ACCIDENT

Aircraft Type and Registration:	Airbus A321-231, G-MARA
No & Type of Engines:	2 International Aero Engine V2533-A5 turbofan engines
Year of Manufacture:	1999
Date & Time (UTC):	28 July 2008 at 2145 hrs
Location:	Manchester International Airport, Greater Manchester
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 8 Passengers - 159
Injuries:	Crew - None Passengers - None
Nature of Damage:	Nose landing gear internal shock absorber assembly severely distorted
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	6,930 hours (of which 1,545 were on type) Last 90 days - 200 hours Last 28 days - 79 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft made a hard landing, in a flat attitude, in which the nose landing gear sustained internal damage. An engineer, following the process in the Aircraft Maintenance Manual (AMM), determined that no inspections were required as the relevant recorded parameters had not exceeded the stated threshold values. On the next flight, the flight crew were unable to retract the landing gear. Subsequent nvestigation of this defect identified internal damage to the nose landing gear and a bent proximity switch link rod. The nose landing gear was replaced and extensive inspections conducted before the aircraft was released to service. Three Safety Recommendations are made.

History of the flight

G-MARA was operating a night charter flight from Malaga to Manchester Airport, with the co-pilot as the pilot flying (PF). The flight had been operated in accordance with company procedures and had been without incident until the landing.

The landing flare was initiated slightly early and the aircraft settled into a 'float' at approximately 10 ft above the runway (radio height). Whilst in the 'float', the co-pilot's sidestick briefly moved to fully forward then to fully aft. The aircraft reacted with a rapid nose-down pitch and touched down in a near flat attitude. A significant bounce occurred, which was controlled by the co-pilot; a second touchdown and rollout ensued.

The commander taxied the aircraft to the parking stand where it was shut down normally.

Three passenger service unit oxygen masks had dropped from their stowages but no other effects of the landing were apparent and no injuries had occurred.

Initial maintenance actions

As the passengers were disembarking, a company ground engineer boarded the aircraft. He spoke to the flight crew, who reported that they informed him the landing had been heavy, and that they were certain some sort of damage must have occurred. The ground engineer later stated that he had understood from this conversation that the aircraft had landed heavily and bounced. Neither party mentioned that they were aware that the nosewheel may have touched down first.

The engineer referred to the relevant part of the AMM, Section 05-51-11-200-004-A, *'Inspection after hard/ overweight landing for aircraft with enhanced DMU/ FDIMU LOAD <15> report*[1]*'*, to determine his course of action.

Because of the crew report, the engineer expected to see an automatically printed LOAD <15> report but, as there was not one, he accessed the Aircraft Integrated Data System (AIDS) Data Management Unit (DMU) to look for a stored report in the event that it had not printed. The DMU did not contain any such report; consequently, the engineer concluded that the landing could not have been as hard as the crew suspected as none of the DMU parameter limits had been exceeded. Therefore, no inspection was required. However, because of the crew's concerns, he thought it would be prudent to carry out the visual items of the Phase 1 inspection for a heavy landing. This was completed and no damage was identified. The dropped oxygen masks were re-stowed, the technical log entry was cleared with these actions, and the aircraft released back into service.

Later that night, G-MARA departed Manchester but the flight crew were unable to raise the landing gear and received a landing gear shock absorber fault message. The aircraft returned to Manchester and landed without further incident.

Further maintenance activity

Fault finding of this defect initially concentrated on the nose leg proximity sensors. In order to check their operation, the nose of the aircraft was jacked up, but the nose leg did not extend as expected and fluid started leaking from the assembly. Further examination and disassembly identified that the internal shock absorber assembly was severely distorted and a link rod, which connects the upper arm of the torque link to the moving proximity sensor target mounting, was bent.

The aircraft manufacturer was approached by the operator and provided with the data from the Flight Data Recorder (FDR) relating to the landing, to determine the extent of any further inspections they might consider necessary. The nose leg assembly was replaced, but the various additional inspections did not identify any other damage to the aircraft.

Flight Recorders

In accordance with regulatory requirements, the aircraft was equipped with a FDR and a Cockpit Voice Recorder (CVR). The FDR recorded just over 60 hours of data and the CVR 120 minutes of audio[2]. Parameters from

Footnote

1 See paragraph headed *'Automatic LOAD<15> report'*.

Footnote

2 Unlike the FDR, which operates upon engine start and ceases on engine shutdown, the CVR operates whenever the aircraft is electrically powered and so is more susceptible to being overwritten unless prompt action is taken to preserve its record.

the FDR included the position of both the commander's and co-pilot's sidestick, the aircraft pitch attitude, radio altimeter height and normal acceleration, sensed by an accelerometer mounted near to the aircraft's centre of gravity. A time history of the relevant parameters during the final stages of the landing is shown in Figure 1. The aircraft was also equipped with a Quick Access Recorder (QAR), which recorded the same data as that of the FDR onto a removable memory device.

Recorded information

The FDR, CVR and QAR media were removed from the aircraft and successfully replayed. The FDR provided a complete record of both the incident flight and the proceding outbound sector from Manchester. Unfortunately, by the time the severity of damage to the nose gear had been identified, the CVR record relevant to the arrival at Manchester from Malaga, had been overwritten. The QAR data was replayed by the operator.

