ACCIDENT

Aircraft Type and Registration:	Airbus A320-214, G-OZBY	
No & Type of Engines:	2 CFM56-5B4/P turbofan engines	
Year of Manufacture:	2000 (Serial no: 1320)	
Date & Time (UTC):	10 April 2013 at 1425 hrs	
Location:	Prestwick Airport	
Type of Flight:	Training	
Persons on Board:	Crew - 14	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to the nose landing gear	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	58 years	
Commander's Flying Experience:	15,085 hours (of which 2,791were on type) Last 90 days - 41 hours Last 28 days - 6 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft was being operated on a flight crew 'base training' detail. While taking off after a touch-and-go landing, a takeoff configuration warning was generated. The commander rejected the takeoff and brought the aircraft to a halt on the remainder of the runway. The nose landing gear sustained some damage as the aircraft de-rotated on to the nosewheel during the manoeuvre. The crew did not consider the touchdown on the nose landing gear to be excessive and were not aware of the damage.

After a short delay, the training detail was continued. On the subsequent takeoff, with the co-pilot as PF, an ECAM message, L/G SHOCK ABSORBER FAULT was generated. This meant that the landing gear could not be retracted and that the autopilot and autothrust were unusable. During the climbout the aircraft started to descend so the commander took control and resumed the climb to circuit altitude.

After considering the status of the aircraft, the commander cancelled the training detail and the aircraft was diverted to a maintenance base.

History of the flight

Fourteen flight crew, comprising two training captains, 11 trainees and a safety pilot, reported for duty at Birmingham Airport at 0630 hrs, before departing for a flight crew 'base training' detail[1] at Prestwick Airport. A joint briefing was carried out, specifying that each trainee would carry out four circuits. The safety pilot was a company first officer, who would fulfil this role for the whole of the base training detail. The two training captains planned to share the instructional duties between them, one covering the first half of the training and the other completing the second half. The flight to Prestwick was uneventful and, on arrival, training circuits were carried out using Runway 13.

After the first half of the training detail, the training captains changed over and the second session began. Before each touch-and-go, the commander briefed the trainee on the specific actions to be carried out on the runway during the landing roll. No autobrake was to be set, no reverse thrust would be used, the trainee was to land on the centreline, then take their hand off the thrust levers while keeping the aircraft straight. The commander would disarm the spoilers, select flap 2, check the stabiliser trim was running, 'stand up' the thrust levers, check flap 2 was set and the trim was 'in the green', set TOGA thrust, check the speed and call rotate at $V_{APP.}$ The commander made these movements deliberate in order to avoid mistakes through rushing.

The fourth trainee of the second group, a co-pilot, was completing his final touch-and-go landing, with flap FULL. The landing and initial rollout were normal. The commander disarmed the spoilers, selected flap 2 and checked the trim and flap indications. He 'stood up' the thrust levers and, when the trim was set, selected MCT thrust and called "rotate". Shortly afterwards, there was a CONFIG warning. He glanced down and noted a red SPD BRK NOT RETRACTED message on the ECAM.

The commander decided to reject the takeoff and, with the aircraft rotating, he intervened on the controls. He closed the thrust levers and made a nose-down input on the sidestick but did not recollect calling "stop". There followed a period of a few seconds of dual inputs on the sidestick controls by the commander and co-pilot. Initially, both inputs were nose-down then, briefly, both were nose-up before stabilising around neutral. The commander applied the brakes hard but then reduced the brake pressure, once he judged that the aircraft would stop on the runway surface. After bringing the aircraft to a stop he taxied off the runway. The crew were aware of a hard touchdown on the nose landing gear but did not consider it was excessive.

Following the rejected takeoff (RTO) the crew was contacted by ATC to check whether any assistance was required. The crew advised that none was needed. The brake temperatures were checked and the brake fans selected ON. The commander then sought the assistance of the other training captain. They spent some time trying to determine the reason for the configuration warning but there were no indications as to the cause. So, believing that there might be a spoiler system fault, it was decided to continue the training but without arming

Footnote

[1] Circuits with touch-and-go landings.

the spoilers. Before continuing, the training captains discussed the firm nosewheel contact with several of the other crew members. None of them considered that it constituted a heavy landing and it was decided that an inspection was not required.

The training detail was resumed with the next trainee co-pilot occupying the right seat and acting as PF. The crew experienced difficulty entering a flight plan into the multi-function control display unit (MCDU), which appeared to have remained in go-around mode. They tried re-loading a flight plan using the secondary flight plan page and activating it, but were unable to do so. The commander eventually decided that a flight plan in the Flight Management System (FMS) would be unnecessary because visual circuits only were being flown. He also briefed that the landing gear should not be retracted immediately after the next takeoff, to aid brake cooling.

