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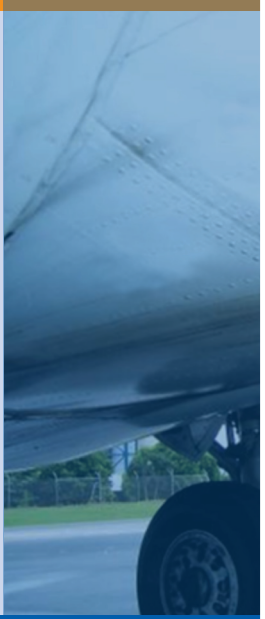

ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation AO-2008-007
Final

Hard landing
Darwin Airport, Northern Territory
7 February 2008
VH-NXE
Boeing Company 717 – 200

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Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office location: 62 Northbourne Ave, Canberra City, Australian Capital Territory, 2601
Telephone: 1800 020 616; from overseas + 61 2 6257 4150
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117; from overseas + 61 2 6247 3117
E-mail: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

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Acknowledgements

Figure 1: Airservices Australia
Figure 2: Boeing Commercial Airplanes
Figure 3: Cobham Aviation Services Australia
Figure 4: Jeppesen Sanderson Inc.

Abstract

On 7 February 2008, a Boeing Company 717–200 aircraft, registered VH-NXE, was being operated on a scheduled passenger service from Cairns, Queensland via Nhulunbuy (Gove) to Darwin, Northern Territory with six crew and 88 passengers.

The flight crew were cleared by air traffic control to fly a visual approach to runway 29 at Darwin Airport and elected to follow the instrument landing system to the runway. The aircraft was above the glideslope for the majority of its approach and temporarily exceeded the operator's stabilised approach criteria shortly before landing. The aircraft sustained a hard landing resulting in structural damage. The flight crew completed the landing roll and taxied the aircraft to the terminal without further incident. There were no reported injuries; however, the extent of the damage to the aircraft led the ATSB to classify the occurrence as an accident. The investigation identified a number of relevant safety factors, including the flight crew's actions and control inputs, the aircraft operator's stabilised approach criteria and operational documentation, and the visual cues associated with runway 11/29 at Darwin Airport.

As a result of this occurrence, the aircraft operator implemented a number of safety actions in relation to enhancing their stabilised approach criteria and pilot training, the monitoring of third party training providers, and the amendment of relevant operational documentation. In addition, the Civil Aviation Safety Authority undertook to prioritise the completion of proposed legislation in relation to third party training providers.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flight

On 7 February 2008, a Boeing Company 717–200 (717) aircraft, registered VH-NXE (NXE), was being operated on a scheduled passenger service from Cairns, Queensland via Nhulunbuy (Gove) to Darwin, Northern Territory with six crew and 88 passengers. The flight crew consisted of the pilot in command (PIC) and copilot. The copilot was the handling pilot for the descent, approach and landing and the PIC was the monitoring pilot.

The flight crew were cleared by air traffic control (ATC) to fly a visual approach to runway 29 at Darwin Airport, and elected to follow the instrument landing system (ILS)[1] to the runway. Following the approach, the aircraft landed heavily at 2115 Central Standard Time[2] and sustained structural damage. The crew had received a weather briefing before their departure from Cairns. The Darwin area was forecast to have showers at the time of arrival, and thunderstorms shortly afterwards. The automatic terminal information service (ATIS)[3] at Darwin Airport stated that crews should expect a visual approach for runway 29.

The PIC recalled that the runway was in sight before the aircraft passed over the Howard Springs non-directional beacon (NDB), which was 9.3 NM (17 km) from the runway threshold (Figure 1). The crew of a preceding aircraft that was conducting visual circuits to runway 29, advised ATC that there was a rain shower on the approach and that the runway threshold was wet. That report was passed by ATC to the flight crew of NXE.

Flight data recorder (FDR) information indicated that at 2111:47, NXE flew over the Howard Springs NDB at 3,100 ft above mean sea level (AMSL), at a computed airspeed of 220 kts and with the aircraft's autopilot engaged (Appendix A). The aircraft was above the glideslope at that time and the autopilot did not capture the glideslope. The copilot reported attempting to descend the aircraft onto the glideslope using the autopilot's 'vertical speed' mode.

The FDR data showed that 10 seconds after overflying the Howard Springs NDB, the aircraft's rate of descent (ROD) increased to over 1,000 ft/min for a period of 13 seconds, of which 3 seconds were at the maximum recorded ROD of about 1,600 ft/min. The aircraft's speed varied between 209 kts and 211 kts during that time. The FDR data showed that from this point on during the approach until touchdown, the wind direction varied between 098° and 194° true (T) and that the wind speed varied between 4 and 12 kts. There was no indication of any significant turbulence during the approach.

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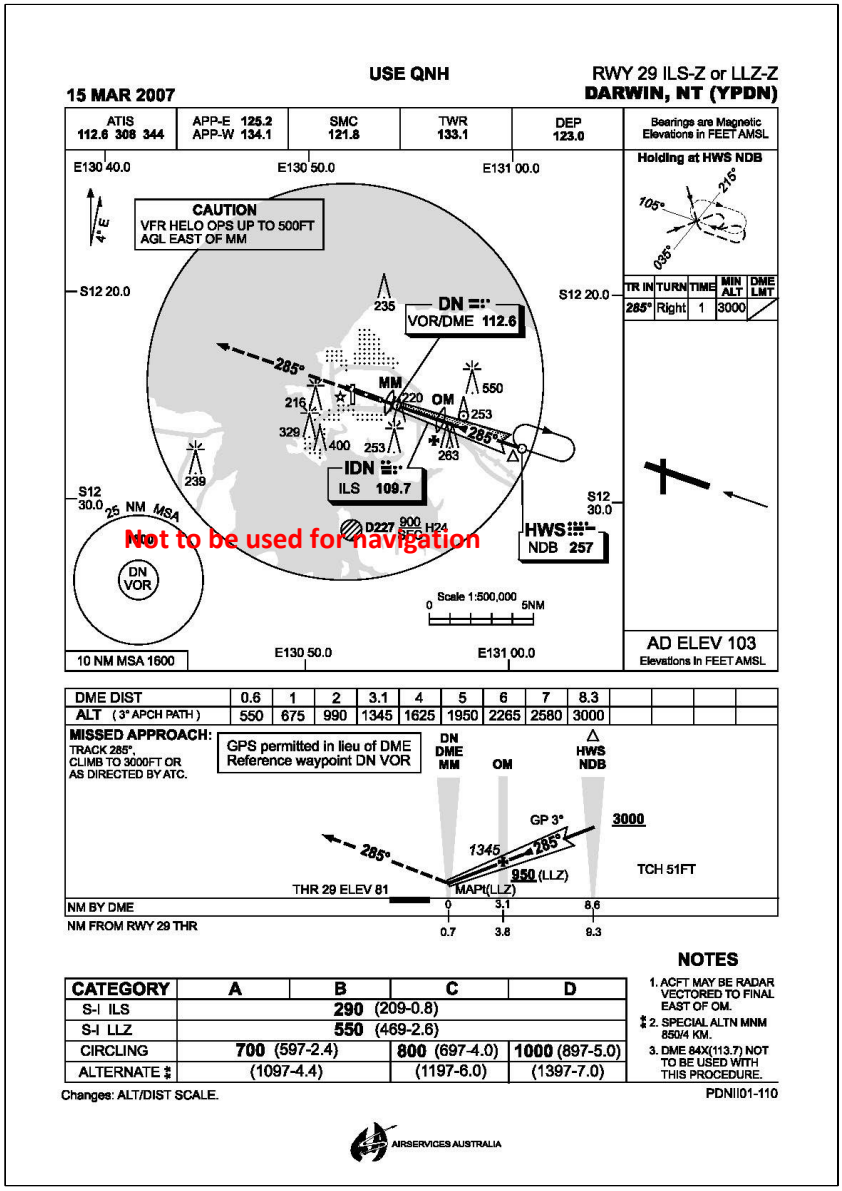
[1] A ground-based navigation aid that provided lateral (localiser) and vertical (glideslope) guidance to the runway.

[2] The 24-hour clock is used in this report to describe the local time of day, Central Standard Time (CST), as particular events occurred. Central Standard Time was Coordinated Universal Time (UTC) + 9.5 hours.

[3] A continuous, automated broadcast of routine, non-control aerodrome information that is used to improve controller effectiveness and relieve radio congestion.

Figure 1: Aeronautical Information Publication (AIP) Darwin Runway 29 ILS approach chart



At 2112:30, the aircraft was 6.7 NM (12 km) from the runway at a speed of 194 kts and about 350 ft above the glideslope at 2,544 ft when the ROD again increased to over 1,000 ft/min. The crew commenced extending the wing leading edge slats and trailing edge flaps at that time. At 2112:47, the crew selected the landing gear down and, 12 seconds later, the copilot disconnected the autopilot. At that time, the aircraft was at 1,893 ft, with a descent rate of 1,900 ft/min.

At 2113:20, the aircraft flew over the outer marker at 168 kts at 1,379 ft with a ROD of 707 ft/min. The aircraft was in the landing configuration with the landing gear down and the trailing edge flaps at 40°. Four seconds later, the aircraft's ROD increased to over 1,000 ft/min and, at 2113:31, the glideslope was captured at 1,159 ft. The aircraft continued descending at over 1,000 ft/min and, at 2113:34, was at 153 kts and 1,063 ft when it descended through the glideslope at a descent rate of 1,840 ft/min. The aircraft was then flown slightly below the glideslope.

