SERIOUS INCIDENT

Aircraft Type and Registration:	BAE Systems (Operations) Ltd ATP, SE-MHE
No & Type of Engines:	2 Pratt & Whitney Canada PW126 turboprop engines
Year of Manufacture:	1989 (Serial no: 2012)
Date & Time (UTC):	14 February 2018 at 0700 hrs
Location:	In flight from East Midlands to Guernsey Airport
Type of Flight:	Commercial Air Transport (Cargo)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	42
Commander's Flying Experience:	8,500 hours (of which 6,500 were on type) Last 90 days - 84 hours Last 28 days - 22 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was carrying out a cargo flight from East Midlands Airport to Guernsey Airport. As the aircraft commenced its descent from FL180, the ball in the slip indicator moved out to the left as normal and the pilot under training attempted to trim it back into the centre. He was unable to do so, and the autopilot disconnected automatically, causing a significant left bank and a nose-down attitude. The commander took control, closed the power levers and returned the aircraft to a safe flightpath. He had difficulty moving the flight controls and could not advance the power levers, believing both to have frozen due to ice. As the aircraft descended, the flight controls and power levers returned to normal and a safe landing was carried out.

It is possible that the initial control upset was the result of the crew applying aileron trim instead of rudder trim whilst attempting to correct the yaw. Although the cause of the stuck power controls could not be established definitively, it is possible that the left power lever was restricted because of wear in the roll-over lever locking mechanism, although this would not explain the locking of the right power lever reported by the pilots.

Action was taken by the manufacturer to improve the effectiveness of both an existing Service Bulletin, relating to wear in the locking mechanism, and an electronic Service Information Leaflet, relating to the purging of moisture from engine control cables.

History of the flight

The flight was a Commercial Air Transport cargo flight from East Midlands Airport to Guernsey Airport, Channel Islands. Both pilots reported for duty at 0345 hrs after three days free of flight duty during which they had adequate rest. The pilot who would occupy the left seat was a direct entry captain undergoing line training after type conversion who had a total of 4,100 flying hours of which 12 hours were on type. The pilot who would occupy the right seat was a line training captain who was experienced on the type. They carried out the pre-flight inspection of the aircraft together and, as it had areas of frost on it, de-icing was carried out.

The commander was to be the Pilot Flying (PF) for the sector and, following normal checks and procedures, the aircraft departed from Runway 27 at 0551 hrs. It followed the Daventry 3N Standard Instrument Departure, with the crew engaging the autopilot at an altitude of 1,000 ft and continuing to a cruising level of FL 180. There were no visible signs of icing during the flight with the Total Air Temperature (TAT) and Outside Air Temperature (OAT) recorded in the cruise as -14°C and -22°C respectively.

Just before the top of the descent into Guernsey, control was handed to the pilot under training in the left seat in order to give him experience in the strong (22 kt) crosswind being experienced at the airport. He reduced power by moving the power levers back, without any restriction or difficulty, setting approximately 50% torque on each engine. He used the autopilot pitch trim wheel to pitch the aircraft nose-down and at 210 kt he engaged the IAS mode which gave a rate of descent (ROD) of about 1,000 fpm. He then selected the Vertical Speed mode (VS), which maintained the ROD and resulted in an IAS of between 200 and 215 kt. As normal, the ball in the slip indicator moved out to the left and the PF stated later that the rudder trim was used in an anticlockwise direction in an attempt to bring the aircraft back into balanced flight. Despite this, the ball remained out to the left. The PF continued to trim but the TRIM caution light illuminated[1] and, shortly afterwards, the autopilot disconnected automatically.

The aircraft immediately rolled to the left some 45° and pitched nose-down. The commander took control, closed both power levers, levelled the wings and raised the nose. He noticed that the elevator control was normal but the rudder was stiff. He tried to operate the rudder and aileron trims but they were also stiff, although the pitch trim was working. The crew had just changed frequency to Guernsey approach and they transmitted a MAYDAY stating that they had "CONTROL PROBLEMS" which was later expanded to explain that they were unable to increase power. Guernsey radar cleared the aircraft to descend to 3,000 ft and gave radar vectors for Runway 27. The weather was, surface wind 170/22, visibility 25 km, FEW at 2,500 ft, SCT at 4,800 ft with showers in the vicinity, OAT +6°C, dew point 0°C, and QNH 1005 hPa. ATC also offered Alderney at 9 nm and Cherbourg at 30 nm as alternative airports but the crew elected to continue for Guernsey. Shortly afterwards, the commander informed ATC that everything was back to normal.

Footnote

1 The TRIM caution light indicates an out of trim condition in either pitch or roll and it illuminates when a pre-defined threshold has been achieved.

During the descent, the commander believed that the flight and engine controls were restricted due to icing of the systems. The crew tried to find a checklist which dealt with frozen controls but were unable to do so[2]. They attempted to operate the standby power controls, but this would not increase power either. The commander stated that he tried to move the power levers independently, but they would not move. He also operated the roll-over levers[3], entering the beta[4] range, before returning them to the FLIGHT IDLE position, but the power levers would still not move. Approximately three minutes later he was able to advance the power levers, initially in small, 'notchy' movements but then normally.

Having all controls back to normal, the crew were radar vectored by ATC, descended for an ILS approach to Runway 09, which was the duty runway, and made an uneventful landing at 0701 hrs.

Crew background and experience

The pilot under training (PUT) began flying in 1999 and, having obtained a Flight Instructor's qualification, carried out instructional flying on a number of different types. He obtained his commercial qualifications and began flying the Shorts 330 and 360 in 2003. He flew the Shorts 330 until 2004, when it was phased out, but continued to fly the Shorts 360 until July 2006. After that he flew the Citation Bravo from August 2006 until October 2010. He had a break from flying until 2015 after which he flew the Shorts 360 until January 2017 when he began converting to the ATP.

The Line Training Captain (aircraft commander) started flying in 1998 and obtained his commercial licence before operating Beech 90 and then Beech 200 King Air aircraft. He also flew the Piper Cheyenne, and Dassault 2000 and 2000 EX before moving to the ATP in 2008. He flew the ATP as a Line Training and Line Check Captain for 10 years before joining the operator in February 2018.