The aircraft took off from Runway 13 using TOGA thrust and, as soon as it had lifted off, the commander selected the thrust levers to MCT. During the initial climb, a L/G SHOCK ABSORBER FAULT message was displayed on the ECAM. The commander moved the thrust levers from the MCT detent to the CL detent, as the aircraft climbed through a height of 800 ft, and the thrust unexpectedly reduced to idle.[2] The safety pilot noticed the reduction in thrust and drew it to the commander's attention. The airspeed reduced and the aircraft started to descend. The commander took control, applied manual thrust and resumed the climb to circuit altitude. The crew requested, and were granted, an orbit in their present position. They then carried out the ECAM actions for L/G SHOCK ABSORBER FAULT, limiting the speed to a maximum of 280 kt and leaving the landing gear DOWN.

The trainee co-pilot was replaced in his seat by the other training captain and the two training captains reviewed the status of the aircraft. They determined that, with no landing gear retraction capability and the inability to engage the autothrust, autopilot or flight directors, the training should be discontinued and the aircraft flown back to Birmingham.

The crew transmitted a PAN call, advising ATC of their intentions, and an en-route clearance towards Birmingham was issued. After ATC had checked that a climb would be acceptable to the crew, the aircraft was cleared to climb to FL190.

En-route to Birmingham, the crew contacted the operator's engineering department to seek further guidance on the possible nature of the problem. A decision was made to divert the flight to Manchester, instead of continuing to Birmingham, and an uneventful landing was made at Manchester Airport following a VOR/DME approach.

The commander reported afterwards that, following the RTO and despite the lack of automation, the aircraft handled normally and, in the conditions, he had not found it especially demanding to fly. However, he also commented that the workload had been increased by the lack of information about the status of the aircraft's systems. He believed they had experienced a speedbrake fault and did not necessarily associate the shock absorber fault

Footnote

[2] The manufacturer provided the following explanation for the observed thrust behaviour: *'The auto-thrust (A/THR) engaged automatically when the thrust levers were retarded to CL. As the current speed was around 180kt and the selected speed was 130kt, the A/THR commanded a thrust reduction.'*

message with a hard landing. He could not understand why the autopilot and autothrust were not available and stated that the relevant information was not provided either by the ECAM or in the Flight Crew Operating Manual (FCOM).[3]

Meteorological information

The METAR for Prestwick issued at 1450 hrs was:

> surface wind from 120º at 6 kt, visibility 9,000 m, temperature 10ºC, dewpoint -2ºC and pressure 1003 hPa

The METAR for Manchester issued at 1550 hrs was:

> surface wind from 150° at 7 kt visibility 4,000 m in haze, few cloud at 4,600 ft, temperature 10ºC, dewpoint 1ºC and pressure 1002 hPa

Airport information

Prestwick Airport Runway 13 has a displaced threshold and an LDA of 2,743 m (8,999 ft).

Aircraft information

Configuration warning

The thrust levers can be moved into one of four detents for forward thrust. They are: 0 (idle thrust), CL (climb thrust), FLX/MCT and TOGA (both takeoff power settings). The takeoff configuration (CONFIG) warning becomes active when the thrust levers are set at or above FLX/MCT. There are eight red configuration warnings, of which speedbrake lever position is one, and four amber configuration cautions. If the speedbrake lever is out of its detent, the CONFIG SPD BRK NOT RETRACTED red warning will appear on the ECAM display when takeoff power is set.

Speed control

The aircraft may be operated in either managed or selected speed. Managed speed targets are computed by the Flight Management Guidance Computer (FMGC). When the speed target is managed, the SPD/MACH window of the Flight Control Unit (FCU) shows dashes and the Primary Flight Display (PFD) speed scale shows the speed target in magenta. To use a selected speed/Mach target, the flight crew uses the knob on the FCU to set the target speed, which is then displayed in the FCU window. It is also displayed in blue on the PFD speed scale.

During the pre-flight phase the flight crew has to insert V_1, V_R, and V_2 in the PERF TO page of the MCDU manually. These speeds are then displayed on the PFD during takeoff. If the speeds are not inserted in the MCDU before takeoff the FCU will show the last selected target speed.

Footnote

3 The manufacturer stated that autopilot and autothrust would be displayed in the INOP SYS list on the ECAM.

Landing gear shock absorber fault

The ECAM message L/G SHOCK ABSORBER FAULT is generated when the shock absorber does not extend after the aircraft becomes airborne. Additional information is provided on the ECAM Status page, advising that the landing gear must remain DOWN, if it has not been retracted, and the speed limit is 280 kt. The crew are also advised that the fuel consumption will be increased. In the INOP SYSTEMS field of the Status page the L/G RETRACT is listed, indicating that landing gear retraction is not possible.

