Jetstream 31, G-EEST

AAIB Bulletin No: 12/2004	Ref: EW/C2003/09/04	Category: 1.1
Aircraft Type and Registration:	Jetstream 31, G-EEST	
No & Type of Powerplants:	2 Garrett AiResearch TPE331-10UGR-516H turboprop engines driving McCauley propellers	
Year of Manufacture:	1987	
Date & Time (UTC):	17 September 2003 at 1447 hrs	
Location:	Wick Airport, Scotland	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 3	Passengers - 4
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Right propeller, right main landing gear, right rear wingspar, left wing and fuselage	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	54 years	
Commander's Flying Experience:	7,885 hours (1,195 on type)	
	Last 90 days - 160 hours	
	Last 28 days - 23 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft was landing on Runway 31 at Wick Airport. It crossed the threshold at 130 kt which was 21 kt faster than the correct threshold speed. After the co-pilot closed the power levers the aircraft floated about six feet above the runway surface. The aircraft touched down and bounced before touching down a second time more heavily, cracking a wing spar and flexing the aircraft structure sufficient to allow the right propeller to contact the runway. The aircraft bounced again before touching down for the third and final time. The investigation determined that just before the first touchdown, one or both power levers were moved aft of the flight idle position. It was concluded that both the commander and co-pilot were making inputs on the flying controls from that moment onwards until after the second, heavy touchdown. There was no evidence of any technical fault on the aircraft and the weather conditions were well within the limitations set for the aircraft. No safety recommendations were made.

History of the Flight

The crew reported at their Aberdeen base at 0950 hr for a six sector duty. The duty was scheduled to take them to Belfast and back, Wick and back and, finally, Humberside and back. By coincidence, the commander and co-pilot had operated the last four sectors of this duty, together, the previous day. Since completing that duty they had had 14 hours and 25 minutes rest.

The first two sectors of the duty (on the day of the accident) were completed in a Jetstream 32, registration G-BYRM. The commander was designated the pilot flying (PF) on the initial sector to Belfast and the co-pilot was PF for the return to Aberdeen. Both sectors were completed without incident. On the return sector the surface wind at Aberdeen was reported as being 220°/20 kt with gusts to 30 kt. There was moderate turbulence reported during the final approach and a strong crosswind component on landing. The landing was uneventful and, having shut the aircraft down and disembarked the passengers, the crew transferred to a Jetstream 31, registration G-EEST, for the remaining four sectors of the duty. Another crew had already operated this aircraft for three sectors earlier in the day, from Humberside to Aberdeen, Aberdeen to Wick and back to Aberdeen and they had not reported any problems. Similarly, the oncoming crew did not observe any faults during their pre-flight inspection.

G-EEST departed for Wick at 1414 hrs with four adult passengers. Two passengers were sat in Row 6, and the other two were sat in Rows 3 and 5, respectively. The co-pilot was PF and immediately after takeoff the crew experienced much the same turbulence as they recalled from the preceding approach. The aircraft climbed into smoother air and was established in the cruise at Flight Level (FL) 125. On the basis of the actual meteorological conditions at Wick, as transmitted on the Wick Automatic Terminal Information Service (ATIS), the flight crew briefed for an approach to Runway 13. However, during the early stages of the descent, Wick ATC informed them that the surface wind had veered and Runway 31 had become the runway in use. The crew re-briefed for a VOR/DME approach to Runway 31 and at about 20 nm range they informed Wick ATC that they were visual with the airfield. G-EEST was cleared for a visual approach and the aircraft was established on final approach, fully configured with 35° of flap selected, at approximately 4 nm.

The commander gave a reassuring commentary during the approach encouraging the co-pilot to make positive control inputs and to avoid a tendency to stray to the right of the centreline. Wick ATC gave three surface wind reports during the final stages of the aircraft's approach. The first was 210°/17 kt, then 230°/19 kt and, finally, 230°/17 kt. All these wind velocities would have caused the aircraft to fly with a certain amount of drift to the right but they were within the aircraft's maximum allowable crosswind component of 35 kt. The commander recalled there being some turbulence as the aircraft was descending through about 1,500 feet QNH (1,400 feet aal) and the co-pilot stated that there was a negative windshear of about 15 kt at approximately 900 feet QNH (800 feet aal). Following the loss of airspeed, the co-pilot was aware of an updraft which resulted in the aircraft becoming high on the glidepath, as indicated by three white lights on the Precision Approach Path Indicator (PAPI). Concerned that there might be a further windshear, the co-pilot did not reduce the power as much as she normally would have done while attempting to regain the correct glide path.

