SERIOUS INCIDENT

Aircraft Type and Registration:	DHC-8-402 Dash 8, G-JECI
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2005
Date & Time (UTC):	23 December 2008 at 1600 hrs
Location:	On approach to Edinburgh Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 59
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	6,926 hours (of which 150 were on type) Last 90 days - 109 hours Last 28 days - 45 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft descended below a cleared altitude and then below the ILS glideslope because the appropriate mode of the flight director was not selected. The deviation from the correct flight path was noticed by an ATC controller when the aircraft had descended to within 800 ft of local terrain approximately 5 nm from the runway threshold. The crew were advised accordingly and although the aircraft's descent rate was adjusted, it did not regain the correct vertical flight path, however, the aircraft landed without further incident. A subsequent event involving the same operator and aircraft type is also considered in this report.

Two Safety Recommendations are made and the operator and ATC unit have taken safety action aimed at preventing a recurrence.

History of the flight, G-JECI

The aircraft was being operated on a scheduled passenger service from Southampton to Edinburgh as BEE247S ("JERSEY TWO FOUR SEVEN SIERRA"). As it commenced its final approach to Runway 24 at Edinburgh the approach controller (APC) instructed the aircraft to turn onto a heading of 280° to intercept the ILS localiser, descend from 3,000 ft to 2,100 ft and maintain a speed of at least 160 kt until 4 nm from touchdown. During the descent the aircraft accelerated to approximately 200 kt with flap and landing gear up.

The aircraft did not level off as intended at 2,100 ft but continued to descend at a constant vertical speed such that it remained at all times below the ILS glideslope. At an altitude of approximately 1,800 ft, apparently without

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having noticed that the aircraft had descended below the cleared altitude before intercepting the ILS, the APC instructed the pilots to contact the aerodrome controller (ADC). At about this time Flap 5 was selected and the aircraft decelerated to approximately 180 kt.

The ground movement controller (GMC), who sat beside the ADC in the visual control room (VCR), saw the aircraft when it was approximately 5 nm from touchdown and noticed that it looked "substantially below the glidepath". He mentioned this to the ADC. When shortly afterwards the co-pilot called, "TOWER JERSEY TWO FOUR SEVEN SIERRA IS FIVE AND A HALF MILES TWO FOUR", the ADC responded "JERSEY TWO FOUR SEVEN SIERRA ROGER AND WE'VE GOT YOU FIVE MILES OUT SHOWING NINE HUNDRED FEET IS EVERYTHING OK".

The co-pilot replied "ERR AFFIRM JERSEY TWO FOUR SEVEN SIERRA". Not content with the response the ADC replied "JERSEY TWO FOUR SEVEN SIERRA HOW LOW ARE YOU PLANNING ON DESCENDING AT THE MOMENT". The co-pilot responded "ERR WE'RE GONNA LEVEL NOW ACTUALLY OUR GLIDESLOPE CAPTURE OBVIOUSLY FAILED JERSEY TWO FOUR SEVEN SIERRA". The controllers in the VCR saw the aircraft climb slightly and continue an apparently normal approach.

Attempting to regain the correct flight path manually, the commander initially experienced some difficulty disconnecting the autopilot and found that the aircraft tended to adopt a pitch attitude 8° below the horizon. When able to resume full control, at approximately 700 ft agl, he called for Flap 15 and landing gear down. The landing was completed without further incident.

After landing the commander and co-pilot discussed the event and decided that the most likely cause of the deviation from the intended flight path was failure of the ILS. They communicated this to the ADC.

Meteorological information

A report of meteorological conditions valid at the time of the event indicated a surface wind as 240°/1kt, visibility in excess of 10 km, temperature 10°C and dew point 7°C. Sunset was at 1542 hrs and the commander described the light conditions as "night".

Flight director control

The flight director (FD) on the Dash-8-402 provides lateral and vertical guidance displayed in the form of a vertical and horizontal bar on each pilot's Primary Flight Display (PFD). It can also be coupled to the autopilot (AP) for automatic control of the aircraft.

Pilots manage the flight director and autopilot engagement using a Flight Guidance Control Panel, (FGCP) mounted in the centre of the glare shield above the main instrument panel, and two buttons on each pilot's control wheel; a Tactile Control Steering (TCS) pushbutton[1] and an AP disengage switch.

The status of the FD is displayed on the Flight Mode Annunciator (FMA) at the top of each PFD. The FMA has three fields. Vertical guidance modes are indicated in the right field in white if armed and in green if active. A mode is considered to be engaged only when it is indicated on the FMA, not just when the associated pushbutton has been pressed. It is therefore vital for pilots to monitor the FMA in response to each selection on the FGCP or control wheel.

Altitude Select mode

In the ALTITUDE SELECT mode the FD provides commands to acquire and hold a selected altitude target.

Footnote

[1] When pressed the TCS pushbutton overrides the autopilot momentarily without disconnecting it. When the pushbutton is released the flight director modes update their targets to the roll, pitch, altitude, airspeed and vertical speed values at the moment of release.

