SERIOUS INCIDENT

Aircraft Type and Registration:	Airbus A320, G-DHJZ
No & Type of Engines:	2 CFM56-5B4/P turbofan engines
Year of Manufacture:	2003
Date & Time (UTC):	5 July 2007 at 1205 hrs
Location:	Kos Airport, Greece
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 180
Injuries:	Crew - None Passengers - None
Nature of Damage:	Severe damage to main landing gear
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	47 years
Commander's Flying Experience:	12,100 hours (of which 950 were on type) Last 90 days - 174 hours Last 28 days - 38 hours
Co-pilot's Age	34 years
Co-pilot's Flying Experience	381 hours (of which 147 were on type) Last 90 days - 154 hours Last 28 days - 49 hours
Information Source:	AAIB Field Investigation, at the request of the Greek Air Accident Investigation & Aviation Safety Board

Synopsis

The aircraft landed heavily on Runway 32 at Kos Airport, causing substantial damage to the aircraft's main landing gear. It touched down with a high rate of descent, following a late initiation of the flare by the co-pilot, who was undergoing line training. Three safety recommendations are made.

History of the flight

The flight crew, who were well rested and fit, reported for duty at 0500 hrs to operate a return non-scheduled passenger service from London Gatwick Airport to the Greek island of Kos. The crew consisted of a line training captain, who was the aircraft commander occupying the left flight deck seat, and a 'cadet' co-pilot, who occupied the right seat.

The co-pilot was undergoing line training on the A320/321 aircraft and the two flights were to be the 37th and 38th sectors of his line training programme. During the pre-flight briefing, the commander decided that the

co-pilot should be the Pilot Flying (PF) for the sector to Kos where it would be possible for him to carry out a managed approach[1], to fulfil an outstanding training requirement. He had flown with the co-pilot early in his line training programme and had been notified by his training manager that the co-pilot's landing technique had then been a cause for concern. However, the co-pilot's training file, examined by the commander prior to the flight, did include some favourable reports regarding his landings during recent sectors.

The aircraft departed LGW at 0610 hrs and, aside from a technical problem which was resolved before takeoff, the flight began uneventfully. However, during the climb, Electronic Aircraft Central Monitoring (ECAM) system displayed a message relating to an engine bleed fault and later, after appropriate crew actions, a status message of MAX FLT LVL 100. The crew entered a hold near the south coast to resolve the issue in discussion with their company maintenance staff. In due course, it was determined that the status message was not relevant. The flight crew, after a delay of approximately 45 minutes, then recommenced the climb towards FL310 and proceeded en-route.

As the fuel remaining following the hold was now insufficient to continue to Kos with the required reserves, a decision was made to divert to Thessaloniki, where the co-pilot carried out a manual landing without incident. The aircraft was refuelled, and departed for Kos at 1100 hrs; the co-pilot remained the PF.

As the aircraft neared Kos, the flight crew obtained the arrival ATIS, which indicated that the surface wind was 300°/10 kt, variable between 190° and 300°, the visibility was 10 km or more with no cloud, the temperature was 34°C, the dewpoint 13°C, and the QNH 1005 mb. The FMGS[2] was programmed with this information. Runway 32 was in use and the crew briefed and prepared to fly the VOR/DME approach using the autopilot. They noted that the approach speed, based on the aircraft's weight and the ambient conditions, would be 137 kt. Analysis of the CVR recording showed the atmosphere on the flight deck to be relaxed with the crew operating in a professional manner.

At 1205 hrs, three minutes before touchdown, the aircraft started its final approach with the flight crew in visual contact with the runway. At 5 DME and an altitude of 1,870 ft, they confirmed that the aircraft was on the approach profile; the aircraft was then configured for landing with full flap. The aircraft continued on-the profile and, at 1,400 ft amsl, the co-pilot disconnected the autopilot and adjusted the aircraft's track to follow the extended runway centreline, rather than the slightly offset VOR radial published for the approach. The autothrottle remained engaged for the approach and landing, and the approach speed stabilised between 132 kt and 138 kt. Almost simultaneously with the disengagement of the autopilot, the co-pilot applied two aft inputs to his sidestick, following which the aircraft deviated slightly above the optimum glide path.

At about 2 DME (830 ft aal), the flight crew gained sight of the runway PAPIs. The commander initially advised the co-pilot that he could see three, and then, four white lights, indicating that the aircraft was high on the approach, and advised him to increase the rate of descent to about 1,000 ft/min. The co-pilot increased the rate of descent and requested that the flight directors

Footnote

[1] In a managed approach in the A320 aircraft, the Flight Management Guidance Computer (FMGC) directs the aircraft onto the final approach via the autopilot and autothrottle.

Footnote

[2] Flight Management Guidance System.

be selected off. The barometric descent rate and the ground speed stabilised at about 1,000 ft/min and 138 kt respectively, equating to a descent path of about four degrees[3]. At 500 ft aal, the commander stated that the approach was stable. The co-pilot confirmed that the descent rate was being maintained at 1,000 ft/min, and stated that he did not want to increase it any further. Some 11 seconds before touchdown, at about 160 ft aal, the commander confirmed "THREE WHITES AND ONE RED AND CORRECTING", before advising that the wind was from the left at seven knots. During the final stages of the landing flare, the recorded groundspeed and wind data from the FMGS indicated that the wind direction had changed from a crosswind to a tailwind of between 3 kt and 4 kt.

It was apparent that the commander was 'coaching' the co-pilot somewhat during the final approach but he stopped mid-sentence at the automatic FIFTY callout from the RA. The subsequent FORTY, THIRTY and TWENTY callouts came in very rapid succession, with the touchdown occurring almost immediately after the TWENTY callout. At about 35 ft aal, approximately three seconds before main gear touchdown, the co-pilot retarded the thrust levers and started the flare, progressively moving the sidestick aft about two thirds of full travel; the airspeed was 133 kt. Almost co-incidentally, the commander applied nearly full aft sidestick, (A) Figure 1. The aircraft's pitch attitude increased to about 6° before touching down with a descent rate of 900 ft/min. Normal acceleration was recorded at 3.15g, (B) Figure 1, as the aircraft touched down almost simultaneously on both main landing gears, following which it bounced.

Footnote

[3] The approach plate for Runway 32 at Kos defines the approach path angle at 2.99°, which is equivalent to a rate of descent of 741 ft/min at a ground speed of 140 kt.