The commander stated that at about 400 feet agl the airspeed was 130 kt and reducing. The bugs on the airspeed indicators had been set at a V_{REF} of 103 kt and a V_2 of 111 kt. However, the loadsheet gave the landing weight as 12,575 lb and, for that, the operations manual gave a V_{REF} of 102 kt. The co-pilot remembered G-EEST crossing the displaced threshold a little higher and somewhat faster than normal but recalled that the aircraft's speed was 120 KIAS and reducing just before reaching that point. The commander observed that the aircraft was slightly to the right of the centreline but correcting. Witnesses on the airfield who observed G-EEST stated that the aircraft approached the runway more rapidly than they would have expected for a Jetstream 31. While the commander continued to make reassuring comments, the co-pilot flared the aircraft to a level landing attitude, reduced the power to flight idle and then placed both hands on the control column. G-EEST floated an estimated six feet above the runway surface while the speed decayed and, just before touchdown, the commander noticed the aircraft pitch down a small amount but too quickly for him to intervene.

At much the same time, the cabin attendant, who was sitting in the rearmost seat on the left side of the cabin, felt the aircraft suddenly move to the left and roll to the right. The aircraft touched down, bounced 10 to 15 feet in the air, as observed from the control tower building, touched down again, bounced once more and landed for the final time. One witness described seeing the aircraft touch down nose wheel first each time before pitching up and then down during each of the bounces. A second witness recalled G-EEST landing left wing low initially before bouncing and landing heavily right wing low but in a nose-down attitude. One of the personnel on duty in the Visual Control Platform (VCP) of the control tower thought that the aircraft might go around after the first bounce.

The commander's recollection was that the nose wheel touched down first, with a substantial noise, followed immediately by the main wheels. The aircraft bounced, pitched 'dramatically' nose up, then pitched down and descended. The commander stated that at this point he took control but did not advise the co-pilot that he had done so. However, the co-pilot reported being aware that the commander was assisting her. The commander estimated that the aircraft landed a second time, heavily, one and a half seconds after first bouncing. Again, he considered that the nose wheel touched the runway first, followed by the main wheels, with the aircraft in a wings-level attitude. The commander applied the brakes fully and selected reverse thrust. In doing so, he stated that he could feel that the power levers had been left forward of the flight idle gate, giving a modicum of residual power, although the co-pilot recalled closing them completely during the flare.

When taking control before the second touchdown the commander remembered trying to raise the nose of the aircraft but found the control column 'frozen' and difficult to move. Immediately after the second touchdown he was able to move the control column as normal. The aircraft then bounced a second time. The commander considered going around after the first bounce but decided against such action because of his concern that the aircraft might have been damaged during the initial touchdown. The cabin attendant also thought that the aircraft had landed nose wheel first during the initial touchdown and then heavily on the main wheels during the second landing. The co-pilot felt that the first touchdown was no heavier than 'normal' but remembered the second landing being firmer. None of the crew considered that the final touchdown was particularly heavy.

During the subsequent landing roll the commander used reverse thrust down to an airspeed of 70 kt. This would normally be carried out by PF but the co-pilot had relinquished the controls realising that the commander had already retarded the power levers and was controlling the aircraft. The commander stated that he then moved the power levers from reverse to ground idle, checked that the BETA lights extinguished and requested 'taxi' RPM on the propellers. While the aircraft was slowing down, the co-pilot expressed surprise at what had just happened. The commander was also unable to explain the aircraft's behaviour during the landing.

Having brought the aircraft to a halt, the commander scanned the instruments and looked at the outside of the aircraft, as much as he could from his seat, before taxiing back to the apron. He also 'felt' for any signs of a flat tyre but all seemed normal. The co-pilot completed the after landing checks and, once on stand, the commander shut the aircraft down and the passengers disembarked.

While completing the pre-flight inspection before the next sector, the commander observed that the right propeller had suffered a tip strike and he cancelled the next flight. Inside the aircraft it was observed that a light cover had fallen from the cabin ceiling adjacent to the airstairs door, that most of the lifejackets had fallen out of their stowage positions under the seats and that the hydraulic hand-pump lever was in the up position. There were no reported injuries to the passengers or crew.

Personnel Information

Both crew were suitably qualified and rested. The commander was older than the co-pilot, had accrued 6,800 more flying hours and had nearly 1,000 more hours on type. The commander was not a training captain but he adopted an avuncular manner giving the co-pilot encouragement and advice.

There was no record of any previous incident or flying technique, in either pilot's career, which might have been pertinent to the accident.

