Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT

Aviation Occurrence Investigation – AO-2008-037
Final

Air-ground communication event
19 km north-north-east of Perth Airport, WA
28 May 2008
PK-GGE
Boeing Company 737-5U3

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Figure 1: Reproduced courtesy of Jeppesen

Appendix A: Satellite photograph underlay Copyright © Commonwealth of Australia, Geoscience Australia (2000)

Abstract

On 28 May 2008, a Boeing Company 737-5U3 (737) aircraft, registered PK-GGE was being operated on a scheduled passenger transport service from Jakarta, Republic of Indonesia to Perth, WA. The flight was conducted under the Instrument Flight Rules (IFR) and Perth Airport was affected by low cloud, rain showers and reduced visibility during the aircraft's arrival.

Shortly after clearing the flight crew to make an instrument landing system (ILS) approach to runway 21, the approach controller assessed that the required separation between landing aircraft was not going to be maintained and cancelled the approach clearance. The controller instructed the crew to maintain 2,500 ft, which was the radar minimum vector altitude (MVA) in that area, and to expect radar vectors for an ILS approach to runway 24. Subsequently, while being radar vectored, two-way communication between the controller and the crew ceased.

The late notice change of approach and landing runway represented a significant increase in workload for the crew, and the investigation concluded that the crew probably inadvertently deselected the approach radio frequency soon after being issued a radar vector for the amended approach and landing.

The crew did not follow the published loss of communication procedure, which resulted in the aircraft operating below the published 25 NM (46 km) minimum safe altitude and below the relevant MVA in instrument meteorological conditions (IMC) for just over 1 minute. There were no warnings or alerts from the aircraft's enhanced ground proximity warning system (EGPWS) during the flight, and the aircraft was not less than 1,421 ft above terrain during the loss of communication.

As a result of this incident, the aircraft operator undertook a number of safety actions. Those actions sought to enhance the operator's operations into Australia, and to review the procedures in the case of a communications failure with air traffic control.

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

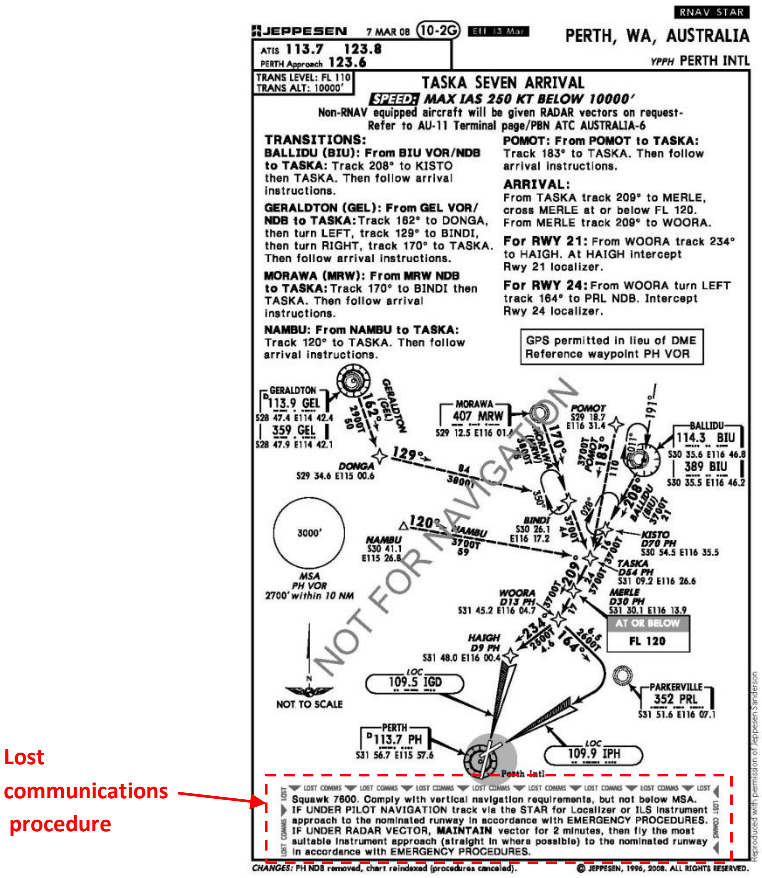
FACTUAL INFORMATION

History of the flight

On 28 May 2008, a Boeing Company 737-5U3 (737) aircraft, registered PK-GGE, was being operated on a scheduled passenger transport service from Jakarta, Republic of Indonesia to Perth, WA. On board the aircraft were 61 passengers, five cabin crew and two flight crew. The flight crew comprised the pilot in command (PIC) and copilot. The PIC was the handling pilot for the flight and was providing input to the automatic flight system. The flight was conducted under the Instrument Flight Rules (IFR).

The crew were assigned a TASKA SEVEN Standard Arrival Route (STAR) by air traffic control (ATC) via the Morawa transition, and advised to expect an instrument landing system (ILS) approach to runway 21. That arrival included the requirement to overfly the Morawa non-directional beacon (NDB) ground navigation aid, before tracking to intercept the runway 21 ILS via a series of waypoints (Figure 1). The arrival of the 737 in the terminal area was being sequenced with another arriving aircraft that was making an ILS approach to runway 24. The sequencing was necessary to ensure that there was a 3-minute separation between landing aircraft at the intersection of the runways, which allowed ATC to sequence departing and arriving aircraft from the airport's runways.

Figure 1: TASKA SEVEN Standard Arrival Route



The crew were communicating with ATC using very high frequency (VHF) radio. The weather conditions in the terminal area for the aircraft's arrival were instrument meteorological conditions (IMC), and included low cloud and reduced visibility in rain showers.