The aircraft had departed Malaga Airport at 1912 hrs and the flight was uneventful until the later stages of the landing. At 2131 hrs, three minutes before touchdown, the aircraft was stabilised on the ILS approach for Runway 05L at a height of about 1,300 ft and was configured for landing with full flap and the landing gear down and locked. At a height of 1,150 ft, the autopilot was disconnected and the co-pilot took manual control. The autothrust remained engaged for the approach and landing, with the approach speed stabilised between 140 kt and 147 kt. The recorded wind was from an easterly direction and had reduced to less than 15 kt during the final 150 ft of the approach.

The aircraft remained stabilised on the ILS approach and, at a height of about 35 ft, the co-pilot started to flare the aircraft, Figure 1, Point A. The initial part of the flare appeared normal, with the thrust levers being retarded and the aircraft pitch attitude being stabilised at about 4° nose-up; roll attitude was wings level and the airspeed was 135 kt. As the aircraft closed to within about 10 ft of the runway, the co-pilot's sidestick was moved rapidly to the fully forward position, before moving to the fully aft position, Figure 1, Point B. The aircraft responded, de-rotating rapidly at 4.5°/second before touching down at a pitch attitude of about 1° nose down, Figure 1, Point C. A peak normal acceleration of 1.99g was recorded as both the nose and right main gear oleos compressed within one second of each other; the left main gear oleo compressed less than a second later. The aircraft then bounced, indicated by the extension of both main gear oleos and change in normal acceleration to less than 1g. The aircraft remained airborne for just over a second, during which the co-pilot attempted to reduce the aircraft sink rate by applying full aft sidestick and advancing the thrust levers; however, the aircraft touched down on the main gear with a normal acceleration of 2g. The thrust levers were then fully retarded. The spoilers had deployed automatically on landing and reverse thrust and manual wheel braking were applied. There had been no movement of the commander's sidestick during the entire approach and landing phase. Aircraft gross weight at touchdown was 63,133 kg.

Following the initial bounced landing, the aircraft had pitched to 6° nose up and both main gear oleos extended. However, the nose landing gear indicated that it was still compressed, when it could not have been in contact with the ground. Subsequent analysis of the FDR data confirmed that none of the LOAD <15> report limits had been exceeded. At a landing weight of 63,133 kg, a LOAD <15> report would have been triggered if the radio altimeter-derived descent rate and normal acceleration limits of 9 ft/sec and 2.6g had been exceeded. At the initial touchdown, these parameters were recorded as 3 ft/sec and 2g respectively.

During the taxi for departure at Malaga, a full-and-free check of the primary flight controls was made; both the commander's and co-pilot's sidesticks were operated through their full range of movement, with no evidence of any abnormalities being recorded. The performance of the aircraft was also analysed, in conjunction with the aircraft manufacturer. During the flare it was found to have responded normally to the recorded movement of the co-pilot's sidestick. There were no reports from the operator of any defects associated with the co-pilot's sidestick, either before or after the accident.

Co-pilot's training

The co-pilot had commenced commercial jet operations in August 2005, when he started flying the 737-500 aircraft. In February 2008, he began line flying the Airbus A320 series and had accrued 248 hours on type at the time of the accident. During type conversion training, he had found the conventional hand position on the sidestick uncomfortable to use and, at the suggestion of a training captain, he began using a different 'grip', much lower on the sidestick.

A review of landings conducted by the co-pilot was carried out using stored flight data.

- On the 30 June, the commander took control from the co-pilot following a 1.83g touchdown
- On the 5 July, a high de-rotation event of a similar nature to the accident flight occurred, but with no resultant damage to the aircraft
- On the 16 and 17 July, high de-rotation events had occurred, although resulting from different sidestick inputs from that on G-MARA

Following the accident to G-MARA, the operator conducted additional simulator, base and line training with the co-pilot. No issues were found during this training and he was cleared to resume line flying. Subsequently, a review of his landings was conducted using OFDM data, to validate the training, and no issues with his ability to land the aircraft were discovered.

Sidestick issues

Information was sought from the manufacturer about the 'design' hand position for the sidestick controller. They commented that the intended method of use of the sidestick is:

'- *Use the armrest at all times and memorise the letter and digit which gives the more comfortable position when found and confirmed.*

- *The side stick has an ergonomic design. It has on its top a hollow for the thumb rest. The normal use is to grasp the stick, rest the thumb in the hollow being ready to press the takeover push button when needed. The index finger is used to press the trigger to talk.*

The side stick should be used carefully by giving slight inputs to avoid the large pitch or bank variations.'