Normal Procedures

The normal landing procedure for a visual landing is described in the company's Operations Manual. It states that crews should:

> *Maintain the glideslope, aiming for 125 kt minimum at 200 ft, reducing speed thereafter to V_{REF} [which is diagrammatically shown as the target speed at which to cross the threshold]....Below 50 ft, the aircraft should be flared and the power levers retarded to achieve flight idle at touchdown. After touchdown, the nosewheel should be gently lowered to the runway, the power levers lifted and ground idle selected.*

There is also a warning that:

> *DURING FLIGHT, THE POWER LEVERS MUST NEVER BE MOVED BELOW THE FLIGHT IDLE STOPS.*

The Operations Manual also specifies the procedure for the reversal of roles from PNF to PF, which is that:

> *If at any time the Captain when PNF wishes to reverse roles he/she shall do so by stating "I have control", the PF responds with "You have Control".*

The manual also states:

> *"The pilot-in-command shall, in an emergency situation that requires immediate decision and action, take any action he considers necessary under the circumstances. In such cases he may deviate from rules, operational procedures, and methods in the interest of safety".*

Advice is given on the increment that can be added to V_{REF} when landing:

> *Add an increment of one-third average gust factor to the applicable VREF, up to a maximum of VREF + 15 kt.*

Also:

> *In severe conditions the target speeds may be increased by one third of the reported wind speed, but must not be increased above VT_{MAX} .... The Maximum Threshold Speed VT_{MAX} for landing with both engines operating is V_{ATO} plus 15 knots.* (V_{ATO} equals V_{REF}.)

Flight Recorders

The aircraft was fitted with a Flight Data Recorder (FDR)[1] capable of recording a limited range of flight parameters on a continuous 25-hour tape loop when electrical power was applied to the aircraft. Only five parameters were recorded. These were time, pressure altitude, indicated airspeed (IAS), normal acceleration, and heading. Analysis of the data was difficult because critical parameters vital to the investigation were not recorded. In particular, aircraft pitch and roll attitudes and engine parameters were not recorded, nor were they required to be recorded under the UK regulations[2].

The aircraft was also fitted with a Cockpit Voice Recorder (CVR)[3] which recorded crew speech and area microphone inputs on a continuous 30-minute tape loop when power was applied to the aircraft. A spectral analysis of the CVR recording was carried out that enabled engine RPM to be calculated

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[1] Allied Signal UFDR: *Part Number 980-4100 GWXS, Serial Number 7097.*

[2] Recommendations addressed to the CAA and JAA to increase the number of parameters recorded for this class of aircraft will be published separately. As a minimum requirement, these extra parameters would include aircraft pitch and roll attitude and engine power.

[3] Fairchild A100A CVR: *Part Number 93-A100-32, Serial Number52842.*

and warning horns in the cockpit to be detected. The use of spectral analysis of engine sounds recorded on the CVR cannot be used to distinguish between individual engines to identify the behaviour of *specific* engines. This was not an issue for this accident as no differences between the two engines were detected by the analysis.

A time-history of the relevant parameters during the landing at Wick is shown in Figure 1. The figure starts at 40 seconds before touchdown; with the landing checks completed and the engines at 100% RPM. The aircraft was descending at about 700 feet/minute and 130 KIAS. At just under nine seconds before touchdown, both engine RPMs started reducing as the commander called "POWER OFF", initially dipping to 97% and finally stabilising at about 98%. As the power was reduced, the descent rate slowed to about 250 feet/minute before the aircraft levelled off at a pressure altitude of 375 feet, three seconds before touchdown. Also, the speed began to decay at a rate of 2.5 knot/second, reducing to 112 KIAS at touchdown, 9 kt above V_{REF}. The recorded normal acceleration at touchdown was 2.5g.