The manufacturer advised:

> *'In case of a failure or a mis-rigging of both NLG [Nose Landing Gear] proximity sensors or if the NLG did not fully extend due to some mechanical damage, the Nose Shock-Absorber discrete associated with the proximity sensor, and directly connected to the FAC* [Flight Augmentation Computer] *(from each LGCIU* [Landing Gear Control Interface Unit]*), will be set to the Nose Shock-Absorber 'ON GROUND' state. As a result, the FAC will detect a mismatch between the NLG and the MLG [Main Landing Gear] and will inhibit the AP* [Autopilot]*, FD* [Flight Director] *and A/THR* [Autothrust] *engagement. In this case, AP1+2 and ATHR will be displayed in the INOP SYS list on the ECAM.'*

and

> *'There are several mechanical problems that may lead to a proximity sensor position failure, and therefore to a L/G SHOCK ABSORBER FAULT. Depending on the number and location of the failed proximity sensor(s), the consequences are different but whatever the failure scenario; the ECAM display will be correct and will reflect the real situation of the aircraft.'*

The manufacturer also advised that, in order to keep the FCOM as simple as possible, only the most frequent failure is covered (single failure of a shock absorber proximity sensor on a single landing gear leg). In this case, auto-pilots, flight directors and auto-thrust are available. For the situation where multiple proximity sensors fail, the FCOM does not provide guidance on the status of the aircraft systems.

Landing gear

The landing gears on A320 series aircraft are equipped with target proximity sensors, which effectively function as weight-on-wheels switches. Operation of the landing gear is controlled via two LGCIUs, with the proximity sensor outputs being used by a number of aircraft systems, including autoflight and autothrust. Data from most aircraft systems is collected by a Data Management Unit (DMU) which forms part of an Aircraft Integrated Data System (AIDS) and is used for condition monitoring and the generation of associated reports. A LOAD <15> report is automatically generated in the event of normal 'g' exceeding pre-determined values on landing and/or the radio altimeter descent rate exceeding a threshold value. The report, which is available on the flight deck printer, is to ensure the appropriate inspections are carried out by reference to the Aircraft Maintenance Manual (AMM). However, nose gear strut compression is not used within the landing gear detection logic.

Speed brake/ground spoiler control

The speed brake control lever is located on the left side of the flight deck centre pedestal and, when lifted into the ARMED position, arms the ground spoilers such that they deploy automatically on landing. When the control lever is pushed down into a detent at the front of the slot, movement in an aft direction results in proportional deployment of the speed brake surfaces. The control lever is connected to a series of transducers which send the command to the three spoiler-elevator computers (SECs), which in turn signal the spoiler servo controls that move the surfaces. These servos are equipped with linear variable displacement transducers (LVDTs) which provide position feedback to the SECs and ECAM indication.

Examination of the aircraft

Examination of the aircraft revealed no visible evidence of any damage to the nose landing gear or adjacent structure. However, on jacking the nosewheel off the ground it was apparent that the oleo would extend only 50 mm or so from its 'on ground' position. This resulted in the proximity sensors, which were attached to a linkage operated by the scissors assembly, remaining in the 'ground' as opposed to 'air' position.

With electrical power applied to the aircraft the operation of the speed brake lever was checked. It was found that when the lever was pushed down and moved aft from the front end of the gate, an ECAM indication of inboard spoiler operation appeared after the lever had moved approximately 2 mm. This was in accordance with correct operation of the system and indicated that spoiler deployment was initiated after a relatively small movement of the lever.

A copy of the Post-Flight Report (PFR) was obtained from the printer on the flight deck pedestal. This provided a record of faults logged by the Central Fault Display System (CFDS), showing both the ECAM messages, together with any associated failure messages. giving diagnostic information to maintenance personnel. The first pertinent fault report was 'BRAKES HOT', timed at 1428 hrs, together with a Flight Phase and ATA chapter reference. This reflected the time the takeoff was aborted following the configuration warning. The next message was 'L/G SHOCK ABSORBER FAULT' at 1447 hrs, followed by 'AUTO FLT A/THR OFF', also timed at 1447 hrs. The final relevant ECAM message was another 'L/G SHOCK ABSORBER FAULT', at 1448 hrs. The time-stamps of the final three messages indicated the elapsed time of approximately 19 minutes from the rejected takeoff to the subsequent departure, while the aircraft was taxied back to the start of Runway 13.

