ACCIDENT

Aircraft Type and Registration:	DHC-8-402 Dash 8 (Q400), G-PRPC
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2010 (Serial no: 4338)
Date & Time (UTC):	14 December 2016 at 0624 hrs
Location:	On departure from Manchester Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 27
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to engine access panel, impact damage to vertical stabiliser and VOR/LOC antennas
Commander's Licence:	Airline Transport Pilot Licence (Aeroplanes)
Commander's Age:	45 years
Commander's Flying Experience:	7,120 hours (of which 142 were on type) Last 90 days – 142 hours Last 28 days – 63 hours
Information Source:	AAIB Field Investigation

Synopsis

Following overnight maintenance work, the outboard engine access panel on the No 1 engine was incorrectly latched shut. This was not identified by the engineer completing the task, by the flight crew during the subsequent pre-departure inspection, or by the ground operations personnel dispatching the aircraft. During takeoff the panel failed at the hinge attachment points and departed the aircraft, striking and damaging the vertical stabiliser, before coming to rest on the runway and its grass verge. A previous incident, where the same engine panel was lost during takeoff, had occurred on the aircraft a month earlier. This report addresses both incidents. Safety action has been taken by the aircraft manufacturer to add labelling and amend the Aircraft Maintenance Manual (AMM), and the operator has revised its maintenance procedures. In addition, two Safety Recommendations have been made relating to flight crew pre-departure inspection procedures and dissemination of safety information to ground crew.

History of the flight

Following a day of routine flying operations on 13 December, the aircraft night-stopped at Manchester Airport and was parked on a remote stand. The operator's contracted maintenance organisation completed a routine daily check on the aircraft that evening. This included

checking the oil content of the No 1 engine, accessed by opening the outboard main access panel on the engine nacelle. The check was concluded by approximately 2115 hrs, with the aircraft scheduled to return to service for a 0610 hrs departure the next morning. The aircraft Technical Log entry for the daily check was signed by the engineer at 0010 hrs.

The operating flight crew arrived at the aircraft at 0530 hrs and began their normal pre-flight checks. At 0550 hrs, in accordance with company procedures for the first flight of the day, the commander conducted the pre-departure inspection. As it was still dark, he used a torch to supplement the ambient airport lighting during his inspection. He did not identify any issues with the aircraft and the crew continued with their normal departure routine.

The ground crew, who were responsible for pushing the aircraft back off the stand, subsequently arrived and conducted their own walkround check of the aircraft, also identifying nothing of note. The aircraft was dispatched on time and taxied to Runway 23R for takeoff. At approximately 0624 hrs the aircraft commenced its takeoff roll and then continued on an apparently uneventful flight to Hannover, Germany, landing there at 0752 hrs.

After the aircraft had parked on the stand and the passengers had disembarked, the ground crew informed the cabin crew that a panel was missing from the No 1 engine. The message was relayed to the flight crew, who inspected the aircraft prior to contacting the operator's maintenance control department. The operator informed Manchester Airport operations staff at 0836 hrs, who then conducted an inspection of Runway 23R. The panel was recovered from a grass area to the side of the runway, approximately 440 m from the runway threshold. Sections of the panel hold-open strut were also recovered from the runway and adjacent paved areas in the same vicinity (Figure 1).