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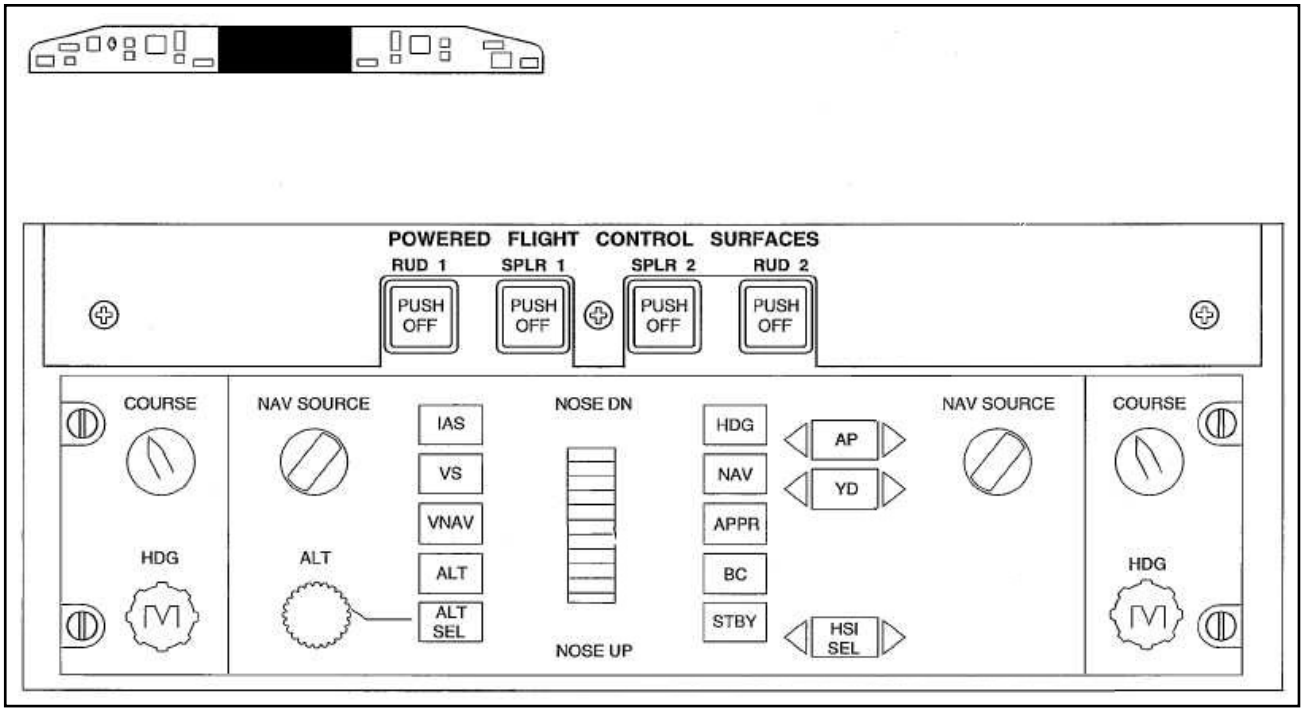

Figure 1

Flight guidance and control panel, location and functions

It has ARM and CAPTURE sub-modes. To operate the ALTITUDE SELECT mode, pilots must preselect an altitude target using the ALT knob, press the ALT SEL pushbutton to arm the mode and manoeuvre the aircraft towards the preselected altitude target using a FD vertical mode.

When armed, the symbol 'ALT SEL' appears in white on the FMA. If the ALTITUDE SELECT mode is not armed, the aircraft will continue through the selected altitude in the active vertical mode unless either pilot intervenes to change the flight path.

Vertical modes

The aircraft can be manoeuvred vertically in several modes using the FD and AP. The pilots of G-JECI used the VERTICAL SPEED mode to descend the aircraft below 3,000 ft. This mode is activated by pressing the VS pushbutton on the FGCP and indicated by the symbol 'VS' in green in the right field of the FMA when active. The desired vertical speed is selected using the pitch thumbwheel in the centre of the FGCP, labelled 'NOSE UP' and 'NOSE DN', and indicated beside the 'VS' symbol in the same FMA field.

With the AP engaged, and in the absence of further pilot inputs or system failures, as the aircraft approaches the selected altitude, the FD will change automatically to the ALTITUDE CAPTURE mode and the symbol 'ALT*' (referred to by this operator as "altitude live") will appear in green on the FMA. As the aircraft levels at the selected altitude, the FD will change automatically to the ALTITUDE HOLD mode and the symbol 'ALT' will appear in green on the FMA. If, before the FD enters a capture mode, the altitude selection is changed to one above the current aircraft altitude, the aircraft will continue to descend in the active vertical mode and in an 'open descent' until the pilots intervene to change the flight path.

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ILS Approach mode

The ILS APPROACH mode is a combined lateral and vertical mode in which the FD captures and tracks the ILS localiser (lateral) and glideslope (vertical) beams. When an appropriate ILS frequency is tuned and selected as the navigation source, the GLIDESLOPE sub-mode (and, simultaneously, the LOCALIZER sub-mode) is armed by pressing the APPR pushbutton on the FGCP and indicated by the symbol 'GS' in white on the FMA.

As the aircraft approaches the ILS glidepath, the FD will change automatically to the GLIDESLOPE CAPTURE mode and the symbol 'GS*' (referred to by this operator as "glideslope star") will appear in green on the FMA. Having intercepted the glideslope beam, the FD will change automatically to the GLIDESLOPE TRACK mode and the symbol 'GS' will appear in green on the FMA. If the vertical path of the aircraft remains below the ILS glideslope the FD will not be able to capture the glideslope and the aircraft will continue to descend in the active vertical mode unless the pilots intervene to change the flight path.

The GLIDESLOPE mode is deactivated if the localiser modes are deactivated, the pitch thumbwheel is operated or any other vertical mode is activated.

Flight director standby mode

The STBY pushbutton on the FCGP clears all active and armed FD modes and removes the flight director bars from the PFD if the autopilot is disengaged.

Proposed modification by manufacturer

The operator stated that prior to these events the aircraft manufacturer proposed to modify the FD software so that selection of the ALTITUDE SELECT mode would be automatic upon selection of a new altitude and vertical mode. Recent correspondence between the two parties indicated that the manufacturer had delayed implementation of the modification.

Ground proximity warning system

The ground proximity warning system monitors the flight path of the aircraft when its height is between 50 ft and 2,450 ft. The system compares aircraft position, attitude, airspeed and glideslope inputs with internal terrain, obstacle and airport databases to determine if the present flight path would result in impact with terrain and, if so, will provide visual and aural indications to alert the pilots.

