ACCIDENT

Aircraft Type and Registration:	Airbus A321-211, G-DHJH
No & Type of Engines:	2 CFM56-5B3/P turbofan engines
Year of Manufacture:	2000
Date & Time (UTC):	18 July 2008 at 2010 hrs
Location:	Manchester Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 9 Passengers - 219
Injuries:	Crew - None Passengers - None
Nature of Damage:	Crack observed in wing gear rib lug.
Commander's Licence:	Airline Transport Pilot's Licence with Type Rating Instructor and Type Rating Examiner qualifications
Commander's Age:	51 years
Commander's Flying Experience:	12,200 hours Last 90 days - 124 hours Last 28 days - 56 hours
Information Source:	AAIB Field Investigation

Synopsis

During a landing at Manchester Airport the aircraft was not flared sufficiently and a 'hard' landing, categorised as 'severe hard', occurred. The possibility of a landing parameter exceedence was not reported by the crew following discussion with ground engineers who had been on the flight. The presence of a landing parameter exceedence report was identified after a further two sectors had been flown, when an unrelated inspection of the landing gear found a crack in a wing rib gear support lug. Four Safety Recommendations have been made.

History of the flight

The crew reported to fly two sectors, Manchester to Ibiza and return, on an A321 aircraft. The flight crew consisted of three pilots; a training captain who occupied the left flight deck seat and was the commander, a co-pilot undertaking the first two sectors of line training who occupied the right flight deck seat, and another first officer who occupied a flight deck jump seat[1].

The commander read the co-pilot's training file before the flight crew made their way to the aircraft. The co-pilot had recently completed base training on an

Footnote

[1] The company rostered an additional first officer for the first two sectors of every pilot's line training.

A320 aircraft. When interviewed after the accident, the commander's interpretation of the co-pilot's file was that he "had had difficulty landing the aeroplane and had had to have extra landings".

The commander decided that the co-pilot should be pilot flying on the sector to Ibiza. During the flight the commander covered some training items and briefed the co-pilot about the landing. He spoke about the differences between the landing and those during base training, notably that the aircraft was larger and heavier, and he explained that the landing technique for the A321 was different from the A320. The commander instructed the co-pilot that he would "talk him through" the landing and specifically that he would instruct him to "check" the rate of descent with a nose-up sidestick input at 20 ft above touchdown. This would involve selecting 5°of positive pitch attitude and looking outside at the attitude, while simultaneously retarding the thrust levers.

The co-pilot flew a visual circuit onto the final approach to Runway 06 in good weather with a light wind. The landing was "firm", and during the turn-around, the co-pilot identified that he had flared too late. The commander decided that he would fly the aircraft back towards Manchester but would hand control to the co-pilot for the final approach and landing. He briefed that he would, again, talk the co-pilot through the landing and that the co-pilot should look out of the window and learn the visual picture of the landing attitude of the aeroplane. He briefed the co-pilot once again that he would instruct him to "check" on the sidestick at 20 ft, hold the attitude and simultaneously retard the thrust levers.

The flight towards Manchester progressed normally and the commander prepared the aircraft for a flap FULL landing on Runway 23R, adjusting the approach speed in the FMGS to ensure a five knot margin above V_{LS}. The weather at Manchester was good with the 1950 hrs observation indicating that the wind was 180°/5 kt.

At approximately 8 nm from touchdown, the commander handed control to the co-pilot. The co-pilot disconnected the autopilot at 1,200 ft and left the autothrust engaged. The commander watched the co-pilot's sidestick inputs and recalled that he was "over-active" on the sidestick. He stated that he perceived this to be a common problem with pilots transitioning onto the Airbus aircraft.

At 1,000 ft, the commander noted that the operator's stable approach parameters were satisfied and stated "stable A321" in accordance with the operator's SOPs.

The commander gave a coaching narrative during the final moments before touchdown but, as the co-pilot closed the thrust levers, realised that the landing was "going to go wrong". The aircraft touched down firmly and bounced. The commander stated that he considered taking control, but noted that the co-pilot appeared to be holding the aircraft's attitude and that intervention was not necessary. Although the commander believed that he made no sidestick input, FDR data showed that he did move it slightly. After the second touchdown, the landing progressed normally. The co-pilot taxied the aircraft to its parking stand and disembarkation took place.

The commander and co-pilot discussed the landing and both considered it not to have been "heavy". The commander asked some company line engineers, who had travelled back from Ibiza as passengers, for their opinions of the landing and specifically whether they thought it was a 'hard' landing. They replied that if no "load 15 report" had been produced on the flight deck printer and the commander did not consider the landing to have been "heavy", then in their opinion, no action needed to be taken. The commander was unfamiliar with this "load 15 report" (though he knew that the aircraft was capable of printing a report after a heavy landing), but confirmed that no report had been printed.

The flight crew returned to the crew room and discussed the landing. The commander wrote in the co-pilot's training file that he had made a:

> *'good start to line training. Good outbound sector as PF – excellent visual circuit at Ibiza but when thrust retarded for landing, forgot to flare giving hard landing. [The co-pilot] was fully aware of the reason during debrief. PNF inbound, but PF for landing. Another even firmer landing, tried to watch what [the co-pilot] is doing with the sidestick but failed! Perhaps need a demo and talking through again…'*

The commander gave an overall assessment of the co-pilot's progress as 'below target' and telephoned the training captain who was due to conduct the co-pilot's next flight, to brief him on the events.

