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KOMITE NASIONAL KESELAMATAN TRANSPORTASI

Aircraft Accident Investigation Report

PT. Lion Mentari Airlines (Lion Air)
Boeing 737 - 800; PK-LKS
Ngurah Rai International Airport, Bali
Republic of Indonesia
13 April 2013

NATIONAL TRANSPORTATION SAFETY COMMITTEE
REPUBLIC OF INDONESIA
2014

This Final Report was produced by the Komite Nasional Keselamatan Transportasi (KNKT), 3rd Floor Ministry of Transportation, Jalan Medan Merdeka Timur No. 5 Jakarta 10110, Indonesia.

The report is based upon the initial investigation carried out by the KNKT in accordance with Annex 13 to the Convention on International Civil Aviation Organization, the Indonesian Aviation Act (UU No. 1/2009) and Government Regulation (PP No. 62/2013).

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ABBREVIATIONS AND DEFINITIONS

ABP	:	Able Bodied Passenger
AGL	:	Above Ground Level
AOC	:	Air Operator Certificate
ARFF	:	Airport Rescue and Fire Fighting
ATC	:	Air Traffic Control
ATIS	:	Aerodrome Terminal Information Services
ATPL	:	Air Transport Pilot License
ATS	:	Air Traffic Service
BMKG	:	*Badan Meteorologi Klimatologi dan Geofisika* (Meteorological Climatology and Geophysical Agency)
°C	:	Degrees Celsius
CAA-UK	:	Civil Aviation Authority - United Kingdom
CAM	:	Cockpit Area Microphone
CASR	:	Civil Aviation Safety Regulation
CB	:	Cumulonimbus
CCTV	:	Closed Circuit Television
CPL	:	Commercial Pilot License
CRM	:	Crew Resource Management
CSN	:	Cycles Since New
CVR	:	Cockpit Voice Recorder
DGCA	:	Directorate General of Civil Aviation
DH	:	Decision Height
DME	:	Distance Measuring Equipment
DMI	:	Deferred Maintenance Item
EGPWS	:	Enhance Ground Proximity Warning System
FAC	:	Flight Attendant Certificate
FCTM	:	Flight Crew Training Manual
FDR	:	Flight Data Recorder
FIR	:	Flight Information Region
FL	:	Flight Level
FMC	:	Flight Management Computer
FOQA	:	Flight Operational Quality Assurance
ft	:	Feet
hPa	:	Hectopascals
ICAO	:	International Civil Aviation Organizationn
IFR	:	Instrument Flight Rules
IIC	:	Investigator in Charge
In Hg	:	Inch Hydrargyrum
Kg	:	Kilogram(s)
Km	:	Kilometer(s)

kts	:	Knots (nm/hours)
LNAV	:	Lateral Navigation
LOFT	:	Line-oriented flight training
LPPNPI	:	*Lembaga Penyelenggara Pelayanan Navigasi Penerbangan Indonesia* (AirNav Indonesia)
mbs	:	Millibars
MDA	:	Minimum Descend Altitude
METAR	:	Meteorological Terminal Air Report
mHz	:	Mega Hertz
Mm	:	Millimeter(s)
MTOW	:	Maximum Take-off Weight
NDB	:	Non Directional Beacon
Nm	:	Nautical mile(s)
NOTAM	:	Notice to Airman
NTSB	:	National Transportation Safety Board
KNKT (NTSC)	:	*Komite Nasional Keselamatan Transportasi* (National Transportation Safety Committee)
P/A	:	Passenger Address
PAPI	:	Precision Approach Path Indicator
PF	:	Pilot Flying
PIC	:	Pilot in Command
PM	:	Pilot Monitoring
QFE	:	Height above airport elevation (or runway threshold elevation) based on local station pressure
QNH	:	Height above mean sea level based on local station pressure
RFFS	:	Rescue and Fire Fighting Service
SA	:	Situation Awareness
SAR	:	Search and Rescue
SIC	:	Second in Command
S/N	:	Serial Number
SPECI	:	Special Weather report Issued
SSCVR	:	Solid State Cockpit Voice Recorder
TAC	:	Temporary Airmen Certificate
TCAS	:	Traffic Collision Avoidance System
TDZ	:	Touch Down Zone
TEM	:	Threat and Error Management
TSN	:	Time since New
TT/TD	:	Ambient Temperature/Dew Point
UTC	:	Universal Time Coordinate
VNAV	:	Vertical Navigation
VOR	:	Very High Frequency Omnidirectional Range

INTRODUCTION

SYNOPSIS

On 13 April 2013, a Boeing 737-800 aircraft registered PK-LKS was being operated by PT. Lion Mentari Airlines (Lion Air) on a scheduled passenger flight as LNI 904. The aircraft departed from Husein Sastranegara International Airport (WICC) Bandung at 0545 UTC to Ngurah Rai International Airport (WADD), Bali, Indonesia. There were two pilots and 5 flight attendants with 101 passengers on board consisted of 95 adults, 5 children and 1 infant.

The Second in Command (SIC) was the Pilot Flying (PF) and the Pilot in Command (PIC) was the Pilot Monitoring (PM). The flight from the departure until the start of approach was uneventful.

The aircraft followed the VOR DME runway 09 instrument approach procedure. The weather while the aircraft was on final was raining.

At 0708 UTC, when the aircraft was at approximately 1,300 ft, the Ngurah Tower controller saw the aircraft on final and gave a landing clearance with additional information that the wind condition was 120° / 05 knots.

The significant information selected from the CVR, FDR and from the flight crew interview of the circumstances during final approach was as follows:

At 0708:56 UTC, while the aircraft altitude was approximately 900 feet AGL the SIC commented that the runway was not in sight whereas the PIC commented “OK. Approach light in sight, continue”. From the interview, the PIC stated that he saw flashing light at the beginning of runway 09 which was also observed by the SIC later on. Both pilots stated that the weather condition at that time was hazy and the PIC stated that he noticed that on the right side of short final area was dark.

At aircraft altitude approximately 550 feet AGL, the PF disengaged the autopilot and the auto throttle then continued to approach.

At 0709:47 UTC, the CVR recorded sound similar to rain hitting the windshield. The PIC stated that the outside environment was “totally dark”.

At 0709:53 UTC, while the aircraft altitude approximately 150 feet AGL the PIC took over the control. The SIC handed the control to the PIC and stated that he could not see the runway.

At 0710:01 UTC, after the EGPWS warning “TWENTY”, the PIC commanded for go around.

At 0710:02 UTC, the aircraft impacted to the water.

The aircraft came to a stop facing north about 20 meters from the shore or approximately 300 meters south west of the runway 09 threshold.

The Ngurah Tower controller was informed by a pilot of an aircraft was holding on short runway 09, that the aircraft that was on approach had crash into the sea near the beginning of runway 09.

At 0711 UTC, the Ngurah Tower controller pressed the crash bell.

At 0713 UTC, the rescue team departed from the ARFF station and arrived at 0715 UTC. The ARFF deployed 4 units foam tender, 1 unit ambulance and 2 units rescue tender.

At 0755 UTC, all aircraft occupants were completely evacuated, the injured passengers were

taken to the nearest hospitals and uninjured occupants to the airport crisis centre. Four passengers suffered serious injury and some others were minor or no injury.

The aircraft was substantially damaged and submerged into shallow water.

The investigation determined that there were no issues with the aircraft and all systems were operating normally.

Prior to issuing this final report, the KNKT has been informed several safety actions taken by PT. Lion Mentari Airlines and Ngurah Rai ARFF.

The investigation concluded several factors to this accident are as follows:

- An examination of the pitch angle versus engine power on the FDR data indicated that the basic principle of jet aircraft flying was not adhered during manual flying.
- The aircraft flight path became unstable below MDA when the rate of descend exceeding 1000 feet per minutes. This situation was not recognized by both pilots.
- The PIC decision and execution to go-around was conducted at an altitude which was insufficient for the go-around to be executed successfully.

The flight crew loss of situational awareness in regards of visual references once the aircraft entered a rain cloud during the final approach below minimum descend altitude (MDA).

Included in this final report, the KNKT has issued several safety recommendations to the PT. Lion Mentari Airlines, PT. Angkasa Pura I, Directorate General of Civil Aviation and Badan Meteorologi Klimatologi dan Geofisika (BMKG) to address the safety issues identified in this final report.

The investigation involved the U.S. National Transportation Safety Board (NTSB) as accredited representative.

1 FACTUAL INFORMATION

1.1 History of the Flight

On 13 April 2013, a Boeing 737-800 aircraft, registered PK-LKS, was being operated by PT. Lion Mentari Airlines (Lion Air) on a scheduled passenger flight as LNI 904.

The aircraft departed from Husein Sastranegara International Airport (WICC) Bandung[1] at 0545 UTC[2] to Ngurah Rai International Airport (WADD), Bali[3], Indonesia. The flight was the last sector of four legs scheduled for the crew on that day which were Palu (WAML) – Balikpapan (WALL) – Banjarmasin (WAOO) – Bandung (WICC) – Bali (WADD).

The aircraft flew at FL 390, while the Second in Command (SIC) was the Pilot Flying (PF) and the Pilot in Command (PIC) was the Pilot Monitoring (PM).

There were 2 pilots, 5 flight attendants and 101 passengers comprising 95 adults, 5 children and 1 infant making a total of 108 persons on board

The flight from the departure until start of the approach into Bali was uneventful.

At 0648 UTC, the pilot made first communications with the Bali Approach controller (Bali Director) when the aircraft was located 80 Nm from BLI[4] VOR. The pilot received clearance to proceed direct to the TALOT IFR waypoint and descend to 17,000 feet.

At 0652 UTC, the Bali Director issued a further clearance for the pilot direct to KUTA point and descent to 8,000 feet.

At 0659 UTC, the aircraft was vectored for a VOR DME approach for runway 09 and descent to 3,000 feet.

At 0703 UTC, while the aircraft was over KUTA point, the Bali Director transferred communications with the aircraft to Bali Control Tower (Ngurah Tower).

At 0704 UTC, the pilot contacted Ngurah Tower controller and advised that the aircraft was leaving KUTA point. The Ngurah Tower controller instructed the pilot to continue the approach and to reduce the aircraft speed to provide sufficient separation distance with another aircraft.

At 0707 UTC, the Ngurah Tower issued take-off clearance for a departing aircraft on runway 09.

At 0708 UTC, with LKS at approximately 1,600 feet AGL, the Ngurah Tower controller saw the aircraft on final approach and gave a landing clearance with additional

1 Hussein Sastranegara International Airport, Bandung will be named Bandung for the purpose of 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 for Bali is Waktu Indonesia Tengah (WITA) is UTC + 8 hours.