During the remainder of the approach, the aircraft was close to being on the glideslope as the copilot flew the aircraft manually by reference to the ILS information displayed in the cockpit, and to external visual information from the runway lighting and the precision approach path indicator (PAPI)[4]. The aircraft's autothrottle[5] was engaged throughout the approach and landing, as recommended by the aircraft manufacturer.

The flight crew reported passing through a rain shower at about 700 ft and that, in response, the PIC switched on the windscreen wipers. They could see the runway lighting and the PAPI and continued the approach. At 580 ft, the aircraft was established on the approach at 136 kts with a ROD of 707 ft/min. The airspeed tolerance for the approach was for a speed of between 133 kts and 148 kts.

At 213 ft radio altitude[6], which was 15 seconds before touchdown, the aircraft's ROD increased and, at 167 ft radio altitude, was 1,168 ft/min. The PIC called 'sink rate' in accordance with the aircraft operator's standard operating procedures and the copilot increased the aircraft's nose-up pitch attitude, resulting in the descent rate reducing to below 1,000 ft/min at 136 ft radio altitude. The PIC reported that he allowed the approach to continue because the high ROD was considered to be momentary and the copilot had taken corrective action.

Four seconds before touchdown, at 82 ft radio altitude, the aircraft's ROD again increased and the copilot recalled hearing the synthesised altitude callouts from the aircraft's radio altimeter system. At 33 ft radio altitude, the FDR recorded a ROD of 952 ft/min, at the same time as an abrupt, nose-up command was applied to the control column, and the autothrottle retarded the engine thrust to IDLE.

At 2114:51, the aircraft landed heavily on the left main landing gear at 128 kts, with a recorded vertical force of 3.6 g[7] resulting in damage to the aircraft (Refer page 5 Aircraft damage) The touchdown was within 300 m of the runway threshold, to the left of the runway centreline, and with a ROD of 1,072 ft/min. The relevant FDR information, from a radio altitude of 180 ft until after touchdown, is provided in Appendix B.

The recorded information showed that, following touchdown, the ground spoilers[8] partially extended and then retracted (Appendix C). The spoiler retraction was due to the thrust levers being momentarily advanced beyond the position at which the

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4 A ground-based approach light system that assists pilots to maintain the glidepath during an approach.

5 An automated engine power control system that is electro-mechanically linked to an aircraft's flight control and automatic landing systems so that engine thrust is varied automatically to maintain the aircraft on glidepath, and reduced correctly for landing.

6 The radio altimeter system computed the aircraft's height above ground level (AGL) directly below the flight path from 2,500 ft and displayed the radio altitude in the cockpit. The radio altimeter system also provided data to generate a range of synthesised aural altitude callouts, including at 50, 40, 30, 20 and 10 ft.

7 *g*-force is the value of acceleration expressed in multiples of gravitational acceleration, where 1 *g* is the acceleration due to the Earth's gravity.

8 The ground spoilers were only available after landing, and acted to 'dump' lift and transfer the aircraft's weight to the landing gear, making the wheel braking more effective.

spoiler panels retract automatically. The flight crew did not subsequently extend the ground spoilers manually.

The FDR data also recorded a forward movement of the control column after the initial touchdown, with the transfer of some of the aircraft's weight onto the nosewheel. The aircraft's weight was not evenly distributed on all three landing gear until the aircraft's speed reduced to below about 93 kts.

The PIC took control of the aircraft during the landing roll and taxied the aircraft to the terminal, where the hard landing was reported to the operator's engineers. There were no reported injuries to passengers or crew.

Personnel information

Pilot in command

Licence type	Air Transport Pilot (Aeroplane) Licence (ATPL(A))
Total hours	8,466 hours
Total hours on type	1,947 hours

The pilot in command (PIC) was endorsed on the 717 in September 2005 and completed command upgrade training in July 2007.

Copilot

Licence type	ATPL(A)
Total hours	7,500 hours
Total hours on type	400 hours

The copilot was endorsed on the 717 in July 2007.

Crew training

During their endorsement training, which was conducted by a third party training provider, both the PIC and copilot were trained to the procedures, checklists and checklist announcements as prescribed in the aircraft manufacturer's Flight Crew Operating Manuals (FCOM). Once the pilots obtained their 717 endorsements, they underwent line training that was conducted by the aircraft operator to learn the procedures, checklists and announcements that were specific to the aircraft operator. The operator reported that, during the command upgrade flight simulator sessions, the PIC was trained to conduct and assess landings.

Fatigue

Both flight crew reported resting adequately during the 72 hours prior to the occurrence. There was no evidence that either pilot was affected by fatigue.

Aircraft information

Aircraft data

Aircraft model	Boeing 717-200
Serial number	55063
Date of manufacture	September 2000
Certificate of Registration	Valid, issued 20 June 2007
Certificate of Airworthiness	Valid, issued 25 July 2005
Total airframe hours and cycles	19,090.41 hours, 14,560 cycles

Aircraft damage

The damage to the aircraft included several creases to the fuselage skin above the wing area and to the underside of the fuselage behind the wing (Figures 2 and 3). Several longerons[9] in the rear cargo area were also damaged. The left main landing gear was removed and inspected in response to minor damage to the upper wing above the landing gear assembly. The outer left main landing gear tyre was also damaged.

The damage to the aircraft resulted in this occurrence being classified as an accident[10].

[9] Longitudinal structural components that give an airframe its shape and provide support for the skin.

[10] The *Transport Safety Investigation Act 2003* defined an accident as including an investigable matter where '...the [transport] vehicle is destroyed or seriously damaged as a result of an occurrence associated with the operation of the vehicle;...'.

Figure 2: **Rear of the aircraft showing the area of damage**

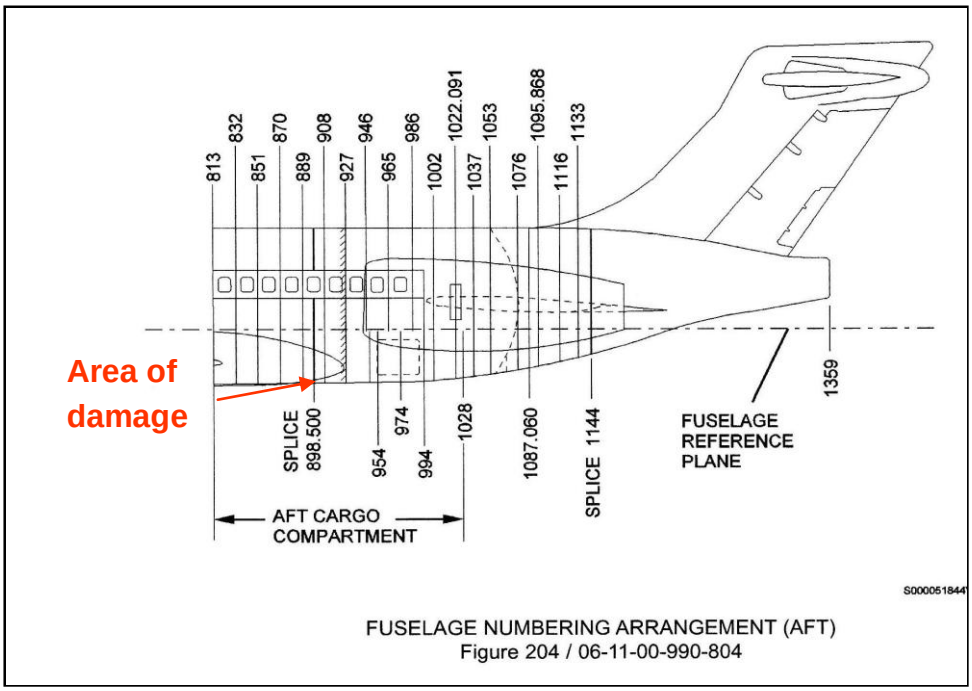
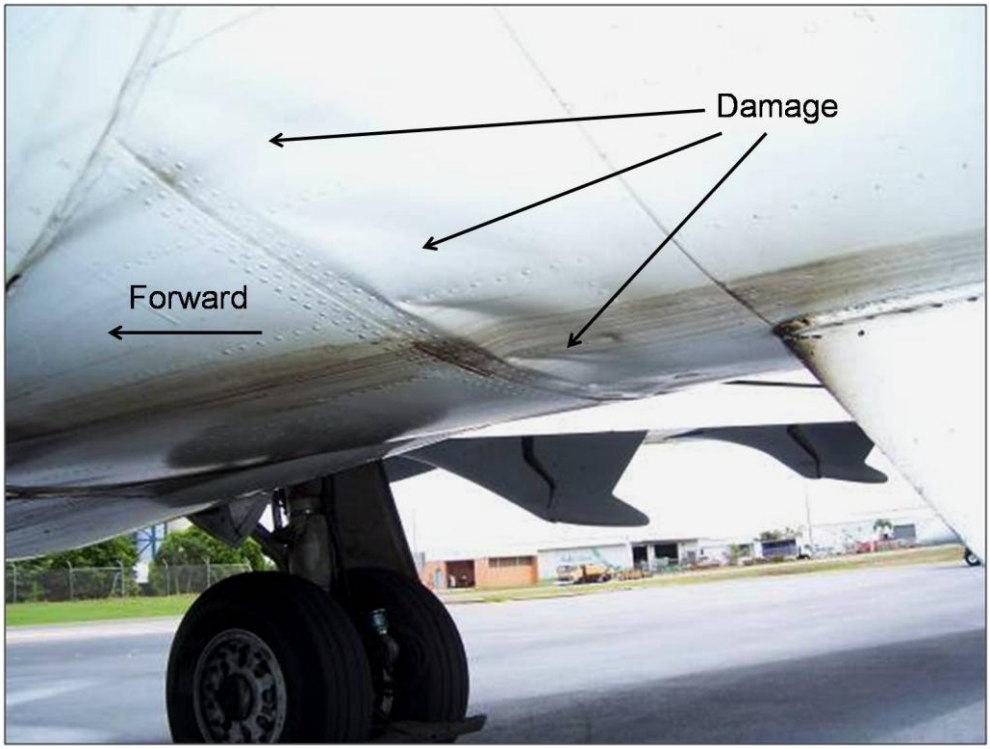