During the investigation, pilots from a range of operators were asked how they grip the sidestick. There appeared little consensus from their comments, other than that many pilots do not hold the sidestick in the manor intended by the manufacturer. The nature of the fly-by-wire flight control software is such that a 'bump and release' technique appears common when flying manually. This lends itself to a much looser 'two fingered grip than when flying a

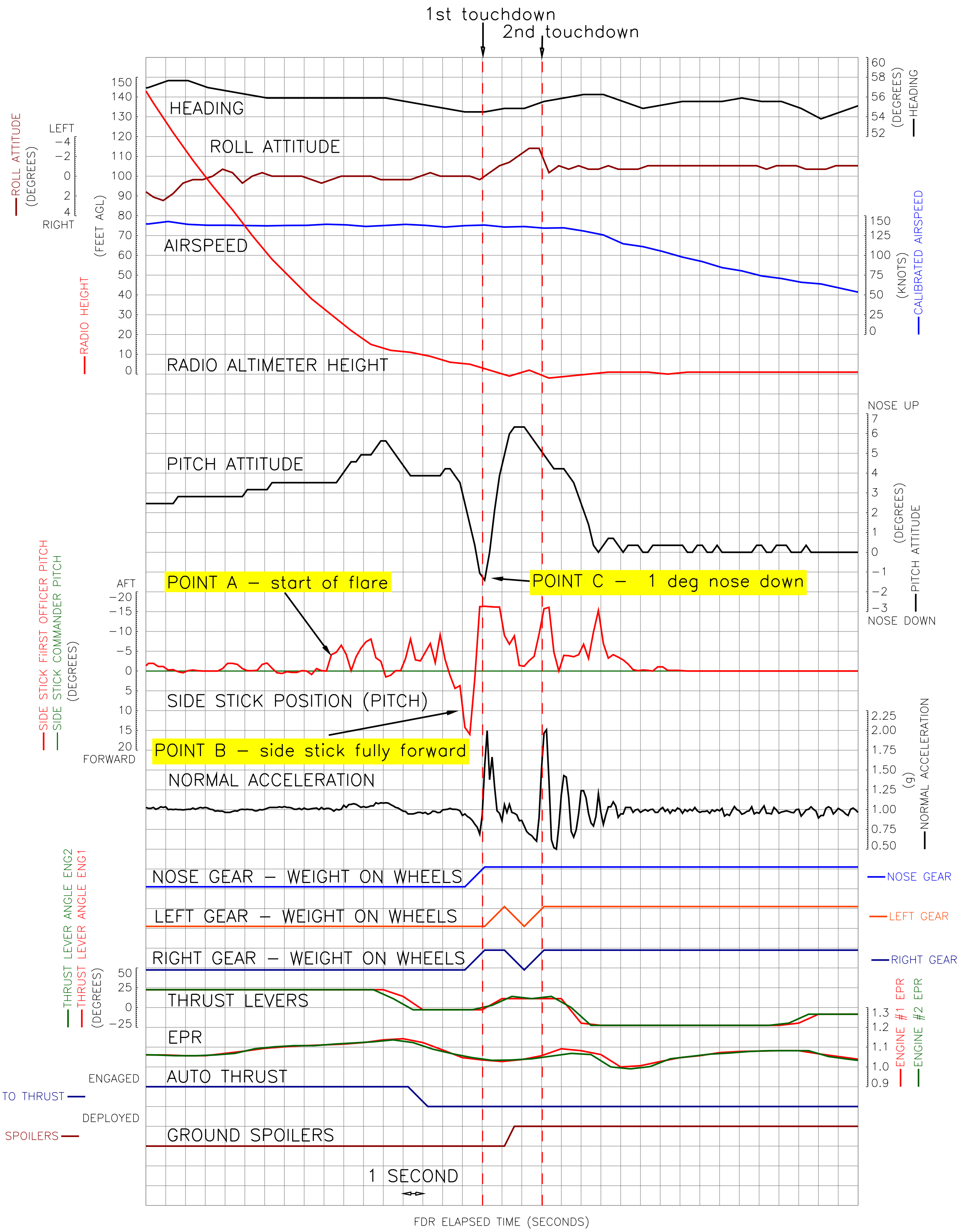

Figure 1

Salient FDR Parameters
(Incident to G-MARA on 28 July 2008)

conventionally controlled aircraft. The takeover button and radio trigger are located on the sidestick such as to require minimal movement of the hand when using the manufacturers intended grip position. Alternative grip techniques may compromise the pilot's ability to operate these buttons simultaneously.

Heavy landing determination

Many commercial transport aircraft have no immediately accessible instrumentation for the flight crew to determine normal acceleration during landings. As such, it is incumbent on the flight crew to report heavy landings. The assessment of the severity of a heavy landing is therefore highly subjective.

The A320 series of aircraft are fitted with a system that will sense when landing parameters, including normal acceleration, have been exceeded, and will generate a LOAD<15>report, following which inspection of the aircraft for damage is required (see paragraph headed '*Automatic Load<15> report*'). Where instrumented limits are set, the various aircraft manufacturers use different acceleration limits for defining such landings where, mostly, the normal acceleration is sensed close to the aircraft's centre of gravity position. In this case, the pilots were convinced that a heavy landing had occurred and, indeed, were surprised that no damage appeared to have resulted. For this landing, in which the aircraft's attitude was 1° nose-down, the nose and right main gears touched down within approximately one second of each other and within one second in advance of the left main gear, it is probable that the forces imparted to the flight deck from the nosewheel touchdown would have appeared higher than normal to the flight crew.

Co-pilot's landing

During the landing, the co-pilot was unaware of pushing the sidestick fully forward, having intended only to release the backpressure he had been applying. He had no issues with landing the aircraft before the 30 June, and none have been detected since the incident flight. As such, it is considered that the forward sidestick inputs may have been a subconscious reaction to the firm landing event of 30 June, where his commander took over. The co-pilot's landing technique appears to have altered following that landing. The Flight Data Monitoring (FDM) software in use by the operator tracked this change, but the information was not reviewed until after the heavy landing with G-MARA. During a CAA audit of the operator, in February 2008, an observation was raised that the current establishment assigned to FDM oversight appeared inadequate. In response, the operator was in the process of increasing staffing numbers at the time of the accident.

