Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT

Aviation Occurrence Investigation –AO-2007-055

Final

Procedures-related event
Melbourne Airport, Vic.
4 November 2007
HS-TJW
Boeing Company 777-2D7

Australian Government

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CONTENTS

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Figure 1. Courtesy of Lido

Figure 3. Courtesy of the Boeing Company

Abstract

On 4 November 2007, a Boeing Company 777-2D7 (777) aircraft, registered HS-TJW, was being operated on a scheduled passenger service from Bangkok, Thailand to Melbourne, Vic. with 17 crew and 277 passengers on board. During the conduct of a non-directional beacon (NDB) non-precision approach to runway 16 at Melbourne, the crew descended the aircraft below a segment minimum safe altitude. Soon after, the crew received two enhanced ground proximity warning system cautions. At that time, the crew became visual with the ground below and the Melbourne aerodrome controller observed the aircraft ‘unusually low for an aircraft’. The crew levelled the aircraft and made a visual approach and landed, on runway 16.

The investigation found that the aircraft had descended below a critical altitude whilst carrying out an NDB approach and that the crew did not monitor the aircraft’s progress correctly during the NDB approach.

The aircraft operator had known about the difficulties in flying approaches without constant angle approach paths and was in the process of training flight crews on procedures specific to NDB approaches when the incident occurred. In October 2007, the operator introduced a training program to instruct pilots on a new method to conduct those approaches. At the time of the incident, the pilots of the 777 had not undergone that training.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal bureau within the Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. ATSB investigations are independent of regulatory, operator or other external organisations.

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 enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, 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 proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

FACTUAL INFORMATION

Sequence of events

On 4 November 2007, a Boeing Company 777-2D7 (777) aircraft, registered HS-TJW, was being operated on a scheduled passenger service from Bangkok, Thailand to Melbourne, Vic. with 17 crew and 277 passengers on board. At 1309 Eastern Daylight-saving Time[1], during a non-directional beacon (NDB) non precision approach[2] to runway 16 at Melbourne, the aircraft descended below a segment minimum safe altitude. Soon after, the crew received two enhanced ground proximity warning system (EGPWS)[3] cautions. At that time, the crew became visual with the ground below and the air traffic control (ATC) aerodrome controller (ADC) observed the aircraft 'unusually low for an aircraft'. The crew levelled the aircraft and made a visual approach to land on runway 16.

The flight crew consisted of the pilot in command (PIC), a copilot and a relief pilot. The copilot was the pilot flying (PF) for the descent, approach and landing at Melbourne. The PIC was the pilot monitoring (PM).The relief pilot was not occupying a control seat, and was in the observer seat behind the PIC and the copilot. The crew had received a notice to airmen (NOTAM) prior to departure from Bangkok stating that the instrument landing system (ILS)[4] for runway 16 at Melbourne was not available.

The copilot reported that, about 10 minutes prior to top of descent, he conducted an approach briefing, which included a briefing for the NDB approach to runway 16. The pilots used instrument approach charts produced by Lido[5] (Figure 1), which they had displayed on their respective control columns for reference during the approach. The crew also reported that the approach briefing stated the intention to conduct a constant angle approach path using the vertical navigation mode of the aircraft's automatic flight control system (AFCS).

The provider of the flight management computer (FMC) database stated that the NDB runway 16 approach was loaded in the database. However, the pilots could not locate the approach in the database.

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1 The 24-hour clock was used in this report to describe the local time of day, Eastern Daylight-saving Time, as particular events occurred. Eastern Daylight-saving Time was Coordinated Universal Time (UTC) + 11 hours.

2 The non-directional beacon (NDB) was a ground-based navigation aid. An NDB instrument approach provided lateral guidance to a point where a circling approach, a straight-in approach or a missed approach could be made. In this occurrence, it also provided vertical guidance via a number of altitudes and distances that provided terrain protection and also the desired 3° slope guidance.