Figure 3: **Damage to the rear underside of the aircraft**



Flight recorders

The FDR, cockpit voice recorder (CVR) and quick access recorder (QAR) were sent to the Australian Transport Safety Bureau (ATSB) in Canberra for data downloading and analysis. The CVR data from the accident flight had been overwritten as more than two hours had elapsed by the time the aircraft underwent an engineering inspection and the operator was advised of the outcome of that inspection.[11]

Meteorological information

When the aircraft was about 17 km from the threshold of runway 29, ATC advised the crew that the cloud base was 1,000 ft AGL and that the visibility was reduced by rain. At about 4 km from the threshold, the crew was cleared to land by ATC, and advised that the crew of a preceding aircraft had reported that the runway 29 threshold was wet.

The flight crew reported that visual conditions existed throughout the approach until about 700 ft, when the aircraft entered a rain shower. Visual contact with the runway approach lighting was maintained by using the aircraft's wipers to clear the windshield. The PIC recalled that the aircraft was not in a rain shower during the flare and touchdown.

The Bureau of Meteorology (BoM) automatic weather station data for Darwin Airport indicated that the wind backed from 211° to 188° T during the period from immediately before, until after the landing. The wind strength varied by 2 kts from 9 kts to 11 kts during this period.

The FDR recorded a wind of 168° to 183° T at 9 kts to 11 kts between a radio altitude of 180 ft and touchdown.

Additional weather information is provided in Appendix D.

Aerodrome information

Aerodrome facilities

Darwin Airport was a joint user facility that was located at Royal Australian Air Force Base Darwin. The runway and other lighting facilities were owned by the Department of Defence, but maintained by a civil aerodrome operator. Flight operations were conducted by both civil and military aircraft.

Runway 29 at Darwin had a threshold elevation of 81 ft and was 60 m wide. That was significantly wider than most Australian runways that were used by the aircraft operator's 717 fleet, which were 45m wide.

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[11] The CVR retained the last 2 hours of information in solid-state memory, operating in an endless loop principle. Whenever electrical power was supplied to the recorder, previously recorded information was progressively overwritten.

The runway was equipped with a Category I ILS that had a 3° glideslope. A very high frequency omni-directional radio range (VOR) radio navigation aid and distance measuring equipment (DME) were co-located on the extended centreline of the runway.

Runway 29 was also equipped with high intensity approach lighting, high intensity runway edge lighting, and a PAPI. At the time of the occurrence, the PAPI approach and runway edge lighting systems were illuminated and all navigation aids were serviceable.

Runway 29 visual conditions

The potential for degraded visual information at night or in poor visibility increases the difficulty for a pilot to judge the landing flare, and poor timing and execution of the flare has been implicated in a significant proportion of landing accidents and incidents.[12] A number of the physical characteristics of runway 29, and the prevailing conditions at the time, had the potential to affect the pilots' perception during the flare, including:

- The runway was significantly wider than other Australian runways used by the operator's 717 fleet, resulting in the visual cues and runway perspective being different to those normally available to complete a landing.
- There were two distinct crests along the runway that obstructed portions of the runway, and altered the pilot's view of the runway during the final stages of the approach and the landing flare.
- A wet runway surface that reduced the surface definition and the conspicuity of the painted runway markings.

Runway 29 centreline lighting

Runway 29 was not equipped with centreline lighting, nor was this required for runways equipped with a Category I ILS. However, the Manual of Standards Part 139 – *Aerodromes*[13] that was issued by the Civil Aviation Safety Authority (CASA) contained the following recommendation*:*

> **Note:** Provision of runway centreline lights on a precision approach runway Category I where the width between the runway edge lights is greater than 50m is recommended.

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[12] Benbassat, D., & Abramson, C. (2002). Landing Flare Accident Reports and Pilot Perception Analysis. *The International Journal of Aviation Psychology, 12(2)*, 137-152.

[13] Section 9.10.24 *Runway Centreline Lights.*

The CASA recommendation was consistent with the International Civil Aviation Organization (ICAO)[14] publication International Standards and Recommended Practices, Annex 14 – Aerodromes, Volume 1 – *Aerodrome Design and Operations* that included the following recommendation:

> 5.3.12.2 **Recommendation.** – *Runway centre line lights should be provided on a precision approach runway category I, particularly when the runway is used by aircraft with high landing speeds or where the width between the runway edge lights is greater than 50m.*

The ATSB drew attention to the risks associated with the lack of centreline lighting on runway 29 at Darwin Airport in investigation report BO/200300418, *Runway excursion at Darwin International Airport*, Boeing Co 737-376, VH-TJB and the associated safety recommendation R20040090, which were released to the public on 4 March 2005 (available at www.atsb.gov.au).

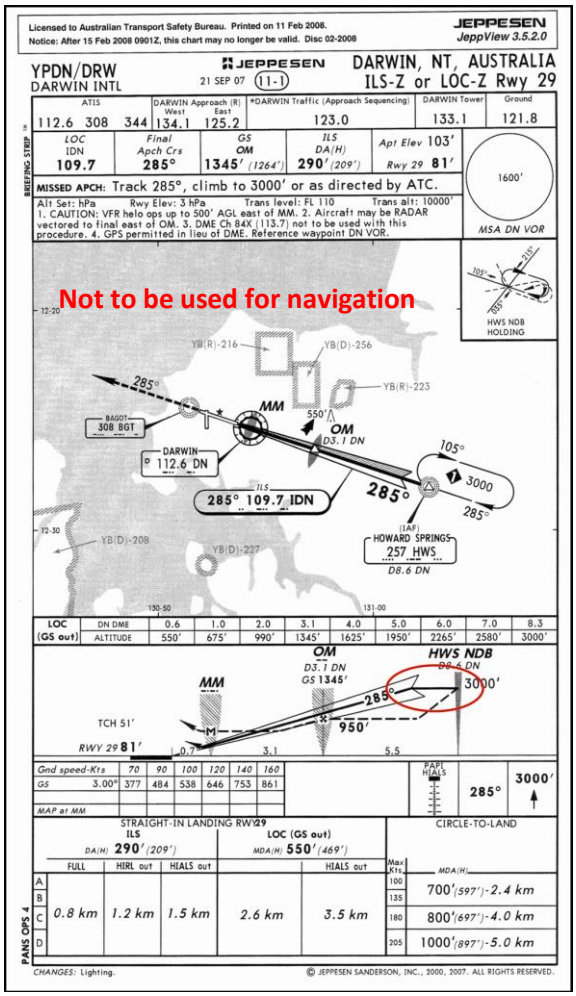
Darwin ILS-Z or LOC-Z Rwy 29 approach chart

During the approach, the flight crew was using the Jeppesen-Sanderson Inc. chart *Darwin ILS-Z or LOC-Z Rwy 29*. The profile diagram on that chart depicted a level segment after the Howard Springs NDB (Figure 4). That depiction was inconsistent with the Aeronautical Information Publication Australia (AIP) chart *ILS-Z or LOC-Z RWY 29 Darwin, NT (YPDN)* that was current at the time of the occurrence, which showed the descent commencing overhead the Howard Springs NDB.

The investigation determined that the depiction of the level segment on the Jepperson-Sanderson Inc. chart was incorrect.

[14] The International Civil Aviation Organization (ICAO) is a specialised agency of the United Nations, which was established by the Convention on International Civil Aviation (Chicago 1944), commonly referred to as the Chicago Convention. Australia is a signatory to the Chicago Convention. Under the Convention, ICAO can issue standards and recommended practices for aviation activities through Annexes to the Chicago Convention.

Figure 4: Jeppesen-Sanderson Darwin Runway 29 ILS approach chart dated 21 SEP 07 (level segment highlighted within red ellipse)



Quick Access Recorder data

Utility of Quick Access Recorder data

Quick Access Recorder (QAR)[15] data has been used for some time by major operators to identify fleet-wide trends in flight parameters and performance during normal operations. Aircraft operators set event limits for the parameters that they wish to monitor and, when a limit is exceeded, the relevant data is captured by the QAR. This data is then downloaded to a ground station for further analysis.

