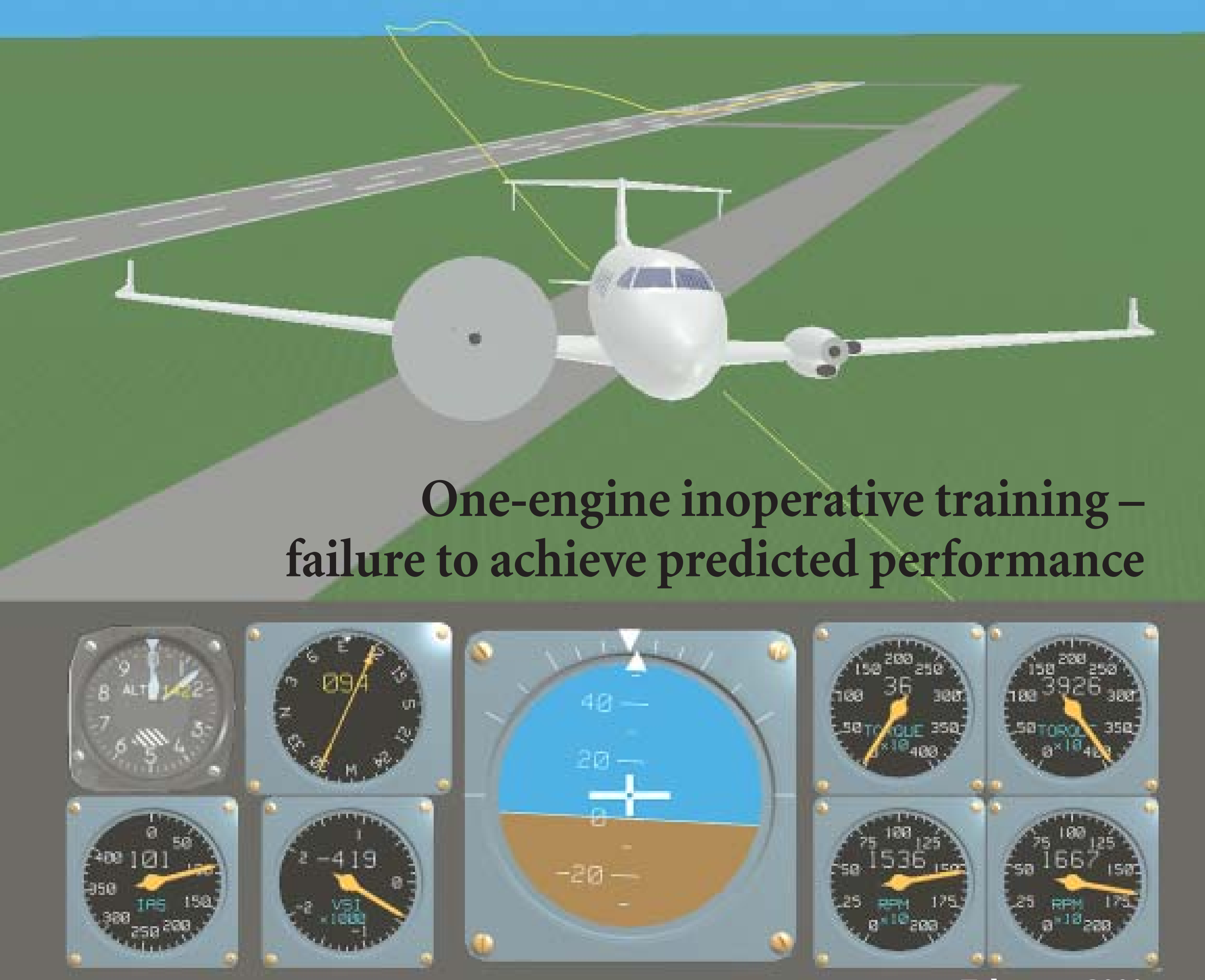
AUSTRALIAN TRANSPORT SAFETY BUREAU

AVIATION SAFETY REPORT
BO/200000492



One-engine inoperative training – failure to achieve predicted performance

February 2000

COMMONWEALTH DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES

Department of Transport and Regional Services

Australian Transport Safety Bureau

INVESTIGATION REPORT
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One-engine inoperative training – failure to achieve predicted performance

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This report was produced by the Australian Transport Safety Bureau (ATSB), PO Box 967, Civic Square ACT 2608.

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INTRODUCTION

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Commonwealth Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

In terms of aviation, the ATSB is responsible for investigating accidents, serious incidents, incidents and safety deficiencies involving civil aircraft operations in Australia, as well as participating in overseas investigations of accidents and serious incidents involving Australian registered aircraft. The ATSB also conducts investigations and studies of the aviation system to identify underlying factors and trends that have the potential to adversely affect safety. A primary concern is the safety of commercial air transport, with particular regard to fare-paying passenger operations.

The ATSB performs its aviation functions in accordance with the provisions of the *Air Navigation Act 1920*, Part 2A. Section 19CA of the Act states that the object of an investigation is to determine the circumstances surrounding any accident, serious incident, incident or safety deficiency to prevent the occurrence of other similar events. The results of these determinations form the basis for safety recommendations and advisory notices, statistical analyses, research, safety studies and ultimately accident prevention programs. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations.

It is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and conclusions reached. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. 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.

Time reference in this report is Eastern Summer Time (ESuT), and the local time was UTC + 11 hours.

EXECUTIVE SUMMARY

On 13 February 2000 a Beech 1900D Airliner, VH-NTL, was on a local training flight. The pilot in command simulated a failure of the left engine shortly after takeoff by retarding the left power lever to the 'FLIGHT IDLE' position. The handling pilot applied full right rudder and right aileron to counter the resultant yaw to the left, but the yaw continued until power was restored to the left engine to regain directional control. In the 21 seconds following takeoff, the aircraft did not climb above 160 ft above ground level, and at one stage had descended to 108 ft.

The aircraft was then climbed to a height of 2,000 ft where the pilot in command simulated another failure of the left engine by retarding its power lever to the 'FLIGHT IDLE' power setting. The aircraft again lost controllability. Power was restored to the left engine, and the aircraft landed without further incident.

There was no evidence that any aircraft or systems malfunctions contributed to the controllability problems experienced by the crew during the occurrence flight.

Since 1992, it was the practice of the operator's check pilots to simulate one-engine inoperative by retarding the power lever of the 'failed' engine to 'FLIGHT IDLE'. That was contrary to the procedure prescribed in the Federal Aviation Authority-approved Beech 1900D Airplane Flight Manual, and also to that specified in the operator's Civil Aviation Safety Authority-approved Training and Checking Manual. Reducing power to 'FLIGHT IDLE' also had the effect of simulating a simultaneous failure of the engine and its propeller auto-feather system. The simulation of simultaneous inflight failures was contrary to the provisions of the CASA-approved Training and Checking Manual. During each of the simulated one-engine inoperative sequences, control of the aircraft was not regained until the power on the 'failed' engine was advanced to the manufacturer's prescribed one-engine inoperative thrust power setting.

The operator's training and checking organisation and its check pilots were aware that the likely consequences of simulating an engine failure by retarding its power to less than zero thrust were reduced aircraft climb performance and increased air minimum control speed (V_{MCA}). They were also aware that risk increased when inflight training exercises involved the simulation of multiple failures. The prescribed procedures were therefore necessary defences to minimise those risks. The circumvention of those defences significantly increased the risks associated with the operator's training and checking procedures, and was a safety-significant concern. This occurrence demonstrated the potentially serious consequences of degraded aircraft performance by setting 'FLIGHT IDLE' to simulate one-engine inoperative. The practice has the potential to jeopardise the safety of flight and should be strongly discouraged.

The ATSB's investigation established that the failure to achieve predicted performance during take-off and subsequent climb was the result of an incorrect procedure. As a result of this serious occurrence, the ATSB recommended that the Civil Aviation Safety Authority (CASA) publish information for the guidance of operators and pilots regarding the correct procedures for simulating engine failures in turbo-propeller aircraft. CASA advised that it will publish an amendment to Civil Aviation Advisory Publication 5.23-1(0) to highlight appropriate engine-out training procedures in turbo-propeller aircraft. CASA also advised that it would ensure that operators' manuals contained appropriate procedures for the conduct of multi-engine training, and that it would draw attention to those procedures during forthcoming safety promotion activities. The operator advised that it had instructed its check pilots that an engine's power lever must not be retarded below the zero thrust torque setting when simulating an engine failure on takeoff, and that those simulations were not be carried out until the aircraft had reached 250 ft above ground level.

1. FACTUAL INFORMATION

1.1 History of the flight

On 13 February 2000 at 1215 ESuT, a Beech 1900D Airliner, VH-NTL, took off from Williamtown, NSW on a local training flight. The flight was under the command of a check pilot, and the handling pilot was undergoing recurrent base training. The pilot in command occupied the right control seat, and the handling pilot occupied the left control seat. The pilot in command simulated a failure of the left engine shortly after takeoff on runway 12 by retarding the left power lever to the 'FLIGHT IDLE' position. The pilot in command reported that the handling pilot applied full right rudder and right aileron to counter the resultant yaw to the left. However, the yaw continued until the pilot in command restored power to the left engine to regain directional control.

The aircraft was then climbed to a height of 2,000 ft, where the pilot in command simulated another failure of the left engine. The left engine power was reduced to 'FLIGHT IDLE' and full power set on the right engine. Again, despite the application of right rudder, the aircraft yawed to the left and began to descend at a rate of about 1,000 ft/min. Power was restored to the left engine and the aircraft was stabilised and returned to Williamtown where it landed without further incident.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Others*	*Total*
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	2	-	-	2

1.3 Damage to aircraft

The aircraft sustained no damage.

1.4 Other damage

Not a factor in this occurrence.

1.5 Personnel information

The pilot in command held an Air Transport Pilot (Aeroplane) Licence, a valid Class 1 medical certificate, and a Command Multi-Engine Instrument Rating. He had a total flying time of 8,300 hours, of which more than 3,000 hours were on the Beech 1900D Airliner type.

He was also approved by the Civil Aviation Safety Authority (CASA) to act as a check pilot on the Beech 1900D Airliner, and had previously held a Grade 1 Instructor Rating with more than 2,500 hours flight instructor experience.

The handling pilot held an Air Transport Pilot (Aeroplane) Licence, a valid Class 1 medical certificate, and a Command Multi-Engine Instrument Rating. He had a total flying time of 5,043 hours, of which 1,143 hours were on the Beech 1900D Airliner type.

1.6 Aircraft information

1.6.1 Certification of the Beech 1900D Airliner

The Beech 1900D Airliner was certified under Part 23 of the US Federal Aviation Regulations (FARs). Type Certificate Data Sheet No. A24CE related to the aircraft type, and noted that the flight idle propeller pitch stops were set to 1,500 rpm. The type certificate data sheet also noted that the Airplane Flight Manual (AFM), formed part of the aircraft equipment. Australia recognised FAR23 certification of the Beech 1900D Airliner under Civil Aviation Regulation (CAR) 22A.

1.6.2 VH-NTL (Serial number UE-117)

The maintenance release for the aircraft was valid and formed part of the aircraft technical log. It showed that the aircraft had 13,533 hours total time in service with the next scheduled service being due at 13,576 hours. The aircraft carried no deferred defects on engines, propellers or the rudder boost system.

1.6.3 Weight and balance

The load and trim sheet data for the flight showed that the brakes release weight was 5,983 kg, which was 78 per cent of the performance-limited maximum take-off weight of 7,688 kg. The trim sheet showed that the centre of gravity (CG) was close to the maximum allowable forward limit. The Beech 1900D FAA-approved AFM provided information on forward and aft CG limits for various weights. The forward and aft CG limits for 5,983 kg brakes release weight were calculated to be 277.0 inches (703 cm) and 299.9 inches (761 cm) respectively, aft of the aircraft CG datum point.

The take-off safety speed (V_2) of the aircraft was 113 knots indicated airspeed (KIAS) for the brakes release weight of 5,983 kg. That was the minimum speed at which the aircraft could be flown to ensure that climb performance could be achieved following an engine failure.

1.6.4 Engines and propellers

The aircraft had two Pratt & Whitney Canada Inc. PT6A-67D turbo-propeller engines. Each engine had a four-blade, full-feathering, constant-speed propeller of composite construction. The propeller manufacturer was Hartzell Propeller Inc.

The PT6A-67D engines were of the ‘free turbine’ type and had two independent turbine sections. The gas turbine section drove the compressor in the gas generator section of the engine. The power turbine section was a two-stage turbine that drove the propeller through a reduction gearbox. Power levers in the cockpit controlled the power that the engines delivered to the propellers, and propeller levers set the required propeller RPM. Propeller rotation was clockwise when viewed from behind the aircraft. The left engine was the ‘critical’ engine; this is discussed at subsection 1.16.3.

Each engine had a primary (constant speed) engine-driven governor to control its propeller pitch and speed. The primary governor controlled the high and low pitch limits of the propeller by applying engine oil under pressure to the propeller hub. The governed speed range was between 1,400 and 1,700 RPM. The engine's propeller control lever was connected to a shut off valve inside the governor. The applied load on the propeller determined the speed of the governor flyweights. The governor compensated for changes in flyweight speed by adding or removing oil from the propeller hub to adjust the propeller blade angle to a new constant speed position. The propeller blades were moved towards the low RPM (high pitch) and into the feathered position by centrifugal counterweights, aided by a feathering spring. They were moved to the high RPM (low pitch) hydraulic stop and the reverse position by governor-boosted oil pressure.

The power in the gas turbine section reduced when the power lever was retarded. The power turbine speed decreased and propeller RPM reduced to a value below that selected by the propeller lever. The primary governor sensed the 'underspeed' condition and reduced the pitch of the propellers to lessen the load on the propeller blades. The decrease in blade angle then allowed an increase in propeller RPM to match the RPM setting selected by the propeller control lever.

The propellers on the Beech 1900D Airliner had flight idle and ground idle pitch stops. The angle of propeller blades was approximately 13 degrees at the flight idle pitch stop, which was the minimum inflight blade angle. During ground operations the angle of propeller blades was approximately seven degrees at the ground idle pitch stops.

The flight idle low pitch stops were mechanically actuated hydraulic stops. The ground idle low pitch stops were electrically actuated stops, controlled by solenoids that were unpowered when the aircraft was airborne. When the aircraft touched down, a 'weight on wheels' squat switch mounted on the right main landing gear leg provided power to the solenoids, allowing the ground idle low pitch stops to reposition. Aircraft subsequent to serial number UE-335 were equipped with an annunciator warning light to alert crews of the failure of either of the ground idle low pitch solenoids. The annunciator, labelled 'PROP GND SOL', was available as a modification kit (Kit 129-9011-1, "Kit - Ground Idle System") for aircraft manufactured prior to UE-335. The occurrence aircraft, serial number UE-117, was not fitted with the modification.

If one or both ground idle low pitch stop solenoids was in the (unpowered) flight position during ground operations, the 'PROP GND SOL' annunciator illuminated. In that condition, the propeller RPM on the affected engine(s) would be abnormally low, because the propeller blades were at the 13 degrees flight idle setting, which was coarser than the 7 degrees ground idle pitch setting. The coarser pitch created significant drag, resulting in lower than expected engine RPM.

Inflight illumination of 'PROP GND SOL' annunciator indicated that one or both ground idle low pitch solenoids were in the (powered) ground position. In that condition, it was possible for the pitch on one or both propellers to decrease to the ground idle pitch stop when power and airspeed were reduced, resulting in an increase in drag and a yawing moment if only one propeller was affected. If only one solenoid was affected, the aircraft would yaw towards the affected engine when power and speed were reduced.

In August 2000, the manufacturer amended Section III of the Beech 1900D Airliner Pilot's Operating Manual (POM). The amendment included information about illumination of the 'PROP GND SOL' annunciator, and advised that power could be removed from the low pitch solenoids by pulling the 'PROP GND SOL' circuit breaker on the co-pilot's circuit breaker panel. It also included advice that if the annunciator did not extinguish after the circuit breaker was pulled, then a stuck solenoid was indicated. In those circumstances, a modified approach would need to be flown to ensure that the propellers did not reach the low pitch stop until after the aircraft had landed. The amended information provided no advice on how to recognise a stuck solenoid on aircraft not fitted with modification kit 129-9011-1, "Kit – Ground Idle System". The modification kit is further discussed at subsection 1.6.5.

The manufacturer advised that if a propeller inadvertently entered the ground idle range during flight, it would result in an increase in propeller RPM and a corresponding decrease in engine torque. The magnitude of propeller RPM change depended, among other things, upon airspeed, but would be about 200 RPM; that is, the same as would be observed during the preflight Ground Idle Low Pitch Stops check.

The propeller governor controlled the propeller pitch in flight. The lowest pitch setting permitted in flight was the flight-idle low pitch stop. If the pilot selected a pitch setting below the flight-idle low pitch stop during normal operation of the governor, it would continue to control the propeller and the propeller would continue to operate at the governor-selected RPM.