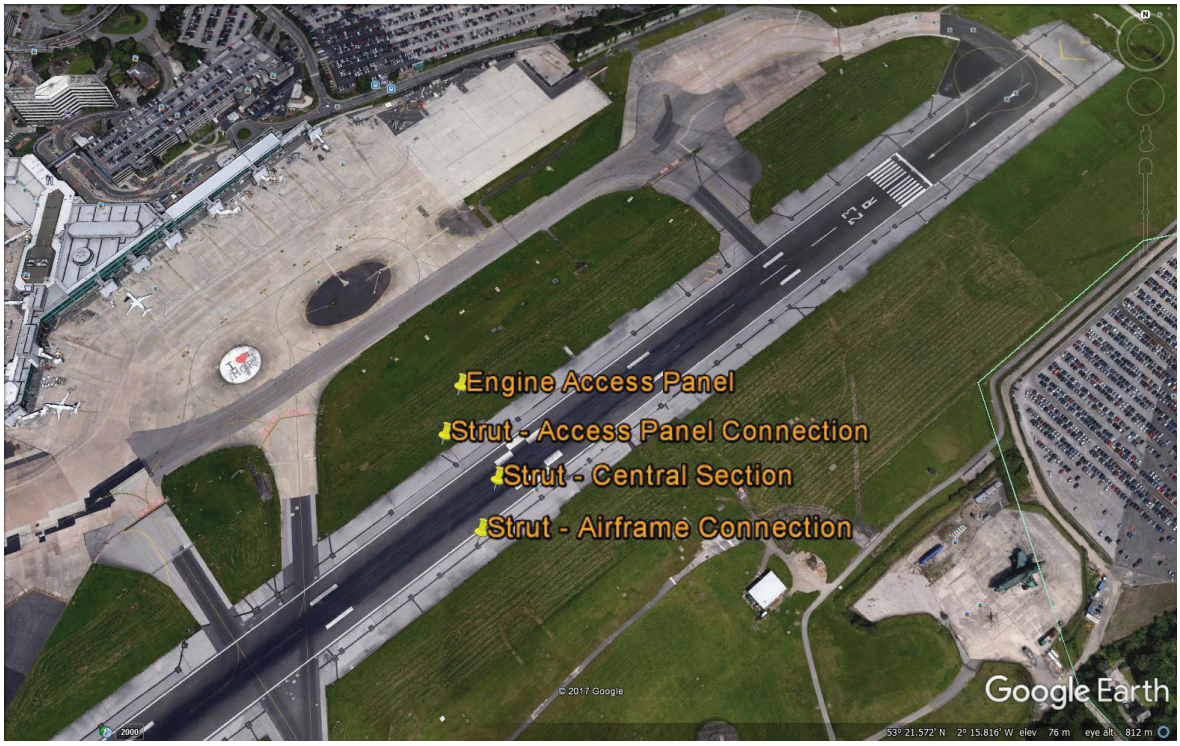

Figure 1

Location of items released from the aircraft during takeoff

Aircraft information

The DHC-8-402 Dash 8 (Q400) is a twin-turboprop, medium-range, passenger aircraft. The main engine bay of each engine nacelle has two large forward access doors, one inboard and one outboard. These access doors are made from a carbon/epoxy composite material with integral foam-filled stiffening ribs. Each door is hinged at the top, has a single telescopic hold-open strut and is secured in the closed position by four quick-release lock pin latches (Figure 2). Each latch, when closed, engages a pin into a receiver mounted within the engine nacelle structure. The outboard door on the No 1 engine and the inboard door on the No 2 engine allow access to service the engine oil system.