The utility of QAR data depends on the speed at which the information becomes available after downloading and analysis. QAR data is not intended to provide for

[15] Quick Access Recorders record flight data and are similar to Flight Data Recorders. They use a recording medium that is readily removable and designed to be read by equipment attached to a desktop computer.

the instantaneous monitoring of aircraft operations, and is normally evaluated days or weeks after it is recorded.

The evaluation of the operator's QAR data occurred as part of a routine Flight Operational Quality Assurance (FOQA)[16] program, in which regular reports were generated for review by the operator's flight operations and safety departments. Those reports were de-identified in terms of the location, the aircraft and flight crew details, and were used in accordance with an agreement between the operator and flight crews.

In addition, the operator's QAR equipment retained an aircraft's vertical acceleration data that was captured during landing, which could then be sent to a ground station through a digital datalink system.

Review of previously recorded QAR data

The aircraft operator had been using its fleet of 717s for 30 months before the occurrence. A review of the operator's 717 QAR data for that period revealed a number of occasions when the operator's vertical acceleration limits[17] for the 717 were exceeded during landing. However, those exceedances were below the aircraft manufacturer's hard landing threshold for the 717 of 2.1g.

After this occurrence, the operator became aware of two previous hard landings by the copilot during the preceding 15 days, with no aircraft damage recorded on either occasion. Both hard landings were evident in the QAR data, although this information had not been immediately available to the flight crew or the operator.

Organisational information

Regulatory framework - pilot training

Civil Aviation Regulation (CAR) 217 required operators of regular public transport aircraft with a maximum take-off weight exceeding 5,700 kg to have a training and checking organisation. The intent of that CAR was to ensure that operating crews were trained appropriately and that they maintained competency. In addition, Civil Aviation Order 82.5 (3) placed a number of obligations on an operator with regard to the provision of training for, and the checking of its crew. Appendix 2 of that order identified the responsibilities of the operator's training and checking organisation; in particular, the obligations with regard to the employment or contracting of persons to conduct the training and checking of crew.

At the time of the occurrence, there was no regulation or order that identified the responsibilities of third party training organisations.

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[16] A program that analysed QAR data to identify fleet-wide trends. This information could then be used to improve flight safety and to increase operational efficiency.

[17] A positive vertical acceleration was set by the aircraft operator at 1.8 g. US Federal Aviation Regulation (FAR) 25.473 identified a vertical acceleration limit for the 717 type of 10 ft/sec, or about 2.1 g, beyond which a hard landing inspection was required.

Training provided by a third party

At the time of the occurrence, when third party trainers provided endorsement[18] training to private individuals, an employee of the training provider who held a CASA delegation was responsible for ensuring that the minimum requirements of the endorsement were met. However, should a pilot who was endorsed on an aircraft as a private individual be subsequently employed by an Air Operator's Certificate (AOC) holder to operate that aircraft type, it was the responsibility of the AOC holder to ensure that the pilot met all the requirements for a flight crew member conducting regular public transport operations.

Proposed Civil Aviation Safety Regulation Part 142

The proposed Civil Aviation Safety Regulation (CASR) Part 142 - *Training and Checking Operators* is intended to formalise the responsibilities of third party training organisations. In instances where training would be provided to AOC holders, CASR Part 142 would define the responsibilities of the training provider, and their relationship with the AOC holder.

A Notice of Proposed Rule Making in respect of CASR Part 142 was issued by CASA on 22 July 2003; however, the regulation had not been enacted at the time of writing this report.

Aircraft operator's 717 endorsement training

Training documentation

At the time of the occurrence, pilots undergoing training on the 717 were provided with a copy of the aircraft operator's generic pilot training manual, which was intended for application across all of the company's aircraft types. The manual had not been updated to reflect the third party training organisation's role in endorsing company pilots.

In addition, pilots were provided with a copy of the aircraft manufacturer's 717 flight crew operating manuals (FCOM)[19]. The suite of 717 FCOMs was not operator specific, and was intended to provide a reference for operators when developing their company-specific standard operating procedures (SOPs) for the type. The aircraft manufacturer did not produce a 717 flight crew training manual.

Provision of endorsement training

The aircraft operator did not provide initial aircraft endorsement training to its pilots; instead, a third party training provider was contracted to endorse pilots who

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[18] An aircraft endorsement comprised classroom training across a broad range of technical information relating to that aircraft type, including its specifications, performance, limitations and operation. Aircraft handling and procedures were also learned in the simulator, in the aircraft itself, or in a combination of both. After completing the endorsement, a pilot underwent further training with an aircraft operator training captain during passenger operations.

[19] The aircraft manufacturer's operating manuals set out the manufacturer-recommended procedures for operating the 717.

were either employed, or were going to be employed on the 717. The contract between the operator and the third party training provider identified the training provider's responsibility for the issue of the endorsement, but did not specify the roles and responsibilities of both parties during that training.

The third party training provider's endorsement training included aircraft systems and simulator training. On completion of the training, a recommendation to issue the endorsement was made by a CASA-approved simulator instructor who was employed by the training provider. No assessments of the experience and ability of the candidates were given to the third party training provider by the operator before the commencement of their prospective employee's training.

Landing technique instruction

The third party training provider taught the 717 landing technique as part of the contracted endorsement training. During the final simulator session conducted by the training provider, the simulator instructor identified whether the pilot had met the required standard, and recommended to the training provider that the endorsement be issued.

The aircraft operator subsequently provided further landing technique training during a transition simulator exercise. That exercise was part of the 717 training program that was approved by CASA at the time the aircraft type was added to the operator's AOC. The simulator exercise was conducted by one of the operator's check pilots, with an instructor from the third party training provider in attendance. The exercise included the demonstration by the check pilot of the aircraft operator's 717 landing technique, before the trainee pilot practiced the technique. In addition, the simulator exercise introduced the pilot to the aircraft operator's procedures, checklists and announcements, prior to the commencement of line training.

Neither the operator nor the aircraft manufacturer provided pilots with detailed written instructions on the correct 717 landing technique. However, the manufacturer's FCOM stated that the nosewheel should be promptly lowered to the runway after touchdown.

Additional information

The 717 operation

Training oversight

The copilot reported having voiced concerns to a number of check captains in respect of difficulty experienced with landings in the 717. That included following a hard landing that occurred 3 days before this occurrence, and again before the occurrence at Darwin itself. The copilot did not otherwise pursue the matter with the operator's training organisation or senior management. The aircraft operator reported that the check captain who flew with the copilot during the initially reported hard landing, held the view that the copilot's concerns had been adequately resolved.

The aircraft operator had identified a number of issues in relation to the reporting by pilots of training difficulties to senior management, and with training on the 717 being overseen by the Manager Pilot Training and Checking, who was responsible for pilot training across all aircraft types. Although there was no dedicated 717 training manager, the operator reported that the Head of Pilot Training 717 was the technical captain for the 717 fleet. Together with the 717 check and training captains, the Head of Pilot Training 717 was available to flight crews to discuss any training issues.

Operational documentation

The aircraft operator's *Route Manual* provided flight crew with information about the airports to which they operated, especially those airports that had unusual characteristics or that required the application of special procedures. In the case of operations to Darwin Airport, that information included the potential for an aircraft to be too high overhead Howard Springs NDB, and the provision of a procedure to ensure glideslope capture.

Although the *Route Manual* did not include information about the hump on runway 11/29 and its greater-than-normal width, or the lack of centreline lighting, the flight crew of NXE were familiar with operations to Darwin Airport, and were current in those operations at the time of the occurrence. In addition, the operator's formal training for flight crews operating into Darwin for the first time included a flight with a captain who was current with Darwin operations.

Autothrottle and rate of descent at touchdown

The aircraft manufacturer recommended the use of autothrottle during all approaches, whether or not the autopilot was engaged. The autothrottle maintained the approach speed as set by the pilot and, at 30 ft radio altitude, was programmed to reduce engine thrust to idle for the landing.

The aircraft operator's SOPs did not require flight crew to manually override the autothrottle if the ROD was high immediately before touchdown, although it was reported that crews were taught that recovery action during their endorsement training.

Stabilised approaches

Stabilised approach advisory material

In August 2000, the Flight Safety Foundation (FSF)[20] released the *Approach-and-Landing Accident Reduction (ALAR) Briefing Notes* as part of an initiative to reduce approach and landing accidents. The *FSF ALAR Briefing Note*

[20] The Flight Safety Foundation is an independent, non-profit, international organisation engaged in research, auditing, education, advocacy and publishing to improve aviation safety. In 1996 the Foundation established the Approach-and-Landing Accident Reduction (ALAR) Task Force, which presented its final working group reports in 1998. The ALAR Briefing Notes were released in 2000 as part of the Task Force ALAR Tool Kit.

7.1 – Stabilized Approach[21] listed nine criteria that constituted a stable approach. In regard to the ROD during an approach, the approach was considered stable when:

> 6. Sink rate is no greater than 1,000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, a special briefing should be conducted

In respect of the requirement to discontinue an approach, the FSF briefing suggested that:

> An approach that becomes unstabilized below 1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.

In 2003, the US Federal Aviation Administration (FAA) released amended stabilised approach advisory material relating to stabilised approach criteria. FAA Advisory Circular AC 120-71A *Standard Operating Procedures for Flight Deck Crewmembers*, Appendix 2 *Stabilized Approach: Concepts and Terms*[22], listed six stabilised approach criteria and, in respect of the aircraft's ROD, stated:

> The rate of descent is no greater than 1000 feet per minute (fpm).
>
> - If an expected rate of descent greater than 1000 fpm is planned, a special approach briefing should be performed.
> - If an unexpected, sustained rate of descent greater than 1000 fpm is encountered during the approach, a missed approach should be performed. A second approach may be attempted after a special approach briefing, if conditions permit.