Soon after clearing the crew to make an ILS approach to runway 21, the approach controller assessed that the required separation between landing aircraft at the runway intersection could not be assured and cancelled the approach clearance for the 737. The controller instructed the crew to maintain 2,500 ft above mean sea level (AMSL), which was the radar minimum vector altitude[1] (MVA) in that area, and to expect radar vectors for an approach to runway 24. Subsequently, while being radar vectored, two-way VHF communication between the controller and the crew ceased.

The controller made a number of attempts to re-establish communication with the crew, including: checking with the tower and previous sector controllers whether the crew were operating on those frequencies; making 'blind' transmissions[2] on the voice–modulated, VHF omni-directional radio range (VOR) navigation aid at Perth; selection of standby lines to the respective ATC radio transmitters; and the use of a direct transmitter that was independent of the normal ATC radio system. The approach controller did not receive any warning indications on his console to indicate a communication fault with any of the ATC radio equipment.

The crew reported that they did not hear any of the transmissions made by the approach controller. The flight data recorder (FDR) data indicated that, as the aircraft approached the localiser for runway 24, there was a 5-second microphone keying of the aircraft's VHF - 1 communication radio. That transmission corresponded with the crew's recollection of attempting to make a transmission to the approach controller. Concurrent with the 5-second microphone keying that was recorded on the FDR, a short (less than 0.5 second) 'BRRP' was recorded on the audio recording from the approach controller's console. The FDR subsequently recorded a number of other keyings of the aircraft's VHF - 1 and VHF - 2 communication radios, but with no corresponding transmission recorded on the output from the controller's console position.

During the period that the crew were not in communication with the approach controller, they maintained the last assigned radar heading and altitude. In doing so, the aircraft transited into airspace where the radar MVA increased to 3,000 ft, and the published 25 NM (46 km) minimum sector altitude[3] (MSA) was 3,000 ft.

About 4 minutes elapsed before the crew established communications with the aerodrome controller (ADC) on the control tower frequency. The crew were instructed by the ADC to immediately climb to 3,000 ft and, soon after, to 4,000 ft.

Once the aircraft was established above the minimum safe altitude, the ADC coordinated its transfer back to the approach controller. The crew established communication with the approach controller and radar vectors were issued for the crew to intercept the localiser for runway 24. The crew recalled that the subsequent

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1 The minimum vector altitude was the lowest altitude that was able to be assigned to a pilot by a radar controller.

2 A radio transmission where the station that was called (in this case, the 737) could not talk back.

3 The minimum sector attitude was the lowest altitude that was able to be used and ensured a minimum clearance of 1,000 ft above all objects located within the defined area.

ILS approach and landing were completed without incident, and that they established visual reference with runway 24 at about 600 ft.

The sequence of events associated with the approach to Perth is provided in Table 1, which was derived from an analysis of the aircraft's FDR and the examination of air traffic services (ATS) recorded radar and audio data; supplemented by information obtained during interviews with the flight crew and approach controller. Appendix A illustrates the radar-recorded flight path of the aircraft with relevant events overlaid.

Table 1: Sequence of events, comprising data obtained from the FDR or ATS radar/audio recordings, and supplemented by interviews with relevant personnel

Local time	Altitude, airspeed	Event
-	Flight level 330 (FL330)	*Prior to the top of descent, the crew conducted their approach briefing for a TASKA SEVEN STAR and runway 21 ILS.*
1551:48	-	Top of descent, the aircraft left FL330.
1601:52	Descending through FL159, 248 kts	The enroute controller requested the crew to reduce speed to 230 kts.
1603:40	Descending through FL137, 228 kts	The crew contacted the approach controller on frequency 123.6 megahertz (MHz). The FDR recorded a corresponding keying of the aircraft's VHF - 1 radio. The controller instructed the crew to reduce speed to 210 kts. At that time, the aircraft was 76 km (41 NM) north-north-east (NNE) of Perth.
1608:10	Descending through 8,300 ft, 212 kts	The controller cancelled the STAR, and instructed the crew to turn right heading 250, which was radar vectoring for a longer final approach. The aircraft was 41 km (22 NM) NNE Perth at that time.
1608:41	-	FDR - left ILS/VOR selected to the runway 21 ILS frequency, 109.5 MHz.
1609:33	Descending through 6,700 ft	The controller instructed the crew to turn left, heading 235, to intercept the runway 21 localiser. At that time, the aircraft was 33 km (18 NM) NNE Perth.
1610:49	Descending through 4,800 ft, 210 kts	The aircraft intercepted the localiser and the controller instructed the crew to reduce to final approach speed and cleared them for an ILS approach. The aircraft was 28 km (15 NM) NNE Perth at that time.
1611:02	-	FDR - wing flaps extended to flap 5.
1611:19	-	FDR - right ILS/VOR selected to the runway 21 ILS frequency.
1611:31	Descending through 4,000 ft	The controller cancelled the approach clearance and instructed the crew to maintain 2,500 ft and to expect radar vectors for a change of runway to runway 24. At that time, the aircraft was 22 km (12 NM) NNE Perth.
1611:49	Descending through 3,800 ft	The controller instructed the crew to turn left heading 110, which was vectoring for a right downwind, runway