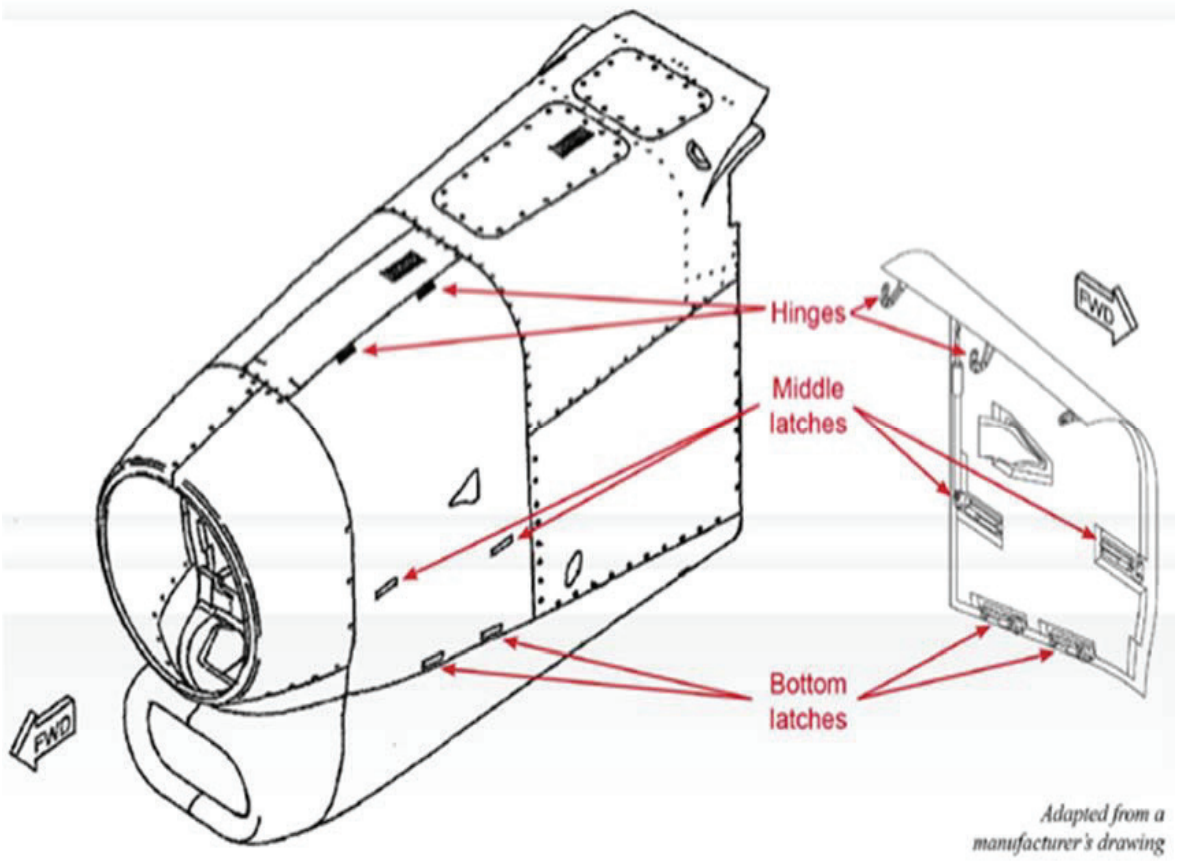

Figure 2

Forward engine bay access panel

Aircraft examination

On inspection of the recovered panel all four latches were found to be in the closed and latched position. There was no damage to the latch bolts or the receiving fixtures on the nacelle (Figure 3).

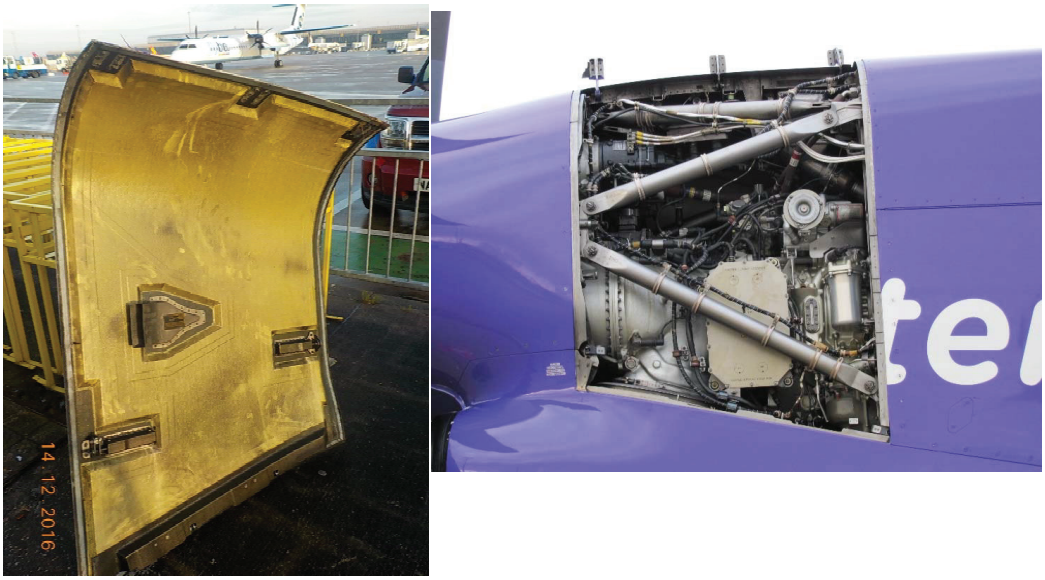

Figure 3

Engine access panel and nacelle

Inspection of the aircraft vertical stabiliser showed puncture holes in the skin on both sides, with impact marks also present on the leading edge de-icing boot. There was also impact damage to both VOR/LOC antennas.