Heavier than desired landings occur throughout the industry, for a range of reasons, and damage occasionally results. The critical requirement is that the aircraft is not then dispatched without this damage being identified and rectified.

Automatic LOAD <15> report

The AIDS is a centralised system which automatically collects and processes aircraft information for the purpose of supporting Aircraft Performance Monitoring (APM), Engine Condition Monitoring (ECM) and APU Condition Monitoring (ACM) programs. For G-MARA, the AIDS consists of a remote print function (located on the flight deck centre pedestal), a Data Management Unit (DMU) and the option to equip the aircraft with a Digital AIDS Recorder (DAR). Over 3,000 parameters are available to the DMU for display, monitoring and recording.

APM, ECM and ACM functions are supported by DMU generated reports, with a report being generated when programmed trigger mechanisms are activated. Upon report activation, the DMU collects groups of parameters specific to the report. Once generated, a report may then be printed on the flight deck, copied to the DAR or sent via the Aircraft Communication Addressing and Reporting System (ACARS) direct to the operator. In addition to the automatic generation of reports, a manual report function is also available through the flight deck Multi Function Control Display Unit (MCDU) or remote print function. When a report has been manually generated, parameters in the report will be collected immediately and independently of any other 'start based' logic. A manual report may then be printed, copied to the DAR or sent via ACARS in the same way as one that was automatically generated.

A structural exceedence report, termed LOAD <15>, was introduced following a hard landing of an A320 aircraft on 3 March 1994. Following that hard landing, the aircraft flew another three flights before problems with landing gear retraction, were discovered. Examination revealed the left gear had suffered a fracture of the upper diaphragm tube and the right gear had an ovalised upper diaphragm tube. Had the landing parameter limits been exceeded, a LOAD <15> report[3] would have been available on G-MARA after the accident.

Within the LOAD <15> report, a landing is determined by activation of either of the main gear oleo compression switches; nose gear oleo compression is not used within the landing detection logic. 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 landing (+/-0.5 second). If the aircraft weight exceeds the maximum landing gross weight, the normal acceleration limit is reduced to 1.7g
- The radio altimeter descent rate is greater than 9 ft/sec at landing (+/-0.5 second). If the aircraft weight exceeds the maximum landing gross weight, the radio altimeter descent rate limit is reduced to 6 ft/se.
- For a bounced landing, the normal acceleration exceeds 2.6g

The LOAD <15> report was introduced to identify if a hard landing has occurred, and to ensure appropriate inspections are carried out, by reference to the AMM. However, damage to the nose gear assembly was sustained during the landing of G-MARA without exceeding the LOAD <15> report limits set by the aircraft manufacturer. The LOAD <15> report has certain limitations with respect to monitoring of airframe loads and unusual landing attitudes, as discussed below.

The normal acceleration parameter used within the LOAD <15> report computation is provided by an accelerometer mounted near the aircraft's centre of gravity; the same accelerometer is used by the FDR system. The accelerometer, by design, 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 g level. In addition, acceleration levels experienced at other sections of the airframe, such as the nose gear, may be different from those measured at the centre of gravity during various phases of flight.

Footnote

[3] It should be noted that the provision of the LOAD<15> report for some A320 aircraft required installation of an upgraded DMU. Service Bulletin (SB) A320-31-1124 refers.

Although certain considerations need to be applied when using just one accelerometer for load monitoring, excessive descent rate at landing may also trigger the report. Activation logic relies upon compression of either main gear oleo before determining if an exceedence has occurred. Nose gear compression does not feature in the activation logic. The report may dynamically change exceedence limits dependant upon aircraft gross weight at landing, but the report does not apply alternate limits if the aircraft lands at an unusual attitude, such as in a flat or nose-down attitude.

Manually generated LOAD <15> report

A LOAD <15> report for the incident landing was manually generated by the maintenance staff and printed, Figure 2. The AMM details:

> *'if a report is requested manually with the remote print button, it is generated immediately (independently of any other start logic).'*

The printed report apparently recorded the maximum touchdown acceleration (VRTA) as 0.95g. However, the DMU was manufactured by Teledyne Controls and loaded with software part number FLY2240A1BXX312. The manufacturer later confirmed that with this software standard a manually generated LOAD <15> report would not contain stored parameters from a previous landing and that the parameter values actually related to the aircraft being parked at Manchester.

Prior to this investigation, the operator reviewed data from another of its A321 aircraft whose landing had been reported as heavy by the flight crew. After this landing, the AIDS had been checked for a LOAD <15> report, but none was found. The aircraft was at an outstation and the operator wanted to understand the severity of the landing before releasing the aircraft back into service. As at most outstations, there was no facility to read out the FDR or QAR. A manually generated LOAD <15> report was printed, Figure 3. The report appeared to provide data from the landing, with both the acceleration and radio altimeter descent rate being below AMM limits. The aircraft was subsequently released back into service. Upon return to the operator's main base, the QAR was read out. Data from the QAR confirmed that the manually generated report had contained the landing information. The aircraft was equipped with a different DMU from that on G-MARA; this DMU was manufactured by Sagem Avionics, part number ED45A300, software part number 360-03795-015, data base V1423. Following the findings from the G-MARA event, the operator inspected the other aircraft for damage but none was found.

