Australian Government

Australian Transport Safety Bureau

Operational non-compliance involving Boeing 777-3D7, HS-TKD

15 km south of Melbourne Airport, Victoria | 24 July 2011

Investigation

ATSB Transport Safety Report

Aviation Occurrence Investigation

AO-2011-086

Final

Australian Government

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ATSB TRANSPORT SAFETY REPORT

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Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Published by: Australian Transport Safety Bureau
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ISBN and formal report title: see 'Document retrieval information' on page v

SAFETY SUMMARY

What happened

At 2019 Eastern Standard Time on 24 July 2011, a Thai Airways International Boeing Company 777-3D7 aircraft, registered HS-TKD, was conducting a runway 34 VOR approach to Melbourne Airport, Victoria. During the approach, the tower controller observed that the aircraft was lower than required and asked the flight crew to check their altitude. The tower controller subsequently instructed the crew to conduct a go-around. However, while the crew did arrest the aircraft's descent, there was a delay of about 50 seconds before they initiated the go-around and commenced a climb to the required altitude.

What the ATSB found

The ATSB established that the pilot in command may not have fully understood some aspects of the aircraft's automated flight control systems and probably experienced 'automation surprise' when the aircraft pitched up to capture the VOR approach path. As a result, the remainder of the approach was conducted using the autopilot's flight level change mode. In that mode the aircraft's rate of descent is unrestricted and therefore may be significantly higher than that required for an instrument approach. In addition, the flight crew inadvertently selected a lower than stipulated descent altitude, resulting in descent below the specified segment minimum safe altitude for that stage of the approach and the approach not being managed in accordance with the prescribed procedure.

What has been done as a result

In response to this occurrence, Thai Airways International issued a notice to flight crews that emphasized the importance of constant angle non-precision approaches and adherence to the segment minimum safe altitudes. Other actions included a review of the training in support of non-precision approaches and the provision of additional information relating to the use of the aircraft's autopilot flight director system.

Safety message

This occurrence highlights the risks inherent in the conduct of non-precision approaches and reinforces the need for flight crews to closely monitor the aircraft's flight path to ensure it complies with the prescribed procedure.

Modern air transport aircraft are equipped with ever increasing levels of automation that, when used appropriately, can greatly reduce flight crew workload. While flight crews retain the option of flying the aircraft manually, the use of automation is generally preferred and often provides increased levels of safety and efficiency. To effectively manage the aircraft and flight path, however, flight crews need to maintain a thorough understanding of the relevant automatic flight systems. Worldwide, errors associated with the use and management of automatic flight systems have been identified as causal factors in more than 20% of approach and landing accidents.

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DOCUMENT RETRIEVAL INFORMATION

Report No.	Publication date	No. of pages	ISBN
AO-2011-086	19 February 2013	27	978-1-74251-310-2

Publication title

Operational non-compliance involving Boeing 777-3D7, HS-TKD
15 km south of Melbourne Airport, Victoria, 24 July 2011

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Acknowledgements

Figure 1: Modified from the original document, Airservices Australia
Figure 2: The Boeing Company
Appendix A: Airservices Australia

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 appropriate, or to raise general awareness of important safety information in the industry. 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

Sequence of events

On 24 July 2011, a Thai Airways International Boeing Company 777-3D7 (777) aircraft, registered HS-TKD, was approaching Melbourne Airport, Victoria after a flight from Bangkok, Thailand. The first officer was the flying pilot.

At 2013 Eastern Standard Time[1], the aircraft was cleared by the approach controller to descend to 3,000 ft above mean sea level (AMSL) for a Melbourne runway 34 very high frequency omnidirectional radio range (VOR)[2] approach (Appendix A). Weather reports indicated that visual meteorological conditions[3] existed at that time and visibility was reduced to about 8 km due to rain showers. The wind was reported to be from the north at about 20 km/h.

At 2015, the aircraft was on descent with the autopilot, lateral navigation (LNAV) and vertical navigation (VNAV) modes engaged. VNAV speed (SPD) mode was selected on the aircraft’s autopilot flight director system (AFDS) at that time with target values of 230 kts and 3,000 ft set in the mode control panel (MCP). In that mode, the auto-flight system acted to maintain the selected airspeed of 230 kts and limit the descent to not below 3,000 ft.