It has five modes of operation. Mode 5 – *'deviation below glideslope'* operates when the following conditions are met:

- An ILS frequency is set
- The landing gear is down
- The aircraft is less than 925 ft agl
- The aircraft is below the glidepath
- The BELOW G/S pushbutton is not pushed

When activated the system provides the aural warning "GLIDESLOPE" accompanied by illumination of an amber BELOW G/S pushbutton on the glare shield in front of each pilot. An alert will occur if the aircraft descends 1.3 dots or more below the ILS glideslope. Further alerts will occur for each subsequent 20% increase in deviation. Below 300 ft agl, if glideslope deviation is 2 dots or more, the aural alert "glideslope, glideslope" is given at twice the volume of the single alert and every three seconds until the aircraft exits the warning envelope. The BELOW G/S pushbuttons remain illuminated until glideslope deviation reduces to less than 1.3 dots.

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Recorded information

Salient parameters obtained from analysis of the data from G-JECI's Quick Acces Recorder (QAR) for the incident are presented in Figure 2. The data starts just under four minutes before touchdown on Runway 24 at Edinburgh airport. At this point, the aircraft was flying straight and level at 3,000 ft amsl, with the landing gear and flaps retracted; the airspeed was 190 kt and decelerating. The autopilot was engaged with ALTITUDE HOLD mode and HEADING mode selected.

A heading of 280º was then selected, and as the aircraft turned, the autopilot was switched from ALTITUDE HOLD mode to VERTICAL SPEED with a descent rate of 1,100 ft/min.

Flap 5 was selected as the aircraft passed through 1,800 ft amsl. The aircraft was four dots right of the localizer and two dots below the glideslope. The autopilot was then switched from HEADING mode to LOCALIZER. The aircraft was now two dots to the right of the localizer so a turn to the left was initiated. The aircraft captured the localizer 20 seconds later at 1,250 ft amsl, 3.5 dots below the glidepath. The crew selected the Edinburgh Tower frequency and as the aircraft passed through 1,000 ft amsl they transmitted:

16:06:26 G-JECI	"TOWER JERSEY TWO FOUR SEVEN SIERRA IS FIVE AND A HALF MILES TWO FOUR"
16:06:30 Tower	"JERSEY TWO FOUR SEVEN SIERRA ROGER AND WE'VE GOT YOU FIVE MILES OUT SHOWING NINE HUNDRED FEET IS EVERYTHING OK"
16:06:38 G-JECI	"ERR AFFIRM JERSEY TWO FOUR SEVEN SIERRA"

With the aircraft at 800 ft amsl and four dots below the glidepath, the autopilot was disengaged and the descent rate was reduced to about 225 ft/min. Communications continued as the aircraft descended at the reduced rate and as the airspeed slowed from 185 kt to 150 kt:

16:06:48 Tower	"JERSEY TWO FOUR SEVEN SIERRA HOW LOW ARE YOU PLANNING ON DESCENDING AT THE MOMENT"
16:06:51 G-JECI	"ERR WE'RE GONNA LEVEL NOW ACTUALLY OUR GLIDESLOPE CAPTURE OBVIOUSLY FAILED JERSEY TWO FOUR SEVEN SIERRA"
16:06:57 Tower	"JERSEY TWO FOUR SEVEN SIERRA THANKS NOW SHOWING FOUR MILES OUT AT SIX HUNDRED FEET"
16:07:01 G-JECI	"THAT'S COPIED JERSEY TWO FOUR SEVEN SIERRA"

During the descent the landing gear was selected down, and by 630 ft amsl (still four dots below) and 3.5 nm DME[2], the gear was down and locked.

At 570 ft amsl and 3 nm DME, Flap 15 was selected and clearance to land was given. The aircraft commenced a short climb, reaching 750 ft amsl (0.5 dots below) about 20 seconds later, before completing an uneventful descent and landing.

Standard operating procedures

Part B4 of the company's operating manual, relevant to operation of the Dash 8-402 and referred to colloquially as "the B4", is intended to provide operating crew members with information on the technical, procedural and performance characteristics of the aircraft. Section 2.2 of this document, entitled *'Flight deck management'* states, in part:

Footnote

[2] Distance measuring equipment.

