ACCIDENT

Aircraft Type and Registration:	Airbus A319-111, G-EZFV
No & Type of Engines:	2 CFM56-5B5/3 turbofan engines
Year of Manufacture:	2010 (Serial no: 4327)
Date & Time (UTC):	14 February 2012 at 1359 hrs
Location:	London Luton Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 142
Injuries:	Crew - None Passengers - None
Nature of Damage:	All landing gear legs exceeded their maximum certified load
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	10,700 hours (of which 500 were on type) Last 90 days - 128 hours Last 28 days - 61 hours
Captain U/T's Licence:	Airline Transport Pilot's Licence
Captain U/T's Age:	37 years
Captain U/T's Flying Experience:	3,998 hours (of which 672 were on type) Last 90 days - 170 hours Last 28 days - 19 hours
Information Source:	AAIB Field Investigation

Synopsis

The flight crew carried out a manually flown ILS approach to Runway 26 at London Luton Airport. Shortly before touchdown, both pilots sensed the aircraft was sinking and a go-around was initiated. The aircraft made firm contact with the runway before starting to climb. The normal acceleration recorded at touchdown was 2.99g, which is classified as a Severe Hard Landing. The subsequent landing was uneventful. All three landing gear legs exceeded their maximum certified loads and were replaced; there was no other damage to the aircraft.

History of the flight

The aircraft was on a scheduled flight to London Luton Airport, from Faro, Portugal. The pilot flying (PF) was a captain-under-training (Capt U/T), occupying the left seat; the right seat was occupied by a training captain, who was the commander of the aircraft.

The aircraft was inbound to Luton from the south on the LOREL 4C standard arrival procedure. This procedure requires the aircraft to cross the extended runway centreline, before positioning for the Runway 26 ILS/DME approach from the north. When traffic allows, ATC will vector the aircraft towards the final approach course before the arrival procedure is completed, thereby shortening the track mileage to the landing. The flight crew were familiar with the airport procedures and were prepared for this to happen.

The aircraft was given an early radar vector towards the final approach track and the PF increased the rate of descent to close the correct descent profile from above. The aircraft was then allocated a heading of 220°M, cleared to intercept the localiser and, once established, to descend on the glidepath. The PF realised that the aircraft would be high and configured the aircraft with flap 2 and the landing gear down, to capture the 3º glideslope from above. He armed the localiser mode and then attempted to arm the approach mode but inadvertently selected the EXPED[1] pushbutton. The expedite climb mode engaged but, to prevent a climb or any mode confusion and to regain the correct profile, the PF disconnected the autopilot and the autothrust. The aircraft passed through the localiser and ATC issued a revised heading to enable the aircraft to intercept from the south.

The PF decided to continue flying the approach manually and the aircraft was established on the localiser at 5.5 nm. It was configured for landing, with full flap, at 5 nm. Landing clearance was issued at 1355 hrs, with a reported surface wind of 320°/15 kt. A subsequent wind check of 320°/16 kt was broadcast at 1356 hrs, three minutes before touchdown. The wind conditions were gusty and gave rise to some turbulence on the approach.

Footnote

[1] EXPED - Expedite mode is used in climb or descent to reach the desired altitude with the maximum vertical gradient.

Stabilised approach criteria were met at 1,000 ft and 500 ft radio altitude (RA). The V_{APP} (final approach) speed was 129 kt and at 50 ft RA the approach remained stable. Just below 50 ft there was a small nose-up pitch input followed by two nose-down inputs and, below 50 ft, the flight data indicated an increasing rate of descent from about 600 fpm to about 850 fpm. The data also showed that, below 100 ft RA, there were some left and right roll control inputs.

Below 30 ft, over the runway, both pilots sensed that the aircraft was sinking rapidly and both initiated a TOGA 10[2] go-around. The PF momentarily retarded the thrust levers to idle before advancing them to the TOGA (Takeoff and Go-around) position. At the same time, he made a full forward sidestick input, within one second, which was then rapidly reversed to full aft sidestick. As the PF made the forward sidestick input, the commander initiated an aft sidestick input which reached the full aft position within one second. He followed through the PF, pushing the thrust levers fully forward and announced "I HAVE CONTROL". The aircraft made firm contact with the runway, on all three landing gear legs simultaneously, before lifting off and starting to climb. During this phase the PF relinquished control and reverted to the PNF role.

