Australian Government
Australian Transport Safety Bureau

Flight below minimum altitude involving Boeing 787, registered 9V-OJC

Near Perth Airport, Western Australia on 4 December 2015

ATSB Transport Safety Report
Aviation Occurrence Investigation
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Addendum

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Safety summary

What happened

On 4 December 2015, a Scoot Boeing 787-9 aircraft, registered in Singapore as 9V-OJC (OJC) was operating a scheduled passenger flight from Changi International Airport, Singapore, to Perth International Airport, Western Australia. At about 1743 Western Standard time, OJC commenced an instrument landing system (ILS) approach to runway 21 at Perth.

During the approach, the aircraft's autopilot flight director system (AFDS) entered a degraded mode, and presented the crew with information that they erroneously believed represented the glideslope. The crew followed the displayed information, which resulted in a descent below the designed approach path and the subsequent activation of the aircraft's enhanced ground proximity warning system. The crew conducted a go-around, and completed an uneventful approach and landing.

What the ATSB found

During the approach, a disturbance of the ILS glideslope signal occurred, likely due to an aircraft taxiing for take-off on runway 21, resulting in OJC capturing the ILS glideslope prematurely. Because of this, the AFDS entered a degraded mode, presenting the crew with information extrapolated from a previous position, rather than updated glideslope information.

While taking actions to reset the AFDS, the crew continued descending as per the presented information, without identifying cues that indicated the information was unreliable. This resulted in an abnormally high rate of descent, leading to a descent below the designed approach path, and activation of the aircraft's enhanced ground proximity warning system.

The flight crew were likely experiencing higher than normal workload, due to a combination of the high speed approach and troubleshooting the unexpected glideslope indications. This reduced the effectiveness of cockpit communication and delayed correction of the aircraft's low altitude.

What's been done as a result

The aircraft operator advised they communicated the essential elements of this event and associated AFDS implications (including primary flight display and head-up display indications) to the pilot group. Pilots have been reminded to monitor the basic flight instruments and relevant check heights during the approach, in addition to the aircraft calculated guidance.

Stabilised approach criteria and associated callouts and actions have also been emphasised. In addition, the importance of energy management and use of the HUD to monitor appropriate descent path information has been highlighted.

Safety message

Flight crew are reminded that when conducting an ILS approach in visual conditions, ILS signal paths are not protected by air traffic control, and may be subject to interference. The aircraft's flight path needs to be constantly monitored to ensure that guidance presented to the flight crew is valid. Constant monitoring will also ensure that early action can be taken to correct any deviation from the approach path.

Contents

The occurrence

On 4 December 2015, a Scoot Boeing 787-9 aircraft, registered in Singapore as 9V-OJC (OJC), was operating a scheduled passenger flight from Changi International Airport, Singapore, to Perth International Airport, Western Australia. The first officer was the pilot flying (PF), and the captain was the pilot monitoring (PM)[1]. Also on the flight deck was a second officer conducting his first observation flight as part of his training on the 787 aircraft.

During the descent into Perth, Air Traffic Control (ATC) cancelled the normal speed restriction of a maximum of 250 kt below 10,000 ft, and requested the flight crew maintain 280 kt. This higher-than-normal speed was required to allow sequencing with other arriving traffic.

At about 1736 Western Standard Time,[2] as the aircraft was approaching 9,000 ft, the crew contacted the Perth approach controller and were instructed to maintain 9,000 ft. About a minute later, they were cleared to descend to 5,000 ft. At this time, the flight crew had a conversation about the speed they were flying being higher than the operator's guidelines, which recommended a speed no greater than 250kts below 5,000 ft. The captain subsequently instructed the first officer to maintain the higher speed, as per the ATC instructions.

At 1740, after being cleared to descend to 4,000 ft, the crew reported to the controller that they were still maintaining 280 kt. In response, the approach controller advised the crew to resume their desired speed. The standard arrival speed at this point was 230 kt.

At 1741, the flight crew were cleared for a further descent to 2,500 ft and were given clearance to conduct the Runway 21 Instrument Landing System[3] (ILS) approach (Figure 1). At 1742, the approach controller instructed the crew to reduce speed for the approach. After 30 seconds, the crew were instructed to reduce speed further to 170 kt. At this time, the aircraft was approaching waypoint HAIGH, the initial approach fix (IAF) of the ILS approach, at an altitude of 2,600 ft and with an airspeed of about 240 kt. The published arrival speed from HAIGH was between 160 kt and 185 kt.

At 1743:13, both the ILS localiser (LOC) and glideslope (G/S) functions appeared to have been captured normally, with flight crew noting green indications for both on the flight mode annunciation panel. At this point, the aircraft was clear of cloud and the flight crew had the runway in sight. The Perth Automated Terminal Information Service identified the visibility as greater than 10 km, and the cloud as 'FEW'[4] at 3,000 ft.