Following a review of the AMM hard/overweight inspection procedure, it was identified that the subtask that checked for, and printed, a LOAD <15> report contained a note reflecting that a manually generated LOAD <15> report was not to be used to confirm if a hard/overweight landing had occurred. A manually generated LOAD <15> report may be identified by the Trigger code 1000 appearing on row C1 of the report, Figures 2 and 3.

Aircraft examination

Nose landing gear damage

Discussions with the landing gear manufacturer revealed that they had previously seen similar damage to the inner cylinder of nose landing gear legs, Figure 4. They advised that the collapse of the inner cylinder is the direct result of very high damping pressures which act between the inner and outer cylinders, which typically occur during a very hard three point landing[4],

Footnote

[4] A three point landing is one where all three landing gears touch down at the same time.

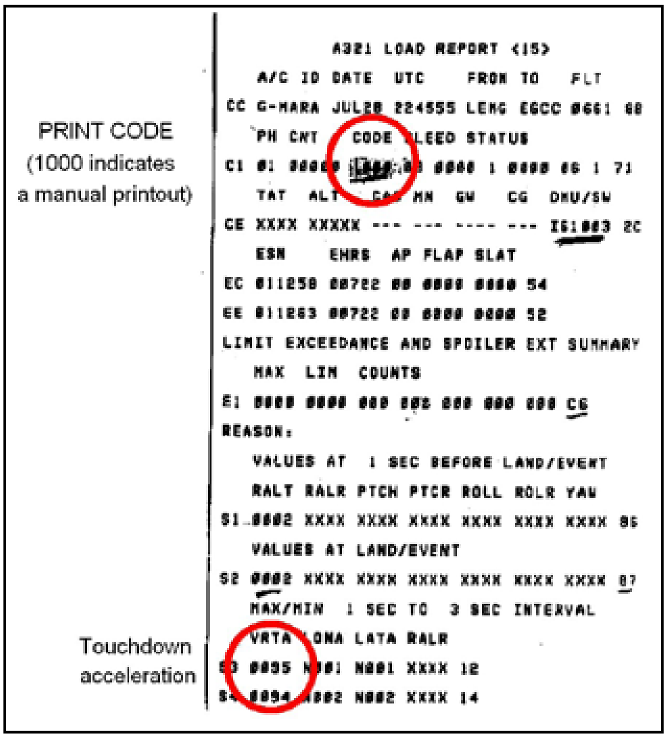

Figure 2

Teledyne Controls DMU
G-MARA post-landing manually generated LOAD <15> report

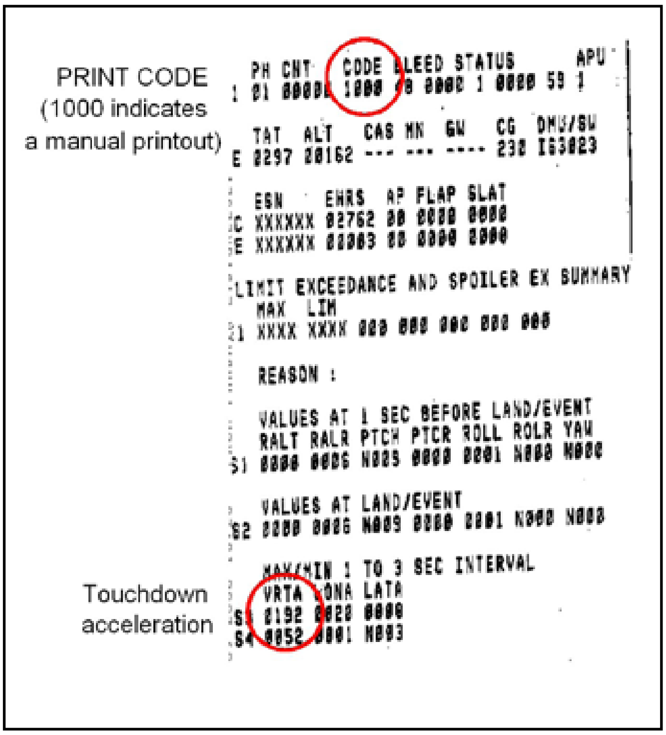

Figure 3

Sagem Avionics DMU
Post-landing manually generated LOAD <15> report

or a nose gear first landing. The damage only occurs when the certificated design criteria for the landing gear is grossly exceeded.

Previous analysis of the link rod which moves the target for the gear-extended proximity sensor through its range of movement showed that, in cases of full leg compression, it is possible for the link rod to be bent by contact with the fixed leg. On this occasion, the rod was bent and witness marks were present on both the rod and the fixed leg which confirmed that contact had occurred, Figure 5.

The landing gear manufacturer identified a number of previous cases where the link rod had been found bent, attributing this to a lack of greasing and ingress of dirt, causing the bearings to seize and impart bending loads in the link as the gear compresses. In response to this issue, two modifications were introduced: the link rod material was changed from aluminium to stainless steel, and different rod end bearings were introduced. These modifications were implemented on the production line and recommended for components already in service. G-MARA had this modification embodied.