The propeller pitch could be manually controlled and set below the flight-idle low pitch stop setting only when the propeller was operating off the governor's control. That occurred when the propeller was operating at the lower end of its speed range, which required the aircraft airspeed to be below about 120 KIAS. At that low airspeed and low propeller speed condition, lifting the power levers operated the pedestal ground-idle low pitch stop switch, which powered the ground-idle low pitch stop solenoid and changed the propeller pitch to the ground-idle setting.

The pedestal switch was a secondary means to automatically power the ground-idle low pitch stop solenoids during the landing roll until the right landing gear squat switch activated due to 'weight on wheels'. A crosswind or a very gentle landing could prevent the right squat switch from activating for a substantial part of the ground roll. The pedestal switch was activated automatically as the power levers were raised over the first gate to transition from flight idle to the ground fine range immediately after touchdown. Lifting either power lever would activate the pedestal switch, which in turn powered the solenoids on both engines. That ensured the blade angles on both propellers were reset simultaneously, and also ensured there was a means available to activate a single solenoid during a single engine landing. The power levers had to be intentionally lifted to activate the solenoid. That required a separate and distinct movement to lift the levers over the flight-idle low pitch stop. If that was done in flight, and if the propeller was operating off the governor's control, the aircraft would experience a sudden increase in drag and a decrease in lift. It was for that reason there was a limitation against lifting the power levers in flight.

The manufacturer advised that it was aware of only one instance where the pilot of a Beech 1900D Airliner had selected the power levers to the ground idle ("beta") range during flight. The National Transportation Safety Board (NTSB) investigated the event, and determined that that accident was due to:

> The captain's improper placement of the power levers in the BETA position, while the airplane was inflight.

An aircraft may become uncontrollable because of drag produced by a propeller windmilling at high RPM in the low pitch range. The loss of engine power at high propeller RPM may cause sufficient drag and yawing moment to overcome the opposing yaw forces produced by the rudder. Under those circumstances, a system to provide automatic feathering of the windmilling propeller may be necessary.

The Beech 1900D Airliner was equipped with an auto-feather system. The Beech 1900D Airliner FAA-approved Airplane Flight Manual contained information on the auto-feather system in Section II - Limitations. It stated:

> The propeller auto-feather system must be operable for all flights and must be armed for takeoff, climb, approach, and landing.

The system armed when the power levers were advanced to establish engine power settings greater than 85 per cent to 90 per cent of the maximum gas-generator rotation speed. If an engine failure occurred, the auto-feather system caused oil to be immediately dumped from the propeller governor. That allowed the feathering spring and centrifugal counterweights to move the propeller blades to the feathered position to reduce the drag associated with a windmilling propeller.

The manufacturer's recommended procedure for simulation of one-engine inoperative on the aircraft was included in Section IV of the AFM. The procedure required that zero thrust be set on the simulated 'failed' engine. By setting zero thrust, a condition was established that simulated the failure of an engine and the operation of its propeller's auto-feather system. If a power setting less than zero thrust was used to simulate a 'failed' engine, for example, 'FLIGHT IDLE', it resulted in a higher drag from the windmilling propeller. This setting therefore had the effect of simulating the failure of both the engine and the auto-feather system of the propeller.

1.6.5 Modification Kit 129-9011-1 "Kit – Ground Idle System"

The modification kit was developed in response to a customer request to provide the Beech 1900D Airliner with the capability to perform steeper than normal landing approaches. The modification kit provided an illuminated 'PROP GND SOL' warning to alert the crew that either ground idle pitch solenoid was not in a position appropriate to the particular phase of flight.

1.6.6 Rudder boost system

The aircraft was equipped with a rudder boost system that sensed engine torque from both the engines. When the torque difference between both engines exceeded a preset level, the rudder boost electric servo activated and deflected the rudder to aid pilot effort. The servo contribution increased in proportion to the increase in torque differential resulting from the loss of power from an engine.

1.7 Meteorological information

The wind direction and speed at Williamtown was reported as being 150 degrees magnetic at 20 kts, gusting to 28 kts. Visibility was reported to be more than 10 km, and no cloud was reported to exist below 5,000 ft above ground level.

1.8 Aids to navigation

Not a factor in this occurrence.

1.9 Communications

Not a factor in this occurrence.

1.10 Aerodrome information

Not a factor in this occurrence.

1.11 Flight recorders

1.11.1 General

The aircraft was equipped with a Loral Data systems (Fairchild) F1000 solid-state digital flight data recorder (SSFDR). It was designed to record information under Aeronautical Radio, Inc. (ARINC) Equipment Characteristic 542A.

The parameters recorded by the SSFDR included pitch and roll attitude angles, as well as control column pitch input. They did not include control column roll input or 'weight on wheels'. Additionally, variations in acceleration on the aircraft's vertical and longitudinal axes were recorded, but no parameter was provided for recording variations in acceleration on the aircraft's lateral axis.

The pitot system was calibrated during the investigation and revealed that SSFDR recorded airspeed value was roughly seven kts less than the indicated airspeed (KIAS) that was correctly displayed on the pilots' airspeed indicators. The airspeed and altitude plots from the calibration revealed 'sawtooth' irregularities, which suggested that the leakage rate within the pitot static system was more than that allowed by CASA AD/INST/9.

1.11.2 Occurrence sequences

The flight path derived from the SSFDR was examined during the investigation. Attachment A to this report provides SSFDR data plots for the take-off sequence. Attachment B provides a tabular presentation of the SSFDR data for the take-off sequence. It includes calculations derived from the SSFDR data for vertical speed, yaw rate, roll rate, certified air minimum control speed (V_{MCA}[1]) factored for bank angle of less than five degrees, and margin of corrected airspeed over factored V_{MCA}.

Airspeeds are quoted as KIAS, that is, recorded airspeed, corrected for the leakdown of seven kts, as referred to in subsection 1.11.1.

The manufacturer's FAA-approved Airplane Flight Manual provided information that V_{MCA} for the Beech 1900D Airliner was 92 KIAS. V_{MCA} for multi-engine aircraft is established during the certification procedure. When establishing V_{MCA}, the aircraft CG is required to be at its most rearward position. During the occurrence flight, the CG was near its forward limit. Therefore, the actual V_{MCA} for the occurrence aircraft would have been slightly less than the certified V_{MCA} of 92 KIAS. The CG range of the occurrence aircraft at the brakes release weight was relatively small (58 cm), and its effect in reducing certified V_{MCA} would not have been overly significant.

As the aircraft became airborne, the left engine power was reduced to 33 ft-lbs of torque ('FLIGHT IDLE'). The left engine power did not exceed 50 ft-lbs of torque until

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[1] The letter 'V' is used to define airspeed. Relevant airspeeds are defined by the letter V, followed by a descriptive code of other letters or numbers, for example, V_{MCA}, which is further discussed in subsection 1.16.1 below.

the pilot in command restored power about 21 seconds after the simulated failure had been initiated.

The operator reported that its check pilots regularly used the technique of introducing a simulated engine failure by selecting the engine's power lever to 'FLIGHT IDLE'. The practice had been in regular use since the introduction of the Beech 1900D Airliner into the operator's fleet in April 1992, but was contrary to the aircraft manufacturer's prescribed technique and the provisions of the operator's CASA-approved Training and Checking Manual. These matters are discussed in subsection 1.17.1.

About eight seconds after the simulation of one-engine inoperative flight was initiated, speed had reduced below the V_2 speed of 113 KIAS. It remained below the V_2 speed for the next 14 seconds until power on the left engine was restored. The speed reduction was in excess of the operator's permitted one-engine inoperative climb speed flight tolerance.

In the 21 seconds following the simulated failure of the left engine, the aircraft heading decreased from 112 degrees magnetic to 088 degrees. The heading change was in excess of the operator's permitted one-engine inoperative heading flight tolerance. However, the rate of heading change was not constant. In the three seconds following simulated failure of the left engine, the aircraft heading increased from 112 degrees magnetic to 119 degrees. This equated to a yaw rate of 2.3 degrees per second towards the operative engine. In that same period, the aircraft nose-up pitch increased from 10.3 degrees to 12.3 degrees. In the next 18 seconds, the aircraft heading decreased from 119 degrees magnetic to 090 degrees, equating to a yaw rate of 1.6 degrees per second towards the inoperative engine. In the same period, the aircraft nose-up pitch decreased from 12.3 degrees to seven degrees, however, the change in pitch attitude was not constant.

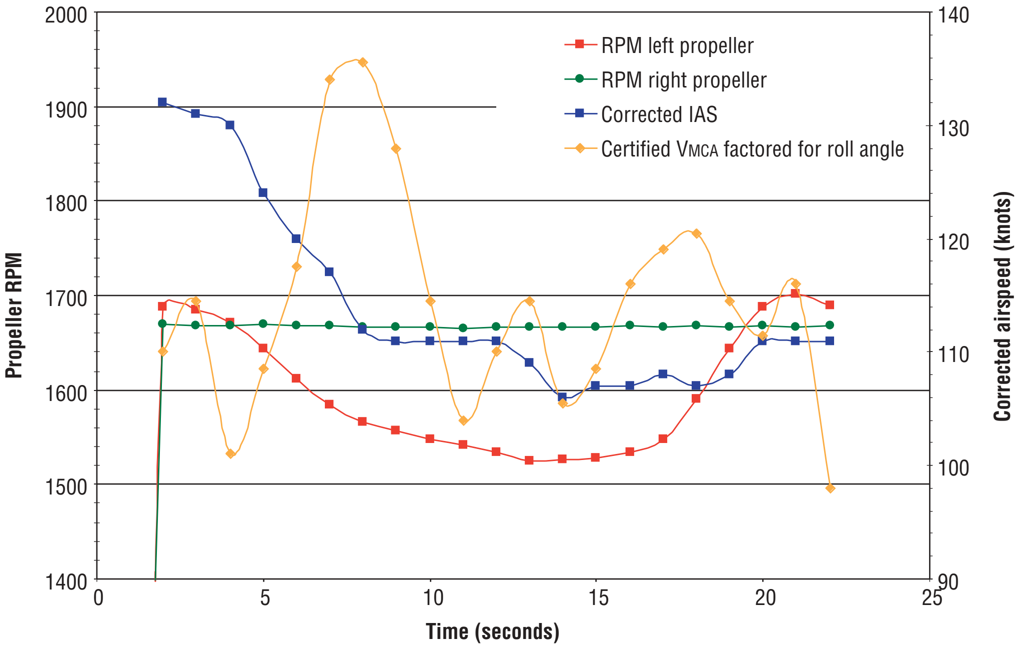
The altitude plot revealed that in the 21 seconds following takeoff the aircraft did not climb above 160 ft, and at one stage it had descended to 108 ft.

The roll plot showed that the aircraft was banked towards the left engine, the simulated 'inoperative' engine, for most of the 21 seconds following takeoff. The maximum-recorded bank angle to the left was 9.5 degrees. The bank angle was not constant throughout the period, and there were occasions when the aircraft was banked to the right, towards the operative engine.

The pitch plot showed that significant variation in nose-up pitch occurred during the take-off sequence. In the five seconds following the simulated failure of the left engine, aircraft nose-up pitch was increased from 10.3 degrees to 12.5 degrees. During the next four seconds it reduced to 6.5 degrees, then increased to 10.8 degrees in the next two seconds. Pitch variations continued throughout the sequence until power was restored on the left engine and control of the aircraft regained.

During the sequence, the left propeller RPM reduced by about 160 RPM. The lowest propeller RPM was coincident with the lowest recorded airspeed. The handling pilot regained normal control 21 seconds after takeoff when the left engine torque was increased to 232 ft-lbs and the propeller had returned to the governing range. The relationship between the left propeller RPM and airspeed is shown in Chart 1 below.

Chart 1:
VH-NTL relationship between propeller RPM and airspeed



Following climb to a higher altitude, the pilot in command simulated another failure of the left engine. Attachment C provides a tabular presentation of the SSFDR data for the upper air sequence, and includes calculations derived from the SSFDR data for vertical speed, yaw rate, roll rate, certified V_{MCA} factored for bank angle of less than five degrees, and margin of corrected airspeed over factored V_{MCA}.

The left engine power was again reduced to 'FLIGHT IDLE' and remained at that setting for the next 71 seconds, except for a momentary increase in torque about 38 seconds after the failure was initiated (see below). The failure was initiated at 2,000 ft as the aircraft was passing through 026 degrees magnetic heading in a descending left turn at a bank angle of about 34 degrees. The recorded airspeed at the time of that simulated engine failure was 140 KIAS.

The right engine power fluctuated between 492 and 575 ft-lbs of torque for about nine seconds after the left engine power was reduced to 'FLIGHT IDLE', then increased, as the aircraft was passing through a heading of 339 degrees magnetic with about five degrees of left bank. Wings-level attitude occurred about 18 seconds after the failure was initiated, as the aircraft was on 333 degrees magnetic heading, descending through 1,790 ft at a rate of about 1,300 ft/min. The recorded airspeed at that point was 116 KIAS corrected.

The right engine reached maximum continuous torque about 28 seconds after the failure was initiated, while the aircraft was on heading 326 degrees magnetic with 0.5 degrees of left bank. In the 20 seconds after achieving wings level, the aircraft descended to 1,445 ft. In that time, the recorded airspeed fluctuated within the range of 116 to 121 KIAS , and the heading reduced to 318 degrees magnetic. In the same period the aircraft pitch attitude increased from 1.0 degrees to 6.0 degrees nose-up pitch.

At 38 seconds after the initiation of the failure, the left engine torque increased to 170 ft-lbs for one second, then reduced to 'FLIGHT IDLE'. During that one-second period, the left engine propeller RPM reduced. The aircraft immediately yawed four degrees to the right as the torque increased, then resumed its original heading of about 318 degrees magnetic when the torque reduced to 'FLIGHT IDLE'.

At 56 seconds after the initiation of the failure, the recorded airspeed started to reduce. At 66 seconds elapsed time recorded speed was 107 KIAS , and heading had reduced to 307 degrees magnetic. During that period the aircraft attitude increased to 10 degrees aircraft nose-up pitch, then reduced to 6.3 degrees nose-up pitch, and the recorded altitude increased from 1,484 ft AGL to 1,522 ft AGL. While the airspeed was below 113 KIAS, the aircraft was being operated at less than the scheduled V_2 speed for the brakes release weight of 5,983 kg.

At 66 seconds elapsed time the power on the left engine was increased, and both engines were operating at symmetrical power by 72 seconds elapsed time.

Power was restored to the left engine, and the aircraft then returned to Williamtown, where it landed without further incident. Attachment D provides SSFDR data plots of the landing sequence. Touchdown occurred at timeframe 3894, and is evidenced by the oscillation of the vertical acceleration parameter. Ground fine pitch was selected at about timeframe 3900, and was evidenced by transient variations in the propeller RPM and engine torque parameters. The transition of both propellers from ground idle to ground fine was evidenced by the rapid reduction in longitudinal acceleration at timeframe 3900.

The operator expressed concern to the ATSB that the performance degradation of the aircraft may have resulted from an intermittent defect in the left propeller. The operator surmised that the defect led to the propeller's blades being at less than the flight idle position at times during the flight, thus leading to the controllability problems experienced by the handling pilot. The SSDFDR plots for the occurrence sequences displayed no evidence of intermittent increases in the left engine propeller RPM, accompanied by corresponding decreases in engine torque, and indicated that the left propeller blades had not entered the ground idle range during flight.

The handling pilot controlled the aircraft pitch attitude with the elevators. The flight data for the initial take-off and the upper air sequences displayed significant oscillations of aircraft pitch and vertical acceleration. There was a lag between aircraft pitch and control column pitch, however, the lag reduced as airspeed increased. The vertical acceleration also displayed significant oscillations that were coincident with the oscillations in aircraft pitch.

The operator reported that in its experience, a Beech 1900D Airliner remained controllable throughout the phase of flight when an engine's power lever was selected to 'FLIGHT IDLE', but that:

> The rate of climb was less than with zero thrust selected, the difference being in the order of 200 ft/min.

Significant drag penalties result from a windmilling propeller and would partly account for the degraded climb performance reported by the operator. This is further discussed in subsection 1.16.4.

The operator also reported that the pilot in command observed that the aircraft performance and handling were significantly different from what he had previously experienced and he therefore initiated recovery action. This concerned him and led him to conduct a further flight check (Upper Air Sequence). Again, the aircraft performance and handling were significantly different. The pilot in command was sufficiently concerned that he terminated the exercise and declared the aircraft unserviceable after landing. Examination of the aircraft technical log revealed that the pilot in command had made the following entry into the log:

> Left prop in flight producing too much drag. Aircraft uncontrollable on right engine only.

The ATSB sought an opinion from the aircraft manufacturer about the SSFDR data for the occurrence sequences. The manufacturer reported that the data was consistent with:

> expected airplane response when power on one engine is reduced to idle with takeoff power on the other engine, a bank is not immediately established toward the operating engine, a significant sideslip is allowed to develop, and the airspeed is allowed to decay below about 120 KIAS.