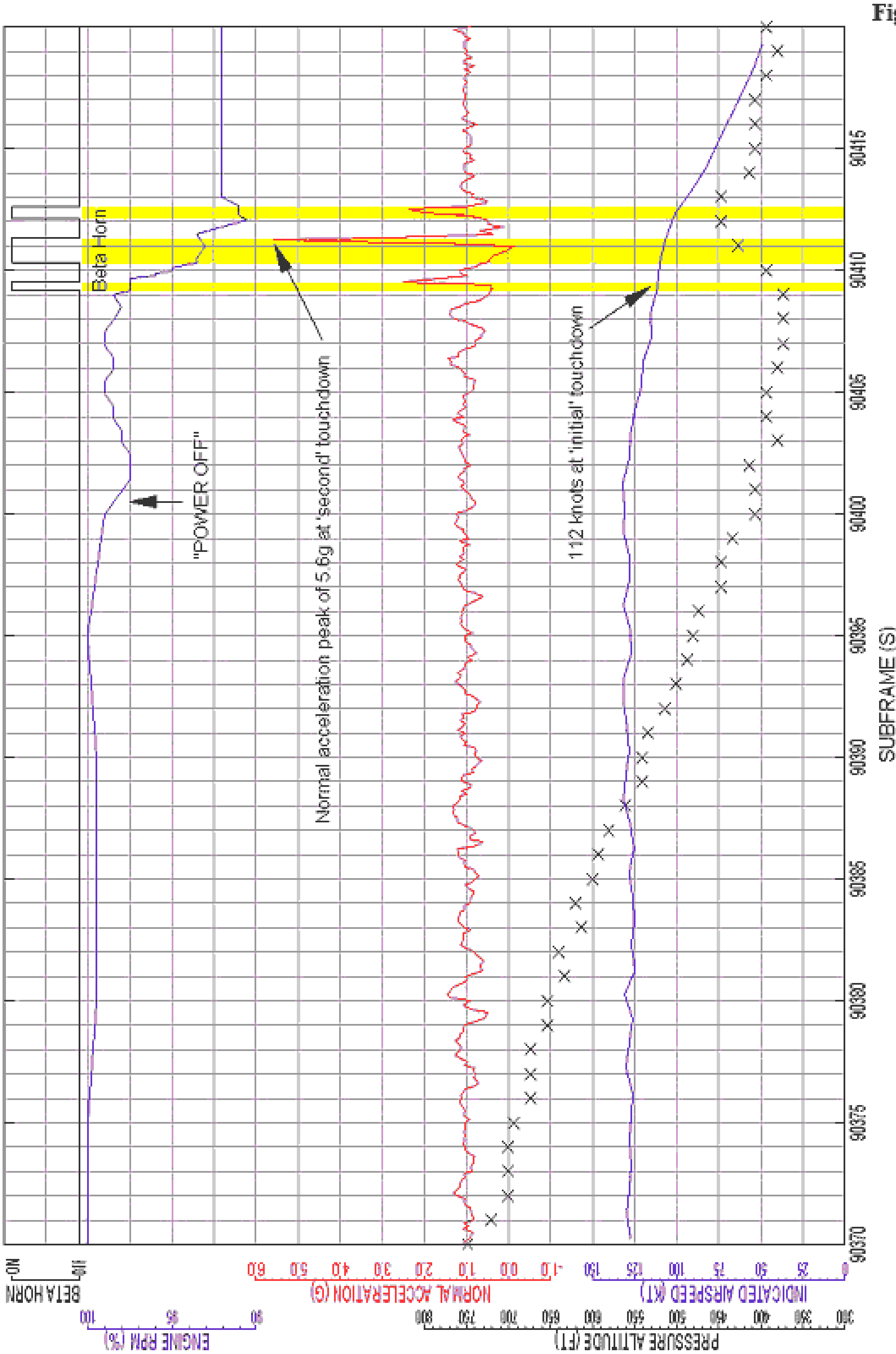

Figure 1

Salient CVR derived/FDR Parameters
(Accident to G-EEST on 17 September 2003 at Wick Airport)

At 0.28 seconds prior to touchdown, the beta warning horn started sounding and continued to do so until touchdown. There was then a pause of about 0.8 seconds, during which time the normal acceleration fell to just under 1g before the beta horn sounded again, this time for just over one second. As the horn sounded, the normal acceleration continued to fall to just below 0g and then rose rapidly reaching a peak of 5.6g. A second pause of about 0.8 seconds followed during which the normal acceleration again fell, this time to 0.5g, before the horn sounded one final time (for 0.5 seconds). As the horn sounded, the normal acceleration rose to 2.3g, falling to a nominal 1g once the horn stopped. Throughout this period of horn soundings, the engine RPMs and aircraft speed continued to fall. There was also a 75 feet rise in the pressure altitude (at 1,400 feet/minute); an unreliable number particularly if the aircraft was pitching, potentially introducing position errors in the altitude pressure sensing system. Knowledge of aircraft pitch attitude, which was unavailable, would be required to determine if these errors existed.

Power management

The engines and propellers on Jetstream 31 aircraft operate at a selectable constant RPM. The normal landing propeller RPM of 100%, which equates to 1,591 RPM at the propeller and 41,730 RPM at the engine, is set by the RPM levers in the centre pedestal. The power settings (torques) used in flight are achieved by variation of the propeller blade angles, rather than any significant change in engine rotational speed. The power levers are mechanically connected to the manual fuel valve in the fuel control unit and propeller pitch control via the underspeed governor. Movement of the power levers operates cable quadrants below the centre pedestal in the cockpit (see Figure 2). The right power lever is connected, via a cross shaft and adjustable rod, to the right inner cable quadrant. The left power lever is linked by an adjustable rod to the left inner cable quadrant. These quadrants are then mechanically connected via cables, pulleys and push-pull teleflex linkages to the engine.