At 2015:47 and at an altitude of about 3,300 ft, the AFDS automatically changed mode from VNAV SPD to VNAV path (PTH) to ensure compliance with runway 34 VOR initial approach altitude constraint of 3,000 ft. As the flight management computer (FMC)-calculated flight path altitude at that time was 3,440 ft, the auto-flight system commanded a pitch-up change to achieve level flight and intercept the approach path profile.

A short time later, the flight crew changed the MCP target airspeed and altitude to 210 kts and 2,000 ft respectively. At 2016:05, the crew selected flight level change (FLCH) mode with the intent of ensuring that the descent continued. The crew then selected the wing flaps to position 1 and changed the target speed and altitude values on the MCP to 190 kts and 3,000 ft respectively. At 2016:46, the aircraft captured the MCP altitude of 3,000 ft and the pitch mode automatically changed from FLCH to altitude (ALT) mode to maintain the selected altitude.

At 2017:04, the flight crew changed the MCP target altitude to 970 ft[4], selected FLCH mode and the aircraft commenced descent. To maintain the target airspeed of 190 kts, the autothrottle reduced engine thrust to flight idle. The aircraft

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1 Eastern Standard Time (EST) was Coordinated Universal Time (UTC) +10 hours.

2 A ground-based navigation aid that emits a signal that can be received by appropriately-equipped aircraft and represented as the aircraft’s bearing (called a 'radial') to or from that aid.

3 Visual Meteorological Conditions is an aviation flight category in which visual flight rules (VFR) flight is permitted — that is, conditions in which pilots have sufficient visibility to fly the aircraft maintaining visual separation from terrain and other aircraft.

4 The minimum descent altitude (MDA) for the approach was 760 ft. However, a Notice to Airmen (NOTAM) current at the time raised the MDA to 920 ft because of crane operations beneath the approach path. The operator advised that ‘the pilots added approximately 50 feet to the MDA due to [a] CANPA [constant angle non-precision approach] requirement’.

subsequently intercepted the final approach track and at 2018:31, the flight crew contacted the tower controller and reported that the airfield was in sight.

The tower controller then cleared the aircraft for a visual approach, provided the aircraft was '... established on PAPI[5] and inside the circling area[6]'. At 2018:48, with the aircraft at 8.5 DME[7] (about 7 NM (13 km) to the runway threshold) and at an altitude of 1,284 ft, the flight crew disconnected the aircraft's autopilot.

At 2018:56, the tower controller observed both visually and by radar that the aircraft was low on the approach and asked the flight crew to 'check altitude'. Four seconds later the controller instructed the crew to 'climb go-around carry out missed approach runway 34', to which the flight crew responded 'climbing'. The aircraft's lowest altitude before the go-around of 984 ft was recorded a few seconds later, when the aircraft was 6.4 NM (12 km) from the runway threshold.

At 2019:26, and with the aircraft's altitude still low at 1,167 ft, the tower controller asked the flight crew to confirm that they were going around. The flight crew replied 'we are climbing Thai 461 we are maintaining 1,200 copy'. The controller again instructed the crew to carry out a missed approach, to which they replied 'on visual approach'. The tower controller then responded 'negative, missed approach runway 34, climb to 4,000 ft'. At 2019:50 the flight crew reported that they were climbing to 4,000 ft.

The subsequent runway 34 VOR approach was conducted by the captain using both LNAV and VNAV modes.

The aircraft's track and some of the key events associated with the first approach are depicted in Figure 1. A sequence of events table listing the active AFDS modes and various altitudes during the occurrence is at Appendix B.