The PFR contained two relevant maintenance messages, which were associated with the 'L/G SHOCK ABSORBER FAULT' messages. Both were timed at 1447 hrs and referred to the two nose landing gear proximity sensors, '25GA' and '24GA', one message for each sensor. The source (ie component) for each message was identified as LGCIU 2 and LGCIU 1 respectively. This indicated that neither LGCIU had received valid 'air mode' signals from the proximity switches after takeoff. As a result a baulk signal was generated that would have prevented retraction of the landing gear following a gear UP selection. This feature is designed to prevent potential additional damage arising from retracting a damaged landing gear.

The nose leg was subsequently removed and sent to the manufacturer's overhaul facility for further examination. This revealed that a degree of distortion had occurred to the inner oleo cylinder, such that it could no longer move freely relative to the outer cylinder; it was this feature that had prevented the strut extending, under the oleo gas pressure, to the 'air' position. The damage was less severe than that which has been seen in previous A320 damaged nose landing gear events, notably that to registration G-MARA, which was published in AAIB Bulletin 6/2009. In this incident the aircraft touched down in a flat, perhaps slightly nose down attitude. Apart from the damage to the cylinder, part of the linkage that moved the target proximity sensor was noted to be distorted. This had occurred as a result of the landing gear geometry, which was such that it caused distortion in the linkage at full strut compression.

One of the AAIB Safety Recommendations (2009-047) made in the G-MARA report, recommended that Airbus include a specific reference in the AMM to inspecting the nose landing gear proximity target link rod for damage, as this could be a likely indicator of full strut compression and thus potential additional damage. Airbus stated they would change their procedures to be followed in the event of abnormal landings in a manner that effectively introduced the intent of the Recommendation. In the event, the amended AMM did not include any reference to the gear proximity target link rod. However, Airbus did update the relevant subtask for nose landing gear inspections (ref 05.51.11.210.091) to inspect the aircraft *"…if the hard or hard overweight landing was on the nose gear only (high pitch rate)…."* The required tasks in this event include lifting the aircraft on the forward jacking point.

Additional information

Information from the aircraft manufacturer indicated that if the compression status of the nose landing gear differs from that of the main gears for more than 20 seconds, the LGCIU is considered invalid. Since both sets of proximity switches failed to register 'air mode', both LGCIUs were considered failed by the Flight Augmentation Computers (FACs) with the result that 'L/G SHOCK ABSORBER FAULT' messages were generated approximately 20 seconds after the main landing gears uncompressed.

The aircraft manufacturer additionally stated that the invalid LGCIU status meant that the FACs, which, among other functions, provide flight envelope protection, would have no indication of landing gear position. This information is used in complex configuration and operational speed computations so the lack of it reduces the integrity of these calculations. This in turn can lead to errors in the weight and selectable speeds and is the reason why the autopilot/autothrust and flight directors cannot be engaged.

Recorded data

The aircraft was fitted with an FDR and a CVR. Before the event was notified to the AAIB the operator initiated an internal investigation. The FDR was downloaded and the data was supplied to the manufacturer, to help determine the appropriate maintenance actions. Subsequently, a copy of the data was obtained by the AAIB investigation.

The CVR was a two-hour recorder. The circumstances surrounding the RTO were overwritten and the CVR recording began during the flight to Manchester.

Other on-board sources of data were the EGPWS and an in-cockpit video of part of the RTO sequence, captured using a handheld smart phone. The smart phone captured three minutes and nine seconds of high definition video and audio recording, filmed from the rear left section of the flight deck by a fourth pilot, a trainee secured in a crew jump seat, and directed mainly towards the trainee in the right seat. The recording started early in the approach and was stopped during the RTO.

Other evidence included RTF, radar and CCTV recordings.

The following information is an amalgamation of the recorded data. Figure 1 shows the pertinent extracts from the recordings leading up to and including the RTO.