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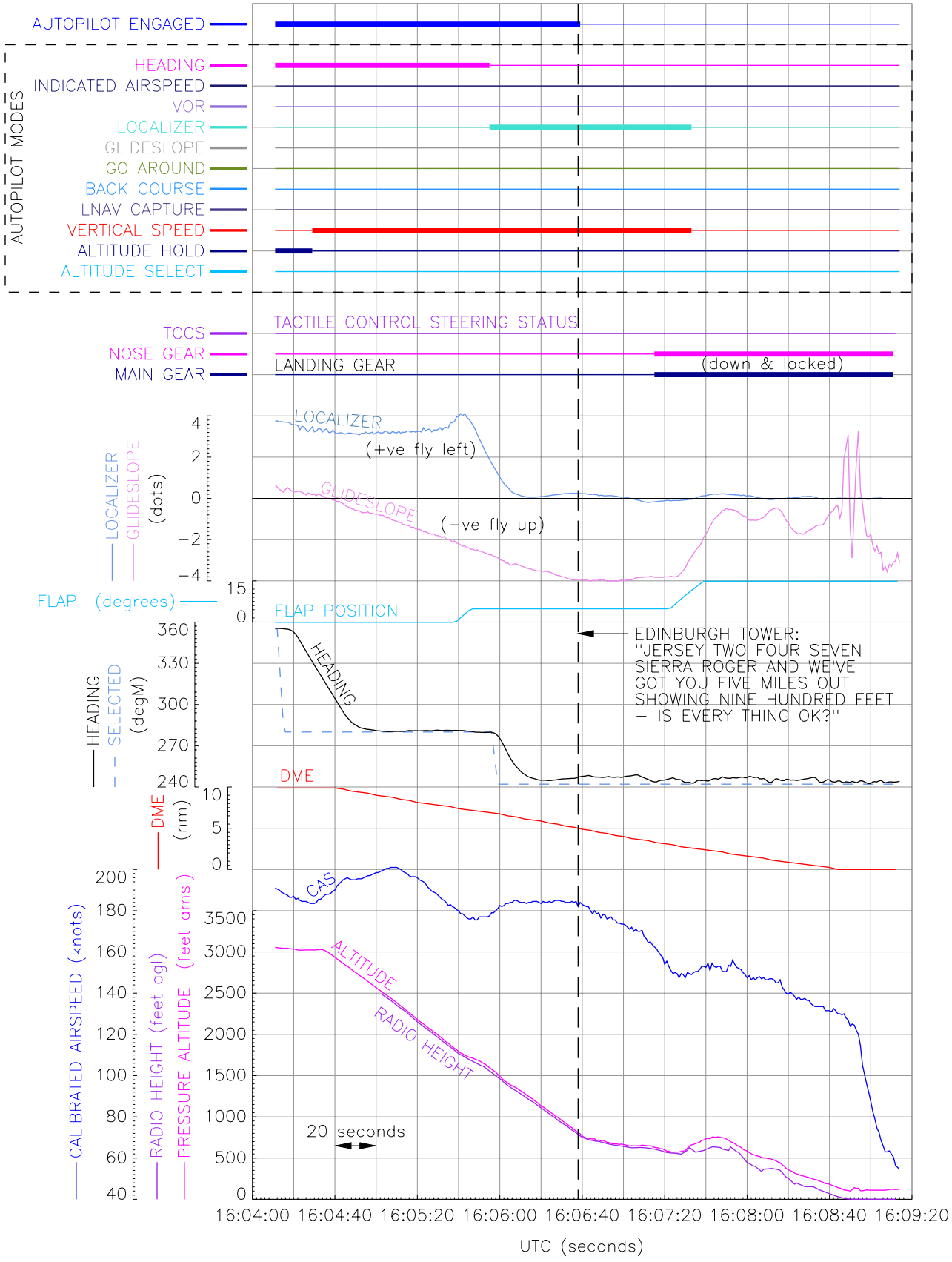

Figure 2

Salient FDR Parameters, G-JECI

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'Pilots must adhere to the company standard operating procedures (SOPs). It is important that each pilot knows what to expect of the other and that each pilot can perform his tasks without continual reference to the other for agreement.

'Occasionally, there is a need to depart from some aspect of the SOPs. In this case, the aspect should be clearly briefed and announced as **"non standard"***. Non-standard calls should be the exception rather than the norm. If difficulty is found in following these SOPs, it must be reported.'*

This section makes several references to the importance of monitoring the flight path of the aircraft, including the statement:

'PFs[3] main task is to fly the aircraft and monitor its flight path. PNF[4] must also monitor the aircraft flight path whenever possible whilst carrying out his other tasks.'

Section 2.13 – *'Approach'* describes the manner in which the approach phase of a flight is to be conducted. Under the heading *'stabilised approach criteria'* it states that when the aircraft is 4 nm from touchdown the following criteria *should* be met: landing gear down, flap at least 5° and speed not above 160 kt. At 500 ft agl (referred to as the "must gate") the following criteria *must* be met: landing gear down, landing flap set, speed V_{REF} +15 kt maximum, landing checks complete. It states that a go-around is mandatory if these criteria are not met.

Footnote

[3] Pilot flying.
[4] Pilot not flying.

The operator's procedure for conducting an ILS approach requires pilots to monitor the vertical profile by comparing the actual altitude of the aircraft to the altitude shown on published charts at a specific location on the approach such as over a marker beacon, a locator beacon or at a fixed distance from a DME transmitter. This is sometimes referred to as the "final fix". According to the B4 current at the time of the incident:

'Provided PF has called **"visual"***, no further reference to altitude is required and if the visual profile is normal, no reference to speed and sink.'*

Commander's perspective

The commander recalled that in making selections on the FGCP to descend from 3,000 ft to 2,100 ft he pressed the ALT SEL pushbutton and announced that he had done so. He observed LOC* on the FMA when the aircraft intercepted the localiser and then set the go-around heading. He recalled that when he announced "visual" (in sight of the runway) the PAPI[5] was showing 4 red lights. He commented that when he attempted to disconnect the autopilot to regain the required vertical flight path he may have pressed the TCS button. When he released whichever button he had pressed, the aircraft pitched nose down and continued to descend with the FD bar indicating an attitude 8° below the artificial horizon indicated on his PFD.

He recalled that approaching 4 nm the altitude check was incorrect and ATC queried the aircraft altitude. He then pressed the autopilot disconnect button to remove all automatic flight inputs and flew the aircraft manually to

Footnote

[5] Precision Approach Path Indicator. Four red lights indicate that the observer is more than 2.5° below the glidepath for which the system is calibrated.

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regain the required flight path. At 700 ft amsl he called for Flap 15 and landing gear down. He did not recall if there had been any GPWS "glideslope" warnings prior to the event. Although the speed of the aircraft as it approached 500 ft was higher than he intended, his earlier difficulties taking manual control of the aircraft persuaded the commander to continue the approach rather than execute a go-around and missed approach.

The commander assessed the causes of the event as excessive airspeed, a rushed approach and not complying with the standard operating procedures. He noted that the co-pilot's capacity to monitor the flight may have been reduced during the time he was changing frequency to call the ADC.

Co-pilot's perspective

The co-pilot recalled that the commander selected an altitude of 2,100 ft and pressed the ALT SEL button on the FGCP. He then received an ATC instruction to change to the Edinburgh Tower frequency.