Commander's recollection of the incident

When the commander saw the ball in the slip indicator moving more and more to the left, he said to the PUT "you need to trim more", maybe three times, and put his hands on the control yoke. When the AP disconnected, which was coincident with him pressing the disconnect button on the control yoke, he took control of the aircraft. The aircraft was out of trim, very stiff on the aileron and pitching down with a left bank. In order to prevent the airspeed from exceeding the maximum limit, he retarded the power levers fully. Simultaneously, he trimmed the aircraft using aileron and rudder trim which were both very stiff to operate.

He attempted to use some asymmetric power to assist with trimming the aircraft but when he advanced the left thrust lever, he found it jammed. He immediately tried to advance the

Footnote

2 The Emergency and Abnormal Checklist contains a decision flow-chart under the title: '*Engine Control Levers Malfunction'*. Part of the flow-chart considers the possibility that the power levers are restricted due to icing, in which case it recommends descending the aircraft into warmer air.

3 See later section: *Engine power levers and roll-over levers.*

4 Beta control: control mode for a normally automatic propeller in which the pilot exercises direct command of pitch for braking and ground manoeuvring.

right engine but found it was also jammed. He attempted to use the standby engine control system, but this did not increase engine power. This caused him great concern because he had just moved the power levers aft and could not move them forward again, and the aircraft was descending through 17,000 ft amsl at 1,800 fpm.

He recalled that both engines were indicating zero torque with the aircraft diving, and the abnormal check list did not cover the situation. Since he had experienced icing on the power 'Bowdenflex' cables before, he tried every 20 seconds to operate the standby engine control system and the power levers. He hoped that they would move at a lower altitude, where the temperature would be higher, which they eventually did. During this activity the crew prepared for a glide approach into Guernsey. ATC offered other, alternative airfields but he elected to continue to Guernsey. He adjusted the pitch to achieve a glide airspeed of 150 kt (135 kt plus 15 kt for icing). With the resulting groundspeed and rate of descent he estimated the aircraft could glide 46 nm and Guernsey airport was 43 nm away. With the wind increasing from the south, he thought it was tight but possible.

With a workable plan in place he elected to check the quadrant safety on the roll-over levers, which he was able to move, but this did not free the power levers and so he concentrated on flying the aircraft.

When he felt the power lever cables were "unfreezing", feeling notchy but allowing him to advance the power levers slightly and making some power available, he felt sure that the aircraft would be able to reach Guernsey. He informed ATC of the improvement and suggested a slightly wider vectoring to get back to a normal descent path angle. On touch down, the power levers and flight controls were moving normally.

These recollections were supported by the captain under training.

Recorded information

SE-MHE was equipped with a cockpit voice recorder (CVR) that recorded 2 hours of audio, during which this event occurred. It was also fitted with a tape-based flight data recorder (FDR) and solid-state quick access recorder (QAR), which replicated the 25 hours of data on the FDR and older recordings. Each of these recorders was removed from the aircraft and taken to the AAIB where they were successfully downloaded and their recorded information analysed.

Flight data

Figure 1 is a plot of the salient parameters for the event with extracts from the CVR relating to the use of trim. Due to the age of the FDR installation there were no requirements to record certain parameters, such as the position of the control column and wheel, roll and yaw trim, and power levers, that would have been useful for the investigation. Also, the aileron, elevator and pitch trim position recordings vary between aircraft, so small biases exist in the data presented; however, these did not affect the analysis of the recorded data for this investigation.

Figure 1 starts with the aircraft stable on descent towards Guernsey, with the autopilot engaged, passing through 16,500 ft amsl, with the propeller speed at about 82% (of the maximum 1,200 rpm), and engine torques of about 55%. In summary, the data indicates the following:

UTC (hh:mm:ss)	Event
06:39:48	Aircraft starts to roll slowly to the left - aileron movement was not observed in the data until about 6 seconds later[1]. No movement in rudder position.
06:39:51	Commander states "YOU NEED MORE [TRIM]" Over the following 12 seconds, the aircraft continues to roll to the left.
06:39:55	Pilot Under Training states "IT NEEDS A LOT DOESN'T IT"
06:39:57	Commander states "YOU NEED RUDDER TRIM OR SOMETHING … LOOK"
06:39:59	Commander states "YOU WILL DISCONNECT IT NOW"
06:40:01	Commander states "BE CAREFUL BE CAREFUL BE CAREFUL"
06:40:03	Autopilot disconnects – continuous cavalry charge sounds in cockpit – with aircraft 9.3° left wing down, 1.4° pitch nose-down, vertical acceleration 1.1g, airspeed 213 kt, altitude 16,039 ft amsl. Rudder immediately moves to the right and aircraft pitches down and rolls to the left reaching a peak value of 48° five seconds later.
06:40:11	Aircraft begins to pitch up from 8° nose-down. 1.8g recorded vertical acceleration during pitch up.
06:40:13	Commander states "I HAVE CONTROL"
06:40:14	Engine torque (and N_H and N_L[2]) reduce. Propeller speed momentarily reduces before recovering back to about 82%. Landing gear config horn sounds in cockpit (for the next 24 seconds).
06:40:23	Cavalry charge stops sounding.
06:40:38	Config horn stops sounding (not shown).
06:40:42	Engine torques nominally zero (where they remain until 06:43:22) – propeller speed still about 82% (not shown).
06:41:02	Propellers taken in and out of beta range over eight seconds (not shown).