The commander took control of the aircraft and decided to carry out a TOGA 10 manoeuvre[4] and placed his hand on the thrust levers. He did not state that he was taking control, but the co-pilot later said that he had been in no doubt that the commander was taking over at that instant. The commander advanced the thrust levers to the TOGA position, (C) Figure 1, and attempted to stabilise the pitch attitude at 10° nose up. The co-pilot's sidestick returned to the neutral position. The takeoff configuration warning then sounded, and the commander retarded the thrust levers, (D) Figure 1. The aircraft momentarily became airborne before touching down a second time with a normal acceleration value of 2.75g being recorded (E) Figure 1. During the bounce, the aircraft's pitch attitude reached 11.6º. (The pitch attitude at which a tail strike occurs, with the main gear compressed, is 11.7º.)

The aircraft bounced twice more before settling on the runway, following which heavy braking was applied. The spoilers had deployed automatically, the thrust reversers unlocked at 70 kt but no reverse thrust was selected. No standard callouts were made by the crew during the landing roll. The aircraft gross weight at touchdown was 63,900 kg.

The initial touchdown was approximately 225 m beyond the runway threshold and, by the time the wheel brakes were applied, the aircraft was 1,400 m from the end of the runway. Its groundspeed had reduced to 40 kt by the time 850m of runway remained.

As the aircraft cleared the runway, the flight crew noticed that the brakes were indicating HOT, before the commander said "THE FLARE WAS RATHER LATE THERE……..BUT THEN I SHOULD HAVE TAKEN OVER".

Footnote

[4] A balked landing recovery manoeuvre in which the pilot selects TOGA thrust and aims for a pitch attitude of 10°.

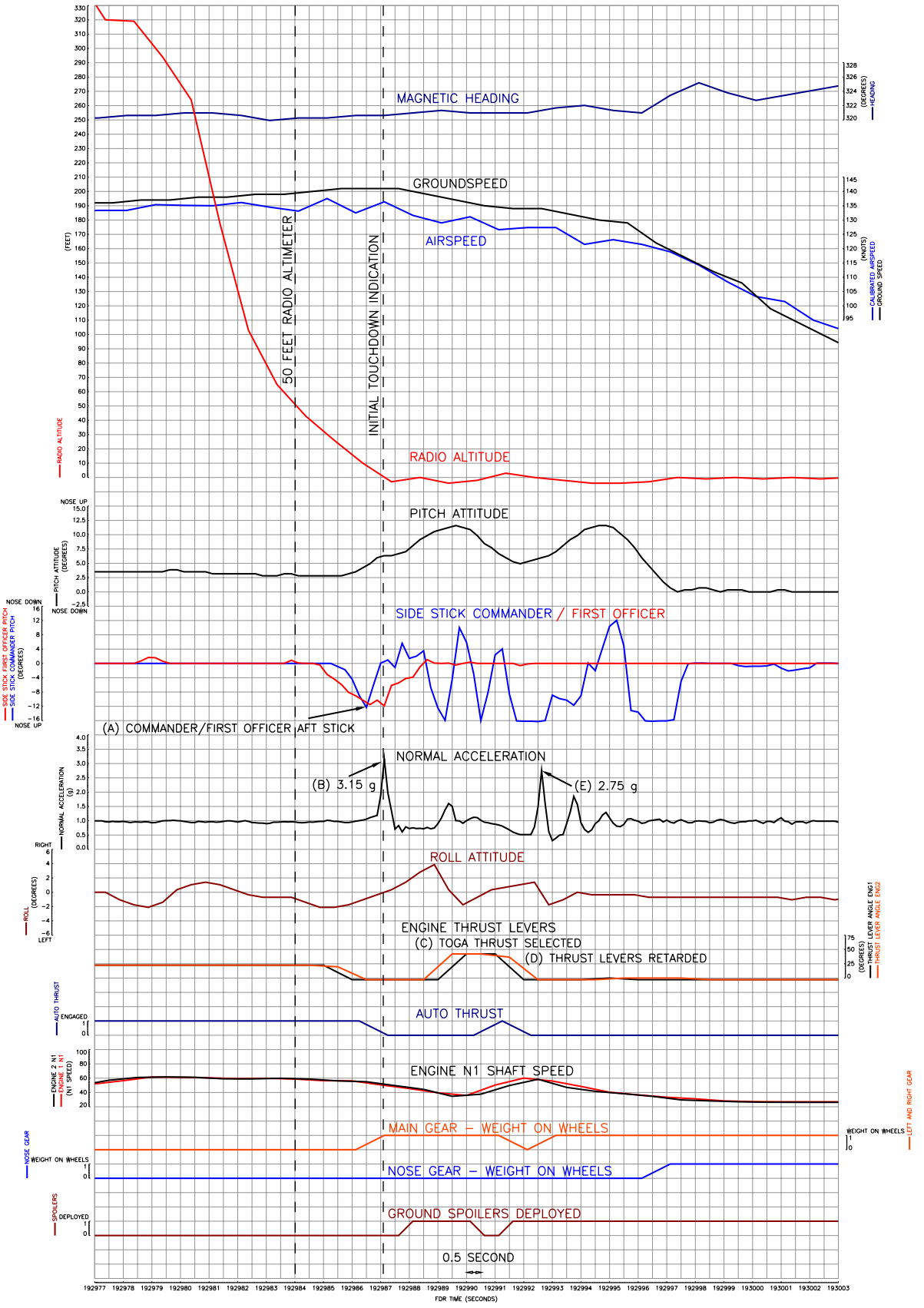

Figure 1

Time history of relevant data covering the landing at Kos

The aircraft taxied to a stand, where it was shut down, and the passengers disembarked normally. The Aircraft Condition Monitoring System (ACMS)[5] produced a report on the flight deck printer, indicating that the landing had been classified as 'heavy'. The commander reported this to the company and the aircraft was declared unserviceable.

Two members of the cabin crew reported some physical discomfort following the landing, and obtained 'over-the-counter' medicine to relieve their symptoms.

Radio altimeter callouts

The approach to runway 32 at Kos is made over a ravine which is aligned with the runway and the ground rises steeply towards the threshold. The terrain affects the automatic RA callouts, causing them to occur at different times compared to those during an approach over flat ground. Providing the aircraft is following the normal glideslope, or is above it and its trajectory is towards the aiming point, the automatic callouts at and below 50 ft occur over the runway surface and are not affected by the terrain further out.

Analysis of the landing at Kos showed that the 'FIFTY' callout, occurred only three seconds before touchdown with little or no flare having occurred. In the previous landing at Thessaloniki, the interval was seven seconds.

Aircraft normally touch down adjacent to the PAPIs, some 300 m from the threshold, following a normal flare. G-DHJZ was determined to have touched down some 225 m from the threshold, short of the aiming point, having flown the last part of the approach at a speed of 133 kt, and with a descent rate of approximately 900 ft/min. Although this equated to a flight path angle of just below 4°, the aircraft would still have been over the paved surface when passing 50 ft aal.