Figure 4

Damage to vertical stabiliser (similar damage occurred on both sides of the vertical stabiliser)

Previous incident on the same aircraft

On 9 November 2016 the No 1 engine access panel was found missing from G-PRPC.

On the day before, it had arrived at Belfast City Airport at 2145 hrs following a day of routine operations. Engineers from the operator's subsidiary maintenance company met the aircraft and completed a routine daily check on the aircraft, which included checking the engine oil contents of both engines. After topping up the No 1 engine with oil, the engineer closed the access panel and completed the remaining parts of the aircraft check. The Technical Log for the aircraft was signed at approximately 0030 hrs.

Later that morning the flight crew arrived to prepare for the first flight of the day. At 0609 hrs the aircraft commander carried out a pre-departure inspection of the aircraft, which did not identify any issues. The ground crew responsible for departing the aircraft arrived at 0615 hrs and also conducted a walkround inspection. At 0643 hrs, the aircraft departed from Runway 22 for a flight to Glasgow Airport.

At 0700 hrs the flight crew from another departing aircraft from the same operator reported a foreign object on the runway. An inspection of the runway was carried out by Airport Operations at the request of Air Traffic Control and an engine access panel was recovered some 300 m from the threshold of Runway 22.

G-PRPC landed at Glasgow at 0715 hrs, at which time the ground handling personnel informed the flight crew that the No 1 engine access panel was missing from the aircraft. Further inspection also identified damage to the left wing leading edge de-icing boot and wing skin panel. The recovered access panel showed that all four latches were closed. There was no damage to the nacelle where the latching bolt receiving features were located.

Following this incident, on 29 November 2016, the operator issued Notice to Engineers (NTE) 22 requiring that:

> *'Following completion of all work either an independent person carries out a walkround inspection to verify all access panels are fitted/secure, or the certifying engineer must return after a notable period of time for a double check of the security of the disturbed panel security. The independent person could be a technician or a pilot, or the notable period of time could be after completion of paper work.'*

The NTE did not require the additional walkround inspection to be recorded in the maintenance paperwork or the aircraft Technical Log.

CCTV footage

Airport CCTV footage was recovered showing the commander's pre-departure inspection, which was done with the aid of a torch. The torch beam could be seen on various parts of the aircraft as the commander went to the nose of the aircraft first, then to the tail, followed by the No 2 engine and the landing gear. The commander then inspected the No 1 engine and the torch light could be seen on the access panel area. The inspection had a total duration of 3 minutes.

No CCTV footage was available for the period when the maintenance check was carried out on the No 1 engine.

Previous incidents on the global fleet

The manufacturer reported that there have been nine other incidents of engine access panel loss in-flight across the worldwide Q400 fleet. In each case there was no damage to the airframe latch bolt receiving fixture, suggesting that the panel latches had been closed incorrectly.

January 2017	Nacelle door detached
November 2015	No 1 nacelle outboard door detached
July 2015	Outboard door detached
August 2014	Nacelle door detached
July 2014	No 2 nacelle inboard door detached
December 2012	No 2 nacelle inboard door detached
April 2010	No 2 nacelle inboard door detached
July 2008	No 1 nacelle - outboard door detached
December 2005	No 1 nacelle inboard door detached

Human factors

Engineering

The maintenance carried out on the aircraft on the evening of 13 December was conducted by a third party maintenance provider under contract to the operator. Following the incident, the maintenance provider's staff based at Manchester Airport stated that they were unaware of the existence of NTE 22 at the time the work was carried out, so had not conducted any additional post-maintenance inspection to check the security of the latches and panels. The operator's safety investigation established that, unlike the operator-owned maintenance subsidiary, there was no procedure in place for contracted maintenance company staff to read and sign NTEs.