The commander remained as the PF, completed the go-around and subsequently carried out an uneventful landing on the same runway. There were no reported injuries.

Flight crew information

The Capt U/T had completed nine sectors of command training without notable incident and the training reports prior to the event had all been positive. His command

Footnote

[2] TOGA 10 Baulked landing procedure.

training had included practice in TOGA 10 manoeuvres in the simulator but he had never carried out a TOGA 10 manoeuvre in the aircraft.

The commander had previous experience of line training on another aircraft type, but was relatively inexperienced in this capacity on the Airbus 320 series aircraft. He reported that he had practised TOGA 10 manoeuvres in the simulator but this was his first experience of one in the aircraft.

Meteorological information

The ATIS information issued at 1320 hrs, and copied by the crew, was surface wind from 300°M at 12 kt, CAVOK, temperature 7°C, dewpoint 3°C and pressure 1024 hPa. There was no significant change between 1320 hrs and 1400 hrs.

Wind data was obtained from the Runway 26 touchdown zone sensor. Readings are taken every 10 minutes and include the average direction and speed reported, along with min/max variations. The readings for 1400 hrs were average wind direction from 315°M, varying between 297°M and 342°M, and average wind speed 13 kt, varying between 9 kt and 17 kt.

The crew were aware that some turbulence can be expected on the final approach to Runway 26 when the wind is from the north-west.

Baulked landing procedure

The operator provides the following Baulked Landing Procedure, entitled *TOGA 10*, in its operations manual. Either pilot may carry out this manoeuvre.

> *'In the event of a rejected landing from flare initiation until thrust reverser selection*
>
> - *call "TOGA TEN"*
> - *select TOGA*
> - *pitch to 10° (this may mean holding the attitude or de-rotating to achieve or maintain 10° pitch.)*
> - *do not retract the flaps until a positive rate of climb is established.*
> - *When positive ROC confirmed, call "GO AROUND FLAPS" and apply normal go around procedure.'*

Through its Flight Data Monitoring programme, the operator has carried out several analyses of TOGA 10 manoeuvres conducted by its crews. The most recent analysis, which was completed following a programme of TOGA 10 training for crews in the simulator, examined 67 events. The report concluded that the manoeuvre was generally well flown and there were no significant dual inputs recorded.

Aircraft information

Autothrust

The manufacturer provides the following information concerning the use of autothrust:

> *'The A/THR is, in particular, best suited to tracking a moving target speed, when flying in managed speed mode. Statistically, the A/THR provides the best protection against airspeed excursions and its use is, therefore, recommended even in turbulent conditions, unless thrust variations become excessive.*

A/THR response to airspeed variations is the result of a design compromise between performance and comfort, and it is optimized when the AP is engaged. Therefore, in turbulent conditions and when flying manually, the pilot may sometimes find it to be too slow or lagging.'

Sidesticks

There is a sidestick for each pilot, located outboard of the seating position. There are two switches on the sidestick, one of which is the autopilot disconnect and sidestick takeover pushbutton. The sidestick controls move independently, so one pilot may not be aware of a control input being made by the other.

The manufacturer advises:

'When the Pilot Flying (PF) makes an input on the sidestick, an order (an electrical signal) is sent to the fly-by-wire computer. If the Pilot Not Flying (PNF) also acts on the stick, then both signals/ orders are added.'

And:

'If the PNF (or Instructor) needs to take over, the PNF must press the sidestick takeover pushbutton, and announce: "I have control".'

Further:

'In the event of simultaneous input on both sidesticks the two green SIDE STICK PRIORITY lights on the glareshield come on and "DUAL INPUT" voice message is activated. A pilot can deactivate the other stick and take full control by pressing and keeping pressed his priority takeover pushbutton.'

The operator provides the following guidance for flight crew in their operations manual:

'If a take-over becomes necessary during flight, the PNF must call clearly "I have control", and press the sidestick priority pushbutton, keeping it pressed until the transfer of control is clearly established. During critical phases of flight the PNF should be in a position to takeover, this may be achieved by resting the hand on the console or indeed on the stick itself but it is imperative that no input is made on the sidestick.'