TOGA 10 manoeuvre

The operator had introduced the TOGA 10 manoeuvre into its Operations Manual as a balked landing recovery technique following a number of tailstrike events. Following extensive consultation with the manufacturer, the operator introduced the TOGA 10 manoeuvre to ensure flight crews hold a steady pitch attitude during a late go-around or a bounce from a touchdown. Since this serious incident, the operator has withdrawn this manoeuvre and now recommends to pilots the manufacturer's revised balked landing recovery technique, as described in the FCOM,

Aircraft examination

Several of the operator's maintenance staff travelled to Kos and carried out elements of the Severe Heavy Landing Check, in accordance with the Aircraft Maintenance Manual (AMM). Both main landing gear oleos were found deflated and fluid had leaked from the charging points. As the facilities for repairs at Kos were extremely limited, it was decided that the aircraft should be ferried, gear down, to the manufacturer's repair facility at Toulouse. Here it was inspected and repaired. Both main landing gear assemblies were replaced before the aircraft returned to service.

Airbus Flight Crew Operating Manual (FCOM)

Standard operating procedures applicable following touchdown, are detailed in the FCOM, as follows:

Footnote

[5] The ACMS is part of the flight data recording system. It continuously monitors the aircraft's systems and power plants and, if operational limits are exceeded, automatically notifies the flight crew through the flight deck printer.

'GROUND SPOILERS CHECK
Check ground spoilers fully deployed after touchdown on ECAM WHEEL page
ANNOUNCE (PNF) "GROUND SPOILERS"
ANNOUNCE (PNF) "REVERSE GREEN"
ANNOUNCE(PNF) "DECEL"
At 70 knots:
ANNOUNCE (PNF) "SEVENTY KNOTS"
REVERSE levers IDLE'

Flight crew experience

The commander

The commander joined the operator as a Boeing 757 first officer in 1990, having previously flown the Shorts 330 and 360, and the Boeing 737. He was promoted to captain in 2000, and subsequently to training captain with a Type Rating Instructor (TRI) rating.

In April 2005, he converted to the A320/321, and flew the aircraft for five months that year. He accrued 200 hours flying time on the type, but did not carry out any training duties before returning to the Boeing 757 fleet in October 2005. In May 2006, he was re-assigned to the A320/321 fleet.

In April 2007, following a standards check with a senior training pilot, he was approved to carry out line training duties on the A320/321 aircraft Although the commander remembered being taught the TOGA 10 procedure during his initial Airbus training, he had not rehearsed it since or had cause to use it in line flying.

The commander stated that, in his opinion, the task of monitoring a trainee in the Airbus aircraft was "certainly not as intuitive" as in the Boeing aircraft, as he was unable to sense any control inputs made by the co-pilot.

The co-pilot

The co-pilot began his flying training in late October 2005, on an intensive course with a flying school in Florida, USA, for a UK JAA PPL on single engine piston (SEP) powered aircraft. He passed the skills test for licence issue approximately one month later, after 45 hours of flying. He then gained hours, flying privately, with the aim of obtaining a Commercial Pilot's Licence (CPL). In 2002, he passed the CPL skills test at the second attempt and the Instrument Rating (IR) skills test at the third attempt.

He flew privately for nine hours in 2003, and eight hours in 2004. In 2005, he flew a further eight hours and trained for a Multi-crew Co-operation Certificate (MCC), for which he undertook 20 hours of simulator training. In 2006, he flew for five hours. All his flying between 2003 and 2006 was in SEP aircraft types. Between 2005 and 2006, he worked as a ground manager for the operator at one of their bases.

Late in 2006, he attended selection tests for a 'Cadetship' programme offered by a commercial flying training organisation (FTO), in conjunction with the operator (of G-DHJZ)[6]; the tests were run by the training organisation. Under the scheme, a cadet would pay for a 'Jet Bridge'[7] course, type rating and 150 hours of line flying with the airline. Thereafter, there would be a possibility of employment should the airline concerned have any vacancies. The commercial training organisation paid the airline for its involvement in the training, enabling the airline to generate revenue through their training department,

Footnote

[6] A number of airlines have similar arrangements with flying training organisations.
[7] A course intended to teach skills relevant to operating large jet aircraft.

and to have a 'pool' of trained pilots available to meet seasonal operational needs.

For consideration for the cadetship programme, the co-pilot underwent psychometric, literacy and numeracy tests, and an interview, before his flying skills were assessed in a Boeing 737 simulator. Although he performed well in the non-flying aspects of the assessment, his performance in the simulator did not meet the required standard. However, he was offered a further assessment in an A320 simulator with a senior training captain employed by the training organisation. He passed this second assessment and was offered a place on the scheme. His previous commercial flying training record was not reviewed.

In January 2007, having by then logged 180 hours SEP and 60 hours Multi-Piston Engine (MEP) flying, the co-pilot began the 'Jet Bridge' course. This included a number of training details, including landings in an A320 simulator but this did not cover the specific landing technique relevant to the A320 type.[8] The course consisted of 14 hours in an A320 fixed base training device, and 16 hours in an A320 full flight simulator. After this course, he undertook simulator training towards the grant of an A320 type rating, which consisted of a further 28 hours in a fixed base device and 50 hours in a full flight simulator.

His first training detail in the full flight simulator was on 10 March 2007 and, during this part of his training, he was taught by six different instructors. During this period his landing technique was a recurring theme of concern and relevant notes were made a number of times in his reports. Some of these indicated that a satisfactory landing had been performed, others identified unsatisfactory performance. Although instructors identified that more time needed to be spent training the co-pilot to land, this time was not found, and the training was repeatedly deferred. Moreover, it was not until the tenth detail that specific comment was made as to the cause of the co-pilot's inconsistency, with the instructor noting that the co-pilot appeared to be following the flight director commands below 200 ft.