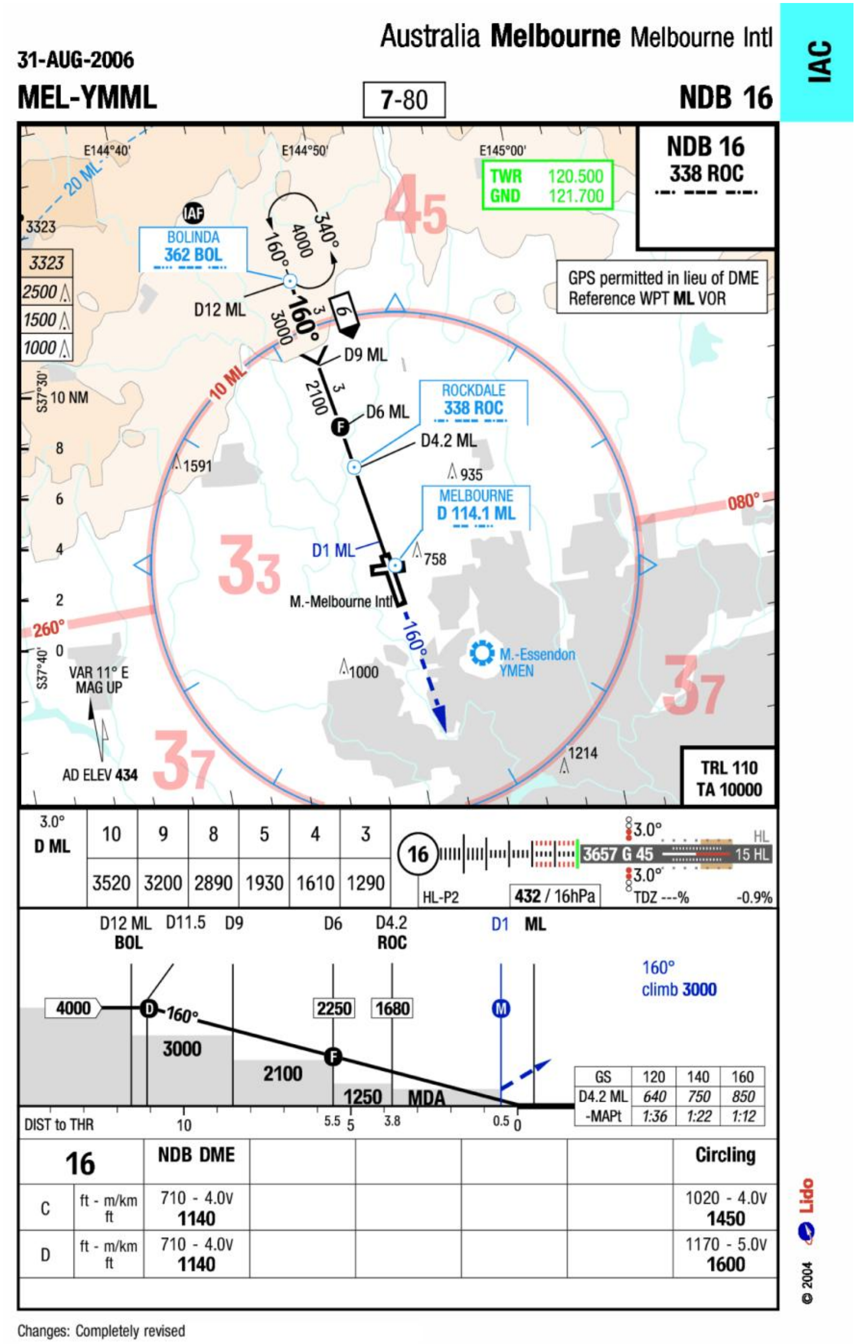
3 EGPWS provided immediate alerts, and look-ahead obstacle and terrain alerts for potentially hazardous flight conditions involving imminent impact with the obstacles and the ground.

4 Instrument landing system (ILS) referred to a ground-based navigation aid, which was able to align an aircraft both vertically and horizontally with a particular runway.

5 Lido supplied approach charts and FMC data base information as part of the Lido Route manual.

The copilot reported that he entered the final approach fix waypoint at 6 DME[6] (11 km) with an altitude constraint of 2,100 ft above mean sea level (AMSL) into the FMCs. Other segment minimum safe altitude constraints associated with the NDB approach were not entered into the FMCs. The only other waypoint that was entered was the runway 16 threshold height of 432 ft AMSL.

Figure 1: Melbourne Runway 16 NDB approach chart



6 Distance measuring equipment (DME) was a ground based aid that provided distance information in nautical miles. The aircraft was equipped with two DME receivers that displayed the distance from a DME facility. The Melbourne DME was located about 900 m south-east of the runway 16 threshold.

The following events were obtained from air traffic control (ATC) radar, flight crew interviews, automatic voice recording and data from the aircraft's flight data recorder:

1232:05 ATC cleared the crew to conduct the ARBEY FOUR ARRIVAL, standard arrival route (STAR) to runway 16.