The co-pilot recalled that darkness was setting in as he landed[2] and commented that he might have touched down on 'the hump' of the runway; he suggested that these factors may have contributed to the hard landing.

The co-pilot

The co-pilot began flying training in 2000 on an integrated course towards a 'frozen' ATPL. Following successful completion of the course, he worked as a flying instructor until 2004 when he was employed by the operator of G-DHJH as a co-pilot on the Boeing 757 aircraft. He operated the Boeing 757 throughout the operator's worldwide route structure until winter 2007/8, when he spent five months flying the Boeing 757 in Canada under a contract arranged by the operator. By the end of this contract, he had 3,500 hrs total flying time, of which approximately 3,000 were on the Boeing 757.

The co-pilot volunteered to convert to the Airbus aircraft and undertook ground school and full flight simulator training during May and June 2008. In early July 2008, he completed base training in the A320 aircraft with CFM56 engines at Prestwick, before commencing line training on the day of the accident. The report on his base training stated that he:

> *'…quickly settled down to fly some nice circuits. Tendency to be slightly late on the flare on 2 occasions so an extra landing was given. This final landing was very good. Overall good standard for base training…'*

The co-pilot described the landing technique learnt during simulator training. He stated that at the 'thirty' automatic voice call, he would commence the flare and retard the thrust levers. He also stated that he was "confused" by the commander's coaching during the landing.

The co-pilot's subsequent training

The day after the accident flight, and before the event had come to light, the co-pilot operated another line training flight with the training captain who had conducted his base training. The co-pilot flew the aircraft to Menorca (Mahon), where he carried out a good landing with "minimal" coaching. The commander flew the aircraft back to Manchester where the co-pilot took control on the approach and made another good landing without coaching. This training

Footnote

[2] Sunset was at 2026 hrs, 16 minutes after the landing.

captain commented that the co-pilot's technique was *'perfectly correct'* and that both touchdowns were smooth and accurate.

The co-pilot's training continued after the accident flight, and he received eight sectors of line training, followed by a successful two-sector line release check. The relevant training report stated he flew *'to a good standard'*.

The commander's sidestick technique while training

The commander during the accident flight stated that when training, his custom during the landing phase was to keep his left hand on the sidestick, with his palm touching the sidestick. He added that he was "very wary" of making an involuntary sidestick input while training on the aircraft, and that he would not do so without operating the takeover pushbutton. Previous investigations have revealed that occasionally Airbus training pilots make surreptitious sidestick inputs when training new pilots, applying nose-up pitch just before touchdown to ensure a reasonable landing. The commander stated that this was not his practice.

Manufacturer's instruction

The Standard Operating Procedures contained in the Airbus Flight Crew Operating Manual (FCOM) issued to flight crew by the operator, included the recommended landing procedure, shown in Figure 1.

In comparison, the advice with regard to A321 aircraft is shown in Figure 2.

The Flight Crew Training Manual (FCTM) for the aircraft, which the company suggested was mainly used as guidance for training staff, (although line pilots would be expected to have some knowledge of its contents), stated:

'PITCH CONTROL

'When reaching 50 ft, auto-trim ceases and the pitch law is modified to flare law. Indeed, the normal pitch law, which provides trajectory stability, is not the best adapted to the flare manoeuvre. 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 at a predetermined rate of 2 ° down in 8 s. Consequently, as the speed reduces, the pilot will have to move the stick rearwards to maintain a constant path. The flare technique is thus very conventional.

From stabilized conditions, the flare height is about 30 ft. This height varies with different parameters, such as weight, rate of descent, wind variations...

Avoid under flaring.

- *The rate of descent must be controlled prior to the initiation of the flare (rate not increasing)*
- *Start the flare with positive backpressure on the sidestick and holding as necessary*
- *Avoid forward stick movement once Flare initiated (releasing back-pressure is acceptable)*

At 20 ft, the "RETARD" auto call-out reminds the pilot to retard thrust levers. It is a reminder rather than an order. The pilot will retard the thrust levers when best adapted e.g. if high and fast on the final path the pilot will retard earlier. In order to assess the rate of descent in the flare, and the aircraft position relative to the ground,

- **At 30 feet approximately (A330: 40 feet)**

- **FLARE……………... PERFORM**

- **ATTITUDE………………………………………………………………….MONITOR**

  The PNF's primary responsibility in this critical phase of flight is to ensure that the correct pitch attitude is achieved thereby avoiding a tailstrike. The PNF should continuously monitor the attitude until nosewheel touchdown and call out:

  "PITCH, PITCH" if the pitch angle reaches -2.5º or +7.5º (A320/1)
  "PITCH, PITCH" if the pitch angle reaches 0º or +7.5º (A330)
  "BANK, BANK" if the bank angle reaches 7º

- **THRUST levers..IDLE**

  In manual landing conditions, the call out "RETARD" is generated at 20 feet RA as a reminder. Commence a gentle progressive flare and allow the aircraft to touch down without prolonged float. If the thrust levers are not retarded when the flare is started, the AT will remain in SPEED mode. The thrust will increase in order to maintain Vapp, which could result in prolonged float.