The co-pilot stated that from this point in the approach he had been able to see the runway and was able to keep it in sight throughout the subsequent approach. He stated, however, that he "could not make out" the PAPI, although it did become visible when the aircraft was approximately 4 nm from touchdown. A mandatory check by pilots of aircraft altitude at the "final fix", regardless of weather conditions, would, in his opinion, improve monitoring and help to prevent a recurrence.

The co-pilot recalled seeing the magenta "cross hairs" of the FD centred over the aircraft attitude symbol on his PFD, indicating that the autopilot was correctly following the selected flight director parameters. He therefore assumed that the aircraft had captured the ILS glideslope.

Commenting on the difficulty that the commander experienced in raising the nose to regain the correct flight path, the co-pilot noted that, when engaged, the autopilot would have trimmed the aircraft to maintain the selected vertical speed and that the effort to overcome this trim may have caused the commander to believe he was encountering "control problems". Accordingly, at the "must gate" height of 500 ft the co-pilot was content with the commander's decision to continue the approach instead of executing a go-around.

The co-pilot stated that during the flight he was experiencing physical discomfort from a "back problem". For pain relief he had taken "one or two" tablets or capsules of an ibuprofen type analgesic approximately 5 hours before the incident. He concluded that although his performance was degraded by the affects of his back problem he did not believe he was suffering from fatigue.

His greatest concern during the approach had been what he considered to be the excessive speed of the aircraft, not its altitude.

Airport information

The Edinburgh control tower is situated towards the centre of the airport approximately 1 km from the Runway 24 threshold. Consequently an aircraft 5 nm (9.25 km) from touchdown on approach to this runway will be over 10 km from the tower.

The ATC watch manager stated that the PAPI would normally be on throughout the operating hours of the airport. The Airside Safety and Environment Coordinator for the airport stated that system function was checked visually and automatically throughout the day and that there had been no problems reported.

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Medical information

The "Medical" section of the United Kingdom Civil Aviation Authority (CAA) website provides general guidance on the use of "over the counter" medications by pilots which states, in part:

> *'If you need medication to 'make you feel better' you should not be flying unless your authorised medical examiner or medical adviser (who knows you are a pilot) has approved its use. Professional pilots should take advice from a doctor experienced in aviation medicine.*
>
> *If you have been taking a medication that can affect judgement, especially those with drowsiness or dizziness listed as potential side effects, a suitable period should elapse after the last dose to enable any effects to dissipate. If the dosage regime is 'every 4-6 hours' do not fly until 12 hours has elapsed after the last dose. If dosage is 'every 10-12 hours' do not fly for 24 hours'*

Subsequent event

History of the flight

On 8 May 2009 a Dash-8-402, G-JECK, departed Southampton on a scheduled passenger service to Glasgow with 60 passengers and four crew members on board. The commander was the pilot flying the aircraft. Before the flight the pilots were informed by the previous crew that earlier that day the aircraft had failed to follow an ILS glidepath in gusty conditions and that the yellow CAT 2 FAIL[6] amber caution had flashed in the FMA field of the PFD.

During the initial approach to Runway 23 at Glasgow Airport the pilots requested several heading changes to avoid adverse weather conditions. The approach controller cleared the aircraft to descend from 3,000 ft to 2,000 ft, turn onto a heading of 270° to intercept the ILS localiser and when established, descend further with the ILS glideslope. The commander selected a target altitude of 2,000 ft, armed the ALT SEL mode, activated the VERTICAL SPEED mode and set a vertical speed of -1,000 fpm (down). When the aircraft was established on the localiser, the commander also armed the GLIDESLOPE mode.

The aircraft encountered turbulence throughout the approach and its indicated airspeed fluctuated but with the AP engaged it appeared to follow the flight director guidance on what the commander considered to be a "normal descent profile". Both pilots reported that they could see the ground. The commander stated that at an altitude of approximately 1,100 ft the GPWS "glideslope" warning sounded, in response to which he disconnected the AP and deactivated the flight director by pressing the STBY pushbutton. Simultaneously, the ADC queried the aircraft's height. The commander then manoeuvred the aircraft to intercept the correct glidepath and landed without further incident.

Meteorological information

A report of meteorological conditions valid at the time of the event indicated a surface wind from 240° at 6 kt, gusting to 18 kt, visibility greater than 15 km with light showers of rain and hail, broken cumulonimbus cloud with a base at 2,000 ft, temperature 7°C and dew point 4°C. Sunset was at 2149 hrs and the commander described the light conditions as "twilight".

Footnote

[6] This indicates that the dual FD mode necessary for a CAT 2 ILS approach is cancelled. The operator stated that in its experience this can occur in gusty conditions if the aircraft is unable to follow FD commands in ILS mode.

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Recorded information

Salient parameters from the QAR for this flight are presented in Figure 3 which start about six minutes before touchdown on Runway 23 at Glasgow Airport. At this point, the aircraft had levelled at 3,000 ft amsl, the landing gear was up, the flaps retracted and the airspeed was 190 kt. The autopilot was also engaged with ALTITUDE HOLD mode and HEADING mode selected.

A heading of 300º was selected and as the aircraft turned, the flaps were extended to the Flap 5 position. The selected heading was then changed to 300º and the autopilot was switched from ALTITUDE HOLD mode to VERTICAL SPEED with a descent rate of 1,000 ft/min.

As the aircraft passed through 2,600 ft amsl, the autopilot was switched from HEADING mode to LOCALIZER. The aircraft was 3.5 dots right of the localizer and one dot below the glideslope at 9 nm DME.