Inspection procedure following hard/overweight landing

Task 05-51-11-200-004A of the AMM describes the required inspections after a hard/overweight landing for aircraft with enhanced DMU/FDIMU LOAD <15> report capability. The task defines the categories of hard/overweight landings, and the process for confirmation of the hard/overweight landing, which is in three steps:

Figure 4

View of damaged inner cylinder

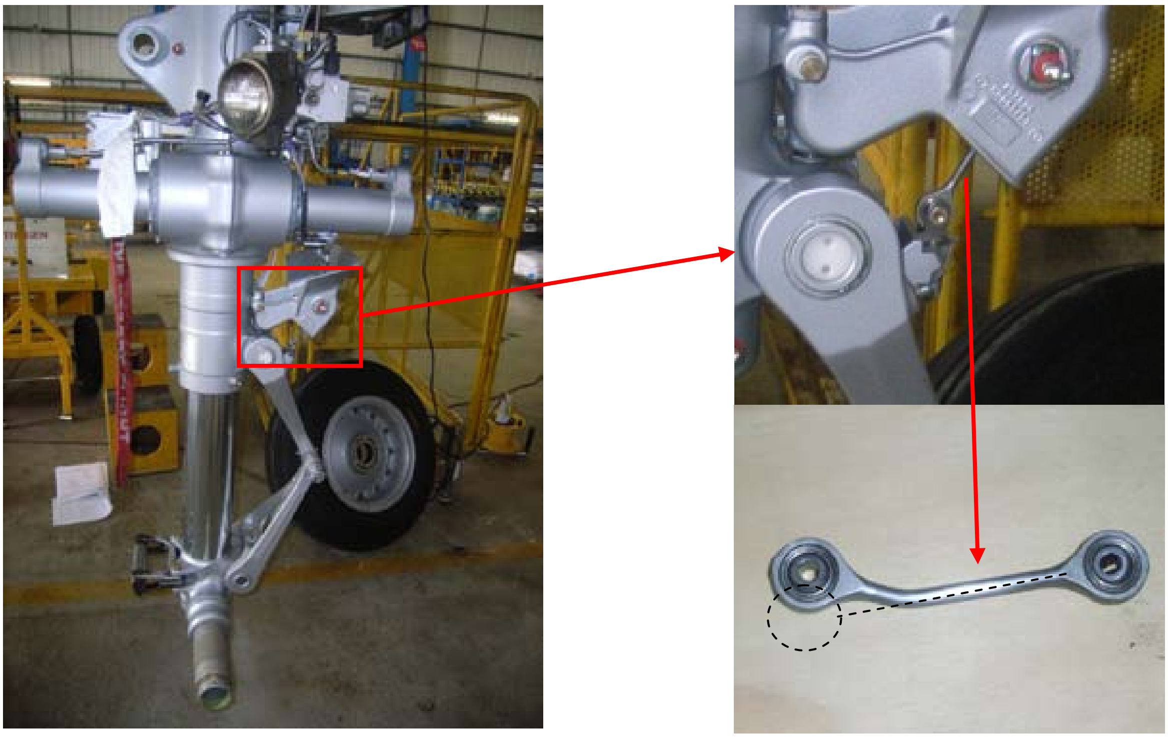

Figure 5

View of replacement nose gear leg showing location of link rod and bent link rod from incident leg

- Flight crew must report if they think a hard/overweight landing was made
- After crew report, impact parameters must be confirmed using either the DMU LOAD <15> report or the FDR readout
- When the category of landing is known, the inspections for that category must be performed

The process then goes on to describe preparation for the inspection, which is in two steps:

Firstly, it requires that the category of landing is established. If this is not possible then it states that an inspection must be carried out, with the steps appropriate for a severe hard/overweight landing.

Secondly, it requires that information is obtained from the flight crew regarding landing conditions, for example: touch down straight or drifting, wing low; tail or nose heavy; touchdown on main gears or on main and nose gears, or high pitch rate on nose gear; weight of aircraft; quantity of fuel in each tank; instrument indications, and other information such as a noise that could be related to a structural failure. Obtaining the post-flight report is recommended and a reminder is included to do all additional checks related to events specified in the flight crew report or the post-flight report.

The remainder of the task goes on to detail safety precautions and the required inspection tasks. A flow chart that summarises the process to determine the level of inspection is included in the task.

Use of the hard/overweight landing inspection procedure flow chart

On arrival, after the G-MARA flight crew reported the suspected hard landing to the engineer, he followed the AMM process to determine the level of inspection required using the inspection flow chart, Figure 6. The aircraft manufacturer's intended decision making process and that of the engineer's, is illustrated.

After the pilot report of a hard landing, the first decision is:

> *'DMU load report available.'*

The engineer answered YES to this question as the equipment was fitted and serviceable, ie, if the limits had been exceeded, he would have expected to see a report. This answer then gives three options depending on the severity of the touchdown. The first option is:

> *'DMU shows IRALRI <10 ft/sec and VRTA < 2.6g for a hard landing.'*

The engineer chose this option, as a DMU LOAD <15> report had not been generated, indicating that neither of these limits had been exceeded. This choice leads to the conclusion that no more steps are required.

