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NATIONAL TRANSPORTATION SAFETY COMMITTEE

Aircraft Accident Investigation Report

BOEING AIRCRAFT COMPANY B737-200

PK–RIL

ABDURRACHMAN SALEH AIRPORT,
MALANG
EAST JAVA

REPUBLIC OF INDONESIA

1 NOVEMBER 2007

NATIONAL TRANSPORTATION SAFETY COMMITTEE
MINISTRY OF TRANSPORTATION
REPUBLIC OF INDONESIA
2009

This report was produced by the National Transportation Safety Committee (NTSC), Karya Building 7th Floor Ministry of Transportation, Jalan Medan Merdeka Barat No. 8 JKT 10110, Indonesia.

The report is based upon the investigation carried out by the NTSC in accordance with Annex 13 to the Convention on International Civil Aviation, Aviation Act (UU No.1/2009), and Government Regulation (PP No. 3/2001).

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GLOSSARY OF ABBREVIATIONS

AD	:	Airworthiness Directive
AFM	:	Airplane Flight Manual
AGL	:	Above Ground Level
ALAR	:	Approach-and-Landing Accident Reduction
AMSL	:	Above Mean Sea Level
AOC	:	Air Operator Certificate
ATC	:	Air Traffic Control
ATPL	:	Air Transport Pilot License
ATS	:	Air Traffic Service
ATSB	:	Australian Transport Safety Bureau
Avsec	:	Aviation Security
BMG	:	Badan Meterologi dan Geofisika
BOM	:	Basic Operation Manual
°C	:	Degrees Celsius
CAMP	:	Continuous Airworthiness Maintenance Program
CASO	:	Civil Aviation Safety Officer
CASR	:	Civil Aviation Safety Regulation
CPL	:	Commercial Pilot License
COM	:	Company Operation Manual
CRM	:	Cockpit Recourses Management
CSN	:	Cycles Since New
CVR	:	Cockpit Voice Recorder
DFDAU	:	Digital Flight Data Acquisition Unit
DGCA	:	Directorate General Civil Aviation
DME	:	Distance Measuring Equipment
EEPROM	:	Electrically Erasable Programmable Read Only Memory
EFIS	:	Electronic Flight Instrument System
EGT	:	Exhaust Gas Temperature
EIS	:	Engine Indicating System
FL	:	Flight Level
F/O	:	First officer or Copilot
FDR	:	Flight Data Recorder
FOQA	:	Flight Operation Quality Assurance
GPWS	:	Ground Proximity Warning System
hPa	:	Hectopascals

Hrs	:	Hours
ICAO	:	International Civil Aviation Organization
IFR	:	Instrument Flight Rules
IIC	:	Investigator in Charge
ILS	:	Instrument Landing System
Kg	:	Kilogram(s)
Km	:	Kilometer(s)
Kt	:	Knots (nm/hours)
Mm	:	Millimeter(s)
MTOW	:	Maximum Take-off Weight
NM	:	Nautical mile(s)
NTSB	:	National Transportation Safety Board (USA)
KNKT/NTSC	:	Komite Nasional Keselamatan Transportasi / National Transportation Safety Committee
PIC	:	Pilot in Command
QFE	:	Height above airport elevation (or runway threshold elevation) based on local station pressure
QNH	:	Altitude above mean sea level based on local station pressure
RESA	:	Runway End Safety Area
RPM	:	Revolution Per Minute
ROV	:	Remotely Operated Vehicle
SCT	:	Scattered
S/N	:	Serial Number
SSCVR	:	Solid State Cockpit Voice Recorder
SSFDR	:	Solid State Flight Data Recorder
TS/RA	:	Thunderstorm and rain
TAF	:	Terminal Aerodrome Forecast
TPL	:	Towed Pinger Locator
TSN	:	Time Since New
TT/TD	:	Ambient Temperature/Dew Point
TTIS	:	Total Time in Service
UTC	:	Universal Time Coordinate
VFR	:	Visual Flight Rules
VMC	:	Visual Meteorological Conditions

INTRODUCTION

SYNOPSIS

On the afternoon of 1 November 2007, a Boeing Company B737-200 aircraft, registered PK-RIL, operated by PT. Mandala Airlines as flight number MDL 260, on a scheduled passenger flight from Jakarta Soekarno-Hatta International Airport, Jakarta, was substantially damaged as a result of a severe hard landing sequence at Abdurrachman Saleh Airport, Malang, East Java. There were 94 persons on board the aircraft, consisting of two pilots, three cabin crew, and 89 passengers.

The investigation determined that the crew did not refer to the aircraft rate of descent when it exceeded 1,000 feet/minute during the landing approach, and was therefore an unstabilized approach condition.

The investigation also determined that the PIC did not respond appropriately to the any of ground proximity warning system voice ‘aural warnings that were initiated during the latter stages of the approach as a result of the high rate of descent of the aircraft.

The derived FDR data revealed that the aircraft bounced to a height of about 20 feet after the initial severe hard landing. However, there was no attempt by the crew to recover from the high bounce by initiating a go-around.

The investigation concluded that:

- the flight crew did not appear to have an awareness that the aircraft was above the desired approach path to runway 35 at Malang until they sighted the visual approach slope indication lighting system; and
- Non-adherence by the flight crew to stabilized approach procedures, which resulted in the initial severe hard landing at Malang, together with the omission of a high bounced landing recovery, resulted in substantial damage to the aircraft.

On 2 December 2009, Mandala Airlines informed the NTSC that its safety action included issuing a Safety Quality Notice to all pilots stressing required procedures for stabilized approach in IMC and VMC. The SQN reinforced previous SQNs issued in November 2007 and September 2008, and a 10 November 2007 Mandala safety news letter article.

