SERIOUS INCIDENT

Aircraft Type and Registration:	Jetstream 4102, G-MAJV
No & Type of Engines:	2 Honeywell TPE331-14GR-901H turboprop engines
Year of Manufacture:	1995
Date & Time (UTC):	9 April 2008 at 0804 hrs
Location:	Climbing through FL90 north-west of Aberdeen
Type of Flight:	Non-scheduled Commercial Air Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 10
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	12,000 hours (of which 4,000 were on type) Last 90 days - 60 hours Last 28 days - 28 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft departed Aberdeen in snow and freezing conditions, but had not been de-iced and anti-iced appropriately. During the climb the elevator became jammed by ice. The crew used changes in power and higher forces on the elevator controls to gain sufficient control to descend into warmer air, where the ice melted. Two Safety Recommendations are made. The investigation also identified that the commander's fitness to fly, coupled with pressures he may have felt to operate the flight, may have been contributory factors in the incident.

History of the flight

The crew of two pilots and one cabin crew member reported for a planned 0645 hrs departure from Aberdeen to Vagar in the Faroe Islands. The operator had categorised Vagar airport as category 'C', meaning that special training was required for pilots to operate there. The commander, who worked on a freelance basis for the operator, had been engaged specifically to operate the flight as no other captain was available to do it at Aberdeen. He had travelled to Aberdeen the previous afternoon and spent the night in a local hotel.

The commander was recovering from a bad cold and reported that he had not slept "that well". Before the duty started, he discussed his fitness to fly with the co-pilot, saying he felt well enough to operate but that he would monitor his own performance as the duty went on. He had taken a soluble Aspirin the night before. The co-pilot reported that he was fully fit and had slept well.

The flight crew examined the weather and NOTAM information and planned the day's flying. The commander was to be pilot flying for the first sector. The weather in Aberdeen was inclement, with snow falling and lying on the ground in a temperature of 0°C. The aircraft was parked on a remote stand. He was aware that "there were clearly delays" over de-icing and ramp handling and called the company's operations staff to inform them that the flight would not depart on time. The commander recalled that the general situation regarding de-icing and despatch of aircraft was somewhat "chaotic". The flight crew decided to arrange to have the aircraft de-iced before departure, and the co-pilot spoke to the ground staff to arrange this.

The crew walked to the aircraft, where the commander carried out the walk-round inspection. He noted that "although there were some contaminants on the airframe, they were loose" and that he "could not see any sign of ice". Despite this, it was still the commander's intention that the aircraft should be de-iced before departure. He described that "it took some considerable time" for the aircraft to be fuelled and then moved to a suitable stand for loading. Both pilots were aware that de-icing and anti-icing of other aircraft was taking place, and appropriate equipment and personnel were at work, and would in due course be available to them. Their perception was that waiting for de-icing would incur a delay, and they communicated this to the company's operations staff. The airport's records showed extensive delays to departing flights.

Once the aircraft had been re-positioned, the commander carried out another walk-round. He decided that the aircraft "probably did not require fluid de-icing, and that the contaminants could be swept off". He instructed the ground crew to do this.

The commander joined the co-pilot on board the aircraft which was loaded with 10 passengers, 16 bags, and 53 kg of freight. The departure fuel was 2,370 kg, and the takeoff weight was 10,310 kg. The centre of gravity was calculated to be within the envelope and towards the aft end.

While the aircraft was being loaded, two members of the engineering company's ground staff arrived at the aircraft and began sweeping the snow from the wing surfaces. The flight crew continued preparing for flight, also observing the sweeping taking place. In due course, one of the ground staff stood in front of the aircraft and gave a 'thumbs up' signal to the commander. The commander stated that at this time he "was happy that the wings were clear" and that he "clearly made the assumption that they had done the tail section". Following this incident, the commander had no particular recollection as to how he came to this assumption.

The flight crew started the engines, powered back, and taxied for departure. Throughout this time, light snow was falling, and the RVR was varying between 1,100 and 1,400 metres; the temperature was still 0°C. The co-pilot noticed that there was light contamination of snow flakes on the wings. During taxi, the flight crew checked the flying controls "a number of times"; on one occasion the co-pilot remarked to the commander that he thought the controls felt a little heavier than usual. The commander then exercised the elevators and concluded that they felt "normal". As the aircraft lined up for takeoff, a further control check was carried out.