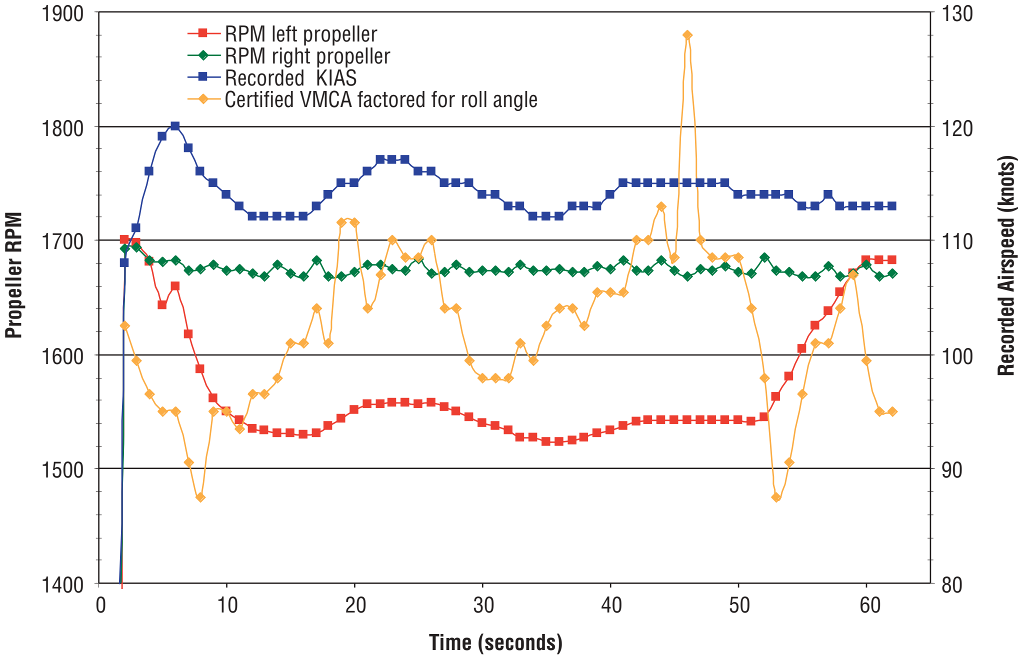
1.11.3 Test flight

The operator subsequently carried out a test flight in another Beech 1900D Airliner, VH-FOZ, to further investigate the controllability problems experienced by the crew of NTL. Details of the test flight were recorded on the aircraft's SSFDR, which was sent to the ATSB for analysis.

The pitot system of the aircraft used for the test flight was not calibrated to determine whether the recorded airspeed value required correction to correlate with indicated airspeed value. Attachment E provides SSFDR data plots for the test flight sequence. Refer also to Attachment F, which provides a tabular presentation of the SSFDR data for the test flight sequence. It includes calculations derived from the SSFDR data for vertical speed, yaw rate, roll rate, certified V_{MCA} factored for bank angle of less than five degrees, and margin of corrected airspeed over factored V_{MCA}.

During the test flight sequence the highest recorded value for the left propeller was 1,700 RPM, and the lowest recorded value was 1,524 RPM. The lowest propeller RPM was coincident with the lowest recorded airspeed of 112 KIAS. The relationship between the left propeller RPM and airspeed is shown in Chart 2 below.

Chart 2:
VH-FOZ relationship between propeller RPM and airspeed



Attachment G shows the SSFDR data plots of the test flight landing sequence. Touchdown occurred at about timeframe 29824, and is evidenced by the oscillation of the vertical acceleration parameter. Ground fine pitch was selected at about timeframe 29840, and is evidenced by transient variations in the propeller RPM and engine torque parameters. The transition of both propellers from ground idle to ground fine is evidenced by the rapid reduction in longitudinal acceleration at timeframe 29840.

1.12 Wreckage and impact information

Not a factor in this occurrence.

1.13 Medical information

Not a factor in this occurrence.

1.14 Fire

Not a factor in this occurrence.

1.15 Survival aspects

Not a factor in this occurrence.

1.16 Training in multi-engine aircraft

1.16.1 Air minimum control speed (V_{MCA})

A multi-engine aircraft equipped with wing-mounted engines will experience asymmetric thrust if one engine suffers a total or partial loss of power. Consequently, the aircraft will yaw towards the failed engine, and the pilot must counteract that asymmetric thrust moment by applying rudder towards the operative engine. The rudder's effectiveness will depend on the velocity of airflow across it. If the aircraft decelerates, the airspeed will eventually reach a speed below which the rudder moment can no longer balance the asymmetric thrust moment. Directional control will then be lost.

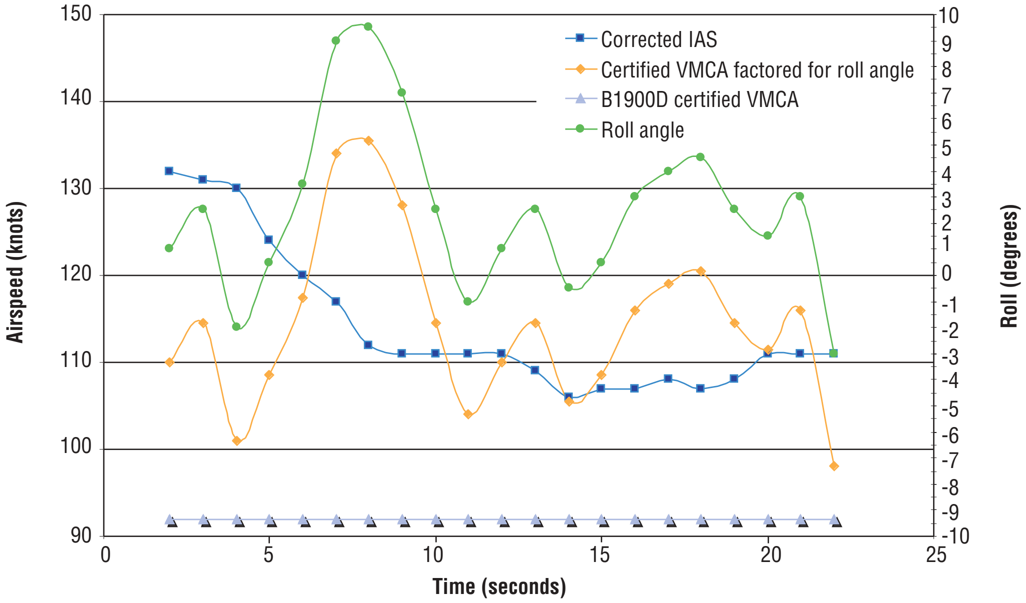
V_{MCA} is the minimum speed at which it is possible to maintain directional control of the aircraft with the critical engine inoperative. When flown at V_{MCA}, and with a bank angle of about five degrees towards the operating engine, the pilot should be able to maintain directional control of the aircraft. The aircraft certification process includes demonstration of V_{MCA}. FAR 23.51 requires that the take-off safety speed (V_2) must not be less than 1.10 V_{MCA}. Therefore, if an aircraft is flown at V_{MCA} rather than the V_2 speed following an engine failure, climb performance will not be achieved.

By banking the aircraft towards the operative engine, the wings develop a lateral force that results in the aircraft sideslipping towards the operative engine. The sideslip creates a positive angle of attack of the airflow over the rudder. The resulting moment around the aircraft CG counters the moment produced by operating with one engine inoperative, and the other engine producing thrust.

The aircraft manufacturer provided advice on the effect of bank angle on V_{MCA}, based on information contained in the Federal Aviation Administration (FAA) FAA-H-8083-3 *Airplane Flying Handbook*. The Handbook stated that banking towards the operative engine would reduce V_{MCA}, and banking away from the operative engine would increase V_{MCA} by about three KIAS per degree of bank.

The relationship between roll angle and certified V_{MCA} for the occurrence take-off sequence is shown in Chart 3 below. The speed at which the aircraft was operating was below the certified V_{MCA} factored for bank angle of less than five degrees at certain stages during that sequence.

Chart 3:
Relationship between roll angle and V_{MCA}



The FAA-H-8083-3 *Airplane Flying Handbook* also contained advice that V_{MCA} would be greater when the CG was at the rearmost allowable position. A rearward CG would not affect the thrust moment, but would shorten the arm to the centre of the rudder's horizontal lift. That would require a higher force (airspeed) to counter the yaw resulting from an inoperative engine. The CG range of the aircraft at the brakes release weight was relatively small (58 cm), and its effect on V_{MCA} would not have been overly significant.

1.16.2 Safe one-engine inoperative speed (V_{SSE})

In 1996, the Beech Aircraft Corporation published information about a new airspeed limitation, V_{SSE}, and the procedure for demonstration of V_{MCA}. Beech noted that the new airspeed limitation was necessary because some pilots, instructors, and examiners were suddenly cutting power on one engine at or close to the stall speed. This had the potential to lead to a sudden loss of control of the aircraft.

Beech also noted that some aircraft had the 'desirable characteristic' of V_{MCA} being less than the power-off stall speed. Under the circumstances, an effective flight demonstration of V_{MCA} was impossible and was not to be attempted to meet the FAA Flight Test Guide requirement for engine-out control speed demonstration.

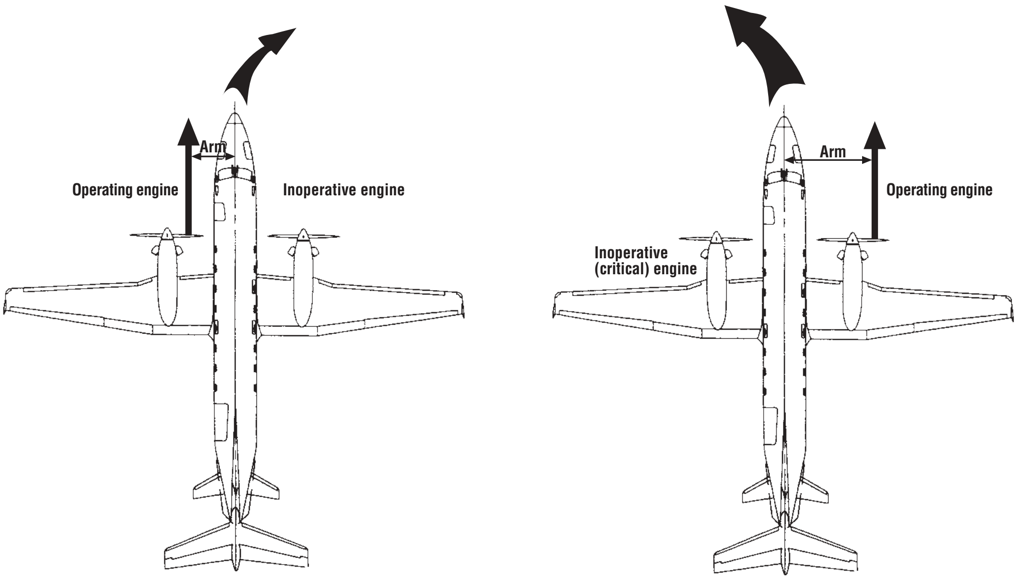
Beech advised that a new procedure was required for slow flight manoeuvres below V_{SSE} that required an engine cut to be made above V_{SSE}, then allowing airspeed to reduce slowly until the onset of V_{MCA} or stall warning. Beech warned that loss of control was possible if the new procedure was not followed, and that a rapid rolling and yawing motion could develop if the aircraft became fully stalled with one engine inoperative. Under those circumstances, aileron and rudder would be ineffective, and the aircraft would become inverted during the onset of a spin.

1.16.3 Asymmetric propeller loading (‘P’ factor) and the ‘critical engine’

‘P’ factor is the result of dissimilar thrust from rotating propeller blades during certain flight conditions. Downward moving propeller blades have a greater angle of attack than upward moving blades when the relative airflow striking the blades is not aligned with the thrust line. The effects of ‘P’ factor, or asymmetric propeller loading, are most pronounced when engines are operating at a high power setting and the aircraft is flown at a high angle of attack.

The propellers of most U.S. designed multi-engine aeroplanes rotate clockwise when viewed from the rear. At low airspeed and high-power conditions, the downward moving propeller blades of each engine develop more thrust than the upward moving blades. That asymmetric propeller thrust, or ‘P’ factor, results in the centre of thrust shifting to the right of the propeller centreline. The turning (or yawing) force of the right engine is greater than the left engine because the centre of thrust is farther from the centreline of the fuselage and therefore has a longer leverage arm. When the right engine is operative and the left engine is inoperative, the turning (or yawing) force is greater than when the left engine is operative and the right engine inoperative. In other words, directional control is more difficult when the left engine (the ‘critical’ engine) is suddenly made inoperative.

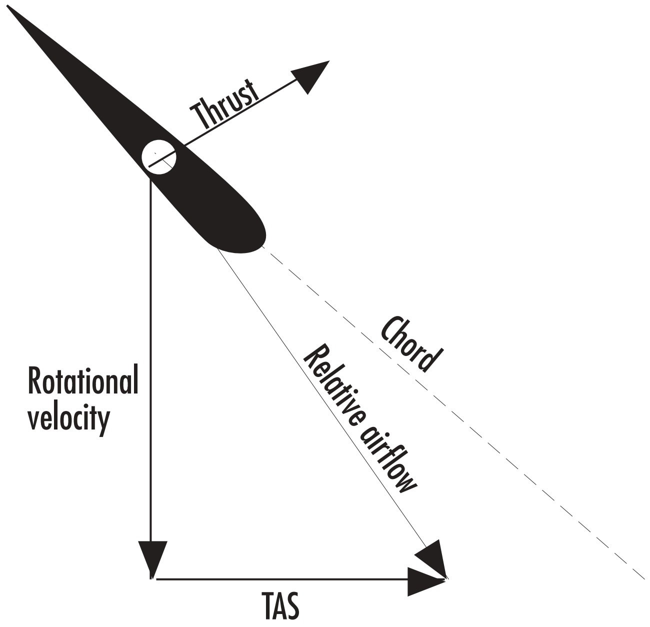
FIGURE 1:
Asymmetric propeller loading (‘P’ factor)



1.16.4 Drag from a windmilling propeller

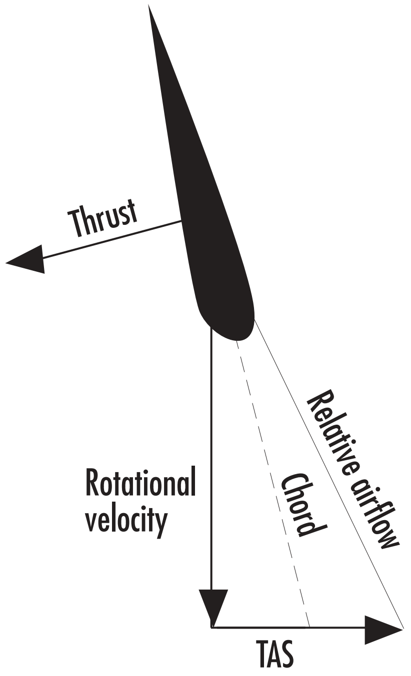
A relative airflow over propeller blades produces lift, or ‘thrust’. Positive thrust occurs when propeller blades are at an angle and speed that produces a positive angle of attack to the relative airflow. The angle of attack of propeller blades decreases when the propeller RPM decreases.

FIGURE 2:
Angle of attack of a propeller in normal flight



A propeller will normally continue to rotate following an inflight engine failure. When a propeller stops producing thrust, drag causes its rotation to decrease. That drag comprises drag of the relative airflow against the propeller blades, and frictional drag within the engine itself. As the propeller RPM decreases, the angle of attack of the blades eventually becomes negative, and blade thrust commences to act in a rearward direction, causing further drag. The energy to maintain propeller rotation comes from the relative airflow over the propeller. Therefore, instead of producing positive thrust, a 'windmilling' propeller increases the amount of drag being experienced by an aircraft.

FIGURE 3:
Angle of attack of a windmilling propeller



1.16.5 Adverse yaw effect

Ailerons are used to roll an aircraft about its longitudinal axis. The downward deflection of an aileron increases lift on the respective wing and raises the wing. However, the increased lift results in increased drag. At the same time, the opposite wing experiences decreased lift and drag from the upward deflection of its aileron. The descending wing moves forward because of its reduced drag and the rising wing moves backward because of its increased drag. That results in a tendency for the aircraft to turn into the rising wing, and is referred to as adverse yaw effect.

1.16.6 Simulation of one-engine inoperative (zero thrust)

Most engine inoperative training on large aircraft is conducted in flight simulators. When simulators are not available, the training is conducted in-flight, and reducing power on the engine performs simulation of an engine failure. Nevertheless, particular handling and performance problems may result from simulating an engine failure by retarding the power lever. A turbo-propeller engine that is retarded to 'FLIGHT IDLE' produces more drag than an engine that has failed and its propeller has auto-feathered. That results in a reduction of performance that may lead to decay in airspeed and an inability to maintain directional control or satisfactory obstacle clearance. The appropriate technique is to retard the power lever to a power setting that equates to the zero thrust condition of a feathered propeller. The power lever should be retarded at a rate that is commensurate with the engine's normal deceleration behaviour.

CASA issues Civil Aviation Advisory Publications (CAAPs) to provide guidance and information on designated subject areas, or to show a method for complying with a related Civil Aviation Regulation. The contents of the CAAPs are not binding, nevertheless, they provide guidance on the preferred method of achieving for complying with the regulations.