The National Transportation Safety Committee’s (NTSC) report includes recommendations to PT. Mandala Airlines and the Directorate General of Civil Aviation to address safety deficiencies relating to flight crew training for the prevention of unstabilized approaches.

1 FACTUAL INFORMATION

1.1 HISTORY OF THE FLIGHT

On 1 November 2007, a Boeing Company B737-200 aircraft, registered PK-RIL, operated by PT. Mandala Airlines as flight number MDL 260, was on a scheduled passenger flight from Jakarta Soekarno-Hatta International Airport, Jakarta, to Abdurrachman Saleh Airport[1], Malang, East Java. The pilot in command (PIC) was the handling pilot, and the copilot was the support/monitoring pilot. There were 94 persons on board the aircraft, consisting of two pilots, three cabin crew, and 89 passengers.

The aircraft landed at Malang at 1324 Western Indonesian Standard Time (06:24 Coordinated Universal Time (UTC)[2]).

It was reported to have been raining heavily when the aircraft landed on runway 35 at Malang. The aircraft bounced twice after the initial severe hard landing[3], and the lower drag strut of the nose landing gear fractured, resulting in the rearwards collapse of the nose landing gear and separation of the lower nose landing gear shock strut and wheel assembly. The aircraft's nose then contacted the runway, and the aircraft came to rest 290 metres before the departure end of runway 17.

The crew subsequently reported that during the visual segment of the landing approach, they realized that the aircraft was too high with reference to the precision approach path indicator (PAPI) for runway 35. The PIC increased the aircraft's rate of descent (ROD) to capture the PAPI. The high ROD was not arrested, and as a consequence, the severe hard landing occurred which substantially damaged the aircraft.

No one of the passengers or crew was injured.

1.2 INJURIES TO PERSONS

There were no reported injuries as a result of this occurrence.

1 Abdurrachman Saleh Airport is referred to as 'Malang' in this report.

2 The 24-hour clock used in this report to describe the time of day as specific events occurred is in Coordinated Universal Time (UTC). Local time, Western Indonesian Standard Time (WIB) is UTC+ 7 hours.

3 The National Transportation Safety Committee (NTSC) defines a 'severe hard landing' as one which results in damage to the aircraft.

1.3 DAMAGE TO AIRCRAFT

The aircraft was substantially damaged as a result of the severe hard landing sequence.

The underside of the forward fuselage area, extending aft to the electrical and electronics compartment bay, was severely damaged. The damage occurred following contact with the runway after the lower drag strut of the nose landing gear fractured. This resulted in the rearwards collapse of the nose landing gear, and the separations of the lower nose landing gear shock strut and wheel assembly. Both nose landing gear axles and wheel rims were fractured by the impact forces.

Figure 1: Fractured lower strut of the nose landing gear

The right centre fuselage section aft of the right wing was wrinkled, and the right inboard wing section was deformed.

The skin of that section of the wing was also wrinkled, and it was 'oil canned'[4]. The left engine cowling was damaged due to impact with the runway, and there was oil leakage from the left engine accessory gearbox.

The left aft cabin attendant crew seat attachment was broken as a result of the severe hard landing sequence.

4 Compressive stress which resulted in slight local bulging between rows of rivets or other attachments which, when subjected to pressure differential or perpendicular force at the centre, can suddenly spring inwards noisily.

Figure 2: Wrinkling on the right centre fuselage section

1.4 OTHER DAMAGE

The surface of runway 17/35 at Malang was gouged as a result of the occurrence.

1.5 PERSONNEL INFORMATION

1.5.1 Pilot in command

Age	: 45 years
Date of birth	: 19 April 1962)
Gender	: Male
Type of licence	: Air Transport Pilot Licence
Valid to	: 20 December 2007
Rating	: B737-200
Total flying time	: 19,357 hours (as reported by the operator)
Total on type	: 10,667 hours
Total last 90 days	: 175 hours
Total on type last 90 days	: 73 hours
Total on type last 7 days	: 19 hours
Total on the type last 24 hours	: 1 hour 15 minutes

Last proficiency check	: 18 July, 2007
Medical certificate	: First Class
Date of medical	: 20 June 2007
Valid to	: 20 December 2007
Medical limitation	: Required to wear corrective lenses

The PIC was wearing the required corrective lenses at the time of the serious incident.

The operator provided information that the PIC was a company check pilot on B737-200/400 aircraft.

1.5.2 Copilot

Age	: 31 years
Date of birth	: 9 November 1975
Gender	: Male
Type of licence	: Commercial Pilot Licence
Valid to	: 28 February 2008
Rating	: B737-200
Total flying time	: 2,300 hours
Total on type	: 1,528 hours
Total last 90 days	: 102 hours
Total on type last 90 days	: 102 hours
Total on type last 7 days	: 30 hours
Total on the type last 24 hours	: 1 hour 15 minutes
Last proficiency check	: 11 August, 2007
Medical certificate	: First Class
Date of medical	: 23 August 2007
Valid to	: 23 February 2008
Medical limitation	: No medical restriction

1.6 AIRCRAFT INFORMATION

1.6.1 General

Aircraft manufacturer	: The Boeing Company
Model	: B737-200
Serial number	: 22137
Year of manufacture	: 1995
Nationality	: Indonesia
Registration mark	: PK-RIL
Certificate of airworthiness	: Valid until 29 November, 2007
Certificate of registration	: Valid until 29 November, 2007
Total hours since new	: 57,823 hours

Engine details are not relevant in this occurrence.