		24. The aircraft was 20 km (11 NM) NNE Perth at that time.
1612:09	-	FDR - left ILS/VOR selected to the runway 24 ILS frequency, 109.9 MHz.
-	-	*The crew recalled that, following the change of runway instruction, they re-briefed for the runway 24 ILS approach and programmed the aircraft navigation systems for that approach.*
1612:23	-	The controller instructed the crew to continue the left turn, heading 095. There was no response from the crew to that instruction.
1612:37	-	The controller repeated the instruction to continue the turn. There was no response from the crew.
Between 1612:48 and 1616:25	-	A number of attempts to were made by the controller to establish communication with the crew, including: checking with the tower and previous sector controllers whether the crew were operating on those frequencies; making a number of 'blind' transmissions on the voice–modulated, VOR navigation aid at Perth; the selection of standby lines to the respective ATC radio transmitters; and the use of a direct transmitter that was independent of the normal ATC radio system.
1613:08	-	FDR - radar altimeter active.
1613:16	-	FDR - right ILS/VOR selected to the runway 24 ILS frequency.
1613:20	Level at 2,518 ft, 184 kts	FDR – the aircraft commenced levelling out at 2,500 ft. Radar altimeter indicated about 2,300 ft.
1614:35	-	FDR - keying of VHF - 1 radio (5 seconds). That transmission corresponded with a short 'BRRP' on the audio recording from the approach controller's console position, which included audio output from the approach frequency of 123.6 Mhz. At that time, the aircraft was 22 km north-east (NE) of Perth and passing through the localiser for runway 24.
1615:07	Level at 2,518 ft, 178 kts	FDR - radar altimeter at the minimum recorded reading of 1,421 ft for the period of the loss of communication.
1615:16	-	FDR - keying of VHF - 1 radio (5 seconds).
1615:34	-	FDR - keying of VHF - 1 radio (2 seconds).
1615:48	-	FDR - keying of VHF - 2 radio (3 seconds).
1616:03	Level at 2,530 ft, 179 kts	Aircraft 30 km (16 NM) NE of Perth, radar MVA increased to 3,000 ft.
1616:16	-	FDR - keying of VHF - 1 radio (2 seconds).
1616:27	-	FDR - keying of VHF - 1 radio, which corresponded with the crew establishing 2-way communication with the ADC on the tower frequency of 120.5 MHz. The crew were instructed by the ADC to climb to 3,000 ft.
1616:42	-	FDR - aircraft commenced climbing.
1616:50	-	The ADC instructed the crew to climb to 4,000 ft.
1616:58	-	FDR - flaps retracted from flap 5.
1617:14	-	FDR - aircraft climbing above 3,000 ft.

1618:27	-	FDR - left and right ILS/VOR selected to Perth VOR, 113.7 MHz.
1619:07	-	FDR - keying of VHF - 1 radio, corresponding with a transmission by the crew to the approach controller on 123.6 MHz.

Personnel information

Pilot in command

The pilot in command held a valid Airline Transport Pilot Licence (Indonesian), which included a command endorsement for the Boeing 737-300/400 and 500 series aircraft that was issued in May 1996. Records maintained by the operator indicated he had accumulated 16,777 hours total flight time, of which 8,196 hours was in command of 737 aircraft. He had logged 76 hours flight time during the last 28 days.

Company records indicated that the pilot in command's instrument rating was valid to 31 August 2008, and recorded the satisfactory completion of a simulator proficiency check on 6 December 2007 and a line check on 16 April 2008. Those records also recorded the completion by the pilot of a company route/airport requalification[4] for Perth on 20 May 2008.

The pilot in command recalled that he had visited Perth once during the previous 12 months. He had completed the International Civil Aviation Organization (ICAO) English Language Proficiency[5] assessment on 20 March 2007, and was assessed as complying with the 'Level 4' proficiency standard.[6]

The pilot in command recalled being fit and well rested prior to commencing duty. At the time of the incident, he had been on duty for about 5 hours 30 minutes and awake for 7 hours 30 minutes.

Copilot

The copilot held a valid Airline Transport Pilot Licence (Indonesian), which included a copilot endorsement for the Boeing 737-300/400 and 500 series aircraft that was issued in November 2004. Records maintained by the operator indicated that the copilot had accumulated 4,244 hours total flight time, of which 2,932 hours was on 737 aircraft. He had logged 66 hours flight time during the last 28 days.

4 The route requalification was a training package relevant to operations into Perth. If a pilot in command of a flight had not operated into a destination during the previous 12 months, it was a company requirement for that pilot to complete the route requalification prior to conducting the flight.

5 In September 2007, ICAO adopted Assembly Resolution A36-11, which related to the implementation of language proficiency requirements for holders of all flight crew licences issued by contracting States. That resolution recommended the implementation of those proficiency requirements prior to 5 March 2008.

6 Level 4 was the minimum standard stipulated for crews conducting international operations.

Company records indicated that his copilot instrument rating was valid to 30 September 2008, and recorded the satisfactory completion of a line check on 10 May 2008 and of a simulator proficiency check on 27 May 2008. The copilot had completed the ICAO English Language Proficiency assessment on 14 February 2007, and was assessed as complying with the ‘Level 4’ proficiency standard.

The copilot recalled visiting Perth once during the last 3 months and three or four times during the last 12 months. He recalled being fit and well rested prior to commencing duty. At the time of the incident, he had been awake for about 9 hours 15 minutes.

Aircraft information

Radio communication systems

The aircraft was equipped with 3 independent[7] VHF communication radios that were labelled ‘VHF - 1’, ‘VHF - 2’ and ‘VHF - 3’. The communication panels for those radios were situated on the aft electronic panel, at the rear of the centre pedestal (Figure 2). Routine voice communications were conducted on VHF - 1 and VHF - 2, with the transmitter for VHF - 3 used primarily for the exchange of data and messages between the aircraft and ground stations via the Aeronautical Radio Incorporated (ARINC)[8] Communication Addressing and Reporting System (ACARS) datalink system.