3 Ngurah Rai International Airport, Bali will be named Bali for the purpose of this report.

4 BLI is the code of VOR which used in Ngurah Rai International Airport.

information that the wind was from 120° at 05 knots.

At 0708:47 UTC, the aircraft Enhance Ground Proximity Warning System (EGPWS) aural alert called “ONE THOUSAND”, the SIC said one thousand, stabilized, continue, prepare for go-around missed approach three thousand.

The FDR showed that the pilot flown using LNAV (Lateral Navigation) and VNAV (Vertical Navigation) during the approach until disengagement of the Auto Pilot.

The sequence of events during the final approach is based on the recorded CVR and FDR data, and information from crew interviews as follows:

At 0708:56 UTC, while the aircraft altitude was approximately 900 feet AGL, the SIC commented that the runway was not in sight, whereas the PIC commented “OK. Approach light in sight, continue”.

At 0709:33 UTC, after the EGPWS aural alert “MINIMUM” sounded at an aircraft altitude of approximately 550 feet AGL, the SIC disengaged the autopilot and the auto-throttle and then continued the approach.

At 0709:43 UTC, the EGPWS called “THREE HUNDRED”.

At 0709:47 UTC, the CVR recorded a sound similar to rain hitting the windshield.

At 0709:49 UTC, the EGPWS called “TWO HUNDRED”.

At 0709:53 UTC, while the aircraft altitude was approximately 150 feet AGL, the PIC took over control of the aircraft. The SIC handed control to the PIC and stated that he could not see the runway.

At 0710:01 UTC, after the EGPWS called “TWENTY”, the PIC commanded for go-around.

At 0710:02 UTC, the aircraft impacted the water, short of the runway.

The aircraft stopped facing to the north at about 20 meters from the shore or approximately 300 meters south-west of the beginning of runway 09.

Between 0724 UTC to 0745 UTC, three other aircraft took-off and six aircraft landed using runway 09.

At 0750 UTC, the airport was closed until 0850 UTC.

At 0755 UTC, all occupants were completely evacuated, the injured passengers were taken to the nearest hospitals and uninjured occupants to the airport crisis centre.

Map courtesy of Google Map

Figure 1: The sequence of events

1.2 Injuries to Persons

Injuries	Flight crew	Passengers	Total in Aircraft	Others
Fatal	-	-	-	-
Serious	-	4	4	-
Minor/None	7	97	104	Not applicable
TOTAL	7	101	108	-

1.3 Damage to Aircraft

The aircraft was substantially damaged and submerged in shallow water.

Figure 2: The aircraft after the accident

1.4 Other Damage

There was no other damage to property and/or the environment.

1.5 Personnel Information

1.5.1 Pilot in Command

Gender	:	Male
Age	:	48 years
Nationality	:	Indonesian
Date of joining company	:	3 February 2003
License	:	ATPL
Date of issue	:	26 August 1994
Validity	:	11 October 2013
Aircraft type rating	:	B737-NG
Instrument rating valid to	:	31 December 2013
Medical certificate	:	First Class
Last medical check	:	19 October 2012
Validity	:	19 April 2013
Medical limitation	:	The holder shall possess glasses that correct for near vision.
Last line check	:	9 February 2013

Last proficiency check	:	31 October 2012

Flying experience

Total hours	:	15,000 hours
Total on type	:	6,173 hours 50 minutes
Last 90 days	:	272 hours
Last 60 days	:	205 hours 20 minutes
Last 24 hours	:	5 hours 20 minutes
This flight	:	1 hour 50 minutes

The PIC's last flight to Bali prior to the accident was on 10 January 2013.

Training and assessment result

The operator provided the record of training and assessment of the PIC on the aircraft type as follows:

- Completed three simulator transitions training on B737-900 ER on August 2007. The simulator check on third session indicated that the PIC received comment from the instructor*: "emphasize on his habit to continue approach and land even violate from stabilized approach element"*. The PIC was graded satisfactory with briefed and meet company standard.
- Completed simulator proficiency check on 9 November 2007 and was assessed as standard performance.
- Completed line check on 25 April 2009 and was assessed as satisfactory.
- Completed and passed the performance evaluation on proficiency check on 31 October 2012. The record indicated that the PIC was graded at minimum standard at CRM/Threat & Error management of workload management.
- Completed and passed the performance evaluation on line check on 9 February 2013.

The operator's performance evaluation included the grading of CRM/Threat & Error management.

1.5.2 Second in Command

Gender	:	Male
Age	:	24 years
Nationality	:	Indian
Date of joining company	:	25 April 2011
License	:	CPL
Date of issue	:	20 February 2010
Validity	:	19 February 2015
Aircraft type rating	:	B737-NG
Last Instrument rating	:	July 2012
Medical certificate	:	First Class

Last medical check	:	2 April 2013
Validity	:	2 October 2013
Medical limitation	:	NIL
Last line check	:	15 May 2012
Last proficiency check	:	15 December 2012

Flying experience

Total hours	:	1,200 hours
Total on type	:	923 hours
Last 90 days	:	174 hours 45 minutes
Last 60 days	:	132 hours 55 minutes
Last 24 hours	:	5 hours 20 minutes
This flight	:	1 hour 50 minutes

The SIC's last flight to Bali prior to the accident was on 4 March 2013.

Training and assessment result

The operator provided the record of training and assessment on the aircraft type he flown as follows:

- The SIC had performed standardization simulator check on 12 July 2011, the SIC was graded below standard on flying ability item. Most items were also graded as minimum standard. The result of this check was unsatisfactory.
- The SIC had completed and passed company standardization Full Flight Simulator training and check which consisted of two simulator training and one simulator check. The Training Comment Form record indicated that on first on 19 September 2011 and second on 20 September 2011 simulator standardization training the SIC was graded below standard on procedural for landing item and crosswind item. On the third simulator session which was the check on 22 September 2011, the SIC was assessed satisfactory standard for company requirement for all items. This third simulator check was also served as proficiency check. Total simulator hours were twelve hours.
- The SIC had completed line training started from 9 March 2012 until 15 May 2012. The Line Training Record showed that line training consisted of 54 sectors. The line training items included Crew Resource Management item. The SIC was assessed satisfactory as First Officer on B737 NG on 15 May 2012.

1.5.3 Flight Attendant 1

Gender	:	Female
Age	:	25 years
Nationality	:	Indonesian
Date of joining company	:	10 November 2007
License	:	FAC

Date of issue	:	17 January 2008
Validity	:	13 March 2014
Aircraft type rating	:	B737-NG
Medical certificate	:	Second Class
Last of medical	:	19 March 2013
Validity	:	7 March 2014
Medical limitation	:	None

1.5.4 Flight Attendant 2

Gender	:	Female
Age	:	22 years
Nationality	:	Indonesian
Date of joining company	:	12 July 2011
License	:	FAC
Date of issue	:	5 August 2011
Validity	:	31 March 2014
Aircraft type rating	:	B737-NG
Medical certificate	:	Second Class
Last of medical	:	28 March 2013
Validity	:	11 March 2014
Medical limitation	:	The holder shall wear corrective lenses

1.5.5 Flight Attendant 3

Gender	:	Female
Age	:	20 years
Nationality	:	Indonesian
Date of joining company	:	26 March 2013
License	:	Temporary Airman Certificate (TAC)
Date of issue	:	26 March 2013
Validity	:	25 April 2013
Aircraft type rating	:	B737
Medical certificate	:	Second Class
Last of medical	:	14 November 2012
Validity	:	14 November 2013

Medical limitation	:	None

1.5.6 Flight Attendant 4

Gender	:	Female
Age	:	20 years
Nationality	:	Indonesian
Date of joining company	:	17 August 2012
License	:	FAC
Date of issue	:	2 October 2012
Validity	:	25 April 2013
Aircraft type rating	:	B737 NG
Medical certificate	:	Second Class
Last of medical	:	23 May 2012
Validity	:	23 May 2013
Medical limitation	:	The holder shall wear corrective lenses

1.5.7 Flight Attendant 5

Gender	:	Female
Age	:	20 years
Nationality	:	Indonesian
Date of joining company	:	28 March 2013
License	:	Temporary Airman Certificate (TAC)
Date of issue	:	26 March 2013
Validity	:	25 April 2013
Aircraft type rating	:	B737
Medical certificate	:	Second Class
Last of medical	:	30 November 2012
Validity	:	30 November 2013
Medical limitation	:	None

1.6 Aircraft Information

1.6.1 General

Registration	:	**PK-LKS**
Manufacturer	:	Boeing Aircraft Company
Country of Manufacturer	:	United States of America
Type/ Model	:	B737-800 NG
Serial Number	:	38728
Date of manufacture	:	19 February 2013
Certificate of Airworthiness		
Issued	:	21 March 2013
Validity	:	20 March 2014
Category	:	Transport
Limitations	:	None
Certificate of Registration		
Registration Number	:	3276
Issued	:	21 March 2013
Validity	:	20 March 2014
Time Since New	:	142 hours 37 minutes
Cycles Since New	:	104 cycles
Last Major Check	:	NIL
Last Minor Check	:	NIL

1.6.2 Engines

Manufacturer	:	CFM International
Type/Model	:	Turbo Fan / CFM56-7B24E
Serial Number-1 engine	:	962584
Time Since New	:	142 hours 37 minutes
Cycles Since New	:	104 cycles
Serial Number-2 engine	:	962593
Time Since New	:	142 hours 37 minutes
Cycles Since New	:	104 cycles

On 13 April 2013, after landing at Banjarmasin from Balikpapan, the right engine "OIL FILTER BYPASS" caution light illuminated. The engineer performed a FMC #2 test and found the message "Oil filter bypass signal disagree". The engineer performed a magnetic chip detector check with no anomalies found and then repositioned the connector plug. The engine was run at idle power for 2 minutes and

the caution light did not illuminate.

Prior to the leg from Banjarmasin to Bandung, during taxi out, the "OIL FILTER BYPASS" caution light illuminated and the pilot decided to return to the apron. The engineer performed a FMC engine #2 checks and found message "oil filter bypass signal disagree" and replaced the engine oil filter. The engine was run for 2 minutes at idle power and the caution light did not illuminate.

After landing at Bandung, the pilot reported that the problem related to the ENGINE OIL FILTER BYPASS reoccurred. The engineer suspected that the problem was due to the Differential Pressure switch and transferred the defect to the Deferred Maintenance Item (DMI) category C (valid for 10 days).