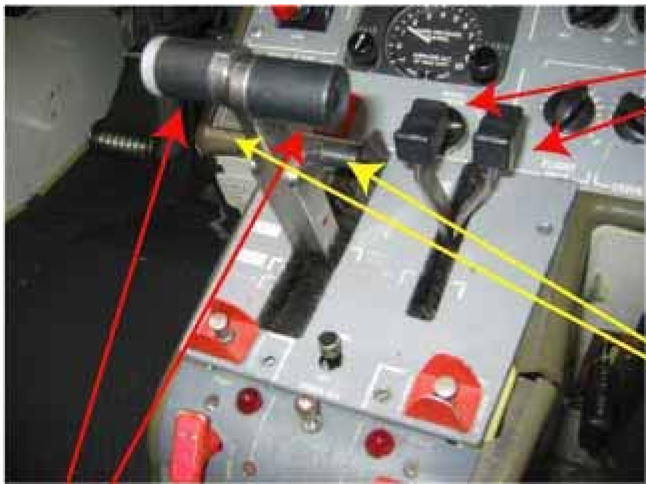

Figure 2
Centre pedestal

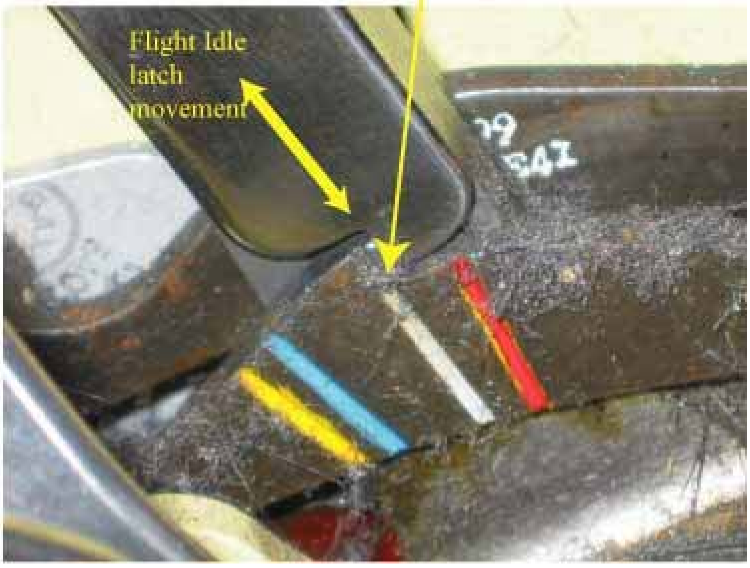

Figure 3
Flight Idle latch mechanism and four marked positions of microswitch operation

The propeller has two modes of operation. In flight the propeller governor controls the propeller blade angle to maintain the selected RPM. Below flight idle, in the 'beta mode' of operation, the power lever controls the propeller blade angle directly through the propeller pitch control and allows a reverse pitch selection. As the power lever is retarded through flight idle, a valve is opened allowing high oil pressure to the propeller pitch control which results in direct (beta) control of the propeller blade angle. When a propeller enters the beta range, the engine RPM droop (reduce) temporarily due to insufficient fuel flow to maintain the selected RPM. Located between the propeller governor and the propeller pitch control is the beta pressure switch, which illuminates the BETA caption on the flight deck when high oil pressure in the beta tube is sensed.

The Jetstream 31 aircraft was initially certificated with Dowty propellers. A Supplementary Type Certificate (STC) modification to fit McCauley propellers to Jetstream 31 aircraft using the same engine and FCU was approved by the CAA following flight tests in year 2000 (Airworthiness Approval Note (AAN) 27314). The flight test included an in-flight assessment of the Flight Idle torque which was considered acceptable. G-EEST was fitted with McCauley propellers which were installed and rigged in accordance with McCauley STC SA1372GL.

Power lever microswitches

Each power lever activates four microswitches that operate at selected positions and which are colour coded to match that of an associated segment on the control pedestal guide plate (see Figure 3). The first microswitch (red) provides an input to the landing gear audio warning. The lowest available power setting in flight is FLIGHT IDLE and unintentional movement of either power lever below this position is prevented by a latch mechanism. Any movement of either power lever below the flight idle position into the ground (beta mode) range will operate the second microswitch (white) and result in a high pitch audio warning tone on the flight deck if the nose landing gear 'weight-on-wheel' microswitch is not made. As either power lever is retarded further, a third microswitch (blue) allows the automatic lift dump to operate and the final microswitch (yellow) illuminates the REV caption on the instrument panel to indicate a propeller reverse pitch selection.

There is an optional modification (Service Bulletin 76-JK 12071 for early Jetstream 31s or 76-JK 2967 for later aircraft and Jetstream 32 models) which introduces a solenoid operated baulk which limits the travel of the power lever. In flight the solenoid is powered to engage the baulk and prevent the power lever being inadvertently or deliberately selected below flight idle. The solenoid is operated by the nose landing gear weight-on-wheel microswitch. This modification was not widely fitted to Jetstream 31/32 aircraft and it was not fitted to G-EEST.

Flap/lift dump system

The double slotted flaps mounted on each wing are interconnected via a torque shaft and operated hydraulically. The flap positions RETD (retracted), 10°, 20° and 35° are controlled by a four position selector on the centre pedestal which operates electro-hydraulic selector valves. On landing with 35° flaps selected, as the weight of the aircraft is sensed by the microswitch on the nose landing gear and if the power lever has been retarded to the ground idle position, the flaps automatically extend beyond the 35° position to a DUMP position (70°) to act as an airbrake. In this position the flaps reduce wing lift which in turn increases wheelbrake effectiveness.