The routine daily check requirement was laid out in a set of task sheets where each task, once completed, required sign off by an engineer licensed on type. The list of the tasks commenced with checks to internal systems and components, identified as tasks 1 to 14. The first external check was task 15, which required a full external walkround of the aircraft checking for damage, leaks and panel security. Checking the engine oil content of each engine was listed as tasks 26 and 27. These tasks were highlighted as safety critical and had a requirement for an independent check of the oil cap (or repeat inspection after a period of time, in the case of a licenced engineer completing the task). There was no similar instruction regarding the closing of the panel. Whilst the task stated the oil contents check should be in accordance with the Aircraft Maintenance Manual (AMM), a subsequent review with the aircraft manufacturer confirmed that, at the time of this event, the AMM did not contain any instructions on opening or closing the engine access panel.

The operator's expectation was that each item on the daily check task sheet would be signed for. The individual pages would then be certified complete and an entry would be added to the aircraft Technical Log, stating that the daily check had been completed. The signed hard copies of the task sheets and Technical Log pages should then have been posted to the operator's HQ in accordance with their procedures. The operator's safety investigation identified that the contracted maintenance company was not certifying the individual tasks or task sheet pages, but was just adding an entry directly into the aircraft Technical Log. The hard copy documents were also not being sent to the operator.

Interviews with the engineers involved in both the first and second incidents identified a common technique used to secure the engine access panel. This involved closing the two upper latches first, followed by the two lower ones. Practical assessment of this technique showed that occasionally, as a result of a slight misalignment of the panel, it did not close correctly into the gap in the engine nacelle. Given the height of the panel and shorter distance to the hinge line, it was difficult to apply the necessary force to fully engage the panel at the level of the top latches, when compared to applying a similar force at the bottom of the panel. This could result in the top latches being closed, without the panel being properly located. As a consequence, the locking pin would not be engaged in the receiving fixture on the nacelle side, but the latch would externally look and feel as if it was properly closed. Once the upper latches were closed in this manner, the panel would rest on the

upper latch pins. Significant force could then be applied to the bottom of the panel while the lower latches were closed, but the pins would not engage in their receiving fixtures. The only external visual confirmation of the incorrect closure of the panel, was a small gap between the access panel and the surrounding nacelle panels (Figure 5).

Figure 5

Panel gap resulting from an incorrectly latched panel (viewed from the ground under similar lighting conditions to both incidents)

The engineers in both incidents involving G-PRPC were standing on steps to access the engine which meant once the access panel was closed, they were looking downwards at the panel and using a head torch to supplement the ambient lighting on the stand. Figure 6 shows how the perspective of the gap in the panel changes, when viewed under these circumstances. This would have been further exacerbated on the incident aircraft as the surrounding panels were painted purple rather than white, providing much less contrast to the shadow cast by the access panel.

Figure 6

View of the panel gap following incorrect closure, from the perspective of the engineer conducting the task.

The operator subsequently revised NTE 22 post-incident to introduce a procedure where a sticker is placed over the bottom of the panel, when it is closed post-maintenance. This provides visual and tactile confirmation to the engineer that the panel is correctly closed and secured.

Flight operations

The airline procedures for pre-departure inspection of the aircraft were documented in the Operator's Operations Manual Part B4 section 2.5.8 '*External Inspection*,' which stated:

> *'The external checks are normally performed walking clockwise around the aircraft starting at the front passenger door. Crews shall not open any panels as part of the external inspection, unless there is a specific reason to believe that a security threat exists, or the Crew is pre-selecting a refuel figure. Particular attention should be made to ensure that all panels, equipment bay doors, engine cowlings are properly closed and secure and all pitot and static ports are not damaged or obstructed.'*

The inboard and outboard engine access panels were also highlighted as a specific check item in the pre-departure inspection checklist. The operator provided information on what initial and recurrent training was provided for flight crew with respect to the pre-departure inspection. Guidance was provided at several points through the training which was delivered whilst walking around the aircraft:

- During an initial ground school hangar visit
- During base training
- During line training
- Assessed on final line check and then bi-yearly line check.