  Be aware of a tendency for the nose to pitch up slightly at spoiler deployment.

Figure 1

If you handle the A321 correctly in the landing phase, a tail strike will not occur. Correct handling includes:

1. Flying a stable approach and not chasing the PAPIs or Glideslope below 200'.
2. Ensuring you have a 5kt buffer between VLS and Vapp on the PFD on approach.
3.. On landing, not holding any back sidestick and being prepared to counteract any pitch up by flying the nose onto the runway

Please note that the SOP on approach <u>on the A321 only</u> is to check that there is at least a 5kt gap between VLS and Vapp and, if necessary, to overwrite Vapp on the MCDU to ensure that this is the case.

Further information is in FCOM Bulletin 806/1 and 819/1.

Figure 2

look well ahead of the aircraft. The typical pitch increment in the flare is approximately 4°, which leads to -1° flight path angle associated with a 10 kt speed decay in the manoeuvre. A prolonged float will increase both the landing distance and the risk of tail strike.'

Recorded data

The aircraft performed two further flights prior to the incident being reported to the AAIB and consequently the CVR was overwritten. Flight data was recovered from the operator's Flight Data Monitoring (FDM) programme and used to analyse the approach and landing in Manchester.

The data showed G-DHJH established on the ILS for Runway 23R at Manchester with the autopilot and autothrottle engaged and landing gear, flaps and slats fully extended. At 1,200 ft, the autopilot was disconnected and flight control inputs for the rest of the approach were controlled using the co-pilot's sidestick. The autothrottle remained engaged until touchdown.

Relevant flight parameters during the final stages of the approach and landing at Manchester are shown in Figure 3. The data starts with G-DHJH approximately 2.2 nm from the Runway 23R threshold at a radio altitude of 584 ft, indicated airspeed of 147 kt and calculated rate of descent[3] of approximately 750 feet per minute (ft/min). The airspeed, which had progressively decreased during the descent, was 2 kt above V_{APP} with a recorded wind speed of 218°/11 kt.

At a radio altitude of 42 ft, the co-pilot initiated a pitch-up demand on the sidestick. At the same time, the aircraft began drifting below the glideslope, achieving maximum deviation one second after the pitch up command.

Just less than one second later, the aircraft pitch began to increase from approximately 1° nose up, at a rate of approximately 2° per second. At the same time, the throttle levers were retarded to idle. One second from touchdown, the aircraft was at 15 ft radio altitude and a derived rate of descent of approximately 900 ft/min (15 ft per second (ft/s)).

The recorded position of the co-pilot's sidestick showed a continued stick-back command, to the maximum achievable position of 16°. This full back position was recorded at the same time as the initial spike in normal acceleration, signifying aircraft touchdown. Indicated airspeed was 145 kt, pitch attitude 3.9° and derived rate of descent was approximately 840 ft/min (14 ft/s). Rate of descent is approximate due to the one second sampling rate of the radio altitude.

After the initial spike in normal acceleration, the data shows a peak of 2.66g, a quarter of a second later. The initial spike prior to the maximum may have been due to one main landing gear touching down prior to the other (roll attitude was 0.7° left wing down). Both the left and right landing gear squat switches registered weight on wheels at the same time but these parameters are sampled every second so would not register a difference in touchdown time of the left and right gear of less than one second.

Just after touchdown, the commander applied 2° of forward and 4.3º of right sidestick. The normal acceleration then decreased to less than 1g which is indicative of a bounce but the MLG squat switches did not register weight off wheels. Pitch attitude reduced and three seconds after main gear the nose landing gear touched down.