Emergency lowering of the flaps and gear are achieved by hand pump pressure from an emergency hydraulic system directed by a manually operated selector. A spring check valve connects the emergency hydraulics from the hand pump to the services (gear and flap) if the emergency selector valve is in the normal position. With both engines operating and the associated engine driven pumps supplying hydraulic pressure at 2,000 psi, the spring check valve would close and thus movement of the hand pump would not generate sufficient pressure to overcome normal system pressure, open the valve and affect gear and flap operation.

Runway marks

A set of tyre marks consistent with the track of the main landing gear of a Jetstream 31 were identified beginning at a position approximately 675 metres beyond the displaced threshold of Runway 31 (see Figure 4). The marks were approximately equidistant either side of the centreline and in line with the runway heading. To the left of the right hand tyre mark, approximately 0.85 metres towards the centreline, five propeller strikes were evident with a mean spacing of 0.53 metres. No other runway marks associated with this accident were identified.

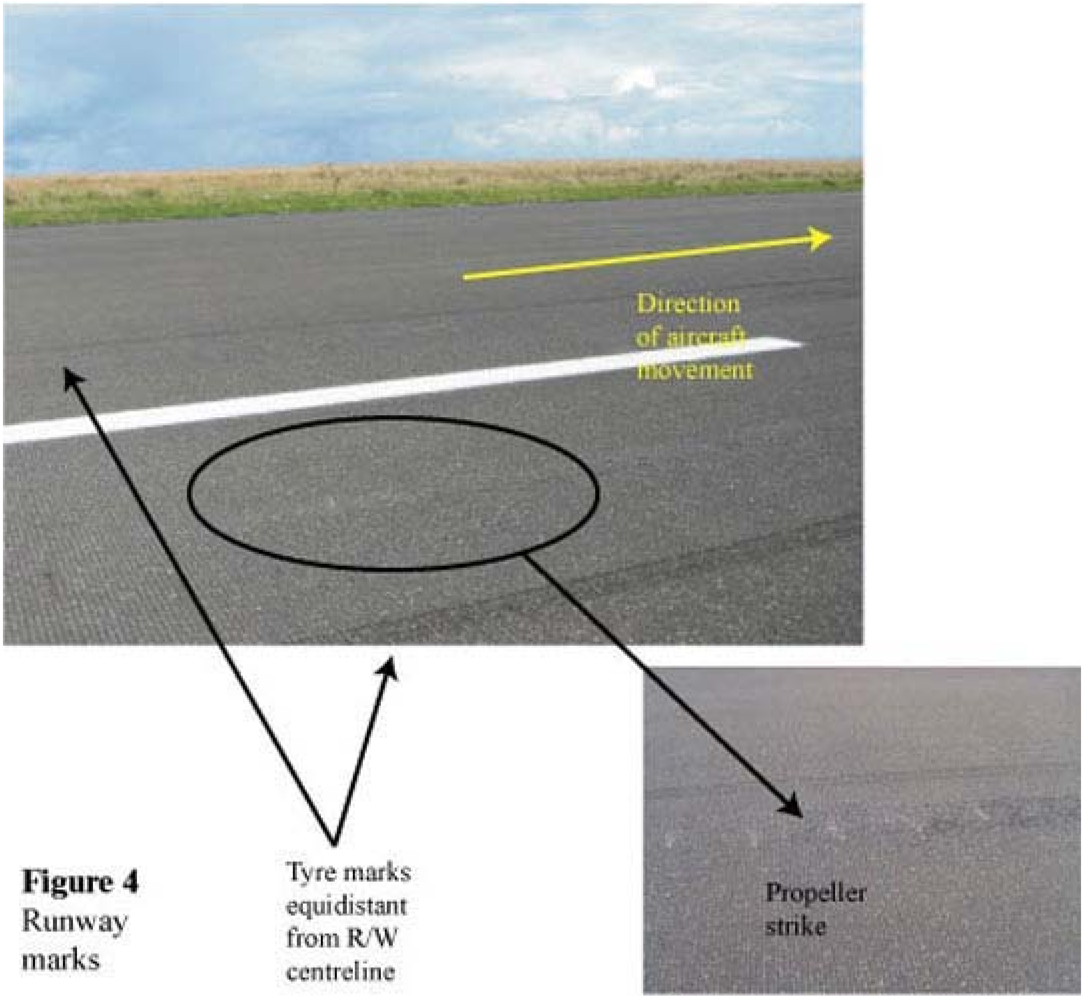

Figure 4
Runway marks

The groundspeed at the time the propeller strikes were made was estimated to be 96 kt using the formula given in the ICAO Manual of Accident Investigation and assuming 94% propeller RPM at the second touchdown.