The aircraft continued descending at 1,000 ft/min, turning to the left, and intercepted the localizer at 7.5 nm DME and at 2,150 ft amsl (1.5 dots below the glideslope). By 1,600 feet amsl the landing gear was down and locked. The flaps were then moved to Flap 10 then Flap 15. The first GPWS "glideslope" warning was recorded at 5.4 nm DME as the aircraft descended through 975 ft agl, 3 dots below the glideslope.

Initially the aircraft continued to descend with the same vertical speed but after the second GPWS "glideslope" warning was recorded at 920 ft agl and 5.3 nm DME, the autopilot was disconnected and the rate of descent reduced. The third GPWS "glideslope" warning was recorded at approximately 730 ft agl and the aircraft continued in level flight over slightly rising ground. At 630 ft agl, 4.1nm DME the fourth GPWS glideslope warning was recorded. The aircraft remained in level flight with a full "fly up" indication on the glideslope indicator and the final GPWS "glideslope" warning was recorded at 4.0 nm DME. The aircraft intercepted the ILS glideslope at 3.6 nm DME, and continued to an uneventful landing.

Safety investigation by the operator

The aircraft QAR data was downloaded by the operator's flight safety department on 26 May 2009, almost 3 weeks after the event. The proprietary flight data monitoring (FDM) tool, used by the operator, did not automatically register an event requiring investigation by the flight safety department. Operational issues relating to the incident involving G-JECK were first identified on 31 July when, having found no fault with the ILS system, the operator's maintenance department requested that the Flight Safety Manager (FSM) examine flight data relevant to the flight.

When interviewed by the operator, both pilots recalled seeing a green GS* symbol on the FMA, although there was no record of this annunciation and other data indicated that the aircraft did not get close enough to the glidepath for this annunciation to appear. The FSM suggested to the pilots that they may have misidentified LOC* as GS*, because selection of the go-around altitude occurred almost coincidentally with localiser capture, whereas the go-around heading was not selected until approx 2 seconds later. The FSM concluded, however, that selection of the go-around heading followed correct identification of LOC* and that something else triggered selection of the go-around altitude.

The pilots may have had reduced confidence in the accuracy of the glideslope presentation on the PFDs with the knowledge that the aircraft had failed to follow the glideslope on an earlier approach. However, having examined data for that flight the FSM concluded that

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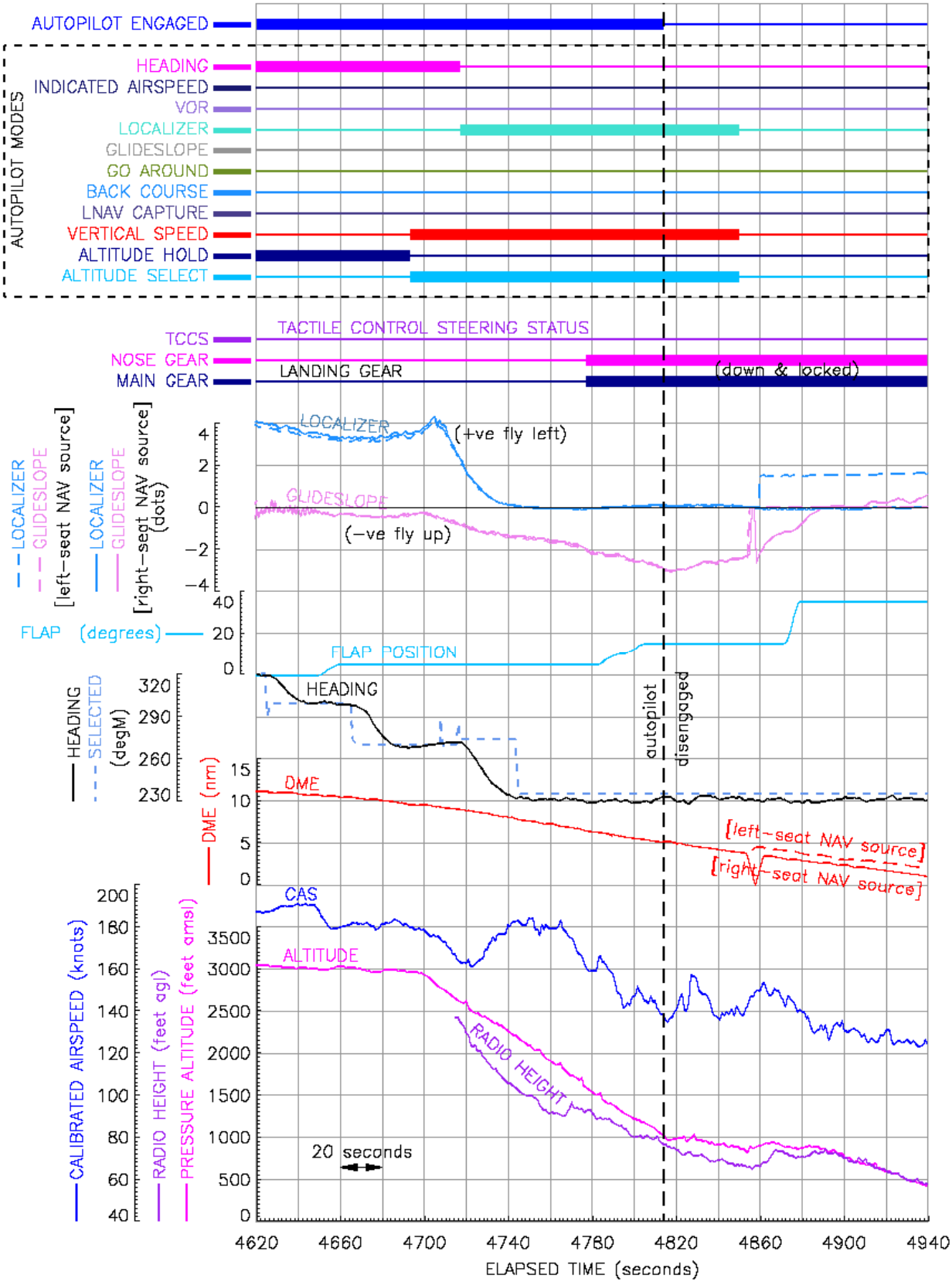

Figure 3

Salient FDR Parameters, G-JECK

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on that previous approach, the aircraft had followed the glideslope adequately in what he described as "moderate turbulence" with winds in excess of 40 kt.