At 1743:32, the aircraft was directed by ATC to slow to the minimum approach speed. At 1744, the aircraft approached the outer marker (OM) (Figure 1) while descending through an altitude of about 1,000 ft, with a descent rate of about 1,800 fpm and an airspeed of 184 kt. This altitude was about 500 ft below the required height for this point of the approach, with a descent rate about double that required to maintain the glideslope.

A review of recorded Continuous Parameter Logging flight data after the incident indicated that, at around the time of the glideslope capture, there was a three-second disturbance to the glideslope signal. This disturbance should have appeared as a slight oscillation of the glideslope indications

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1 Pilot flying (PF) and pilot monitoring (PM): procedurally assigned roles with specifically assigned duties at specific stages of a flight. The PF does most of the flying, except in defined circumstances; such as planning for descent, approach and landing. The PM carries out support duties and monitors the PF's actions and the aircraft's flight path.

2 Western Standard Time (WST): Coordinated Universal Time (UTC) + 8 hours.

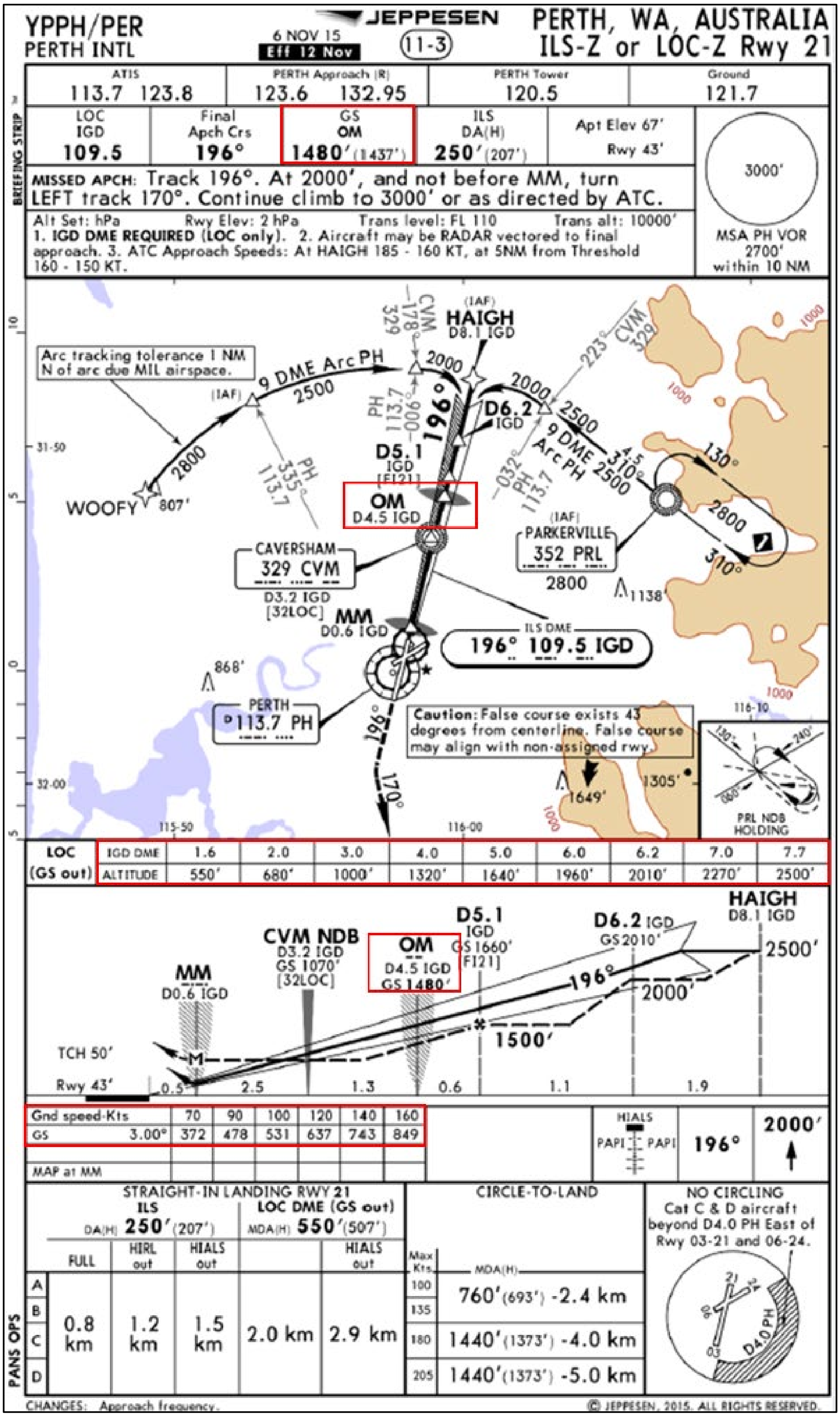
3 The instrument landing system is a ground-based precision approach and landing aid. The main elements are (1) the localiser antenna, which provides centreline guidance; (2) the glideslope antenna, which provides a nominal 3° descent guidance; (3) the marker beacons (outer, middle and inner), which are used for altimetry checks and to indicate what stage of the approach has been reached; and (4) the approach lights (Distance Measuring Equipment (DME) and/or Global Navigation Satellite System (GNSS) may be used in lieu of marker beacons).