The co-pilot's ninth training detail was scheduled as the Licence Skills Test (LST) for issue of the A320/321 type rating, but the co-pilot did not perform satisfactorily. The report stated that one landing was:

> *'firm - little or no flare'*

and, in detailing the examiner's three main areas of concern, stated:

> *'landings are still an area of concern with very late flare leading to very firm touchdown.'*

A further note stated:

> *'following discussion with the chief pilot it has been decided that [the co-pilot's] next sim will concentrate on further training to include single engine handling and landings. It has also been decided that a full LST shall be completed after this [next] training detail. Note - no items have been recorded as tested so far on Form SRG/1158.'*

The final, twelfth, detail of his simulator training occurred on 30 March 2007 and was dedicated to pre-base training, and consisted of 15 touch-and-go

Footnote

[8] There is no requirement that the instructor on such a course should be type rated on the aircraft type used for training.

landings and one full stop landing. This detail was completed:

> *'to a satisfactory standard,'*

and the report stated that there were some:

> *'good touchdowns;'*

however, these were:

> *'not always consistent'*

and the co-pilot still had a:

> *'tendency to flare late sometimes.'*

The report noted that he was asked to:

> *'remember to look outside in the last stages of the landing.'*

On 5 April 2007, the co-pilot undertook base training at Prestwick Airport. A low cloudbase made it necessary for each circuit to be directed by radar, culminating, each time, in an ILS approach. The report on this training stated:

> *'initial landing OK but [the co-pilot]could not subsequently stabilise the aircraft on approach after going visual.....below 200 feet he allowed the nose to rise leading to a steep descent just prior to a hard landing. Three attempts with no improvement.'*

The instructor recommended further simulator training to improve the co-pilot's final approach technique.

An additional simulator training detail was carried out on 17 April 2007. It was noted in the first half of the detail that:

> *'the variable flare and landing was cause for concern' and that 'the second detail initially did not see much improvement but then something clicked and the final 5 approaches and landings were to a [satisfactory] standard. On that basis [the co-pilot] is cleared to re-attempt base training but he must be under no illusion that he needs to reproduce the standard of the final 5 approaches consistently to pass.'*

On 24 April, the co-pilot completed a base training detail and the report stated that he:

> *'settled into a series of consistently accurate circuits with good landings……'*

He was cleared to commence line training, which began on 26 April 2007.

During the first 38 sectors of line training, he flew with eight different training captains and their reports generally reflected good preparation, good performance and a keen, willing, attitude. However, his landing technique was a recurring theme of concern and relevant notes were made a number of times in his reports. Some of these indicated that a satisfactory landing had been performed, others identified unsatisfactory performance, with many of the comments generated during his earlier training being repeated. On several occasions, the aircraft commander either intervened or took over control. However, towards the end of this period of line training, there were favourable reports of his landings.

Flight Data Monitoring (FDM)

In late May 2007, the operator's FDM scheme indicated that one co-pilot had been involved in three double sidestick events[9] during the landing phase of flight, on 7, 12 and 27 May. The analysts operating this system did not identify any particular individual involved or whether the flights were training flights. On 5 June 2007, a 'firm' landing incident led to an alert from the FDM system which identified that the same individual was involved. In accordance with the operator's agreement with the relevant pilot's trade union, the incident pilot was identified, and found to be the co-pilot involved in the landing at Kos.

On 11 June 2007, the company flight safety officer wrote to the training manager detailing these double sidestick events. The co-pilot was removed from flying duties and interviewed by the training manager. He also discussed the landing events with a member of the safety department. The co-pilot then flew two line training sectors with the company's chief Airbus training captain and performed to a satisfactory standard, although the report on these flights contained the comment *'note about aiming short*'. The co-pilot was returned to line training. At a meeting of training captains on 27 June, the co-pilot's landings were discussed. It was felt that his landings had improved and that he was performing to a satisfactory standard.

Analysis by the company's flight safety department, after the accident at Kos, showed that during line training the co-pilot had carried out 28 landings and, on nine occasions, the commander had intervened.

Footnote

[9] A double sidestick event is one in which both sidesticks are moved, indicating that the PNF is assisting or intervening in the PF's control of the aircraft.

Operator's airfield brief - Kos

The operator had classed Kos Airport as a category B airfield and published an airfield brief, which described the airport and its surroundings. This included the following:

> *'The airfield is located close to the centre of the island on a plateau between two mountain ridges and the terrain drops sharply away from the runway to the south.'*

Regarding the VOR/DME approach to Runway 32, the brief stated:

> *'The approach is straight forward, but offset by 6 degrees. Do not extend outbound due terrain on the island of Nisizos at 2,300 ft asl. There are no approach lights to this RWY however it is easily identifiable due to threshold identification lights and the lack of any other lighting in the vicinity. At night, the landing lights illuminate the undulating terrain and can give a misleading perspective.*
>
> *Note: At night captains are to be the handling pilot.'*

The operator's report into this accident stated that:

> *'This restriction was introduced following FDM data showing that an unusually high number of high descent rate events were generated late in the approach to runway 32 at KGS.'*

The approach to Runway 32 is unusual, in that it is over a ravine which is aligned with the runway extended centreline (Figure 1) and the ground rises steeply towards the runway threshold. This not only results

in the misleading perspective by night, as mentioned in the airfield brief, but also means that the 'picture' by day is unusual. Guidance provided by the aircraft manufacturer warns that an upslope towards the touchdown aiming point may lead pilots to increase the rate of descent inappropriately, with the consequent risk of a hard landing.

The nature of the terrain also causes the automatic height callouts from the RA during the approach, when above 50 ft RA, to occur more rapidly and closer to the moment of touchdown, than would otherwise be the case.

Pilots familiar with Kos Airport spoke of routine difficulties of identifying the PAPIs on Runway 32 by day, especially in bright sunshine. ICAO Annex 14 details Standards and Recommended Practices regarding airports, including the characteristics of PAPI installations. The Annex states:

> *'5.3.5.32 Suitable intensity control shall be provided so as to allow adjustment to meet the prevailing conditions and to avoid dazzling the pilot during approach and landing.'*

Stable approach parameters

The operator's Operation Manual contained the following instruction regarding rate of descent on final approach:

> *'PNF will make call-outs for the following conditions that indicate an unstable final approach….."SINK RATE" when v/s is greater than 1,000 ft/min.'*

The manual did not specify the action to be taken, or state a maximum rate of descent to be respected in order for 'stable approach' criteria to be met.

Simulator assessment

The AAIB investigator carried out an assessment exercise in a full flight A320 simulator taking the role of a 'trainee' pilot, together with an experienced A320 Type Rating Examiner (Aircraft) (TRE(A)). The TRE(A) was current in both line and base training of pilots of all levels of experience.

Having briefed the TRE(A) that he should act as he would during normal operations, the 'trainee' flew normal approaches and landings, interspersed with approaches and landings during which deliberate handling errors were made. No prior warning was given to the TRE (A) of these errors.

In the first of these 'unusual' approaches, a manual approach was flown with autothrust, but the 'trainee' ceased to make sidestick inputs at 50 ft RA. The TRE(A) was unable to intervene in time and the aircraft struck the runway without a flare. In other 'unusual' approaches, the TRE(A) was again unable to intervene, or intervened too late, to prevent a hard landing.