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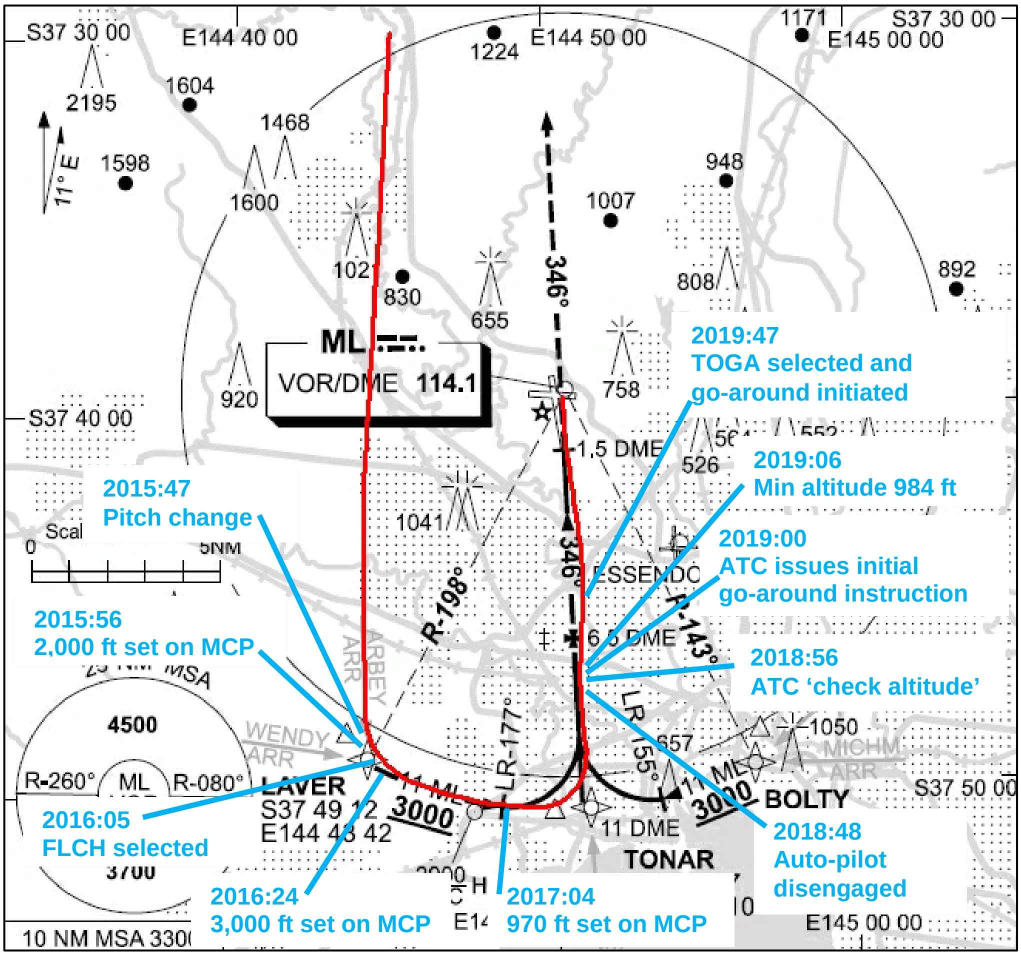
5 Precision Approach Path Indicator. Is a ground based, visual approach indicating system that uses a colour discriminating system used by pilots to identify the correct glidepath to the runway.

6 In this case, given that the runway threshold was located at 1.5 NM DME, the aircraft would have been within the applicable circling area after passing 6.8 NM DME.

7 Distance Measuring Equipment (DME) is a ground-based transponder station. A signal from an aircraft to the ground station is used to calculate its distance in nautical miles (NM) from the ground station.

Figure 1: Recorded track of the aircraft (in red) and key events (in blue)



Flight crew information

The captain reported that an approach briefing was conducted about 30 minutes prior to commencing descent. The briefing included confirmation that the VNAV profile in the aircraft's database agreed with the profile depicted on the approach chart.

The captain recalled that he did not anticipate the aircraft pitching up as it approached 3,000 ft and that he instructed the first officer to engage FLCH mode in response to that pitch up and to continue the descent to the selected MCP altitude. The captain thought that the pitch up may have indicated a fault with the VNAV function and was unsure if VNAV would resume its normal function if reselected. On that basis, the descent was continued using the FLCH mode.