4 When measuring cloud cover, the sky is broken up into eighths (oktas). 'FEW' cloud equates to 1 to 2 oktas of cloud.

on both the primary flight displays (PFDs) and the head-up displays (HUDs). The flight crew later reported that they did not notice the disturbance. The data further showed that the glideslope was prematurely captured by the autopilot flight director system (AFDS). As a result of the temporary disturbance, the AFDS entered a degraded mode of operation several seconds after the disturbance. At the time this occurred, 1743:36, the aircraft was at a distance of about 7 DME[5] (about 13 km) from the Runway 21 threshold, and past the initial approach fix waypoint HAIGH, descending through 2,120 ft with a descent rate of about 1,300 feet per minute (fpm) and an airspeed of 206 kt.

5 Distance measuring equipment (DME): DME display provides pilots with a distance measurement in nautical miles to the relevant DME station. In this case, the runway 21 touchdown point.

Figure 1 - Perth runway 21 ILS approach chart used by Scoot flight crew



Red boxes show the expected height at the outer marker (1480 ft when 4.5 nm from runway threshold), required altitudes to maintain the three degree glideslope for the approach, and the expected decent rate in feet per minute to maintain the glideslope for a range of approach speeds.

Source: Jeppesen annotated by ATSB

In the degraded mode, the glideslope flight path was no longer tracked by the AFDS, and instead the AFDS entered an attitude-stabilising mode based on the inertial data existing at that time. The resulting descent rate guidance displayed to the flight crew on the flight director was higher than that required to maintain the published 3° approach path.

The flight crew did not recall seeing any of the indications in the flight deck about the degraded AFDS mode, which should have normally displayed as both an amber line displayed through the *G/S active mode* text on the PFD, and as a line through the G/S active mode text on the HUD. In addition, an ‘AUTOPILOT’ caution message should have been displayed on the engine indicating and crew alerting system (EICAS). The flight data indicated that the autopilot was manually disconnected at 1743:38, two seconds after the AFDS entered the degraded mode, and the flight directors were cycled off then on again at 1743:45 with the intention of resetting the AFDS. The LOC and V/S modes then became active.

At 1744:24, the flight crew received an aural ‘GLIDESLOPE’ alert from the aircraft’s enhanced ground proximity warning system, indicating an excessive deviation below the required glideslope approach path. The flight crew later recalled that it was after receiving the ‘GLIDESLOPE’ caution alert that they observed a line through the G/S text on their PFDs and failure mode indication on the HUDs. The first officer reported also observing an ‘AUTOPILOT’ caution message on the EICAS at about this time. These indications are consistent with the AFDS degraded mode. Flight data indicated that the crew were taking action to respond to the degraded mode just prior to the aural alert. Resetting the flight directors resulted in the LOC and Vertical Speed (V/S) modes becoming active. The G/S mode remained armed, but did not become active.

In response to the alert, the captain then instructed the first officer to ‘power up’ and stop further descent. The first officer did not respond at this point, as he was reportedly still managing the energy of the aircraft to slow the approach down, and assessing the caution messages received.

As the aircraft passed over the OM, it descended through 930 ft with an airspeed of 180 kt, and a descent rate of 1,700 fpm. The required height at this point was 1,480 ft, the target approach speed was 156 kt, and a descent rate of about 850 fpm. The procedural approach speed limit was 160 kt. At this time, the captain took control of the aircraft with the intention of arresting the descent rate, correcting the flight path, and continuing the approach. However, the first officer advised the captain that the approach was outside the company’s stable approach criteria and recommended they conduct a go-around. As this was occurring, the flight crew visually observed that the precision approach path indicator (PAPI)[6] lights were all red, indicating the aircraft was significantly lower than required for the approach, and commenced a go-around.

At about 1745, the Perth Tower controller asked the crew to confirm they had visual reference with the runway, and to check their altitude. At that stage the aircraft had climbed to an altitude of 650 ft. The crew responded to the controller, advising that they were conducting a go-around.

A minimum altitude of 590 ft (520 ft above the ground) was recorded at 1744:47, when the aircraft was at 3.5 DME (5 km) from the runway, at a position where the glideslope height was 1,160 ft. The time between the first aural ‘GLIDESLOPE’ caution and commencement of the climb in the go-around was 23 seconds.

The aircraft subsequently conducted another ILS approach to the same runway. There was no signal disturbance during that approach and the ILS was conducted in accordance with the prescribed procedure. The aircraft landed at about 1758.