The use of the takeover pushbutton has been shown from previous incidents not to be instinctive.[3] Training in taking over control, including the use of the takeover pushbutton, is provided by the operator.

Flare Mode

When the aircraft descends through 50 ft RA it enters Flare Mode. The manufacturer's description is:

'The system memorizes the attitude at 50 ft, and that attitude becomes the initial reference for pitch attitude control. As the aircraft descends through 30 ft, the system begins to reduce the pitch attitude, reducing it to 2° nose down over a period of 8 s. This means that it takes gentle nose-up action by the pilot to flare the aircraft.'

Engineering investigation

The A319 is fitted with a system that senses when landing parameters have been exceeded and generates a LOAD<15> report, following which inspection of the aircraft for damage is required.

Footnote

[3] Ref ; AAIB Bulletin No: 11/2004 Airbus A320, C-GTDK, AAIB Bulletin No: 5/2001 Airbus A321, D-AIRE and Airbus A321-211, EI-CPE.

A LOAD <15> report will automatically be generated during a landing if any of the following conditions are met:

- The normal acceleration is greater than 2.6g at touchdown (+/-0.5 second). If the aircraft weight exceeds the maximum landing gross weight, the normal acceleration limit is reduced to 1.7g.
- The rate of descent on the radio altimeter is greater than 9 ft/sec at touchdown (+/ 0.5 second). If the aircraft weight exceeds the maximum landing gross weight, the radio altimeter descent rate limit is reduced to 6 ft/sec.
- During a bounced landing, the normal acceleration exceeds 2.6g.

The normal acceleration parameter used within the LOAD <15> report computation is provided by an accelerometer mounted near to the aircraft's centre of gravity; the same accelerometer is used by the flight data recorder (FDR) system. The accelerometer incorporates a filter that attenuates its output above a predefined frequency. Under certain conditions, such as during rapid changes in acceleration, the accelerometer output may not always reflect the maximum attained normal acceleration level. In addition, during various phases of flight, acceleration levels experienced by other areas of the airframe, such as the nose gear, may be different from those measured at the centre of gravity.

A LOAD <15> report for the incident landing was automatically generated shortly after the hard landing, having recorded a normal acceleration of 2.99g and a rate of descent of 12.5 ft/sec.

Aircraft examination

The operator sent the FDR data to the manufacturer. Due to the high level of vertical acceleration and the fact that the aircraft had made a three-point landing, the manufacturer requested a comprehensive list of structural inspections which included several areas of the fuselage, the belly fairing, the pylons, the horizontal stabilizer and the wings. No damage was found in these areas.

The manufacturer's analysis confirmed that the following components had exceeded their design loads and needed to be replaced:

- Nose Landing Gear shock absorber.
- Left Main Gear sliding tube assembly (including shock absorber internals)
- Right Main Gear Main fitting, including both pintle pins
- Right Main Gear sliding tube assembly (including shock absorber internals)

The operator replaced all three landing gear legs, which were returned to the landing gear manufacturer for overhaul.

Recorded flight data

The aircraft's FDR and CVR were removed from the aircraft, downloaded and the recordings were analysed by the AAIB. Recordings on the CVR at the time of the hard landing had been overwritten by more recent recordings while the aircraft was on the ground, after the final landing.

From the FDR data it was determined that at 8.3 nm DME range from Luton and a height of 3,500 ft agl, the Expedite Climb Mode was selected. Three seconds

later, the autothrust was disconnected, followed by the autopilot. The Expedite Climb Mode was deselected after 10 seconds. The aircraft was established on the localizer at 5.5 nm DME and 2,000 ft agl. The flaps were fully extended by 5.0 nm DME.

Figure 1 shows the salient recorded parameters approaching the touchdown. The data illustrated starts at 1358:38 hrs, with the aircraft at 200 ft agl, 130 kt indicated airspeed and descending at 625 ft/min. At this point the aircraft's attitude was 3º nose-up and 2º left wing low. Left-seat sidestick control inputs were made which resulted in the aircraft rolling wings level as it descended though 100 ft agl. The wings remained level for just over one second before further inputs rolled the aircraft right (to 4.5º at 60 ft agl), then left (to 5.5º at 21 ft agl), then back to wings level at touchdown.