The aircraft engines used aviation turbine-engine fuel. There was no evidence of any engine malfunctions that would have required fuel testing as part of the investigation.

The investigation determined that the aircraft had no recorded defects before the accident.

The investigation also determined that the aircraft was being operated within the approved weight and balance limits, as follows:

Maximum take off weight	: 52,617 kg
Actual take off weight	: 48,864 kg
Maximum landing weight	: 46,720 kg
Actual landing weight	: 44,964 kg

The aircraft was equipped with a ground proximity warning system (GPWS). The GPWS provided the crew with voice aural 'SINK RATE' and 'PULL UP' warning alerts if the aircraft had an excessive ROD close to terrain. Activation of either of the aural warnings depended on the aircraft's height above terrain and its ROD.

If the aircraft penetrated the outer alert boundary, the voice aural 'SINK RATE' warning was generated, and if the aircraft penetrated the inner alert boundary, the voice aural 'PULL UP' warning was then generated.

As the aircraft terrain closure (altitude) decreased, the ROD 'SINK RATE' and 'PULL UP' warning activation values also decreased, and the outer and inner alert boundaries trigger values narrowed and reduced to a minimum level of about 1,000 feet per minute ROD for the 'SINK RATE' warning alert value, and 1,500 feet per minute ROD for the ‘PULL UP’ alert warning value.

The investigation determined that the GPWS was serviceable and functioned normally during the landing approach.

1.7 METEOROLOGICAL INFORMATION

During the descent, the controller provided the crew with the following weather information at 0552: Wind 210 degrees at 5-10 knots; visibility 7 kilometres in haze; cloud base broken at 1,500 feet; temperature 30 C and dew point 21 C; altimeter 1011 hPa, 2986 inches; pressure 994 hPa and 2804 inches.

About 5 minutes before the aircraft landed, the controller informed the crew that there was “slight rain and runway wet”.

The recorded voice communications recovered from the aircraft cockpit voice recorder (CVR) revealed that the crew was flying in heavy rain, and did not visually identify the Malang runway 35 approach lights until the aircraft was on the landing approach, about 2 NM from touchdown.

At the time of the accident, 0624, the recorded weather was: Wind calm; visibility 5 kilometres in rain; cloud base broken at 1,400 feet; temperature 30 C and dew point 21 C; altimeter 1011 hPa, 2986 inches; pressure 994 hPa and 2804 inches.

1.8 AIDS TO NAVIGATION

The aerodrome visual ground aids for runway 35 were reported to have been operating normally as the aircraft approached Malang.

The recorded voice communications recovered from the aircraft’s CVR provided information that the aerodrome controller advised the crew that the aerodrome runway lights were at stage 5 intensity[5]. The CVR also provided information that the crew sighted the runway 35 precision approach path indicator (PAPI) lights when the aircraft was about 2.5 nautical miles from the touchdown point.

The investigation concluded that the availability of the Malang ground-based radio navigation aids and the on-board navigation aids, and their serviceability, were not factors in this occurrence.

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5 The intensity (‘brightness’) setting for a surface visibility of between 2,000 and 4,000 meters (1.08 – 2.16 nautical miles)

1.9 COMMUNICATIONS

The investigation determined from the CVR that the very high frequency (VHF) communications between the Malang air traffic controller and the crew were normal during the aircraft's approach to Malang. Therefore, with no identified deficiencies, communications were not considered to be a factor in this occurrence.

1.10 AERODROME INFORMATION

1.10.1 Details

City	:	Malang, Indonesia
Name	:	Abdurachman Saleh Airport
ICAO designators	:	WARA
Latitude	:	7° 55' 42"S
Longitude	:	112° 42' 48"E
Runway Number Designation and Bearing	:	17/35
Runway Length	:	1987 meters
Runway Width	:	40 meters
Air Traffic Services Communication Facilities	:	TWR frequency 122.5 MHz
Radio Navigation Facilities	:	VOR[6] 'ABD', NDB[7] "ML'

Runway 35 at Malang was a paved runway. As the aircraft approached Malang, the controller advised the crew that the runway was wet. The runway was provided with a PAPI and runway lights, and they were operational at the time of the occurrence.

1.11 FLIGHT RECORDERS

1.11.1 Flight data recorder

The flight data recorder (FDR) was recovered undamaged from the aircraft, and the readout of the recorded data was conducted at the flight recorder laboratory of the Air Accident Investigation Bureau (AAIB) of Singapore.

6 VOR : very high frequency omni-directional radio range navigation aid.

7 NDB : Non-directional beacon navigation aid.

The flight recorder unit details recorded by the operator were:

Manufacturer	: Sunstrand
Part number	: 980-4100-FWUS
Serial number	: 7111

The flight recorder unit details recorded by the AAIB during the replay and analysis in Singapore were:

Manufacturer	: Sunstrand
Part number	: 980-4100-GQUS
Serial number	: 2488

The maintenance records indicated that the FDR was installed in the aircraft on 29 May 2007 while it was undergoing a 'C3' maintenance check. However, there was no evidence of an airworthiness release certificate to cover the fitment of the FDR into the aircraft. The investigation was not able to determine which unit was installed on 29 May 2007. The actual unit fitted to the aircraft at the time of the accident was as recorded by the AAIB Singapore. However, the FDR manufacturer advised the investigation that the two units were interchangeable.

The FDR was designed to record 12 data parameters. It appeared to have operated normally, but had only recorded three data parameters. Those were magnetic heading, vertical acceleration, and VHF keying. The plots of those parameters during the final stages of the flight are depicted at Figure 3. The FDR manufacturer advised the investigation that the FDR should have been capable of recording 12 parameters. The reason the flight data recorder only recorded three parameters could not be determined.