1.6.3 Weight and Balance

The aircraft departed Bandung for Bali within the proper weight and balance envelope, as shown in the following table:

Maximum take-off weight	:	73,935 kg
Actual take-off weight	:	56,465 kg
MAC TOW	:	28.4 %
MAC TOW Limit	:	6% - 30%
Estimated Landing Weight	:	52,765 kg
MAC LDG	:	15.99 %
MAC LDG Limit	:	6%-35%

1.6.4 Enhanced Ground Proximity Warning System (EGPWS)

The aircraft was equipped with a Honeywell Enhanced Ground Proximity Warning System (EGPWS) serial number: EMKS – 34870 and part number 965-1690-055.

Examination of the FDR and CVR information indicated that no EGPWS warnings occurred during the accident sequence. Further examination of FDR data indicated that the aircraft did not enter the EGPWS alert/ warning envelope during the approach (Figure 3).

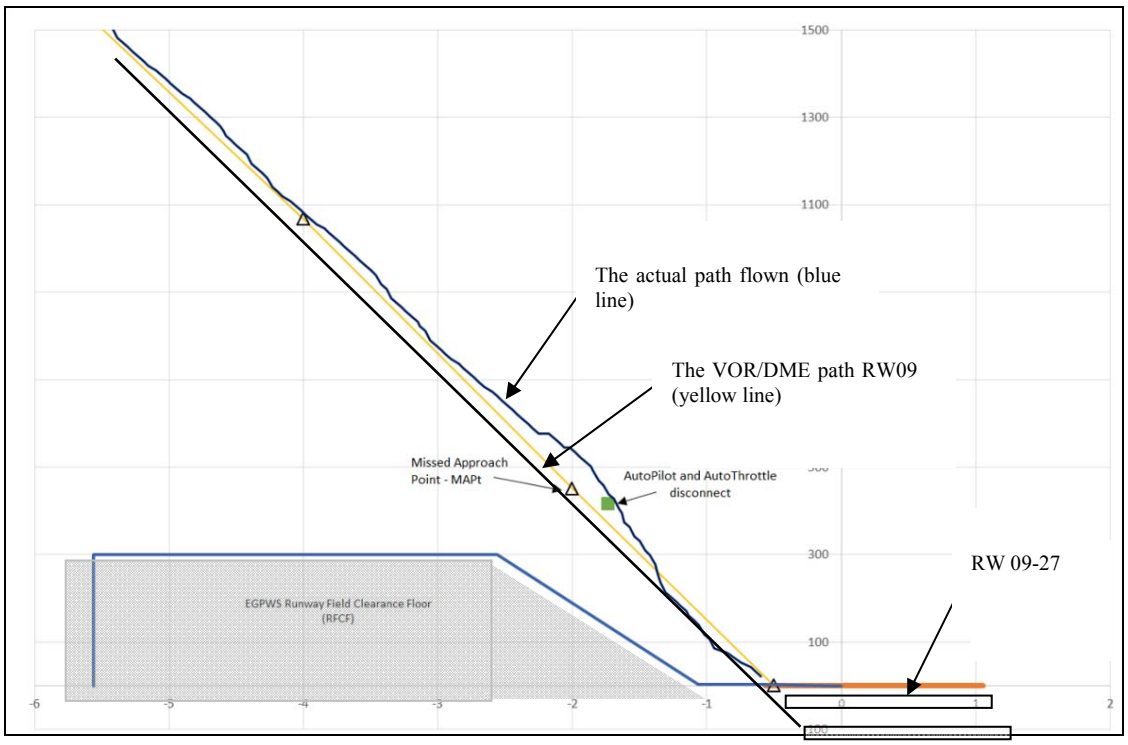


Figure 3: Aircraft flight path with respect to EGPWS envelope

The final approach phase of the flight profile was outside the envelope. Therefore there was no EGPWS terrain warning.

1.7 Meteorological Information

1.7.1 Aerodrome Terminal Information System (ATIS)

The weather data was issued by the Badan Meteorologi Klimatologi dan Geofisika (BMKG) at thirty minutes intervals, with the weather observation being performed ten minutes prior to the issuance.

The weather reported by Bali Aerodrome Terminal Information Services (ATIS) on 13 April 2013 was as follows:

	0630 UTC	**0700 UTC**	**0730 UTC**
Wind	120° / 3 knots	090° / 7 knots	130° / 7 knots
Visibility	10 km	10 km	10 km
Weather	NIL	NIL	NIL
Cloud	Broken 1,700 ft	Broken 1,700 ft	Few CB Scatter 1,700 ft
Temp/ Dew point	30° C / 25° C	30° C / 26° C	30° C / 25° C
QNH	1007 mbar / 29.73 in Hg	1007 mbar / 29.73 in Hg	1007 mbar / 29.73 in Hg

QFE	1007 mbar / 29.73 in Hg	1006 mbar / 29.70 in Hg	1006 mbar / 29.70 in Hg
Remarks	No significant	No significant	No significant

1.7.2 Satellite Image

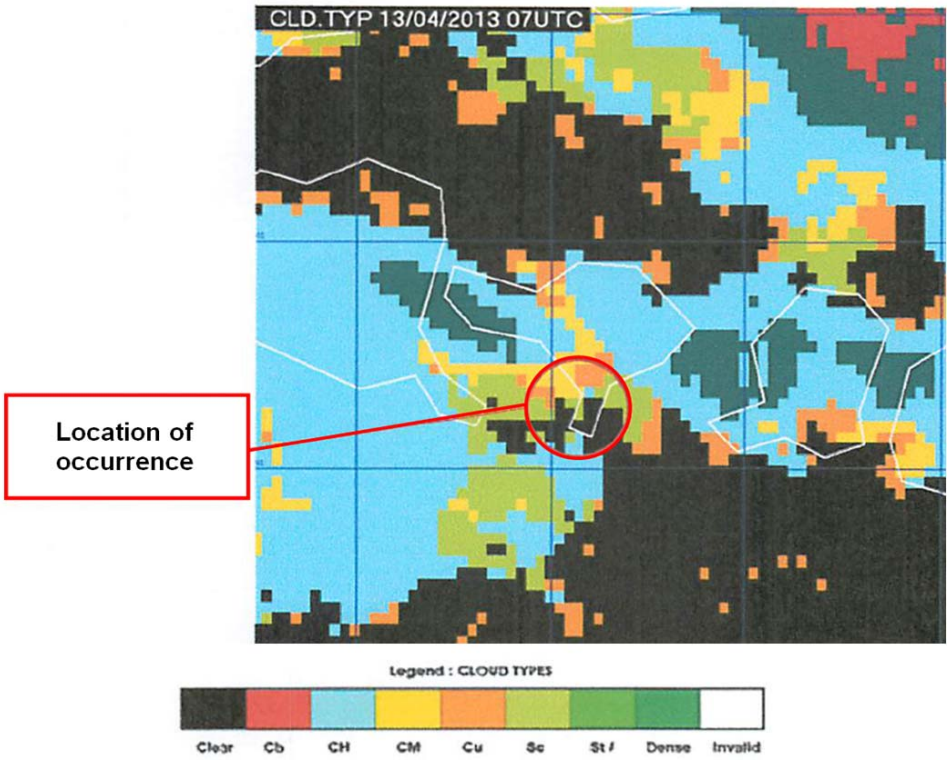


Figure 4: Satellite image at 0700 UTC provided by BMKG

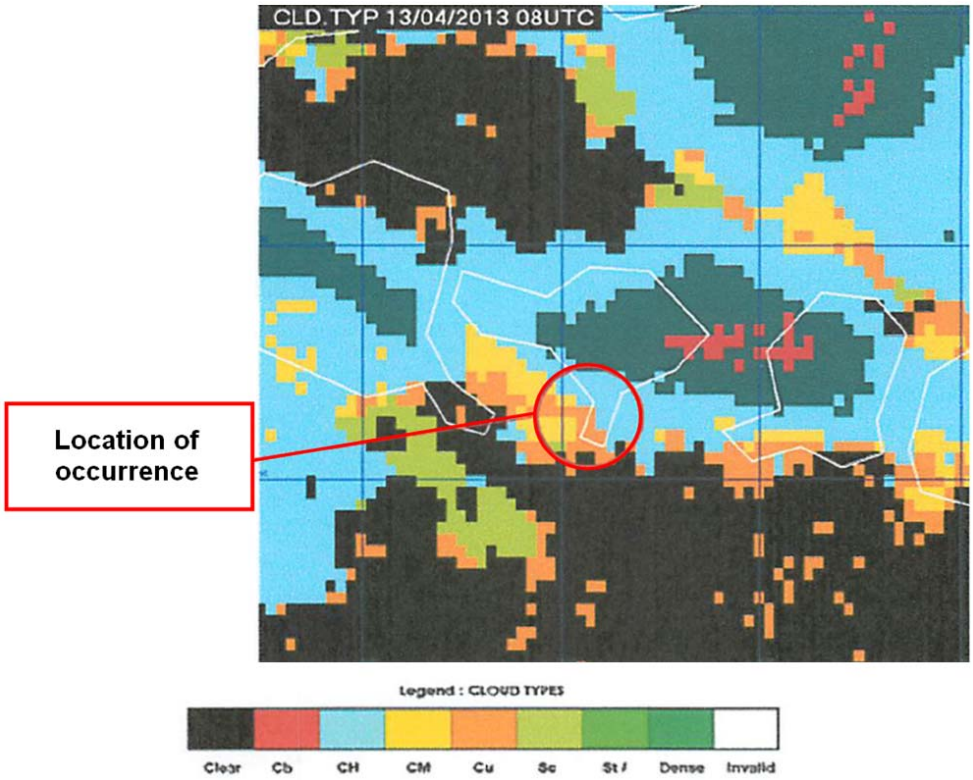


Figure 5: Satellite image at 0800 UTC provided by BMKG

1.7.3 Additional Weather Information

The CVR recorded data revealed that during the approach on short final, the SIC stated that he could not see the runway. In addition, the CVR recorded a sound, similar to rain hitting the windshield during the approach.

A report from the pilot of an aircraft that made an approach 5 Nm behind the accident flight stated that they could not see the runway at the published minima and decided to go-around. During the second approach, the pilots could see the runway before the minima.

Another report from a pilot of an aircraft that was holding short of runway 09 stated that while accident flight made the approach, it was raining between the final area and the runway threshold and the visibility was approximately 1 - 2 km. While PK-LKS was at 3 nm as indicated on the Traffic Collision Avoidance System (TCAS), he could not see the aircraft.

The airport Closed Circuit Television (CCTV) camera located on the south side of the runway recorded the changing weather. The rain showed as a grey area on the left corner, and moving across the short-final area. The weather 4 minutes before the accident (Figure 5) showed the final area was clear.