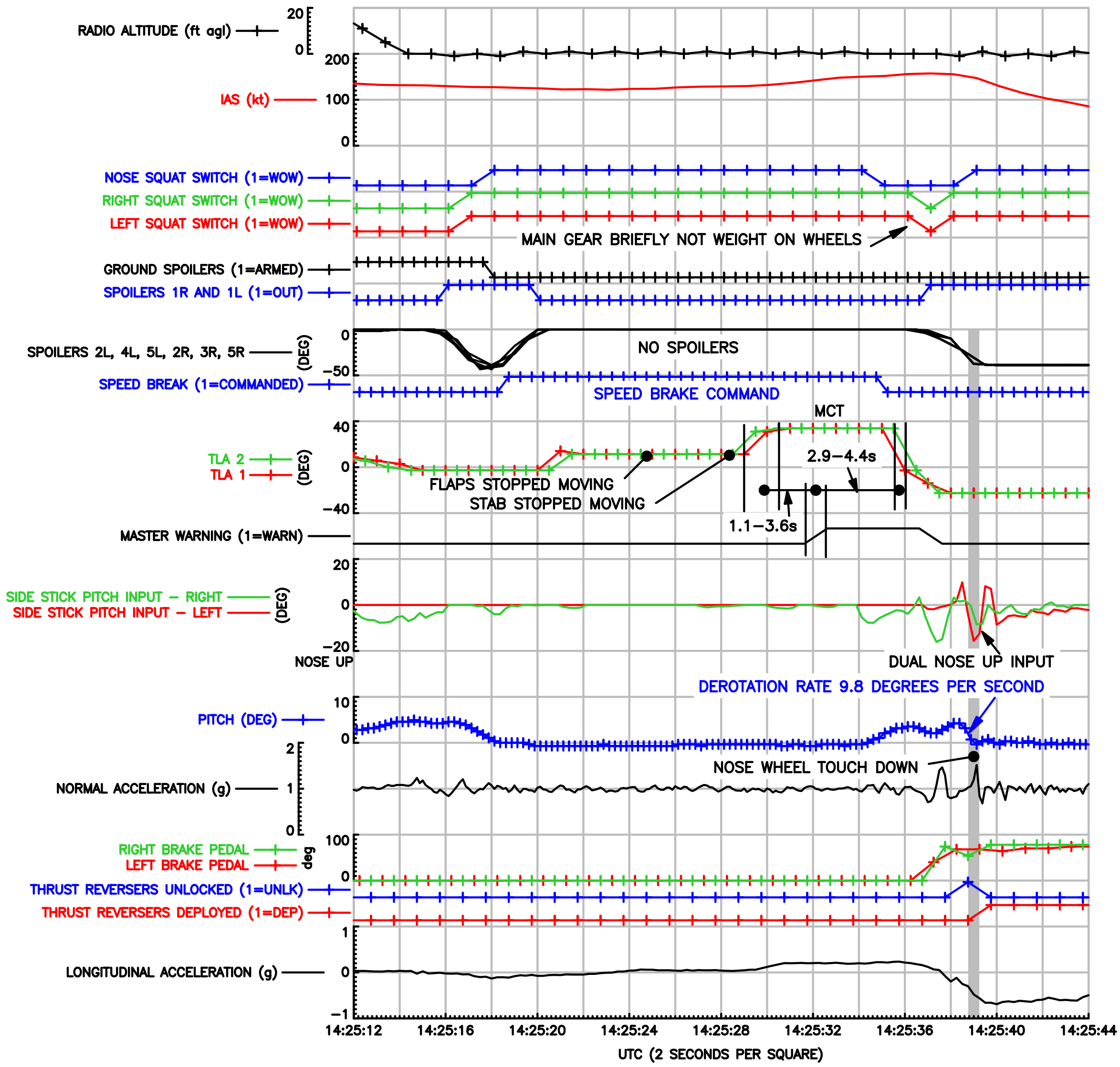

Figure 1

Touch-and-go rejected takeoff

Prior to landing, the ground spoilers had been ARMED and, on landing, they deployed as intended. As the nose landing gear proximity switch registered weight-on-wheels, the ground spoiler system transitioned to NOT ARMED and the speed brake parameter transitioned to COMMANDED. Within the following two seconds the spoilers retracted. During this period the flaps started to move. Shortly after that, the throttle levers were advanced to a position half way to the CLB detent and the stabiliser trim started moving.

When the stabiliser trim stopped moving the throttles were moved to the MCT detent. The in-cockpit video indicates that approximately 1.8 seconds after thrust levers reached MCT, the master warning was triggered. Approximately 2.5 seconds after the onset of the warning, the speed brake command parameter reset to NOT COMMANDED. This was followed by the thrust levers being retarded to idle and then reverse thrust. Meanwhile, the pilot in the right seat had started to rotate the aircraft. With the nose landing gear in the air, the spoilers started to deploy and the brake pedals were applied. The main landing gear proximity switches indicated they were in the 'air' (landing gear uncompressed) position for one sample (the sample rate was 1 per second) and then showed weight-on-wheels, again, shortly following which the thrust reversers unlocked. The aircraft then derotated, nose-down, reaching a rate of 9.8 °/s at the same time as both side stick controls were commanding a pitch-up. A normal acceleration spike of 1.52g was recorded at the centre of gravity as the nose landing gear touched down.

The aircraft came to a stop with approximately 560 ft of runway remaining and immediately turned on to Runway 21, then on to Taxiway R.

Between the onset of the master warning and the first recorded movement of the thrust levers to reject the takeoff, the aircraft had accelerated from a ground speed of 131 kt to 147 kt.