The captain stated that, during the turn onto final approach and while he was attending to radio calls, the aircraft flew through a rain shower that impaired his ability to sight the runway. The captain attributed the steeper than usual descent during the turn onto final to a combination of high workload, a strong headwind and the use of FLCH mode.

The captain recalled that, as the aircraft lined up on final approach, the PAPI was indicating 'four reds' and that they were 'really low' (relative to the standard 3° approach path). The captain told the first officer to stop the descent and to climb with the intention of regaining the correct approach path. The first officer subsequently disengaged the automatic pilot and manually flew the aircraft. The captain stated that when they received the ‘check altitude’ call from the tower, they had already initiated a climb.

The captain indicated that while the standard company practice was to use VNAV and LNAV for all non-precision approaches, this was the first time that he had observed this type of behaviour from the aircraft’s automatic flight control system.

In the 6 months preceding this occurrence, the captain had operated into Melbourne on four occasions and had conducted two non-precision approaches to runway 34 and two ILS[8] approaches to runway 16.

Boeing 777 automatic flight control system

The 777 automatic flight control system consisted of the AFDS and the autothrottle system. The AFDS and the autothrottle were controlled using the MCP and the flight management computers (FMCs). The MCP permitted the flight crew to select and activate the various AFDS modes and to select altitudes, speeds and climb/descent profiles (Figure 2).

Figure 2: Mode control panel

Selection of LNAV and/or VNAV mode commands the auto-flight system to follow the FMC-generated optimum lateral and/or vertical navigation flight path for the manoeuvre or approach. That flight path was calculated using information obtained from the FMC databases, any flight plan information entered into the FMCs by the crew, and other aircraft systems information.

When descending in VNAV SPD, the AFDS will automatically change to VNAV PTH approaching an FMC altitude limitation. When conducting an instrument approach, this change will usually occur approaching the initial approach altitude, but no later than the final approach fix. If the aircraft was below the calculated flight path, the aircraft would level off and maintain the current altitude until the required flight path was intercepted.

8 A standard ground aid to landing, comprising two directional radio transmitters: the localizer, which provides direction in the horizontal plane; and the glideslope, for vertical plane direction, usually at an inclination of 3°. Distance measuring equipment or marker beacons along the approach provide distance information.

Alternatively, the aircraft's vertical flight path could be controlled by additional AFDS modes that did not interface with the FMCs. These modes relied solely on a flight crew's MCP selections and as a result, the aircraft's flight path was not subject to any speed or altitude constraints. The additional AFDS vertical modes included:

- 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 descent by varying the aircraft's pitch attitude to maintain the angle selected on the MCP.

During a descent in any one of the additional vertical modes with the autopilot engaged, the aircraft would automatically change to ALT mode to capture and maintain the altitude selected on the MCP. ALT mode could be selected at any time by pushing the altitude HOLD switch on the MCP. When pushed, the aircraft would level off and maintain the current altitude.

Aids to navigation

Published instrument approach procedures provide an assurance of terrain and obstacle clearance during an instrument approach in instrument meteorological conditions (IMC). They also enable flight crews to descend the aircraft to a position where they can see the runway ('become visual') and continue with a landing or, if they did not become visual, conduct a missed approach. Those procedures also ensured that, where an instrument approach is conducted in controlled airspace, the aircraft remains in that airspace.

A VOR approach is a non-precision approach and as such, does not provide glidepath information. In the case of a VOR approach, the flight crew is responsible for selecting and maintaining an appropriate vertical profile.

The Melbourne Runway 34 VOR approach included an inbound azimuth track or radial of 346 °M to the airport's VOR and a series of descending segment minimum safe altitude (SMSA) 'steps' (see Appendix A). Flight crews typically fly the approach as a continuous descent towards the runway, following a recommended descent profile not below SMSA. The published procedure included advisory altitudes and DME distances to achieve a recommended descent profile of 3°.