Pilot training requirements

The operator's Operations Manual Part D included guidance and instruction to flying training staff. The section entitled *'Enhanced Line Training'*, relevant to direct entry cadet pilots, stated:

> *'Continuity should be achieved as far as possible, aiming for at least 6 sectors with the same instructor at a time. This does not mean that the entire training should be flown with the same instructor, this is equally undesirable.'*

This was not achieved in the co-pilot's case.

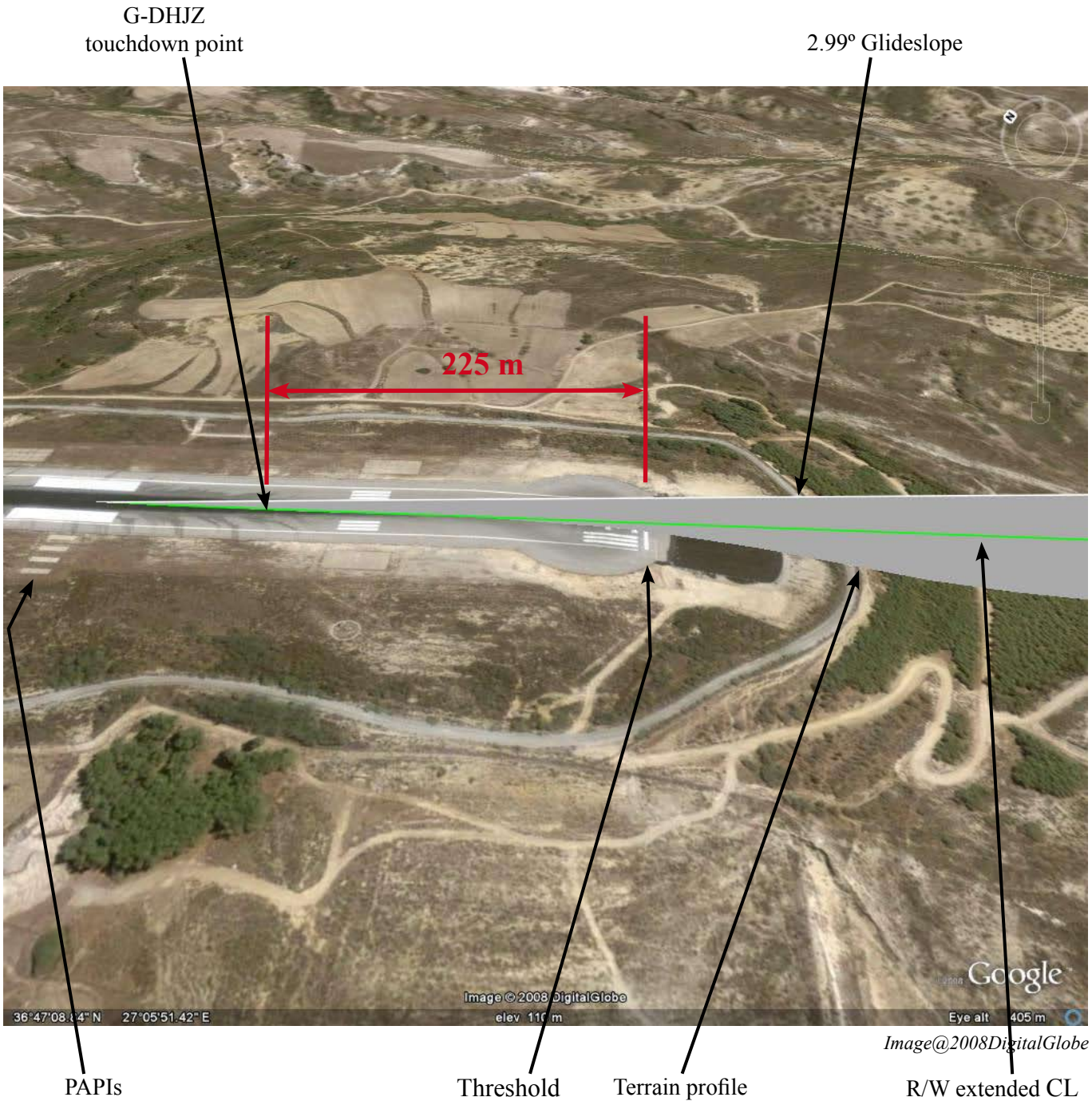

Figure 2

Threshold region of Runway 32 at Kos

The section entitled *'Training and Checking Personnel – DUTIES AND RESPONSIBILITIES'* stated**:**

> **'***Procedures to be applied in the event that personnel do not achieve or maintain the required standard:*
>
> *If at any stage of training, or as a result of a test, it is evident that the pilot has not reached the necessary standards, the training Captain should refer the case to the Chief Training Captain or Training Manager in the first instance. The Training Manager will decide whether or not further training should be given.'*

The 'necessary standards' mentioned in the paragraph were not defined.

In the section *'Conversion Training and Checking'*, it stated:

> *'TRAINING DEFICIENCIES*
>
> *All cases where the pilot under instruction or undergoing a recurrent programme or check experiences difficulties that are likely to lead to more serious consequences, such as withdrawal from training, are to be brought to the attention of the Head of Training as soon as possible. Training failures especially in the later stages are very costly and wasteful of our resources.'*

A relevant Flight Crew Notice regarding line training of direct entry cadet pilots stated:

> *'Any pilot converting to the Airbus should be rostered for line training sectors in accordance with the following guidelines. While this may not be particularly important for a pilot joining us with previous heavy aircraft experience it is particularly important for cadet pilots who are conducting line training on a large aircraft for the first time.*
>
> *Night flights should be avoided during the first 6 sectors.'*

Only two of the co-pilot's first six sectors were by day.

> *'The first 3 landings should ideally be conducted in daylight hours so the opportunity exists for a landing in daylight on at least one of the sectors (the trainer can do the night landing if necessary).'*

The co-pilot's first landing was by day, his second and third by night.

> *'The first 10 sectors should be flown in either the A320 or A321, but "flip flopping" between the two types should be avoided.'*

The co-pilot's first four sectors of training were flown in the A321, the remainder of his line training was in the A320.

Airbus Flight Crew Training Program (FCTP)

The following information is contained in Chapter 02-08-01 of the FCTP produced by the manufacturer under the heading *'Instructor Take-over Proceedure':*

> *'……additive control inputs by the instructor may be of negative value for instruction purposes and can generate confusion in the handling of the trajectory. This should be emphasized and reviewed with the trainees during the preflight briefing. If take-over becomes necessary during the flight, instructor will clearly call "I*

HAVE CONTROL" and press sidestick priority pushbutton…. '

Operator's training department

On 27 June 2007, the operator's training department held one of a series of regular meetings. The minutes of this meeting included the following:

'There have been a number of double sidestick inputs, and control takeovers. Whilst this can occur as a part of line training please do file an ASR. This will help Flight Safety in OFDM analysis, and highlight the number of times this is happening during training.'