In September 1996, CASA issued CAAP 5.23-1 (0) to provide advice on the syllabus of training for the initial issue of a multi-engine aeroplane type endorsement (rating) and subsequent multi-engine type endorsements. The CAAP noted that pilots were required to display ability to deal with an engine failure during or just after takeoff. The syllabus included training to ensure that a candidate had a full understanding of the principles involved in, and the factors affecting, critical/minimum control and safety speeds. Those speeds included V_{MCA}, V_2 and Vcoded (type related).

The FAA-approved Beech 1900D Airplane Flight Manual contained information that simulated one-engine inoperative conditions were to be achieved by retarding one engine power lever to the zero thrust setting at or above the V_{SSE} speed of 105 KIAS. V_{SSE} was therefore a Vcoded speed for the type.

The air exercises included aeroplane handling with one-engine inoperative to develop the candidate's skill to handle the aeroplane competently in the asymmetric configuration. They also included demonstration of zero thrust conditions for one-engine inoperative flight, and the determination of those conditions.

The CAAP contained advice that for training purposes, an aircraft should be loaded to approximately 90 per cent of its maximum all-up weight (MAUW). If loading to that weight was not practicable, then:

> use of a properly developed Training Power setting that approximates the performance of the aircraft at MAUW may be utilised.

An application form for an Initial Multi-Engine Endorsement (Rating) or Type Endorsement on multi-engine turbo propeller aeroplanes was provided in Annex D of the CAAP. It contained advice that engine failures were to be simulated by setting zero thrust.

In 1999, the UK Civil Aviation Authority published Aeronautical Information Circular AIC 52/1999 (Pink 193) that provided guidance for simulating engine failure in aeroplanes. It noted that where specific information was not available from engine or airframe manufacturers for simulation of one-engine inoperative conditions, the following general advice was likely to be appropriate:

> The throttle should be retarded smoothly towards a pre-determined torque setting appropriate to zero thrust. This torque setting should be maintained during the remainder of the takeoff and initial climb.

The FAA *Airplane Flying Handbook* also contained recommendations for engine inoperative training on multi-engine aircraft. One of those was that simulation of an engine shut down at lower altitudes should be accomplished by reducing its power to the zero thrust setting.

1.16.7 Beech 1900D airliner FAA approved airplane flight manual (AFM)

Section II of the AFM contained the compulsory airspeed limitations for the Beech 1900D Airliner, V_{MCA} was listed as 92 KIAS for flaps 0 degrees and flaps 17 degrees. The manual stated that V_{MCA} was the lowest airspeed at which the aircraft would be directionally controllable when one engine suddenly became inoperative and the other engine was at take-off power. The airspeed limitations also referred to the definition of V_{MCA} in Section I of the AFM.

Section I of the AFM contained information about the certification conditions of the Beech 1900D Airliner relating to V_{MCA}. The conditions included a requirement that controllability be maintained when one engine became inoperative with auto-feather armed, and the aircraft was flown with:

- five degrees of bank towards the operative engine;
- take-off power on the operative engine;
- landing gear up;
- wing flaps at the take-off setting; and
- the aircraft was loaded with the centre of gravity at its most rearward position.

Section I of the AFM also referred to V_{SSE}, and defined it as being a speed above both V_{MCA} and the stall speed that would provide a margin of lateral and directional control when one engine was suddenly rendered inoperative. However, the value of V_{SSE} was not quantified in Section I of the AFM.

Section IV of the AFM contained information about the procedure for simulating one-engine inoperative on the Beech 1900D Airliner. Simulated one-engine inoperative flight was to be achieved by retarding one engine power lever to the zero thrust setting at or above the V_{SSE} speed of 105 KIAS. The zero thrust power setting was specified as 200 ft-lbs of torque, and was greater than the 'FLIGHT IDLE' thrust power setting. The procedure for demonstration of V_{MCA} was also described. It included a warning that it should be conducted by retarding one engine power lever to zero thrust at or above the V_{SSE} speed of 105 KIAS. The procedure included a caution note that rudder was to be used to maintain directional control, and ailerons to maintain 5 degrees bank towards the operative engine. The manual included another caution that evidence of V_{MCA} included the inability to maintain heading or lateral attitude.

1.16.8 Beech 1900D Airliner Pilot's Operating Manual (POM)

The Beech 1900D Airliner POM, produced by the aircraft manufacturer, included information on flight with one engine inoperative. V_{MCA} was defined as the:

> airspeed below which directional control could not be maintained.

V_{SSE} was also defined as the:

> airspeed below which an intentional cut should never be made.

The information included advice that V_{SSE} was intended to reduce the accident potential from loss of control after engine cuts at or near minimum control speeds.

1.17 Organisational information

1.17.1 Regulatory authority

1.17.1.1 Operations manuals

CASA advised that there was no formal requirement for the regulatory authority to approve Operations Manuals, and stated:

> In effect, the Training and Checking manual forms part of the Operations Manual, although it is in discrete form and may often be physically separated. Unlike the remainder of the Operations Manual, the content of part C must be approved, but that approval is made pursuant to CAR 217 and not CAR 215.

Part C of a CASA-required Operations Manual is the Training and Checking Manual.

1.17.1.2 CAR 217 – Training and checking organisation

CAR 217 (1) required that:

> An operator of a regular public transport service, an operator of any aircraft the maximum take-off weight of which exceeds 5,700 kilograms and any other operator that CASA specifies shall provide a training and checking organisation so as to ensure that members of the operator's operating crews maintain their competency.

1.17.1.3 Training and checking manual approval

CASA provided guidance for the preparation of Training and Checking Manuals in CAAP 215-1 (0). It included advice that:

> Because of its effect on safety, CASA views the content and 'approval' of training and checking 'manuals' with particular interest.

Section C2 of the CAAP included advice that a Training and Checking Manual should include a subsection to provide information on the simulation of emergencies and abnormal situations, including the procedures for simulated engine failure.

CASA's Air Operator Certification Manual provided a checklist for assessment of an operator's Training and Checking Manual. The checklist required inclusion of:

> prescribed methods of conducting various training sequences, including methods, special procedures and limitations relating to practice and simulated emergency and abnormal flight operations.

It also required that copies of amendments to the manual be distributed to CASA and to all of the operator's training and checking pilots.

1.17.1.4 Aviation Safety Surveillance Program (ASSP)

The surveillance procedures of CASA's surveillance program were outlined in the ASSP Manual that was approved by CASA's Assistant Director, Compliance. CASA reported that it began to implement modifications to the ASSP system in mid-1999 to transform it to a systems-based approach that was centrally planned and monitored. As a result, the Aviation Safety Compliance Division of CASA issued Compliance Management Instructions and Policy Notices to:

> facilitate and standardise CASA's approach to compliance activities during the review of the ASSP manual.

Aviation Safety Compliance Policy Notice 009 – Use of the ASSP Manual – stated that the manual would be extensively reviewed to reflect the change in surveillance focus to a system assessment model. CASA staff were instructed to conduct surveillance activities in accordance with a series of Compliance Management Instructions (CMIs). The use of the ASSP Manual was described CMI 00/07. It referred to the overview of the ASSP, and stated that it was still applicable.

The overview of the ASSP, as published in Version 4.0 of the manual, included the following information:

> ASSP is a surveillance strategy undertaken in a systematic manner to provide an assessment of the aviation industry's safety level and to implement appropriate responses. ASSP is a vital part of CASA's quality management system. The quality approach strongly supports an appropriately developed national surveillance program that should continuously strive to achieve the quality hallmarks of:
>
> - Effectiveness
> - Consistency
> - Efficiency.
>
> Any regulatory body sets its standards by its promulgated regulatory requirements. CASA is a regulatory body and sets the standards for Australian aviation by its regulatory framework – the *Civil Aviation Act 1988*, the *Civil Aviation Regulations* and subordinate legislative documentation.
>
> Compliance with those regulatory requirements achieves a level of aviation safety, but this does not form the complete picture. On the other side of the safety equation, there are non-regulatory factors assessed as risk indicators which in themselves, either individually or collectively, can affect aviation safety.
>
> ASSP enables CASA to plan surveillance in a systematic manner. It enables effective compliance activities to be conducted to determine the level of industry compliance with the regulatory requirements and to record observations on risk indicators. The information obtained from surveillance activities provides an excellent basis to follow up with appropriate corrective action that can range from compliance (education/counselling) to enforcement (administrative action/prosecution).

> The program enables CASA to record, report on, and analyse the information obtained from ASSP activities. Analysis of this information:
>
> - Provides feedback to improve compliance activities
> - Provides feedback to amend the regulatory framework
> - Allows feedback to be provided to the aviation industry
> - Enables CASA to improve enforcement procedures.

CMI 00/07 also included information that CMI 00/08 (Airline Operations) and CMI 00/10 (General Aviation) replaced the:

- National Surveillance Program for 1999/2000;
- Flying Operations Surveillance Guidelines; and
- Flying Operations Surveillance Procedures.

CMI 00/08 was titled “Airline Office Audit Protocols”. It provided general guidance on:

- preparing the office audit plan;
- conducting the audit (including audit methods);
- reporting;
- records;
- follow-up; and
- entry (of details) into the ASSP Support System.

CMI 00/08 did not provide specific guidance on audit elements. The section titled “Audit Methods” included advice that each element of the audit be conducted with the following guidelines in mind:

- identify the current practices (use ‘show me the process’);
- establish that the practices were appropriate;
- establish that the documentation matched the practices;
- review the system for regulatory compliance; and
- identify any immediate safety-significant problems.

CMI 00/08 also reminded CASA personnel to consider if the operator’s staff was appropriately trained/qualified.

1.17.1.5 Surveillance of the operator

The operator was engaged in Regular Public Transport (RPT) operations. The audit methods outlined in the CASA CMI 00/08 should therefore have applied.

CASA advised that formal processes applied for approving amendments to Training and Checking Manuals. CASA’s Director of Aviation Safety had delegated his power under CAR 217 (3) to various CASA field office positions, and those delegates could exercise the power as necessary to approve manuals or changes to manuals. CASA also advised that amendments to Training and Checking Manuals were lodged with the appropriate delegate for approval when an organisation proposed to vary its training and checking procedures. CASA reported that it had not inspected the operator’s Beech 1900D Airliner Training and Checking Manual in the period 1st July 1999 to 13th February 2000 in order to establish that the training and checking practices were in compliance with the training and checking documentation. Additionally, CASA could provide no evidence that it had been advised of or approved the change identified with the 'sidebar' that was incorporated into that manual, on 1 February 2000.

CMI 00/08 did not include specific guidance on the audit elements for an RPT operator. When requested by the ATSB, CASA provided evidence that a CASA delegate had inspected eighteen of the operator's training and checking processes by conducting inflight observation of a number of the operator's check pilots.

The eighteen checks consisted of:

- eight CAR 217 Check Captain - Route Approval Checks;
- three CAR 217 Personnel Inspections - Check Pilots;
- three CAR 217 Personnel - Flight Crew Competency Checks;
- two checks of CAR 217 Personnel to conduct CAO 20.11 Emergency Procedures training;
- one CAR 217 Check Captain - Endorsement Training Approval; and
- one CAR 217 Check Captain - Instrument Rating Renewal / Base Check Approval.

1.17.1.6 Check pilot approval – pilot in command

On 3 December 1999, CASA approved the pilot in command of the occurrence aircraft to conduct flight proficiency tests on the Beech 1900D Airliner. The tests included emergency or abnormal manoeuvres, base checks and instrument rating renewals.

The pilot in command had completed a course of training to conduct flight proficiency tests on the Beech 1900D Airliner. The training was prescribed in the operator's CASA-approved Training and Checking Manual, and included the inflight simulation of engine failure procedures.

A CASA Flight Operations Inspector (FOI) observed a flight test of the pilot that was conducted for the purposes of issuing the pilot with an approval to act as a check pilot. The FOI assessed all aspects of the check as being satisfactory, and that:

> Instrument rating renewal/base check sequences (were) covered, with an emphasis on single engine procedures.

1.17.2 Operator

The operator conducted a regular public transport service and was required to provide a training and checking organisation in accordance with CAR 217 (1). CASA approved the training and checking organisation and the tests and checks it provided, which were specified in the operator's Training and Checking Manual.

The operator reported to the ATSB that its check pilots regularly used the technique of introducing a simulated engine failure by selecting that engine's power lever to 'FLIGHT IDLE'. That procedure had been in constant use since the introduction of the Beech 1900D Airliner to the operator's fleet in April 1992. The operator reported that:

> The coincidental failure of an engine and the autofeather system during take-off presents the operating crew with an emergency situation which must be actioned decisively and accurately. Failure to do so could result in either the feathering of the propeller on the live engine or the failure to achieve guaranteed performance and, therefore, obstacle clearance.

> To simulate the failure of an engine and its autofeather system it was the practice of check pilots to retard the power lever to the IDLE position. When the correct action had been taken the check pilot would advance the power lever to the zero thrust position simulating the reduction in drag as the propeller was feathered.

The operator also reported that:

> The pilot in command (of the occurrence flight) was familiar with this procedure and had used it regularly during the conduct of checks. The use of the procedure on the occurrence flight was not a one off event which was carried out by one check pilot.

That procedure was contrary to the manufacturer's prescribed procedure of setting zero thrust for the simulation of one-engine inoperative that was contained in the Beech 1900D Airliner AFM and Pilot's Operating Manual. It was also contrary to the procedure specified in the operator's CASA-approved Training and Checking Manual.

The aircraft manufacturer reported that moving the power lever to the 'FLIGHT IDLE' position disabled the auto-feather system. Accordingly, the procedure used by the operator's training and checking pilots to simulate one-engine inoperative resulted in the simulation of simultaneous failures of both the engine and its auto-feather system. That was also contrary to the provisions of the operator's CASA-approved Training and Checking Manual. The manual specified that inflight simulation of failures was limited at any time to the simulation of failure of one item of equipment or system.

CASA advised the ATSB that a power lever reduction below an 80 per cent to 85 per cent torque setting would normally disarm the auto-feather system, which was a desirable situation for both normal flight and for simulation of engine failure in training. Auto-feather operation was be simulated in one-engine inoperative training by not reducing torque below the zero thrust setting.

1.17.2.1 Operator's Training and Checking Manual

The operator's CASA-approved Training and Checking Manual detailed the policies and procedures to enable the operator's personnel and contractors to carry out their assigned training, examining, checking and testing duties.

Compliance with the policies and procedures specified in the manual was mandatory for the operator's personnel and its contractors. The manual contained information that:

> failure to comply with instructions specified in this manual constitutes a contravention of CAR 215.

The manual stated that the training and checking organisation was required to conduct activities under CAO 82.5 Appendix 2. This specified the training and checking organisation was to be contained within the operator's organisational structure, and that it was responsible to the operator for the standard of flight operations.

The manual contained advice that the prime responsibility of a Check Pilot or Training Pilot was to:

> ensure that an aircraft or its occupants are NEVER placed in a hazardous situation.

The manual also emphasised that check and training pilots:

> must always be alert to the development of a hazardous situation and must take positive and timely action to prevent the occurrence of a dangerous or irrecoverable situation.

The Manager of Training and Checking was responsible for amendments to the Training and Checking Manual. The manual provided no clear information on how the nature of changes resulting from amendments was to be identified. Section 1–5 of the manual contained a list of recipients of the manual, and included advice that the recipients were responsible for the security and safekeeping of individually issued copies of the manual. The manual contained no instructions, however, about the recipients' responsibility to incorporate amendments into their copies. CASA was included in the distribution list as the recipient of one copy of the manual.

Sections 3 and 4 of the manual provided information relating to the initial ground and air training of flight crew, which included endorsement training on the Beech 1900D Airliner. A syllabus of ground training was provided in Section 3, and included training in handling and performance. A syllabus of training for asymmetric operations was provided in Section 4. Neither syllabus included information on the provision of training to ensure that a candidate had a full understanding of the principles involved in, and the factors affecting, critical/minimum control and safety speeds, specifically, V_{MCA}, V_2 and V_{SSE} for the Beech 1900D Airliner.

Section 16-12 of the Training and Checking Manual contained information on the simulation of engine failure. It stated that:

> The approved method of simulating an engine failure is by retarding the appropriate power lever to the zero thrust position.

The section also contained the following:

> Caution: Retarding a power level beyond the zero thrust setting to simulate engine failure is likely to reduce aircraft climb performance and increase V_{MCA} above the airspeed promulgated in the AFM.

The section provided no information on the factors affecting, critical/minimum control and safety speeds for the Beech 1900D Airliner. It made no reference to V_{MCA}, V_2 and V_{SSE}. Nor did it provide information that simulated one-engine inoperative conditions were to be achieved by retarding one engine power lever to the zero thrust setting at or above the V_{SSE} speed of 105 KIAS.