In this case, the applicable SMSA was 3,000 ft along the 11 DME arc and 1,950 ft between the lead radial (LR-177°) and 6.5 DME. At 6.5 DME the aircraft could then be descended to the minimum descent altitude (MDA). Due to limitations associated with crane operations in the vicinity of the airport and company requirements, the MDA selected by the flight crew on this occasion was 970 ft.

Aircraft operator information

The aircraft operator's non-precision approach (NPA) procedures, including for application in the case of VOR approaches, recommended the use of both LNAV and VNAV as the primary navigation reference coupled with raw data (approach plate) monitoring. Where required, flight crews could independently control the aircraft's vertical profile by the use of either the V/S or FPA modes. Compliance with minimum altitude constraints was strongly emphasised.

To minimise flight crews' exposure to error, minimise the risk of controlled flight into terrain (CFIT) and to assist with the achievement of a stabilised approach, the operator recommended a constant angle non-precision approach (CANPA) method. The operator's simulator training program included the conduct of CANPAs using VNAV. It was stipulated that, where an approach became unstable, or an aircraft descended below a minimum altitude constraint, a missed approach was to be executed.

The aircraft operator commented that, while the flight crew did commence a climb back towards the required approach path, they should have commenced a go-around/missed approach when first instructed. The operator suggested that the delay in complying with this instruction may have been due to a higher that usual workload, associated with operating the aircraft in a manual mode, and the flight crew's attention being directed towards correcting the aircraft's flight path.

Approach and landing accident reduction

The Flight Safety Foundation (FSF) Approach-and-landing Accident Reduction (ALAR) Task Force examined 76 approach-and-landing accidents that occurred worldwide in the period 1984 to 1997. As a result of that research, the FSF published an ALAR Tool Kit, which included briefing notes for flight crew when interacting with automatic flight systems (AFS).[9]

The ALAR briefing note identified a number of common factors that can contribute to an incorrect flight path and, if not recognised, an approach and landing accident - including controlled flight into terrain. Of those, two were relevant to this occurrence:

> Inadequate understanding of mode changes (eg mode confusion, automation surprise)[10]
>
> Changing the AFS control panel altitude target to any altitude below the final approach intercept altitude during approach.

Related events – ATSB investigation AO-2007-055

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, Victoria with 17 crew and 277 passengers on board.[11] 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

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9 See http://flightsafety.org/files/alar_bn1-2-automation.pdf and also http://flightsafety.org/current-safety-initiatives/approach-and-landing-accident-reduction-alar/alar-tool-kit-cd, which is available for purchase from the foundation.

10 An unanticipated or unexpected change in the operation of an automatic system.

11 See the ATSB investigation report at http://www.atsb.gov.au/publications/investigation_reports/2007/aair/ao-2007-055.aspx

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 ATSB 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.

ANALYSIS

Introduction

While descending in flight level change (FLCH) mode, the aircraft descended below the approach segment minimum safe altitude (SMSA) of 1,950 ft. That occurred as a result of the earlier selection of the approach minimum descent altitude (MDA) in the mode control panel (MCP) in lieu of the applicable SMSA.

This analysis will examine the factors leading up to those selections, their implications for the operation of the aircraft and the actions of the flight crew in response to the tower controller’s go-around instructions.

The approach

While descending through an altitude of about 3,300 ft, the automatic flight director system (AFDS) automatically changed from vertical navigation (VNAV) speed (SPD) mode to VNAV path (PTH) mode. That mode change occurred to ensure compliance with the flight management computer (FMC) altitude limitation of 3,000 ft (the runway 34 VOR initial approach altitude) and was in accordance with the system design. As the FMC-calculated approach path altitude was about 3,400 ft and above the aircraft’s current altitude, the AFDS commanded a pitch-up to level flight for interception of the required approach path. While the pilot in command (PIC) reported that he had not observed this type of AFDS behaviour before, it was possible that during previous approaches the aircraft was already on or above the required approach path. In that case, any pitch change would have been minimal.