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[6] Precision Approach Path Indicator (PAPI): a ground based system that uses a system of white and red lights used by pilots to identify the correct approach path to the runway when conducting a visual approach.

Context

Personnel information

Both the captain and the first officer held all licences, medical certificates and training required to operate the aircraft at the time of the incident. There was also a second officer on the flight deck who was completing an observation flight as part of his 787 training.

Both the captain and first officer had previously operated the Boeing 777 aircraft, and completed the conversion training to the Boeing 787 aircraft within six months of this occurrence.

The captain had over 18,000 total flying hours, with over 15,000 hours as pilot in command (PIC) at the time of the occurrence, including 373 hours on the Boeing 787, 338 hours of which were as PIC.

The first officer had over 5,300 hours total flying hours, with 152 on the Boeing 787, including 62 as pilot in command under supervision.

Evidence collected about the pilot rosters and sleep patterns prior to the occurrence indicated that fatigue was not likely to have been a contributing factor in this incident.

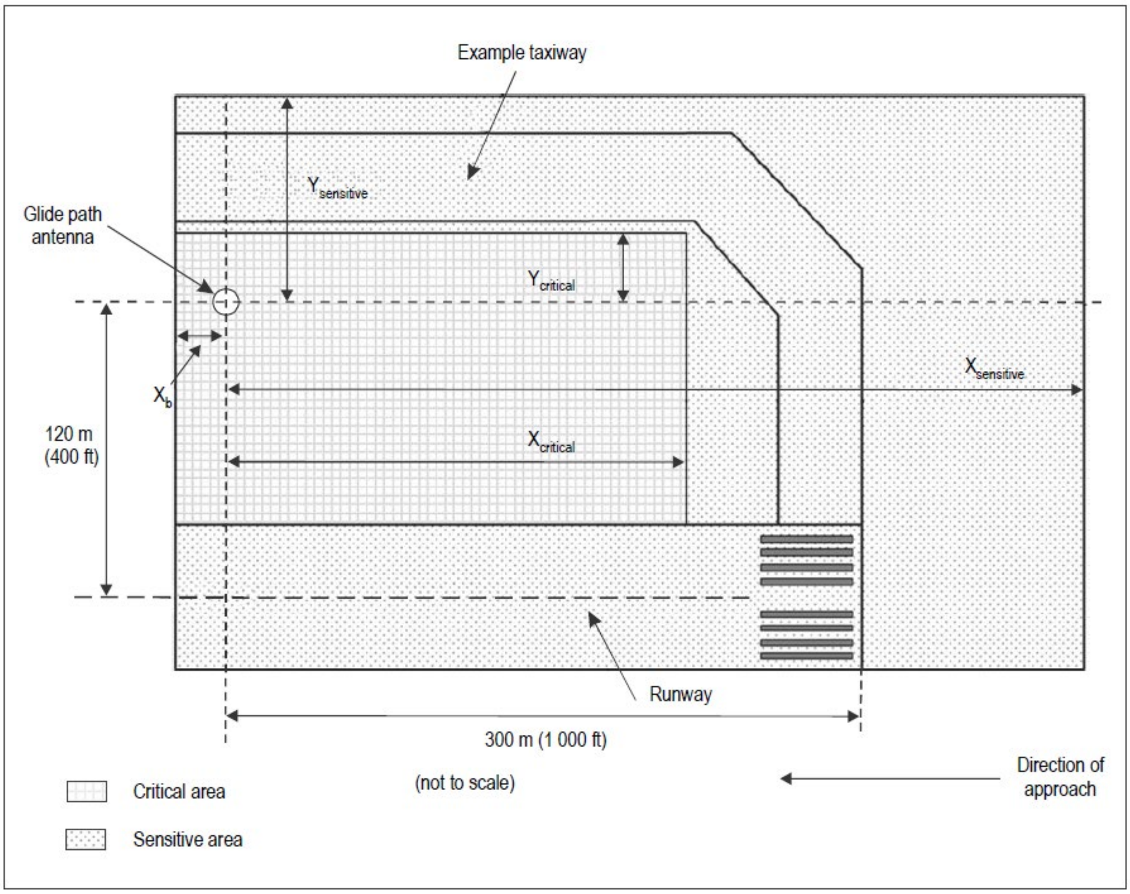
Instrument landing system signal interference

In certain conditions, the integrity of an instrument landing system (ILS) is not protected, and signal disturbances may be experienced, even while the flight crew are conducting an instrument approach. Pilots may experience ILS beam bends and other interference in circumstances where the critical or sensitive areas of the ILS are not protected.

Disturbances to ILS localiser and glideslope courses may be caused by fixed structures, such as buildings (static distortion), or moving vehicles or aircraft (dynamic distortion). The total ILS course distortion is determined by the summation of static and dynamic distortion, and this is used to define critical areas near each localiser and glideslope antenna. [7] The critical area is surrounded by a sensitive area. These areas will differ for each approach. Figure 2 shows an example of the critical and sensitive areas around an ILS antenna.