The commander stated that his main reference was the FD display. Assuming that the pilots would have altered the vertical profile had they been aware that the aircraft was lower than intended, it is probable that no checks were made of the approach profile until either the GPWS "glideslope" warning activated or ATC queried the height of the aircraft. The operator's standard procedures did not require such a check if the pilot flying had called visual, which he could have done in these conditions. Neither pilot could recall if the commander had made the visual call.

The Emergency Checklist (ECL) states that on receipt of a GPWS "glideslope" warning the response is to stop descent and regain the glideslope. The pilots of G-JECK did so by flying level to regain the glidepath.

The human factors element of the operator's investigation found that neither pilot felt fatigued or unwell. Both pilots were certain that they had seen a 'GS*' annunciation on the FMA before setting the go-around altitude, although neither could recall seeing 'ALT' or 'ALT*' indications prior to this.

Both pilots stated that although they were able to see the runway as the aircraft descended below 2,000 ft, it was not immediately obvious that the aircraft was below the correct glidepath.

Nevertheless the commander stated that during the final approach something "felt wrong" and he became preoccupied with trying to identify the cause of his unease. He stated that although the FD "looked correct", both he and the co-pilot became aware visually that the aircraft was descending below the correct vertical path. The commander stated that he continued to follow the FD commands because that is what he had been trained to do.

The co-pilot could not remember checking the aircraft height at 4 DME. Doing so would have provided an opportunity to determine that the aircraft was 649 ft below the ILS indicated glideslope. The pilots were inclined to suspect a problem with the ILS installation, either on the ground or in the aircraft, because of information from the previous pilots. The co-pilot stated that he moved his hand behind the power levers in anticipation of a missed approach but did not initiate one because the rate of descent had been reduced and the aircraft was stable, albeit very low.

The operator made the following observations:

- The pilots set the go-around altitude before the flight director entered a capture mode (GS* or ALT*), causing the aircraft to continue to descend at the selected vertical speed.
- The pilots did not monitor aircraft behaviour adequately during the approach and aircraft profile.
- Knowing that a previous crew had reported a problem with the aircraft ILS system the pilots may have suspected failure, rather than mis-selection, of the associated FD modes.
- Weather avoidance may have been a distraction.
- The commander followed FD guidance with little or no reference to other available data.

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The operator also noted that the ECL did not give clear guidance on what action to take in the event of a GPWS "glideslope" warning.

Minimum safe altitude warning (MSAW) equipment

MSAW utilises secondary surveillance radar[7] and trajectory tracking to determine if an aircraft is at risk of controlled flight into terrain (CFIT). In a policy paper of 22 April 2002 entitled *'Implementation of Minimum Safe Altitude Warning (MSAW) equipment in the UK'*, the CAA determined that:

> *'The system is technically complex (due to the need to compensate for radar processing delays) and requires careful installation, commissioning and operation to ensure that false alert occurrences do not present a hazard to operations.'*

The paper concluded:

> *'Mandating the installation of MSAW facilities in all radar display systems is not justified because:-*
>
> - *Improved Aircraft Equipment (e.g. GPWS, TAWS[8]) is available*
> - *Low level SSR coverage is limited*
> - *Cost benefit analysis does not conclusively support mandatory action'*

Two of the operational radars at Edinburgh are equipped with MSAW for trial purposes but the system was not active at the operational positions used by Air Traffic Control Officers (ATCOs) controlling G-JECI.

Occurrence reporting

Civil Aviation Publication (CAP) 382 – *'The Mandatory Occurrence Reporting Scheme'* published by the CAA states, in part, that:

> *'The objective of the MOR Scheme is to contribute to the improvement of air safety by ensuring that the relevant information on safety is reported, collected, stored, protected and disseminated.'*

Under the heading *'Items to be reported'* it states:

> *'A reportable occurrence in relation to an aircraft means any incident which endangers or which, if not corrected, would endanger an aircraft, its occupants or any other person.'*

And:

> *'A report should be submitted on any occurrence which involves, for example, a defective condition or unsatisfactory behaviour or procedure which did not immediately endanger the aircraft but which, if allowed to continue uncorrected, or if repeated in different, but likely, circumstances, would create a hazard.'*

Section 11 of Part A of the operator's manual, entitled *'handling of accidents and incidents'* details the procedures that the operator wishes pilots to follow in the event of an accident or incident. It contains a list of examples of serious incidents that should be reported, including *'controlled flight into terrain only marginally avoided'*. It also states that:

Footnote

[7] A radar system in which a suitably equipped aircraft can respond to transmissions from a ground installation to provide information other than range and bearing, such as altitude and aircraft identification.

[8] Terrain Awareness Warning System.

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> *'Air Safety reports are to be used to report any incident which may or may not be reportable under the MOR scheme.'*

CAP 493 – *'Manual of Air Traffic Services – Part 1'* contains procedures, instructions and information intended to form the basis of air traffic services within the United Kingdom. It defines a serious incident as one involving circumstances which indicate that an accident nearly occurred. It states:

> *'The AAIB are the final arbiters in deciding whether the incident will be considered serious and so, if doubt exists, an incident should be reported rather than excluded.'*

It gives several examples of incidents likely to be considered serious, including:

> *'Controlled flight into terrain only marginally avoided.'*

Reporting by flight crew

The commander of G-JECI stated that he attempted to file an air safety report (ASR) shortly after the accident but was unable to do so until 6 days after the event, first because of problems with the operator's electronic ASR system and then due to administrative difficulties. The commander of G-JECK filed an ASR in accordance with the operator's procedures.