Aircraft operator's stabilised approach criteria

The aircraft operator required crews to stabilise a number of flight parameters during an approach to land to ensure that the aircraft was in a safe landing condition. In particular, the operator's SOPs defined a 'stabilised approach' as follows:

> 5.8.2 Definition
>
> Below 1000ft Above Aerodrome Level (AAL), the rate of descent is not to exceed 1000ft/min, except as noted below. The aircraft is to be stabilised in the landing configuration by 400ft AAL.
>
> An approach is considered to be Stabilised when all of the following criteria are met:
>
> •The aircraft is not greater than:
>
> •one dot high or low on the T VASIS or

---

[21] Available at: www.flightsafety.org/alar/alar_bn7-1stablizedappr.pdf

[22] Available at: www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/b173ba8a295764f086256cde006a44ad/$FILE/AC120-71A.pdf

•3 red (or 3 white lights on the PAPI, and/or)

•half scale deflection of the glideslope or localiser,

•The aircraft is established on the runway centreline with only small changes in heading or pitch required to maintain the approach path,

•The aircraft speed is not above VAPP +10 kts and not less than VAPP - 5 kt,

•The aircraft is in the landing configuration,

•Momentary excursions of slope and speed, caused by wind gusts or turbulence, are acceptable.

The aircraft operator's SOPs required crews to execute a missed approach[23] if the aircraft was not stabilised at or below 400 ft AAL.

[23] A missed approach is a manoeuvre where the aircraft discontinues an approach and is flown on a predetermined heading to a safe height, after which it holds, diverts to another aerodrome, or makes another approach to the runway.

ANALYSIS

Introduction

The investigation determined that the meteorological conditions were not a factor in the development of the occurrence, and that a number of contributory and other factors to the hard landing related to the management and conduct of the approach and landing by the flight crew. However, had a number of risk controls been in place at the time of the occurrence, the risk of a hard landing would have been reduced.

This analysis will examine the management and conduct of the approach and the application and utility of the available risk controls.

Approach and landing

Runway 29 approach

Despite the clearance for a visual approach, the flight crew's decision to follow the instrument landing system (ILS) to the runway reflected the operator's standard operating procedures (SOPs) and the flight crew's concern that thunderstorms were forecast shortly after their arrival.

The content of the aircraft operator's *Route Manual* should have alerted the flight crew to the risk of being above glidepath overhead the Howard Springs non-directional beacon, and optimised the possibility of glideslope capture. Furthermore, the flight crew's familiarity with operations into Darwin, and their awareness of the inaccuracy in the profile diagram of the in-use *Darwin ILS-Z or LOC-Z Rwy* 29 approach chart, suggested that it was unlikely the inaccuracy in that chart contributed to the aircraft being above the ILS glideslope at the commencement of the approach.

As a result of the aircraft being above the glidepath at Howard Springs, the autopilot did not capture the ILS glideslope. The subsequent action by the copilot to disconnect the autopilot and to fly the approach manually would have increased the copilot's workload for the remainder of the approach. The manual control inputs appear to have contributed to a number of instances of high rates of descent during the approach.

The capture of the glideslope at 1,159 ft above mean sea level (AMSL), instead of at 3,000 ft overhead Howard Springs, reduced the time available to stabilise the approach and to prepare the aircraft for landing. That was consistent with the marked amplitude of the control inputs at a time when only minor adjustments were desirable. The result was a number of noticeable changes to the aircraft's pitch attitude, and pronounced variations in the aircraft's rate of descent (ROD).

Events during and after the landing

The automatic power reduction by the autothrottle just before touchdown exacerbated the situation for the flight crew; increasing the risk of a hard landing. However, had the flight crew overridden the autothrottle and increased thrust in response to the high ROD as the aircraft passed through 30 ft radio altitude, the severity of the hard landing may have been reduced.

Instead, the large rearward movement of the control column at that time, although increasing the aircraft's pitch attitude and causing the aircraft to rotate about its centre of gravity (CG), did little to arrest the ROD because of the aircraft's inertia. The rotation of the aircraft about its CG meant that the main wheels moved down towards the runway at a higher rate than the aircraft's overall ROD. The combination of the high ROD and large nose-up pitch movement resulted in a high landing load on the left mainwheels, which were the first to contact the runway.

The momentary advancement of the thrust levers immediately after touchdown may have indicated an attempt to reduce the ROD but that action inadvertently cancelled the automatic deployment of the ground spoilers. Although called for by the operator's SOPs should the spoilers not deploy automatically, the action to manually extend the ground spoilers was overlooked by the flight crew. The effect was to delay the transition from flight to the landing roll because, without the ground spoilers deployed, the wings continued to generate lift.

The forward movement of the control column after touchdown may have been a result of the high loads experienced during the hard landing. While the aircraft manufacturer's procedures required the pilot to promptly lower the nosewheel to the runway after landing, in this instance, the forward movement of the control column resulted in the aircraft's nosewheel bearing some of the aircraft's weight before the right mainwheels were in contact with the runway.

Stabilised approach criteria

The safety benefits of the application by operators of 'stabilised approach criteria' are well known and generally reflect the Flight Safety Foundation (FSF) publication *Approach-and-Landing Accident Reduction (ALAR) Briefing Note 7.1 – Stabilized Approach* and Appendix 2 to the US Federal Aviation Administration (FAA) Advisory Circular AC 120-71A *Standard Operating Procedures for Flight Deck Crewmembers.*

The FSF and FAA guidance material provides clearly defined parameters that, when incorporated into operators' SOPs, enable flight crews to differentiate between normal adjustments to an approach and those made in an attempt to recover an approach that should be discontinued because of increased risk. The parameters provide crews with defined limits to enable them to make an appropriate assessment of the risk associated with the continuation of an unstabilised approach, rather than relying on their personal tolerance of deviations from the normal approach path and aircraft performance.

Having stabilised approach criteria that allowed 'momentary excursions of slope and speed' to be tolerated by the operator's flight crews when the aircraft was below 400 ft above aerodrome level (AAL), removed a number of the stabilised approach risk

controls inherent in the FSF and FAA guidance material. In particular, it leaves flight crews to make individual and time-critical judgements about what is acceptable, rather than relying primarily on pre-defined limits. Although the pilot in command's (PIC) assessment that the increased ROD as the aircraft passed through 167 ft radio altitude was momentary, the decision to continue the approach did not take account of the variations in the ROD earlier in the approach. A more appropriate decision by the PIC would have been to initiate a missed approach; in particular, once the aircraft was below the operator's minimum stabilisation height of 400 ft AAL.

Pilot training

Reporting of flight crew training issues

Individual flight crew training issues were generally identified and dealt with at 717 operational bases, and not shared more broadly among all of the aircraft operator's 717 operations. This reduced the likelihood that potentially fleet-wide issues would be communicated to all of the operator's 717 flight crews.

The lack of any record of landing incidents involving the copilot prior to this occurrence meant that there was no trigger for the aircraft operator to review the relevant quick access recorder landing data. Together with the base-specific approach to the reporting of training difficulties, that resulted in the operator's senior flight operations management being unaware of the copilot's previous landing difficulties in the 717.

Training procedures and documentation

Operators need to be able to assure themselves that the training being provided to newly-appointed pilots, whether by their own or third party resources, takes account of the diverse backgrounds, experience levels and capabilities of those pilots. That information was not supplied to the third party training provider, who conducted a generic endorsement training program. Such an approach did not ensure that trainees who were less experienced in jet transport operations received any additional training to achieve the required standards.

The provision of a dedicated 717 training manual would have provided for the standardisation of instructional technique by the third party training provider, and during the operator's transition simulator exercise. The provision to pilots of the aircraft manufacturer's 717 Flight Crew Operating Manual, and an operator-specific training manual, would form the basis of an ongoing reference document for pilots during and after their training.

Training by third parties

The use by the operator of a third party training provider was reflective of the current commercial aviation environment, in which it is common practice for prospective airline employees to pay for some or all of their aircraft endorsement training before gaining employment with an aircraft operator. That arrangement did

not, however, absolve an operator of their responsibility to ensure that pilots are appropriately trained for their particular operation.

The 717 endorsement training that was conducted by the third party training provider was generic in nature and operator-specific techniques and procedures were taught separately. The risk with such a separation of training into 'endorsement' and 'post-endorsement' training, in which each is provided by different organisations, is that techniques or procedures may either be overlooked or taught differently, requiring trainees to modify previously-learned techniques. There is also the risk of pilots reverting to previously-learned techniques during critical or high workload situations.

To optimise the training process, an operator and a third party training provider should have complementary roles and responsibilities, which are clearly documented, implemented and monitored.

Proposed Civil Aviation Safety Regulation Part 142

Although a Notice of Proposed Rule Making (NPRM) in respect of Civil Aviation Safety Regulation (CASR) Part 142 *Training and Checking Operators* was issued on 22 July 2003, it had not been enacted at the time of writing this report. In that case, the regulatory framework does not reflect the roles and responsibilities of third party training organisations when providing training on behalf of aircraft operators. The effect is that the provision to operators of contracted third party training has not been subject to direct regulation.