1.11.2 Cockpit voice recorder

Manufacturer	: Fairchild Aviation Recorders
Part number	: A100
Serial number	: 53141

The aircraft CVR was recovered undamaged from the aircraft, and readout of the recorded data was conducted at the flight recorder laboratory of the AAIB of Singapore.

1.11.3 Notable facts from the CVR

The CVR had operated normally, and the quality of the recorded data was good. The transcript of relevant sections of the CVR, including English translation where appropriate, is included in the table below. The crew used the term VASI for the precision approach path indicator.

Elapsed time[8]	**Cockpit voice recording transmissions (<u>not</u> a verbatim**[9] **transcript)**	
00:30:25	PIC:	*Anda pokok tugas anda cari runway ya saya lihat dalam* '*You, your prime task is to look for the runway and I will look inside [monitor the instruments].'*
00:31:56	Copilot:	*'…look heavy rain yah.'*
00:32:00	PIC: Copilot:	*'…the runway is not in sight?'* *'…not yet.'*
00:32:03	Copilot:	*'Are the runway [35] lights illuminated?'* VHF radio call to the controller
00:32:06	Controller:	*'Yes…set to level five'* VHF radio call to the aircraft
00:32:09	Copilot:	*'OK…level five.'* VHF radio call
00:32:12	Controller:	*'What is your distance…[can you see the runway]?'* VHF radio call
00:32:15	Copilot:	*'Three [nautical] miles…negative'* VHF radio call to the controller
00:32:16	Controller:	*'OK, continue approach and report runway in sight.'* VHF radio call to the aircraft
00:32:19	SOUND OF AIRCRAFT WINDSHIELD WIPERS OPERATING	
00:32:21	PIC: There was no response from the copilot to the request of the PIC	*'Can you see the VASI*[10]*?'*

8 Elapsed time in hh.mm.ss from the commencement of the flight.

9 The CVR transcript in this section of the report is not a word-for-word presentation of the voice data that was recorded on the aircraft CVR, as some of recorded conversations were in Bahasa Indonesia.

10 VASI - visual approach slope indicator.

00:32:36	PIC: Copilot:	*'…two miles.'* *'[The runway 35]…approach light[s are] in sight.'*
00:32:40	PIC: Copilot	*'[Can]…you see [them]?'* *'[Yes…they are] in sight.'*
00:32:43 (approx)	PIC: Copilot PIC:	*'[Can]…you see [the PAPI[11]]?'* *'[Yes…they are] all white.'* *'[We are too high, aren't we]?'*
00:32:55	PIC: Copilot	*'Too high'* *'Yes…in sight.'*
00:33:01	PIC: Copilot	*'[We are too high, aren't we]?'* *'Three white [PAPI lights].'*
00:32:19	SOUND OF AUTOFLIGHT SYTEM DISENGAGE AURAL WARNING	
00:33:04	Controller:	*'[PK-RIL]…request your [distance from the aerodrome by] DME?'*[12] - VHF radio call
00:33:14	Copilot:	*'[PK-RIL has] runway 35]in sight'* - VHF radio call
	SOUND OF GPWS AURAL 'SINK RATE, SINK RATE' WARNING	
00:33:16	Controller:	*'[PK-RIL] confirm you are on final?'* VHF radio call
00:33:17	SOUND OF GPWS VOICE AURAL 'PULL UP, PULL UP' WARNING	
00:33:18	Copilot:	*'[PK-RIL] affirmative, runway [35] in sight'* VHF radio call to the controller
	SOUND OF GPWS VOICE AURAL 'PULL UP, PULL UP' WARNING	
00:33:20	Controller:	*'[PK-RIL…roger…clear to land'* VHF radio call to the aircraft
00:33:23	PIC:	*'Careful…careful!'*
	SOUND OF GPWS VOICE AURAL 'PULL UP, PULL UP' WARNING	

11 PAPI : precision approach path indicator

12 DME : distance measuring equipment

00:33:28	PIC:	*'[…let's land]!'*
	Copilot:	*'Go around Captain…Go around Captain!'*
00:33:32	SOUND OF INITIAL SEVERE HARD LANDING IMPACT	

1.12 WRECKAGE AND IMPACT INFORMATION

Refer to S.1.3 above. Various damaged nose landing gear components were found scattered along runway 35 when it was inspected after the accident.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

No medical or pathological investigations were conducted as a result of this occurrence, nor were they required.

There was no evidence that physiological factors or incapacitation of the pilots affected their performance.

1.14 FIRE

Not a factor in this occurrence.

1.15 SURVIVAL ASPECTS

After touchdown, the controller activated the airport fire service crash alarm bell, and the airport fire fighting and rescue teams responded immediately. They arrived at the accident site less than 3 minutes after the crash alarm was activated.

The passengers disembarked from the aircraft via the emergency evacuation slides after it had come to rest on runway 35 after the hard landing sequence.

1.16 TESTS AND RESEARCH

The assessment and verification of the FDR data tables conducted during the investigation revealed that the magnitude of vertical acceleration at the severe hard landing initial touchdown of 5.28 G indicated on the flight data plot was incorrect. The actual touchdown G was unable to be accurately determined, but analysis of the data indicated that it was likely to have been about 2.17 G.[13]

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[13] Boeing Commercial Aviation Services have provided information that a peak recorded vertical acceleration which exceeds 2.1G is an indication of a hard landing (Maintenance Tip, 737 MT

The assessment and verification of the FDR data tables also revealed that during the 22 seconds before the severe hard landing initial touchdown, the aircraft's average derived ROD had been about 1,750 feet / minute. That therefore represented an unstabilized approach.[14]

Derivation of the FDR data also revealed that the aircraft bounced to a height of about 20 feet after the initial severe hard landing.