Footnote

3 Rate of descent was not recorded but has been calculated from the rate of change of radio altitude.

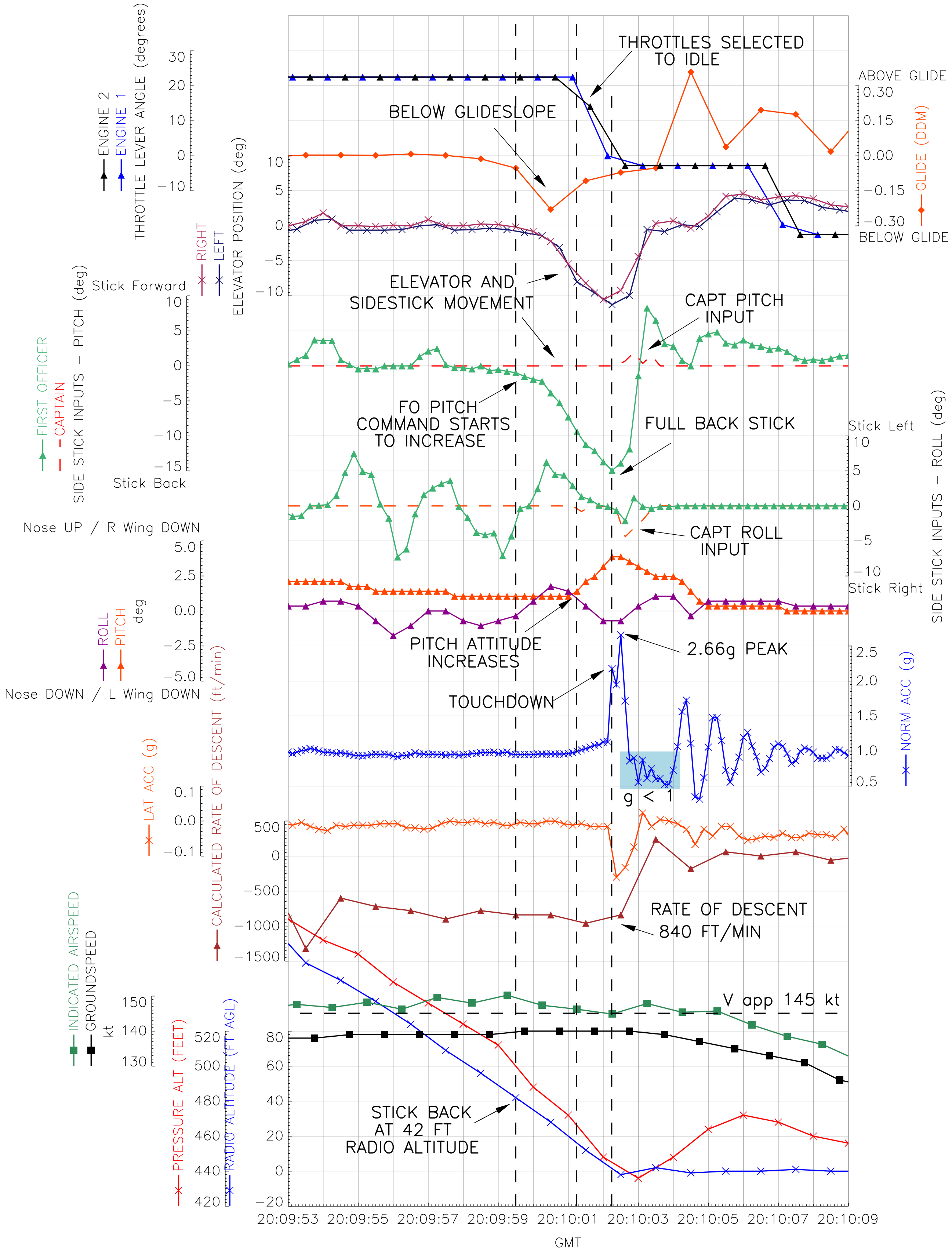


Figure 3

G-DHJH landing in Manchester, 18 July 2008

Training in Airbus fly-by-wire aircraft

Manual control inputs in the Airbus fly-by-wire aircraft are made through sidestick controllers. One sidestick is located on each outboard side of the flight deck. The sidestick positions do not reflect the positions of the flying control surfaces. Whereas traditional control columns are mechanically linked so that they move in synchronisation regardless of whether an input is made by the left or right seat pilot, the sidesticks do not.

The commander commented that although he realised that the landing was not going to be normal, he was aware that it was impossible to "watch the sidestick all the time". He stated that he "always liked to try", but "usually failed" to watch the sidestick inputs effectively, because he "liked to see what was going on outside".

Landing technique: A320 and A321 aircraft

The commander stated that in his opinion, the A320 and A321 aircraft required different landing techniques and that further differences in technique were necessary to take account of the engines fitted to the aircraft[4]. He mentioned that although the Airbus FCOM stated that the flare and retardation of the thrust levers should take place at 30 ft, the operator's training pilots "think that's too high" in an A321. He also stated the A321's used by this operator are operated at significantly higher weights than those operated in a scheduled service configuration.

Another experienced Airbus training captain, with current experience on the A320 and A321 aircraft, considered that the advice about flare heights published in the Airbus FCOM was adequate and that 20 ft would be too late to commence the flare in an A321 aircraft.

Footnote

4 The operator's fleet included A320 and A321 aircraft, with CFM56 and IAE V2500 engines.

The operator's training department clarified with the commander that company policy is to teach the same landing techniques for both the A320 and A321 aircraft.

Post-flight events and aircraft examination

Given that no technical log entry or air safety report had been raised by the crew following the 'firm' landing event into Manchester, the aircraft was released for service as normal and operated a further two sectors without reported incident.

The operator used an electronic tech log system for the aircraft, which had been unavailable for a period of time prior to this point. It became available for use on the proposed next sector but when consulted, it warned that a mandatory out of phase inspection had become overdue on the aircraft. The aircraft was grounded until this inspection could be completed. It was later determined that the inspection was only *due* rather than *overdue*, as issues with the software of the tech log result in any aborted flight and return to stand still being counted as a full flight cycle. This problem is due to be rectified in a new software standard.

The mandatory inspection was a visual check for cracking on the main landing gear pintle support lugs which are part of wing rib 5. The inspection is mandated by EASA Airworthiness Directive (AD) 2007-0213 and is carried out in accordance with Airbus Service Bulletin A320-57-1138. When the inspection took place on 22 July 2008, it identified that the left pintle support rib had a crack extending through the entire section of the forward lug (Figure 4) and had to be replaced prior to further flight.