Table footnotes

1 This was because of limitations in the resolution of the data recording.

2 N_H and N_L: High pressure and low pressure rpm engine speed respectively.

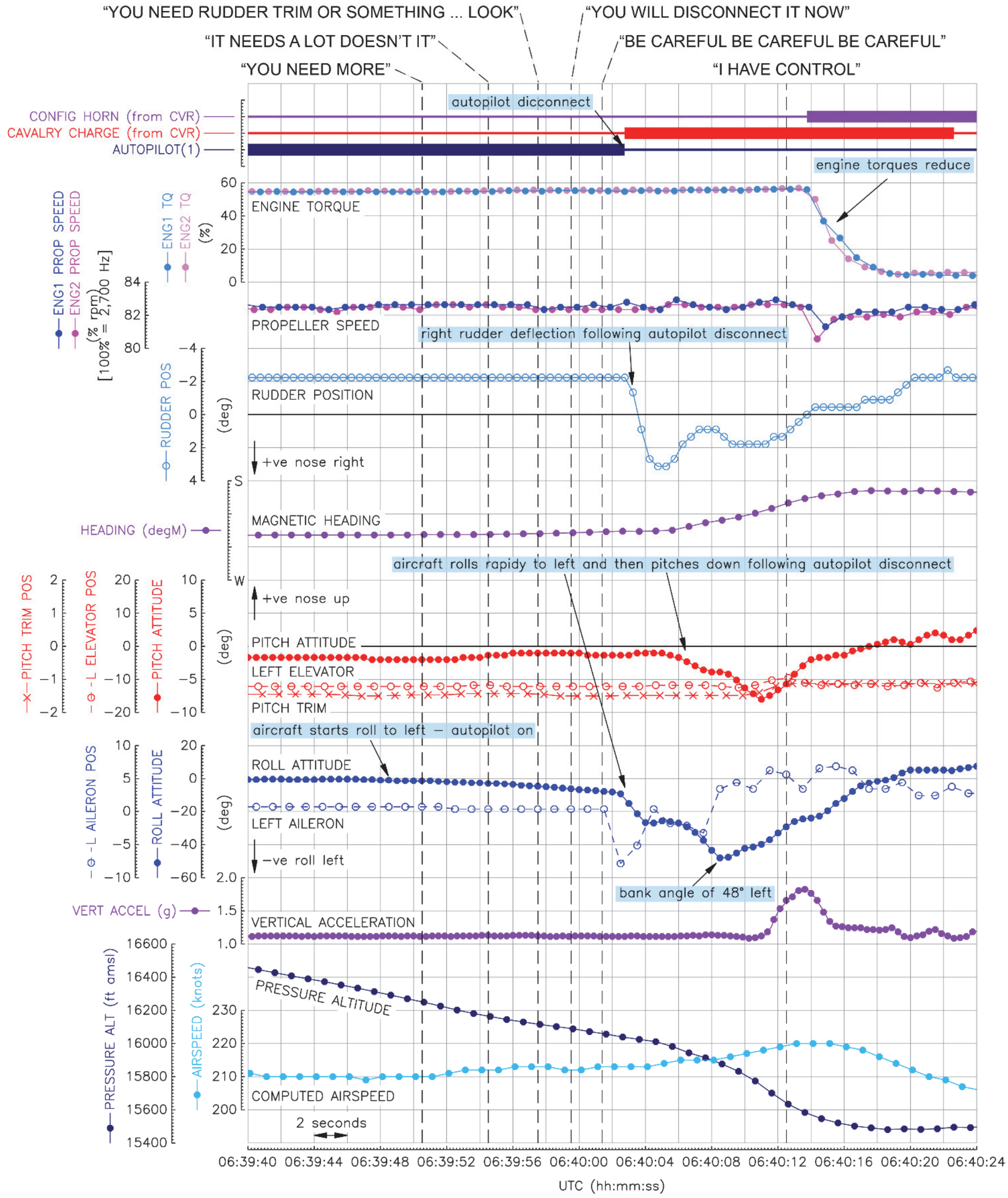

Figure 1

Salient parameters during the event with extracts from the CVR relating to use of trim

Aircraft description

The British Aerospace[5] Advanced Turbo Prop (ATP) was derived from the Hawker Siddeley 748. The aircraft is a low-wing turboprop with a conventional tail configuration and two Pratt and Whitney Canada PW126 turboprop engines, driving six-bladed variable-pitch propellers. ATPs were produced in a passenger configuration and modified to a cargo configuration.

System descriptions

Autopilot

Automatic flight control is provided by two independent autopilots, only one of which can be engaged at any time. The autopilot controls the aircraft by means of electrically actuated servomotors and it is a two-axis system (pitch and roll) with a yaw damper.

Autopilot manual disengagement

The autopilot can be disengaged by pressing the red 'instinctive' autopilot disengage switch on either of the pilots' control wheels. This results in a one-second audible 'cavalry charge' warning.

Autopilot automatic disengagement

An autopilot safety circuit monitors the roll angle and normal acceleration. The autopilot will automatically disengage if the roll angle is greater than 35° or if the normal acceleration is less than 0.4g or greater than 1.6g.

The autopilot will automatically disengage if specific failure conditions are detected. Failure conditions include any autopilot servomotor drawing excessive current eg due to a short circuit or high load on the respective flying control surface.

Automatic disengagement of the autopilot results in a continuous audible cavalry charge warning, which can be cancelled by pressing either of the autopilot disengage switches.

Flying controls - trim

There are three manual trim wheels on the centre console in the cockpit. The elevator trim wheel is on the left side of the console, the rudder trim wheel is on top of the console and the aileron trim wheel is on the rear of the console (Figure 2).