1241:52 The aircraft commenced descent from flight level (FL) 370[7]. That was done in LNAV and VNAV[8] with the autopilot engaged.

1259:20 The crew selected Flight Level Change Mode (FLCH), which took the aircraft out of VNAV, at an altitude of 10,230 ft.

1303:55 When the aircraft was approximately 20 NM (37 km) from the airport at 9,037 ft, the approach controller instructed the crew to 'descend to 4,000, cleared for runway 16 NDB approach'. (That was also a clearance to descend in accordance with the instrument approach procedure to the minimum descent altitude.)

The copilot selected FLCH to continue descent to 4,000 ft with the autopilot engaged. The crew then configured the aircraft for the initial approach with the selection of flaps 5.

1304:25 The crew of another aircraft transmitted to ATC that they were at Avalon Airport '….. and the cloud base is about 1,700 ft'. Avalon Airport was located on the west coast of Port Phillip Bay and about 20 NM (37 km) from Melbourne Airport.

Approximately 1 NM (2 km) before the Bolinda NDB, the crew selected 1,190 ft on the Mode Control Panel (MCP). That altitude was 50 ft above the published minimum descent altitude for the approach[9].

1306:31 The aircraft overflew the Bolinda NDB while maintaining 4,000 ft. The copilot reported that at that time, descent should have been initiated, but he was unsure whether ATC had issued a clearance for the crew to conduct the NDB approach. Remaining at 4,000 ft, the copilot sought confirmation from the PIC that they were cleared for the approach.

The operator later reported that the crew was confused by the descent clearance, as the air traffic controller transmitted 'cleared[10] for runway 16 NDB approach', instead of the standard phrase 'cleared for NDB approach runway 16'.

1307:23 Descent was initiated at 9.9 DME (20 km) from Melbourne and the published descent point was at 11.5 DME (24 km). The copilot reported that, as the aircraft was above the constant approach path, and with the minimum descent altitude plus 50ft (1,190 ft) in the Altitude Window of

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7 Flight level was a surface of constant atmospheric pressure related to a datum of 1013.25 hPa, expressed in hundreds of feet; flight level 370 equated to 37,000 ft AMSL.

8 LNAV and VNAV referred to Lateral Navigation Tracking information derived from the FMC and Vertical Navigation Path derived from the FMC.

9 The operators' procedures required the crew set the minimum descent altitude plus 50 ft.

10 Authorised to proceed under the conditions specified.

the MCP, he selected FLCH on the MCP and initiated descent, instead of using VNAV path as briefed. The copilot explained that he did this to enable the aircraft to regain the constant angle approach path of 3°. At that time, the AFDS modes were FLCH for descent, LNAV for lateral navigation and the autopilot was engaged. The crew then commenced configuring the aircraft for landing by extending the landing gear and selecting flaps 20.

1308:21 The landing reference speed of 142 kts was set on the MCP.

The FDR indicated that the average rate of descent from 4,000 ft was 1,500 ft/min, with a maximum of 1,808 ft/min when the aircraft was at 8.5 DME (16 km). The aircraft descended below the 2,100 ft segment minimum altitude step at 6.8 DME (12 km).

1309:08 The aircraft was approximately 6.25 DME (7 km) and descending through 1,544 ft, which was 556 ft below the 2,100 ft segment minimum safe altitude.

The aircraft descended below the clouds and, almost simultaneously, the EGPWS aural terrain alert, 'CAUTION TERRAIN', sounded for 4 seconds and the terrain display and the terrain caution message appeared on the navigation displays on the forward instrument panel for 15 seconds.

The PIC and the relief pilot reported that they were both attempting to visually locate the runway. The copilot (PF) reported that his monitoring of the instruments was diverted to looking outside the aircraft in an attempt to locate the runway.

1309:18 A second EPGWS aural terrain alert 'TOO LOW TERRAIN' sounded for 4 seconds.

1309:20 The copilot disengaged the autopilot and initiated a pitch-up manoeuvre. The lowest altitude recorded during the manoeuvre was 1,247 ft, which was 513 ft above ground level (AGL).

At about that time, the ADC in the air traffic control tower saw lights below the cloud base that appeared to be unusually low for an aircraft.