Following the first access panel loss in November 2016, the operator's Flight Operations department issued Notice To Air Crew (NOTAC) 146/16 - '*Engine Cowling and Hatches Inspection*', to request extra vigilance whilst conducting pre-departure inspections. The aircraft commander from the second incident on G-PRPC confirmed that he had read this document prior to the flight, but commented in interview that as he had previously been a flight engineer it did not contain any information that was new to him.

The commander stated that he was aware that a daily maintenance check had been signed for in the aircraft Technical Log and that this involved opening the engine access panels. When asked how he would normally assess that the access panel was secure, he stated that the latches would be flush. He advised that this was taught to him during his recent Q400 type conversion course, and was shown to him during the hangar visit and during his line training. (The commander had joined the operator five months earlier.)

Whilst the co-pilot had not been present during the pre-departure inspection prior to the accident flight, he stated that the securing of panels, including engine access panels, had been a classroom discussion on his Q400 type rating course. He had not had the opportunity to see a securely closed panel during the course hangar visit, as they had been open for maintenance at the time. He added that he had been shown the pre-departure inspection procedure by a co-pilot during his line training, who had not specifically highlighted the engine access panels as a check item.

Two further NOTACs (63/16 and 64/16) have subsequently been issued by the operator, to provide specific guidance in identifying correct panel and door closure during the pre-departure inspection and to highlight the engineering requirement to use a sticker over the engine access panel to confirm correct closure.

Ground operations

Ground operations personnel usually work for a company contracted to provide a service for the airport and facilitate the 'push back' procedure for aircraft parked on stands. This consists of using an aircraft tug to reposition the aircraft from the stand to a location where the flight crew can safely start the aircraft engines and taxi away under their own control. Typically a two-man team is used, one to drive the tug and a second who connects a headset to the aircraft intercom, allowing them to communicate with the flight crew and coordinate the process. They are not required to have any technical qualifications and often work on numerous different types of aircraft.

Before the aircraft dispatch process commenced, ground operations personnel were required to complete a final walkround check of the aircraft. Guidance for the task was provided in their Ground Operation Manual section 3.4.3.1:

> *'Before pushback can commence a final walkround and external visual inspection of the aircraft must take place. This should include an inspection of the condition of the apron including the removal of any FOD[1]; confirmation that all hold, passenger and service doors, panels and latches are closed and secure; chocks and ground equipment are removed from the aircraft and there are no other obstructions preventing the aircraft pushback onto the taxiway.'*

Ground operations staff did not receive copies of the operator's NOTAC or NTE. The ground handler during the second incident had completed headset training in April 2014. This training included pre-departure checks. The training certificate from this course listed different aircraft types that were covered by the training, but did not include the Q400. The headset training did not specifically refer to the Q400 type, but did include a generic reference to checking that panels and engine cowlings were closed.

Aircraft manufacturer's response

Advisory label

The aircraft manufacturer has commenced development of a modification to add an advisory label to the access panel which provides pictorial guidance on how to ensure the panel is correctly closed and latched (Figure 7).

Footnote

[1] Foreign Object Debris.