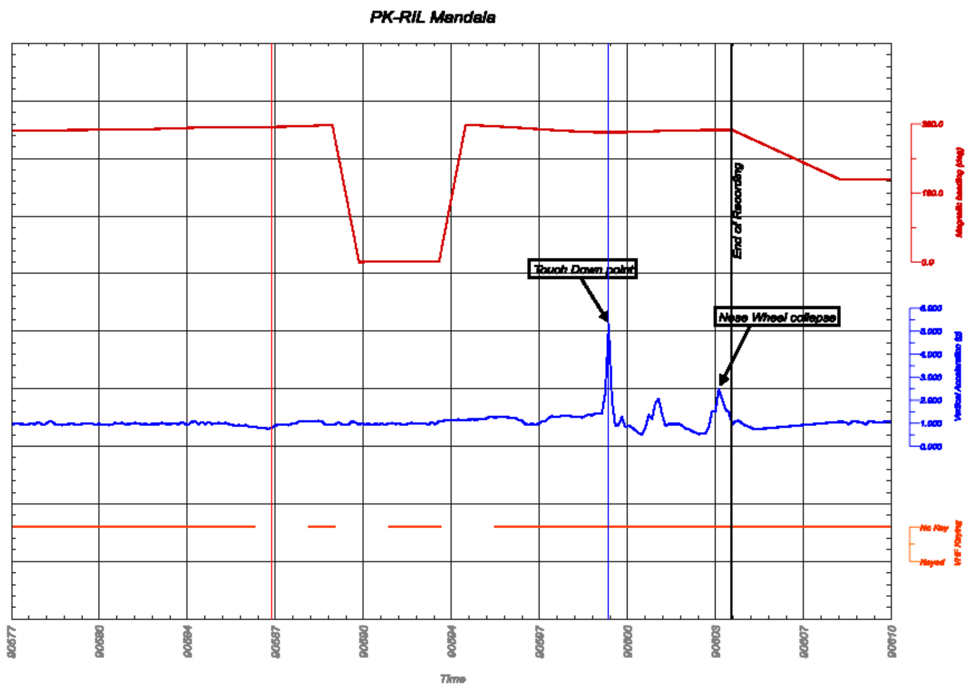

Figure 3: Recorded flight data plots

1.17 ORGANISATIONAL AND MANAGEMENT INFORMATION

Aircraft Owner	: Pann Multifinance
Aircraft Operator	: PT Mandala Airlines Jl. Tomang Raya Jakarta Republic of Indonesia
Air Operator Certificate Number	: AOC/121-005

32-012, 4 October 2001, which is applicable to all Boeing B737-100/-200/-300/-400/-500 aircraft).

14 See S.1.18.1 below for information about unstabilized approaches.

1.18 ADDITIONAL INFORMATION

1.18.1 Stabilized approach

The Mandala Airlines standard operating procedures stated:

> If the aircraft is not stabilized below 1000 ft above airport elevation in IMC and by 500 ft above airport elevation in VMC in accordance with the criteria, the Pilot in Command shall go around.

The criteria mentioned in the procedures was as per the following Flight Safety Foundation information.

The Flight Safety Foundation *Flight Safety Digest*, August – September 2000, provided information about stabilized approaches, as follows:

> *All flights must be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC).*
>
> *An approach is stabilized when all of the following criteria are met:*
>
> 1. *The aircraft is on the correct flight path;*
> 2. *Only small changes in heading/pitch are required to maintain the correct flight path;*
> 3. *The aircraft speed is not more than VREF + 20 knots indicated airspeed and not less than VREF[15];*
> 4. *The aircraft is in the correct landing configuration;*
> 5. *Sink rate is no greater than 1,000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, a special briefing should be conducted;*
> 6. *Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;*
> 7. *All briefings and checklists have been conducted;*
> 8. *Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope an localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when*

[15] VREF = Landing reference speed

the aircraft reaches 300 feet above airport elevation; and,

9. *Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.*

An approach that becomes unstabilized below1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.

1.18.2 Terrain avoidance (GPWS 'Pull up') manoeuvre

The Flight Safety Foundation *Flight Safety Digest*, August – September 2000, provided information about terrain avoidance manoeuvres following a ground proximity warning system (GPWS) 'PULL UP' aural warning, as follows:

The following should be emphasized when discussing CFIT awareness and response to a GPWS/TAWS warning:

- *Situational awareness must be maintained at all times;*
- *Preventive actions (ideally) must be taken before a GPWS/TAWS warning;*
- *Response to a GPWS/TAWS warning by the pilot flying (PF) must be immediate…*

1.18.3 Bounce Recovery – Rejected Landing

The Flight Safety Foundation *Flight Safety Digest*, August – September 2000, provided information about recovery from bounced landings, as follows:

Bouncing during a landing usually is the result of one or more of the following factors:

- *Loss of visual references;*
- *Excessive sink rate;*
- *Late flare initiation;*
- *Incorrect flare technique;*
- *Excessive airspeed; and/or,*
- *Power-on touchdown (preventing the automatic extension of ground spoilers, as applicable).*

The bounce-recovery technique varies with each aircraft type and with the height reached during the bounce.