It appears that the operator was aware of the suspected 'heavy' landing two sectors previously and concerns were raised that the crack was a consequence of that

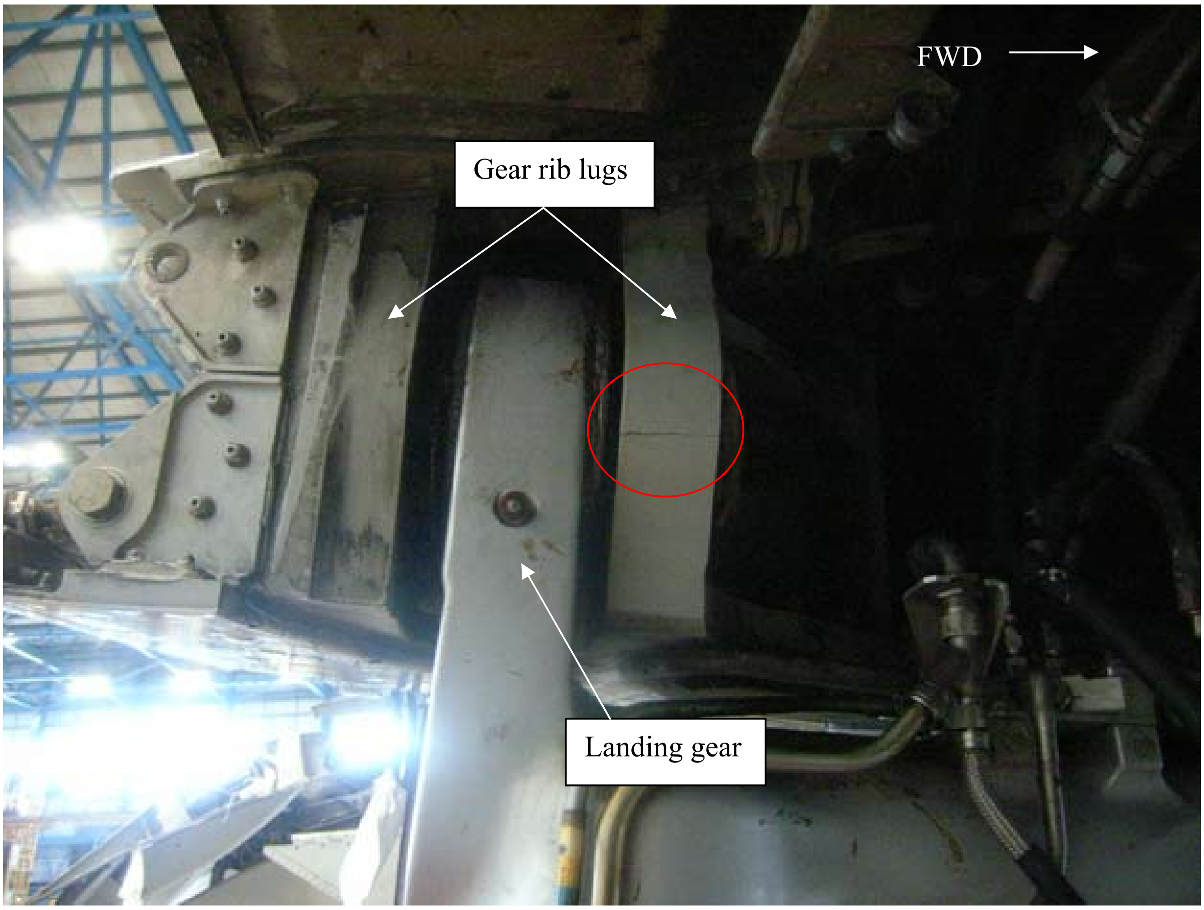


Figure 4

Landing gear support rib with cracked forward lug

landing. Interrogation of the aircraft Data Management Unit (DMU) by engineers confirmed that a LOAD <15> report had been generated. This report recorded vertical acceleration and descent rate exceedences at touchdown during the landing at Manchester on 18 July 2008. The LOAD <15> report gave figures of 2.65g and -11.5 ft/s at touchdown which identified the landing as 'hard' based on maintenance manual limits. Analysis of flight data from that sector identified that the aircraft experienced a vertical acceleration of 2.66g and a rate of descent of 14 ft/s at touchdown. A rate of descent of 14 ft/s classified the landing as 'severe hard' and required the operator to carry out additional, more in-depth inspections of the aircraft. These should have been completed before further flight following the landing but were eventually carried out by the operator while the aircraft was grounded to allow the cracked gear rib to be replaced. Some unrelated corrosion damage in the right wing spar was identified as a result of these inspections, but they confirmed that no damage directly attributable to the severe hard landing had occurred.