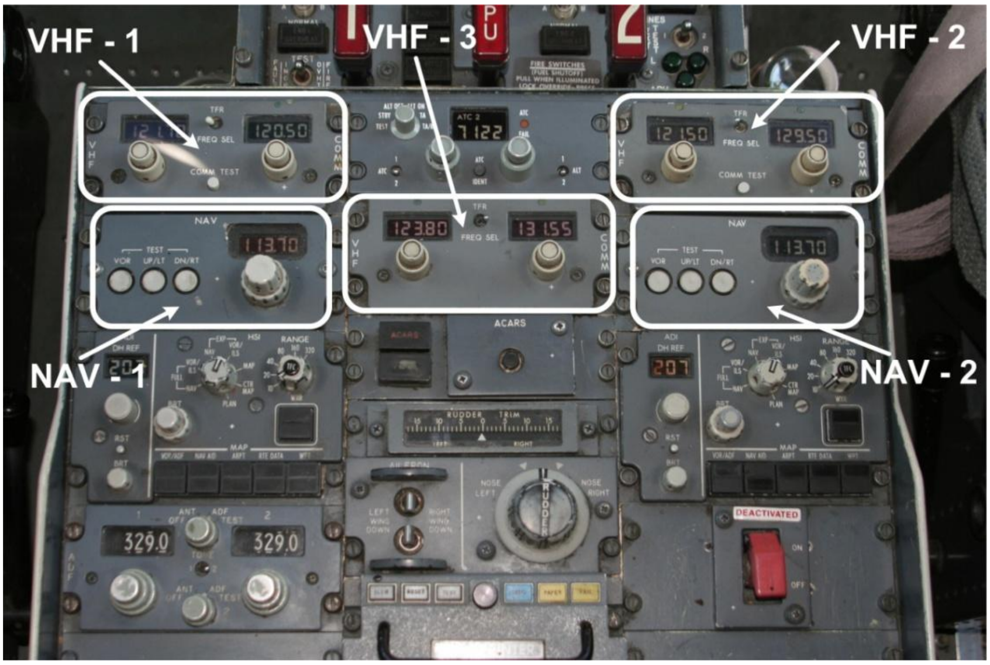
The antenna for VHF - 1 was located on the upper aircraft fuselage and the VHF - 2 antenna was located on the lower aircraft fuselage.

Each of the communication panels provided for the selection of an active and an inactive (preselected) frequency, with the voice transmission and reception separately controlled from each crew station via an audio selector panel (ASP).

7 Those systems comprise separate and independent VHF radio transceivers and external VHF antennas.

8 ARINC, a provider of transport communication systems.

Figure 2: Aft electronic panel on centre pedestal, illustrating the layout of the VHF radio and navigation communication/control panels



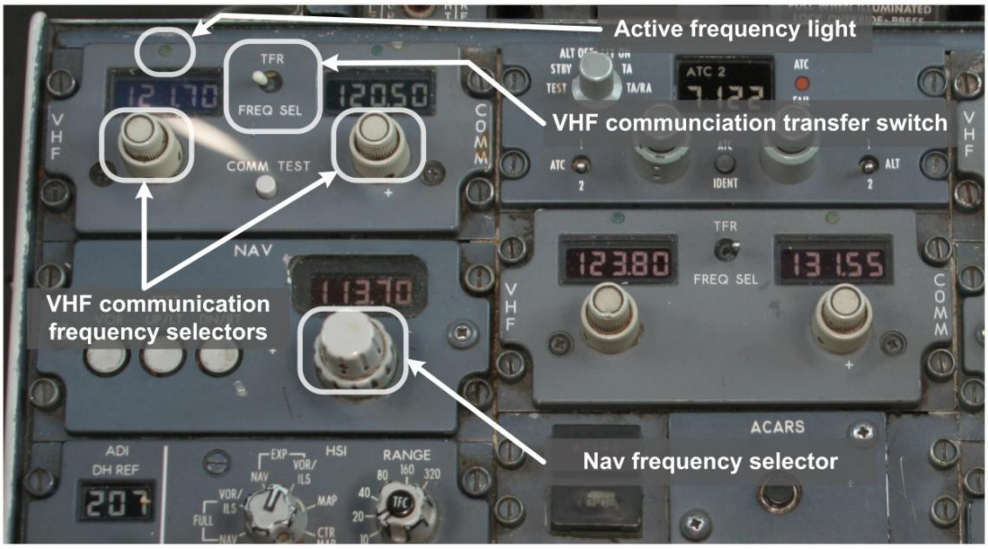
The active and inactive frequency each had a separate frequency selector (Figure 3). A VHF communications transfer 'TFR' switch enabled the crew to independently select the active frequency from either of the displayed frequencies for each transceiver. A light above each frequency indicator illuminated to indicate which of the two displayed frequencies was currently active.

Each crew station had a headphone jack and the respective pilot had an external speaker in the ceiling above their seat. A transmitter selector on each ASP enabled the crew member to select the radio on which they wanted to transmit, and which radio or navigation aid they were listening to through their audio output. Separate volume controls on each ASP enabled the relevant crew member to individually adjust their listening volume for each output. Each of the VHF communication radios had an automatic 'squelch' function.[9]

The aircraft was also equipped with a high frequency (HF) radio transceiver, typically used for long-range communications with ATC when the aircraft was operating outside VHF coverage.

9 'Squelch' referred to a circuit function that suppressed audio output from a receiver in the absence of a sufficiently strong signal. That function eliminated background noise (ie static) associated with the selected frequency.

Figure 3: VHF - 1 and Nav - 1, 121.7 MHz is the active frequency and 120.5 MHz on standby. Nav - 1 is set to frequency 113.70 MHz



Radio navigation systems

Two VHF navigation control panels were installed on the aft electronic panel, immediately aft of the VHF -1 and 2 communication panels (Figure 2). Those panels were used by the crew to select the required VOR and ILS frequencies. The aircraft VHF navigation systems included two ILS receivers, two Distance Measuring Equipment (DME) systems and two VOR receivers.