Until the regulatory framework is updated to reflect the provision of third party training, the oversight responsibility for training by third party training organisations remains with the relevant Air Operator's Certificate holder. As aircraft operators increase their use of third party training providers, it is increasingly important that CASR Part 142 be introduced as a priority.

Operations at Darwin Airport

Aircraft operator's Route Manual

The aircraft operator's *Route Manual* did not include some of the adverse factors associated with operations to Darwin; in particular, the hump on runway 11/29 and its greater-than-normal width, and the lack of centreline lighting. Each of those factors has been previously linked to the possibility of visual illusions during approach.

The presence of visual illusions is a known factor in the development of unstable approaches. It could be expected that the inclusion in the *Route Manual* of a discussion of the factors at Darwin with the potential to cause visual illusions during operations to runway 11/29, would assist crews to anticipate the effects of those illusions, and reduce the risk of an unstable approach as a result.

Runway visual conditions and absence of centreline lighting

The landing flare is a crucial and technically demanding flying skill. Degraded visual information during a night landing has the potential to affect the crew's perception while executing the flare.

Degraded visual cues during a night landing on runway 29 at Darwin Airport have been identified as a factor in a previous ATSB safety investigation report. As found in that investigation, the lack of centreline lighting on a runway that is wider than normal reduces the available visual cues in the latter stages of the approach and landing. That investigation determined that the presence of centreline lighting would have increased significantly the nature of the visual cues available and would have assisted the pilot to recognise a developing sideslip and lateral deviation from the runway centreline.

The hard landing of NXE did not involve a significant lateral deviation from the runway centreline and the investigation concluded that the absence of centreline lighting did not directly contribute to the hard landing. However, the degraded visual information during the landing may have increased the difficulty of judging the aircraft's rate of closure with the runway and the required flare height. Combined with the higher ROD at that time, any difficulty experienced by the copilot with the required judgement, may explain the abrupt control column input shortly before touchdown.

FINDINGS

From the evidence available, the following findings are made with respect to the hard landing involving Boeing Aircraft Company 717, registered VH-NXE, on 7 February 2008 at Darwin Airport, Northern Territory and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The aircraft was above the glideslope at the Howard Springs non-directional beacon and throughout the majority of the approach, resulting in high rates of descent on several occasions as attempts were made to capture the glideslope.

- The copilot disconnected the autopilot at a time of high workload.

- The aircraft's rate of descent below 400 ft above aerodrome level exceeded the operator's stabilised approach criteria; however, because the pilot in command considered the exceedance to be momentary, a missed approach was not conducted.

- The allowance of momentary excursions in the aircraft operator's stabilised approach criteria that were caused by wind gusts or turbulence increased risk by permitting flight crew discretion to continue approaches at or beyond those criteria. *[Minor safety issue]*

- The operator's procedure for the use of the autothrottle in response to high rates of descent when below 30 ft during landing was not included in the operator's standard operating procedures. *[Minor safety issue]*

- At about 30 ft, the copilot made an abrupt rearward movement of the control column resulting in the main landing gear moving faster downwards than the aircraft's overall rate of descent.

Other safety factors

- The operator's process for reporting 717 pilot training issues to senior managers was not utilised by all flight crew, reducing the potential for the communication of fleet-wide issues to all 717 crews. *[Minor safety issue]*

- There was no clear division of responsibilities between the aircraft operator and the third party training provider in regard to ensuring the standards of flight training met all of the operator's requirements, which had the potential to reduce training effectiveness. *[Minor safety issue]*

- There was no provision in the current Civil Aviation Safety Authority regulations or orders regarding third party flight crew training providers, with the effect that the responsibility for training outcomes was unclear. *[Minor safety issue]*

- There was no aircraft operator's or manufacturer's 717 pilot training manual that provided for the standardisation of instructional technique and provided a reference document for pilots during and following training. *[Minor safety issue]*

- The control column moved forward after touchdown, resulting in excessive weight transfer to the nosewheel before the right mainwheel was correctly loaded.

- After touchdown, the thrust levers were advanced, inadvertently cancelling the deployment of the ground spoilers and resulting in unstable conditions while transitioning from flight to the ground.

- The aircraft operator's *Route Manual* did not include all relevant information on the potential for visual illusions during a night approach to runway 29 at Darwin Airport that would have improved the awareness of flight crews. *[Minor safety issue]*

- The Jeppesen-Sanderson Inc. approach chart titled *Darwin, NT Australia ILS-Z or LOC-Z Rwy 29* dated 21 SEP 07 incorrectly depicted a level flight segment after the Howard Springs non-directional beacon that could have been misinterpreted by flight crews. *[Minor safety issue]*

- The lack of runway centreline lighting reduced the available visual cues during the latter stages of the approach and landing to runway 29 at Darwin Airport.

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Aircraft operator

Stabilised approach criteria

Safety issue

The allowance of momentary excursions in the aircraft operator's stabilised approach criteria that were caused by wind gusts or turbulence increased risk by permitting flight crew discretion to continue approaches at or beyond those criteria.

Action taken by the aircraft operator

The aircraft operator has advised the ATSB of the amendment of the stabilised approach criteria to remove the reference to 'momentary' exceedances.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the aircraft operator adequately addresses the safety issue.

Use of autothrottle

Safety issue

The operator's procedure for the use of the autothrottle in response to high rates of descent when below 30 ft during landing was not included in the operator's standard operating procedures.

Action taken by the aircraft operator

The aircraft operator has advised the ATSB that:

> The Head of Training and Checking will ensure all flight crew are aware, if the airspeed is lagging, or a sink rate develops just prior to the flare, delaying the thrust reduction or even increasing thrust, may be necessary during the autothrottle retard mode. This technique will be included in the training provided by Training Captains. The technique will also be further emphasised to crew during recurrent simulator and line checks.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the aircraft operator adequately addresses the safety issue.

Reporting flight crew training issues

Safety issue

The operator's process for reporting 717 pilot training issues to senior managers was not utilised by all flight crew, reducing the potential for the communication of fleet-wide issues to all 717 crews.

Action taken by the aircraft operator

The aircraft operator has advised the ATSB that:

> The position of Head of Pilot Training 717 has been filled with an experienced 717 check-and-training captain.
>
> The operator's Flight Operations department has appointed a check-and-training captain to the position of Head of Pilot Training – B717. All 717 flight crew are able to report inconsistencies in flight standards by individual crew members in a non-jeopardy manner to the Head of Pilot Training – B717. He will address such inconsistencies and determine any extra training considered necessary.
>
> The operator's Flight Operations department will reiterate their 'just culture' policy to all flight crew.
>
> The company CAR 217 organisation will increase the frequency of check-and-training meetings and hold them quarterly. Flight standards and operational standardisation will be discussed.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the aircraft operator adequately addresses the safety issue.

Training oversight

Safety issue

There was no clear division of responsibilities between the aircraft operator and the third party training provider in regard to ensuring the standards of flight training met all of the operator's requirements, which had the potential of reducing training effectiveness.

Action taken by the aircraft operator

The aircraft operator has advised the ATSB that:

> The operator's training organisation is to review the 717 training provided by their third party training provider. The review will ensure the syllabus matches the operator's requirements and that it is flexible enough to ensure that less experienced trainees, who may need more time under training, receive the extra training they need to meet the required standard.
>
> A detailed briefing and PowerPoint™ presentation dealing with 717 landing technique will be provided to all company flight crew, including trainee pilots undergoing conversion training to the 717.
>
> The visual circuit practice simulator session, currently conducted after completion of the initial 717 training simulator sessions, will be made more flexible on a level-of-performance basis so that trainee pilots are given tailored training to meet their individual requirements.
>
> Following the simulator training, an initial demonstration and instruction of the correct landing technique will be conducted by a Check Captain, followed by an assessment of the trainee's landing technique.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the aircraft operator adequately addresses the safety issue.

717 pilot training manual

Safety issue

There was no aircraft operator's or manufacturer's 717 pilot training manual that provided for the standardisation of instructional technique and provided a reference document for pilots during and following training.

Action taken by the aircraft operator

The aircraft operator has advised the ATSB of the production of a manual titled *B717P – Aircraft Operating Procedures Manual* as a reference document for pilots and, in consultation with the aircraft manufacturer, are compiling a separate *Boeing 717 Training Manual*.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the aircraft operator adequately addresses the safety issue.

Aircraft operator's route manual

Safety issue

The aircraft operator's *Route Manual* did not include all relevant information on the potential for visual illusions during a night approach to runway 29 at Darwin Airport that would have improved the awareness of flight crews.

Action taken by the aircraft operator

The aircraft operator has advised the ATSB that:

> The company's *Route Manual* - Domestic Operations has been expanded to provide more information on runway approaches at all aerodromes used by company aircraft.
>
> The operator's Flight Operations department will consider providing audio-visual presentations for all company aerodromes. This will meet CAR 218 Route Qualification Requirements and enable flight crew to familiarise themselves with aerodromes into which they have not flown previously.

ATSB assessment of response/action

The ATSB is satisfied that the action taken by the aircraft operator adequately addresses the safety issue.