The aircraft manufacturer's view of how this decision process should have been applied is as follows:

After the pilot report of a hard landing, the answer to the first decision:

> *'DMU load report available.'*

was expected to be NO, as a DMU LOAD <15> report was not produced. This answer would lead to the next decision:

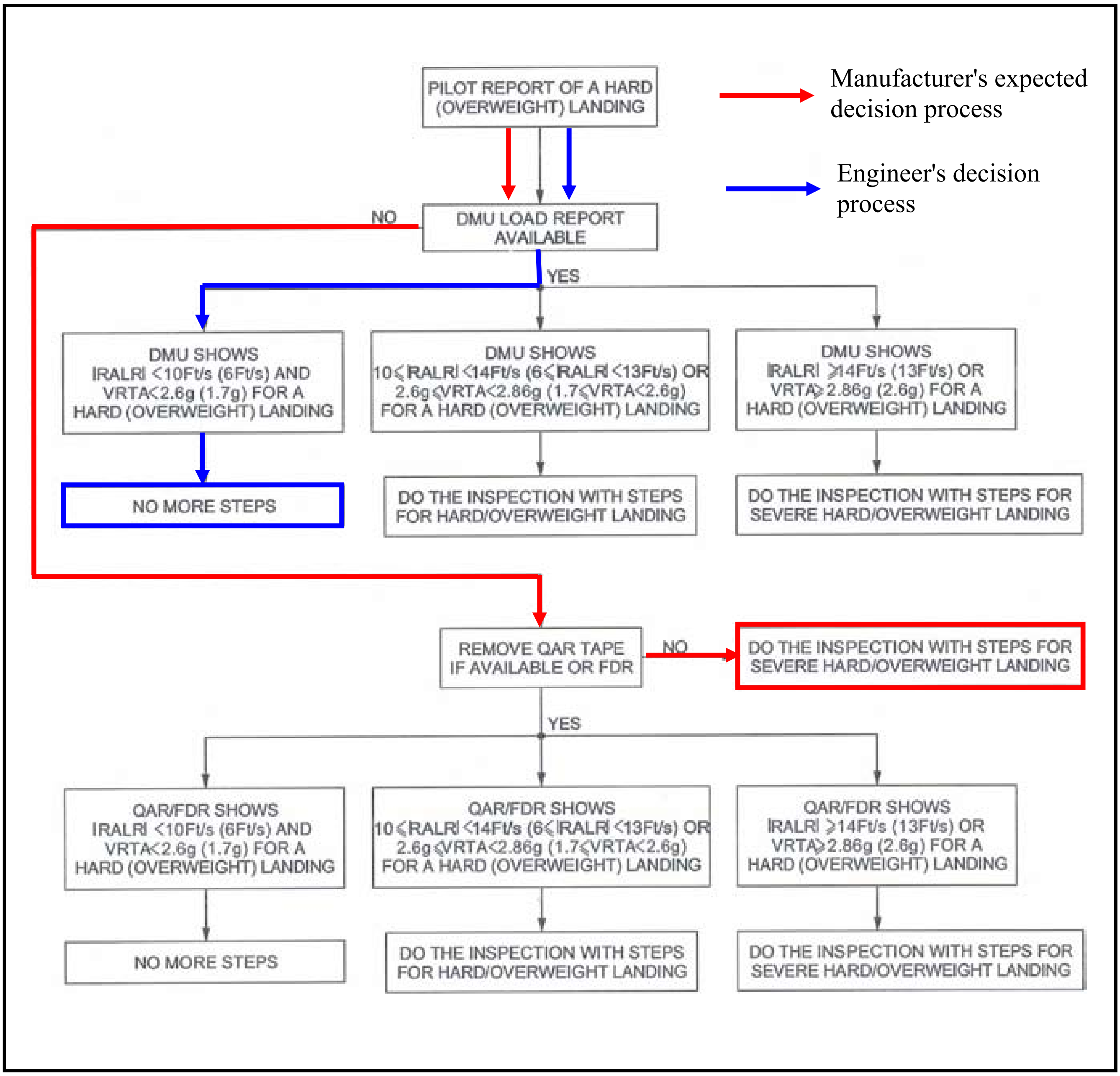

Figure 6

Flow chart for determining category of hard/overweight landing

> *'Remove QAR tape if available or FDR.'*

This was not done, so the answer was NO, which leads to the conclusion:

> *'Do the inspection with steps for severe hard landing.'*

This inspection requires extensive checks and includes jacking the aircraft and functional checks of retraction and extension of the landing gear. Had these checks been completed, it is likely that the damage to the nose landing gear would have been found.

The procedure for determining the level of inspection does not cover all situations and can, as in this case, be interpreted in a different way from that intended by the manufacturer. The DMU LOAD <15> report will only be produced if the recorded parameters exceed pre-determined values. The manufacturer's use of the flow chart implies that a report will be produced even if the parameters are not exceeded. Had the QAR or FDR been replayed as part of the decision making process, the data would also have shown that neither the descent rate nor the normal acceleration limits had been exceeded and, therefore, no inspection would have been required.