Regarding cadet pilots, the minutes recorded:

'Another issue raised was the training of low hours cadets. Whilst the trainers are not objecting, it was felt that this training does expose the company to an increased risk. Cadet training had already been discussed at the top ten safety issues meetings, but the company felt the risk was mitigated by the training syllabus.'

Regarding training of training captains, the minutes recorded:

'Should training captains have simulator details to practice dealing with poor approaches and landings by trainees? This has a great deal of merit and will be considered by the Training Manager and CTCs.'

Human factors

Sidestick issues

Manual control inputs in the Airbus fly-by-wire aircraft are not made through traditional control columns but via sidestick controllers. One sidestick is located on the outboard side of the flight deck for the left seat pilot, another (on the opposite side) for the right seat pilot. 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.

During the landing phase of flight, an instructor pilot monitors the approach by assessing the aircraft's performance, ie, by visually scanning both the flight instruments and the 'picture' through the flight deck windows. In addition, in a 'traditional' aircraft, where the flight controls are fully interlinked, the instructor might also be able to monitor the direction and magnitude of any, albeit relatively small, control inputs made by the student by sensing their movements in a tactile manner. By doing so, they may be able to prime themselves for the flare motion on the control column and, if the motion is late or absent, make an appropriate input in sufficient time to attempt to avert a heavy landing.

In a fly-by-wire aircraft fitted with sidesticks, the instructor also monitors the approach by assessing the aircraft's performance, but does not have an option of sensing control inputs made by the trainee. By the time it is apparent that no flare, or an incorrect flare, has been made, it may be too late for the instructor to intervene and the aircraft to respond before a possible heavy touchdown occurs[10].

The Airbus FCOM describes the operation of the sidesticks as follows:

Footnote

[10] Reference the comment in paragraph *'Instructor Intervention, '……the aircraft demands a relatively high level of 'assured' skill from the trainee; his ability to land the aircraft should not be in doubt before base training commences, and certainly not in doubt during line training where passengers are carried.'*

'When only one pilot operates the sidestick, it sends his control signals to the computers. When the other pilot operates his sidestick in the same or opposite direction, the system adds the signals of both pilots algebraically. The total is limited to the signal that would result from the maximum deflection of a single sidestick.

A pilot can deactivate the other stick and take full control by pressing and keeping pressed his priority takeover pushbutton.'

The priority takeover pushbutton is mounted on the top of each sidestick. Whilst control of the aircraft through manipulation of the sidestick is highly instinctive, operation of the priority takeover button is a highly cognitive action.

Operator's assessment

The operator carried out their own investigation into the accident, and analysed flight data relevant to the co-pilot's landings. Their report stated:

'There was also evidence that the Second Officer had difficulty in judging the amount of flare required to achieve acceptable landings in different circumstances. Predominantly this manifested itself as "firm" landings, although he also "over flared" on occasion. Whilst most trainers who witnessed this believed that he was flaring late, flight data suggested he may in fact have had a tendency to an early but weak flare. In the absence of sidestick feedback, from the Training Captain's perspective, an early weak flare and late flare were likely to have the same effect, a firm landing.'

Manufacturer's assessment

Airbus carried out an analysis using information from the DFDR and the aircraft operator. Salient points from their report are reproduced below:

'Approach was performed with a headwind from the left (300° with QFU at 325°), between 8kt and 10kt, except in the last 80ft where it becomes a tailwind.

The F/O initiated the flare at 30ft with a linear nose up stick input: 3/4 Full Back Stick applied in 2s. About 1s later captain applied also a linear nose up stick input: 3/4 full Back Stick in 1s.'

Simulation Results

***'NB**: Because of the specific ground profile before the runway (RWY 32 KGS), the recorded radio altimeter (ZRA) is not a reliable indication of A/C vertical trajectory above 50ft. We therefore refer to pressure altitude (ZP) above 50ft. Below 50ft, pressure altitude is corrupted by ground effect. We then refer to radio altimeter.'*

The A/C encountered 9kt headwind during approach down to about 250ft AGL which then progressively cancelled down to about 80ft and turned into a 3kts tailwind in the last 80ft.

The A/C encountered no significant lateral or vertical wind.

The A/C behaviour and recorded control surfaces deflections are well matched, which allows concluding that A/C and Flight Control System behaved as per design during the event.

Additional simulation was done to assess the

effect of the 3/4 Full Back Stick orders applied by the captain just before touch down. In a general way, the effect of captain order [input] is minor but it acts in the sense to slightly improve [reduce the severity of] the impact.

The Handling Qualities analysis confirms that the hard landing was the result of a flare initiated slightly too late. Additional contributing factors are a longitudinal wind that turns from headwind to tailwind below 80feet and the 0.5% runway slope (uphill).

Additional simulation done without captain order [input] *shows that the effect of captain order* [input] *is minor but it acts in the sense to improve slightly the impact. Indeed captain order resulted in a slight increase of A/C lift and as a consequence, in a slight reduction of vertical load factor and vertical speed at touch down. It is important to note that this reduction is quite negligible: Nz is reduced by 0.03g and vertical speed by 0.4.ft/s. In the same way, impact on MLG loads is low and still in the sense to reduce them. Pitch rate effect, which tends to increase loads on MLG due to lever arm effect, is offset by lift increase.'*

Analysis

Events prior to the landing at Kos

The commander was aware that the co-pilot's training file detailed concerns about his landing technique. He was also aware that in recent sectors, these concerns had moderated and some good landings had been reported. The flight from Gatwick had been conducted in a professional manner and a relaxed atmosphere, and the co-pilot's satisfactory landing in Thessaloniki was consistent with the moderation of these concerns.

Technical problems before departure and in the climb, necessitating a period of holding and detailed communications with the company's engineers. Also the en-route diversion to Thessaloniki to refuel meant that the aircraft was behind schedule and that the pilots had dealt with a series of unexpected challenges. Whilst neither pilot reported being fatigued, it is possible that they were not in as fresh a condition as they might otherwise have been for the approach at Kos.

The approach

The approach to Runway 32 at Kos Airport presents a number of challenges to pilots. It is a non-precision approach, slightly offset from the runway centreline, and towards terrain that slopes significantly upwards towards the runway threshold. Other considerations, such as the terrain generally around the airport, add complexity to the pilot's task, although the fine weather in which the approach was executed meant that the task was less complex than when approaching in bad weather and/or at night.

The operator had recognised that the approach was challenging and had introduced a restriction requiring that only aircraft commanders would land on Runway 32 at Kos at night. The company report stated that this was done:

'following FDM data showing that an unusual number of high descent rate events were generated late in the approach.'