The crew could identify and monitor audio output from the tuned navigation aid by selecting the relevant aid on the ASP. That included emergency messages that might be transmitted by ATC on ground-based navigation aids which had that capability (see the ‘Aids to navigation’ section of this report).

Radar transponder

The aircraft was equipped with two radar transponders, which were controlled by a single transponder panel (located immediately above VHF - 3 in Figure 2). The transponder operated in conjunction with the ATC radar system, and enabled ATC to identify individual aircraft by allocating a discrete four digit transponder code to aircraft that were under their control. The transponder identified the aircraft to the ATC radar system and provided information about the aircraft’s current altitude.

Standard, pre-assigned transponder codes could be selected by aircraft crews to notify ATC that they had sustained a communication failure or were in distress. By international convention, the relevant transponder code for a communications failure was ‘7600’.

Enhanced ground proximity warning system

The aircraft was equipped with an enhanced ground proximity warning system (EGPWS). That system provided the crew with alerts and warnings for hazardous flight conditions that suggested the potential for the aircraft to contact terrain. The EGPWS provided for various warnings; including of excessive rates of descent, excessive rates of terrain closure, and of unsafe terrain clearance when not in the landing configuration.

The EGPWS system contained a database of terrain in proximity to major airports, and information about terrain in the vicinity of the aircraft could be displayed on each crew members' electronic horizontal situation indicator (EHSI). In the event of a potential terrain hazard, an EGPWS 'look-ahead' alert would be provided, based on the estimated time to impact.

Aircraft maintenance records

There was no record of any defect in the aircraft's technical logbook following the flight. In particular, there was no record of any fault with the aircraft's communication or navigation systems.

Meteorological information

Low cloud and reduced visibility prevailed in the terminal area. The Automatic Terminal Information Service[10] (ATIS) that was current at the time of the aircraft's arrival indicated scattered[11] cloud 500 ft above the aerodrome elevation, scattered cloud at 1,000 ft and broken cloud at 4,000 ft, with 10 km visibility reducing to 2,500 m in rain.

The crew indicated that they were operating in IMC during the approach and that they established visual contact with runway 24 at approximately 600 ft during the ILS approach to that runway.

Aids to navigation

The ground-based navigation aids at Perth were serviceable at the time of the incident.

The published aeronautical information for the Perth VOR indicated that it was a voice-modulated navigation aid that allowed for the continuous broadcast of the ATIS on that frequency. That information also indicated that, in case of emergency, the VOR frequency could be used by ATC to transmit voice instructions to aircraft crews. The receipt of those voice transmissions required an affected crew to tune the relevant VOR frequency on their VHF navigation system, and to select that audio output on their ASP.

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[10] The ATIS provided current, routine information for arriving and departing aircraft by means of a continuous and repetitive broadcast. The ATIS for Perth was continuously broadcast on a discrete VHF frequency, on the Perth VOR frequency, and on the Perth non-directional beacon (NDB) navigation aid.

[11] Scattered, meaning 3 to 4 oktas. An okta is the unit of measurement that is used to report the total sky area that is visible to the celestial horizon. One okta is equal to 1/8th of that visible sky area. The term okta is also used to forecast or report the amount of cloud in an area, along a route or at an airfield. The numbers of oktas of cloud are reported or forecast as follows: Few (FEW), meaning 1 to 2 oktas; Scattered (SCT) meaning 3 to 4 oktas; Broken (BKN), meaning 5 to 7 oktas, and Overcast (OVC), meaning 8 oktas.

The crew reported that the aircraft's navigation equipment and the ground-based navigation aids operated normally during the approach and landing.

Communications

Short-range radio communication between aircraft and ATC was primarily accomplished utilising the VHF band. Communication in the VHF band was essentially 'line of sight', where the antenna of the transmitting station needed to be within radio line of sight of the antenna of the receiving station. Although many of the ATC VHF frequencies were used in several parts of the country, those areas were sufficiently spaced geographically to minimise any possible confusion or frequency congestion as a consequence of an aircraft being in range of two ATC VHF transmitters at the same time.

The crew reported normal VHF communications with ATC en route, during the initial stages of the approach to runway 21, following the re-establishment of communications with the ADC on the tower frequency, and subsequently on the approach frequency.

A review of all audio transmissions that were recorded on the Perth ATC frequencies during the period of the communication failure did not identify any transmissions from the crew that corresponded with the microphone keying recorded on the FDR.

The crew reported that, during the period without communications with ATC, they heard other aircraft transmitting on frequency, but did not hear any response from ATC. They could not recall the callsign(s) or flight number(s) of the aircraft. A review of the recorded ATC audio transmissions on the approach frequency during the loss of communications indicated there were no transmissions on that frequency from the crews of any other aircraft.

There was no evidence in the ATC maintenance records and logs of any anomalies with the ATC VHF equipment during the period of the communication failure.

Flight recorders

Flight data recorder

The FDR was forwarded to the ATSB's technical facilities for download and analysis. Relevant elements from that download are incorporated in Table 1, including: the keying of the VHF communication radios; the tuning of VHF navigation receivers; and the aircraft's speed, altitude and ground position. The VHF communication frequencies that were tuned on the VHF radios were not recorded by the FDR.

A review of the FDR data confirmed that there were no EGPWS alerts or warnings during the flight. During the period that the aircraft was operating below the relevant MVA or MSA, the recorded radar altimeter data showed that the aircraft remained at or above 1,489 ft above terrain, and was not less than 1,421 ft above terrain during the loss of communication with ATC.