Figure 6: The weather 4 minutes prior to the accident

The weather a few seconds prior to the accident on figure 6 shows that the final area was raining as seen from the CCTV camera.

Figure 7: The weather few seconds prior to the accident

1.7.4 Thunderstorm formation

Generally, thunderstorms require three conditions to form:

1. Moisture
2. An unstable air mass.
3. A lifting force (heat)

All thunderstorms, regardless of type, go through three stages: the **developing stage**, the **mature stage**, and the **dissipation stage.** The average thunderstorm has a 24 km (15 miles) diameter. Depending on the conditions present in the atmosphere, these three stages take an average of 30 minutes to go through.

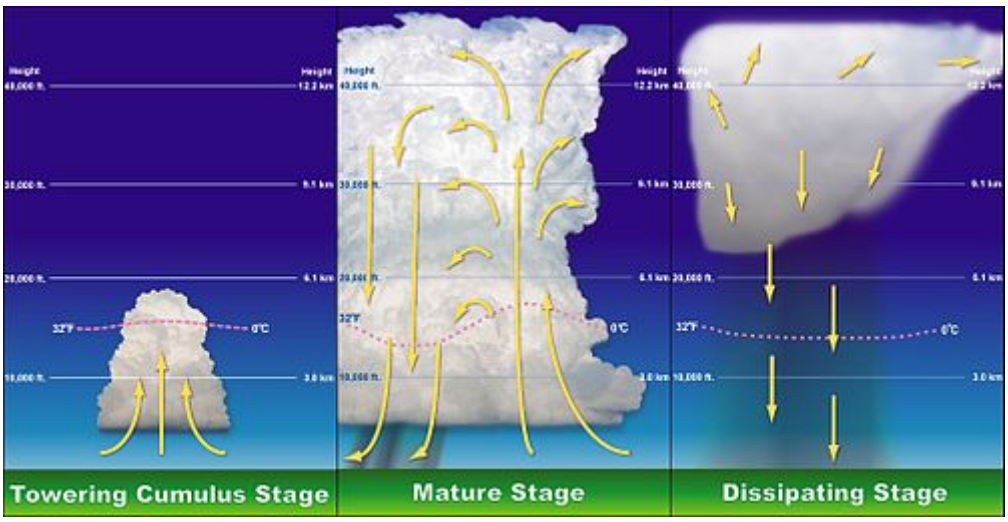


Figure 8: Stages of thunderstorm

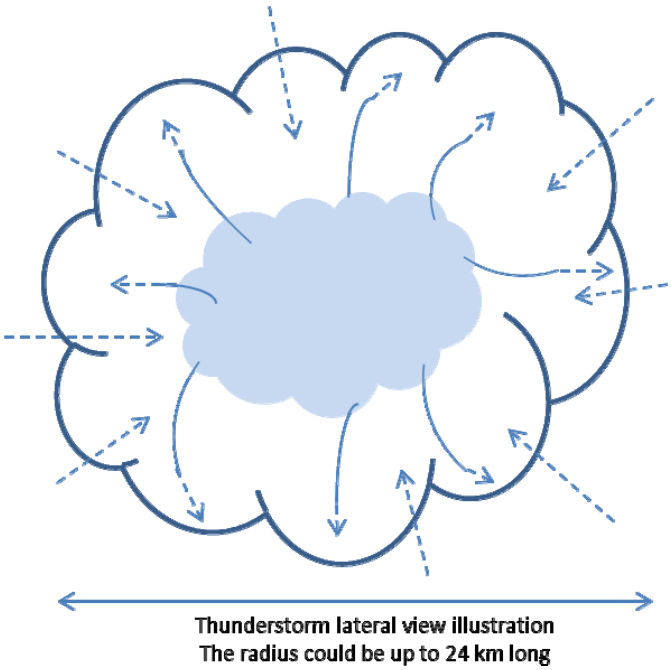


Figure 9: Lateral view illustration of thunderstorm

Cumulus Stage

The first stage of a thunderstorm is the cumulus stage, or developing stage. In this stage, masses of moisture are lifted upwards into the atmosphere. The trigger for this lift can be insolation heating the ground producing thermals, areas where two winds converge forcing air upwards, or where winds blow over terrain of increasing elevation. The moisture rapidly cools into liquid drops of water due to the cooler temperatures at high altitude, which appears as cumulus clouds. As the water vapor condenses into liquid, latent heat is released, which warms the air, causing it to become less dense than the surrounding dry air. The air tends to rise in an updraft through the process of convection (hence the term convective precipitation). This creates a low-pressure zone beneath the forming thunderstorm. In a typical thunderstorm, approximately 5×10^8 kg of water vapor is lifted into the Earth's

atmosphere.

Mature Stage

In the mature stage of a thunderstorm, the warmed air continues to rise until it reaches an area of warmer air and can rise no further. Often this 'cap' is the tropopause. The air is instead forced to spread out, giving the storm a characteristic anvil shape. The resulting cloud is called cumulonimbus incus. The water droplets coalesce into larger and heavier droplets and freeze to become ice particles. As these fall they melt to become rain.

Dissipating Stage

In the dissipation stage, the thunderstorm is dominated by the downdraft. If atmospheric conditions do not support super cellular development, this stage occurs rather quickly, approximately 20–30 minutes into the life of the thunderstorm. The downdraft will push down out of the thunderstorm, hit the ground and spread out.

1.7.5 Recommended Visibility Reporting Requirements

The following paragraphs detail the International Civil Aviation Organization (ICAO) Annex 3 recommended visibility reporting requirements.

> ***4.6 Observing and reporting of visibility***
>
> *4.6.1* ***Recommendation****- the visibility should be measured or observed by reference to objects or light whose distance from the point of observation is known.*
>
> *4.6.3* ***Recommendation****- when local routine and special reports are used for departing aircraft, the visibility observations for these reports should be representative of the take-off/climb-out area: when local routine and special reports are used for arriving aircraft, the visibility observations for these reports should be representative of the approach/landing area. Visibility observations made for reports in the METAR/SPECI codes forms should be representative of the aerodrome and its immediate vicinity: in such observations special attention should be given to significant directional variations.*

1.8 Aids to Navigation

Runway 09 Ngurah Rai International Airport was equipped with a Very High Frequency Omnidirectional radio Range (VOR) and Distance Measuring Equipment (DME) approach guidance facilities operating on a frequency of 116.2 mHz (Figure 8). The last periodic calibration was performed on 24 and 25 May 2012. The next periodic calibration was due to be performed on 25 May 2013. On the day of the accident, the VOR DME was serviceable and functioning properly.

Approach guidance facilities such as Precision Approach Path Indicator (PAPI) lights and runway lights were all serviceable. At the time of accident, only the PAPI lights were ON.

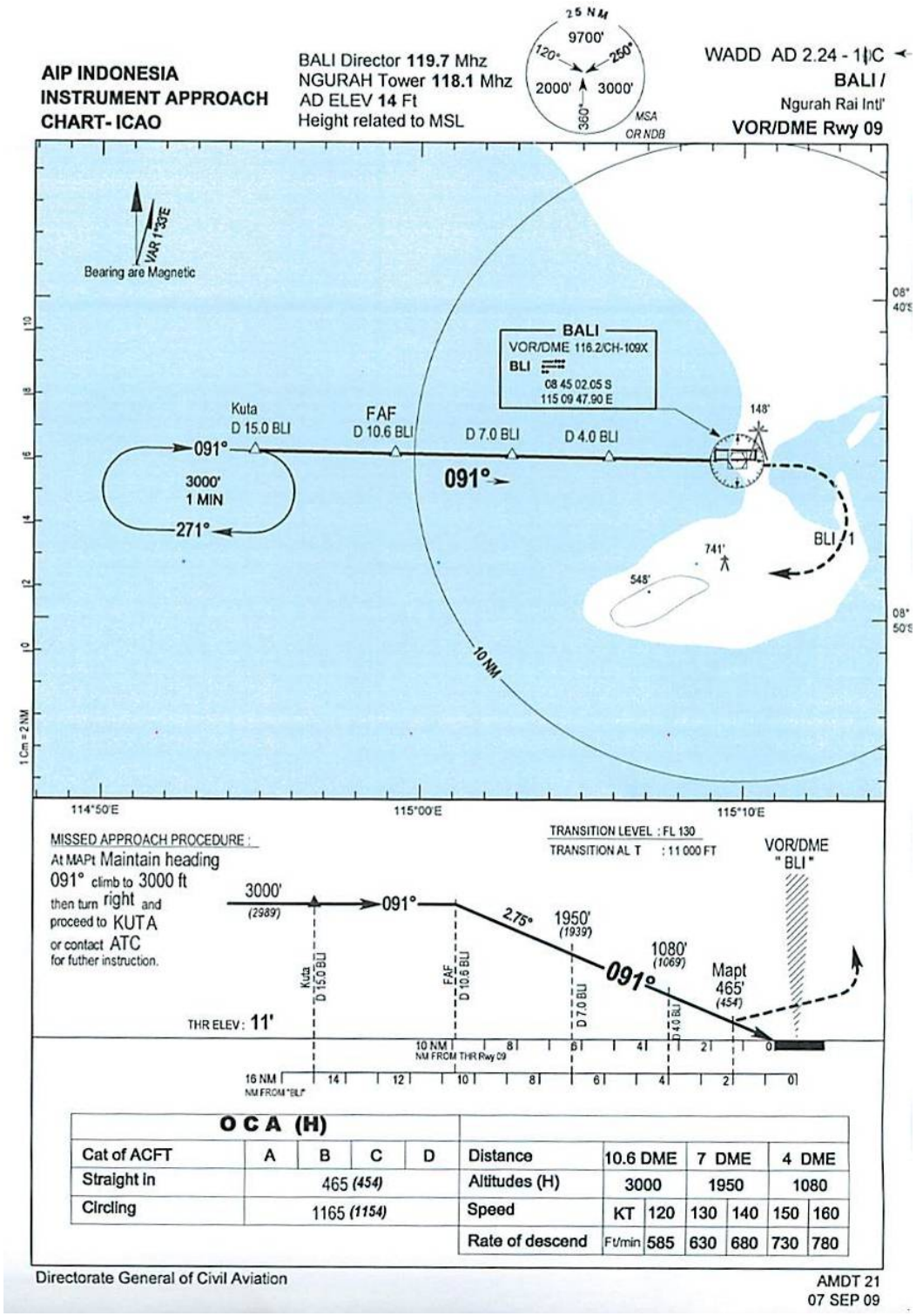


Figure 10: VOR Instrument Approach Procedure for runway 09

VOR approach was offset by 4 degrees from runway centreline. Runway centreline orientation 087 degrees, while VOR approach orientation 091 degrees.