Subsequent flight

The subsequent flight departed at 1446 hrs. The data recorded at the start of the flight is shown in Figure 2. The nose landing gear proximity switches continued to indicate weight-on-wheels after takeoff and the flight directors were engaged at 200 ft agl. At 800 ft agl, the autothrust engaged in 'speed' mode after the thrust levers were retarded to CLB. With the aircraft speed above the selected speed of 130 kt, the engine target N_1 and, subsequently, achieved N_1 values reduced. The flight director and autothrust systems then disengaged as the aircraft passed 1,200 ft agl, with the aircraft decelerating. Five seconds later, the selected speed was increased to above the aircraft speed. A further five seconds later the thrust levers were advanced and subsequently the sidestick control inputs switched from the right to the left. Shortly afterwards, an EGPWS mode 3 (altitude loss after takeoff), warning was triggered.

The aircraft climbed to 1,600 ft agl and remained at this height whilst carrying out a number of orbits. At 1501 hrs, the aircraft initiated a climb to FL190 and flew to Manchester, landing at 1550 hrs. The landing gear remained DOWN throughout the flight. The autopilot was not recorded as engaged during any part of this flight and the aircraft used normal control laws.

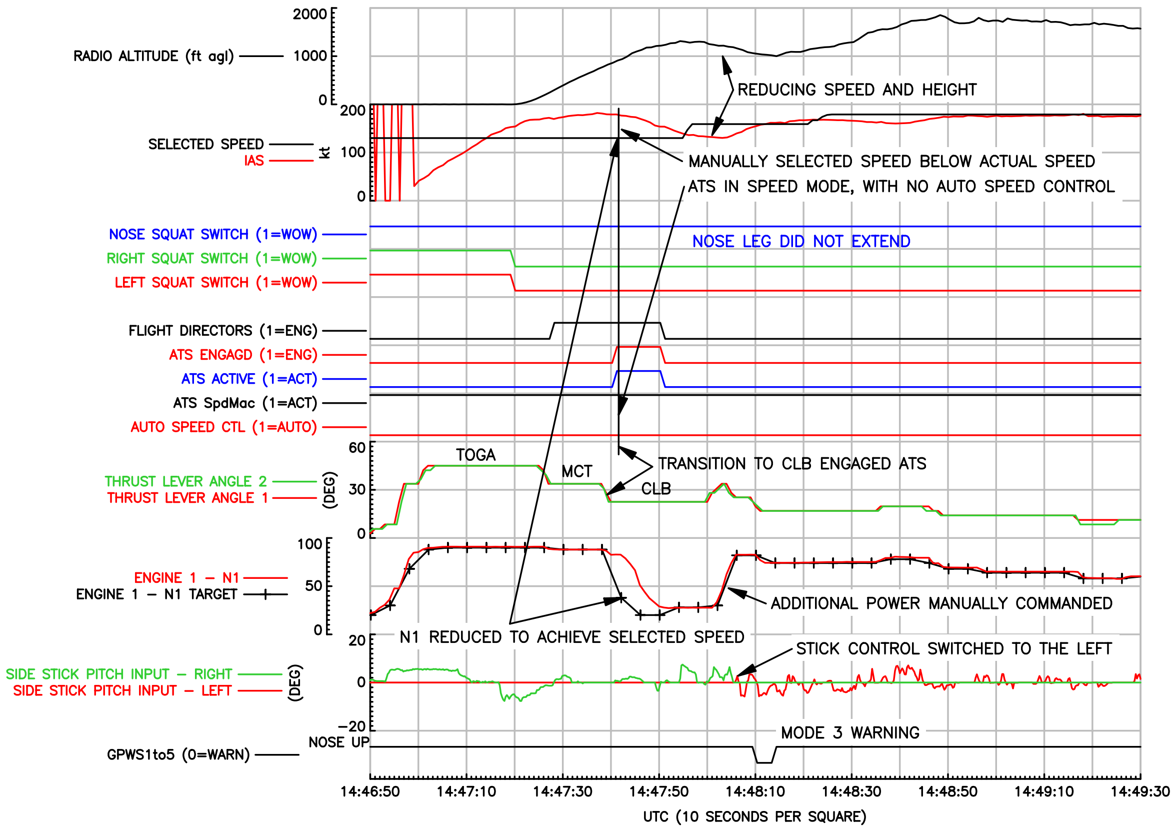

Figure 2

Subsequent takeoff

The CVR recording started 27 minutes prior to the touchdown at Manchester Airport. It included information on the ECAM messages relayed to the operator's engineering department by the crew. They related to: autopilots 1 and 2, autothrust, landing gear retraction, a HOT AIR INOP caption and the aircraft being Category 2 status only. The crew suspected damage to the landing gear proximity sensors and reported three green indicator lights for the landing gear.