However, the report did not specify that these events occurred at night, and it may be that the restriction did not fully address the problem when landing by day.

Shortly after the co-pilot disconnected the autopilot, the aircraft began to deviate above the glidepath. Then, at about two miles from touchdown, the flight crew gained

sight of the PAPIs. At this point, the co-pilot sought to establish the aircraft on the 'visual' PAPI glidepath, identified by two white and two red lights. At this point the commander made references to the PAPI indications, 'coaching' the co-pilot to gain the correct glidepath. When he saw four white lights, he knew that the aircraft was 'high', and mentioned this to the co-pilot, but had no means of knowing how far the aircraft was above the PAPI glidepath. This necessitated an increased rate of descent but, the operator's SOPs indicated that pilots should respect a maximum rate of descent on the approach of 1,000 fpm. The co-pilot was, therefore, restricted to using this as a maximum rate of descent to establish on the glidepath.

The accepted limits for establishing a 'stable approach', which include a limit on the maximum rate of descent to be used, bring safety benefits. However, when an aircraft is in a position from which a correction is required to achieve a visual glidepath defined by PAPIs, or similar aids, the flight crew may be placed in a challenging position. It would be possible to abandon the approach, or ignore SOPs and manoeuvre aggressively, exceeding the stable approach parameters for a short while in order to achieve a stable approach later, but this is not an option likely to be adopted by flight crews except, perhaps, in extremis. The flight crew of G-DHJZ manoeuvred the aircraft within the stable approach parameters in the hope of establishing on the correct glidepath prior to touchdown. Had the PAPIs been visible to the flight crew at a greater range, it is possible that the co-pilot would have been able to acquire the PAPI approach path and stabilise the aircraft on that path well before touchdown. This would have achieved a normal rate of descent and, probably, a normal landing. In light of the apparent difficulty reported by some flight crews of visually acquiring Runway 32 PAPIs at Kos, the following Safety Recommendation is made:

Safety Recommendation 2008-021

It is recommended that the Greek Civil Aviation Authority should review the performance of the PAPI installation of Runway 32 at Kos, to ensure that flight crews are able to acquire them visually in time to stabilise their aircraft on the correct glideslope before landing.

In response to this recommendation, the Hellenic Civil Aviation Authority point out that:

> *'…….usually the density* [brightness] *of the PAPIs of Runway 32 is in the medium position and it is increased only by flight crew request, since if it is leaved in the high level they receive complaints from the flight crews.'*

The steeply rising terrain under the approach to Runway 32 at Kos, can result in a pilot gaining a false perspective of an approach and has the potential to cause pilots to perceive the rate of descent to be greater than it is. This, and the accompanying 'ground-rush', may result in an early and excessive flare. However, this did not occur in this case as the co-pilot used the RA callout of FIFTY as the trigger to begin to flare.

In normal landings, with the aircraft correctly positioned on the glide slope, an aircraft should touch down at the aiming point. In this circumstance, the FIFTY callout will occur with the aircraft over the threshold, and the terrain immediately before the start of the paved surface should not influence the RA callout timings below this height. It was established from the FDR data that G-DHJZ touched down only 225m from the threshold, short of the aiming point, and with a high rate of descent. The data indicated that its glide path was just below 4° and that the time between the

FIFTY callout and touchdown was around 3.2 seconds. Therefore, the high rate of descent immediately before touchdown would have necessitated an earlier initiation and, possibly, a more aggressive flare, to have avoided the heavy landing.

In the previous landing at Thessaloniki, where the aircraft was on the glideslope, the co-pilot also commenced the flare immediately after the FIFTY callout and landed without incident. In this case, the time between the FIFTY callout and touchdown was in the region of seven seconds, the longer time period reflecting the lower rate of descent.

Although the operator's airfield brief for Kos covers many of the challenges the airport poses for flight crews, it did not highlight these specific issues. The following Safety Recommendation is therefore made:

Safety Recommendation 2008-022

MyTravel Airways Limited should revise its airfield brief for Kos Airport to include specific reference to the visual aiming point, the influence of the rising terrain on the visual perspective, and acceptable levels of vertical speed prior to touchdown.

Given the apparent difficulty in making a visual approach to Runway 32 at Kos both by night and day, where the flight crew rely on the PAPIs (which are reportedly difficult to see in bright conditions) for approach path information, the following Safety Recommendation is made:

Safety Recommendation 2008-023

It is recommended that the Greek Civil Aviation Authority carry out a risk assessment at airfields, particularly at Kos, where the local terrain may give aircrews misleading visual cues, with a view to assessing the requirement for the installation of precision approach aids.

The landing

The approach progressed normally until the aircraft reached a height of roughly 50 ft aal, except that it was above the visual glideslope as defined by the PAPIs. The aircraft's rate of descent was somewhat higher than usual and the aircraft was slightly slow, as the autothrottle was maintaining a speed predominantly below the desired approach speed throughout the latter stages of the approach. The slight headwind component of 9 kt at 250 ft had backed and decreased to zero at 80 ft and became a very slight tailwind component of 3 kt at touchdown. The influence of such a light wind would have been minimal and is not considered to be of great significance in this landing.

The effect of the slightly low speed during the flare on the response of the aircraft, with respect to the reduction of its rate of descent, would have been small, and was probably not enough to alert the commander or co-pilot to an impending problem. In the early stages of the flare, aft sidestick commands an aircraft pitch rate, which progressively becomes a direct stick/control surface relationship as the flare progresses. The co-pilot's control inputs resulted in a flare insufficient to arrest the aircraft's high rate of descent and prevent the heavy landing. It was notable that the commander stopped speaking mid-sentence at the FIFTY callout and this was probably a result of his sudden recognition of the situation. Soon after, he made a nearly full aft sidestick input, without pressing the priority button, almost certainly in an attempt to avert a heavy landing, but the effect of this was *'negligible'*, as assessed by the manufacturer's analysis of the event.

Following touchdown, the aircraft bounced; the commander decided to take control and carry out the TOGA 10 balked landing manoeuvre. Although the commander did not state 'I have control', the co-pilot was clearly in no doubt that he had taken over and relinquished control. Given the severity of the impact at touchdown and the shock the flight crew experienced, it is considered unsurprising that the commander did not make the statement. The highly cognitive nature of the sidestick priority control, and the highly instinctive manner in which the commander took control, make it equally unsurprising that he did not activate the priority system.

As the commander advanced the thrust levers and endeavoured to control the aircraft's pitch attitude to 10º nose-up, the takeoff configuration warning sounded, following which he abandoned the manoeuvre. The commander later stated that he had abandoned the TOGA 10 manoeuvre as the engines were slow to spool up, and he assessed that it would be safe to continue the landing.