1.9 Communications

All communications between Air Traffic Services (ATS) and the crew were recorded by ground based automatic voice recording equipment and Cockpit Voice Recorder (CVR) for the duration of the flight. The quality of the recorded transmissions was good.

1.10 Aerodrome Information

1.10.1 General

Airport Name	:	Ngurah Rai International Airport
Airport Identification	:	WADD / DPS
Airport Operator	:	PT. Angkasa Pura I (Persero)
Airport Certificate	:	015/SBU-DBU/VII/2010
Coordinate	:	08°44'51"S 115°10'09"E
Elevation	:	14 feet
Runway 09 elevation	:	11 feet
Runway Direction	:	09 – 27 / 087° - 267°
Runway Length	:	3,000 meters
Runway Width	:	45 meters
Surface	:	Asphalt
Fire fighting category	:	IX

1.10.2 Rescue and Fire Fighting

The Airport Rescue and Fire Fighting (ARFF) vehicles consist of 6 foam tender units, 3 rescue tender units, 2 rescue boats, 1 salvage unit, 1 utility car, 1 commando car and 3 ambulance units.

1.10.3 Air Traffic Services provider

The air traffic services within Indonesian airspace are provided by the *Perum* LPPNPI – *Lembaga Penyelenggara Pelayanan Navigasi Penerbangan Indonesia* (AirNav Indonesia). The Indonesian airspace is divided into two Flight Information Regions (FIR) of Jakarta and Makassar. Air traffic to Bali is included in the Makassar FIR. Bali air traffic services consist of the Bali Director, Ngurah Tower and Ngurah Ground. The Bali Director radar was not provided with weather radar information.

AirNav Indonesia was based on the President Decree number 77 of 2012 subject the AirNav Indonesia. Chapter 3 article 3 of the decree stated that the AirNav Indonesia provides Air Traffic Services (ATS), Aeronautical Telecommunication Services (ATS/COM), Aeronautical Information Services (AIS), Aeronautical Meteorological Services (MET) and Search and Rescue (SAR).

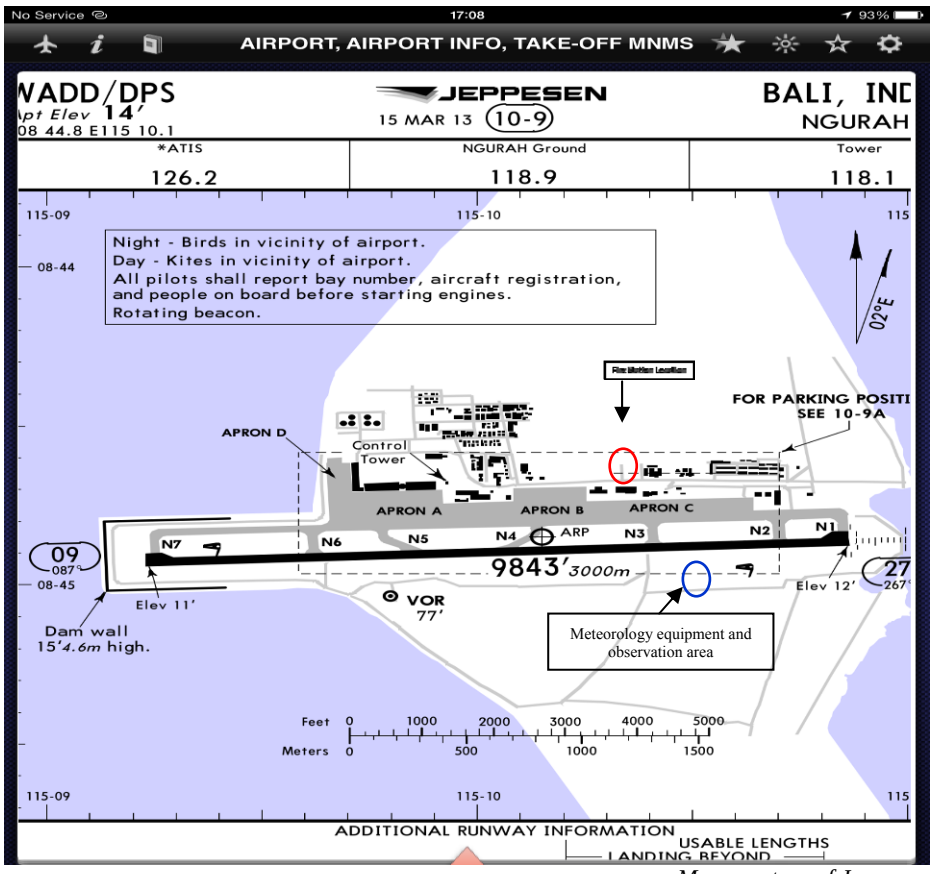
Articles 4 and 5 of the decree stated that the meteorology information may be obtained from the BMKG or any other sources if information from the BMKG is not available.

1.10.4 Badan Meteorologi Klimatologi dan Geofisika (BMKG)

The weather information for Ngurah Rai Airport, Bali was provided by BMKG Ngurah Rai office.

The meteorology equipment was located in the area on the south side of the runway, approximately 1000 meters from the beginning runway 27. Weather observations were also performed in this area (Figure 11).

The weather observations were conducted in 30 minutes interval, ten minutes prior to the issuance of the weather information to Air Traffic Services (ATS).



Map courtesy of Jeppesen

Figure 11: Airport layout, with fire station and meteorological equipment location

1.10.5 Rescue and Fire Fighting Service (RFFS) response

The following paragraphs detail the ICAO Annex 14 recommended RFFS response

requirements:

Annex 14. 9221- 9223

Response time

9.2.21 The operational objective of the rescue and fire fighting service shall be to achieve a response time not exceeding three minutes to any point of each operational runway, in optimum visibility and surface conditions.

9.2.22 ***Recommendation*** *– The operational objective of the rescue and fire fighting service should be to achieve a response time not exceeding two minutes to any point of each operational runway, in optimum visibility and surface conditions.*

9.2.23 ***Recommendation*** *– The operational objective of the rescue and fire fighting service should be to achieve a response time not exceeding three minutes to any other part of the movement area in optimum visibility and surface conditions.*

Note 1 – Response time is considered to be the time between the initial call to the rescue and fire fighting service, and the time when the first responding vehicle(s) is (are) in position to apply foam at a rate of at least 50 percent of the discharge rate specified in table 9-2.

Note 2 – To meet the operational objective as nearly as possible in less than optimum conditions of visibility, it may be necessary to provide suitable guidance and/or procedures for rescue and fire fighting vehicles.

Note 3 – Optimum visibility and surface conditions are defined as day time, good visibility, no precipitation with normal response route free of surface contamination e.g. water, ice or snow.

9.2.24 ***Recommendation*** *– any other vehicles required to deliver the amounts of extinguishing agents specified in table 9-2 should arrive no more than one minute after the first responding vehicle (s) so as to provide continuous agent application.*

Table 1: Aerodrome category for rescue and fire fighting

Table 9-1 Aerodrome category for rescue and fire fighting

Aerodrome Category (1)	*Aeroplane overall length (2)*	*Maximum Fuselage Width (3)*
1	*0 m up to but not including 9 m*	*2 m*
2	*9 m up to but not including 12 m*	*2 m*

3	*12 m up to but not including 18 m*	*3 m*
4	*18 m up to but not including 24 m*	*4 m*
5	*24 m up to but not including 28 m*	*4 m*
6	*28 m up to but not including 39 m*	*5 m*
7	*39 m up to but not including 49 m*	*5 m*
8	*49 m up to but not including 61 m*	*7 m*
9	*61 m up to but not including 76 m*	*7 m*
10	*76 m up to but not including 90 m*	*8 m*

Table 2: ***Minimum usable amounts of extinguishing agents***

Table 9-2 Minimum usable amounts of extinguishing agents

	Form meeting performance level A		*Form meeting performance level B*		*Complementary agents*
Aerodrome category (ICAO Index)	*Water (L)*	*Discharge Rate Foam Solution/ Minute (L)*	*Water (L)*	*Discharge Rate Foam Solution/ Minute (L)*	*Dry Chemical Powders (kg)*
(1)	*-2*	*-3*	*-4*	*-5*	*-6*
1	*350*	*350*	*230*	*230*	*45*
2	*1 000*	*800*	*67*	*55*	*9*
3	*1 800*	*1300*	*1 200*	*900*	*135*
4	*3 600*	*2 600*	*2 400*	*1 800*	*135*
5	*8 100*	*4 500*	*5 400*	*3 000*	*180*
6	*11 800*	*6 000*	*7 900*	*4 000*	*225*
7	*18 200*	*7 900*	*12 100*	*5 300*	*225*
8	*27 300*	*10 800*	*18 200*	*7 200*	*450*
9	*36 400*	*13 500*	*24 300*	*9 000*	*450*
10	*48 200*	*16 600*	*32 300*	*11 200*	*450*

Note 1—The quantities of water shown in columns 2 and 4 are based on the average over-all length of aeroplanes in a given category. Where operations of aeroplane larger than the average size are expected, the quantities of water would need to be recalculated. See airport manual part I for additional guidance.

Note 2 – Any other complementary agents having equivalent fire fighting capability may be used.

Table 3: ICAO RFFS Category Chart

Aerodrome category *(ICAO Index)*	Min Number Of Rescue and fire fighting vehicles	Airplane length (m)	Max Fuselage Width (M)	Water (L)		Foam Solution Discharge Rate (L/min)		Complementary Agents (Kg)
				Performance Level A	Performance Level B	Performance Level A	Performance Level B	
1	1	0<L<9	<2	350	350	230	230	45
2	1	9≤L <12	<2	1000	800	67	55	9
3	1	12≤L<18	<3	1 800	1 200	1 300	900	135
4	1	18≤L<24	<4	3 600	2 600	2 400	1 800	135
5	1	24≤L<28	<4	8 100	5 400	4 500	3 000	180
6	2	28≤L<39	<5	11 800	7 900	6 000	4 000	225
7	2	39≤L<49	<5	18 200	12 100	7 900	5 300	225
8	3	49≤L<61	<7	27 300	18 200	10 800	7 200	450
9	3	61≤L<76	<7	36 400	24 300	13 500	9 000	450
10	3	76≤L<90	<7	48 200	32 300	16 600	11 200	450

1.11 Flight Recorders

1.11.1 Flight Data Recorder

The aircraft was equipped with a Honeywell solid state flight data recorder. The recorder was subject to seawater immersion during the accident and so was rinsed and immersed in fresh water for transport to the KNKT recorder facilities in Jakarta. The FDR was received at the KNKT recorder laboratory still immersed in freshwater on 14 April 2013. The details of the FDR were:

Manufacturer : Honeywell

Type/Model : HFR5-D

Part Number : 980-4750-009

Serial Number : FDR-02070

The FDR was downloaded on 16 April 2013 at the KNKT facility in Jakarta, the recorder contained over 1,000 parameters of 53.5 hours in excellent quality data comprising the accident flight and 39 previous flights commencing from the 8 April 2013. This data also included three Bandung to Bali flights with one landing on Bali runway 09 on 12 April 2013.