Amendment 3 of the Training and Checking Manual was issued on 1 February, 12 days before the occurrence. It replaced amendment 2, which was issued in August 1997. Section 1-4 of the manual contained the Amendment Record. It included information that the issue of amendment 3 had affected various sections of the manual, but it contained no advice on how to identify changes made by amendment. Section 1–7 of the manual contained the List of Effective pages. It included advice that all pages comprising amendment 3 of the manual were issued on 1 February 2000. Examination of amendment 3 revealed that Section 16–12 contained a 'sidebar' that suggested a change from the previous issue. That section contained information on simulation of engine failure. The paragraph to which the 'sidebar' related stated:

> The zero thrust for the particular aircraft can be determined in the AFM (B1900 is 200 FT/LB @ 1700/1550 RPM)

The manual also contained information that inflight simulation of failures was limited at any time to the simulation of failure of one item of equipment or system. It included advice that:

> The risk factor associated with training exercises involving simulated failures is increased when the simulation involves multiple failures.

The manual did not contain any information about training power settings to be used to simulate one-engine inoperative flight at maximum all-up weight when the aircraft was being operated at less than 90 per cent of the maximum all-up weight.

1.17.2.2 Operator's flight tolerances for flight exercises/tests/checks

The operator's Training and Checking Manual contained information on flight within specified tolerances, and included advice that the tolerances were necessary to judge the proficiency of candidates. It also stated that no sustained errors in excess of the tolerances specified were permitted.

The asymmetric (one-engine inoperative) tolerances were specified as:

- Heading (from datum heading) ±20 degrees initially, then ±5 degrees;
- Indicated airspeed
  initial climb: nominated one engine inoperative climb speeds +5, -0 knots
  subsequent operations: ±10 knots;
- Height ±100 feet
  at minimum altitudes: +100 feet and -0 feet
- Angle of Bank
  initial climb: as specified in the approved Flight Manual ±2 degrees.

1.17.2.3 Operator's Beech 1900D Airliner training and checking

Those pilots who held authority to act as a check pilot for the operator conducted the operator's Beech 1900D Airliner training and checking program. Twelve check pilots were approved by CASA under a CASA instrument of delegation to conduct training and flight-tests under CAR requirements. The approval was limited to training and flight tests for pilots employed by the operator and who needed ratings or endorsements for that employment.

The operator's CASA-approved Training and Checking Manual specified checks and tests to examine a candidate's competence to conduct various operations on the Beech 1900D Airliner. The purpose of a Base Check was to ensure that a candidate displayed ability to handle an aircraft during normal and emergency operation. The pilot in command of the occurrence aircraft was approved by CASA to conduct base checks.

1.17.2.4 Maintenance action following the occurrence

Following the occurrence, the pilot in command made an entry in the aircraft's technical log, noting that the left propeller produced excessive drag at 'FLIGHT IDLE', and that the aircraft was uncontrollable when operating with power from the right engine only. The operator reported that its maintenance organisation carried out checks on the aircraft in accordance with the Beech 1900D Airliner Maintenance Manual.

The checks did not reveal any defects in the engines or the propellers that may have been a significant factor in the occurrence.

An engine failure was then simulated by placing the auto-feather switch to 'ARM', increasing both power levers to take-off power of 3,800 ft-lbs torque, then placing the left engine condition lever to the fuel cut-off position. The left engine feathered normally. The maintenance engineer who conducted the check noted that the reported fault could not be reproduced on the ground, and cleared the defect from the aircraft's technical log.

Before further flight, another engineer looked into the defect, and after swapping the left and right propeller governors, determined that the right propeller governor (as originally fitted to the left engine) was faulty. A new governor was then fitted to the right engine. It was rigged and engine ground runs conducted in accordance with the Pratt & Whitney PT6A-67 and Beech 1900D Airliner Maintenance Manuals. No defects were noted, and the aircraft was released for further service.

An inspection of the defective propeller governor revealed that the main parameters of the governor assembly were within service limits. A bench test of the governor determined that the maximum RPM permitted by the governor was slightly high and the air reset bleed rate was low. The maintenance organisation that conducted the inspection noted that these discrepancies would not affect normal operation of the governor. A bulk strip of the governor revealed rough flyweight pivot bearings and a worn reset post roller pin.

1.18 Additional information

1.18.1 Bureau of Air Safety Investigation – Report 9503057

On 16 September 1995, a Fairchild SA227-AC Metro III, VH-NEJ, was destroyed when it crashed shortly after takeoff at Tamworth. The flight was under the command of a check-and-training pilot, who was conducting a type-conversion training flight for the co-pilot. Four seconds after the aircraft became airborne, the check-and-training pilot retarded the left engine power lever to flight-idle. The landing gear was selected up 11 seconds later. After a further 20 seconds, the aircraft struck the crown of a tree and then the ground about 350 m beyond the end of the runway and 250 m left of the extended centreline. It caught fire and was destroyed. The co-pilot and another trainee on board were killed while the check-and-training pilot received serious injuries.

As part of the investigation into the occurrence, the then Bureau of Air Safety Investigation (BASI) sought assistance from a qualified test pilot to examine the effects of simulating an engine failure by retarding the power lever to 'FLIGHT IDLE'. The test pilot reported:

> Overall, it seems there is little if any difference in the drag produced when a propeller is windmilling in the NTS (negative torque sensing) mode and when it is feathered. Furthermore, it is clear that in all published data dealing with OEI (one-engine inoperative) performance, no allowance or consideration has been made for the engine operating at flight idle.
>
> Simulating engine failure by retarding a power lever to flight idle is therefore unrepresentative of any practical emergency. Moreover, the consequences in terms of further degraded performance and the potential for larger control displacement to counter the greater asymmetry, are serious. The practice is unwarranted and should be discouraged.

The test pilot also reported that flight tests conducted on two separate Fairchild SA227-AC Metro III aircraft demonstrated that measured climb performance with the propeller feathered was found to be very close to Flight Manual predictions, and that:

> the OEI tests show that the rate of climb with the 'failed' engine at flight idle and the gear up, is extremely marginal at best.

The BASI Investigation Report noted that torque setting of less than that equivalent to zero thrust on a ‘failed’ engine would reduce the Metro III climb performance below the AFM one-engine-inoperative climb data. BASI issued several recommendations, including IR960035, that contained a recommendation that the CASA review endorsement-training requirements in aircraft above 5,700 kg maximum take-off weight where a flight simulator was not available. CASA responded that it had no power to mandate the use of flight simulators, but that it encouraged the use of an approved type simulator for the conduct of endorsement training.

At the time of the occurrence involving VH-NTL there were no Beech 1900D Airliner flight simulators in Australia, and the operator was conducting its endorsement training on a flight simulator located in the United States.

A further recommendation, IR960098, was also issued as a result of the accident involving VH-NEJ. It concerned the use of ‘FLIGHT IDLE’ to simulate engine failure in practice situations on Garrett-powered aircraft. CASA agreed with the recommendation, and advised that all District Offices had been asked to bring the recommendation to the attention of Chief Pilots responsible for the operation of Garrett-powered aircraft.

1.18.2 Simulation of one-engine inoperative on other turbo-propeller aircraft

Manufacturers’ information on the approved technique to simulate one-engine inoperative on turbo-propeller aircraft differed from type to type. Some manufacturers provided specific guidance in their flight and operations manuals, while others do not.

The Rockwell Aero-Commander 690B FAA-approved Airplane Flight Manual contained a definition for V_{SSE}, and noted that inflight engine cuts below 95 KIAS were prohibited. The manual contained information on simulation of one-engine inoperative for pilot training. It warned that use of ‘FLIGHT IDLE’ power to simulate a failed engine would result in significant asymmetric drag and a minimum controllable flight speed of about 110 KIAS. The warning stated that:

> demonstrations of this type must not be made below this speed.

The Embraer EMB-110 Bandierante Pilot’s Operating Handbook contained information on the power setting needed to simulate one-engine inoperative. It noted that engine malfunctions could be simulated for training pilots in manoeuvres and familiarising them with the single-engine characteristics of the aircraft. The recommended power setting for one-engine inoperative was to retard the power lever on the ‘failed’ engine to 150 lb-ft of torque, with the propeller set to 2,200 RPM.

An operator of de Havilland Canada DHC-6 Twin Otter Series 300 aircraft advised the ATSB that the manufacturer’s flight and operating data manuals did not contain information on one-engine inoperative training or zero thrust settings. The operator instructed its check pilots to set a ‘nominal power’ to simulate minimum drag following the correct engine shutdown procedure. Minimum airspeed and height limitations were also imposed to ensure the safety of the aircraft during training flights, and simulated engine failures were not permitted below 80 KIAS or 100 ft AGL.

An operator of Boeing Canada, de Havilland Division DHC-8 (Dash 8) aircraft advised the ATSB that the manufacturer’s flight and operating data manuals did not contain information on one-engine inoperative training or zero thrust settings. However, the operator provided specific instructions in its Dash 8 Training Manual for the simulation of one-engine inoperative. These stated:

> When conducting simulated asymmetric operations in the aircraft, the power on the failed engine will be set to achieve zero thrust. This corresponds to 15 per cent torque and will result in the power lever being slightly advanced.

Another Dash 8 operator provided similar information. Its one-engine inoperative training procedures specified that simulation of one-engine inoperative be accomplished by reducing power on the 'failed' engine to 15 per cent torque.

The Performance Section of the Saab SF340 Airplane Flight Manual defined V_{MCA} as the minimum speed in flight in the take-off configuration at which the aircraft is controllable. It also included information that the speed was dependent on the aircraft having a maximum of five degrees bank angle, when one engine was suddenly made inoperative with the propeller either auto-coarsened, and the other at take-off power. The manual did not include advice that the five degrees bank angle was to be applied towards the operative engine.

Section 25/12 of the Saab SF 340A Aircraft Operations Manual contained information on Flight Procedures Training. The procedure for simulated engine failure, issued on 30 November 1996, included the following advice:

> Simulate engine failure by retarding PL to 10-20 per cent TRQ. Below 120 KIAS the drag obtained will be approximately comparable to a coarsened or feathered propeller. Retarding PL to FLT IDLE gives a drag which is less than an uncoarsened wind-milling propeller.

On 15 October 1999, the manufacturer issued revised information on the procedure for simulated engine failure, as follows:

> Simulate engine failure by retarding PL to 10-20 per cent TRQ. Below 120 KIAS the drag obtained will be approximately comparable to a coarsened or feathered propeller. Retarding PL to FLT IDLE gives a drag which is higher than an uncoarsened wind-milling propeller.

A Saab 340 operator reported that its Training and Checking Manual contained advice on the Simulation of Engine Failure as follows:

> In turboprop aircraft, it is essential that the power lever is positioned forward of flight idle to prevent a negative thrust problem creating control difficulties.

1.19 New investigation techniques

Not a factor in this occurrence.

2. ANALYSIS

2.1 Introduction

The ATSB investigation established that a failure to achieve predicted aircraft performance and loss of controllability occurred during takeoff and subsequent climb in simulated one-engine inoperative conditions. During the ensuing flight at a higher altitude, one-engine inoperative conditions were again simulated and involved a further failure to achieve predicted aircraft performance and loss of controllability.

The failure to achieve predicted aircraft performance arose from a lack of adherence to the manufacturer's procedure for the simulation of one-engine inoperative events, and from the manner in which the aircraft was handled following those simulations.

The analysis examines the interrelation of those events, and how they resulted in a potentially hazardous and serious incident[2].

2.2 Aircraft serviceability

The post-flight maintenance inspection of the aircraft did not reveal any defects in the engines or the propellers that may have been a significant factor in the occurrence.

There was no evidence that the performance degradation during the take off and upper air sequences was due to the left propeller blades having been at less than the flight-idle blade position. The data plots for the occurrence sequences displayed no evidence of intermittent increases in the left engine propeller RPM, accompanied by corresponding decreases in engine torque to indicate that the left propeller had entered the ground-idle range during flight. The momentary increase in torque that occurred about 38 seconds after the failure during the upper air sequence was consistent with the left power lever having been advanced. The responses of the engine and its propeller were a logical consequence of the power lever being advanced, and not as a result of any propeller malfunction. The reason for the advancement of the power lever was not able to be determined.

2.3 Take-off sequence

During the take-off sequence, the aircraft speed deteriorated rapidly after 'FLIGHT IDLE' was set on the left engine to simulate one-engine inoperative conditions, and the aircraft commenced to yaw to the left. The rapid speed reduction was the likely result of the left propeller blades producing significant drag because the power was set at 'FLIGHT IDLE'. Had the power been reduced to no less than the recommended zero thrust setting, the propeller blades would have windmilled at coarser pitch setting and created less drag than that when the power was set to 'FLIGHT IDLE'.

Significant oscillations of aircraft pitch and vertical acceleration were evident in the flight data recorded during the take-off sequence. There was a time lag between aircraft pitch and control column pitch, however, the lag reduced as airspeed increased. The vertical acceleration data also revealed significant oscillations that were coincident with the oscillations in aircraft pitch. These attitude motions were consistent with aircraft-

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[2] ICAO Annex 13 "*Aircraft Accident and Incident Investigation*". ICAO has defined the gross failure to achieve predicted performance during take-off or initial climb as a serious incident, that is, an incident involving circumstances indicating that an accident nearly occurred.

pilot coupling[3]. The pitch oscillations brought about by the aircraft-pilot coupling and the resultant rapid and continued changes in elevator deflection increased the surface drag of the elevator. That, together with the high drag of the windmilling propeller with the engine being at the 'FLIGHT IDLE' power setting, adversely affected the performance capability of the aircraft.

Although the aircraft airspeed had remained above the published V_{MCA} (92 kt) throughout the take-off sequence, the performance was not consistent with what would be expected had the aircraft been flown in the recommended configuration. The inability of the handling pilot to maintain heading or lateral attitude was evidence that the rudder had became ineffective in maintaining heading. It indicated that the aircraft was probably being operated below V_{MCA} factored for the actual configuration, and that controllability of the aircraft had become marginal. As the speed continued to decrease below the scheduled V_2 speed, climb performance reduced until the aircraft began to descend. Had the handling pilot lost control of the aircraft at this point, it is unlikely there was sufficient height available to effect recovery before the aircraft hit the ground.

The data revealed that controllability of the aircraft was not regained, and climb performance did not improve until the left engine power was advanced to more than the prescribed zero thrust power setting (200 ft-lbs torque).

The CAAP 5.23-1 recommended that an aircraft be loaded to 90 per cent MAUW for asymmetric circuit training. If loading to that weight was not practicable, then a training power setting be used to simulate performance of the aircraft at MAUW. The weight of the aircraft at takeoff was 78 per cent of its performance-limited maximum all-up weight, but there was no reduction made to the take-off power setting to simulate operations at the maximum all-up weight. Consequently, the training exercise was unrepresentative of an actual engine-failure scenario when the aircraft was at MAUW. If the exercise been conducted at the recommended training power setting to simulate one-engine inoperative flight at MAUW, then the aircraft performance would have been further degraded and its controllability even more marginal.

2.4 Upper air sequence

The pilot in command used a similar technique to initiate the simulated engine failure during the upper air sequence by retarding the left engine power lever to the 'FLIGHT IDLE' position. It resulted in similar performance degradation and controllability problems to those experienced by the crew during the take-off sequence. At the onset of this one-engine inoperative sequence, the aircraft was in a left turn at a bank angle of about 34 degrees when the simulated failure was initiated, that is, banking towards the 'critical' engine. The rudder boost system would have activated and assisted the handling pilot's efforts to deflect the rudder towards the operative (right) engine when there was sufficient asymmetry in torque between the left ('inoperative') and right ('operative') engines. The pilot was also likely to have applied right aileron to achieve a wings-level attitude, but never achieved the five degrees bank towards the operative (right) engine as recommended in the AFM. Although rudder was applied towards the operative engine, the combination of left yaw, as evidenced by decreasing heading, coupled with insufficient bank towards the operative engine, was indicative that the

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[3] Aircraft-pilot coupling – an interaction between the pilot and the aircraft that leads to sustained aircraft oscillations that occur over a range of frequencies and amplitudes. The oscillations are unexpected by the pilot. They result from the efforts of the pilot to control the aircraft, and are detrimental to its handling qualities.

aircraft was in a sideslip condition. The inability of the handling pilot to achieve steady-state flight was indicative that the aircraft was probably again operating below V_{MCA} for its actual configuration.

Consequently, the aircraft response was consistent with the left engine being at 'FLIGHT IDLE', the right engine at take-off power, sufficient bank not immediately established towards the right engine, the sideslip, and airspeed decaying below about 114 KIAS (V_2). Those factors probably led to the aircraft experiencing considerable drag. They provide an explanation as to why the aircraft performance was less than expected, and why the aircraft continued to descend.

2.5 Organisational factors

The operator's CASA-approved Training and Checking Manual contained no clear information on how the nature of changes resulting from amendments was to be identified. It was therefore possible that changed information relating to safety-significant matters could be overlooked, which was unsatisfactory from a safety point of view.

The operator's approved method for simulation of one-engine inoperative was by retarding the power lever to the zero thrust setting, and was stated in the operator's CASA-approved Training and Checking Manual. The manual also contained explicit advice that retarding a power lever beyond the zero thrust setting would be likely to reduce climb performance and increase V_{MCA} above the airspeed specified in the FAA-approved Beech 1900D Airliner AFM. The manual did not, however, include specific information to quantify the zero thrust power setting (200 ft-lbs of torque at 1,700 or 1,550 RPM) until the issue of amendment 3 on 1 February 2000.