The aircraft took off uneventfully, and climbed into cloud at about 200 ft aal. Soon after takeoff the co-pilot looked at the wing on his side and saw that it was "completely clear". The commander reported that the rotation and handling in the climb "seemed to be normal". However, he delayed engaging the autopilot for a time, to ensure that the handling was normal.

The co-pilot established contact with Scottish Control and the aircraft was cleared to climb to FL240. The commander engaged the autopilot in IAS mode at a commanded speed of about 170 kt, with the engines at climb power. He recalled later that the conditions were light precipitation in IMC, with light rime ice building up on the airframe.

The flight crew recalled that, as the aircraft passed about FL90, the autopilot pitch trim warning activated. The commander disengaged the autopilot and found that the elevators were immovable, while the ailerons seemed normal, and he sensed that the rudder was also free. He informed the co-pilot of the problem, and handed control to him to assess whether his controls were similarly affected. The aircraft continued climbing and at about FL100 the aircraft climbed out of IMC and into blue sky. The commander reported that he was "now certainly quite concerned", and informed the co-pilot that he thought they should declare a MAYDAY and divert. He was mindful to avoid flying into IMC again and aware that the additional fuel load offered the opportunity to fly for some time to find a safe destination.

The commander made a MAYDAY call to ATC, stating that he had problems with the elevator controls and that he did not have full control of the aircraft in pitch. He informed the cabin crew member of the difficulty and instructed her to prepare for an emergency landing. Although the company's operations manual specified that the NITS[1] format should be used when communicating emergency landing instructions to cabin crew, the commander did not use the format. The cabin crew member did not read back the instructions and prepared for a normal landing. The co-pilot made an announcement informing the passengers of the circumstances.

Controllers at the Scottish Area Control Centre informed the Distress and Diversion Cell and the Rescue Co-ordination Centre at RAF Kinloss. Two RAF Tornado aircraft were tasked to intercept the aircraft, and flew to take position approximately half a mile astern of it. A Search and Rescue helicopter was also tasked in case an accident ensued.

The flight crew saw that the weather ahead of the aircraft and towards Wick looked clearer than that behind them. After consulting with the co-pilot, the commander decided to divert to Wick and to descend the aircraft into warmer air, maintaining VMC, in the hope that the controls would free. Both pilots applied strong forces to the control columns and stated afterwards that they felt that there may have been a small amount of movement in the elevator control. With both pilots forcing the controls forward, and with changes in power, they gained some control of the aircraft in pitch, and following a series of pitching oscillations, the aircraft began to descend. The commander also experimented with using elevator trim to control the aircraft but concluded that, although the trim system seemed to operate correctly, its operation had no apparent effect on the aircraft's pitch attitude.

Still maintaining VMC, the flight crew prepared for an arrival at Wick. During the descent, they continued to

Footnote

1 NITS: Nature of the problem, Intentions, Time before landing, Special instructions.

apply force to the control columns in pitch and at about 4,000 ft amsl the controls suddenly became free and control was regained. The commander then carried out a precautionary and deliberate "handling check" to establish that the aircraft was fully under control.

During the approach the flaps were set, in stages, to FLAP 25. However, to avoid possible control difficulties during the landing, the flaps were then retracted to FLAP 15, and the aircraft landed without difficulty and taxied in to park.

As the aircraft landed, eyewitnesses saw material fall from the tail of the aircraft. Subsequent inspection of the runway revealed large fragments of ice laterally across the runway at the point of touchdown, in a path between four and six metres wide[2]. One eyewitness stated that, after landing, the aircraft's wings were clear of contaminant, but "the top of the fuselage had a coating of ice on it". As the engines were shut down, ice was blown from the tailplane. Personnel who inspected the tailplane from a step ladder after shutdown noted that ice was present in the elevator hinges and that when the elevators were exercised, more ice fell.