Other safety actions taken by the aircraft operator

Spoiler deployment

Although no safety issue was identified in respect of the deployment of the aircraft's spoilers, the operator has advised of the following proactive safety action in response to this occurrence:

> The issue of spoiler deployment/stowing on landing is discussed during line training and during recurrent simulator training. It is also a part of the "auto throttle off" training.
>
> Issue 2 of OM 717P has this as a note:
>
> *For automatic deployment of spoilers, throttles must be at idle. If throttles are above idle at touchdown, spoilers may deploy and retract. If SPOILER lever does not move aft or does not remain at EXT position, the Captain is to lift and pull the spoiler lever aft to the full extend position.*

Maintenance response to hard landings

Although no safety issue was identified in respect of the operator's response to hard landings, the aircraft operator advised the ATSB of the operation of a comprehensive 717 Flight Operations Quality Assurance Program, with the Group Safety Department advising Flight Operations of any adverse trends observed. As a result of this occurrence, the operator has identified a need to more promptly obtain hard landing information. That will allow the operator to determine whether hard landing checks are required or not.

In addition, the manufacturer of the Flight Data Acquisition and Management System has modified their software so that hard landings trigger a hard landing report that is transmitted by the Aircraft Communication Addressing and Reporting System to the data collection organisation. This will allow the operator's engineers to conduct any required action during the daily terminating checks.

Lack of surface definition in the touchdown zone

Although no safety issue was specifically identified in respect of the lack of surface definition in the touchdown zone, the aircraft operator has advised the ATSB of the proactive review of their standard operating procedures to improve the way pilots transition to the touchdown aiming point from either visual slope guidance, or from the instrument landing system glideslope; in particular, when there is a lack of surface definition in the touchdown zone.

The operator has also mandated the use of autopilot-coupled approaches to runway 29 at Darwin Airport at night.

Runway 29 lack of centreline lighting

Although not an organisation having responsibility for the aerodrome lighting at Darwin Airport, the aircraft operator advised the ATSB that, as a result of this occurrence, they intend to approach the airport operator to discuss the installation of centreline lighting on runway 29 at Darwin Airport.

Civil Aviation Safety Authority

Training oversight

Safety issue

There was no clear division of responsibilities between the aircraft operator and the third party training provider in regard to ensuring the standards of flight training met all of the operator's requirements, which had the potential to reduce training effectiveness.

Action taken by the Civil Aviation Safety Authority

The Civil Aviation Safety Authority (CASA) has advised the ATSB that, as a result of this occurrence:

> CASA will review, with operators, their oversight responsibilities in this area. The air operator is responsible for all activities conducted under its Air Operators Certificate, including contracted training.

ATSB assessment of response/action

The ATSB is satisfied that the action proposed by CASA adequately addresses the safety issue.

Proposed Civil Aviation Safety Regulation Part 142

Safety issue

There was no provision in the current Civil Aviation Safety Authority regulations or orders for third party flight crew training providers, with the effect that the responsibility for training outcomes was unclear.

Action taken by CASA

CASA has advised the ATSB that the proposed Civil Aviation Safety Regulation (CASR) Part 142 is under review as a matter of priority and has been progressed to the Office of Legislative Drafting and Publishing.

In addition, in July 2009, CASA issued a Civil Aviation Advisory Publication (CAAP)[24] that provided guidance to the aviation industry in regard to competency based training.

ATSB assessment of response/action

The ATSB is satisfied that the action proposed by CASA adequately addresses the safety issue.

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[24] CASA CAAP 5.59A-1 is available at http://www.casa.gov.au/wcmswr/_assets/main/download/caaps/ops/5_59a_1.pdf

Jeppesen Sanderson Inc.

Darwin runway 29 ILS chart

Safety issue

The Jeppesen Sanderson Inc. approach chart titled *Darwin, NT Australia ILS-Z or LOC-Z Rwy 29* dated *21 SEP 07* incorrectly depicted a level flight segment after the Howard Springs non-directional beacon that could have been misinterpreted by flight crews.

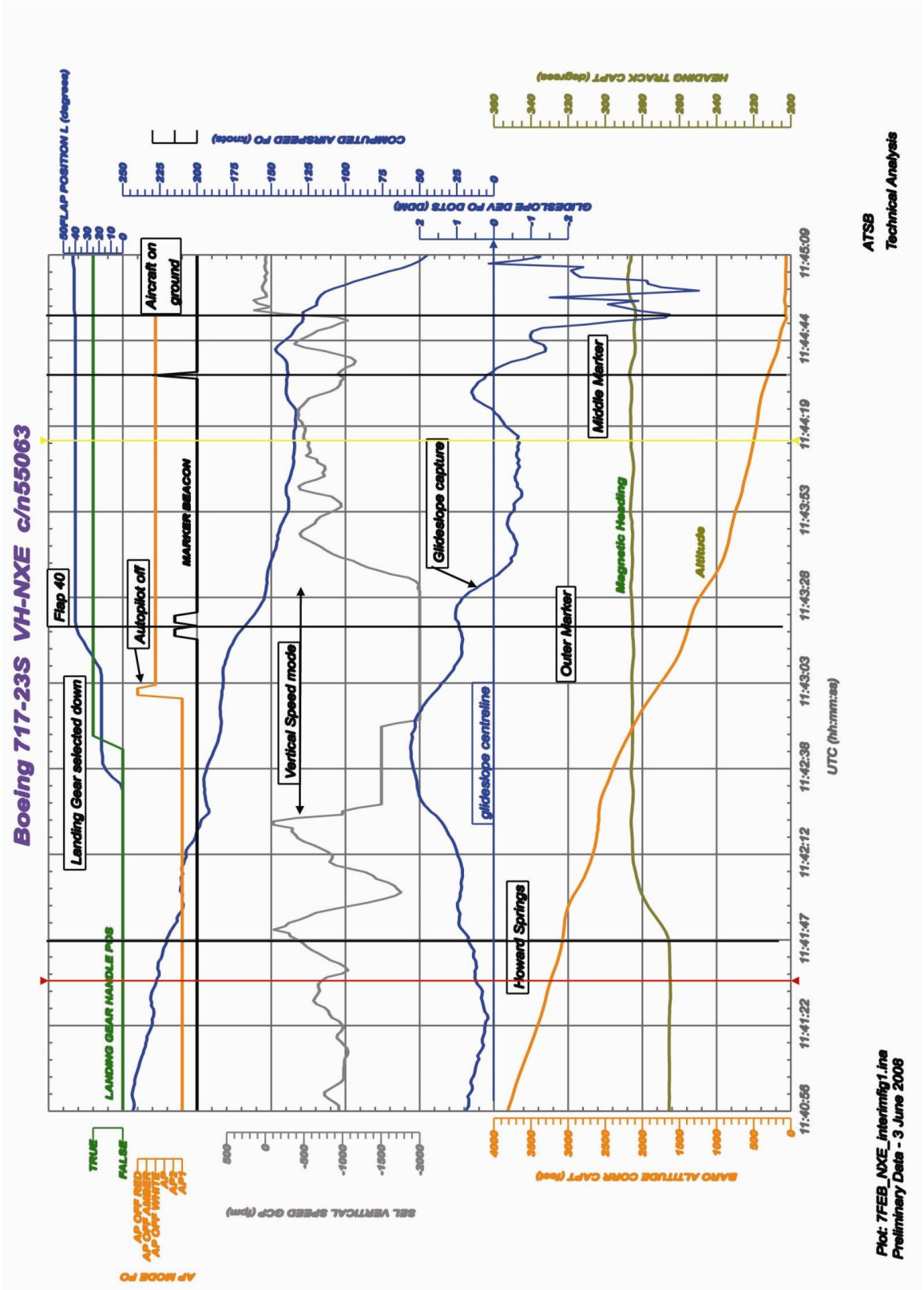
Action taken by Jeppesen-Sanderson Inc.

On 27 June 2008, Jeppesen-Sanderson Inc. issued an updated *Darwin, NT Australia ILS-Z or LOC-Z Rwy 29* chart, which correctly showed the descent commencing overhead the Howard Springs non-directional beacon.

