turn, the additional drag from the windmilling propeller resulted in more thrust required for the approach than was available.

Pilot's actions

The pilot reported that they hesitated in their decision-making and subsequent engine fire drill actions because of their uncertainty in the veracity of the indication and their proximity to landing. At the time of the master warning, they had just started the base turn on approach to land, which required their attention to be divided between the cockpit settings and indications, and the external cues for the visual approach. It is possible that divided attention, combined with their hesitation while performing the steps of the drill, contributed to them omitting the step to feather the propeller in their immediate actions.

After the pilot shutdown the left engine, they experienced increasing difficulty controlling the aircraft in the right turn. They checked to confirm the left engine was shutdown, applied full right aileron and rudder trim, applied climb power to the right engine, retracted the landing gear and flap, and finally extended the landing gear for the landing. However, they did not attempt to feather the propeller at any stage during the approach. This indicates that the pilot did not recognise that their asymmetric handling difficulties were the result of a windmilling propeller, despite the need for climb power on the right engine. The aircraft configuration and performance on approach resulted in the aircraft operating within the airspeed caution range for a loss of directional control.

The pilot's training and assessment reports indicated that their asymmetric flight experience on the B200 extensively involved engine failures on take-off and engine fires in cruise. In the case of engine failures on take-off, the autofeather system will feather the propeller of the failed engine. In the case of engine fires in cruise, the propeller is manually feathered by the pilot in the emergency engine shutdown procedure. The operator's performance standards for asymmetric flight included that the pilot was able to identify the correct control lever and feather the propeller, which was consistent with the performance standards required in the Part 61 Manual of Standards. The pilot was assessed as competent to this standard by the operator with no knowledge deficiencies identified. The pilot's previous successful handlings of an engine fire in the simulator, and their inability to stop the aircraft descending, likely contributed to them continuing the approach.

Based on the above asymmetric training experience, it is likely the pilot had no prior experience of the B200 handling characteristics with a windmilling propeller, which likely contributed to them not recognising (and recovering) from that condition within the timeframe of the accident sequence. However, the pilot's C90 training experience with another operator was not investigated for potential knowledge transfer to the B200. The ATSB only offers this as a possible explanation for why the pilot did not associate the performance and handling difficulties with a windmilling propeller. Operating the aircraft with a windmilling propeller was not a competency requirement.

Differences training

Within CASR Part 61, differences training applied to the 'type rating' system, but not the 'class rating' system. The training requirements for a type rated aircraft are considered more complex than for a class rated aircraft. Therefore, differences training is employed in the type rating system to transition a pilot from the variant[24] the pilot conducted their type rating on, onto another variant covered by the same type rating.[25] The legislative instrument 'Prescribed aircraft, ratings and variants for CASR Part 61 Instrument 2014' (Edition 1), indicated when differences training was required for type rated aircraft, in addition to when initial type-specific training was required for class rated aircraft. The instrument identified the Beechcraft King Air 90 series and King Air 200/250 series as aircraft *types*, which required initial type-specific training.

Within the differences training system, it is permissible to not deliver all the units of competency from the Part 61 Manual of Standards.[26] This avoids unnecessary duplication of training while ensuring the pilot receives the training necessary to operate variants, which are different to the variant the pilot conducted their type rating on. In contrast, a class rated aircraft requires all the units of competency relevant to the aircraft type to be delivered. However, for a class rated aircraft there may be no additional training requirement for a pilot to operate different models (variants) of the same type, as prescribed in the respective legislative instrument. Therefore, the requirement

[24] A variant, in relation to an aircraft model (the first model), means another aircraft model that CASA has prescribed by a legislative instrument under regulation 61.055 as a variant of the first model.

[25] CASR 61.200 Differences training requirements.

[26] CASR 61.200 Differences training requirements.

for differences training increases the overall training burden within the type rating system, in line with the greater complexity of the aircraft, when compared to the class rating system.