Footnote

5 BAE Systems (Operations) Ltd is the design Type Certificate holder.

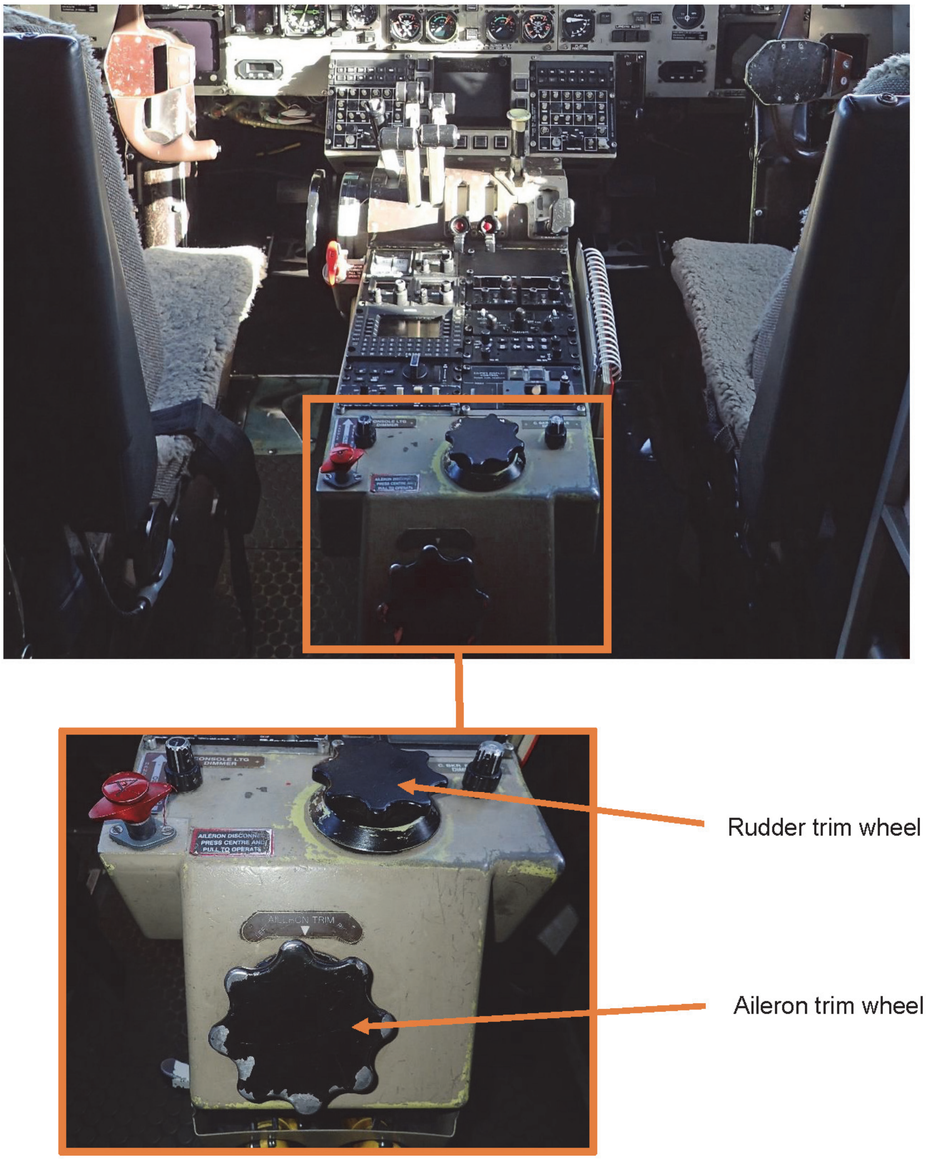

Figure 2

Position of the rudder and aileron trim wheels

If the autopilot is engaged, pitch and roll 'out-of-trim' indicators are deflected proportionally to the respective autopilot servomotor electrical current. If the current exceeds a pre-determined threshold for greater than either 2 seconds in pitch or 12 seconds in roll, an amber TRIM light, adjacent to the out-of-trim indicators, illuminates (Figure 3).

Figure 3

TRIM light and associated pitch and roll out-of-trim indicators

Engine power levers and roll-over levers

The power levers for each engine are on the centre console and each lever has a subsidiary roll-over lever (Figure 4).

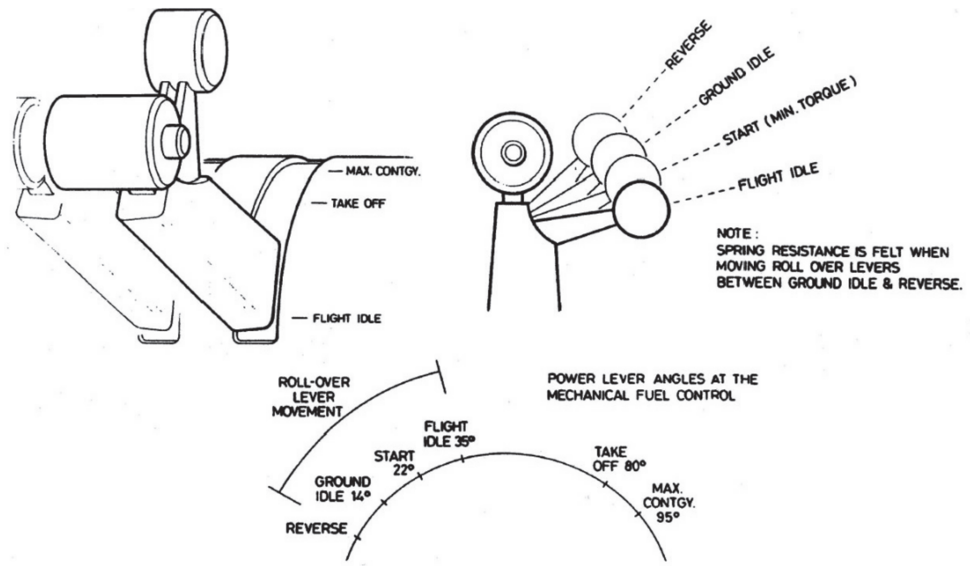

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Figure 4

Schematic of the main power lever and roll-over lever

The main power lever controls engine power between FLIGHT IDLE and MAXIMUM CONTINGENCY. The roll-over lever controls engine power and propeller pitch in the beta range, between FLIGHT IDLE and REVERSE. The roll-over levers are interlocked with their respective power levers so that a power lever can only be advanced above FLIGHT IDLE when the respective roll-over lever is fully forward and locked into its FLIGHT IDLE position.

If the landing gear is up, the flaps are not greater than 15°, and a power lever is retarded to FLIGHT IDLE without the associated propeller condition lever being selected to FEATHER, the landing gear configuration warning horn will sound.

Engine controls

Engine power demands are transmitted to the engine by means of mechanical control rods and metallic cables beneath the cabin floor and along the leading edge of the inboard wing sections (Figure 5). The power levers and the roll-over levers use the same control runs and are not independently connected to the engines.