The flight crew had intended to conduct the Melbourne runway 34 VOR approach using the lateral navigation (LNAV) and VNAV modes. However, the unanticipated pitch-up caught the PIC by surprise to the extent that the PIC believed that the VNAV function was malfunctioning. In response, the PIC changed the MCP altitude to 2,000 ft and selected FLCH mode. While it was likely that those actions were intended to arrest the pitch change and continue the descent, they were symptomatic of ‘automation surprise’ on the part of the PIC, probably due to a lack of AFDS mode appreciation. As a result, the remainder of the descent was conducted using FLCH mode.

While the operator recommended that non-precision approaches be conducted using the LNAV and VNAV functions, the aircraft’s vertical profile could also be controlled by use of either flight path angle (FPA) or vertical speed (V/S) modes. Whereas in VNAV mode the aircraft’s descent profile was managed to ensure compliance with the applicable SMSA requirements, other vertical modes permitted unrestricted descend to the target altitude that was set on the MCP.

The FPA and V/S modes could be adjusted such that the aircraft maintained the required instrument approach path, whereas the FLCH mode generally resulted in higher than required rates of descent. The use of FLCH mode was therefore not recommended due to the increased the risk of inadvertent descent below the required vertical flight path and the applicable SMSA.

In accordance with the approach requirements, the aircraft was to be maintained at or above 3,000 ft until passing the lead radial of 177°. A few seconds after the aircraft passed this radial, the flight crew changed the MCP altitude from 3,000 ft to 970 ft which in this case, was the approach MDA. However, at that position, the applicable SMSA was 1,950 ft and to comply with the procedure, the aircraft was to remain at or above this altitude until passing 6.5 DME.

The flight crew's reselection of FLCH mode resulted in the aircraft commencing an unrestricted descent to 970 ft at a higher than required rate of descent. As a result, the aircraft descended below the SMSA of 1,950 ft about 3 NM (5.6 km) prior to reaching 6.5 DME. By 7.9 DME (6.4 NM (12 km) to the threshold), the aircraft had descended to an altitude of 984 ft. At that distance, based on the recommended approach profile, the aircraft should have been at an altitude of about 2,400 ft.

The flight crew had received an approach clearance to track and descend the aircraft in accordance with the Melbourne runway 34 VOR approach procedure. While the approach and minimum altitude requirements were contained in the FMC database, the PIC's decision not to use the aircraft's VNAV function removed those protections. Regardless of the level of automation being used, it was the responsibility of the flight crew to monitor the approach to ensure that the aircraft tracked and descended in accordance with the published procedure. In this case, the selection of FLCH mode, coupled with an inappropriate MCP altitude setting, resulted in the flight crew not managing the aircraft's descent in accordance with the prescribed instrument approach procedure.

The go-around

Shortly after clearing the aircraft to conduct a visual approach, the tower controller observed that the aircraft was low on the approach and asked the flight crew to check their altitude. At that time, the aircraft was descending through about 1,100 ft and was about 7 NM (13 km) from the runway threshold. This placed the aircraft significantly below the standard approach path height of about 2,500 ft at that point in the approach and below the relevant SMSA of 1,950 ft. As a result, the tower controller instructed the crew to conduct a go-around, but with no effect. The controller issued additional instructions to go-around about 35 seconds and 47 seconds after issuing the initial instruction.

While the flight crew did arrest the aircraft's descent, the time delay between the tower controller's initial go-around instruction and selection of go-around thrust was about 50 seconds. On this occasion, the tower controller issued the go-around instruction because the aircraft's was unusually low on the approach. Equally, however, that instruction may have been issued to ensure separation from other traffic or terrain. In that case, a delay of 50 seconds could have resulted in a more hazardous situation.

FINDINGS

From the evidence available, the following findings are made with respect to the operational non-compliance that occurred 15 km south of Melbourne Airport, Victoria on 24 July 2011 and involved Boeing 777 aircraft, registration HS-TKD. They should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The pilot in command probably experienced an 'automation surprise' when the aircraft's vertical navigation (VNAV) flight management system automatically changed from VNAV speed mode to VNAV path mode.
- The flight crew did not manage the aircraft's descent in accordance with the prescribed instrument approach procedure, resulting in descent below the applicable approach segment minimum safe altitude.