[7] The critical area is a volume of airspace encompassing lateral and vertical dimensions based around the localiser and glideslope antennas to protect the ILS signal transmissions to airborne aircraft in poor weather.

Figure 2: Example of glide path critical and sensitive area dimensions



Source: International Civil Aviation Organisation Annex 10 (2018)

Different levels of protection of the critical or sensitive areas of the ILS are provided by ATC depending on the:

- type of approach being conducted
- position of the aircraft on the approach
- weather conditions at the time.

For low-visibility approaches, when the cloud ceiling is at or below 600 ft, or the visibility is less than 2,000 m, no aircraft or vehicle is permitted to enter the critical areas when an arriving aircraft is within the outer marker, or 4 NM (7.4 km) from the threshold if there is no outer marker. The sensitive area will only be protected if the cloud ceiling or visibility is below that required to conduct a Category 1 ILS approach.

Flight crew are requested to inform ATC if they are conducting an autoland or coupled approach. This does not, however, ensure the critical area will be protected. When the cloud ceiling is above 600 ft, or the visibility is greater than 2,000 m, neither the ILS critical or sensitive areas are protected. When an area is protected, all aircraft will be held at a holding point which is outside of the protected area.

While the weather conditions were suitable for the flight crew to conduct a visual approach, it was not standard practice to assign visual approaches to foreign carriers, unless specifically requested by the pilot, and only after the pilot reported having the runway in sight. In this case, the flight crew had the runway in sight, but had not reported this to the controller while they were continuing with the instrument approach, nor were they required to.

Around the time of the glideslope disruption experienced by OJC, a Boeing 737 taxied from Terminal 1 and took off on Runway 21 (Figure 3). The ATSB assessed that the movement of that aircraft likely caused the signal disruption.

Figure 3: Perth Airport runway 21 showing location of glide path antenna, holding points and path of taxiing aircraft prior to take-off.

Image shows the holding points for runway 21 at Perth. Between the holding points is the critical area which may be disrupted by an aircraft or vehicle movement. The red arrow shows where the 737 taxied onto the runway, likely causing a disturbance to the glideslope. Source: Google, annotated by the ATSB.

Approach speeds

As OJC descended, ATC requested the aircraft maintain a higher than usual speed (280 kt) to maintain separation with other aircraft. The Scoot operations manual advised flight crew that their speed should be reduced to below 250 kt by 5,000 ft, subject to ATC requirements.

An Airservices Australia safety bulletin current at the time of the occurrence (2015), stated

> Standard Terminal Area Arrival Speeds (STAAS) were introduced to improve safety and efficiency by bringing more predictability to arrival sequences at Brisbane, Sydney, Melbourne and Perth airports.

The STAAS speeds for an aircraft arriving were:

- 250 kt at or below 10,000 ft
- 230 kt between 20 NM and either 10 NM or the initial approach fix, unless otherwise specified on the approach chart
- Between 185–160 kt between either 10 NM or the initial approach fix and 5 NM
- Between 150–160 kt within 5 NM of the runway threshold.

On the Runway 21 ILS approach chart (Figure 1), the published maximum speed was 185 kt at the initial approach fix (HAIGH) and 160 kt from 5 NM. Guidance to pilots in the Airservices Australia Aeronautical Information Publication identified that:

> Aircraft are expected to continue at previously specified speeds, commence speed reduction prior to the next promulgated speed and be at the speed by the specified point.
>
> ATC may vary the published speeds where required for traffic management.

Air traffic control provided the following instructions to the flight crew:

- At 1740:16, passing 20 NM, the crew were instructed to descend to 4,000 ft and reduce speed from 280 kt to desired speed
- At 1741:34, passing 14.75 NM, the crew were instructed to descend to 2,500 ft and were cleared for the ILS approach
- At 1742:22, around 11 NM, the crew were instructed to commence speed reduction for the approach
- At 1742:55, around 9 NM, the aircraft was instructed to reduce speed to 170 kt
- At 1743:32, around 7 NM, the crew were instructed to reduce to minimum speed, as the traffic ahead had slowed.

The speed change instructions were issued as the aircraft was descending and setting up to capture the localiser and glideslope for the approach, and during the early stage of the approach. As per the controller instructions, the crew were requested to reduce over 110 kt of speed in under four minutes. The flight crew reduced the speed from 280 kt to just below 200 kt in this time, having flown approximately 18 NM.

Guidance from the Flight Safety Foundation (2009) suggested deceleration on a 3° glideslope is difficult for an aircraft in a clean configuration (gear and flaps up), and can be around 10-20 kt per nautical mile with approach flaps and landing gear down. Additional deceleration can be achieved with deployment of speed brakes.