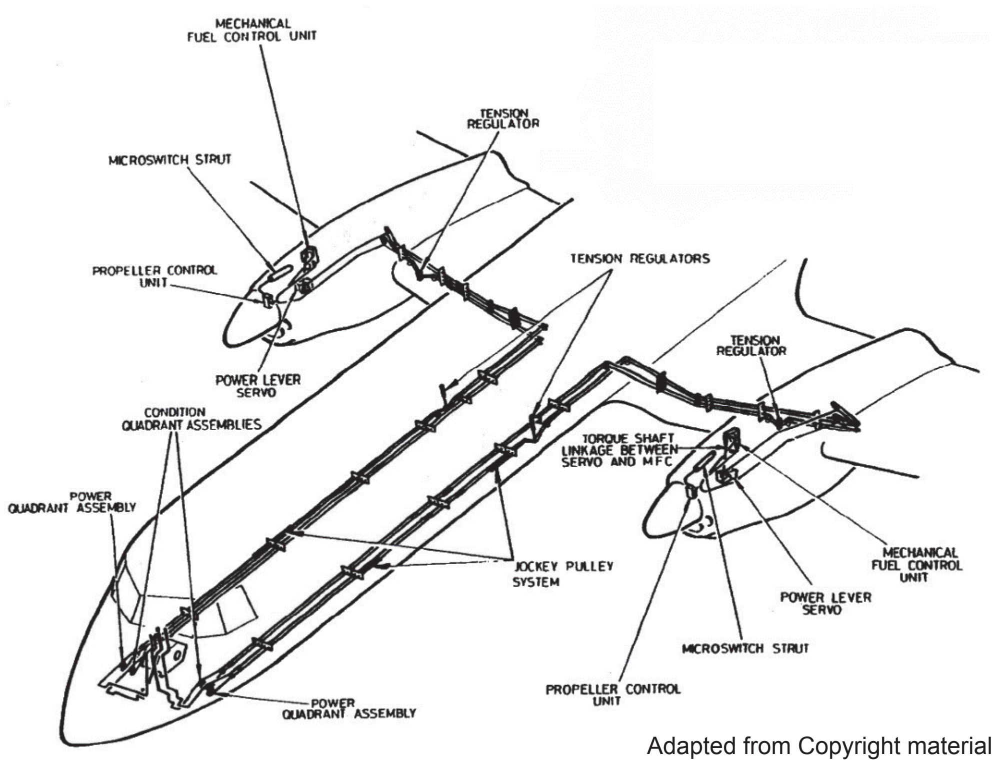

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Figure 5

Schematic depicting the engine control runs

Standby power controls

Each engine has its own electrically actuated standby control system that provides emergency control over the full power lever range. Two switches, immediately behind the power lever quadrant, can be used to increase or decrease engine power by means of a stepper motor on each engine (Figure 6). The system caters for a break in the control cable but cannot be used if the power levers are physically jammed.

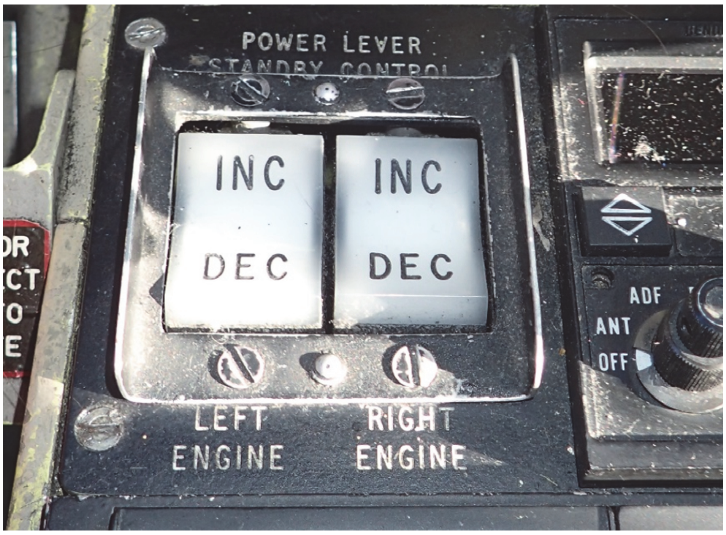

Figure 6

The power lever standby controls

SE-MHE

SE-MHE was manufactured in 1989 and had accrued 28,969 cycles, which equated to 26,416 hours. It was originally configured for passenger transport but was converted for cargo operations in 2007.

According to the operator, the aircraft did not have a history of flying control or engine problems.

Aircraft examination in Guernsey

The aircraft was examined under the supervision of the AAIB.

General external examination

Examination of the aircraft external surfaces and flying controls found no anomalies and there was no evidence of de-icing residue build-up.

Flying controls

The flying controls were operated throughout their range of movement without undue force or restriction. Extensive checks and inspections of the aileron and rudder trim control runs found no problems.

Power levers and engine control runs

The power levers were found to operate normally, and examination of the control runs identified no anomalies.

Both engine control cables were removed for further examination and testing[6] but no faults were found.

Footnote

[6] See later section: *Previous ATP power lever problems and engine power cable modification.*

Standby power controls

Both systems were found to operate throughout their normal range but the right system was occasionally observed to be 'notchy', possibly indicating excessive resistance in the system or that the stepper motor was under-performing. The operator returned the aircraft into service without installing a replacement stepper motor. The right system was subsequently found to be non-operational when the aircraft was examined again three months after this incident and a replacement motor was installed.

Previous ATP power lever problems and engine power cable modification

Between 2014 and 2018, the operator recorded six events on their ATP fleet where pilots reported '*restricted*', '*stiff / notchy*' or '*frozen*' power levers. There was no confirmed link between the events but the engine power 'Bowdenflex' control cables were cited as a possible cause because of their apparent susceptibility to moisture ingress and freezing; the control cables are under the engine cowls (Figure 7).