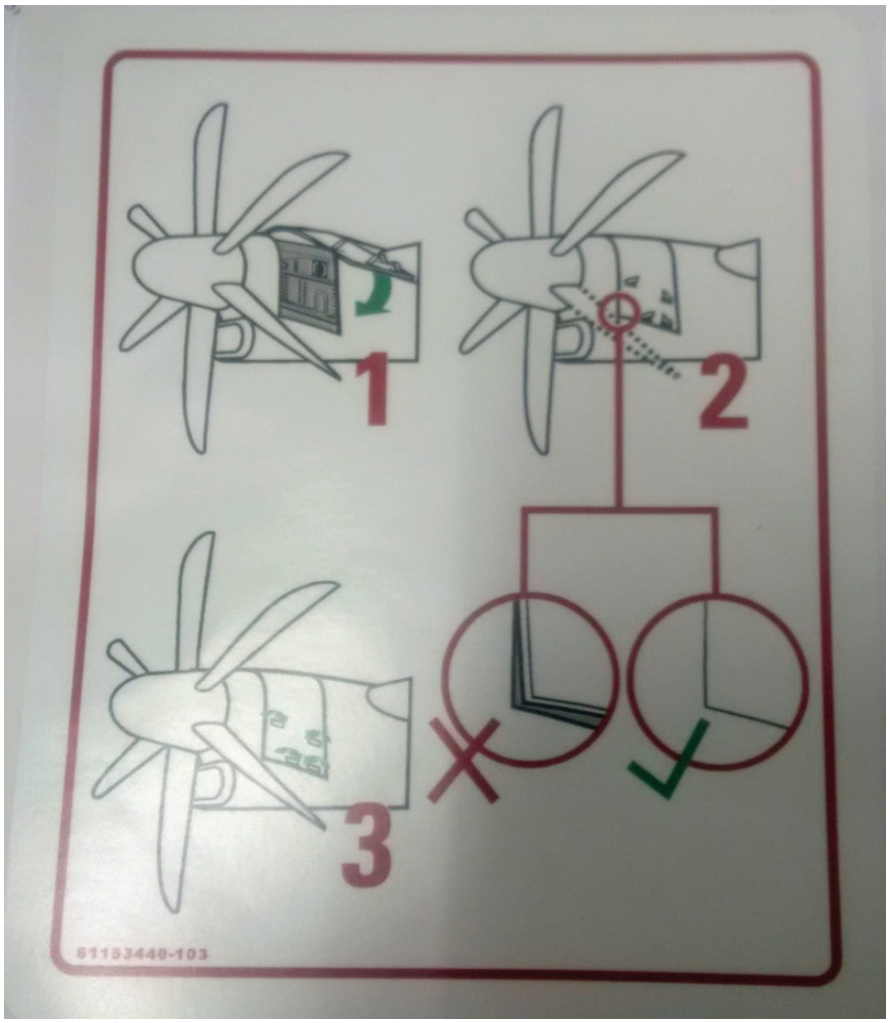

Figure 7
Advisory label modification

AMM Temporary Revision

Since this incident the aircraft manufacturer has issued AMM Temporary Revision 71-197, which includes instructions on how to correctly close the engine nacelle access door.

Analysis

On two separate occasions the outboard engine access panel on the No 1 engine on G-PRPC detached during takeoff. In both cases, the inspections of the panels and aircraft following the event showed that the locking bolts on the panel latches and the bolt receiving features on the nacelle had not failed or been damaged. In addition, the latches on the panels were confirmed to have been fully closed when the panels were recovered. As such, in both events the only explanation for the panels departing the aircraft during takeoff was that the bolts had not engaged in the receivers on the nacelle when the latches were shut. In this event, the aircraft sustained limited damage which did not compromise its ability to

complete the flight safely. However, there is the potential for more serious damage to occur and the departure of such a large panel from the aircraft could also endanger people on the ground.

Engineering

The engineers conducting the maintenance daily check prior to both incidents were experienced and well trained staff, who had safely completed the same task many times during the years preceding these incidents. They came from different companies, with separate training organisations and operated at different airports. No significant contributing factors were identified which differentiated these two incidents from any previous occasions that they had completed the same task successfully. The only apparent common links were the technique used to close the panel, the physical positioning of the engineer as this was done and the lighting conditions at the time.

The technique of closing the top latches first, when combined with an access panel which may not immediately fit into its correct position without additional adjustment, appears to have created the conditions for a sequence of events which allowed the engineer to close the latches believing that they had correctly engaged the locking bolts, when in reality this was not the case. The fact that the engineers were then looking down on the panel, which was predominantly illuminated by the beam from a head torch, meant that the main indication of the gap at the bottom of the panel was only visually identifiable by the shadow that was cast. As the surrounding panels were painted purple this may not have been obvious, particularly considering that the engineer was not expecting the panel to be open once the latches were closed, was not specifically checking for the presence of a shadow, and may not have appreciated the implication of the presence of a shadow in this position.