Recovery From a Light Bounce (Five Feet or Less)

When a light bounce occurs, a typical recovery technique can be applied:

- *Maintain or regain a normal landing pitch attitude (do not increase pitch attitude, because this could lead to a tail strike);*
- *Continue the landing;*
- *Use power as required to soften the second touchdown; and,*
- *Be aware of the increased landing distance.*

Recovery ***From a High Bounce (More Than Five Feet)***

When a more severe bounce occurs, do not attempt to land, because the remaining runway may be insufficient for a safe landing.

The following go-around technique can be applied:

- *Maintain or establish a normal landing pitch attitude;*
- *Initiate a go-around by activating the go-around levers/ switches and advancing the throttle levers to the go-around thrust position;*
- *Maintain the landing flaps configuration or set a different flaps configuration, as required by the aircraft operating manual (AOM)/quick reference handbook (QRH).*
- *Be prepared for a second touchdown;*
- *Be alert to apply forward pressure on the control column and reset the pitch trim as the engines spool up (particularly with underwing-mounted engines);*
- *When safely established in the go-around and when no risk remains of touchdown (steady positive rate of climb), follow normal go-around procedures; and,*
- *Re-engage automation, as desired, to reduce workload.*

1.18.4 Flight crew coordination

In 2003, the Australian Transport Safety Bureau conducted an investigation into the circumstances leading to a controlled flight into terrain accident involving an IL-76 aircraft at Baucau, Timor-Leste. The report, ISBN 1 877071 66 8 (ATSB BO/ 200300263) included information about flight crew coordination during the operation of an aircraft which requires more than one crew member on the flight deck.

The report also included information that aircraft accidents continue to occur in which the failure of flight crew coordination is identified as a significant factor. A lack of assertiveness by copilots has contributed to a breakdown of flight crew coordination in a number of prominent aircraft accidents.

The ATSB report included details of a report prepared by the US National Transportation Safety Board (NTSB) into an aircraft accident involving an Allegheny Airlines Convair CV-580 at New Haven, Connecticut, USA on 7 June 1971. The NTSB report included information that:

> *The regulations prescribe that the pilot-in-command, during flight time, is in command of the aircraft and is responsible for the safety of the passengers, crewmembers, cargo and airplane. In this regard, he has full control and authority in the operation of the aircraft.*
>
> *The second-in-command is an integral part of the operational control system in-flight, a fail-safe factor, and as such has a share of the duty and responsibility to assure that the flight is operated safely. Therefore, the second-in-command should not passively condone an operation of the aircraft which in his opinion is dangerous, or which might compromise safety. He should affirmatively advise the captain whenever in his judgement the safety of the flight is in jeopardy.*

On 23 August 2000, a Gulf Air Airbus A320-212 crashed into the sea about 3 NM north-east of Bahrain International Airport. In its report into the accident, the Accident Investigation Board (AIB) of the Kingdom of Bahrain commented that the copilot played ‘little effective part in flight deck management and decision making’, and that:

> *At no stage did he raise any issues with, or question the captain’s decisions, even though the captain performed non-standard procedures and manoeuvres.*

The AIB 'very strongly emphasised' that at no point in the approach and final phases of the flight did the pilot in command consult the copilot or include him in the decision making process, and that:

> *The first officer was a valuable operational resource available to the captain, which he did not use effectively.*

1.19 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

The investigation was conducted in accordance with NTSC approved policies and procedures, and in accordance with the standards and recommended practices of Annex 13 to the Chicago Convention.

2 ANALYSIS

2.1 INTRODUCTION

The investigation used recovered recorded data from the cockpit voice recorded (CVR) and the flight data recorded (FDR) to analyse the final approach path of the aircraft into Malang. The aircraft flight data recorder (FDR) was designed to record 12 flight parameters, but had only recorded three parameters. The reason the FDR did not record all the intended parameters could not be determined.

The crew had conducted a non-precision approach using the runway 35 VOR at Malang. During the final approach to runway 35, from 5 NM, they were operating in reduced visibility and heavy rain.

The crew did not sight the runway 35 runway lights, or the precision approach path indicator (PAPI), until the aircraft was at about 2 NM from the touchdown point. The PAPI indicated that the aircraft was above the optimum approach path for the landing, and the pilot in command increased the aircraft's rate of descent to regain the correct approach path.

The aircraft remained above the PAPI, and the rate of descent became sufficient to trigger the ground proximity warning system (GPWS) outer alert boundary, generating the voice aural warning 'SINK RATE' sound.

The investigation determined that when the GPWS voice aural 'SINK RATE' warning was generated, the aircraft was at about 0.7 NM from the intended touchdown point on runway 35. At that stage, the aircraft should have been at a height of about 200 feet above the ground. However, the analysis of the flight data revealed that at that point, the aircraft was more than 500 feet above ground level, so above the desired approach path.

During the approach, neither crew member commented on these GPWS voice aural 'SINK RATE' warning, and the aircraft rate of descent was not reduced.

About 3 seconds after the initial GPWS voice aural 'SINK RATE' warning, the GPWS voice aural 'PULL UP' warnings commenced. At that stage the aircraft was about 0.5 NM from touchdown, and should have been at about 150 feet above the ground. However, the analysis of the flight data revealed that at that point, the aircraft was more than 400 feet above ground level, so it was still above the desired approach path.

During the approach, neither crew member commented on these GPWS voice aural ‘SINK RATE’ warnings, and the aircraft’s rate of descent was not reduced.

About 5 seconds later, the GPWS voice aural ‘PULL UP’ warning sounded again. At that stage the aircraft was about 0.3 NM from touchdown, and should have been at about 100 feet above the ground. However, the analysis of the flight data revealed that at that point, the aircraft was more than 250 feet above ground level, so still above the desired approach path.