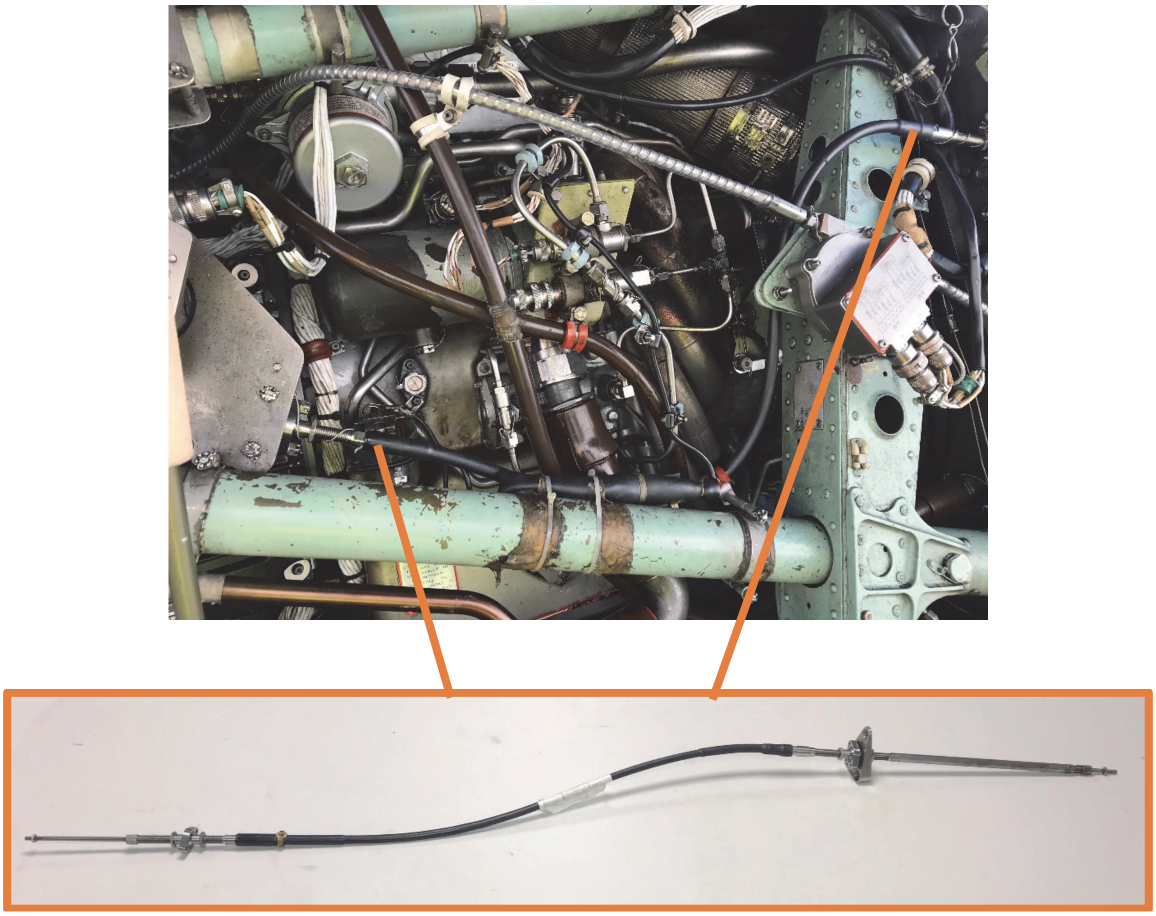

Figure 7
Bowdenflex cable

In June 2014, the aircraft manufacturer issued Service Bulletin (SB) ATP-76-022 to introduce flexible heat shrink sleeving on the engine power control cables because "*There* *have been a number of reports that moisture ingress together with low temperatures has led to cables becoming difficult to move*". The configuration change was optional and formally approved under modification JDM60170A. As part of the investigation following the incident on SE-MHE, the operator checked the modification status of their operational fleet and found that some aircraft were post-modification, some were pre-modification and some were of mixed build standard.

In 2016, the operator introduced a Technical Instruction '*To reduce delays and cancellations due to frozen power lever cables on the northern routes*'. The instruction describes the use of '*a power lever heating kit*', which was commissioned by the operator and is available for use at three airports in Norway and Sweden; the equipment is used (if deemed necessary) to direct warm air onto the engine power control cables when the aircraft is on the ground. Concurrently, the operator introduced a procedure to purge moisture from the cables using low pressure nitrogen or air. The cables are purged every 400 flying hours, but the procedure is not applicable if the heat shrink sleeving has been installed.

In December 2017, the manufacturer introduced an electronic Service Information Leaflet (eSIL) 76-ATP-800-1, recommending operators to periodically purge moisture from the cables using low pressure nitrogen or air. The manufacturer recommended a periodicity of 150 flights but stated that operators should amend the frequency based on their in-service experience and operational environment.

The aircraft manufacturer monitored events in service and, in June 2017, reported to the European Aviation Safety Agency (EASA) that '*the trend constitutes a potential unsafe condition*'[7]. The manufacturer stated it would assess the effectiveness of eSIL 76-ATP-800-1 and consider possible options for long term corrective action with a report to EASA on completion.

Both engine control cables on SE-MHE were post-modification standard with heat shrink sleeving applied. Irrespective of this, however, they were removed for further examination and testing. The harnesses were subjected to freezing conditions but showed no evidence of restricted movement.

Further examination of SE-MHE at East Midlands Airport

Having assessed the recorded data and reviewed the event with the crew, the AAIB revisited the aircraft to examine the power lever installation in more detail. In the time since the incident occurred, the aircraft had completed 112 flights, equating to approximately 120 flying hours. There had been no additional reports of power lever or flying control anomalies.

Visual examination of the power levers and roll-over lever interlocks found no evidence of damage caused by a physical restriction. There was no Foreign Object Debris (FOD) or obvious anomalies inside the area of the centre console through which the controls pass.

Footnote

[7] File number AR.EU-EASA-2018-000040 '*Frozen Engine Controls*'.

Repeated operation of the roll-over levers found that the left lever did not always lock down when it was returned to the forward position; it sometimes 'bounced' out of position and remained unlocked. With the left roll-over lever in this condition, the associated power lever could not be advanced from FLIGHT IDLE. The 'feel' and operation of the right roll-over lever was different and it always 'positively' locked down when returned to the forward position (Figure 8). The anomaly was not always apparent but could be repeated with relative ease. Examination of another aircraft found that both catches showed positive locking.