Head-up display

The head-up display (HUD) is one of the major differences between the Boeing 777 and 787 aircraft. Pilots completing a conversion course between the aircraft must complete training on HUD use, and are required to maintain currency in its use. Both pilots had completed this training.

Gibb, Grey and Scharff (2010) explain:

> A head-up display projects aircraft status information to pilots to minimise their head-down time and allow more time to view the external scene outside the aircraft.

They note that the HUD is:

> designed to remedy the problems associated with pilots shifting lens accommodation as they changed their gaze from close cockpit displays to far outside environmental objects.

While generally beneficial for flight crew in maintaining situational awareness, one issue which can arise with HUD use is that pilots cannot focus on both the HUD information and the outside environment simultaneously, and attention may become focused on one to the expense of the other (Crawford and Neal 2006, Nichol 2015). Wickens et al (2013) identified research showing that pilots using a HUD may be slower at identifying and responding to an unexpected event than when shifting focus between a scan of the primary flight display and the outside environment.

Additionally, as HUD displays are monochromatic, the way standard alerts displayed on the primary flight appear in colours such as green, amber and red are changed for display on the HUD (FAA, 2010). Nichol (2015) stated:

This results in the removal of a layer of information normally provided by colour coding. While the use of identical symbology and similar layout mitigates this somewhat, lack of colour is nevertheless something that pilots will take some time to adjust to.

Communication

At the time of the localiser and glideslope capture, the first officer was the pilot flying and the captain was the pilot monitoring.

In the sequence of events provided by the operator, the captain noted the aircraft was getting low, and instructed the first officer to stop the descent. The first officer reportedly did not take action at this time, as he was assessing the cautions displayed on the PFD and EICAS.

The Captain then took over flying duties from the first officer and arrested the descent. At this time, the first officer called for a go-around either two or three times. After the aural glideslope alert was sounded, the captain increased engine power and commenced the go-around. Flight data indicates that this occurred just prior to 1745.

The flight crew identified later that some standard procedural calls on the approach had been omitted during the first approach.

The approach controller coordinated handover of OJC with the tower controller between 1743 and 1744, advising that he had instructed the flight crew to reduce to minimum speed, and that there was minimum spacing between OJC and the previous aircraft. The flight crew were then instructed to change to the tower frequency. Thirty seconds later, the tower controller called the approach controller to say that the aircraft looked low. The approach controller advised that communication with the aircraft had already been transferred to the tower controller.

At 1745, prior to the go-around call from the crew, the tower controller instructed the flight crew of OJC to check altitude. At this point the crew had commenced the go-around.

Related occurrences

Subsequent Scoot occurrence

On 20 April 2016, another Scoot Boeing 787-9, registered 9V-OJD, also experienced a glideslope anomaly on the runway 21 ILS approach to Perth Airport.

In this occurrence, the flight crew observed a fluctuation of the glideslope indications, which was followed by an unusual pitch-down of the aircraft and an abnormally high rate of descent of about 1,400 fpm. The flight crew recognised the abnormal flight director commands as being the result of a glideslope disturbance, due to safety information released by the operator to their crew following the 4 December 2015 event. The autopilot was disconnected and the aircraft hand-flown to regain and maintain the appropriate flight path. The glideslope signal returned to normal function a short time later and the remainder of the approach and landing were uneventful. Following the landing, air traffic control informed the flight crew that an aircraft had departed from Runway 21 while the Boeing 787 was conducting the approach.

Both the ATSB and Boeing analysed the aircraft flight data, and determined the event to be similar to the occurrence on 4 December 2015.

Other similar occurrences

A search of the ATSB database showed a number of similar occurrences had been reported to the ATSB in the five years from the start of 2015 to the end of 2019. These occurred across Australia, including on Runway 21 at Perth Airport. In most of these events, it was identified that an aircraft was taxiing, or taking off during the time of the glideslope or localiser interruption.

ATSB Investigation AO-2017-023

On 12 February 2017, a Boeing 747-47UF (freighter) aircraft was operating from Honolulu, United States to Sydney, Australia. The Captain was the pilot monitoring (PM), and the first officer was the pilot flying (PF) .Shortly after the turn onto the final approach, the PF called 'glideslope captured' and the aircraft started to descend. However, the PM's primary flight display was still showing the aircraft below the glideslope.

The PM crosschecked the PF's display and noticed the glideslope was captured, then checked their own display and noticed there was a failure flag displayed for the glideslope. The PM again crosschecked the PF's display, noticed there was a failure flag for the PF's glideslope, and instructed the PF to disconnect the autopilot and stop the descent. During this process, a minimum safe altitude-warning alert appeared for the air traffic controller, who instructed the flight crew to conduct a go-around. At the time the 747 intercepted the localiser, another aircraft was on the taxiway within the ILS critical area.