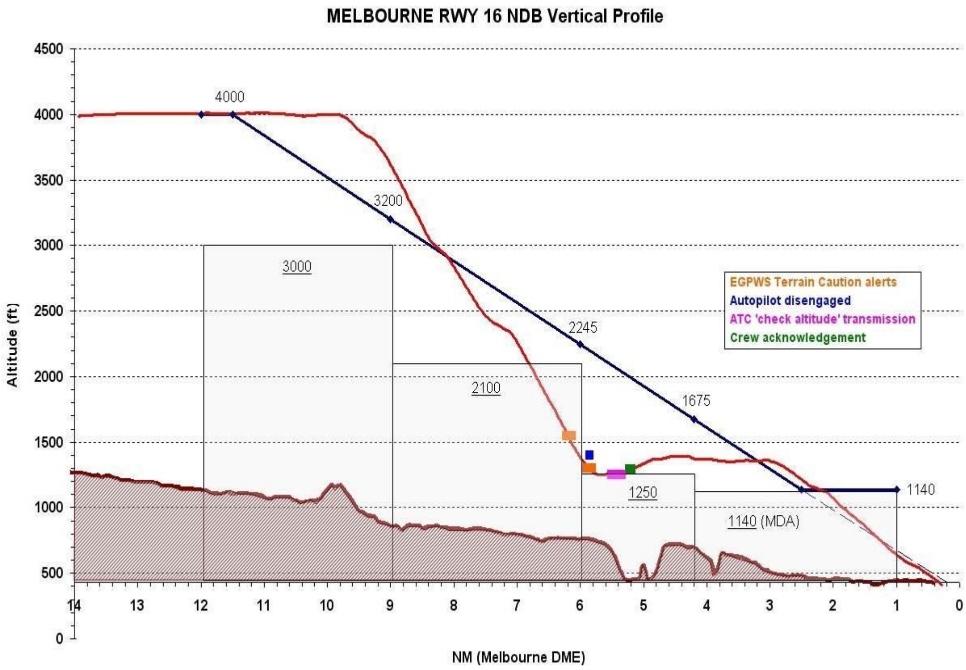
1309:30 After confirming the aircraft position on the air situation display, the ADC transmitted '…low altitude alert check your altitude immediately' to the crew. The copilot reported that, after that transmission, he saw the runway and the PAPI[11]. The PIC replied to the ADC '…okay have the runway in sight now'.

The copilot continued to fly the aircraft manually and climbed the aircraft to about 1,400 ft. The aircraft was held at that altitude until intercepting the PAPI 3° indication, which was then maintained until landing. The approach was stabilised by 500 ft above the runway.

11 The precision approach path indicator (PAPI) was a ground-based light system that provided visual approach slope guidance to a crew during an approach.

The derived approach profile that was flown by the crew, the published constant angle descent path, the segment minimum limiting steps and the terrain profile, are depicted at Figure 2.

Figure 2: Approach profile (in red) derived from recorded flight data, published constant angle descent path (in blue), segment minimum altitude limiting steps (in grey) and terrain profile (in brown).



Personnel information

Flight Crew

The PIC held an Airline Transport Pilot Licence, was type rated on the 777 aircraft, held a current medical certificate, and had 23,707 hours total flight experience. The PIC's flight time included 9,149 hours on the 777 aircraft. He reported that he had last flown into Melbourne 15 days prior to the incident.

The copilot held an Airline Transport Pilot Licence, was type rated on the 777 aircraft, held a current medical certificate, and had 6,282 hours total flight experience, with 4,389 hours on the 777 aircraft. The copilot reported that he had last flown into Melbourne in the month prior to the incident.

The relief copilot held a Commercial Pilot Licence, was type rated on the 777 aircraft, held a current medical certificate, and had 1,914 hours total flight experience, with 1,320 hours on the 777 aircraft. The relief copilot reported that he had last flown into Melbourne about 2 months prior to the incident.

Neither the PIC nor copilot had conducted an NDB approach in the aircraft or simulator in the last 18 months.

Air traffic controllers

Airservices Australia reported that all air traffic controllers involved in the control of the aircraft as it approached Melbourne Airport were licensed, rated and current for the relevant controller positions.

Aircraft systems

Automatic flight control system

The 777 automatic flight control system consisted of the autopilot flight director system (AFDS) and the auto-throttle system. Both the AFDS and the auto-throttle were controlled using the mode control panel (MCP) and the two flight management computers (FMCs). The crew used the MCP to select and activate AFDS modes, and to select altitudes, speeds and climb/descent profiles (Figure 3).

Figure 3: Mode control panel

Crew selection of the lateral navigation (LNAV) mode and/or vertical navigation (VNAV) mode resulted in the FMCs calculating the optimum lateral and/or vertical navigation flightpath. That flightpath was calculated using information obtained from the FMC databases, flight plan information entered by the crew, and other aircraft systems information. When conducting an approach using both the LNAV and VNAV modes, whether that information was taken from the FMC database or entered into the FMC by the pilots, that approach is known as a VNAV/LNAV approach.