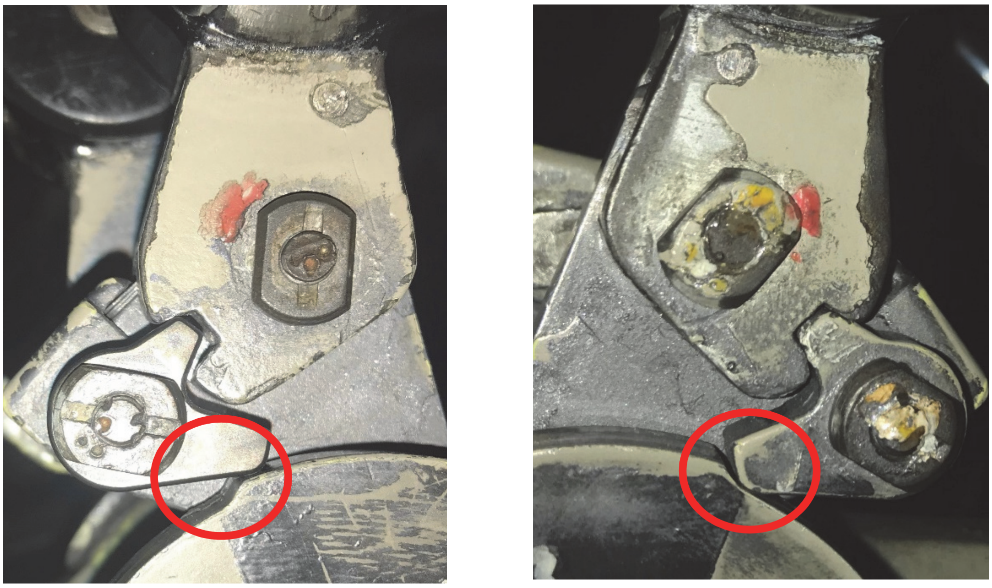

Figure 8

The left roll-over catch did not always lock (left)
The right roll-over catch always showed positive locking (right)

The maintenance agency reported that the roll-over lever 'bounce' was rectified by installing a replacement engine cable harness. The reason for this was unclear because the item that was removed was the harness that had been installed when the aircraft was recovered after the incident. The maintenance records for the recovery of the aircraft did not mention any anomalies relating to the left roll-over lever operation. However, they showed that the right engine cable harness was changed twice because the first replacement item had 'high internal friction'.

Further checks involving the operation of the standby control system found excessive wear in the roll-over mechanism and the locking catch was replaced. Wear is not monitored in service.

Roll-over latch wear

In 2012, the manufacturer issued a Service Bulletin (ATP-76-021) to check for wear in the roll-over locking mechanism. EASA issued an Airworthiness Directive (2014-0007), mandating a one-off check. This check was introduced because the crew of an ATP had unintentionally entered the beta range in flight, resulting in a significant propeller overspeed and engine failure several weeks later. The crew had reduced power to FLIGHT IDLE to increase their rate of descent and were attempting to reduce excessive residual engine torque using the standby power lever controls. Despite the roll-over levers being in the locked position, wear in the locks was such that the crew entered the beta range in flight.

In the light of the AAIB's findings at East Midlands Airport the manufacturer decided to introduce a periodic check for wear in the roll-over mechanism.

Human performance – operation of an incorrect control

Performance shaping factors for the operation of an incorrect control

Human performance is variable. At any time, there is a chance that someone may perform an incorrect action, such as inadvertently operating the wrong control. This is the case regardless of the situation and the level of expertise of that person. Human performance is influenced by 'performance shaping factors' which are present within an individual, the equipment, the environment and the organisation. If performance shaping factors are not favourable, human performance is reduced and the probability of performing an incorrect action is increased.

Different performance shaping factors influence different types of performance to different extents. Manual actions are particularly influenced by design and situational factors.

When someone needs to select a control by touch, the control needs to be identifiable by touch. The ease of identification is a design performance shaping factor. It depends on the following attributes of the control and the controls in proximity to it:

- Position – Where the control is in relation to the user and to other controls.
- Space – The distance between controls.
- Operation – The means by which the control is used including how it is manipulated (eg gripped, pushed, pulled or turned), how the control feels to operate and the limits of its movement.
- Shape – The external form of the control.
- Size - How big the control is.
- Orientation – The positional and directional relationships between the control, surrounding controls, the control mounting and the user.
- Texture – The tactile surface characteristics, or how the control feels to the touch when not being operated.

The more different controls are on these factors, the easier they are to identify by touch. The more similar they are, the more likely it is that an incorrect control will be selected.

The probability of performing a manual action incorrectly is also increased when someone is distracted or experiencing high workload. Experienced people tend to operate manual controls without conscious thought. Novices may still need to consciously think about it.

In high workload or distracted situations, the attentional resource available to plan, execute and check manual actions is reduced and people must rely more on automatic task performance. Novices are therefore particularly vulnerable in high workload situations because their skill to reliably operate controls automatically has not yet fully developed.

The user's experience with a system and other similar systems also influences performance. People apply previously learned skills in new contexts. Skills that have been used frequently over a long period of time will tend to be used in preference to newly learned skills. When the contexts are similar, but with subtle differences, there is a risk that previous learning will be applied inappropriately. This risk further increases if other performance shaping factors, such as high workload, affect the individual's ability to pay conscious attention to the requirements of the new context.

Performance shaping factors for recovery from the selection of an incorrect control

To be able to recover from the inadvertent selection of an incorrect control, the user needs to be able to detect and understand the situation. Success in doing this depends on both the user and the system.

The system needs to provide feedback that is accurate, noticeable and easy to interpret. If feedback is not provided or is not accurate, noticeable and easy to interpret then the user is less likely to be able to correctly understand the problem.

Successful recovery also relies on the readiness and capability of the user to receive and interpret feedback. When monitoring and checking is an explicit part of the role (e.g. in the case of a pilot monitoring), this increases readiness to receive feedback and increases performance. Similarly, a high level of experience and expertise increases capability. It is more difficult for an individual to do this successfully in unexpected or highly unfamiliar situations or when they are experiencing high workload.

Analysis

Autopilot disengagement and initial flight upset

The flight progressed normally and without incident until the commencement of the descent into Guernsey. The power was reduced to 55% torque on both engines and, as normal, the slip indicator ball migrated to the left. The PF reported that he began to retrim the aircraft in yaw and he commented about the amount of trim that he was applying because it was having no effect. The FDR data showed no change in rudder position which indicated that the rudder trim was not being used. The data showed the aircraft rolling slowly to the left and, approximately 12 seconds later, the commander said "YOU WILL DISCONNECT IT NOW", shortly followed by "BE CAREFUL BE CAREFUL BE CAREFUL". The crew recalled that the TRIM warning light was illuminated, which indicated that the aircraft was out-of-trim in pitch or roll.