Meteorological information

Three METARs showing the conditions at Aberdeen before the aircraft's departure are reproduced below:

EGPD 090650Z 06003KT 1500 R34/1200 +SN OVC015 00/M01 Q0996 TEMPO 4000 –RASN=
EGPD 090720Z VRB02KT 1600 R34/1100 SN OVC012 00/M00 Q0996 TEMPO 4000 –RASN=
EGPD 090750Z 00000KT 1600 R34/1100 SN BKN006 OVC010 00/M00 Q0996 TEMPO 4000 –RASN=

These METARs described cold and snowy conditions, with light winds, visibility around 1,550 m, a runway visual range of around 1,150 m in snow or heavy snow, low overcast cloud, and a temperature on the ground of 0°C.

Aircraft description

The Jetstream 41 is a low-wing twin-turboprop aircraft of conventional construction. It has a cruciform tail with the horizontal tail set 3.8 metres above the ground. Some of the upper wing surface is visible from the flight deck, but the upper surface of the horizontal tail cannot be seen. During ground servicing, the top of the horizontal tail can only be seen or accessed by means of a 'cherry picker' or similar equipment. The wing is sufficiently low to the ground that it can be viewed by personnel standing next to it and swept without special access equipment.

The Jetstream 41 is equipped with de-icing and anti-icing systems. The de-icing system comprises pneumatic rubber boots on the leading edges of the wings, tailplane and fin. Anti-icing is provided by electrically operated heater mats on the elevator horn, electrically-heated air data system sensors, windscreen heaters, washers and wipers, together with engine anti-icing using engine bleed air, and electrically operated heating mats on the propeller.

The pitch control system connects the two control columns via pushrods, cables and the elevator final drive quadrant to the elevator surface. The left and right elevator systems can be split by means of a disconnect control that allows each side of the system to move independently. Operation of the disconnect disengages a clutch in a torque shaft that connects the two control columns; this cannot be re-engaged in flight.

Footnote

[2] The Jetstream 41 horizontal tailplane is 6.7 metres wide.

The wing has trailing edge flaps with four positions: UP; FLAP 9; FLAP 15; and FLAP 25.

Aircraft examination

The aircraft was examined by the AAIB at Wick the day after the incident. The examination showed no defects in the de-icing or anti-icing systems.

The pitch control system was inspected in accordance with the maintenance manual and no anomalies were found; the disconnect control had not been operated. The pitch trim system was also checked and found to be working correctly.

Previous incidents have been reported where both the elevator manual trim wheel and the condition lever friction wheel had jammed and were immovable. The condition lever friction wheel, which rotates about a common shaft with the elevator manual trim wheel, can make contact with the trim wheel if a circlip, designed to prevent axial movement of the trim wheel along the shaft, becomes displaced. When the condition lever friction was tightened on G-MAJV, the elevator trim wheel remained free to move, indicating that the circlip was correctly positioned.

Another possible explanation for the loss of pitch control was that repetitive application of thickened de-icing fluids could have led to a buildup of residues in aerodynamically 'quiet' areas such as wing and stabiliser trailing edges and rear spars. This residue can re-hydrate, and increase in volume to many times its original size during flight and freeze under conditions of cold temperatures, high humidity and/or rain, causing moving parts such as elevators, ailerons, and flap actuating mechanisms to stiffen or jam in flight. There was no evidence of any 'gel' residues around the elevator. Water was sprayed on the surface in order to re-hydrate any dried residues which may have been present but none was apparent.

The aircraft was returned to service and no further control difficulties were reported.

Recorded information

The aircraft was fitted with a solid state Flight Data Recorder (FDR) and solid state Cockpit Voice Recorder (CVR). Both recorders were removed from the aircraft and downloaded at the AAIB. The CVR contained a 30-minute four-channel recording which captured the last 15 minutes of the flight plus a further 15 minutes on the ground in Wick. The FDR contained just over 57 hours of operation including the incident flight, which lasted around 29 minutes.

The FDR commenced recording the flight from Aberdeen just after the left engine was started. Recorded Total Air Temperature (TAT)[3] was 0°C. During taxi to the runway a 'full and free' check of all flight control surfaces was performed, including the elevator which deflected to 25.8° (elevator up) and -16.6° (elevator down)[4]. Analysis of previous recorded flights suggests that the deflections achieved were consistent and in line with expected deflections from the aircraft manufacturer. At least two further significant deflections of the elevator were performed during the taxi, achieving maximum deflections of 25.8° and -16.7°.