Manufacturer's comments

During the investigation, the manufacturer was consulted on the recorded behaviour of the flight director and autothrust modes. They provided the following explanation:

> *'After the rejected touch and go, the FD were engaged in Go Around modes. Then they were disengaged at approximately 14:28:00. The most probable hypothesis for this disconnection is that the crew selected them OFF trying to exit the MCDU Go Around phase. When they have been selected OFF, there is no automatic engagement of the FD except during a go around in flight. Therefore, the FD were not engaged during the takeoff. At 14:47:27, FD2 was engaged followed, 1 sec later by FD1. This engagement cannot be automatic and must have been commanded by the crew. The FD engaged in basic modes, V/S and HDGM, then ALT* mode engaged as the aircraft was approaching the selected altitude.'*

and

> *The auto-thrust (A/THR) engaged automatically when the thrust levers were retarded to CL. As, at that time, the Flight Directors (FD) were engaged in ALT* mode, the A/THR engaged in SPEED mode. As the current speed was around 180 kt and the selected speed was 130kt, the A/THR commanded a thrust reduction.*

Previous touch-and-go takeoffs

The previous touch-and-go takeoffs were compared to the takeoff on the final flight that eventually landed in Manchester. The final takeoff was the only one with the AUTO SPD CNTRL parameter not indicating AUTO.

Flight data monitoring

The investigation prompted two questions:

1. How often has the speed brake command been triggered inadvertently when the ground spoilers have been disarmed?
2. Was the derotation rate during the RTO distinct enough from normal operations to trigger an indication that maintenance action may be required?

The operator's Flight Data Monitoring (FDM) program provided the statistical background to these questions. This was achieved using a combination of data from current event triggers and data from new event triggers.

Speed brake command

An FDM trigger event was created for a speed brake command generated within five seconds of the ground spoilers being disarmed. The approach phase of a flight was excluded from this study to avoid distorting the figures with intentional use of the speedbrake controls, which also met the trigger criteria.

The occurrence rate of this event during the landing roll on the operator's A321 and A320 fleet were 2.47 and 2.24 occurrences per 1,000 landing rolls, respectively. No common trends were identified. This event is benign during the landing roll on a full-stop landing. However, the occurrence rate is indicative of how often there is an unintended consequence when disarming the ground spoilers.

Derotation rate

The operator's FDM program has three derotation rate triggers per fleet, measured during landing. They are referred to as Minor, Major and Critical, and correspond to the trigger values given in Table 1.

	Derotation rate events		
	Minor	Major	Critical
Trigger derotation rates (°/s) – A320	-4	-5	-7
Occurrences in 9,787 landings	2	0	0

Table 1

The operator's derotation rate trigger levels and triggered occurrences during normal A320 operations

In the 12 months of operation to the end of August 2013, covering nearly 10,000 A320 landings, there were 2 triggers of the Minor event and no Major or Critical derotation rate triggers. This indicated a clear distinction between normal operations and the derotation that caused the damage to G-OZBY.

Training procedures

The aircraft manufacturer provides guidance on touch-and-go landings in the *Base Training Syllabi* for their aircraft, including specific task sequence and allocation. Spoilers are expected to be ARMED for landing and DISARMED during the touch-and-go landing roll. Additional advice on emergencies states:

> *'The decision to discontinue a touch and go after the application of TOGA must only be taken if the instructor is certain that the aircraft cannot safely fly.*
>
> *Remember there is no V_1 on a touch and go.'*

The operator's Type Rating Training Organisation (TRTO) manual provides specific guidance on the procedures to be used during base training including the sequence of actions during a touch-and-go landing. The procedures reflect those in the manufacturer's guidance, with the exception of the following statement: *'the spoilers will not be armed'* for landing. The manual recommends a minimum LDA of 8,000 ft (2,438 m).

The AAIB was advised that the manufacturer had, in the past, required the spoilers not to be ARMED for a touch-and-go landing but had revised the procedure.

A number of the operator's training captains had been instructed by a third party provider on how to conduct aircraft base training. The procedures for arming and disarming the spoilers, as taught by that provider, differed from the manufacturer's and those described in the operator's TRTO manual. They recommended that spoilers should be ARMED for landing and should remain ARMED for the takeoff phase. The operator reported that their training personnel had standardised amongst themselves and adopted the manufacturer's procedure, namely, to arm the spoilers for landing and disarm them during the ground roll.

Analysis

The available evidence suggested that the configuration warning resulted from the speed brake lever being inadvertently placed in the speed brake range, during the touch-and-go landing, in such a position that it did not command spoiler surface deflection. The timing of this selection indicated that it occurred when the ground spoilers were being disarmed by the commander pressing the lever downwards. This then caused the takeoff CONFIG warning to be activated after takeoff power was set, and the commander rejected the takeoff.