Almost immediately after the commander expressed his words of caution, the autopilot disconnected and the CVR recorded a continuous cavalry charge warning. The aircraft rolled left and pitched nose-down before the commander took control and restored a safe attitude with normal use of the flying controls. The continuous cavalry charge warning indicated that the autopilot disconnected automatically, and the movement of the flying controls indicated that they were not frozen.

No faults were found when the autopilot was tested, and the FDR data showed that the aircraft was operating inside the limits of the safety circuit when the autopilot disconnected. It is possible that the autopilot disconnected because the aircraft was being trimmed in roll instead of yaw. In this case, the current demanded by the aileron servomotor would increase as it tried to resist the effect of the increasing trim tab deflection, and the TRIM warning light would illuminate when the appropriate threshold was exceeded. Further application of aileron trim would cause the autopilot to automatically disconnect and trigger a continuous 'cavalry charge' alert. With the autopilot disconnected, the ailerons would immediately deflect causing a rapid roll to the left. This scenario is consistent with the data and the way the autopilot operates, but both pilots believed that they had operated the rudder trim wheel correctly.

Possible action on the incorrect trim control

The following section considers aspects of human performance which might have influenced events had the aileron trim been used instead of the rudder trim. The reasons why the incorrect trim control might have been used, and the reasons why the situation might not have been corrected before the autopilot disconnected, might be explained by considering the performance shaping factors present during the event.

The rudder and aileron trims are in the same part of the flight deck and are separated by only a small distance. They are operated in the same way, and have the same shape, size and texture. They are, however, orientated differently, being set in different planes. The similarities in these design performance factors, perhaps outweighing the orientation factor, might have increased the probability that an incorrect control would be selected.

The PF had only 12 hours flying the aircraft type out of his total 4,100 flying hours, and his workload while undergoing line training in an unfamiliar aircraft was likely to have been high. Although by no means a novice pilot, he could be considered a novice on type and, therefore, more vulnerable in high workload situations to operating an incorrect control. After a relatively short period on type, he might not yet have developed the automatic task performance skills which would normally be relied upon to avoid mistakes in high workload circumstances.

Successful recovery from the inadvertent selection of an incorrect control requires system feedback to the operator. The pilot thought he was using the rudder trim but was not seeing the appropriate response from the rudder trim indicator. This feedback would have been accurate but confusing. He might even have been encouraged to continue turning the trim wheel, as opposed to stop turning it, by the feedback from pilot in the right seat saying: "YOU NEED MORE [TRIM]".

Had the pilot been using aileron trim with the autopilot disengaged, the aircraft would have rolled to the left. The pilot would have noticed this feedback and probably realised immediately that he was using the incorrect trim. However, the autopilot was controlling the aircraft and would have been resisting any tendency to roll. The pilot would therefore have been denied this feedback indicating that he was using the incorrect trim wheel.

The commander, as the supervising pilot, would probably have had an elevated readiness to receive system feedback because of the nature of that role, and it appeared from the CVR and his recollection of events that he received enough feedback to understand that the autopilot would soon disconnect. However, he was unable to prevent it from happening in the 15 seconds between the aircraft beginning to roll and the autopilot disconnecting.

Power levers

The crew reduced engine power prior to the descent and both power levers were retarded to FLIGHT IDLE after the autopilot disconnected. In both cases, the levers moved without restriction. This indicated that the power levers were not frozen or restricted.

The commander reported that the power levers were stuck at FLIGHT IDLE after he regained control of the aircraft and he believed them to have frozen. He stated that he attempted to control the engines by advancing the power levers, which would not move, and by using the standby control system, but neither method was effective. He briefly pulled the roll-over levers into the beta range and the engines responded with speed and torque increasing accordingly.

The roll-over levers use the same control runs as the engine power levers, so the fact that the commander successfully entered the beta range indicated that the control runs were not restricted or frozen. He deselected the beta range and succeeded in advancing the power levers approximately three minutes after retarding them to FLIGHT IDLE.

Examination of the aircraft in Guernsey identified no explanation for the power lever restriction. When the aircraft was subsequently examined at East Midlands Airport, the left roll-over lever had excessive wear and therefore did not always lock down when it was returned to the FLIGHT IDLE position. The effect of this was that the left power lever could not be advanced from its FLIGHT IDLE position. Had the left roll-over lever been unlocked during this incident, it might have felt like both power levers were physically restricted when the pilot tried to advance them together (even though only the left would have been). However, in these circumstances the right power lever should have been free to move had it been operated independently. The commander stated that he was unable to move the levers by hand or control the engine by using the standby control system. The investigation could not explain why the right power lever might have been jammed.

Conclusion

Shortly after top of descent, the aircraft developed a significantly out-of-trim condition which, when the autopilot automatically disconnected, caused a rapid and significant roll to the left accompanied by a nose-down pitch. The evidence supported the likelihood that the crew used aileron trim instead of rudder trim to balance the aircraft in yaw, leading to the autopilot disconnecting automatically and the initial in-flight upset.

The commander corrected the attitude changes with difficulty but found that both power levers were stuck at FLIGHT IDLE. Approximately three minutes later, he successfully advanced the power levers and the engines responded accordingly. The commander considered that the most likely scenario was icing of the engine controls but this was unlikely. Although the cause could not be established definitively, it is possible that the left power lever was restricted because of wear in the roll-over lever locking mechanism, although this would not explain the jamming of the right power lever reported by the pilots.

Safety action

The manufacturer stated that it:

- Would introduce a periodic wear check of the roll-over lever locking mechanism to supplement the previous one-off check that was introduced in Service Bulletin ATP-76-021.
- Would assess the effectiveness of eSIL 76-ATP-800-1 (to periodically purge moisture from the cables using low pressure nitrogen or air), consider possible options for long term corrective action, and would report to EASA on completion of the assessment.