Other relevant information

In September 2005 the Aerospace Industries Association (AIA) published a Best Practices Guide for inspection processes following high load events (AIA Publication 05-01). The guide was produced by an industry committee consisting of representatives from the AIA, the Air Transport Association (ATA), aircraft manufacturers, operators and regulators. This was in response to safety recommendations made by the National Transportation Safety Board (NTSB) to address concerns that aircraft may encounter high load events during which structural damage occurs, and where the damage may not be found before returning the aircraft to service.

The committee evaluated existing special inspection procedures against five criteria to ensure they were robust and concluded that, for the most part, they were. However, several areas for improvement were identified, in particular, for future aircraft. These included developing clear inspection procedures, evaluation of high load event measured data and the development of systems to allow the quick and effective use of recorded flight data; this should include annunciation in a manner to provide optimum visibility by all stakeholders.

Manufacturer's actions

Following publication of the Best Practice guide, the manufacturer of the aircraft involved in this event set up an internal working group in 2006 to establish their 'hard landing' experience and identify any associated operational and maintenance enhancements. The group made several recommendations, including the simplification of the AMM procedure and ensuring consistent procedures across their range of aircraft. The group noted that, in line with industry policy, the pilot remains the key decision maker. In September 2008, the manufacturer provided a statement to the European Aviation Safety Agency (EASA) stating that they considered the declaration of a high load event is always under the primary responsibility of the flight crew.

Since the internal review, the manufacturer has been working on updating and aligning procedures in the AMM and the next revision, scheduled for release later in 2009, will include additional guidance for maintenance staff following unusual landings such as nose gear first or bounced landings. In addition, revised trigger points for inspections will be defined within a RED, AMBER, GREEN chart that includes consideration of both vertical and lateral loadings as well as factors to account for landing weight.

Summary

The co-pilot made an unusual pitch input whilst the aircraft was in the flare, causing it to land in a slightly nose-down attitude, resulting in the nosewheel touching down first, and also to bounce. The suspected hard landing was reported by the crew, as required. Following a review of the co-pilot's past performance, the operator conducted additional simulator, base and line training with him and, as no issues were identified during this period, the co-pilot was released back to line flying.

The ground engineer, using the AMM flow chart, determined that an inspection was not required, as the recorded radio altimeter rate of descent and normal acceleration values had not exceeded the limits set by the manufacturer. Thus, as no LOAD<15> report was generated a download of the QAR or FDR was not required. The aircraft manufacturer intended the flow chart to be interpreted in a different way and this would have led to the discovery of the damage. A development of the process for determining the inspections required after an unusual landing, resulting from the manufacturer's working group review of the AIA Best Practice Guide, is due to appear in an AMM revision later in 2009.

The AIA Best Practice Guide notes that the pilot remains the key decision maker when determining unusual landings but recommends making the best use of recorded flight data to evaluate a broad range of events, including annunciation in a manner to provide optimum visibility by all stake holders.

The manufacturer's philosophy is to assign the flight crew primary responsibility for declaring potential high load events, but the importance of communicating the aircraft attitude in unusual landings is not clearly explained in documentation available to the flight crew. The AMM contains detailed descriptions of landing conditions that are considered unusual but this information is not readily available to the flight crew.

The only visual indication that the nose landing gear had been fully compressed was the bent proximity target link rod. An inspection for such damage is not referred to in the AMM and such damage is not readily apparent.

The following Safety Recommendations are therefore made:

Safety Recommendation 2008-092

It is recommended that Airbus includes, in the appropriate publications, further information and guidance to flight crew with regard to unusual landings to ensure they are able to properly discharge their responsibilities to declare potential high load events.

Safety Recommendation 2008-093

It is recommended that Airbus review the landing parameters recorded on any of their aircraft types which are able to produce a LOAD<15> report, so that a LOAD<15> report is generated whenever there is potential for damage to be caused to the aircraft and/or its landing gear following both hard/overweight landings or abnormal landings, such as nosewheel first landings.

Safety Recommendation 2009-047

It is recommended that Airbus include a specific reference in the AMM to inspecting the nose landing gear proximity target link rod for damage as, due to the landing gear geometry, it is a likely indicator of full nose landing gear compression.

An investigation into an incident to another aircraft from the same family has drawn similar conclusions relating to the determination and reporting of unusual landings and the subsequent required inspections. The safety recommendations in this report are complimentary to those made in AAIB report EW/C2008/07/02, the texts of which are included below for completeness.

'It is recommended that Airbus ensure that the generation of a LOAD<15> report by the DMU following a landing parameter exceedance, is indicated to the flight crew involved to enable them to record it in the aircraft's technical log.

It is recommended that the Civil Aviation Authority require operators to provide training in the procedures associated with the reporting of suspected hard landings and the information available to assist decision making on reporting for the aircraft types operated. This should include, for Airbus types, the nature, significance and interpretation of Airbus LOAD<15> reports.

It is recommended that the European Aviation Safety Agency ensure adequate training is provided for ground engineers maintaining Airbus aircraft regarding the correct approach to troubleshooting suspected hard landings and the correct means of obtaining and interpreting the Airbus LOAD<15> report.

It is recommended that Airbus review their procedure for identifying and classifying parameter exceedances based on data recorded by the aircraft during landing, either to ensure that all sources of recorded data give the same outcome or to provide guidance on which source of data should take precedence in the event of a discrepancy. Changes resulting from this review should be reflected in the relevant maintenance manual tasks.'