No aircraft systems malfunction were recorded on FDR after the aircraft departed from Bandung on the last flight.

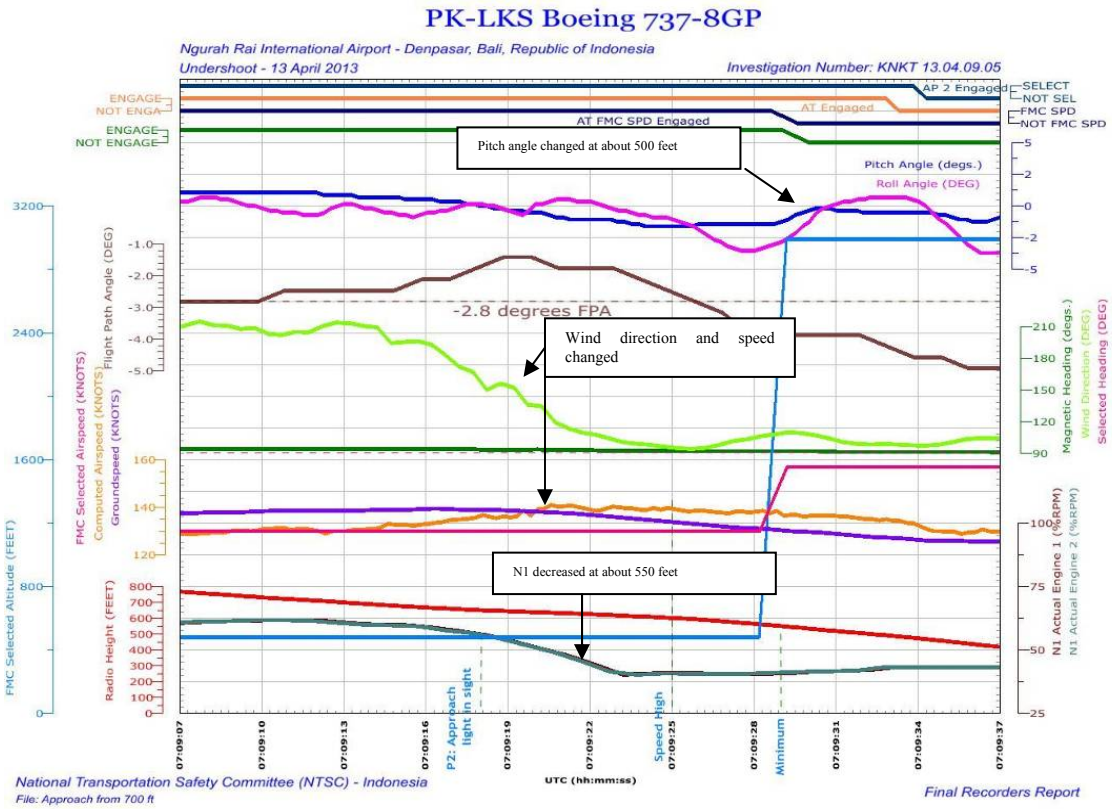


Figure 12: FDR data pitch, wind and N1

Figure 13: Aircraft flight path superimposed to Google Earth

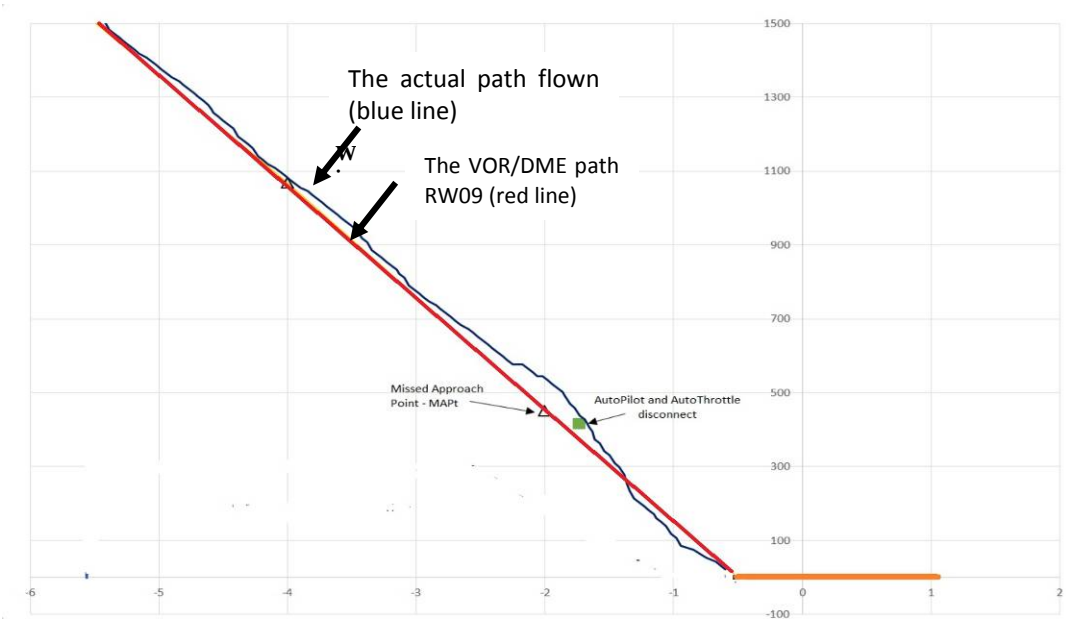


Figure 15: Descend profile during the approach from 1500 feet

The significant events recorded when automatic and manual flying from 700 feet to 20 feet

Time	UTC (hh:mm:ss)	Pressure Altitude (FEET)	Pitch Angle (degs.)	Radio Height (FEET)	Barometric Corrected Altitude 1 (FEET)	Barometric Setting MB (MB)	N1 Actual Engine 1 (%RPM)	N1 Actual Engine 2 (%RPM)	AT Engaged	AP 2 Engaged	Computed Airspeed (KNOTS)	Vertical Speed (FT/MIN)	TOGA Switch Pressed (0-NOT PR,1-PRESSED)
192541,2		733	-1,6	609	544	1006,7	40,8	40,8	ENGAGE	SELECT	139,75	-528	NOT PR
192542,2		724	-1,6	600	544	1006,7	40,9	40,6	ENGAGE	SELECT	138,75	-640	NOT PR
192543,2	7:09:27	714	-1,4	589	512	1006,7	40,8	40,5	ENGAGE	SELECT	138,25	-736	NOT PR
192544,2		702	-1,4	576	512	1006,7	40,6	40,6	ENGAGE	SELECT	138,25	-816	NOT PR
192545,2		689	-1,4	562	512	1006,7	40,6	41	ENGAGE	SELECT	138,5	-880	NOT PR
192546,2		675	-1,1	547	480	1006,7	40,8	41,4	ENGAGE	SELECT	136,75	-896	NOT PR
192547,2	7:09:31	661	-0,2	531	480	1006,7	41,5	41,6	ENGAGE	SELECT	136,5	-880	NOT PR
192548,2		647	-0,4	516	448	1006,7	41,8	41,9	ENGAGE	SELECT	136,25	-880	NOT PR
192549,2		634	-0,5	502	448	1006,7	42,1	43,1	ENGAGE	SELECT	135	-912	NOT PR
192550,2		617	-0,5	486	416	1006,7	43,2	43,2	NOT ENGA	SELECT	134,25	-944	NOT PR
192551,2	7:09:35	602	-0,5	469	416	1006,7	43,2	43,1	NOT ENGA	NOT SEL	130,75	-976	NOT PR
192552,2		587	-0,9	451	384	1006,7	43,2	43,1	NOT ENGA	NOT SEL	129,75	-1040	NOT PR
192553,2		570	-1,2	432	384	1006,7	43,2	43,2	NOT ENGA	NOT SEL	130,75	-1104	NOT PR
192554,2		551	-0,7	414	352	1006,7	43,1	43,2	NOT ENGA	NOT SEL	128,25	-1120	NOT PR
192555,2	7:09:39	534	0,4	394	352	1006,7	43,1	43,2	NOT ENGA	NOT SEL	127,75	-1088	NOT PR
192556,2		517	0,9	375	320	1006,7	43,1	43,2	NOT ENGA	NOT SEL	127,5	-1056	NOT PR
192557,2		498	0,9	358	320	1006,7	43,1	43,2	NOT ENGA	NOT SEL	128,25	-1056	NOT PR
192558,2		482	0,4	339	288	1006,7	43,1	43,4	NOT ENGA	NOT SEL	126,5	-1056	NOT PR
192559,2	7:09:43	467	-0,2	319	288	1006,7	46,4	48,6	NOT ENGA	NOT SEL	126	-1088	NOT PR
192560,2		449	-0,4	302	256	1006,7	51	51,4	NOT ENGA	NOT SEL	127,75	-1120	NOT PR
192561,2		431	-0,2	281	224	1006,7	51,5	50,9	NOT ENGA	NOT SEL	128	-1104	NOT PR
192562,2		413	-0,2	262	224	1006,7	51,2	51	NOT ENGA	NOT SEL	131	-1040	NOT PR
192563,2	7:09:47	398	0,2	245	192	1006,7	53,4	56,6	NOT ENGA	NOT SEL	129,5	-880	NOT PR
192564,2		384	0,5	230	192	1006,7	57,5	59,6	NOT ENGA	NOT SEL	129,25	-784	NOT PR
192565,2		371	1,1	216	192	1006,7	60,6	60,2	NOT ENGA	NOT SEL	130	-720	NOT PR
192566,2		361	1,6	202	160	1006,7	60,9	64,5	NOT ENGA	NOT SEL	131	-656	NOT PR
192567,2	7:09:51	350	1,8	191	160	1006,7	66,1	65,5	NOT ENGA	NOT SEL	130,5	-608	NOT PR
192568,2		339	1,8	181	160	1006,7	66	65,4	NOT ENGA	NOT SEL	128,5	-640	NOT PR
192569,2		329	1,6	166	128	1006,7	66	65,4	NOT ENGA	NOT SEL	128,25	-752	NOT PR
192570,2		315	1,2	154	128	1006,7	66	65,4	NOT ENGA	NOT SEL	128,25	-816	NOT PR
192571,2	7:09:55	300	0,9	139	96	1006,7	66,1	65,4	NOT ENGA	NOT SEL	127,25	-848	NOT PR
192572,2		285	0,9	123	96	1006,7	66,1	65,4	NOT ENGA	NOT SEL	127,25	-880	NOT PR
192573,2		272	0,5	108	64	1006,7	66	65,9	NOT ENGA	NOT SEL	128,75	-896	NOT PR
192574,2		254	-0,5	91	64	1006,7	68,2	67,5	NOT ENGA	NOT SEL	128,75	-944	NOT PR
192575,2	7:09:59	240	-0,9	74	32	1006,7	68,5	65	NOT ENGA	NOT SEL	129,5	-1024	NOT PR
192576,2		217	-1,4	58	32	1006,7	63,2	60,5	NOT ENGA	NOT SEL	130	-1104	NOT PR
192577,2		197	-1,4	37	0	1006,7	62,8	62,8	NOT ENGA	NOT SEL	129,5	-1136	NOT PR
192578,2		171	-1,1	16	-32	1006,7	66,2	64,9	NOT ENGA	NOT SEL	130,5	-1104	NOT PR
192579,2													