Alternatively, the aircraft's vertical flight path could also be controlled by other AFDS modes. Those other vertical modes did not interface with the FMCs and relied solely on MCP selections by the crew. As a result, any speed restrictions and altitude constraints entered by the crew into the FMCs did not alter the aircraft's flight path in those other modes.

The other AFDS vertical modes included:

- flight level change (FLCH) mode, which varied the aircraft's pitch attitude to maintain the speed selected on the MCP, with engine thrust being held at a pre-determined value
- vertical speed (V/S) mode, which varied the aircraft's pitch attitude to maintain the vertical speed selected on the MCP
- flight path angle (FPA) mode, which controlled the aircraft's flight path during a descent by varying the aircraft's pitch attitude to maintain the angle selected on the MCP.

While descending in any one of those modes with the autopilot engaged, the altitude hold mode would automatically level the aircraft at the altitude selected on the MCP. Altitude hold mode could also be selected at any altitude by pushing the altitude hold switch on the MCP and the aircraft would maintain the altitude existing when the switch was pushed.

Enhanced ground proximity warning system

The aircraft was fitted with an EGPWS, also known as a terrain awareness and warning system (TAWS). Compared with the conventional ground proximity warning system, EGPWS was capable of providing an increased warning time to pilots about potential terrain conflicts by incorporating two additional functions: a forward-looking terrain avoidance function, and a premature descent alert function. The EGPWS also enhanced pilot situational awareness by providing coloured terrain information on the navigation displays on the forward instrument panels.

The forward-looking terrain avoidance function used data from the aircraft's global positioning system receiver to compare the aircraft's position and flightpath with a terrain database; to compute if there were any potential conflicts with the terrain. The premature descent alert function compared the aircraft's position and flightpath with an aerodrome database to determine if the aircraft was hazardously below the normal approach path for the nearest runway.

The EGPWS coloured terrain display provided the pilots with a graphical presentation of terrain information. The continuous terrain display also provided various visual indications of imminent contact with the ground, including aural warnings of excessive rates of descent and excessive closure rate to terrain.

Meteorological information

Aerodrome forecasts

The Bureau of Meteorology (BoM) issued a terminal aerodrome forecast (TAF) for Melbourne Airport at 2138 on 3 November 2007, with a local time validity period from 2300 on 3 November to 2300 on 4 November. The forecast was issued about 7 hours prior to the aircraft's departure from Bangkok, and the validity encompassed the aircraft's planned arrival time at Melbourne. From 1100, the forecast wind was from 170° T at 23 kts, gusting to 35 kts; visibility 9 km; rain; and cloud, broken[12] with a cloud base of 1,000 ft above the aerodrome level (AAL).

The BoM issued an amended TAF for Melbourne at 0341, with a validity period that extended beyond the aircraft's planned arrival time at Melbourne. The main difference was that from 1100, the cloud was forecast to be scattered at 1,000 ft and broken at 3,000 ft. A further amended TAF was issued at 0930, with the main difference being that the cloud was forecast to be scattered at 1,000 ft and broken at 1,400 ft during the period of the aircraft's arrival.

12 Cloud amount is described using the following abbreviations Sky Clear- no cloud; Few - 1 to 2 oktas; Scattered - 3to 4 oktas; Broken - 5 to 7 oktas; Overcast - 8 oktas. 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.

Actual weather information

The Melbourne special aerodrome weather report (SPECI)[13], issued at 1230, indicated: the wind was from 150° T at 25 kts, gusting to 32 kts; visibility was 9 km; and rain showers with three oktas of cloud at 1,300 ft and six oktas of cloud at 1,600 ft AAL.

The Melbourne trend type forecast (TTF)[14] that was appended to the 1230 SPECI, indicated that at the aircraft's estimated time of arrival (ETA), the visibility would be 3,000 m in rain, with broken cloud at 800 ft AAL for periods of 30 minutes or more, but less than 1 hour.

The Melbourne SPECI that was issued at 1300, indicated: the wind was from 150° T at 21 kts, gusting to 26 kts; visibility was 9 km; rain showers and with one okta of cloud at 1,100 ft AAL and seven oktas of cloud at 1,500 ft AAL. The TTF that was appended to the 1300 SPECI did not vary from the 1230 TTF.