The FDR indicated that the autopilot was used by the crew throughout the flight, and was disengaged a short time before the aircraft landed.

Cockpit voice recorder

The aircraft was equipped with a cockpit voice recorder (CVR). That recorder had a 30-minute continuous loop recording capacity, and operated whenever electrical power was applied to the aircraft's electrical systems.

The ATSB considered the recovery of the aircraft's CVR for download. However, based on advice from the operator that more than 30 minutes had elapsed with electrical power continuously applied to the aircraft between the aircraft's arrival and that consideration, the CVR was not recovered.

Organisational and management information

Published radio failure procedures

There were published procedures that were to be followed by crews of aircraft operating in Australian airspace, including in the event of a radio failure. Those procedures were consistent with the provisions of *Annex 2 – Rules of the Air* and *Annex 10 – Aeronautical Telecommunications* of the Convention on International Civil Aviation. In the case of loss of communications in controlled airspace, or when operating IFR in any airspace, crews were instructed to 'Squawk 7600' and to 'listen out on ATIS and/or voice-modulated navaids'. The procedure published for the TASKA SEVEN STAR (Figure 1) and used by the crew described the procedure to be followed in event of lost communications as follows:

> Squawk 7600. Comply with vertical navigation requirements, but not below MSA. IF UNDER PILOT NAVIGATION track via the STAR for Localizer or ILS instrument approach to the nominated runway in accordance with EMERGENCY PROCEDURES. IF UNDER RADAR VECTOR, **MAINTAIN** vector for 2 minutes, then fly the most suitable instrument approach (straight in where possible) to the nominated runway in accordance with EMERGENCY PROCEDURES.

The published procedures for the runway 21 and 24 ILS approaches did not include the procedure to be followed in event of lost communications.

The crew were reported to be using aeronautical documentation produced by Jeppeson. The emergency procedures section of that information included the following guidance for the loss of communication while being radar vectored:

> 3.2.4.3 If being radar vectored:
>
> a. maintain last assigned vector for two minutes; and
>
> b. climb, if necessary, to minimum safe altitude to maintain terrain clearance; then
>
> c. proceed in accordance with the latest ATC route clearance acknowledged.

Operator procedures for radio failure

The aircraft operator published a 'Route Information' manual, which included a chapter that was applicable for operations in Australian airspace. That chapter included information for crews on the procedures to follow in the event of a loss of communications with ATC, and reference to the loss of communication procedures that were published in the proprietary aeronautical information, including the requirement to:

- Squawk 7600
- listen out on ATIS/voice-modulated navaids
- if under radar vectors:
  - maintain the last assigned heading for 2 minutes
  - if necessary, climb to MSA to maintain terrain clearance.

Crew procedures

The crew recalled that when they were unable to contact the approach controller as they approached the runway 24 localiser, they made several calls on the approach frequency using VHF – 1, then attempted to establish communication using VHF – 2, before transferring back to VHF – 1 and successfully establishing contact with the ADC on the tower frequency.

The crew reported that they intended to follow the procedure for loss of communications if they did not establish communications on the tower frequency.

Operator procedures for monitoring ATC communication frequencies while in terminal airspace

The operator's standard operating procedure required the crew to maintain a listening watch on the VHF emergency frequency of 121.5 MHz, which included during operations in terminal airspace. The crew reported that, at the time of the loss of communications with ATC, one of the VHF radios was selected to the approach frequency, and the other to 121.5 MHz.[12]

Cockpit workload - change of runway

Although some items of the original briefing for the approach to runway 21 may have been relevant for the subsequent changed approach to runway 24, there were items that required re-briefing by the crew as a result of that change. Those items included briefing: the instrument approach procedure, including its vertical profile; the minimum altitudes (including the MSA), decision heights and required visibility for landing; the missed approach procedure; the responsibility for tuning and identifying the relevant navigation aids; and other actions associated with safely completing the arrival. The completion of those items was particularly significant

12 ICAO *Annex 10 – Aeronautical Communications* recommended that aircraft crews should maintain a listening watch on emergency frequency 121.5 MHz on long overwater flights, and when in areas or over routes where the possibility of the interception of the aircraft or other hazardous situations existed. Furthermore, the Annex recommended that crews should monitor that emergency frequency at other times to the extent possible.

given the weather conditions in the terminal area during the aircraft's arrival, which necessitated an instrument approach, and suggested the likelihood of the crew becoming visual when close to the landing minima.

An analysis of the available radar information indicated that the crew had about 1 minute 30 seconds to fly downwind on the intended radar heading before the controller would need to vector the aircraft onto a heading to intercept the localiser for runway 24. During that time, the crew needed to complete their briefing for the change of runway or, if that time was considered insufficient, to request additional track miles or a holding pattern to enable them to complete the necessary tasks prior to commencing the changed instrument approach.

The crew stated that they had adequate time to brief for the change of runway and to reprogram the aircraft's navigation systems. The aircraft operator estimated that a crew should, when following the standard procedure, take between 2 and 3 minutes to complete the necessary briefing items and to reprogram the aircraft navigation systems for such a runway change.

Additional information

Approach-and-landing Accident Reduction

The Flight Safety Foundation[13] Approach-and-landing Accident Reduction taskforce published an Approach-and-landing Accident Reduction (ALAR) Tool Kit and Briefing Notes, which were designed to address the high proportion of accidents involving jet transport category aircraft during the approach and landing phases, and the incidence of Controlled Flight Into Terrain (CFIT).

The ALAR Tool Kit[14] provided an Approach-and-landing Risk Awareness Identification Tool, which identified late-notification runway changes, operations at unfamiliar airports, and reduced visibility as factors that increased the risk of an accident during an approach and landing. The conduct of an approach briefing was identified as a significant risk mitigator during that phase of flight.