The ATSB acknowledges that an operator may consider previous qualifications and training in determining the number of sequences required to deliver the units of competency within the class rating system. However, reference to differences training may inadvertently imply that not all units of competency are required to be delivered or assessed. In the case of the accident pilot, the ATSB could not find a training or assessment record for the competency 'A5.1 – Enter and recover from stall'[27] in addition to the upper air asymmetric sequences.[28] This would have been captured if the operator delivered their B200 syllabus of training to the pilot.

Upper air asymmetric training sequences are used to teach a pilot the performance and handling characteristics, specific to the aircraft type, in various configurations and flight path parameters. It provides the opportunity for the instructor to direct the trainee pilot's attention to changes in aircraft performance associated with changes in attitude and configuration, without the distraction of checklist actions or instrument approach procedure requirements. This can lead to more effective learning of the underpinning knowledge and skills required to operate a new aircraft type. At the time of the accident, the pilot had operated the B200 for 22 months without training or assessment in stalling.

The ATSB determined that the application of differences training, as defined in CASR Part 61, to the transition of a pilot onto the B200 was inconsistent with the requirement for initial type-specific training in accordance with CASR 61.747. The omission of training or assessment in flight regimes near to or in a loss of control situation (for example, V_{MCA} demonstration and stalling), may result in a degradation of knowledge and skills that are only required in rare, but time-critical, emergency situations.

[27] A competency standard is comprised of five components, which are; units, elements, performance criteria, range of variables and underpinning knowledge. A5.1 is an element within the unit A5: Aeroplane advanced manoeuvres. The elements detail the various functions that must be carried out to satisfy the unit description.

[28] The ATSB acknowledge that the training may have been conducted and not documented.

Findings

From the evidence available, the following findings are made with respect to the collision with terrain involving Beech Aircraft Corporation B200, registered VH-MVL that occurred at Moomba Airport, South Australia on 13 December 2016. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- The operator did not modify the aircraft to include a more reliable engine fire detection system in accordance with the manufacturer's service bulletin, and as subsequently recommended by the Civil Aviation Safety Authority's airworthiness bulletin. The incorporation of the manufacturer's modification would have reduced the risk of a false engine fire warning.
- During the approach phase of flight, the pilot shutdown the left engine in response to observing a fire warning, but omitted to feather the propeller. The additional drag caused by the windmilling propeller, combined with the aircraft configuration set for landing while in a right turn, required more thrust than available for the approach.

Other factors that increased risk

- The advice from the Civil Aviation Safety Authority to the operator, that differences training was acceptable, resulted in the pilot not receiving the operator's published B200 syllabus of training. The omission of basic handling training on a new aircraft type could result in a pilot not developing the required skilled behaviour to handle the aircraft either near to or in a loss of control situation.

Other findings

- The pilot met the standard required by the operator in their cyclic training and proficiency program and no knowledge deficiencies associated with handling engine fire warnings were identified.

Safety issues and actions

Additional safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Civil Aviation Safety Authority

As a result of this occurrence, the Civil Aviation Safety Authority (CASA) advised the ATSB that they concur that the regulatory requirements for pilots transitioning between aircraft models of a type listed in Schedule 13, including from the Beechcraft King Air 90 series to the King Air 200/250 series aircraft, might be open to misinterpretation, and they are taking the following safety action:

Education

CASA intends to take steps to refresh industry and CASA officers of particular terms and concepts within the CASR 1998 flight crew licensing suite to remove any doubt that might exist as to their interpretation and applicability. For example, terms such as differences training, flight review, competency, competency-based-training, recognition of prior learning, qualifications and experience will be clarified.

Operator

As a result of this occurrence, the aircraft operator conducted an internal investigation and advised the ATSB that they are taking the following safety actions:

Recruitment

- Conduct a review of their current recruitment process, including entry standards and consideration of additional processes to the current standard of interview and simulator test.
- Engage with a university to study pilot recruitment in order to better understand the ideal pilot traits required for the company's operations.

Training and checking

- Conduct a review of existing pilot induction/training/clearance to line procedures, and increase use of Level D simulator wherever possible for initial and recurrent emergency procedures.
- All new pilots will complete the company's full induction training, including aircraft endorsement training.
- Review and rewrite of the company operations manual, and training and checking manual.