Provision of weather information to the flight crew

At 1256:40, ATC broadcast to pilots of aircraft on frequency that the Melbourne Airport automatic terminal information service (ATIS) had changed, with the current ATIS being identified as 'X-RAY'. That broadcast occurred while the aircraft was descending through FL 130, about 48 NM (89 km) to the north-west of the airport.

Those changes to the ATIS included the wind being 140° M at 15 to 30 kts, and the cloud being scattered at 1,200 ft AAL and broken at 1,800 ft AAL, and the QNH being 1010 hPa[15]. At 1300:05, the crew contacted ATC on a different radio frequency and reported that they had received ATIS 'X-RAY'. The correct QNH had been set by the crew.

At 1307:54, ATC cleared the crew to land on runway 16. During that transmission, the controller advised the crew that the wind was 140° at 25 kts.

Aids to navigation

Ground-based navigation aids

There were two instrument approach procedures published for runway 16; an ILS precision approach procedure and a runway-aligned NDB non-precision approach procedure, which utilised the Bolinda and Rockdale NDBs and the Melbourne

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13 SPECI is a report of actual weather conditions at a particular aerodrome at a specified time, when conditions have changed beyond specified limits, or when 'special' conditions occur at the time of a routine report.

14 TTF consists of the latest aerodrome weather report followed by a concise statement indicating significant changes, expressed as a trend, expected in the 3-hour period commencing at the time of the report.

15 QNH was the barometric pressure setting that enabled an altimeter to indicate altitude; that was, the height above mean sea level.

DME (see Figure 1). Of all the approach types, the ILS was the most accurate and preferred method of aligning an aircraft with the runway.

Unavailability of the runway 16ILS

In September 2007, work commenced on the Melbourne runway 16 ILS to permit the installation of new equipment. That work was part of a navigation aid replacement program that Airservices Australia had announced to the aviation industry in October 2005.

A Notice to Airmen (NOTAM) was issued by the Australian NOTAM Office on 4 October 2007 to inform appropriate personnel of the planned unavailability of the runway 16 ILS. The NOTAM advised that the ILS would be unavailable from 0900 local time on 8 October to 1700 on 22 November 2007.

Communications

The transmissions between the air traffic controllers and the crew during the aircraft's descent and approach to Melbourne Airport were recorded by ground-based automatic voice-recording equipment. The quality of those recorded transmissions was good.

Aerodrome information

Melbourne Airport was located about 20 km north-west of the Melbourne central business district at an elevation of 434 ft. The airport had two runways: runway 16/34, aligned 160/340° M, which was 3,657 m long and 60 m wide; and runway 09/27, aligned 083/263° M, which was 2,286 m long and 45 m wide.

Runway 16 was equipped with a PAPI that was calibrated for a 3° visual glidepath angle. The touchdown elevation of runway 16 was 432 ft and the runway sloped down to 330 ft at the departure end.

Recorded information

The operator forwarded the aircraft's digital flight data recorder (FDR) to the Australian Transport Safety Bureau (ATSB) and the data was downloaded. The operator also forwarded the data from the quick access recorder (QAR) to the ATSB. Data from the cockpit voice recorder (CVR) for the incident flight had been over-written, and therefore was not available to the investigation.

Airline operations manuals

The operator provided the flight crew with a number of manuals that gave guidance to flight crew on how to carry out their duties and to operate the 777 aircraft.

Those manuals included a Flight Operations Manual (FOM), Flight Crew Training Manual FCT 777 (TM) and a 777 Flight Crew Operations Manual (FCOM).

Flight Operations Manual

The FOM set out mandatory requirements that the airline expected its pilots to abide by and included:

3.1.8.1.3 Briefing

A number of areas were to be covered in relation to a descent briefing. Those areas included weather, navigation aids, clearance limits, type and method of approach, altitudes, decision altitude or minimum descent altitude, constant angle non-precision approach (CANPA), dimming of runway and approach lights, lookout and notices to airmen.

3.1.8.2 Letdown

In regard to the letdown, the FOM stated that:

> Before commencing a letdown the PIC shall carefully cover various aspects with regard to letdown.'

Those aspects included terrain clearance, altitude limit, visual letdown and approach.

3.1.8.2.3 Procedure

The procedure for application during the letdown required that:

> The PM shall carefully monitor the letdown and check that the relevant points and altitudes mentioned during the briefing are adhered to.

Some other requirements were specified with respect to rate of descent and speed.

3.1.8.3 Approach

That section described a number of requirements in relation to ATC clearances, terrain clearance, and weather requirements.