The manufacturer's syllabus, the operator's TRTO manual and a third party training provider each specified different procedures for arming and disarming of the ground spoilers. The commander was using the technique recommended by the manufacturer and adopted by the operator's training personnel.

The decision to reject a takeoff is normally a rule-based decision with clearly defined failure events and a calculated V_1 decision speed. The manufacturer advises that a touch-and-go should not be rejected once TOGA is set, unless the commander is certain the aircraft will not safely fly, and notes that there is no V_1 decision speed on a touch-and-go.

The takeoff CONFIG warning is not activated until the thrust levers reach takeoff power. Therefore, during a touch-and-go the warning will always occur after MCT or TOGA is set and at a higher speed than for a normal takeoff. On this occasion, after setting MCT, the commander believed that the safety of the aircraft might be compromised if they continued, so he rejected the takeoff. During the RTO there was a period of dual inputs on the pilots' sidestick controls, lasting for a few seconds. The absence of a STOP call probably contributed to this.

The commander brought the aircraft to a stop before the end of the runway, which was 305 m (1,000 ft) longer than that recommended in the TRTO manual for touch-and-go landings, and was able to reduce the braking effort during the deceleration.

The two training captains considered the status of the aircraft after the RTO and came to a decision that the touchdown of the nose landing gear during the RTO was not hard enough to merit any further action. They discussed the event amongst those on board and it was not considered that the touchdown of the nose landing gear had been excessive.

Thrust reduction after takeoff

An explanation for the reduction in thrust to idle was provided by the aircraft manufacturer. When CLB thrust mode was engaged the selected target speed was 130 kt, which was below the aircraft's current speed of 180 kt. The selected speed of 130 kt may have corresponded to the approach speed from the previous approach. The observed thrust behaviour was not expected by the crew but appears to have been as a result of crew selection and not related to the damage sustained by the aircraft.

Recorded data

Inadvertent speed brake command

The operator created an FDM trigger for capturing speed brake commands that became active within five seconds of the ground spoilers being disarmed. The occurrence rate on the operator's A321 and A320 fleet were 2.47 and 2.24 occurrences per 1,000 landing rolls, respectively. This provides an indication of the rate at which an inadvertent speed brake command occurs on the operator's A321 and A320 fleet as a consequence of disarming the ground spoilers. It also shows that the probable reason for the configuration warning, and the subsequent RTO, on this investigation is not unique. This has little consequence during a normal, full-stop landing but becomes an issue during touch-and-go landings.

Combining the operator's A320 fleet rate and the number of touch-and-go landings carried out during this training detail, indicates that there was an approximately 8% probability that the inadvertent speed brake command would have occurred that day.

Hard landing/ high derotation rate

Over a 12 month period, on its A320 fleet, the operator did not detect any derotation rates during landings of -5 °/s or greater. The derotation rate during the RTO, which resulted in damage to the nose landing gear, was calculated as -9.8°/s.

No LOAD <15> report was generated as none of the Normal 'g' or radio altimeter descent rate thresholds were exceeded during the RTO. The aircraft manufacturer stated that the LOAD <15> algorithms are not capable of detecting all cases of abnormal landings and that the detection of this kind of occurrence is outside the scope of the LOAD <15> report. The detection of possible nose landing gear damage remains the pilots' assessment of the touchdown. On this occasion, the crew did not consider the touchdown on the nose landing gear to be excessive and there was no indication of damage or fault with the aircraft until the subsequent takeoff.

Safety pilot

Each training captain was scheduled to carry out some 24 takeoffs and landings, assuming that no additional training was required. A safety pilot is required to be on board to monitor the safety of the aircraft during base training as an 'extra pair of eyes' in case of errors or distractions. Therefore, the safety pilot for this detail was responsible for monitoring the safety of at least, 48 takeoffs and landings. For a single crew member to remain alert throughout this whole period would be demanding. During the ground roll in a touch-and-go landing there are a number of actions for the safety pilot to monitor. From the jump seat position, though, it is unlikely that he would have been able to see clearly if the speedbrake lever was slightly out of its detent. During the subsequent takeoff he drew the commander's attention to the unexpected behaviour of the thrust.

Safety actions

The operator carried out a review of its crew training programme following this incident and made a number of changes to their procedures and manuals. These included:

- The operator's Safety Department created a Flight Data Monitoring event to highlight any inadvertent movement of the speedbrake lever during both line and training operations.
- A revised and definitive procedure for base training has been included in the operator's Type Rating Training Organisation (TRTO) Manual.
- The operator has revised its crewing requirements, and documented them in their TRTO Manual, such that the maximum number of trainees/circuits per training captain is limited. Furthermore, one safety pilot is rostered for each training captain, in order to reduce workload and possible fatigue of the safety pilot.