Aircraft manufacturer's safety action

The manufacturer's addition of an advisory label on the panel will assist in raising awareness of the implications of a gap/shadow around the panel. At the time of this accident the AMM did not contain a procedure for opening/closing the panel. Evidence from this investigation suggested that using the technique of shutting the top latches first could, in some circumstances, increase the likelihood of the panel being closed incorrectly and not being secured. It would therefore have been beneficial for an approved technique for closing the panel to be included in the AMM. The aircraft manufacturer has since published Temporary Revision 71-197 to the AMM to introduce these instructions.

Operator's safety action

The operator has modified the daily check task sheet to introduce a final check of engine access panel security. This includes the requirement introduced by the revised NTE 22 to place a security sticker over the panel edge to confirm that there is no gap present. The sticker acts as an additional visual confirmation for flight crew that the panel has been correctly secured. The operator has also introduced a requirement for subcontract maintenance organisations to receive copies of NTEs.

Flight operations

The operator's Operations Manual provides clear guidance on how a pre-departure inspection should be completed, which highlights the need for the security of the engine access panels to be checked. However, there is a degree of inconsistency in the way in which this is taught practically to flight crew during their type training. The results of this were shown in the CCTV footage of the pilot's inspection prior to the first incident, which did not follow the Operations Manual process. It was also identified by the co-pilot's response when questioned about his training experience. If flight crew are not shown the difference between correctly and incorrectly closed panels, misunderstandings such as the belief that closed latches confirm the panel is secure can become accepted custom and practice, and incidents such as this may continue to occur. The improved NOTAC issued by the operator should help to increase awareness amongst their existing flight crew community, but introducing improved and consistent training will provide an opportunity to increase awareness amongst flight crew converting to the Q400. The following Safety Recommendation is therefore made:

Safety Recommendation 2017-014

It is recommended that Flybe Ltd introduces defined and consistently delivered flight crew training on pre-departure inspections for the DHC-8-402 (Q400), compliant with the inspection procedure documented in its Operations Manual. This should include a practical element on the aircraft and a demonstration of correctly secured main engine access panels.

Ground operations

Whilst walkround checks by ground operations crew represent a final opportunity to identify issues such as obviously open access panels, the personnel involved are not technically qualified on type in the same way that engineers and flight crew are. The operator has no control over the quality and content of their training and the service may be provided by multiple companies across all the airports that the operator flies to. As such, their inspection of the aircraft should only be considered a gross check and cannot be relied upon to address issues such as closed but incorrectly secured panels. However, there is potentially some benefit to the operator in increasing general awareness using specifically targeted guidance information relating to safety issues. The following Safety Recommendation is therefore made:

Safety Recommendation 2017-015

It is recommended that Flybe Ltd considers introducing a means of disseminating pertinent safety information to ground operations staff in an appropriate format.

Conclusion

Following overnight maintenance work, the outboard engine main access panel on the No 1 engine was not securely closed by the engineer, due to the latch bolts not engaging in the nacelle receiving features when the latches were closed. Contributory factors may have been a slight mismatch in the closure of the panel and the technique used by the engineer of closing the top latches first. The resulting gap around the panel was not identified by the engineer completing the task, possibly as a consequence of the angle at which he was looking down on the closed panel and the lack of contrast of the shadow cast on the dark coloured engine nacelle.

The aircraft commander did not identify the incorrect closure of the panel during his subsequent pre-departure inspection, neither did the ground operations crew dispatching the aircraft. During the next takeoff, the panel failed at the hinge attachment points and departed the aircraft striking and damaging the vertical stabiliser, before coming to rest on the runway and its grass verge. The investigation identified a lack of consistency in the way flight crew were instructed on completing pre-departure inspections during their training.

A previous accident, where the same engine panel was lost during takeoff, had occurred on the aircraft a month earlier. The circumstances and investigation findings for both accidents were the same. Safety action has been taken by the aircraft manufacturer to add labelling and amend the AMM and the operator has revised its maintenance procedures. In addition, two Safety Recommendations have been made relating to flight crew pre-departure inspection procedures and dissemination of safety information to ground crew, with the intention of preventing recurrence.