3.1.8.3.3 Procedure

That section dealt with the duties and requirements during the approach, and included that:

> Both pilots shall monitor the instruments approach and it is especially a very important duty of PNF (PM) to automatically inform the PF of abnormal deviations from the approach procedure, altitude, rate of descent, speed and timing, and to progressively follow the under briefing in ...
>
> Stabilised approach includes-
>
> While maintaining an acceptable rate of descent, and not exceeding 1000ft per minute.
>
> All instrument approaches and straight-in visual approaches shall be planned to be stabilized at 1000ft AGL, otherwise a go-around shall be made.

3.1.8.5.3 Go-around on approach without glidepath reference

There are a number of situations where a go-around may be required whilst on approach. In this instance the relevant criteria was being:

> Not stabilized at 1000ft AGL

3.2.2.4.11 GPWS Activation

In regard to the activation of the GPWS, the FOM stated that:

> With the surroundings clearly visible in daylight, the pullup requirement may be disregarded, but action must be taken to exit from the warning envelope.

Flight Crew Training Manual 777

The FCT 777 TM provided information and recommendations on manoeuvres and techniques. It was intended to provide information in support of the other manuals that were supplied by the airline.

The section on Non-ILS Instrument Approaches stated:

> Over the past several decades there have been a number of CFIT [controlled flight into terrain] and unstabilized approach incidents and accidents associated with Non-precision (non-ILS) approaches and landings. Many of these could have been prevented by the use of continuous Descent Final Approach (CDFA) methods. Traditional methods of flying non-ILS approaches involve setting a vertical speed on final approach, levelling off at step down altitudes (if applicable) and at MDA (H), followed by a transition to a visual final approach segment and landing. These traditional methods involve changing the flight path at low altitudes and are not similar to methods for flying ILS approaches. Further, these traditional methods often require of the crew a higher level of skill, judgement and training than the typical ILS approach.

The airline had known about the difficulties in flying approaches without constant angle approach paths. In October 2007, it introduced a training program to instruct pilots on a new method to conduct those approaches. At the time of the incident the pilots of the 777 had not undergone that training.

ANALYSIS

Operator actions

The operator had recognised the difficulties associated with flying non-constant angle approach paths and had commenced a training program to improve the situation. Unfortunately, the pilots who were involved in this event had yet to complete the training. Had they completed the training, it is possible that this event would not have occurred.

Crew actions

The crew conducted a detailed briefing that included all of the appropriate information that was required to carry out the approach and landing. As the instrument landing system (ILS) approach to runway 16 was not available, and the crew were unable to locate the non-directional beacon (NDB) runway 16 approach in the aircraft's flight management computer (FMC), they manually entered a number of coordinates into the FMC that had a similar profile to the NDB runway 16 approach. The investigation was unable to determine whether the NDB runway 16 approach was loaded into the aircraft's FMC. The approach was conducted in accordance with the briefing, until the copilot sought confirmation that they were cleared for the approach. The resultant delay in descent put the aircraft above the FMC-computed flightpath. As a consequence, the vertical navigation (VNAV) mode was not available to the crew until they positioned the aircraft closer to the FMC-computed flightpath (where VNAV could once again be selected).

Mode control panel operation

To achieve the required flightpath, there were a number of modes available to the crew. In this incident, the crew chose the flight level change (FLCH) mode for the approach part of the descent. When using this mode, it was very important that the crew were aware that the aircraft would descend without restriction to the altitude set by the pilot in the altitude window of the mode control panel (MCP). In this occurrence, the aircraft was at 4,000 ft when the MCP altitude was set to 1,190 ft. Consequently, the aircraft descended through the height restriction of 2,100 ft at 5.5 DME (11 km), and would have levelled off at 1,190 ft at 5.5 DME (11 km), if the autopilot had not been disengaged and a pitch-up manoeuvre performed by the pilot flying (PF).

To ensure the minimum altitude restrictions on the approach were met, the copilot should have set 2,100 ft in the MCP. The aircraft would then have descended to and levelled off at that altitude. At 5.5 DME (11 km), the pilot should then have reset the MCP to 1,190 ft, and the aircraft would have then descended to that altitude.

Had the pilots been more aware of the operation of the MCP, they would probably have used a number of steps in the procedure to ensure that the protections afforded by the altitude restrictions were maintained.