The manufacturer provided detailed information in the Beech 1900D Airliner AFM about the procedure for simulating one-engine inoperative and specified that zero thrust was the power setting to be used. That procedure correlated with the recommended procedures of a number of other manufacturers of turbo-propeller aircraft for simulating one-engine inoperative on their aircraft.

The manufacturer included additional information about the procedure, and cautioned pilots to maintain directional control with rudder and to use ailerons to maintain five degrees bank towards the operative engine. Pilots were also cautioned that inability to maintain heading or lateral attitude would be evidence of V_{MCA}. That additional advice given by the manufacturer on the procedure for simulating one-engine inoperative provided more comprehensive information than was otherwise generally given by other manufacturers.

Since 1992, however, the routine procedure employed by operator's check pilots to simulate the failure of an engine and its autofeather system was to retard an engine's power lever to the 'FLIGHT IDLE' position. That procedure was therefore contrary to the manufacturer's prescribed procedure and also contrary to the procedure specified in the operator's CASA-approved Training and Checking Manual. Additionally, it resulted in the simulation of simultaneous failures of more than one system or item of equipment, which was also contrary to the provisions of the CASA-approved Training and Checking Manual.

The operator's experience showed that when 'FLIGHT IDLE' was selected to simulate one-engine inoperative, the rate of climb of the Beech 1900D Airliner was about 200 ft/min less than with zero thrust selected. That correlated with the findings of the post-accident one-engine inoperative test flights following the accident of Fairchild

SA227-AC Metro III, VH-NEJ, at Tamworth. The tests demonstrated that the rate of climb was extremely marginal with a 'failed' engine at 'FLIGHT IDLE' and the landing gear up, and that setting 'FLIGHT IDLE' to simulate one-engine inoperative produced more drag than would have occurred with an uncoarsened windmilling propeller at the zero thrust setting.

The operator's training and checking organisation and its check pilots were aware that the likely consequences of simulating an engine failure by retarding its power to less than the recommended zero thrust setting were reduced aircraft climb performance and increased V_{MCA}. They were also aware that risk increased when inflight training exercises involved the simulation of multiple failures. The routine use of a non-compliant procedure to simulate one-engine inoperative by the operator's check pilots was therefore unwarranted.

The prescribed procedures were necessary defences[4] to minimise those risks. The routine disregard of those defences significantly increased the risks associated with the operator's training and checking procedures, and was therefore a safety-significant concern.

CASA conducted 18 inspections of the operator's CAR 217 training and checking personnel in the period July 2000 until the time of the occurrence. Eight of those inspections (44.4 per cent) involved the observation by a CASA delegate of inflight endorsement training or base training exercises, a number of which involved the simulation of one-engine inoperative conditions. The CASA surveillance and audit of the operator did not, however, detect the non-compliant procedures used by the operator's check pilots to simulate one-engine inoperative during those inflight training exercises. Additionally, CASA did not conduct any formal audit of the operator's CASA-approved Training and Checking Manual during that period. CASA audits of the operator's B1900D Airliner operations, if conducted under CMI 00/08, should have established that:

- one-engine inoperative was being simulated by setting 'FLIGHT IDLE', contrary to the provisions of the AFM and the CASA-approved Training and Checking Manual and was therefore an inappropriate procedure;
- the procedure was not in compliance with the AFM and CASA-approved Training and Checking Manual because it did not match the documented procedure; and
- aircraft performance was compromised as a result of the incorrect procedures, and it had the potential to be a safety-significant problem.

The investigation was unable to determine why the CASA audit and surveillance of the operator did not detect the use of the inappropriate and non-compliant procedure.

The practice of setting 'FLIGHT IDLE' to simulate one-engine inoperative significantly increased the risk of degraded aircraft performance. The practice also resulted in the simulation of simultaneous failures, and unnecessarily increased the risk of inflight training exercises. Those increased risks had the potential to increase the hazard of unintended flight into terrain, and the consequent loss of life and/or damage to property and the environment.

This occurrence demonstrated the potentially serious consequences of degraded aircraft performance by setting 'FLIGHT IDLE' to simulate one-engine inoperative. The practice has the potential to jeopardise the safety of flight, and should be strongly discouraged.

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[4] Reason, J. *Managing the Risks of Organizational Accidents*, 1997, ISBN 1 84014 105 0

3. CONCLUSIONS

3.1 Findings

Aircraft

1. There was no evidence of any aircraft or systems malfunctions that contributed to the controllability problems experienced by the crew.

Flight crew

1. The crew was appropriately qualified to fly the Beech 1900D Airliner.
2. The pilot in command was a CASA-approved check pilot on the Beech 1900D Airliner.
3. The pilot in command reduced power on the left engine to 'FLIGHT IDLE' instead of zero thrust to simulate an engine failure event, both shortly after takeoff and again at altitude.
4. The pilot in command placed the aircraft in a potentially hazardous situation by using an incorrect procedure to simulate one-engine inoperative events.
5. The pilot in command did not comply with the instructions contained in the FAA-approved Airplane Flight Manual or the CASA-approved Training and Checking Manual relating to the power settings for simulation of one-engine inoperative events.
6. By reducing the power lever to 'FLIGHT IDLE', the pilot in command also simulated a failure of the auto-feather system.
7. A combination of 3 and 6 above had the effect of introducing two failures simultaneously, that is, failure of the left engine and failure of the left engine auto-feather system.
8. The pilot in command did not comply with the instructions contained in the CASA-approved Training and Checking Manual regarding the limitations on simulation of simultaneous inflight failures, and therefore increased the risk factor associated with the training exercise.
9. The handling pilot exceeded the permitted flight tolerances for flight exercises, tests and checks.
10. The pilot in command did not ensure that the permitted one-engine inoperative flight tolerances were regained.
11. The handling pilot's larger than necessary elevator control inputs during the take-off sequence contributed to the degradation of aircraft performance.
12. The handling pilot maintained less than the recommended five degrees angle of bank towards the operative (right) engine during both simulated one-engine inoperative sequences.
13. The performance of the aircraft was adversely affected during both one-engine inoperative simulations because an appropriate bank angle was not maintained towards the operative engine.

14. The handling pilot allowed the aircraft speed to reduce below the scheduled V_2 speed during both simulated one-engine inoperative sequences.
15. The pilot in command did not act in a positive or timely manner to regain the V_2 speed.

Company documentation and procedures

1. The Airplane Flight Manual contained instructions that Simulation of One-Engine Inoperative was to be accomplished by setting engine power to zero thrust.
2. The Airplane Flight Manual defined the zero thrust power setting as 200 ft-lbs torque.
3. The operator's training and checking pilots did not comply with the instructions contained in the Airplane Flight Manual relating to the simulation of one-engine inoperative.
4. The operator's CASA-approved Training and Checking Manual contained no clear information on how the nature of changes resulting from amendments was to be identified.
5. The operator's CASA-approved Training and Checking Manual contained no information on training power settings to simulate one-engine inoperative flight when an aircraft was operated at less than 90 per cent of its maximum all-up weight.
6. The operator's CASA-approved Training and Checking Manual contained information on the approved method of Simulation of Engine Failure, including advice that zero thrust of 200 ft-lbs torque at 1700/1550 RPM was the required power setting.
7. The operator's training and checking pilots did not comply with the instructions contained in the CASA-approved Training and Checking Manual relating to the simulation of one-engine inoperative.
8. The CASA-approved Training and Checking Manual contained information that inflight simulation of failures was limited at any time to one item of equipment or system, and that the risk factor associated with training exercises increased with simulation of multiple failures
9. The operator's check pilots did not comply with the instructions contained in the CASA-approved Training and Checking Manual relating to the limits for inflight simulation of failures.
10. The operator's check pilots accepted an unnecessarily high risk through the simulation of multiple failures during inflight training exercises.

Regulatory authority

1. CASA surveillance and audit of the operator did not detect the use of an incorrect method of simulating one-engine inoperative flight or the simulation of simultaneous failures of more than one item of equipment or system, contrary to the provisions of the operator's CASA-approved Training and Checking Manual and the FAA-approved Airplane Flight Manual.
2. As a result of 1 above, CASA audit of the operator did not reveal that the practice represented a potentially hazardous safety-significant problem.

3.2 Significant factors

1. An incorrect method was used to simulate one-engine inoperative flight.
2. An inappropriate handling technique was applied following the simulation of one-engine inoperative flight.
3. The aircraft airspeed was permitted to deteriorate below the scheduled V_2 speed.

4. SAFETY ACTION

4.1 Recommendations

4.1.1 R20010072

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority publish information for the guidance of operators and pilots regarding the correct procedures for simulating engine failures in turbo-propeller aircraft.

4.2 Safety action

As a result of this investigation, the following safety actions were initiated:

4.2.1 Civil Aviation Safety Authority

CASA advised that the Authority will issue an amendment to Civil Aviation Advisory Publication (CAAP) 5.23-1(0).

The amendment will highlight appropriate engine-out training procedures, and include a recommendation that engine-out performance in turbo-propeller aeroplanes be simulated by the use of an appropriate torque setting, rather than loading the aircraft to 90 per cent of MAUW as presently recommended.

To support this amendment, CASA's Aviation Safety Compliance Division, as part of scheduled surveillance, will ensure that operator's manuals contain appropriate procedures for the conduct of multi-engine training, and that targeted surveillance is performed on operators of turbo-propeller aeroplanes conducting multi-engine training.

To highlight this important safety initiative to the aviation industry, CASA will draw attention to appropriate engine-out training procedures during forthcoming safety promotion activities.

4.2.2 Operator

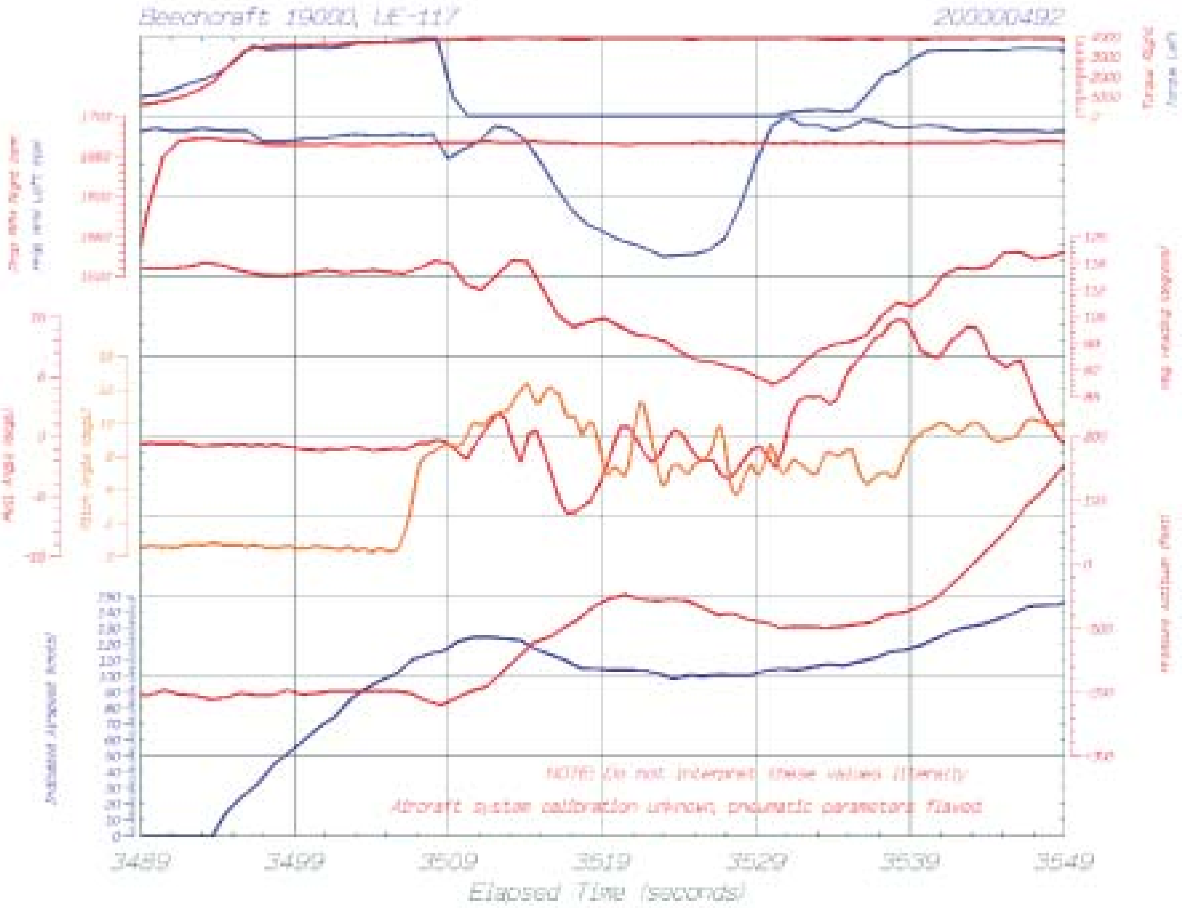
The operator advised that it had issued instructions to its check pilots, titled 'New simulated engine failure procedures.' These stated:

> Check pilots are warned regarding the possibility of a propeller malfunctioning during the simulation of engine failure, with the result that directional control maybe severely degraded.
>
> Until the results of the investigation of a recent incident are available, simulated engine failure of an engine on take-off shall not be carried out until the aircraft has reached 250 feet above ground level and is above the level of obstacles adjacent to the intended flight path.
>
> The power lever must NOT be retarded below the zero thrust torque setting.
>
> At the first indication of any controllability problems power is to be restored to the engine.

Additionally, the operator requested that the ATSB provide it with a video of the ATSB Recovery and Presentation System animation of the occurrence sequence that was compiled from the recorded flight data. The operator intended to use, and has used, the video as a training aid for its Beech 1900D Airliner flight crews.

ATTACHMENTS

Attachement A – Take-off sequence SSFDR data plots for VH-NTL



Attachment B – Occurrence flight take-off sequence

Elapsed Time	Torque Left	Torque Right	RPM Left	RPM Right	Altitude (AGL)	Vertical Speed	Recorded KIAS	Corrected KIAS #	Pitch (avg)	Heading	Yaw Rate	Roll Ø	Roll Rate	VMCA ##	Margin >VMCA
1	33	3924	1688	1669	7		125	132	+ 10.3 °	111.7		1.0 left		110.0	22.00
2	35	3920	1685	1668	29	1320 fpm	124	131	+ 11.0 °	115.2	3.5 °/sec	2.5 left	1.5 °/sec	114.5	16.50
3	32	3948	1671	1668	53	1440 fpm	123	130	+ 12.3 °	119.1	3.9 °/sec	2.0 right	4.5 °/sec	101.0	29.00
4	37	3944	1643	1669	75	1320 fpm	117	124	+ 12.0 °	118.8	0.3 °/sec	0.5 left	2.5 °/sec	108.5	15.50
5	37	3920	1612	1668	84	540 fpm	113	120	+ 12.5 °	111.8	7.0 °/sec	3.5 left	3.0 °/sec	117.5	2.50
6	37	3907	1584	1668	99	900 fpm	110	117	+ 11.0 °	105.3	6.5 °/sec	9.0 left	5.5 °/sec	134.0	-17.00
7	33	3899	1566	1666	114	900 fpm	105	112	+ 9.8 °	102.4	2.9 °/sec	9.5 left	0.5 °/sec	135.5	-23.50
8	35	3916	1557	1666	134	1200 fpm	104	111	+ 9.3 °	103.7	1.3 °/sec	7.0 left	2.5 °/sec	128.0	-17.00
9	33	3936	1547	1666	145	660 fpm	104	111	+ 6.5 °	104.6	0.9 °/sec	2.5 left	4.5 °/sec	114.5	-3.50
10	35	3928	1541	1665	150	300 fpm	104	111	+ 6.8 °	102.6	2.0 °/sec	1.0 right	3.5 °/sec	104.0	7.00
11	35	3924	1534	1666	143	-420 fpm	104	111	+ 10.8 °	100.6	2.0 °/sec	1.0 left	2.0 °/sec	110.0	1.00
12	36	3928	1525	1666	141	-120 fpm	102	109	+ 7.0 °	100.0	0.6 °/sec	2.5 left	1.5 °/sec	114.5	-5.50
13	35	3912	1527	1666	143	120 fpm	99	106	+ 6.8 °	98.7	1.3 °/sec	0.5 right	3.0 °/sec	105.5	0.50
14	36	3887	1528	1666	141	-120 fpm	100	107	+ 6.5 °	96.0	2.7 °/sec	0.5 left	1.0 °/sec	108.5	-1.50
15	35	3924	1534	1668	129	-720 fpm	100	107	+ 7.3 °	94.0	2.0 °/sec	3.0 left	2.5 °/sec	116.0	-9.00
16	36	3928	1548	1666	119	-600 fpm	101	108	+ 8.8 °	93.6	0.4 °/sec	4.0 left	1.0 °/sec	119.0	-11.00
17	32	3928	1590	1668	121	120 fpm	100	107	+ 5.3 °	92.5	1.1 °/sec	4.5 left	0.5 °/sec	120.5	-13.50
18	36	3916	1643	1666	112	-540 fpm	101	108	+ 6.5 °	91.7	0.8 °/sec	2.5 left	2.0 °/sec	114.5	-6.50
19	46	3932	1688	1668	108	-240 fpm	104	111	+ 7.3 °	89.7	2.0 °/sec	1.5 left	1.0 °/sec	111.5	-0.50
20	39	3932	1701	1666	110	120 fpm	104	111	+ 6.8 °	88.0	1.7 °/sec	3.0 left	1.5 °/sec	116.0	-5.00
21	232	3965	1690	1668	108	-120 fpm	104	111	+ 7.0 °	90.2	2.2 °/sec	3.0 right	6.0 °/sec	98.0	13.00
Average									+ 8.6 °		2.3 °/sec		2.5 °/sec		

see Flight Recorders, paragraph 1.11.1 General

see Training in Multi-Engine Aircraft, paragraph 1.16.1 Minimum Control Speed (VMCA)