With Autopilot

Without Autopilot

Figure 15: The significant FDR tabulated data started from 700 feet until the end of recording

The FDR data recorded that, during the approach with autopilot and auto-throttle engaged, the aircraft flight path was relatively constant and consistent to the VOR DME approach profile. The rate of descent around 850 feet per minute, aircraft speed average 136 knots, and N1 42 % and the pitch angle around -1.4°.]

The autopilot was disengaged at an altitude of approximately 465 feet (known as MDA), and following that, the aircraft was consistently and increasing below the required descent profile.

The rate of descent was then recorded at more than 1000 feet per minute, the pitch angle varied between -0.2° to 1.8°, the average N1 62% and, while at 30 feet the FDR recorded a rate of descent of 1136 feet per minute or 18 feet per second.

1.11.2 Cockpit Voice Recorder

The aircraft was equipped with a Honeywell Solid State Cockpit Voice Recorder (SSCVR) designed to record 30 minutes of audio on four channels (P/A, Co-pilot, Pilot, Cockpit Area Microphone/CAM) and 120 minutes of audio on 2 channels (combined crew audio & CAM).

Details of the SSCVR were:

Manufacturer	:	Honeywell
Type/Model	:	SSCVR
Part Number	:	980-6022-001
Serial Number	:	CVR120-15597

The CVR was downloaded and decompressed on 18 April 2013. The CVR contained four channels of 30 minutes and two channels of 120 minutes of good quality recording. The audio files were examined and contained the accident flight.

Significant excerpts taken from the CVR are as follows:

At 0707:47 UTC, SIC stated raining here, right? PIC confirmed yes

At 0707:52 UTC, Controller issued landing clearance and wind condition (120 /05) use runway 09.

At 0708:47 UTC, EGPWS call ONE THOUSAND

SIC confirmed that the approach was stabilized, decided to continue approach and review go-around procedure.

At 0708:56 UTC, SIC stated that the runway was not in sight.

At0709:12 UTC, PIC stated that approach light in sight and decided to continue the approach.

At 0709:28 UTC, EGPWS call MINIMUM.

At 0709:32 UTC, EGPWS call FIVE HUNDRED.

At 0709:33 UTC, SIC stated manual flight.

Auto pilot disengage warning sound.

At 0709:38 UTC, EGPWS call FOUR HUNDRED

At 0709:39 UTC, PIC decided to continue approach.

At 0709:43 UTC, EGPWS call THREE HUNDRED.

PIC call out speed low

At 0709:44 UTC, SIC acknowledged and made correction.

Recorded sound similar to raining hitting the windshields

At 0709:49 UTC, EGPWS call TWO HUNDRED

At 0709:51 UTC, PIC decided to continue approach

At 0709:53 UTC, PIC took over control the aircraft

SIC gives an acknowledgement: “your control… I can’t see the runway.”

At 0709:53 UTC, EGPWS call ONE HUNDRED.
At 0709:59 UTC, EGPWS call FIFTY
At 0710:00 UTC, PIC call out check speed
EGPWS call FORTY
EGPWS call THIRTY
At 0710:01 UTC, EGPWS Call TWENTY
PIC said Go-Around
At 0710:02 UTC, The aircraft impacted the sea
At 0710:06 UTC, End of recording

1.12 Wreckage and Impact Information

The last coordinate recorded on the FDR was 08°45'00.96"S 115°09'01.01"E which was most likely the impact point.

The main landing gears broke and detached. It was found about 300 meters from the last position of the main wreckage. The engines detached from the wing pylon. Those components detached most likely due to impact with rock of the shallow sea bed. After they detached, the aircraft swung to the left at its final position.

The aircraft came to a stop facing north about 20 meters from the shore and approximately 300 meters west of the runway 09 threshold.

The wreckage was submerged in shallow water between 2 to 5 meters in depth.

Figure 16: Final aircraft resting position

The initial photographs revealed that the vertical stabilizer, right stabilizer, wings and control surfaces were in good condition with minimal damage. The right engine and both main landing gears had detached from the main wreckage.

The main cabin doors and escape hatches were all present and in the open position.

All of the observed damages were due to impact to the sea floor, coral reef and sea wall.

In the period while the KNKT investigators travelled to the accident site approximately 6 hours after the accident, the degree of damage to the aircraft had worsened due to the wave and sea current.

The examination of the flight deck found the flap handle in the flaps 15 position. However the number 1, 2, 3 and 4 Kruger flaps were found attached with all hinges intact and with the actuators at full extension. The Kruger flaps were not free to move. This indicated that the flaps were in the flap 40 position.

A review of the initial on scene photographs showed that the No.1 (Left) engine had partially separated from the wing and pylon and was located submerged in water attached at the front spar attach fitting.

Upon recovery and examination, it was noted that three of the 24 fan blades had separated at the blade platforms at about 1, 6, and 9 o'clock positions when viewing the engine rested on the ground, forward to aft. The remaining fan blades were curled and bent opposite the direction of normal clockwise rotation.

The engine intakes rub strip showed scoring, about 4 inches in width, from the 5 o'clock position clockwise to the 1 o'clock position. The compressor booster inlet guide vanes from the 4 o'clock, clockwise to the 7 o'clock position were broken, damaged or missing. The stage-one booster blades showed minor damage. The inlet/exit guide vanes all exhibited leading edge damage. From the 5 o'clock to about the 9 o'clock position the inlet/exit guide vanes were missing.

The inlet cowling was missing from about the 3 to 9 o'clock positions. The remaining cowling had no visible damage. The outboard thrust reverser was in the stowed position, the inboard thrust reverser was missing and not recovered.

1.13 Medical and Pathological Information

The report of the pathological and toxicological examinations for both pilots showed that no alcohol or drugs were detected.

1.14 Fire

There was no evidence of fire in-flight or after the aircraft impact.

1.15 Survival Aspects

The FDR recorded the aircraft impacted the water at 0710 UTC.

After the aircraft stopped, the water entered the aircraft cabin from the aft side and moved forward, the blowout panels on the flight deck door were broken.

The SIC attempted to evacuate the aircraft through the right cockpit window without success. He then evacuated the aircraft through the forward right service door.

The FA1, assisted by an able-bodied passenger (ABP)[5] opened the forward left passenger door (1L), then pulled the manual inflation handle to inflate the evacuation slide.

5 Able Body Passenger (ABP) is a passenger which selected by crewmember to assist in managing emergency situations if and as required.

The FA1 was unable to release the slide that has been inflated from the left passenger door in attempt to use the slide as floating device. During interview FA1 said that the training for this particular task was done through video presentation.

Most of the passengers evacuated the aircraft through the right over-wing exits and the right forward door, as these were the nearest exits to the shore. Some of the passengers jumped into the water then swam to the shore.

The Ngurah Tower controller was informed by a pilot of an aircraft was holding short of runway 09, that the aircraft that was on approach had crashed into the sea near the beginning of runway 09. The controller looked at the position as informed and saw the tail section of the accident aircraft outside the airport fence.

At 0711 UTC, the Ngurah Tower controller pressed the crash bell and then communicated to the Airport Rescue and Fire Fighting (ARFF) via a direct line about the accident. At this time, the airport was temporarily closed to provide unrestricted access to the fire brigade and rescue team to attend the accident site.

At 0713 UTC, the rescue team departed from the ARFF station and arrived at 0715 UTC. The ARFF deployed 4 foam tender units, 1 ambulance and 2 rescue tender units. After the fire brigade arrived at the crash site, the airport was reopened allowing several aircraft which were holding to depart and land. Subsequently at 0750 UTC, the airport operation was closed until 0850 UTC to provide access of the evacuation process of the passengers to the terminal.

Figure 17: The evacuation process

At 0717 UTC, the local armed forces, police, SAR agency and local people supported the evacuation operation.

Figure 18: The situation during evacuation process

Between 0724 UTC to 0745 UTC, three aircraft took-off (An Airbus 330-300, MA60 and Boeing 737-900) and six aircraft landed (A Boeing 737-800, Boeing 737-300, Two Airbus 320, an Airbus 330-200, and a Cessna 208) using runway 09. The largest aircraft to depart was the Airbus A330-300 with a length of 63.69m.

At 0750 UTC, the airport was closed again until 0850 UTC.

At 0755 UTC, all occupants were completely evacuated, the injured passengers were taken to the nearest hospitals and uninjured occupants to the airport crisis centre.

1.16 Tests and Research

The National Transport Safety Board (NTSB) and Boeing Aircraft Company have conducted a simulation of the event based on the FDR data. The simulation concluded that the aircraft was performing as expected given the flight control inputs (either via autopilot or manual) and any external influences on the flight path such as wind.