During the approach, neither crew member commented on these GPWS voice aural ‘SINK RATE’ warning, and the aircraft rate of descent was not reduced.

Five seconds later the copilot instructed the pilot in command (PIC) to initiate a go around (discontinue the approach). However, the PIC did not acknowledge the copilot’s instruction and continued the approach and landing.

Four seconds later, the aircraft first impacted the runway in the severe hard landing sequence.

2.2 THE UNSTABILIZED LANDING APPROACH

The recorded flight data revealed that the landing approach was unstabilized. That was because the aircraft was above the correct flight path (glidepath), and that the PIC intentionally allowed the aircraft ROD to exceed 1,000 feet / minute while the aircraft was below 1,000 feet above the aerodrome elevation.

Neither crew member made any comment about the high rate of descent, or that the approach was unstabilized during the latter stages of the approach.

The investigation concluded that the crew’s apparent lack of awareness about the unstabilized condition was due to their having both been preoccupied in attempting to establish visual contact with the runway environment.

The cockpit voice recorder (CVR) confirmed that the crew was visual at about 2 NM from the touchdown point (at elapsed time 0:32:36). The derived flight data from the flight data recorder indicated that from about 0.8 NM from the touchdown point, the ROD exceeded 1,000 feet/minute.

The Flight Safety Foundation *Flight Safety Digest*, August – September 2000 recommended those circumstances and in an unstabilized configuration; rate of descent (ROD) greater than 1,000 feet/minute, an immediate go-around was required.

The crew did not refer to the rate of descent when it exceeded 1,000 feet/minute, and neither crew member called for a go-around until the copilot called *'Go around Captain…Go around Captain'* 4 seconds before the severe hard landing.

2.3 THE GPWS WARNINGS DURING THE APPROACH

During the landing approach, the high ROD triggered the GPWS voice aural 'SINK RATE' and 'PULL UP' warnings.

The investigation was unable to determine why either crew member did not comment on those GPWS voice aural warnings. The investigation was also unable to determine why the PIC did not immediately respond to the first of the 'PULL UP' warnings that sounded during the final 15 seconds of the approach before the severe hard landing occurred.

The crew's disregard of the GPWS voice aural warnings may have been because they had sighted the runway 35 PAPI and runway lighting during the latter stages of the approach. It may also have been because they were both pre-occupied with the aircraft being too high on approach path to the runway, at that stage of the landing approach.

The investigation concluded that if the PIC had responded appropriately to the first GPWS voice 'PULL UP' aural warning and initiated a go-around at that stage, the severe hard landing probably would not have occurred.

2.4 THE BOUNCED LANDING

The derived FDR data revealed that the aircraft bounced to a height of about 20 feet after the initial severe hard landing. However, there was no attempt by the crew to recover from the high bounce by initiating a go-around.

The bounce of about 20 feet was the result of an excessive ROD at touchdown, and was classified as a 'high bounce'.

The Flight Safety Foundation *Flight Safety Digest*, August – September 2000, provided information about recovery from bounced landings, and that a go-around should be initiated from a 'high bounce' landing; more than 5 feet.

The investigation concluded that had a go-around been performed during the high bounce, the substantial damage sustained by the aircraft during the subsequent ground impacts would have been avoided.

2.5 FLIGHT CREW COORDINATION

There was no evidence of effective coordination between the crew during the landing approach. The PIC instructed the copilot to look outside the aircraft while the PIC monitored the instruments. That effectively led to a complete breakdown in the coordination between the flight crew. It reduced the opportunity of the copilot to monitor or challenge the actions of the PIC in establishing the aircraft into a high ROD in his attempts to establish the aircraft on the PAPI.

Had the copilot been more assertive and challenged the PIC about the high ROD that resulted in the to the GPWS voice aural “SINK RATE’ alert, it may have reinforced to the PIC that the approach had become unstabilized.

The investigation concluded that the lack of effective coordination between the flight crew contributed to the accident.

3 CONCLUSIONS

3.1 FINDINGS

3.1.1 Aircraft

- The aircraft was operated within the approved weight limits.
- The damage to the aircraft was consistent with the reported severe hard landing sequence at Malang.
- The flight data recorder fitted to the aircraft was not the same part number as listed on the airline's maintenance documentation.
- The reason the aircraft's 12-parameter flight data recorder only recorded three parameters could not be determined.
- The emergency evacuation equipment on the aircraft functioned normally.
- None of the aircraft's occupants were injured as a result of the accident.

3.1.2 The pilots

- Both pilots were appropriately licensed to conduct the flight.
- The pilot in command (PIC) was the handling pilot for the flight.
- The PIC was approved by the operator as a check pilot on B737-200/400 aircraft.
- The PIC allowed the approach at Malang to become unstabilized and did not correct that condition.
- The PIC continued the approach in reduced visibility and heavy rain; marginal visual meteorological conditions.
- Neither pilot responded appropriately to the ground proximity warning system voice aural 'SINK RATE' or 'PULL UP' warnings that sounded during the final approach to Malang.
- The PIC did not initiate action to recover from the high bounced landing following the initial severe hard landing impact.
- The PIC did not ensure that effective crew coordination was maintained during the landing approach.

3.1.3 Communications

- Communications between the Malang Aerodrome Controller and the flight crew were normal during the aircraft's approach to Malang.

3.1.4 The weather

- There was reduced visibility and heavy rain in the vicinity of Malang at the time of the accident.

3.2 CAUSES

The flight crew did not appear to have an awareness that the aircraft was above the desired approach path to runway 35 at Malang until they sighted the visual approach slope indication lighting system.

The pilot in command continued the approach in reduced visibility and heavy rain; marginal visual meteorological conditions.