LOAD <15> report

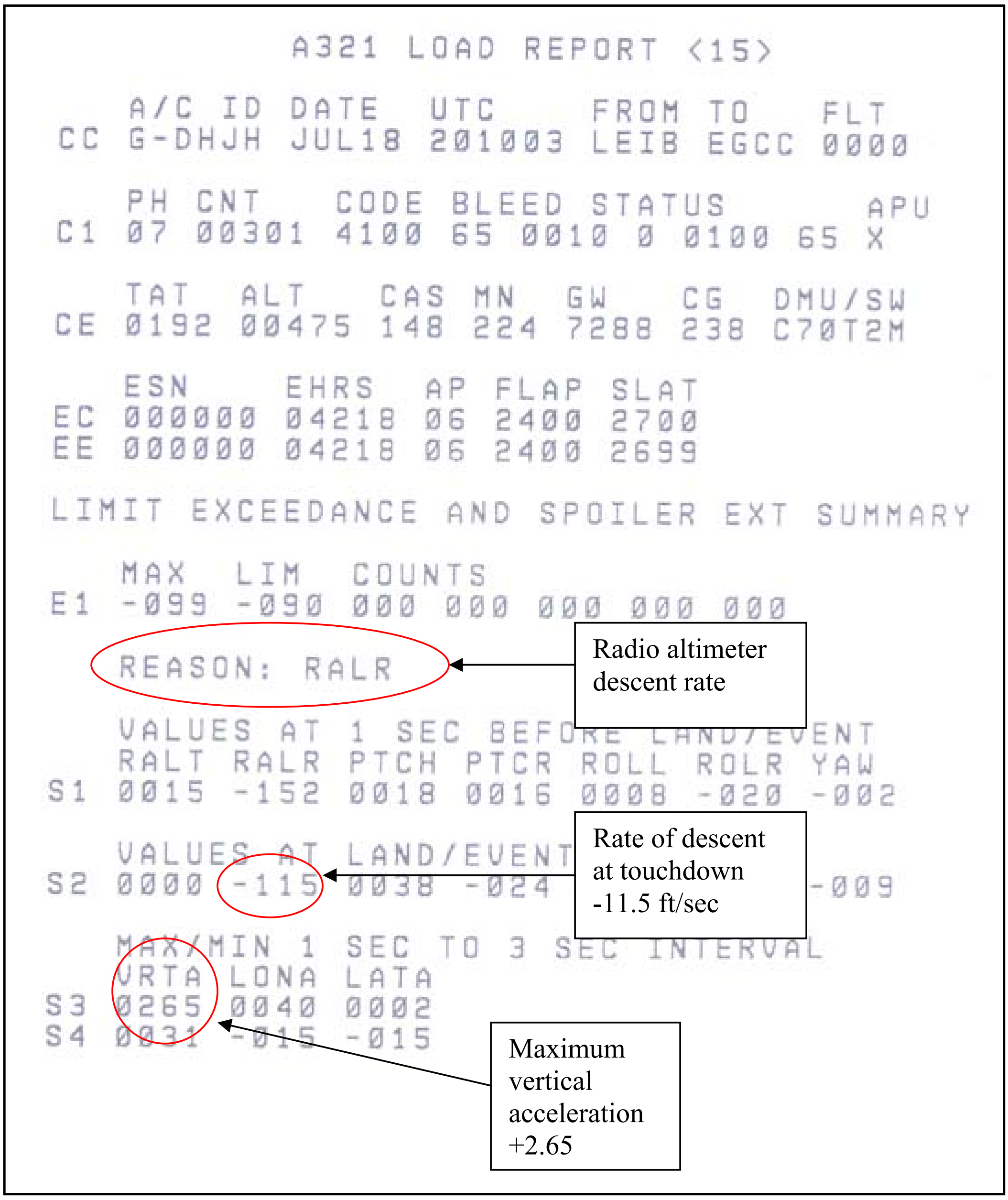
The A320 family of aircraft have an Aircraft Integrated Data System (AIDS). This system receives information from many other systems on the aircraft through its DMU. The DMU then processes this data and produces reports based on various parameters, such as an exceedence. One such group of reports is based on structural parameters. The structural report is identified as a LOAD <15> report (Figure 3) and is produced when any of the following landing conditions are met:

1) The radio altimeter descent rate (RALR) is less than (higher rate of descent) -9 ft/sec.

2) The vertical acceleration (VRTA) is more than +2.6G during +/- 0.5 seconds before and after landing.

3) The aircraft gross weight (GW) is more than the maximum landing gross weight (GWL) and the radio altimeter rate (RALR) is less than -6 ft/sec.

4) The aircraft gross weight (GW) is more than the maximum landing gross weight (GWL) and vertical acceleration is more than +1.7G.



```
              A321 LOAD REPORT <15>

    A/C ID DATE  UTC    FROM TO   FLT
CC  G-DHJH JUL18 201003 LEIB EGCC 0000

    PH CNT   CODE BLEED STATUS        APU
C1  07 00301 4100 65 0010 0 0100 65  X

    TAT  ALT   CAS MN  GW   CG  DMU/SW
CE  0192 00475 148 224 7288 238 C70T2M

    ESN    EHRS  AP FLAP SLAT
EC  000000 04218 06 2400 2700
EE  000000 04218 06 2400 2699

LIMIT EXCEEDANCE AND SPOILER EXT SUMMARY

    MAX  LIM  COUNTS
E1  -099 -090 000 000 000 000 000

    REASON: RALR

    VALUES AT 1 SEC BEFORE LAND/EVENT
    RALT RALR PTCH PTCR ROLL ROLR YAW
S1  0015 -152 0018 0016 0008 -020 -002

    VALUES AT LAND/EVENT
S2  0000 -115 0038 -024               -009

    MAX/MIN 1 SEC TO 3 SEC INTERVAL
    VRTA LONA LATA
S3  0265 0040 0002
S4  0031 -015 -015
```


Figure 3

LOAD<15> Report

5) For a bounced landing the vertical acceleration (VRTA) exceeds +2.6G for +/- 0.5 seconds of a detected bounced landing.