Safety and quality assurance

- Accelerate the introduction of the flight data analysis program and undertake a trial of line orientated safety audit.

Aircraft and systems

- Install flight data recorders on all aircraft and include flight data recorders as a mandatory item for aircraft standards.
- Install Pratt & Whitney flight acquisition, storage and transmission (FAST) on all aircraft and include FAST as a mandatory item for aircraft standards.

Communications

- In-person briefing program with the pilot workforce to discuss findings and agreed safety actions from the company's internal investigation with a focus on lessons learned from the accident.

General details

Occurrence details

Date and time:	13 December 2016 – 1255 EDT	
Occurrence category:	Accident	
Primary occurrence type:	Collision with terrain	
Location:	Moomba Airport, South Australia	
	Latitude: 28° 05.97’ S	Longitude: 140° 11.82’ E

Pilot details

Licence details:	Commercial Pilot (Aeroplane) Licence
Endorsements:	Manual propeller pitch control (MPPC), Pressurisation system (PXS), Gas turbine engine (GTE), Retractable undercarriage (RU)
Ratings:	Multi-engine aeroplane (MEA), Single-engine aeroplane (SEA), Instrument MEA
Medical certificate:	Class 1
Aeronautical experience:	3,470.0 hours
Last flight review:	8 March 2016

Aircraft details

Manufacturer and model:	Beech Aircraft Corporation B200	
Year of manufacture:	1989	
Registration:	VH-MVL	
Serial number:	BB-1333	
Type of operation:	Aerial work – EMS	
Persons on board:	Crew – 1	Passengers – 2
Injuries:	Crew – 0	Passengers – 0
Damage:	Substantial	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Civil Aviation Safety Authority
- Textron Aviation (B200 Type Certificate Holder)
- operator
- pilot.

References

Civil Aviation Safety Regulation Part 61, dated 4 November 2014

Civil Aviation Safety Authority legislative instrument 'Prescribed aircraft, ratings and variants for CASR Part 61 Instrument 2014' (Edition 1), dated 5 January 2015

Civil Aviation Safety Authority explanatory statement 'Prescription of aircraft and ratings – CASR Part 61 (Edition 1), dated 5 January 2015

Civil Aviation Advisory Publication 5.23-2(0): Multi-engine aeroplane operations and training, dated July 2007

Civil Aviation Advisory Publication 5.59A-1(0): Competency based training and assessment in the aviation environment, dated July 2009

Raytheon Aircraft Company, Beechcraft King Air B200 & B200C pilot's operating handbook and FAA approved airplane flight manual, dated 2004

Raisbeck Engineering Company, pilot's operating handbook and FAA-approved airplane flight manual supplement for the Beechcraft Super King Air models B200/B200C/B200T/B200CT, dated 2016

Operator's training and checking manual, version 2.1, dated 19 January 2015

Operator's quick reference handbook for Raisbeck B200/C, dated 15 June 2004

Beechcraft service bulletin 2596, Fire protection – continuous loop fire and overheat detection system installation, dated October 2015

Civil Aviation Safety Authority airworthiness bulletin 26-005, Beech B200 series engine fire detection systems, issue 1, dated 10 April 2013

Super King Air 200 series maintenance manual, propeller autofeathering system – description and operation, revision D4, 1 November 2016, printed from Beechcraft Corporation Interactive Maintenance Library

H. H. Hurt, Jr., Aerodynamics for naval aviators, NAVAIR 00-80T-80, University of Southern California, USA, 1965.

United States Federal Aviation Administration advisory circular (AC 120-53B CHG 1), guidance for conducting and use of flight standardisation board evaluations, dated 5 November 2013

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the Civil Aviation Safety Authority, Textron Aviation, the operator and the pilot.

The submissions from those parties were reviewed and where considered appropriate, the text of the draft report was amended accordingly.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
LEngine shutdown and collision with terrain involving Beech Aircraft Corporation B200, VH MVL, Moomba Airport, South Australia, 13 December 2016

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