Attachment C – Occurrence flight upper air sequence — 1 of 3

Elapsed Time	Torque Left	Torque Right	RPM Left	RPM Right	Altitude (AGL)	Vertical Speed	Recorded KIAS	Corrected KIAS #	Pitch (avg)	Heading	Yaw Rate	Roll Ø	Roll Rate
1	858	848	1687	1675	1994		133	140	+ 1.5 °	26.0		34.0 left	
2	692	814	1688	1675	1978	-960 fpm	134	141	+ 1.0 °	20.8	5.2 °/sec	34.5 left	0.5 °/sec
3	659	773	1688	1675	1970	-480 fpm	133	140	+ 1.0 °	16.2	4.6 °/sec	35.0 left	0.5 °/sec
4	638	773	1688	1675	1966	-240 fpm	132	139	+ 1.0 °	11.7	4.5 °/sec	33.5 left	1.5 °/sec
5	395	517	1682	1677	1949	-1020 fpm	124	131	+ 0.8 °	6.4	5.3 °/sec	30.5 left	3.0 °/sec
6	39	492	1681	1677	1937	-720 fpm	133	140	+ 1.0 °	1.4	5.0 °/sec	29.5 left	1.0 °/sec
7	27	506	1691	1677	1923	-840 fpm	132	139	+ 2.0 °	357.5	3.9 °/sec	27.5 left	2.0 °/sec
8	27	495	1691	1677	1910	-780 fpm	131	138	+ 11.0 °	353.2	4.3 °/sec	22.0 left	5.5 °/sec
9	27	486	1690	1678	1900	-600 fpm	129	136	+ 3.0 °	349.0	4.2 °/sec	16.0 left	6.0 °/sec
10	25	476	1691	1678	1890	-600 fpm	126	133	+ 3.0 °	345.7	3.3 °/sec	12.5 left	3.5 °/sec
11	29	488	1691	1677	1884	-360 fpm	125	132	+ 3.3 °	342.7	3.0 °/sec	10.5 left	2.0 °/sec
12	27	465	1691	1677	1884	0 fpm	123	130	+ 4.0 °	341.4	1.3 °/sec	7.5 left	3.0 °/sec
13	27	454	1690	1678	1878	-360 fpm	121	128	+ 4.0 °	341.2	0.2 °/sec	7.0 left	0.5 °/sec
14	29	452	1691	1677	1874	-240 fpm	119	126	+ 3.3 °	339.9	1.3 °/sec	6.5 left	0.5 °/sec
15	27	575	1681	1677	1870	-240 fpm	116	123	+ 3.0 °	339.0	0.9 °/sec	5.5 left	1.0 °/sec
16	27	1168	1651	1681	1867	-180 fpm	113	120	+ 3.0 °	339.1	0.1 °/sec	5.5 left	0.0 °/sec
17	29	1387	1618	1679	1855	-720 fpm	110	117	+ 2.3 °	335.8	3.3 °/sec	8.5 left	3.0 °/sec
18	27	1652	1599	1675	1843	-720 fpm	107	114	+ 2.0 °	334.7	1.1 °/sec	7.0 left	1.5 °/sec
19	27	2050	1589	1675	1829	-840 fpm	106	113	+ 1.8 °	335.2	0.5 °/sec	3.0 left	4.0 °/sec
20	29	2429	1589	1677	1812	-1020 fpm	107	114	+ 2.0 °	334.1	1.1 °/sec	1.0 left	2.0 °/sec
21	30	2832	1587	1675	1790	-1320 fpm	109	116	+ 1.5 °	332.9	1.2 °/sec	0.5 left	0.5 °/sec
22	29	2981	1587	1675	1769	-1260 fpm	109	116	+ 1.0 °	331.5	1.4 °/sec	0.5 right	1.0 °/sec
23	29	3308	1589	1677	1749	-1200 fpm	109	116	+ 1.0 °	330.7	0.8 °/sec	1.0 right	0.5 °/sec
24	27	3481	1589	1677	1728	-1260 fpm	109	116	+ 1.0 °	330.1	0.6 °/sec	1.0 right	0.0 °/sec
25	29	3514	1587	1677	1705	-1380 fpm	109	116	+ 2.3 °	329.1	1.0 °/sec	1.5 right	0.5 °/sec
26	27	3540	1592	1677	1685	-1200 fpm	110	117	+ 3.0 °	328.7	0.4 °/sec	2.0 right	0.5 °/sec
27	29	3618	1596	1678	1664	-1260 fpm	111	118	+ 3.0 °	328.2	0.5 °/sec	2.0 right	0.0 °/sec
28	27	3629	1597	1677	1648	-960 fpm	111	118	+ 3.0 °	328.0	0.2 °/sec	2.0 right	0.0 °/sec
29	27	3664	1596	1675	1635	-780 fpm	111	118	+ 3.3 °	327.4	0.6 °/sec	3.0 right	1.0 °/sec
30	29	3675	1597	1675	1619	-960 fpm	110	117	+ 3.8 °	326.9	0.5 °/sec	2.0 right	1.0 °/sec
31	27	3683	1596	1675	1608	-660 fpm	110	117	+ 3.0 °	326.3	0.6 °/sec	2.5 right	0.5 °/sec

see Flight Recorders, paragraph 1.11.1 General

Attachment C – Occurrence flight upper air sequence — 2 of 3

Elapsed Time	Torque Left	Torque Right	RPM Left	RPM Right	Altitude (AGL)	Vertical Speed	Recorded KIAS	Corrected KIAS #	Pitch (avg)	Heading	Yaw Rate	Roll Ø	Roll Rate
32	29	3683	1596	1675	1594	-840 fpm	110	117	+ 3.0 °	326.3	0.0 °/sec	1.0 right	1.5 °/sec
33	27	3710	1596	1675	1578	-960 fpm	111	118	+ 3.0 °	325.6	0.7 °/sec	0.5 left	1.5 °/sec
34	29	3706	1594	1675	1565	-780 fpm	111	118	+ 2.0 °	324.8	0.8 °/sec	2.0 left	1.5 °/sec
35	27	3714	1596	1675	1549	-960 fpm	111	118	+ 2.0 °	323.4	1.4 °/sec	2.0 left	0.0 °/sec
36	29	3733	1594	1674	1534	-900 fpm	111	118	+ 2.5 °	322.7	0.7 °/sec	0.5 left	1.5 °/sec
37	29	3718	1596	1675	1518	-960 fpm	111	118	+ 3.0 °	322.7	0.0 °/sec	0.5 right	1.0 °/sec
38	29	3737	1596	1675	1503	-900 fpm	112	119	+ 3.3 °	321.7	1.0 °/sec	1.0 right	0.5 °/sec
39	27	3741	1596	1675	1491	-720 fpm	112	119	+ 4.0 °	320.5	1.2 °/sec	2.0 right	1.0 °/sec
40	30	3752	1596	1675	1477	-840 fpm	112	119	+ 5.0 °	319.6	0.9 °/sec	1.5 right	0.5 °/sec
41	29	3752	1596	1675	1464	-780 fpm	111	118	+ 5.0 °	318.8	0.8 °/sec	0.5 right	1.0 °/sec
42	27	3741	1596	1675	1455	-540 fpm	111	118	+ 5.3 °	318.1	0.7 °/sec	1.0 right	0.5 °/sec
43	27	3745	1594	1677	1449	-360 fpm	110	117	+ 6.0 °	317.1	1.0 °/sec	1.0 right	0.0 °/sec
44	170	3737	1485	1675	1445	-240 fpm	110	117	+ 6.3 °	317.7	0.6 °/sec	3.0 right	2.0 °/sec
45	27	3741	1508	1675	1447	120 fpm	112	119	+ 6.0 °	321.6	3.9 °/sec	1.5 right	1.5 °/sec
46	27	3756	1563	1677	1445	-120 fpm	114	121	+ 6.0 °	318.5	3.1 °/sec	0.5 right	1.0 °/sec
47	29	3752	1560	1675	1445	0 fpm	115	122	+ 7.0 °	317.1	1.4 °/sec	0.5 right	0.0 °/sec
48	27	3772	1551	1675	1445	0 fpm	116	123	+ 6.3 °	320.1	3.0 °/sec	1.5 right	1.0 °/sec
49	27	3764	1574	1675	1449	240 fpm	117	124	+ 6.8 °	319.7	0.4 °/sec	1.0 right	0.5 °/sec
50	29	3768	1590	1675	1453	240 fpm	117	124	+ 7.0 °	318.2	1.5 °/sec	0.0	1.0 °/sec
51	29	3764	1602	1674	1457	240 fpm	117	124	+ 7.3 °	319.1	0.9 °/sec	0.5 right	0.5 °/sec
52	29	3768	1629	1675	1464	420 fpm	117	124	+ 8.0 °	319.6	0.5 °/sec	1.0 right	0.5 °/sec
53	27	3764	1643	1675	1470	360 fpm	117	124	+ 8.0 °	318.1	1.5 °/sec	0.5 right	0.5 °/sec
54	27	3756	1645	1675	1468	-120 fpm	116	123	+ 8.0 °	317.6	0.5 °/sec	0.0	0.5 °/sec
55	36	3756	1645	1675	1486	1080 fpm	114	121	+ 8.0 °	317.7	0.1 °/sec	1.0 left	1.0 °/sec
56	33	3789	1633	1675	1484	-120 fpm	114	121	+ 7.8 °	315.8	1.9 °/sec	2.5 left	1.5 °/sec
57	33	3768	1613	1674	1491	420 fpm	113	120	+ 8.0 °	311.8	4.0 °/sec	2.0 left	0.5 °/sec
58	33	3764	1599	1674	1495	240 fpm	110	117	+ 8.0 °	309.3	2.5 °/sec	0.5 right	2.5 °/sec
59	35	3764	1589	1674	1491	-240 fpm	109	116	+ 9.0 °	308.8	0.5 °/sec	3.5 right	3.0 °/sec
60	35	3772	1580	1675	1503	720 fpm	108	115	+ 9.0 °	308.8	0.0 °/sec	6.0 right	2.5 °/sec
61	35	3764	1573	1675	1507	240 fpm	107	114	+ 10.0 °	308.8	0.0 °/sec	6.5 right	0.5 °/sec
62	33	3768	1564	1674	1511	240 fpm	106	113	+ 9.0 °	308.9	0.1 °/sec	7.0 right	0.5 °/sec
63	33	3793	1557	1674	1516	300 fpm	105	112	+ 9.0 °	309.1	0.2 °/sec	7.0 right	0.0 °/sec

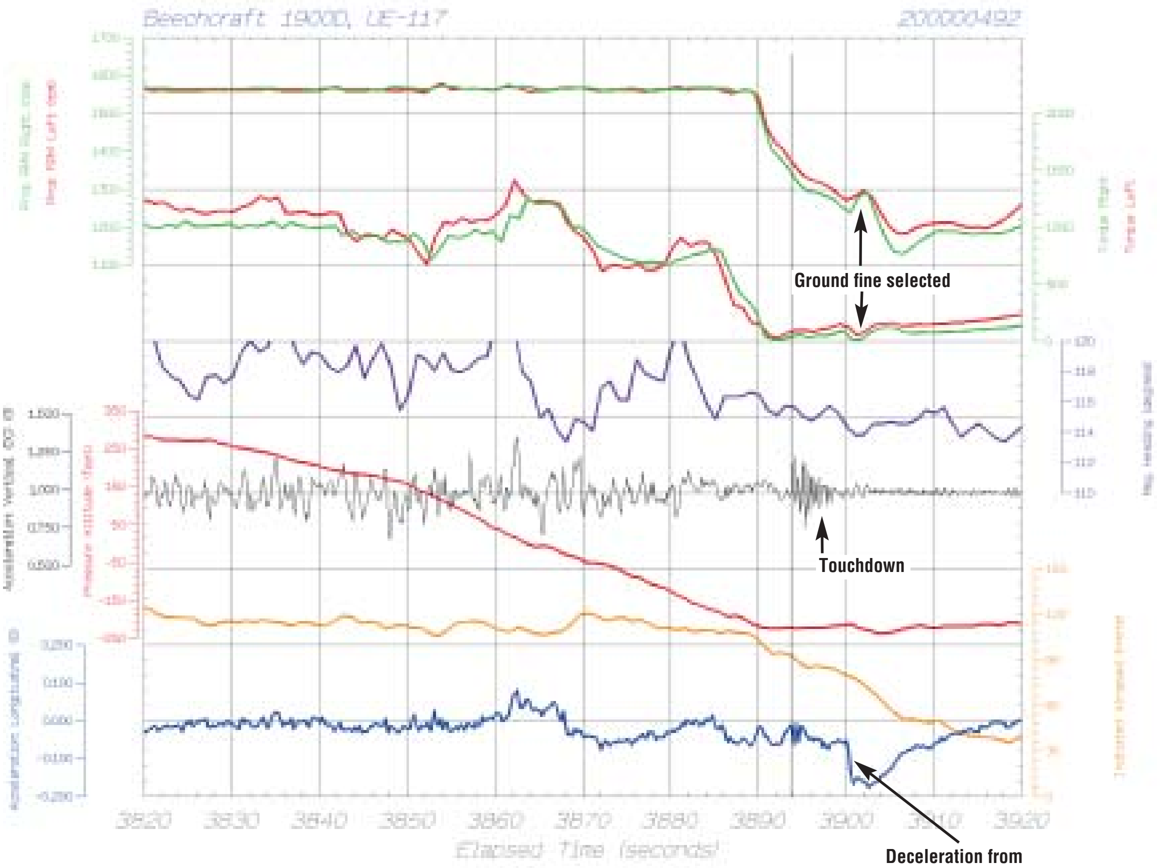
see Flight Recorders, paragraph 1.11.1 General