As the aircraft descended through 60 ft agl, at 1358:46 hrs, a momentary 2º reduction in angle of attack was recorded while the pitch attitude remained steady at 3.5º nose-up. A maximum pitch attitude of 4.2º occurred at 32 ft agl, 2.5 seconds before touchdown. This was followed by some pitch-down control inputs (from the left seat) which resulted in a decreasing pitch attitude, the descent rate peaking at just under 900 ft/min, and the aircraft descended below the nominal glideslope. The left-seat pilot then applied an aft sidestick control input of 10º (out of a maximum of 16º) which was coincident with a small aft-stick input by the commander. Both thrust levers were then advanced to the TOGA position. However, there was also a simultaneous forward sidestick input of 15º from the left seat pilot, which was countered by an aft input of 8º by the commander (ie a net input of 7º forward). Both sidesticks were then moved to the fully aft position. Half a second later the aircraft touched down on all three landing gear simultaneously, during which a normal acceleration of 2.99 g was recorded. The aircraft then lifted off, completed a go-around and returned for an uneventful landing.

The manufacturer's analysis of the data provided the following information:

> *'Inputs performed simultaneously by pilots were equivalent to a pitch down order at ~+7° of side sick deflection leading to a strong pitch decrease.'*

Analysis

In the early stages of the approach there was a period of increased workload for the PF, caused by the aircraft being above the nominal 3º descent profile. This was exacerbated when the PF inadvertently selected the Expedite Mode, instead of the Approach Mode, and missed intercepting the localiser. He recovered from this by reverting to manual flight and the aircraft was re-established on the expected profile by 5 nm. This does not appear to have directly affected the outcome of the approach other than that it led to the PF's decision to use manual thrust for the remainder of the approach, which increased the workload in turbulent conditions.

The manufacturer advises the use of autothrust in most circumstances but also notes that there are conditions in which autothrust may not be the best option. Thus, it is accepted that a pilot may need to use manual thrust.

Once established on the ILS in the landing configuration, the remainder of the approach was stable and it was only at a late stage that it deviated from what would normally be expected. There was a momentary reduction in angle of attack at about 60 ft agl and an increasing rate of descent below around 50 ft agl, with an increasing