Other safety factors

- The flight crew's selection of flight level change mode during the approach increased the risk of inadvertent descent below the required vertical flight path.

Other key findings

- Following the tower controller's initial instruction to go around, there was a delay of about 50 seconds before the flight crew selected take-off/go-around thrust and commenced a climb to the required altitude.

SAFETY ACTION

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.

The investigation did not identify any organisational or systemic issues that might adversely affect the future safety of aviation operations. However the following proactive safety action was reported in response to this occurrence.

Thai International Airways

On 19 August 2011, Thai International Airways advised the ATSB of the following actions in response to the occurrence.

Initial action

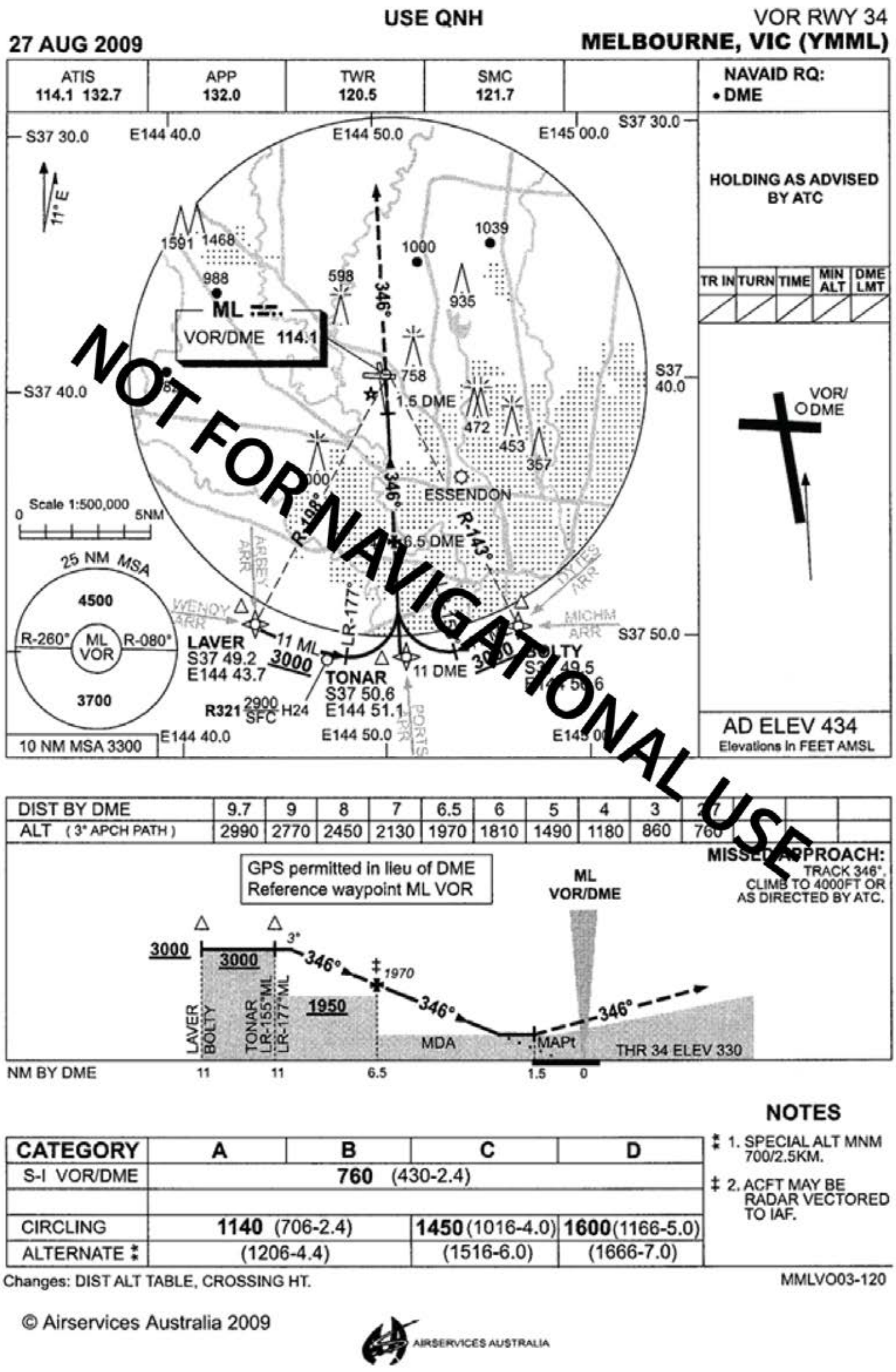
In response to this occurrence, a notice was issued to flight crews that emphasised the need to conduct constant angle non-precision approaches. The need to comply with and crosscheck the applicable segment minimum safe altitude requirements was also emphasised.