The manufacturer offers the option of the DMU automatically printing out the LOAD <15> report at the end of the flight, when one has been generated. However, the unit fitted to this aircraft was not configured to produce this automatic printout and required manual interrogation of the DMU to access the report. The presence of a LOAD<15> report is not highlighted by the Central Fault Display System (CFDS) or the Electronic Centralised Aircraft Monitor (ECAM).

Since this event, the operator has configured all its Airbus aircraft to have the LOAD<15> auto-print facility enabled.

EASA AD 2007-0213

This AD supersedes AD 2006-069R1 which was introduced in response to several incidents of cracked main landing gear support lugs being identified across the A320 family of aircraft in service. The cracks are initiated from corrosion pitting which occurs in the rib forward lug bore when moisture penetrates between the lug and the bushing. The crack will eventually propagate across the entire thickness of the lug, with an associated impact on the structural integrity of the main landing gear installation. The AD provides a choice of repetitive inspection regime depending on whether the inspection is done by ultrasound or visually. The operator involved in this accident had elected to inspect visually and as such was obliged to inspect the lug

> *'within 100 flight cycles following the last inspection as per AD 2006-0069R1'*

until the terminating modification action had been embodied. The AD also places an additional requirement on the operator to inspect the lug

> *'before next flight following a hard landing.'*

Under the visual inspection regime, once a crack of any size has been identified, the rib must be replaced before further flight.

A320/321 Approved Maintenance Manual

The maintenance manual has a specific task reference *'05-51-11-200-004 – inspection after hard/overweight landing for aircraft with enhanced DMU/FDIMU Load Report 15'* to cover the engineering response to a reported hard landing. Paragraph A (2) (a) states that

> *'it is the responsibility of the flight crew to make a report if they think there was a hard/overweight landing.'*

Part (b) states:

> *'after a crew report of a hard/overweight landing, you must confirm the impact parameters to know the category of the landing. To know this, refer to: - the DMU load report 15*[5] *or - the FDRS read out.'*

Once the extent of the parameter exceedence has been identified, the task directs specific inspections to be carried out on the aircraft.

Gear rib 5 failure analysis

The rib was removed from the aircraft by the manufacturer and passed to the AAIB for further

Footnote

5 The user is referred to AMM Task 31-37-00-200-001 in order to obtain the report.

investigation and analysis. The cracked section of the lug was removed (Figure 6), the fracture faces cleaned and then inspected using a scanning electron microscope. This analysis determined that the crack was caused by fatigue growth initiating from surface corrosion pitting around the edge of the bore (Figure 7). From the staining on the surfaces and oxidation/corrosion damage on the fracture surface, it is likely that the fatigue growth had taken place over a considerable period of time before the final fracture occurred. It was not possible to find sufficient detail to determine exactly how long the fatigue crack had been present but the critical crack length was consistent with previous failures. There is no evidence to suggest that the material was in any way deficient as the microstructure, hardness and conductivity all appeared to be as per specification. The crack was located in the one o'clock position of the lug looking forward. A crack in this location represents a failure of the primary load path for the lug. The secondary load path is via the opposite quadrant of the lug and no cracking was found in this location.

Operational analysis

The operational aspects of this accident stem from the training captain's perceived differences between landing the Airbus A320 and A321 aircraft. According to the manufacturer's FCOM and the complementary FCTM, the same landing technique applies across the A320 family of aircraft[6] but the opinion of the commander was that the A321 required a different technique and

Figure 6

Cracked section of forward lug with the bush removed

Footnote

[6] The A318, 319, 320, and 321.