Safety analysis

The aircraft's descent below the approach path glideslope occurred in daylight visual conditions following a disturbance to the glideslope signal. This analysis will examine the likely source of the glideslope disturbance, subsequent autopilot operation, and factors that contributed to the abnormal descent profile.

Glideslope disturbance

The glideslope signal disturbance occurred at about the same time that a Boeing 737 aircraft taxied and departed on runway 21. As the movement of that aircraft was in the vicinity of the ILS critical area, it was likely that this aircraft's proximity to the antenna as it entered and lined up on the runway caused the interference to the glideslope signal.

As this event occurred in day visual flight rules conditions, and 9V-OJC was outside the outer marker of the approach when the disruption occurred there was no requirement for air traffic control to protect the ILS critical area. While weather conditions did not require the conduct of an instrument approach, it was normal for all international aircraft arriving at Perth to be sequenced via the prevailing runway instrument approach.

Approach flight path

The glideslope signal disturbance caused the autopilot flight director system (AFDS) to capture the glideslope prematurely. When an anomaly between the aircraft's expected and actual flight paths was detected, the system by design entered into a degraded mode of operation.

The speed of the aircraft was high (206 kt) at the time the aircraft entered the degraded mode. As the descent rate required to maintain the designed glideslope is directly proportional to the speed of the aircraft, the calculated descent rate at that point in time was also relatively high. In the degraded mode, the AFDS maintained the aircraft in an attitude-stabilising mode, and in this case, with a higher-than-required descent rate. As the speed of the aircraft reduced, the difference between the required and actual descent rate increased.

A review of the recorded data indicated that glideslope mode failure indications appeared on both the primary flight displays and the head-up displays, however the flight crew did not recall seeing this initially. In addition, an 'AUTOPILOT' caution message should have been displayed on the engine-indicating and crew-alerting system, but again the crew did not see this at the time. As they did not notice any warnings, the crew continued to descend as per the displayed flight director information. The crew reported they only observed the indications after hearing the aural 'GLIDESLOPE' caution.

Recorded flight data indicated that the crew manually disconnected the autopilot, and deselected and reselected the flight directors after the autopilot entered the degraded mode, when the aircraft was at 2,150 ft. The flight crew did not recall these actions, likely due to the workload at the time.

The actions of disconnecting the autopilot and re-selecting the flight directors re-set the AFDS, resulting in localiser (LOC) and vertical speed (V/S) modes becoming active with the glideslope (G/S) mode armed. However, as the aircraft's flight path was diverging below the glideslope, the glideslope approach mode did not become active.

Based on analysis of the recorded flight data, it appears that, following autopilot disconnect and re-selection of the flight directors, the flight crew did not confirm the activation of the glideslope approach mode. As the aircraft was diverging below the glideslope in V/S mode, the glideslope mode remained in the armed (white) mode and not the active (green) mode. Consequently, rather than providing guidance to maintain the glideslope, the flight directors were providing guidance to maintain the descent rate approximate to that which existed when the modes were reselected.

This led to a descent rate about 1,000 feet per minute higher than was required for the approach, and in excess of the permitted rate of descent to comply with the operator's stabilised approach procedures. Based on the flight path flown, it appears likely the flight crew misinterpreted the flight director commands as guidance to maintain the glideslope.

Workload

Periods of high workload are a normal function of the various stages of a flight, particularly during take-off, approach and landing. Workload during these periods is managed by following standard operating procedures and effective communication and teamwork, both between the pilots and with air traffic control.

While pilots are trained to operate under a range of conditions, familiarity and recency with an aircraft type can affect a pilot's ability to manage these high-workload situations. The pilot flying had experience on the Boeing 777, but had only been operating on the Boeing 787 for a few months, and was likely still developing expertise specific to this aircraft type.

The Boeing 787 was also the first aircraft where the pilot flying had experienced using a head-up display. While head-up displays have been identified to be preferred by pilots over traditional head-down displays, they are known to have a potential inattentional blindness effect, meaning that pilots may inadvertently focus on one piece of information to the detriment of others (Gibb, Grey and Scarff, 2010).

The high-speed descent clearance given to the crew of OJC, while not unusual, was continued below the operator's normal limit of 5,000ft. The air traffic controller directed the crew to use 'desired speed', an instruction that permitted the crew to reduce speed, but the flight crew did not slow the aircraft. The crew only began slowing the aircraft when cleared for the approach. This put OJC closer to the proceeding aircraft and, to ensure separation was maintained, the controller directed the crew to reduce speed to 170 kt, then to minimum speed. This was a relatively large speed reduction, to be completed in a limited time, which resulted in a further increase in workload for the crew.

The high-speed descent and subsequent high-speed approach also meant that there was limited opportunity for the crew to identify any abnormal attitude changes associated with the glideslope disturbance. In interview afterwards, remarks by the pilot flying about being mindful of the need to slow down, the deviation from normal speeds, the time taken to process the meaning of indications displayed on the HUD and PFD, and the communication and control changes between the crew were likely indicative of a higher-than-normal workload.