After takeoff from Aberdeen, the aircraft was flown under manual control until passing through FL38 when

Footnote

[3] TAT is the temperature measured on the airframe where the air is brought to rest causing an adiabatic increase in temperature when the aircraft is moving through the air. TAT is higher than static (or ambient) air temperature when the aircraft is moving.

[4] Elevator position is only sampled once per second and only for the left elevator. As the full elevator movement was not held for more than one second, it is possible that further movement was achieved but not recorded.

the autopilot was engaged. The climb continued with the aircraft trimmed at around 13° nose-up.

Just after passing FL66, the autopilot commanded a pitch-down movement by applying an increasing pitch trim command over a period of 13 seconds. Recorded TAT was -4°C. Autopilot pitch trim warnings were not recorded but, according to the manufacturer, the warning would have been activated if the elevator trim was commanded in the same direction for more than nine seconds.

The autopilot was disengaged and it was then that the flight crew reported the elevator restriction. Control column position and force were not recorded. FDR data indicated that recorded elevator position was not completely static, as might be expected from a totally restricted control surface, with between 1.3° to 3.0° of movement. Just over 3 minutes after the restriction started, a spike in the elevator position was noted from 2.6° to 5.5° deflection, with a corresponding pitch change. As the control column position was not recorded, it is not known what caused this but it is possible that, with significant force applied to the control column, the elevator momentarily freed before then becoming restricted again. After this momentary recovery the elevator position varied between 1.3° to 2.8°.

For the duration of this restriction, a number of pitch oscillations were seen, along with a number of pitch trim inputs and changes in power settings. The maximum pitch attitudes attained were 18° nose-up pitch and 2.5° nose-down pitch. After analysis, the effect of applying an increasing pitch trim command (normally leading to a pitch-down effect) led to the aircraft pitching up. Conversely, applying a decreasing pitch trim led to the aircraft pitching down. This suggested that the effect of pitch trim had become reversed. The use of pitch trim in each instance led to oscillations in pitch which were then seen to decrease in amplitude as soon as the variations in pitch trim stopped. The data suggested that, at times, the flight crew were attempting to trim the aircraft using the pitch trim, which was acting in the opposing sense.

Just over 13 minutes after the disconnection of the autopilot, when descending through FL41, the FDR recorded a spike in the elevator position from 2.8° to 7.2°. When time-aligned with the crew discussion on the CVR, it was confirmed that the elevator authority had then been recovered. TAT at the time of recovery was -0.75°C.

No further unusual pitch activity was noted on the FDR for the remainder of the flight. Seven and a half minutes after the elevator recovery, during the approach to Wick, the CVR indicated that the commander elected to perform a "HANDLING CHECK BEFORE COMMITTING TO THE APPROACH TO LAND AT WICK". This appeared to consist of lowering the flaps a further two stages until full flap was achieved. One stage of flap was then retracted and the landing was performed with flap 15.

The commander

The commander was a very experienced type rating examiner on the Jetstream 41 and other aircraft types. He was engaged by the aircraft operator on a freelance basis and his duties included training and testing of the operator's pilots. Previously, he had been employed by the manufacturer of the Jetstream 41 and had worked for this operator in a management capacity.

Interviewed after the event, the commander stated that he believed that the purpose of sweeping contaminants from the airframe was "to clear the contaminants off the .... surfaces" and that once this had been done, it would be appropriate to depart, given that the conditions were "wet". However, he was also aware that sweeping sometimes preceded application of de-icing and anti-icing fluids.

In discussing the event, the commander was not aware of the possibility that, if the elevator was jammed, the elevator trim system might produce pitching in the opposite sense to that in which it usually operated (nose-down trimming would produce nose-up pitching in the aircraft).

The commander was aware that the emergency and abnormal checklist included a procedure appropriate to a jammed elevator. This procedure addressed a mechanical jam, affecting one side of the system. He stated that he had chosen not to carry out this procedure, as he felt that the problem was not a control jam but a restriction caused by ice.