Subsequent actions

Thai International Airways subsequently advised that it had also:

- Added this occurrence to their training program as a case study, and provided additional technical information and training in the use of the autopilot flight director system (AFDS).
- Modified the standard instrument approach briefing to include the nomination of the expected AFDS operation.
- Conducted a review of their stabilised approach policy.
- Emphasized to all flight crew that, should an approach become unstabilised or unsafe, a go-around is to be conducted in accordance with standard operating procedures as soon as possible.

APPENDIX A: RUNWAY 34 VOR INSTRUMENT APPROACH CHART



APPENDIX B: SEQUENCE OF EVENTS TABLE

Time (EST)	Event	AFDS Pitch mode	Aircraft ALT ft (3°app)	SMSA ft	MCP altitude
2013:13	Aircraft cleared for runway 34 VOR approach	VNAV SPD	6,000	3,000	3,000
2015:47	Pitch-up as the AFDS changes from VNAV-SPD to VNAV-PTH	VNAV PTH	3,300	3,000	3,000
2015:56	Flight crew set 2,000 ft on the MCP		3,300	3,000	2,000
2016:05	Flight crew select FLCH	FLCH	3,250	3,000	2,000
2016:24	Flight crew set 3,000 ft on the MCP	FLCH	3,300	3,000	3,000
2016:46	Aircraft captures the MCP altitude of 3,000 ft	ALT	3,000	3,000	3,000
2017:04	Flight crew set 970 ft on the MCP	FLCH	2,900	1,950	970
2018:12	Aircraft inbound at 9.7 DME	FLCH	2,100 (3,000)	1,950	970
2018:31	Flight crew advise that they have the airfield in sight	FLCH	1,700 (2,800)	1,950	970
2018:48	Aircraft's autopilot disconnected	FLCH	1,300 (2,500)	1,950	970
2018:56	Flight crew told to 'check altitude'	ALT	1,100 (2,500)	1,950	970
2019:00	Flight crew instructed to go-around and to carry out missed approach runway 34. Crew responds 'copied'	ALT	1,000 (2,450)	1,950	970
2019:26	Go-around instruction re-issued to flight crew, who respond that they are maintaining 1,200 ft	ALT	1,100 (2,200)	1,950	970
2019:35	Flight crew instructed to carry out a missed approach. The crew's reply is inaudible	ALT	1,150 (2,100)	920	4,000
2019:47	The tower controller responds, 'Negative, missed approach runway 34 climb to 4,000 ft' Flight crew acknowledges that they are climbing to 4,000 ft	TOGA	1,200 (1,900)	920	4,000

Altitudes in red are below the segment minimum safe altitude (SMSA). Altitudes shown in parentheses are the approximate recommended altitude for the aircraft to be on a standard 3° approach path.

APPENDIX C: SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included the:

- operator and flight crew of the aircraft
- aircraft manufacturer
- Airservices Australia (Airservices).

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), 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 operator and flight crew of the aircraft, the aircraft manufacturer, the Department of Civil Aviation Thailand, the Civil Aviation Safety Authority (CASA) and Airservices. Submissions were received from the aircraft operator and CASA and where considered appropriate, the text of the draft report was amended accordingly.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
Operational non-compliance involving Boeing 777-3D7, HS-TKD
15 km south of Melbourne Airport, Victoria, 24 July 2011

AO-2011-086
Final