About 25 seconds after capturing the glideslope, the autopilot was manually disconnected and the pilot monitoring (captain) made several rapid changes to the flight directors and approach modes. Those actions appear to have been performed in response to the unusual indications displayed following the glideslope disturbance. They also appear to have been actioned without the usual action and confirmation as required by normal standard operating procedures.

As a consequence of not confirming the status of the reselected modes, both flight crew members appear to have experienced a degree of autopilot and flight director mode confusion. The crew incorrectly assumed that the correct glideslope information was being displayed, and did not notice any indications to the contrary. The high workload may also explain the discrepancy between when the flight crew thought they disconnected the autopilot and when the recorded data indicated the disconnection occurred.

Reports from the flight crew that they missed making, and/or did not hear some of the required standard approach calls, including the altitude crossing check at the outer marker, indicate some task-shedding occurred due to the high workload.

Findings

From the evidence available, the following findings are made with respect to the flight below minimum altitude involving Boeing 787, registered 9V-OJC, on 4 December 2015.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- The aircraft prematurely captured the runway 21 glideslope as a signal anomaly occurred, most likely caused by another aircraft taxiing to take off on the same runway. This resulted in the autopilot flight director system reverting to a degraded mode of operation.
- Following disruption to the glideslope, the crew descended the aircraft unaware that the information they were following was taking them below the ILS glideslope, leading to activation of the aircraft's ground proximity warning system.
- The flight crew were likely experiencing higher than normal workload, due to a combination of the high speed approach and troubleshooting the unexpected glideslope indications. This reduced the effectiveness of cockpit communication and delayed correction of the aircraft’s low altitude.

Safety issues and action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Scoot

As a result of this occurrence, Scoot has advised the ATSB that they communicated the essential elements of this event and the associated autopilot flight director system implications and primary flight display and head-up display (HUD) indications to the pilot group. Pilots have been reminded to monitor the basic flight instruments and relevant check heights during the approach, alongside the aircraft calculated parameters. Stabilised approach criteria and associated callouts and actions have also been emphasised, and the importance of energy management and use of the HUD to monitor appropriate descent path information have been highlighted.

This communication assisted the captain in the event on 20 April 2016 in identifying the glideslope disruption shortly after it occurred.

General details

Occurrence details

Date and time:	4 December 2015 – 1745 WST	
Occurrence category:	Incident	
Primary occurrence type:	Navigation - other	
Location:	About 13 km from Perth Airport	
	Latitude: 31° 51’ 33’’ S	Longitude: 115° 59’ 00’’ E

Aircraft details

Manufacturer and model:	The Boeing Company 787-9
Year of manufacture:	2012
Registration:	9V-OJC
Operator:	Scoot
Serial number:	MSN 37114
Type of operation:	High Capacity Air Transport

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the crew of 9V-OJC
- Scoot
- Airservices Australia
- Boeing

References

Airservices Australia (2015), Safety Bulletin – Standard Terminal Area Arrival Speeds. 23 January 2015.

Crawford, J and Neal, A (2006), A Review of the Perceptual and Cognitive Issues Associated with the Use of Head-Up Displays in Commercial Aviation*. International Journal of Aviation Psychology*, Volume 16, Number 1 pp 1-19.

Federal Aviation Administration (2010); *Advisory Circular AC-25.1322-1 Flightcrew Alerting*. US Department of Transportation, Federal Aviation Administration.

Flight Safety Foundation (2009), *Approach and Landing Accident Reduction Toolkit Briefing note 4.2 – Energy Management*. Flight Safety Foundation.

Gibb, R, Gray, R and Scharff, L (2010), *Aviation Visual Perception*. Ashgate, United Kingdom

International Civil Aviation Organisation (2018); *Annex 10 – Aeronautical Telecommunications Volume 1 Radio Navigation Aids*. Seventh Edition, July 2018. International Civil Aviation Organisation.

Nichol, RJ (2015), Airline Head-Up Display Systems: Human Factors Considerations. *International Journal of Economics and Management Sciences*, Volume 4, Issue 5.

Wickens, CD, Hollands, JG, Banbury, S and Parasuraman, R (2013); *Engineering Psychology and Human Performance*. Fourth Edition. Pearson Education.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the 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 crew of 9V-OJC, the operator, Airservices Australia, Boeing, the Civil Aviation Safety Authority, the National Transportation Safety Board (United States) and the Transport Safety Investigation Bureau (Singapore)

Submissions were received from the operator, the Transport Safety Investigation Bureau (Singapore) and Boeing. The submissions were reviewed, and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The ATSB is an independent Commonwealth Government statutory agency. The ATSB 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 the ATSB's 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 operations involving the travelling public.

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 factors related to the transport safety matter being investigated.

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 factor: a 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 factor would probably not have occurred or existed.

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

Other findings: 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.