13 The Flight Safety Foundation was an 'independent, non-profit, international organisation engaged in research, auditing, education, advocacy and publishing to improve aviation safety'.

14 Available at http://www.flightsafety.org/cfit4.html.

ANALYSIS

The recorded air traffic control (ATC) audio information indicated a loss of two-way communication between ATC and the crew for just over 4 minutes, during which, the crew would have been aware of their inability to contact the approach controller for 1 minute and 52 seconds. That loss of communication occurred while the aircraft was operating in instrument meteorological conditions (IMC), and at a minimum vectoring altitude (MVA) that, although initially appropriate for the aircraft's anticipated track, was below the published 25 NM (46 km) minimum sector altitude (MSA). In the event, and despite the lack of any alerts or warnings from the aircraft's Enhanced Ground Proximity Warning System (EGPWS), the action by the crew in response to the loss of communication resulted in the aircraft being below the relevant MVA and MSA for 1 minute and 11 seconds.

The lack of any evidence to indicate that the loss of communication was due to a failure in the ATC or aircraft's radio systems, and the ongoing controller communication with pilots of other aircraft on the relevant approach frequency, suggested an operational focus to the development of the incident. This analysis will examine the operational factors that contributed to the development of the loss of communication.

Change of runway

The late notice requirement for the approach controller to cancel the crew's initial approach clearance and to issue an amended clearance at the MVA to the north-north-east of Perth, compressed the time available for the crew's approach planning. Indeed, at the re-cleared altitude of 2,500 ft and the intended heading, there was less than 2 minutes for the aircraft to fly downwind, before the controller needed to either vector the aircraft onto a heading for a base/localiser intercept to runway 24, or to climb the aircraft to the MVA beyond 16 NM (30 km) north-north-east of Perth of 3,000 ft. Although the crew felt that amount of time was sufficient, it was at the lower end of the time estimated by the operator for its crews to manage a change of runway.

The conduct of the approach in IMC, combined with the number of crew tasks as a result of the runway change, elevated the workload being experienced by the crew. Although not utilised, the crew had the opportunity to request additional track miles, or of entering a holding pattern in order to manage that workload. By not taking either of those options, there was the potential for the elevated workload to impact on the crew's capacity to manage the amended approach clearance, or any non-normal or emergency situation(s) that might have occurred during the approach; such as a communications failure.

The late change of runway, operation at a relatively unfamiliar airport, and an approach in IMC were consistent with a number of the risk factors identified in the Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) tool kit as increasing the risk of an incident during an approach and landing. The compressed time available for the crew as a result of the runway change could have pressured the crew to hurry their approach briefing, reducing its effectiveness as an important approach risk mitigation tool. That included the degradation of its utility as an 'aide memoire' when setting the required navigation aids, radio frequencies for the approach, and so on.

Loss of communication

The correlation of the flight data recorder (FDR) data with the recorded ATC communications confirmed the proximity of the loss of communication to the retuning of the VHF - 1 navigation receiver by the crew for the amended approach to runway 24. The location of that navigation receiver's frequency selector immediately below the frequency selectors for the VHF - 1 communication radio suggested the possibility for the crew to have inadvertently knocked or otherwise changed the intended approach communication frequency.

The likelihood for the crew to have inadvertently selected the incorrect approach communication frequency was supported by the crew report of hearing transmissions from other aircraft during the loss of communication, whereas there were no corresponding transmissions recorded on the approach frequency during that time. That strongly indicated that, whatever frequency the crew was monitoring, it was not the frequency on which the approach controller was transmitting. Similarly, the lack of any recorded voice transmission by the crew on the ATC audio recording indicated that they were, in all likelihood, not transmitting on the correct approach frequency.

It was unlikely that the transmit and receive functions would have simultaneously failed in the independent VHF - 1 and VHF - 2 radio communication systems that were used by the crew in their attempts to resolve the communications failure. The investigation concluded that the apparent failure to the crew of the aircraft's second, autonomous VHF communications system may have been because they had copied the incorrect frequency that was displayed on the VHF - 1 communication radio.

The action by the crew to not follow the published loss of communications procedures compounded the risk associated with that loss. Squawking the relevant transponder code would have alerted the controller of the failure, rapidly identifying the need for controller action in support of the crew. In combination, the compliance by the crew with the minimum altitude, tracking and approach requirements of those procedures would have reduced the risk to their aircraft. It would also have allowed the controller to more efficiently manage any other traffic to remain clear of the aircraft, and to expedite the aircraft's approach and landing. By not listening out on the Perth VHF omni-directional radio range (VOR) frequency, the crew precluded ATC from providing support for their subsequent approach and landing to the maximum extent possible. By the time the crew had tuned to the VOR frequency, they had re-established communication with ATC, and were operating above the published MSA.

The crews' failure to adhere to the relevant procedures for loss of communication may have been influenced by hearing crews from other aircraft transmitting on frequency. That may have indicated that their radio was still capable of receiving transmissions and may have delayed their implementation of the relevant procedures for a loss of communications, as they attempted to re-establish contact with the approach controller.

FINDINGS

From the evidence available, the following findings are made with respect to the loss of communication between air traffic control (ATC) and Boeing Company 737-5U3 aircraft, registered PK-GGE, during its approach to Perth on 28 May 2008 and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The crew inadvertently deselected the approach frequency when tuning the very high frequency (VHF) navigation receiver to the frequency for the amended runway 24 instrument landing system (ILS) approach, resulting in a loss of communication between the crew and approach controller.
- The crew did not follow the published procedure for a loss of communications, with the effect that the aircraft was below the published 25 NM (46 km) minimum safe altitude (MSA) and the relevant minimum vector altitude (MVA) whilst in instrument meteorological conditions (IMC).