Non-adherence by the flight crew to stabilized approach procedures, which resulted in the initial severe hard landing at Malang, together with the omission of a high bounced landing recovery, resulted in substantial damage to the aircraft.

4 SAFETY ACTIONS AND RECOMMENDATIONS

4.1 SAFETY ACTIONS

On 2 December 2009, Mandala Airlines informed the National Transportation Safety Committee (NTSC) that it had taken the following safety action as a result of discussions with NTSC investigators and the recommendations contained in the draft report. The safety action included:

On 16 November 2009, issued Safety Quality Notice, SQN No: 01009 titled *Stabilized Approach in IMC and VMC*, which referred to NTSC recommendation 4.2.2 from report KNKT.07.11.27.04.

The 16 November 2009 SQN reiterated the following safety action that had previously been taken by Mandala Airlines:

On 10 November 2007, the company's safety bulletin *mandala safety talk, Volume 2, Issue 1,* contained an article titled *Wet Season Operation and ALAR Tool Kit*.

On 27 November 2007, issued SQN No: 002/XI/2007, drawing flight crews' attention to approach stability criteria detailed in the Flight Safety Foundation's *Approach and Landing Accident Reduction* (ALAR) Toolkit.

On 8 September 2008, issued SQN No: 010/IX/2008 detailing approach stability criteria.

4.2 RECOMMENDATIONS

As a result of the investigation into this accident, the National Transportation Safety Committee made the following recommendations.

4.2.1 Recommendation to PT. Mandala Airlines

The National Transportation Safety Committee recommends that PT. Mandala Airlines should ensure that its documented flight crew training procedures include information about stabilized approaches, particularly, that all flights must be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC).

4.2.2 Recommendation to PT. Mandala Airlines

The National Transportation Safety Committee recommends that PT. Mandala Airlines should also ensure that its documented flight crew training procedures include information about stabilized approach criteria, and that an approach is stabilized when all of the following criteria are met:

a. The aircraft is on the correct flight path;

b. Only small changes in heading/pitch are required to maintain the correct flight path;

c. The aircraft speed is not more than VREF + 20 knots indicated airspeed and not less than VREF;

d. The aircraft is in the correct landing configuration;

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

f. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;

g. All briefings and checklists have been conducted;

h. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope an localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation; and,

i. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

4.2.3 Recommendation to PT. Mandala Airlines

The National Transportation Safety Committee recommends that PT. Mandala Airlines should ensure that its documented flight crew procedures include information that an approach that becomes unstabilized below 1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.

4.2.4 Recommendation to PT. Mandala Airlines

The National Transportation Safety Committee recommends that PT. Mandala Airlines should ensure that all documented flight crew procedures for the management of unstabilized approaches are implemented in the PT. Mandala Airlines flight crew flight training program.

4.2.5 Recommendation to PT. Mandala Airlines

The National Transportation Safety Committee recommends that PT. Mandala Airlines review the procedures used by their maintenance organization for ensuring that flight recorders meet the relevant manufacturers' specifications.

It is further recommended that the annual inspection procedures for flight recorders, including functional checks, should also be reviewed to ensure that all parameters are being recorded in accordance with CASR 121.343 and ICAO Annex 6, Part I. 3. 4., Table D-1. The method of inspection should follow the manufacturer specification.

4.2.6 Directorate General of Civil Aviation

The National Transportation Safety Committee recommends that the Directorate General of Civil Aviation (DGCA) ensure that PT. Mandala Airlines and other Indonesian Part 121 and 135 operators have documented flight crew training procedures that include information about stabilized approaches. In particular the procedures should ensure that all flights must be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC).

4.2.7 Directorate General of Civil Aviation

The National Transportation Safety Committee recommends that the Directorate General of Civil Aviation (DGCA) ensure that PT. Mandala Airlines and other Indonesian Part 121 and 135 operators have documented flight crew training procedures that include information about stabilized approach criteria, and that an approach is stabilized when all of the following criteria are met:

a. The aircraft is on the correct flight path;

b. Only small changes in heading/pitch are required to maintain the correct flight path;

c. The aircraft speed is not more than VREF + 20 knots indicated airspeed and not less than VREF;

d. The aircraft is in the correct landing configuration;

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

f. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;

g. All briefings and checklists have been conducted;

h. Specific types of approaches are stabilized if they also fulfil the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope an localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation; and,

i. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

4.2.8 Directorate General of Civil Aviation

The National Transportation Safety Committee recommends that the Directorate General of Civil Aviation (DGCA) ensure that PT. Mandala Airlines and other Indonesian Part 121 and 135 operators have documented flight crew procedures that include information that an approach that becomes unstabilized below 1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.

4.2.9 Directorate General of Civil Aviation

The National Transportation Safety Committee recommends that the Directorate General of Civil Aviation (DGCA) ensure that PT. Mandala Airlines and other Indonesian Part 121 and 135 operators have documented flight crew procedures for the management of unstabilized approaches that are implemented in the PT. Mandala Airlines flight crew training program.

4.2.10 Directorate General of Civil Aviation

The National Transportation Safety Committee recommends that the Directorate General Civil Aviation (DGCA) review the quality assurance procedures used by PT. Mandala Airlines and other Indonesian airline maintenance organizations for ensuring that flight recorders meet the relevant manufacturers' specifications.

It is further recommended that the annual inspection procedures for flight recorders, including functional checks, should also be reviewed to ensure that all parameters are being recorded in accordance with CASR 121.343 and ICAO Annex 6, Part I. 3. 4., Table D-1. The method of inspection should follow the manufacturer specification.