Aircraft Examination

The aircraft structure was examined in accordance with the heavy landing checks in the Aircraft Maintenance Manual (AMM) 05-50-10 601. Structural damage consistent with a heavy landing was evident on the right hand side of the aircraft; there was a crease in the right hand fuselage skin above the main spar below one of the cabin windows. Both upper and lower right hand wing skins showed evidence of buckling and on the inner rear spar, both top and bottom booms had cracked and the web had buckled and sheared between Wing Stations (WS) 70 and 83 (see Figure 5). The damage had caused fuel leaks from the underside of the left wing near the main landing gear, from the left main landing gear forward mounting structure, and on the upper surface of the right wing.

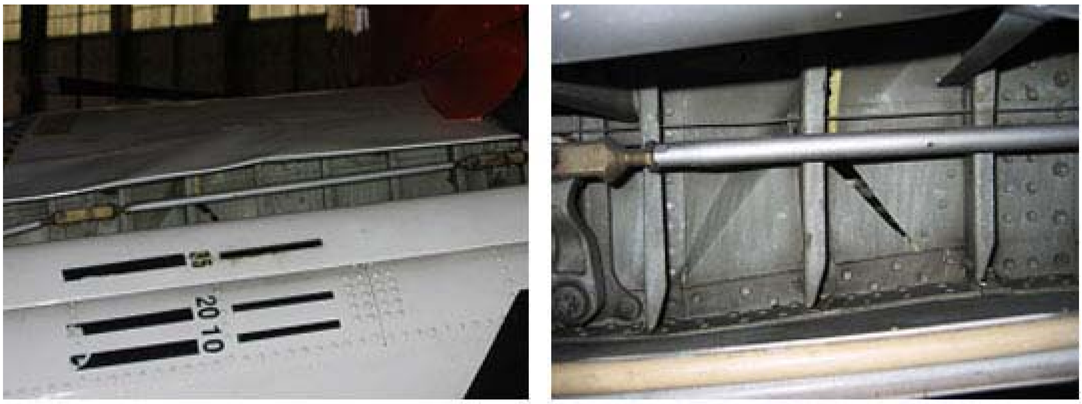

Figure 5 Structural damage to upper wing skin and rear spar

All four right propeller tips had been bent and showed evidence of scoring caused by contact with the runway.

The right landing gear oleo extension was slightly less than that of the left and fluid was leaking from the seal. Similarly, the tyre pressure on the right main landing gear was lower than the left (left tyre pressure 82 psi, right tyre pressure 59 psi measured, AMM limit 88 psi) and, when re-inflated, the right main landing gear tyre continued to lose pressure slowly.

Aircraft testing

A functional check was performed on the operation of the four power lever microswitches with no faults being found. Movement of the power levers aft of the position of the white microswitch operated the audio warning correctly and this was cancelled by the nose landing gear microswitch. The correct operation of the flight idle latch mechanism was also confirmed.

The engine power lever control system was checked on both engines and the flight idle settings on the manual fuel valve and the propeller pitch control were confirmed. An engine run was performed on the left engine without problems and the flight idle fuel flows were within limits. The right engine could not be run due to the propeller damage.

Aircraft History

The aircraft had completed 17,845 hrs and 20,730 landings at the time of the incident. The last maintenance check had been carried out on 5 September 2003.

The last adjustment made to the flight idle settings on the engines was made on 24 September 2001 following a crew report that the fuel flows on both engines were 3% high. Both Fuel Control Units (FCUs) were adjusted and there were no further pilot reports relating to the flight idle setting.

There have been instances of spurious alerts from the beta warning system on another of the same operator's Jetstream 31 aircraft; these have all been attributed to microswitch problems. No such defects had been reported on G-EEST.

Simulator tests

Bearing in mind that simulators are not entirely representative of aircraft performance, tests were carried out in the manufacturer's Jetstream simulator in an attempt to replicate the conditions and aircraft behaviour described by the crew and witnesses. Using the same parameters and control inputs indicated by the recorded data, it was only possible to repeat the landing manoeuvres by making significant pitch inputs on the control column.

Limited credence was given to the test results but it was considered noteworthy that the manufacturer's instructor, who is a simulator/aircraft instructor/examiner, in all respects, was of the opinion that considerable control inputs would be required to produce such landing manoeuvres.

Analysis

There was no indication that the aircraft had suffered a technical fault or failure before the accident occurred. Nor was there any indication that the aircraft had displayed any unusual characteristics, until the accident, either with this or the preceding crew. Since there were no reported hydraulic failures, the anomalous UP position of the hydraulic hand-pump on the flight deck was most probably a consequence of the sequence of heavy, bounced landings. Inertial movement of the hand pump was unlikely to generate sufficient pressure to overcome normal system pressure and affect gear and flap operation.

The aircraft crossed the threshold of the runway at 130 kt (V_{REF} plus 28 kt). This was 13 kt faster than advised in the company's operations manual, taking into account the maximum additional increment of 15 kt, which could be added to V_{REF} for surface wind conditions. In the wind conditions on the day, the appropriate increment would have been 6 kt (⅓ of the surface wind of 17 kt), meaning that the aircraft was 22 kt faster than the appropriate threshold speed of 108 kt, using a V_{REF} of 102 kt, which is one knot less than that used by the crew.