Other safety factors

- The requirement for the controller to cancel the initial approach clearance, and to change the landing runway, significantly increased the crew's workload.

Other key findings

- There were no warnings or alerts from the aircraft's enhanced ground proximity warning system (EGPWS) during the flight, and the aircraft was not less than 1,421 ft above terrain during the loss of communication.

SAFETY ACTION

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

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

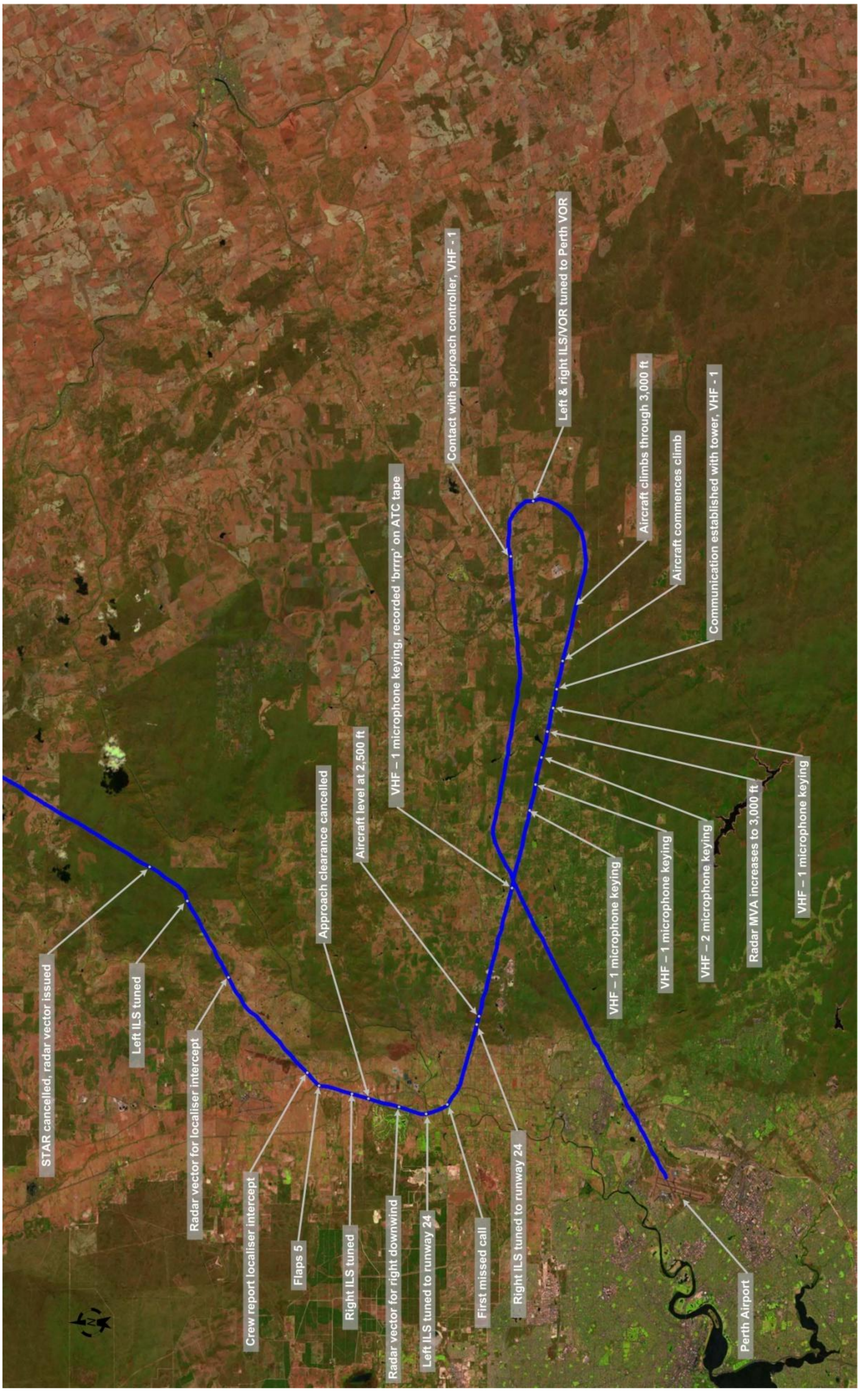
Action in the event of a loss of communications

Aircraft operator

Although not identified by the investigation as a safety issue, as a result of this incident, the aircraft operator undertook a number of safety actions, including:

- issuing a notice to all flight crews, which included reference to the relevant procedures to be followed in the event of loss of communication with air traffic control (ATC)
- the inclusion of ‘communication failure’ as an exercise scenario in the ‘Type Recurrent and Proficiency Check Syllabus’ simulator recurrent training in the Boeing 737 NG fleet
- the inclusion of discussion points from this incident during Boeing 737-300/400/500 flight crew recurrent training
- the distribution of a booklet containing general information for the operator’s crews when operating to Australia, including the relevant procedures to follow in event of a communications failure.

APPENDIX A: AIRCRAFT GROUND TRACK AND RELEVANT EVENTS DURING THE APPROACH



APPENDIX B: SOURCES AND SUBMISSIONS

Sources of information

The sources of information during the investigation included:

- the aircraft operator
- the flight crew
- the aircraft's flight data recorder
- Airservices Australia (Airservices)
- the approach controller
- Jeppesen.

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 aircraft operator; the flight crew; the approach controller; Airservices; and the Civil Aviation Safety Authority (CASA).

A submission was received from the aircraft operator. That submission was reviewed and where considered appropriate, the text of the report was amended accordingly.