The co-pilot

The co-pilot had undertaken a full-time integrated course of training between 1998 and 2000 and then worked as a flying instructor before being employed by the operator of G-MAJV. He flew the Jetstream 32 for two years before converting to the Jetstream 41 a year before the incident. He had received appropriate training to operate into Vagar.

The co-pilot stated that, at the holding point ready for departure, he was watching the wing carefully with the intention of suggesting that the aircraft should be de-iced before takeoff, if any significant contamination built up.

The de-icing personnel

The operator did not have staff or equipment at the airport for de-icing aircraft but had a contract with an engineering company to provide this, and other services.

The personnel who swept the snow from the wings of G-MAJV had only recently started their employment with the engineering company, though they had been engaged in similar tasks with another employer. The engineering company had not provided them with training in de-icing and anti-icing procedures.

On the morning of the incident, they were provided with appropriate equipment and instructed to sweep the snow from the wings of G-MAJV. They carried this task out in the anticipation that colleagues would then apply de-/anti-icing fluid to the aircraft. They stated that "heavy snow" had been falling when they reported for duty. Most of the material they removed from G-MAJV was "slush" and they recalled that as they were sweeping the aircraft, sleet was falling.

The purpose of de-icing and anti-icing of aircraft

Contamination of aircraft flying surfaces can cause catastrophic loss of lift and loss of control. Contaminants may also add significant weight to an aircraft. Therefore, prior to departure two criteria must be met.

First, all contaminants must be removed from the aerodynamic surfaces of the aircraft before flight. This is usually accomplished by application of de-icing fluid, and may sometimes be preceded by mechanical cleaning with brushes or similar equipment, which has the benefit of reducing the amount of fluid required to achieve de-icing.

Second, if precipitation is present, the aircraft must be protected against the accretion of further ice during the time between de-icing and takeoff. This is accomplished by the application of appropriate anti-icing fluid in the correct manner as well as ensuring that the aircraft takes off before the relevant holdover time[5] has elapsed; the

Footnote

[5] The period, in the given conditions, during which the fluid provides adequate protection.

application of the fluid relates to the conditions against which the aircraft must be protected. Following de-icing and anti-icing, flight crews ensure that there are no contaminants on the aircraft prior to flight. Once airborne, an aircraft's anti-icing and de-icing systems protect it against ice accretion in flight by heating the relevant surfaces or by clearing ice from them mechanically or by fluid.

Operations manual and other published advice

The operator's operations manual for the Jetstream 41 stated in paragraph 1.27.4 that:

> *'The aircraft must be cleared of all deposits of snow, ice and frost adhering to the surfaces immediately before take-off.'*

and in paragraph 2.3 that:

> *'If operating in cold conditions ensure that all snow, ice and hoar frost has been removed from fuselage, wings, ailerons, flaps and tail area, including elevators and rudder.'*

The manual did not state that safe flight is dependant not only upon removal of contaminants but also, in icing conditions involving precipitation, the protection of the aircraft's surfaces by the application of appropriate fluids.

The operator's emergency and abnormal checklist for the aircraft included a number of checklists for use in event of failure of various ice protection systems. Some of these checklists included the following note:

> *'In the event of any failure of the airframe de-icing system whilst flying in actual or potential icing conditions, it is recommended that the maximum flap used is 15º. If airframe buffet is experienced, the airspeed must be increased until the buffet stops.'*

There was no checklist applicable to an icing encounter or ice accretion not associated with a systems failure.

The operator's Emergency and Abnormal Procedures included the following advice and instruction about preparation for flight in icing conditions in section 3.3.6.1:

> *'Preparation for Flight*
>
> *External Inspection*
>
> *A thorough pre-flight inspection of the aircraft is vital for safe operation in icing conditions. Flight Crew should pay particular attention to the condition of the airframe de-icing boots and the propeller de-icing mats. In addition to normal checks, Pilots must ensure that the aircraft is clear of ice, frost or snow.*
>
> *THE AIRCRAFT MUST BE TOTALLY FREE OF ICE DEPOSITS BEFORE TAKE-OFF AS THE AERODYNAMIC PERFORMANCE OF THE WINGS AND TAIL CAN BE SEVERELY REDUCED EVEN BY THICK FROST.*
>
> *The Flight Crew must ensure that the following items are not contaminated, and arrange for de-icing where required:*
>
> *All external surfaces.*
> *Gaps between control surfaces and aircraft structures.*
> *Landing gear and associated doors.*

Engine nacelles, inlets and propellers.
ECS packs inlet / exhaust.
Pitot and static (main and standby) systems, AOA probes.