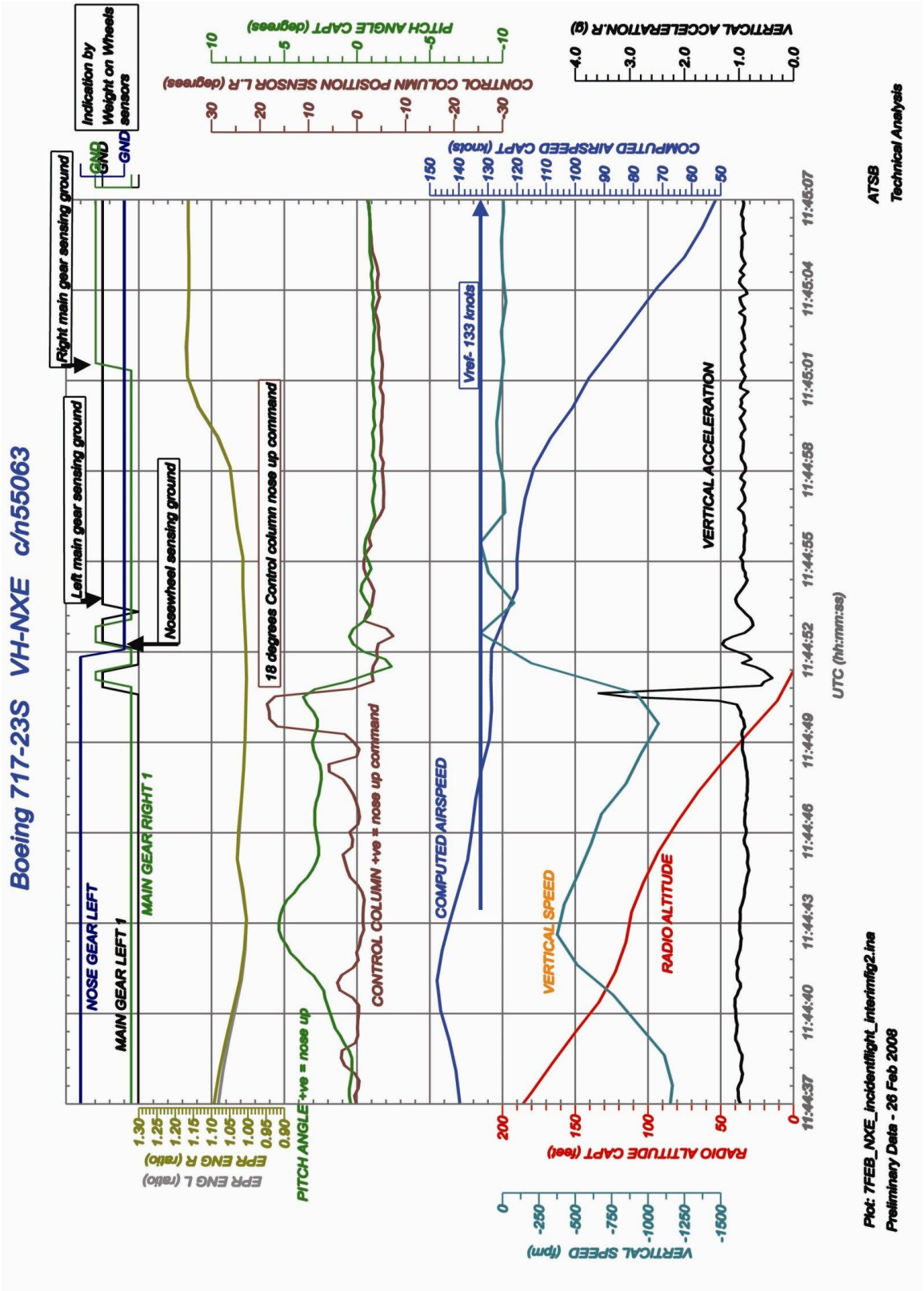
ATSB assessment of response/action

The ATSB is satisfied that the action taken by Jeppesen Sanderson Inc. adequately addresses the safety issue.

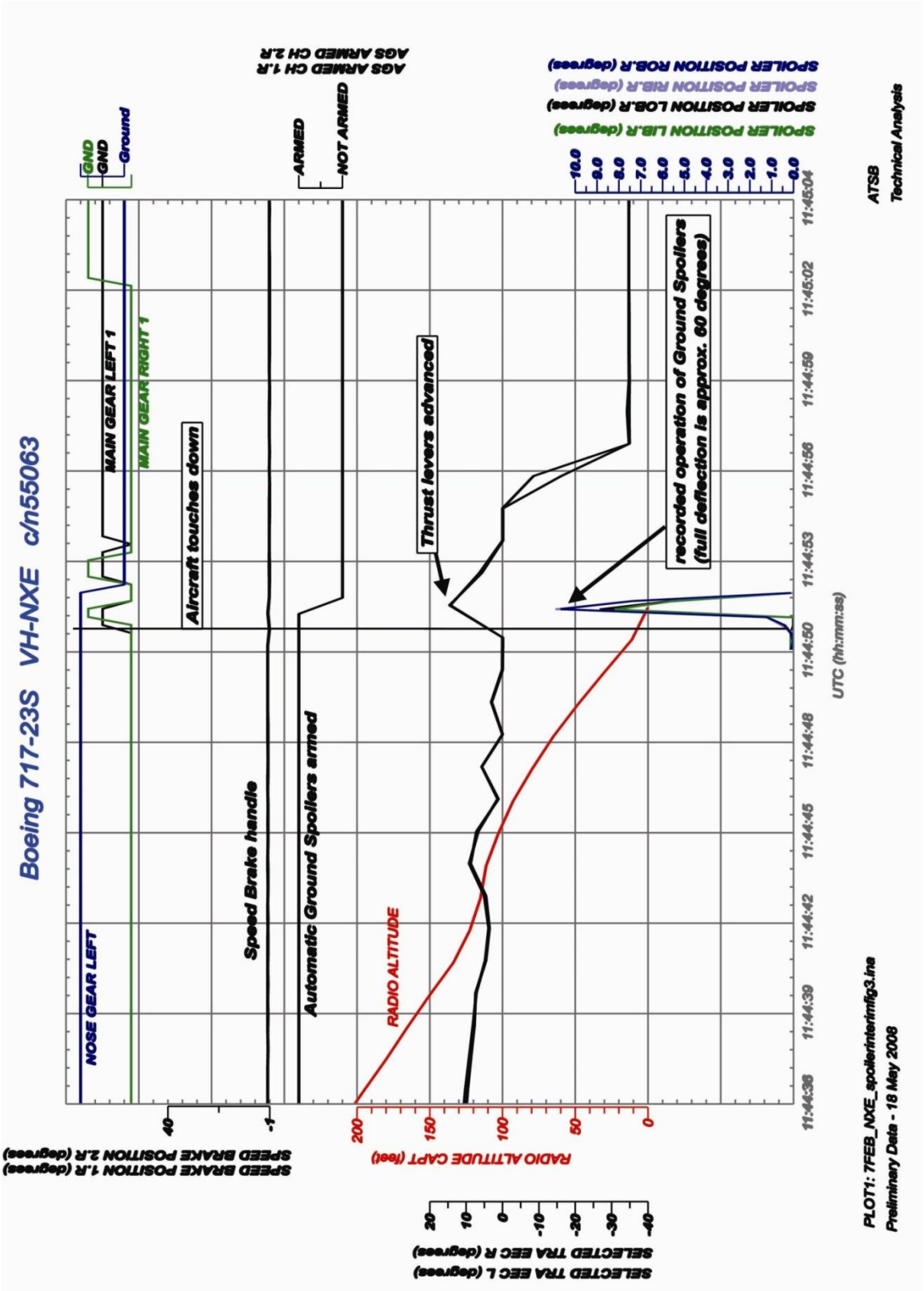
APPENDIX A: FLIGHT RECORDER DATA – APPROACH



APPENDIX B: FLIGHT RECORDER DATA – SHORT FINAL



APPENDIX C: FLIGHT RECORDER DATA – SPOILERS



APPENDIX D: WEATHER AT DARWIN

Darwin Airport forecasts

The Bureau of Meteorology (BoM) issued an amended aerodrome forecast (TAF) for Darwin Airport at 1801 Central Standard Time on 7 February 2008. Light showers in a prevailing westerly flow of 12 kts with 1 to 3 okras[25] of cloud at 1,500 ft above the aerodrome were forecast.

The Darwin TAF was further amended at 2057 to indicate the probability of thunderstorms from 2130, with visibility reducing to 1,000 m and wind gusting to 35 kts from the north east.

The trend type forecast (TTF) for Darwin Airport issued at 2102 indicated that, at the aircraft's estimated time of arrival, that the wind would be 210° true at 7 kts, the visibility would be greater than 10 km, with 3 to 4 okras of cloud at 1,600 ft. The TTF also forecast thunderstorms from 2130.

A special aerodrome weather report (SPECI) issued at 2115 reported a heavy shower at Darwin Airport, visibility reduced to 5,000 m, and wind from the south-south-west at 7 kts. A SPECI at 2119 reported visibility further reduced to 1,000 m in a heavy shower and wind from the south west at 7 kts. A SPECI at 2124 reported a thunderstorm at the airport, with visibility of 1,000 m.

Actual weather at Darwin Airport

The BoM automatic weather station data for Darwin Airport provided weather information every 60 seconds. Wind direction and speed immediately before and after the landing are shown in Table 1.

Table 1: Tabular wind data

Time	Wind direction (degrees true)	Wind speed (knots)	Comment
21:12	211	7	
21:13	216	8	
21:14	216	9	
21:15	213	8	Time of landing
21:16	191	8	
21:17	184	7	
21:18	188	8	

[25] Cloud amounts are reported in oktas. An okta is a unit of sky area equal to one-eighth of total sky visible to the celestial horizon. Few = 1 to 2 oktas, scattered = 3 to 4 oktas, broken = 5 to 7 oktas and overcast = 8 oktas.

APPENDIX E: SOURCES AND SUBMISSIONS

Sources of information

The sources of information during the investigation included:

- the flight crew of VH-NXE
- the aircraft operator
- the training provider
- the aircraft manufacturer
- the Civil Aviation Safety Authority (CASA)
- Jeppesen-Sanderson Inc.
- the Bureau of Meteorology.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following:

- the flight crew of VH-NXE
- the aircraft operator
- the training provider
- the aircraft manufacturer
- CASA
- the Department of Defence
- the operator of Darwin Airport.

Submissions were received from; the flight crew, the aircraft operator, the training provider, CASA and the operator of Darwin Airport.

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Hard landing, Darwin Airport, Northern Territory, 7 February 2008
VH-NXE, Boeing Company 717 – 200.