The aircraft's behaviour in the flare and as it floated at an estimated six feet above the runway surface appears to have been normal until it suddenly pitched down just before the first of three touchdowns. Just 0.28 seconds before this touchdown the beta warning horn activated, indicating that one or both of the power levers had been retarded aft of the flight idle position with the nose landing gear weight-on-wheel microswitch not made. Nothing was discovered during the investigation which would question the integrity of this warning system and the accompanying reduction in propeller RPM supports the deduction that the power levers had been retarded when the warning occurred.

Neither the co-pilot who was PF nor the commander can explain what initiated the warning. At that time the co-pilot had both hands on the control column and the commander did not recall placing his hands on the controls until after the aircraft had bounced and was about to touchdown for the second time. When the commander did take the controls, he did not advise the co-pilot that he had done so and reported that the controls felt as if they were 'frozen'. This indicates that both pilots were attempting to make inputs on the controls, although it is not possible to specify what these inputs were.

After the second and heaviest (5.6g) touchdown, the commander felt the restriction in the control column relax and he retarded the power levers and engaged reverse thrust. There is a discrepancy between the co-pilot's recollection of reducing the power to flight idle in the flare and the commander's statement that he found the power levers forward of that position. In the absence of relevant recorded data it is not possible to say which of these was the case, although it is clear from the temporary reduction in propeller RPM and the subsequent reduction in speed as the aircraft floated before touchdown, that the power had been retarded. Moreover, since it is movement of the power levers that triggers the beta warning horn in flight and not the behaviour of the engine or its propeller, the CVR evidence confirms that the power levers were moved into the ground range earlier than the commander recalled. This difference in the version of events could not be resolved.

The co-pilot could not explain what happened during the landing. The co-pilot had landed a Jetstream 32 in more turbulent conditions at Aberdeen at the end of the previous sector and there was no indication that her landing technique was inconsistent. Also, there was no record of any earlier landing incident that might suggest a flawed technique.

With a crosswind of 17 kt from the left, the aircraft would have had to be straightened for the landing. The associated yaw may explain the movement to the left felt by the cabin crewmember before the initial touchdown, although she did describe the movement as unusual.

It is clear that before and during the second touchdown both pilots were attempting to make inputs on the flying controls. However, it is not possible to say with certainty at what point the commander joined the co-pilot on the controls. Since the co-pilot had both hands on the control wheel, the CVR evidence indicates that this was at least 0.28 seconds before the first touchdown in the case of the power levers, although this is not the commander's recollection. The co-pilot let go of the flying controls at some stage after the second touchdown.

The tests in the manufacturer's Jetstream simulator were treated with the caution appropriate to such a training device. However, in attempting to replicate the sequence of events described by the crew and other witnesses in the conditions at the time, it is considered telling that the manufacturer's instructor should regard such manoeuvres during landing as requiring considerable inputs to the aircraft's controls.

Conclusion

It is reasonable to conclude that the manoeuvres conducted by G-EEST during the landing were the result of combined control inputs made by the commander and co-pilot. The evidence indicates that this period of combined control started at least 0.28 seconds before the first touchdown and finished at some stage after the second and damaging touchdown. After the first touchdown the aircraft became airborne in a high-drag, low-lift configuration which was intended for ground operation only and a 5.6g impact ensued on the second touchdown. There was no evidence of any technical fault on the aircraft that could have been a factor and the meteorological conditions were within the limitations set for the aircraft. A more complete understanding of the accident might have been possible with additional flight data parameters such as engine performance, aircraft pitch, and power lever position.

Adequacy of recorded flight data

The absence of information regarding aircraft pitch attitude, roll attitude and engine power on the flight recorder has precluded a more detailed analysis of the events surrounding the accident landing to G-EEST. It should be noted that the recorder installation complied with the applicable requirements of JAR-OPS 1 but the AAIB believes that these requirements are inadequate with regard to the provision of recorded information for accident investigation purposes. A number of previous AAIB investigations have been impeded for the same reason.

The AAIB is in the process of collating evidence of these inadequacies with a view to recommending enhancement of the minimum standards of flight data recording by the inclusion of a requirement for the additional parameters of aircraft pitch attitude, roll attitude and engine power or thrust to be recorded. So as not to delay unnecessarily the publication of this report, this supporting evidence and associated safety recommendations will be published separately at a later date.

[1] Allied Signal UFDR: *Part Number 980-4100 GWXS, Serial Number 7097.*

[1] Recommendations addressed to the CAA and JAA to increase the number of parameters recorded for this class of aircraft will be published separately. As a minimum requirement, these extra parameters would include aircraft pitch and roll attitude and engine power.

[1] Fairchild A100A CVR: *Part Number 93-A100-32, Serial Number52842.*