De-Icing and Anti-Icing

De-icing may be accomplished manually or by the use of hot air or fluid. These methods do not provide any ongoing anti-ice protection and may only be used when the aircraft is not subject to further icing before take-off.

Manual De-Icing

Manual de-icing should be performed using only soft brushes or rubber scrapers, taking care to avoid damaging the aircraft skin or any equipment.'

In the section dealing with ground operation of the aircraft in icing conditions, the manual stated:

'Pre Take-Off

The gust locks should be disengaged, and a careful check for full and free control movement must be made to ensure that freezing has not occurred. This should be repeated at intervals if awaiting take-off clearance, and especially performed immediately before take-off.

TAKE-OFF IS PROHIBITED IF DEPOSITS OF SNOW, ICE OR FROST ARE ADHERING TO THE SURFACE OF THE AIRCRAFT.

All visible parts of the airframe must be inspected for evidence of re-freezing, or contamination immediately prior to take-off. Do not assume freedom from contamination by observing other aircraft, they may have been treated more recently and/or effectively. If in doubt, and if possible, ask for an external inspection, otherwise always return for a de-icing re-spray.'

The operations manual did not include advice applicable to flight following departure with ice on the tailplane as such events should not occur. However, the section entitled *'Approach and Landing with Residual Ice Following Airframe De-Ice Fault'* included the following information and advice:

'Excessive ice may be present on either the tail, or the wings, or both. The maximum flap selection should not exceed 15 in order to maintain a safe margin from a possible tailplane stall.'

The emergency and abnormal checklist included a procedure for use in event of the autopilot pitch trim warning.

Manufacturer's advice

The manufacturer of G-MAJV had produced a guidance booklet entitled *'Think Ice!'* which had been updated from time to time. The 2007 edition included an extensive passage describing the rationale for reducing flap settings in landings following possible ice accretion events, to avoid the possibility of tailplane stall.

Previous events

Examination of the AAIB database identified three previous events involving pitch control restriction in Jetstream 41 aircraft in the UK[6]. In one event, lack of lubrication of the gust lock mechanism was the cause. In another, the condition lever friction control interfered with the pitch trim wheel.

Footnote

[6] Other events worldwide were also identified.

In the third event, in February 2005, a Jetstream 41 aircraft operated by the operator of G-MAJV experienced pitch control difficulties during climb after departure from Aberdeen. The AAIB report into the event[7] stated that 'The captain considers that, because no de-icing fluid was applied to the aircraft, ice which was not visible from the ground was present on the tailplane before takeoff' and that later, the commander believed:

> *'that failure to ensure proper de-icing prior to departure had permitted ice to remain on the horizontal tail surfaces and that a further accumulation in flight caused the elevator to become jammed.'*

Safety actions

The engineering company involved in this event incorporated the following instruction into their de-icing procedures shortly after this event:

> *'In the event that ice/snow deposits are required to be removed from the aircraft using brooms prior to de-icing, and the de-icing equipment is not immediately available to complete the de-icing procedure the Aircraft Commander must be advised of the delay and that de-icing has not been completed.'*

In the course of the investigation, the incident to G-MAJV was discussed with the CAA's Flight Operations Inspectorate (FOI), who then reviewed the operator's operations manual. The review resulted in the CAA issuing a number of findings related to the de-icing and anti-icing of aircraft.

Footnote

[7] AAIB report EW/G2005/02/16.

Simulation

The operator had a Jetstream 41 simulator at its headquarters. In the simulator the incident flight was recreated, with an elevator jam being introduced shortly before climbing through FL90. The simulator accurately replicated the aircraft's responses to power changes, and with some difficulty, the investigator succeeded in gaining sufficient control to establish a descent and then maintain the aircraft's altitude within a few hundred feet.

Analysis

Cause of the elevator jam

Extensive engineering investigation after the incident found no fault with the aircraft and no evidence of re-hydration of fluid residue, which has caused control restrictions in the past on other aircraft types. Having dismissed a mechanical cause of the control restriction within the aircraft, environmental factors became the most likely cause for the elevator jam.