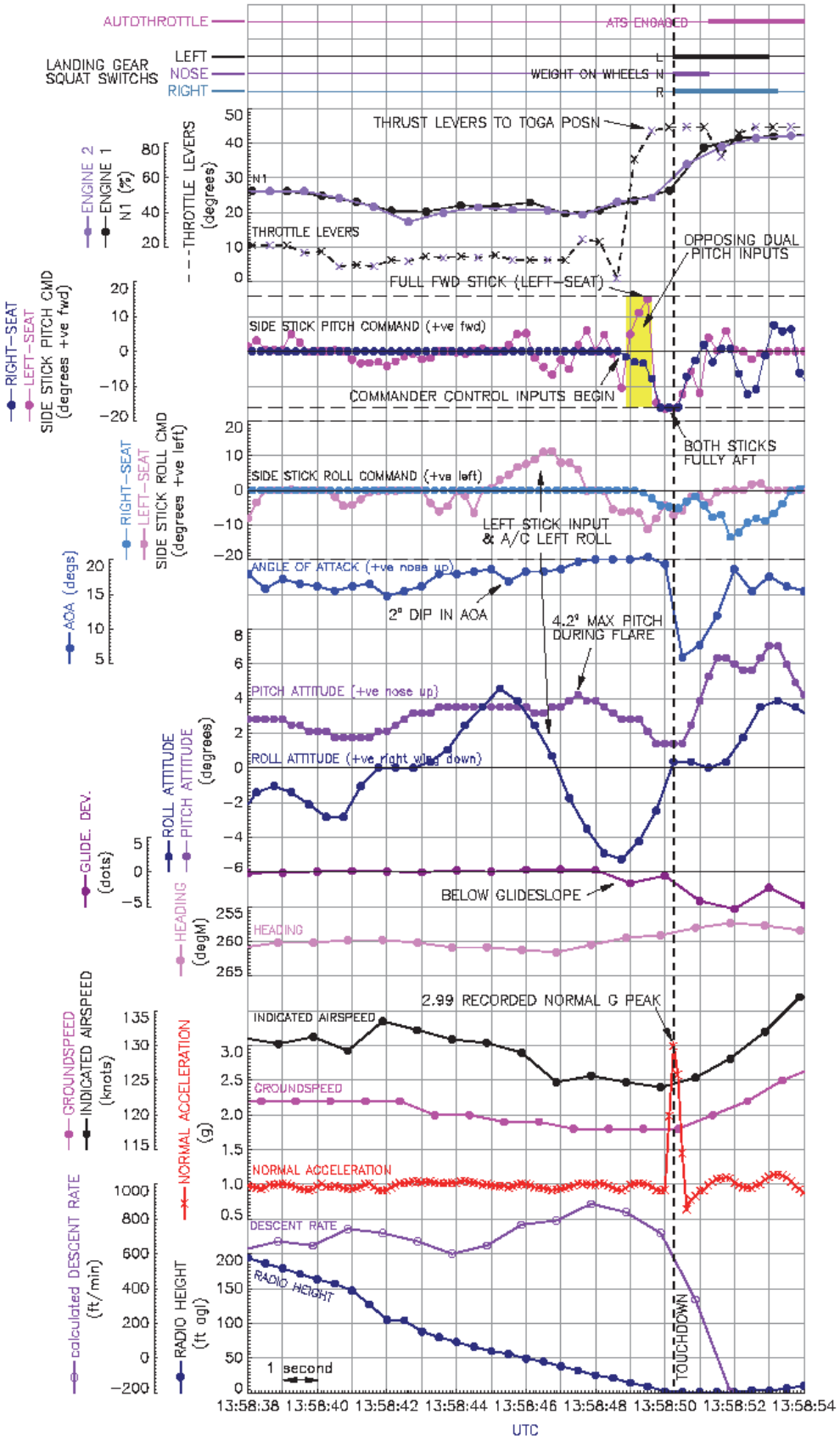

Figure 1

Salient FDR parameters for incident touchdown at Luton

pitch attitude. The PF then made two brief nose-down inputs and the aircraft's pitch attitude decreased. One or all of these factors may have provided the cue to the pilots that the aircraft was sinking.

As the pilots responded to the sink, a period of dual sidestick inputs was recorded. The dual input phase lasted for approximately four seconds before the commander established sole control and took over as PF. Initially these dual inputs were in opposing directions, before the Capt U/T's input was reversed. The commander made a nose-up control input on the sidestick but did not use the takeover pushbutton to establish control, so the effect was limited to reducing the magnitude of the nose-down input made by the Capt U/T. If the commander had used the sidestick takeover pushbutton the severe hard landing may have been prevented.

The brief nose-down inputs made by the Capt U/T occurred at a time when a nose-up control input would normally be expected and probably took the commander by surprise. The sidesticks move independently. So he would have had no knowledge of the inputs being made by the Capt U/T until the flightpath of the aircraft changed.

In attempting to carry out the TOGA 10 manoeuvre, the Capt U/T appears to have made a sidestick input opposite to that expected and there was also a brief retardation of the thrust levers before they were pushed forward to the TOGA position. One possible explanation is that there was momentary confusion between the actions of his left and right hands.

When the aircraft entered the Flare Mode at 50 ft the pitch attitude was 3.2° nose-up. The system would have ordered a nose-down pitch to reach 2° nose-up over a period of 8 seconds. However, this would have been a relatively gradual change and was not considered to be a significant factor in this event.

Following this event, the operator provided additional simulator training for both pilots before returning them to line flying duties. The Capt U/T was returned to line flying as a co-pilot for a period.

Conclusion

Both pilots responded to an increased rate of descent approaching touchdown and each initiated a TOGA 10 go-around. Their initial sidestick inputs were in opposition and, without the use of the takeover sidestick pushbutton, the net effect was a pitch-down control input. If the commander had operated the sidestick takeover pushbutton, his nose-up pitch input would not have been counteracted by the nose-down input of the Capt U/T. In the event, his control input reduced the effect of the nose-down input made by the Capt U/T.