Weather aspects

Due to the weather conditions being different to the pilots' expectations, the pilot monitoring's (PM's)[16] attention was outside the cockpit as he attempted to gain visual reference with the airport/ground. The flight crew did not realise that the weather report from the other aircraft was made from Avalon Airport, not Melbourne Airport. Had the pilot in command (PIC) been monitoring the aircraft's flightpath in accordance with the flight operations manual, it is likely that he would have recognised that the aircraft was deviating from its intended flightpath and brought the situation to the attention of the pilot flying (PF).[17]

Company procedures

The operator's Operations Manuals outlined stabilised approach criteria. At 1,000 ft above ground level, the aircraft was still in cloud with a descent rate in excess of 1,000 feet per minute, which did not comply with the stabilised approach criteria. In that situation, the flight crew were required to carry out a missed approach and position the aircraft for another approach and landing. It is most likely that the PM was distracted as a result of his attempt to establish visual reference, and was unaware that the aircraft was operating outside the operator's stabilised approach criteria.

System defences

A VNAV/lateral navigation (LNAV) approach, used in conjunction with the autopilot, afforded the most protection whilst carrying out an instrument approach. Once the approach is entered into the FMC, and the details are checked for correctness against the applicable approach chart, there are no further MCP inputs necessary and the pilot's workload during the approach is significantly reduced when compared with a non-precision approach. The pilot's primary duty is then to monitor the aircraft's flightpath and configure the aircraft for landing. In other modes, such as FLCH (as was used in this case), the pilots were required to manage the aircraft's flightpath and to make changes as required to comply with the approach chart requirements. In this case, it would have meant making several inputs to the MCP altitude to comply with the altitude restrictions, and to the MCP speed to configure the aircraft for landing. This would have increased the crew's workload during the approach, and affected their ability to adequately monitor the aircraft's flightpath.

As the pilots had not conducted an NDB approach in over 18 months, their workload may also have increased because of a lack of familiarity with this type of approach flown in the selected MCP modes.

As the PM became visual with the ground, the aircraft's enhanced ground proximity warning system (EGPWS) terrain caution sounded. That caution signal alerted the pilots to the aircraft's close proximity to the ground, but as they were already visual with the ground, this served as an advisory alert. Similarly, the warning provided by

16 The pilot in command.

17 The copilot.

the aerodrome controller that the aircraft was low, assisted in improving the pilots' situational awareness. Under the circumstances, either warning would have been sufficient to alert the pilots of the proximity to terrain in sufficient time for them to react and respond to ensure a safe outcome.

FINDINGS

From the evidence available, the following findings are made with respect to the procedures-related event involving Boeing Company 777-2D7 (777) aircraft, registered HS-TJW, that occurred near Melbourne Airport, Vic. and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The copilot was unsure of the descent clearance, which delayed further descent. This placed the aircraft above the flight management computer (FMC)-computed flightpath.
- The crew did not maintain awareness of the aircraft's profile during the approach.
- The crew did not fly a 3° constant angle descent.
- The operator's Continuous Descent Final Approach training had not been provided to the crew. *[Safety issue]*
- The crew did not conduct a 'go-around' as was required by the operator's procedures when the aircraft was 1,000ft above terrain with a high rate of descent.

Other safety factors

- The pilots had not conducted a non-directional beacon (NDB) approach in an aircraft or simulator for 18 months.

SAFETY ACTIONS

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

Continuous Descent Final Approach training

Safety Issue

The operator's Continuous Descent Final Approach training had not been provided to the crew.

Action taken by the operator

The aircraft operator advised the ATSB that it has put in place a Continuous Descent Final Approach (CDFA) method training package. This package trains pilots so that they are able to achieve a stabilised approach to a landing once suitable visual reference to the runway environment has been established.

In response to its own investigation, the operator also advised that the following actions were undertaken or are being undertaken:

- developing positive actions by the pilot flying in confirming approach clearances
- emphasising to crew the requirement to call out altitude steps during non-precision approaches
- providing all crew with automation complacency and degraded management training
- developing, at an organisational level, relevant defences against items that might be found in notices to airman and that might affect a flight .
- emphasising to all crew to carry out a go-around in case of an unstabilised approach in accordance with company procedures.

APPENDIX A: SOURCES AND SUBMISSIONS

Sources of Information

The main sources of information were:

- the flight crew of HS-TJW
- the aircraft operator
- Airservices Australia
- the Bureau of Meteorology.

Submissions

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

A draft of this report was provided to the Civil Aviation Safety Authority, the flight crew, the operator, the aircraft manufacturer, the Thailand Department of Civil Aviation and Airservices Australia.

Submissions were received from the operator and the aircraft manufacturer. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.