Snow had been falling prior to the flight crew's arrival at the airport and continued to fall during the time preceding their departure. The precipitation left G-MAJV covered with contamination, in the form of wet snow and slush. Closer to their departure time, the snow gave way to lighter sleet. It is, therefore, highly likely that, before the aircraft took off, slush and/or ice was present on the horizontal tail surfaces and that, as the aircraft entered colder air at altitude, this contamination caused the mechanical pitch control to become restricted.

Actions before departure

During the preparation for flight, events proceeded normally up to the commander's decision not to have the aircraft de-iced and anti-iced with fluid. The fact that precipitation, albeit light, was still falling, and the temperature was 0°C, meant that anti-icing, and an appropriate holdover time, were essential to ensure that the aircraft was protected from contamination before takeoff. This was not done, although de-icing and anti-icing resources at Aberdeen were available. The resources were not, however, adequate to ensure all aircraft were de-iced prior to achieving on-time departures.

The ground crew gave the clear 'thumbs up' sign to the commander once they had swept the wings. The gesture, intended as a greeting, may have seemed more of an assurance that their task had been completed and the aircraft was free of contamination. The flight crew were not aware that the tail had not been swept, and the commander's assumption that the tail had been cleared appears to have been a consequence of the signal. However, the safety actions taken by the engineering company after the event guard against a repetition of this sequence.

Examination of the operator's operations manual showed that it stated the importance of de-icing aircraft (removing contaminants prior to flight) very clearly. However, there was less clear exposition of the need to anti-ice an aircraft prior to takeoff in icing conditions and the CAA's review of the operations manual provides the opportunity for corrective action.

Actions in flight

After takeoff the flight proceeded uneventfully until the autopilot pitch trim warning illuminated. The commander carried out the relevant procedure from memory, without reference to the checklist. The checklist provided appropriate guidance for a trim malfunction caused by a mechanical malfunction, but not one caused by ice accretion in the tailplane. The commander's diagnosis, that the problem related to ice accretion rather than a systems problem, was correct.

Notwithstanding the autopilot pitch trim warning checklist, the emergency and abnormal checklist did not include a relevant checklist for the circumstances in which the crew found themselves. The circumstances of this flight were not unique: at least one previous UK event has been investigated by the AAIB and further events are likely to have occurred elsewhere. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2009-077

It is recommended that BAE Systems review the emergency and abnormal checklist for the Jetstream 41 aircraft to ensure that it includes adequate instruction and advice for flight crews who encounter in-flight control problems associated with airframe ice.

The advice in the operations manual stated that flap setting greater than 15 should be avoided following an icing encounter. Given that the consequences of tailplane stall could be catastrophic, it may be better to prohibit extension of the flaps beyond 15 unless a safe landing is reliant upon the use of flap 25 (for example, because the landing distance is limiting).

Therefore, the following Safety Recommendation is made:

Safety Recommendation 2009-078

It is recommended that BAE Systems review the advice contained in the emergency and abnormal checklist concerning flap extension following failure of the aircraft's ice protection systems, or when ice is present on the airframe, to ensure that advice and instruction relating to flap extension is optimized for safety.

'Fitness to fly'

This event involved two experienced flight crew; the commander, in particular, was highly experienced. His decision-making was critical in the sequence of events, particularly the decision not to have the aircraft de-iced and anti-iced prior to departure and also his assumption that the tailplane had been mechanically de-iced. The additional 'full and free' checks of the controls prior to departure indicated a concern about the state of the aircraft, as did the commander's decision to hand-fly the initial part of the departure.

Before the flight, the commander discussed with the co-pilot his (the commander's) fitness and the poor quality of his pre-flight sleep and said he would monitor his performance as the duty went on. He knew there was no other captain at Aberdeen available and qualified to operate to Vagar so the flight would be cancelled, or significantly delayed, if he did not operate it. The service was a non-scheduled (charter) flight, and the usual option of transferring passengers onto a later flight was not available. It is thus possible that the commander's physical condition, coupled with a motivation to complete the flight, was a contributory factor in this incident.