Attachment C – Occurrence flight upper air sequence — 3 of 3

Elapsed Time	Torque Left	Torque Right	RPM Left	RPM Right	Altitude (AGL)	Vertical Speed	Recorded KIAS	Corrected KIAS #	Pitch (avg)	Heading	Yaw Rate	Roll Ø	Roll Rate
64	32	3801	1554	1672	1522	360 fpm	104	111	+ 8.3 °	308.5	0.6 °/sec	5.5 right	1.5 °/sec
65	35	3805	1609	1672	1520	-120 fpm	101	108	+ 7.5 °	307.9	0.6 °/sec	2.5 right	3.0 °/sec
66	71	3805	1648	1672	1522	120 fpm	100	107	+ 6.3 °	307.4	0.5 °/sec	2.0 right	0.5 °/sec
67	755	3789	1607	1674	1530	480 fpm	102	109	+ 6.0 °	310.1	2.7 °/sec	2.5 right	0.5 °/sec
68	1103	3809	1613	1672	1534	240 fpm	106	113	+ 5.5 °	314.3	4.2 °/sec	1.0 right	1.5 °/sec
69	1874	3813	1607	1672	1534	0 fpm	110	117	+ 5.0 °	313.8	0.5 °/sec	1.0 right	0.0 °/sec
70	2194	3042	1605	1671	1538	240 fpm	113	120	+ 4.5 °	315.0	1.2 °/sec	1.5 right	0.5 °/sec
71	2789	2934	1600	1669	1526	-720 fpm	117	124	+ 4.0 °	315.3	0.3 °/sec	3.0 right	1.5 °/sec
72	2912	2881	1594	1671	1522	-240 fpm	121	128	+ 3.3 °	315.2	0.1 °/sec	2.0 right	1.0 °/sec
Average									+ 4.6 °		1.1 °/sec		0.5 °/sec

see Flight Recorders, paragraph 1.11.1 General

Attachment D – Occurrence flight landing sequence for VH-NTL

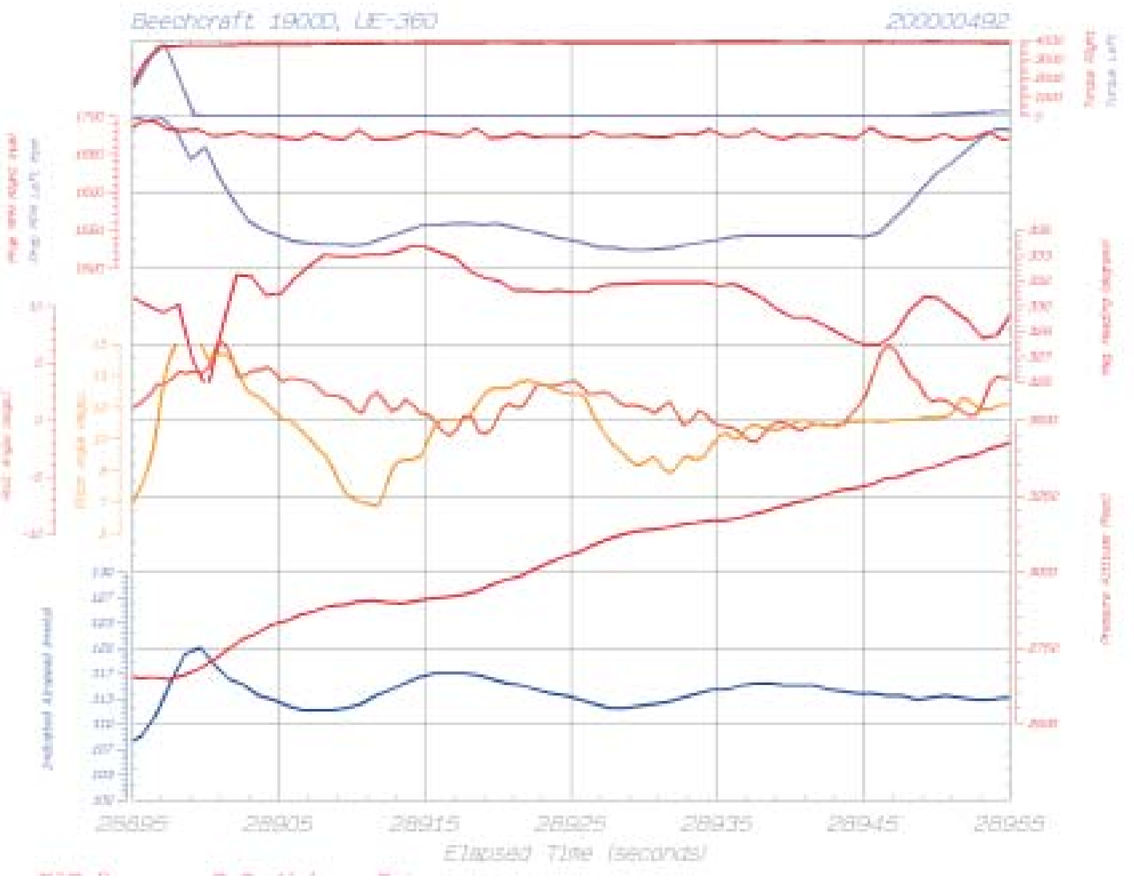


Ground fine selected

Touchdown

Deceleration from propellers at ground fine pitch setting

Attachment E – Test flight sequence SSFDR data plots for VH-FOZ



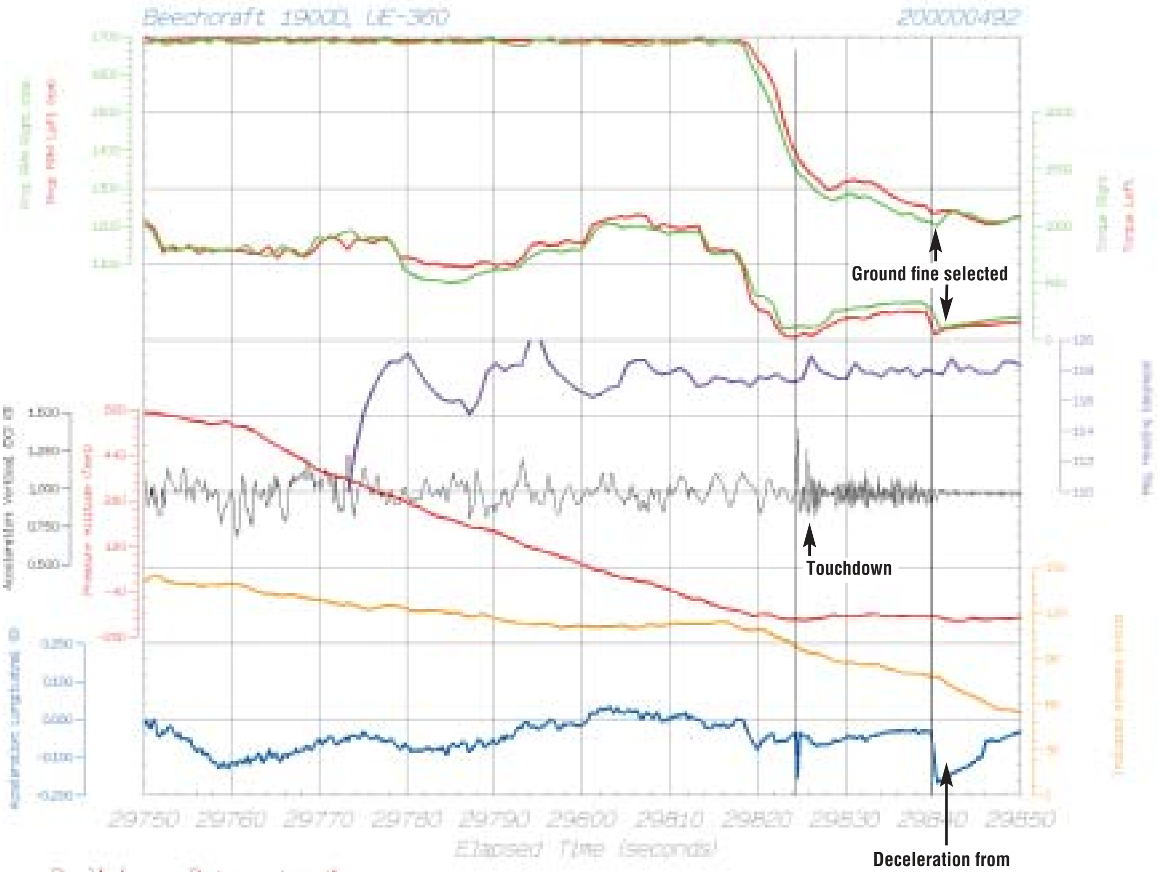
Attachment F – Test flight sequence — 1 of 2

Elapsed Time	Torque Left	Torque Right	RPM Left	RPM Right	Altitude (AGL)	Vertical Speed	Recorded KIAS	Pitch (avg)	Heading	Yaw Rate	Roll Ø	Roll Rate	VMCA ##	Margin >VMCA
0	1688	2730	1700	1692	2650		108	+ 7.5 °	330.5		1.5 right		102.5	5.50
1	3045	3633	1698	1694	2652	120 fpm	111	+ 10.5 °	330.0	-0.5 °/sec	2.5 right	-1.0 °/sec	99.5	11.50
2	3784	3679	1681	1682	2646	-360 fpm	116	+ 14.3 °	329.6	-0.4 °/sec	3.5 right	1.0 °/sec	96.5	19.50
3	1844	3725	1643	1681	2660	840 fpm	119	+ 15.5 °	330.1	-0.5 °/sec	4.0 right	-0.5 °/sec	95.0	24.00
4	45	3729	1659	1682	2680	1200 fpm	120	+ 15.0 °	326.5	3.6 °/sec	4.0 right	0.0 °/sec	95.0	25.00
5	12	3733	1618	1674	2708	1680 fpm	118	+ 14.0 °	324.4	2.1 °/sec	5.5 right	-1.5 °/sec	90.5	27.50
6	12	3769	1587	1675	2744	2160 fpm	116	+ 14.0 °	328.5	-4.1 °/sec	6.5 right	-1.0 °/sec	87.5	28.50
7	13	3772	1561	1679	2778	2040 fpm	115	+ 13.3 °	332.0	3.5 °/sec	4.0 right	-2.5 °/sec	95.0	20.00
8	12	3772	1550	1674	2798	1200 fpm	114	+ 12.0 °	331.9	-0.1 °/sec	4.0 right	0.0 °/sec	95.0	19.00
9	12	3780	1543	1675	2826	1680 fpm	113	+ 11.5 °	330.7	-1.2 °/sec	4.5 right	0.5 °/sec	93.5	19.5
10	12	3789	1535	1671	2838	720 fpm	112	+ 11.0 °	330.8	0.1 °/sec	3.5 right	-1.0 °/sec	96.5	15.50
11	12	3789	1533	1669	2860	1320 fpm	112	+ 10.3 °	331.8	1.0 °/sec	3.5 right	0.0 °/sec	96.5	15.50
12	12	3801	1531	1678	2872	720 fpm	112	+ 9.8 °	332.7	0.9 °/sec	3.0 right	-0.5 °/sec	98.0	14.00
13	12	3813	1531	1671	2888	960 fpm	112	+ 8.5 °	333.4	0.7 °/sec	2.0 right	-1.0 °/sec	101.0	11.00
14	12	3817	1530	1669	2892	240 fpm	112	+ 7.3 °	333.3	-0.1 °/sec	2.0 right	0.0 °/sec	101.0	11.00
15	12	3813	1531	1682	2904	720 fpm	113	+ 7.0 °	333.3	0.0 °/sec	1.0 right	-1.0 °/sec	104.0	9.00
16	12	3821	1538	1669	2906	120 fpm	114	+ 6.8 °	333.4	0.1 °/sec	2.0 right	1.0 °/sec	101.0	13.00
17	12	3838	1544	1669	2898	-480 fpm	115	+ 8.0 °	333.6	0.2 °/sec	1.5 left	-3.5 °/sec	111.5	3.50
18	13	3842	1551	1672	2896	1551 fpm	115	+ 9.0 °	333.6	0.0 °/sec	1.5 left	0.0 °/sec	111.5	3.5
19	12	3850	1557	1679	2906	600 fpm	116	+ 9.0 °	334.0	0.4 °/sec	1.0 right	2.5 °/sec	104.0	12.00
20	12	3854	1557	1678	2912	360 fpm	117	+ 10.5 °	333.9	-0.1 °/sec	0	-1.0 °/sec	107.0	10.00
21	13	3871	1558	1675	2918	360 fpm	117	+ 11.0 °	333.5	-0.4 °/sec	1.0 left	-1.0 °/sec	110.0	7.00
22	13	3862	1558	1674	2924	360 fpm	117	+ 11.0 °	333.2	-0.3 °/sec	0.5 left	0.5 °/sec	108.5	8.50
23	12	3862	1557	1684	2936	720 fpm	116	+ 11.8 °	332.3	-0.9 °/sec	0.5 left	0.0 °/sec	108.5	7.50
24	12	3875	1558	1671	2956	1200 fpm	116	+ 12.8 °	331.8	-0.5 °/sec	1.0 left	-0.5 °/sec	110.0	6.00
25	13	3875	1554	1672	2974	1080 fpm	115	+ 13.0 °	331.6	-0.2 °/sec	1.0 right	2.0 °/sec	104.0	11.00
26	13	3871	1550	1678	2984	600 fpm	115	+ 13.0 °	331.0	-0.6 °/sec	1.0 right	0.0 °/sec	104.0	11.00
27	12	3871	1545	1672	3010	1560 fpm	115	+ 13.0 °	331.0	0.0 °/sec	2.5 right	1.5 °/sec	99.5	15.50
28	13	3875	1540	1674	3030	1200 fpm	114	+ 13.0 °	330.9	-0.1 °/sec	3.0 right	0.5 °/sec	98.0	16.00
29	12	3866	1537	1674	3050	1200 fpm	114	+ 12.3 °	331.0	0.1 °/sec	3.0 right	0.0 °/sec	98.0	16.00
30	12	3866	1533	1672	3064	840 fpm	113	+ 12.0 °	330.9	-0.1 °/sec	3.0 right	0.0 °/sec	98.0	15.00

Attachment F – Test flight sequence — 2 of 2

Elapsed Time	Torque Left	Torque Right	RPM Left	RPM Right	Altitude (AGL)	Vertical Speed	Recorded KIAS	Pitch (avg)	Heading	Yaw Rate	Roll Ø	Roll Rate	VMCA ##	Margin >VMCA
31	12	3871	1527	1679	3089	1500 fpm	113	+ 11.3 °	330.9	0.0 °/sec	2.0 right	-1.0 °/sec	101.0	12.00
32	12	3866	1527	1674	3107	1080 fpm	112	+ 10.0 °	331.3	0.4 °/sec	2.5 right	0.5 °/sec	99.5	12.50
33	13	3866	1524	1674	3123	960 fpm	112	+ 9.3 °	331.4	0.1 °/sec	1.5 right	-1.0 °/sec	102.5	9.50
34	13	3866	1524	1675	3135	720 fpm	112	+ 9.0 °	331.4	0.0 °/sec	1.0 right	-0.5 °/sec	104.0	8.00
35	12	3871	1525	1672	3139	240 fpm	113	+ 9.0 °	331.5	0.1 °/sec	1.0 right	0.0 °/sec	104.0	9.00
36	12	3871	1527	1672	3145	360 fpm	113	+ 8.3 °	331.5	0.0 °/sec	1.5 right	0.5 °/sec	102.5	10.50
37	12	3879	1531	1677	3155	600 fpm	113	+ 8.8 °	331.5	0.0 °/sec	0.5 right	-1.0 °/sec	105.5	7.50
38	13	3879	1534	1675	3161	360 fpm	114	+ 9.0 °	331.5	0.0 °/sec	0.5 right	0.0 °/sec	105.5	8.50
39	13	3883	1537	1682	3169	480 fpm	115	+ 9.5 °	331.5	0.0 °/sec	0.5 right	0.0 °/sec	105.5	9.50
40	12	3883	1541	1674	3169	0 fpm	115	+ 10.0 °	331.3	-0.2 °/sec	1.0 left	-1.5 °/sec	110.0	5.00
41	13	3883	1543	1674	3177	480 fpm	115	+ 10.0 °	331.4	0.1 °/sec	1.0 left	0.0 °/sec	110.0	5.00
42	12	3887	1543	1682	3190	780 fpm	115	+ 11.0 °	331.0	-0.4 °/sec	2.0 left	-1.0 °/sec	113.0	2.00
43	13	3883	1543	1674	3202	720 fpm	115	+ 10.5 °	330.5	-0.5 °/sec	0.5 left	1.5 °/sec	108.5	6.50
44	12	3875	1543	1669	3218	960 fpm	115	+ 10.8 °	329.8	-0.7 °/sec	7.0 left	-6.5 °/sec	128.0	-13.00
45	12	3879	1543	1675	3230	720 fpm	115	+ 11.0 °	329.2	-0.6 °/sec	1.0 left	6.0 °/sec	110.0	5.00
46	13	3883	1543	1674	3240	600 fpm	115	+ 11.0 °	329.2	0.0 °/sec	0.5 left	0.5 °/sec	108.5	6.50
47	12	3879	1543	1677	3256	960 fpm	115	+ 11.0 °	328.8	0.4 °/sec	0.5 left	0.0 °/sec	108.5	6.50
48	12	3879	1543	1672	3268	720 fpm	114	+ 11.0 °	328.3	0.5 °/sec	0.5 left	0.0 °/sec	108.5	5.50
49	12	3879	1541	1671	3277	540 fpm	114	+ 11.0 °	327.8	0.5 °/sec	1.0 right	1.5 °/sec	104.0	10.00
50	12	3883	1545	1685	3287	600 fpm	114	+ 11.0 °	327.4	0.4 °/sec	3.0 right	-2.0 °/sec	98.0	16.00
51	12	3879	1563	1674	3307	1200 fpm	114	+ 11.0 °	327.4	0.0 °/sec	6.5 right	-3.5 °/sec	87.5	26.50
52	12	3879	1581	1672	3313	360 fpm	114	+ 11.0 °	328.2	-0.8 °/sec	5.5 right	1.0 °/sec	90.5	23.50
53	19	3879	1605	1668	3331	1080 fpm	113	+ 11.0 °	329.7	-1.5 °/sec	3.5 right	2.0 °/sec	96.5	16.50
54	59	3883	1625	1669	3341	600 fpm	113	+ 11.0 °	330.6	-0.9 °/sec	2.0 right	1.5 °/sec	101.0	12.00
55	86	3879	1638	1677	3356	2580 fpm	114	+ 11.0 °	330.5	-2.3 °/sec	2.0 right	3.5 °/sec	101.0	13.00
56	111	3879	1654	1669	3376	1200 fpm	113	+ 11.8 °	329.8	0.7 °/sec	1.0 right	-1.0 °/sec	104.0	9.00
57	153	3879	1671	1671	3382	360 fpm	113	+ 12.0 °	327.9	1.1 °/sec	2.5 right	-2.5 °/sec	99.5	13.50
59	246	3871	1682	1669	3417	2100 fpm	113	+ 12.0 °	328.1	-0.9 °/sec	4.0 right	4.0 °/sec	95.0	18.00
60	246	3866	1682	1671	3437	2100 fpm	113	+ 12.0 °	329.6	1.7 °/sec	4.0 right	1.5 °/sec	95.0	18.00
Average								+ 10.9 °		0.0 °/sec		-0.1 °/sec		

Attachment G – Test flight landing sequence for VH-FOZ



Ground fine selected

Touchdown

Deceleration from propellers at ground fine pitch setting