The TOGA 10 manoeuvre was intended to recover the aircraft from difficulties during a landing but was not the manoeuvre recommended by the manufacturer. In this event, the manoeuvre did not achieve its intended outcome and, indeed, a tailstrike was narrowly avoided. Following this event, the operator decided to adopt the manufacturer's balked landing procedure, so no Safety Recommendation is made concerning action following a balked landing.

Having abandoned the TOGA 10 procedure, the commander selected idle thrust again and continued with the landing rollout, but this was not conducted in accordance with the company's Operations Manual. Standard calls were absent and reverse thrust was not selected. Given that the flight crew were distracted, some deterioration in the performance of their tasks might be expected. The co-pilot did not adopt the pilot monitoring role, possibly because no formal exchange of control had occurred but, in the event, the runway was relatively long and the aircraft was brought to taxi speed well before its end.

Co-pilot's training

The co-pilot's training record to PPL issue was not available. The fact that he achieved licence issue in 45 hours of flying could be taken as a sign that he did not experience significant problems at that stage. However, it took him two attempts to pass the CPL skills test, and three to pass the IR test. From 2003 until he began the cadetship programme, he flew fewer than ten hours each year and not being particularly current, possibly, did not enable him to progress as straightforwardly as others through the conversion course onto the Airbus. Having failed to achieve the required standard at the simulator stage of the selection process, his second attempt was assessed not by an employee of the operator, but by an employee of the flying training organisation. The purpose of the 'jet bridge' course is to provide pilots whose only experience is of piston-engine powered aircraft, with a general awareness of the operation of the more complex jet powered airliner and, as such, is a valuable way of beginning their conversion to such aircraft.

In the case of the co-pilot on G-DHJZ, the course provided him with the opportunity to carry out a number of landings in the A320 simulator, but without any type specific formal training to do so. It is possible that this, at least, led to his rehearsing actions of his own choosing in circumstances where formal learning of the correct technique was desirable.

Once the formal simulator training towards the issue of the Airbus type rating began, his difficulties in landing were soon identified. By the fourth training detail, the instructor commented that:

> *'there is a need to greatly improve the landing technique which is still almost out of control.'*

However, it was not until the tenth simulator detail that an instructor wrote any detailed analysis of the co-pilot's landing technique. Constraints of time meant that early action to concentrate upon correcting his landing technique was not taken and it is surprising that such a comment made at this stage of his training, did not result in an immediate attempt to remedy his difficulties.

His training report noted that he was a keen and well-prepared trainee and that he was a very pleasant individual. Instructors knew that he had invested considerable time and money into his chosen career and that the operator's training manual mentioned *'Training failures especially in the later stages are very costly and wasteful of our resources'*.

The operator has subsequently stated that this comment in the manual is not guidance for instructors to just focus on cost control. They also point out that, on a number of occasions, decisions to terminate training have been taken in a robust manner.

Instructor intervention

The circumstances of the landing at Kos showed that it was not a stabilized approach; by 160 ft aal (11 seconds before touchdown), the aircraft was still above the glidepath as defined by the PAPIs and descending at around 1,000 ft/min. The instructor did not intervene until the co-pilot retarded the thrust levers and initiated the flare at about 35 ft aal, progressively moving the sidestick aft about two thirds of its travel.

Once the aircraft reaches flare height, if the trainee does not flare effectively, the aircraft may touch down more firmly than intended, with the possibility that such touchdowns could be heavy. By the time the commander realised that the aircraft was not going to land 'normally', it was too late to recover the situation.

Therefore, the aircraft demands a relatively high level of 'assured' skill from the trainee; their ability to land the aircraft correctly, consistently, should not be in doubt before base training commences, and certainly not in doubt during line training where passengers are carried.

The commander, on this occasion, was not able to prevent the heavy landing, despite his application of nearly full aft sidestick. The aircraft touched down heavily, with a recorded normal acceleration of 3.15g, before bouncing and touching down again at 2.75g, during which period a tailstrike was narrowly avoided. His decision to implement the company's TOGA 10 recovery manoeuvre after the first touchdown was reversed when the takeoff configuration warning sounded and the engines appeared to be slow to spool-up. Given the relative difficulty in which the training captain finds himself when mentoring trainees whose landings may not be of a consistently high standard, it seems logical that any landing recovery manoeuvre should be flown with some expertise, and certainly without further hazarding the aircraft. Therefore, and taking note of the commander's actions when confronted by the takeoff configuration warning, the following Safety Recommendation is made:

Safety Recommendation 2008-024

It is recommended that MyTravel Airways Limited should introduce training for all training captains, which allows them to rehearse the balked landing recovery manoeuvre in the simulator during recurrent training, and involving a take-over of control from the co-pilot. The training should highlight the possibility that a takeoff configuration warning will occur during the manoeuvre.

Safety action

Many of the factors relevant to this serious incident were discussed at an operator's training meeting, slightly more than a week before the accident. It is very possible that, had the accident not occurred so soon after this meeting, the operator would have had time to put measures into place addressing many of the factors associated with this event. However, since this accident, the operator has instituted the following changes to the training syllabus:

- *'A mid course review has been introduced. The Training Manager will review each student's progress approximately halfway through their programmed line training.*
- *All Taining Captains will undertake landing handling training before instructing low hours and inexperienced student pilots.*
- *Only nominated Training Captains can perform final line checks on Cadet Pilots.*
- *A Flight Crew Notice (97/07) has been issued with further guidance on landing techniques.*
- *A further simulator training detail has been introduced to the MyTravel Airways cadet pilot syllabus – simulator 5A, to concentrate on landing techniques and handling.*
- *Trainees fax a copy of the relevant report to the training department immediately following each training duty.*
- *The "TOGA 10" procedure has been replaced with the Airbus recommended technique.'*

In addition, the operator now requires that a training captain, when converting to a new type will conduct all the training as required by the initial syllabus. Issues specific to fly-by-wire aircraft are highlighted in a 'Train the Trainer' simulator exercise, designed to familiarise line training captains with typical handling errors that can occur when training pilots. The exercise focuses on errors when the aircraft is close to the ground, ie, when taking off and landing. This simulator exercise is a pre-requisite before conducting any line training with low experience pilots.

The decision taken after the co-pilot's ninth simulator detail, which was to be a LST, not to record it as such, was not in keeping with the relevant instructions from CAA.

The CAA has discussed completion of the LST form with the operator who has been reminded that when a skills test has begun, it must be recorded as such, even if it is clear to the examiner that the candidate will not pass. Therefore, no safety recommendation is made on this issue.