Reporting by Edinburgh Air Traffic Control Unit

The incident involving G-JECI was not reported at the time by the controllers on duty and no information was logged in the watch log. Managers of the unit conducted an investigation when they became aware of the event following a request from the operator for information.

The ATC investigation found that before passing control of the aircraft to the ADC the APC appeared "busy on the frequency" and did not notice that the aircraft had already descended below its cleared level. The ADC indicated that when first challenged, the pilots of G-JECI did not appear concerned. When, after a period of observation, the ADC again notified the pilots that the aircraft was significantly below the glide path the "tone of voice" of the responding pilot became "stressed".

The ATC investigation determined that collectively the controllers assisted in preventing the aircraft from descending into terrain. It noted that the GMC reported "fluctuations" in the ILS glideslope to the airport telecommunications engineers in accordance with the pilot's comments but that otherwise controllers did not file a report of any kind. It was apparent that not all Air Traffic Control Officers (ATCOs) at the unit were aware of when a report was required.

The ATC investigation concluded that although the ATCOs helped to resolve the situation, "more proactive measures could have been taken to significantly reduce the possible risk of controlled flight into terrain". It noted that the investigation was delayed due to the lack of reporting.

Analysis

Flight director operation

In the case of G-JECK the vertical modes were armed but the target altitude was reselected to a value above the current aircraft altitude before the FD captured the glideslope. In both cases, starting from a position below the ILS glideslope and with a vertical speed sufficient to remain below it, the aircraft could not intercept the glideslope even if the ILS APPROACH mode was armed. Both incidents demonstrate the importance of ensuring that the desired FD modes are indicated in the FMA

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field of the PFD. It is not sufficient simply to press the associated buttons.

Both incidents appear to have been initiated by FGCP selections which resulted in FD modes other than those intended by the pilots. In the case of G-JECI, recorded data indicates that the ALTITUDE SELECT mode was not armed after selection of a lower altitude. This problem would be alleviated if the ALTITUDE SELECT mode was automatic upon selection of a new altitude and vertical mode, as is the case on several other aircraft types and as envisaged by the aircraft manufacturer in its discussions with operators. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2009-005

It is recommended that Bombardier Aerospace enable automatic arming of the altitude select mode of the flight director fitted to Dash-8-400 series aircraft upon selection of a new altitude and vertical mode.

Standard operating procedures

The conditions were such that a visual approach could be conducted and a "final fix" check was not required under existing operator procedures. However, as a procedure already exists for making such a check, its use on all instrument-based approaches, even those flown in visual meteorological conditions, would not introduce additional complication but may assist pilots' monitoring of the vertical flight path. Accordingly, the following Safety Recommendation is made:

Safety Recommendation 2009-006

It is recommended that Flybe consider amending its standard operating procedures to require an altitude check whilst on final approach even when the pilots are in visual contact with the runway.

In relation to this Safety Recommendation the operator is in the process of reviewing the approach procedure such that pilots must make a "final fix" check even if they are conducting the approach visually.

Having determined that the aircraft was substantially below the intended flight path the pilots took action to regain it. In the case of G-JECK the recovery flight path was essentially level, in accordance with the procedure described in the ECL for responding to the GPWS "glideslope" warning, namely to *'Stop descent, regain glideslope'*. The FSM indicated that the operator would prefer pilots to take positive action to climb the aircraft to regain the proper profile and has taken the safety action noted below.

In each case, failure of the aircraft to maintain the intended flight path indicates either that the pilots chose not to follow the ILS glideslope or that they were unaware that the aircraft was not following it. The latter would indicate that the pilots were not monitoring the FD against other data such as basic indications of ILS glideslope and localiser deviation, commonly referred to as "raw data".

In its Operating Manual, the operator refers several times to the importance of monitoring the flight path.

ATC issues

In the case of G-JECI, deviation from the cleared altitude was not identified by the APC and the subsequent descent of the aircraft below the normal glidepath was not identified by the ADC. The proximity of the aircraft to terrain was eventually identified by the GMC, who had no formal role in this phase of flight. At the point that he did so the aircraft was approximately 10 km away from the tower. Any reduction in visibility below 10 km would have delayed the moment at which the GMC

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was able to see the aircraft and determine that it was lower than usual. Had visibility degraded to 6 km the GMC might not have seen the aircraft until its original flight path intercepted local terrain. Correct operation of the GPWS would then have been the only warning of impending flight into terrain.

In its policy paper of 2002 the CAA concluded that mandatory installation of MSAW was not justified, but the Edinburgh ATC concluded in its own report that MSAW equipment already installed for trial purposes should be considered for operational use.

Safety action

Safety action by the operator

The General Manager responsible for DASH-8-402 operations indicated that the company is considering a change to the ECL to reflect the procedure that the operator expects its pilots to adopt in response to a GPWS "glideslope" warning. Because the wording of the ECL follows that of the aircraft manufacturer's original document the General Manager has undertaken to liaise with the manufacturer to achieve the appropriate change.

At the request of the FSM, the FDM tool provider has activated parameters within the system that will in future highlight events such as those involving G-JECI and G-JECK during routine FDM operations.

Safety action by Edinburgh ATC

Edinburgh ATC took the following safety action:

1. The issue of whether high controller workload contributed to the APC not identifying the initial altitude deviation will be highlighted in unit publications.

2. The example of the incident involving G-JECI will be used to reiterate the need for ATCOs to comply with the provisions of CAP382.

3. The unit has emphasised to its controllers the correct action to be taken in the event an aircraft becomes dangerously positioned on final approach.

The unit will also consider the operational use of MSAW.

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