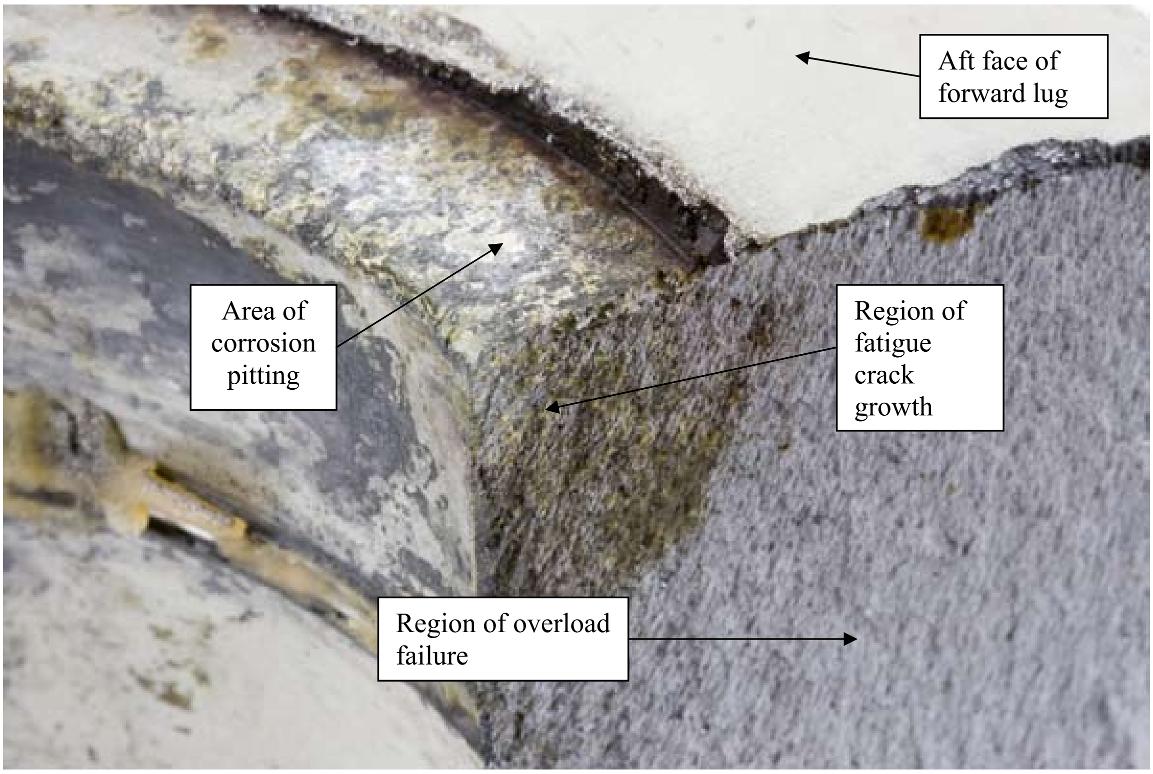


Figure 7

Detailed view of forward lug fracture surface

therefore he considered it necessary to coach the co-pilot through his first landings. The acceptance of the manufacturer's technique by other experienced training pilots and the absence of specific advice or information in the manufacturer's documents, suggest that the same technique is applicable across all variants.

The commander's impression that the co-pilot "had had difficulty landing the aeroplane" during base training was based on the base training report which stated that the co-pilot had a *'Tendency to be slightly late on the flare on 2 occasions'*. This had led to one extra landing being included in the training detail, that final landing being *'very good'* and an *'overall good standard for base training'*. The commander's impression of this report may have influenced him to be more prescriptive in his training technique than would otherwise have been the case.

Following the landing in Ibiza, the training captain discussed the landing with the co-pilot and agreed with his observation that the flare was commenced too late. Analysis of the recorded flight data showed that the co-pilot flared at about the correct time but not at a sufficient rate. Consequently, on the accident flight, the flare was commenced above the Airbus recommended height but still at an insufficient rate of pitch change to reduce the rate of descent significantly prior to touchdown.

Engineering Analysis

After consulting with ground engineers and informally discussing the incident within the airline, the flight crew chose not to report a suspected parameter exceedence formally. The lack of any supporting evidence available at the time, such as an automated printout of a LOAD <15> report, required the crew to make a subjective assessment of the landing. The ground engineers consulted by the flight crew were unaware that a LOAD<15> report would not always be automatically printed and the subsequent lack of even a precautionary tech log entry meant that no process for a formal engineering investigation was initiated. Consequently the DMU was not interrogated and the presence of the LOAD <15> report confirming the hard landing was not identified before the next flight.

Therefore:

Safety Recommendation: 2009-059

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

Safety Recommendation: 2009-060

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.

Safety Recommendation: 2009-061

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.

The manufacturer's approach to dealing with a hard landing and its associated airworthiness implications requires the flight crew involved to initiate the process. A readily available LOAD<15> report would substantially reduce the subjective element of the flight crew reporting process. A technical log entry by the crew then ensures that further action is instigated.

In this accident, once the presence of the LOAD<15> report was confirmed, the level of parameter exceedence identified that the landing should be classified as 'hard' based on maintenance manual limits. However, analysis of the flight data identified a calculated rate of descent at touchdown higher than that recorded on the LOAD<15> report, resulting in a re-classification of the landing as 'severe hard'. This resulted in more significant inspections being carried out on the aircraft. In order for the two sources of data to correlate, various factors and calculations need to be applied to the raw flight data which are only available within a specialist department of the manufacturer. However, the maintenance manual currently instructs the operator to classify the landing based on either the LOAD<15> report or the flight data readout, without identifying that analysis of the raw flight data is required to give an accurate result. The difference between the DMU and the raw flight data, as occurred in this event, can result in significantly different levels of inspection being required to comply with the maintenance manual. This creates the potential for either an excessive maintenance burden to be placed on the operator, with an associated increase in risk of human factors-type errors or aircraft damage to remain undetected prior to further flight.

Therefore:

Safety Recommendation: 2009-062

It is recommended that Airbus review their procedure for identifying and classifying parameter exceedences 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.

The manufacturer has advised that this issue is intended to be addressed by a planned change in approach to maintenance following a hard/severe hard landing, which will result in an entirely new maintenance manual procedure.

The final overload phase of the lug failure in the gear support rib is likely to have been accelerated by the hard landing, though it was not possible to confirm this from the fracture surfaces. All other characteristics of the crack are consistent with the manufacturer's analysis of previous failures in this location. The mitigating actions already in place under EASA AD 2007-0213 are adequate to ensure the continued airworthiness of the aircraft. However, the effectiveness of the AD is dependent on all inspections being completed at the correct time. This includes the additional inspection following a hard landing.

An investigation into an accident 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/C2008/07/05, the text of which is shown below for completeness.

'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.

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.'