The results of the simulation are contained in the appendix 6.2

1.17 Organisational and Management Information

Aircraft Owner	:	Avolon Aerospace AOE 50 Limited
Address	:	PO. BOX 309 Ugland House, Grand Cayman KY1-1104 Cayman Island
Aircraft Operator	:	PT. Lion Mentari Airlines
Address	:	Jalan Gajah Mada No. 7 Jakarta Pusat, Republic of Indonesia
Operator Certificate Number	:	AOC/121-010

1.17.1 Company Operation Manual

COM.4.10.7.4.F

An approach shall not be continued below the applicable MDA/H or DA/DH unless:

a. The aircraft is continually in a position from which a descent to landing on intended runway can be made at a normal rate of descent using normal manoeuvres and where such a descent rate will allow touchdown to occur within TDZ of the runway of intended landing, and

b. The flight visibility is not less than the visibility prescribed in the standard instrument approach procedure; and

c. At least one of the following required visual references for the intended runway is distinctly visible and identifiable to the flight crew:
- *i. Elements of the approach lights system, except that below 100 ft above TDZ, the approach lights shall not be used as references,*
- *ii. The threshold,*
- *iii. The threshold markings,*
- *iv. The threshold lights,*
- *v. The visual glide slope indicator,*
- *vi. The TDZ markings,*
- *vii. The TDZ lights,*
- *viii. The runway or runway marking,*
- *ix. The runway lights.*

If any time after descent below MDA or DH/DA the PF cannot maintain visual references, he/she shall immediately execute a missed approach, follow the appropriate missed approach procedure and ATC shall be notified.

1.17.2 Operator's Crew Resource Management (CRM)

Operator's Company Operation Manual indicated that all pilots must be CRM (Crew Resource Management) certified and this program will be provided by other Training facility who is approved to conduct the CRM course, developed and design a culture to enhance safety by increasing the efficiency of pilots. This increased efficiency is realized through training in team management, communications, situation awareness, decision-making, and recognition of the resources available to assist the crew in the safe, efficient completion of any flight operations activities.

The CRM training program for pilot consists of the following discussion:

- Situational awareness
- Perception
- Role theory
- Culture
- Cockpit crew's working styles
- Motivation
- Initiative
- Personality and stress

- Interpersonal communication
- Team work
- Small organized group
- Conflict
- Decision making
- Threat and error management (TEM)
- Critique

The manual also stated that approved recurrent CRM training is to ensure each pilot is adequately trained and currently proficient with respect to the type airplane and crewmember position involved. According to information obtained from one of the operator's CRM instructors, the operator had performed routine CRM recurrent training as required by the DGCA CASR part 121.406. Since 2011, the CRM training included Threat and Error Management (TEM).

The recurrent CRM training contained the following topics:

- Relationship of crew members,
- Review of incidents/accidents from the operator's experience,
- Presentation and discussion of selected coordinated emergency procedures, and
- Crewmember evacuation drills and debriefing.

The Operational Directives chapter, sub-chapter Crew Resource Management on this manual stated that operator's CRM principles of which the crewmembers should think deeply about this idea as follows:

- Safety is my duty.
- No one is perfect, everybody makes mistakes.
- CRM is the way to correct mistakes.
- Teamwork is the result of cooperation, not competition.
- It is what is right, not who is right, that matters.
- Do first things first.
- Encourage open discussion
- Be self-critical and self-correcting.
- Good EQ (emotional intelligence) enhances crew performance.
- When in doubt, check it out.
- Don't rush! Stay cool! Think it out!
- Take care of each other.

The sub-chapter Crew Resource Management also mentioned that CRM training is focused on specific teamwork, communication, decision making, and workload management behaviors that have been proven to enhance personal effectiveness and job satisfaction. As a result of CRM training, employees will be better able to function as members of self-criticizing, self-correcting teams.

The sub-chapter also stated that each pilot shall be responsible for notifying the Pilot-in Command of any condition or circumstance that might endanger the aircraft or impair the performance of any flight crewmember.

The sub-chapter emphasized that CRM skills and performance will be periodically evaluated at all organizational levels to provide regular feedback and ensure continuous improvement.

Further the sub-chapter stated that operator's CRM training is designed to provide participants with a clear understanding of CRM Behavioral Objectives. These behavioral objectives fall into four major categories:

1. Teamwork,
2. Communication,
3. Decision -making, and
4. Workload management.

Crewmembers are expected to master these behaviors in the course of CRM and CRM LOFT training and to apply them during flight operations.

1.17.3 Reference of attitude flying

Refers to *Performance Inflight PI-QRH.20.2 Sep26.2013* about *Flight with Unreliable/ Turbulence Air Penetration.*

Final Approach (1500 FT)
Gear Down, %N1 for 3° Glideslope

FLAP POSITION (VREF+INCREMENT)		WEIGHT (1000 KG)				
		40	50	60	70	80
FLAPS 15 (VREF15+10)	**PITCH ATT**	**1.5**	**1.5**	**2.0**	**2.0**	**2.0**
	%N1	41	46	49	53	56
FLAPS 30 (VREF30+10)	**PITCH ATT**	**0.5**	**1.0**	**1.0**	**1.0**	**1.5**
	%N1	47	52	56	60	63
FLAPS 40 (VREF40+10)	**PITCH ATT**	**0.0**	**0.0**	**0.5**	**0.5**	**0.5**
	%N	51	56	61	65	68

The table above shows that to maintain a normal 3° glideslope with the flaps at 40°, the pitch angle is varied between 0.0 to maximum 0.5 and the N1 is between 51% at the lowest and 68% at maximum landing weight.

The estimated landing weight according to the weight and balance sheet was 52,765 kg. *Based* on the table above, the required pitch angle was approximately 0.1 and the N1 58%.

1.18 Additional Information

1.18.1 Flight Crew Interview Summary

The Flight crew statements during the interview were as follows:

- When at 900 feet both pilots stated that the weather condition during approach was hazy, and in addition the PIC observed that to the right side of the short final approach area was dark. The PIC added that he saw a flashing light at the beginning of runway 09. The SIC stated that he also observed the flashing light. This flashing light was called by the PIC as "approach light" as recorded in the CVR.

- The PIC also stated that the decision to continue the approach while it was raining, was based on his observation of the dark area on the right side of the final approach track was relatively narrow and he expected to be able to see the runway shortly after passing through the rain.

- When at 300 feet the PIC stated that he entered the cloud and then at 200 feet the outside environment was ”totally dark” and he added that this was his first experience flying into such condition.

1.18.2 Monitoring and Crosschecking

Monitoring task

In the context of flight operations it is defined as:

The observation and interpretation of the flight path data, configuration status, automation modes and on-board systems appropriate to the phase of flight. It involves a cognitive comparison against the expected values, modes and procedures. It also includes observation of the other crew member and timely intervention in the event of deviation. (CAA-UK Paper 2013/02, Monitoring for Pilots)

The designated Pilot Flying (PF) is responsible for flying the aircraft in accordance with the operational brief and monitoring the flight path. The Pilot Monitoring (PM) will have an explicit set of activities designated by the Standard Operating Procedures (SOPs), and as such will have a specific and primary role to monitor the aircraft’s flight path, communications and the activities of the PF. Both pilots will be responsible for maintaining their own big picture gained through cross checking each other’s actions, communication of intent and diligent observation of the PF selections, mode activations and aircraft responses.

All accurate monitoring activities result in an output following judgment and decision making and this can take the form of:

- Verbalization to other pilot or self;
- Non-verbalization in the form of gesture/eye contact;
- Note-taking in the case of auditory monitoring;
- Reinforcement of collective Situation Awareness (SA); and
- Maintenance of mental model.

Operator Flight Deck Procedures

It stated that during non-precision approach a standard instrument approach call-out must be made to facilitate awareness of flight path monitoring.

Operator Landing Procedures

The FDR data indicated that the approach lateral mode was in LNAV whilst the vertical mode was in VNAV. It stated that when Landing Procedure - Instrument Approach using VNAV is planned, the use the autopilot during the approach provides:
• Autopilot alerts and mode fail indications
• More accurate course and glide path tracking
• Lower RNP limits.

Landing Procedure - Instrument Approach using VNAV

Use the autopilot during the approach to give:

- autopilot alerts and mode fail indications
- more accurate course and glide path tracking
- lower RNP limits.

This procedure is not authorized using QFE.

Pilot Flying	Pilot Monitoring
	Notify the cabin crew to prepare for landing. Verify that the cabin is secure.
Call "FLAPS ___" according to the flap extension schedule.	Set the flap lever as directed. Monitor flaps and slats extension.
The recommended roll modes for the final approach are: • for an RNAV or GPS approach use LNAV • for a LOC-BC, VOR or NDB approach use LNAV • for a LOC, SDF or LDA approach use LNAV or VOR/LOC.	
	Verify that the VNAV glide path angle is shown on the final approach segment of the LEGS page.
When on the final approach course intercept heading for LOC, LOC-BC, SDF or LDA approaches: • verify that the localizer is tuned and identified • verify that the anticipation cue or LOC pointer is shown	
Select LNAV or arm the VOR/LOC mode.	
WARNING: When using LNAV to intercept the localizer, LNAV might parallel the localizer without capturing it. The airplane can then descend on the VNAV path with the localizer not captured.	
Use LNAV or HDG SEL to intercept the final approach course as needed.	
Verify that LNAV is engaged or that VOR/LOC is captured.	

Pilot Flying	Pilot Monitoring
Approximately 2 NM before the final approach fix and after ALT HOLD or VNAV PTH or VNAV ALT is annunciated: • verify that the autopilot is engaged • set DA(H) or MDA(H) on the MCP • select or verify VNAV • select or verify speed intervention, as needed.	Approximately 2 NM before the final approach fix, call "APPROACHING GLIDE PATH."
Call: • "GEAR DOWN" • "FLAPS 15."	
	Set the landing gear lever to DN. Verify that the green landing gear indicator lights are illuminated. Set the flap lever to 15. Set the engine start switches to CONT.
Set the speed brake lever to ARM. Verify that the SPEED BRAKE ARMED light is illuminated.	
Beginning the final approach descent, call "FLAPS ___" as needed for landing.	Set the flap lever as directed.
Call "LANDING CHECKLIST."	Do the LANDING checklist.
When at least 300 feet below the missed approach altitude, set the missed approach altitude on the MCP.	
At the final approach fix, verify the crossing altitude and crosscheck the altimeters.	
Monitor the approach.	

Pilot Flying	Pilot Monitoring
If suitable visual reference is established at DA(H), MDA(H) or the missed approach point, disengage the autopilot in accordance with regulatory requirements, and disengage the autothrottle at the same time. Maintain the glide path to landing.	

Operator Recommended Callouts - Non-ILS or Non-GLS Approach

CONDITION / LOCATION	CALLOUT (Pilot Monitoring, unless noted)
First positive inward motion of VOR or LOC course deviation indication	"COURSE/LOCALIZER ALIVE"
Final approach fix inbound	"VOR/NDB/FIX"
1,000 ft. AFE	"1,000 FEET"
500 ft. AFE	"500 FEET"
100 ft. above DA(H) or MDA(H)	"APPROACHING MINIMUMS"
Individual sequence flasher lights visible	"STROBE LIGHTS"
At DA(H) or MDA(H) with individual approach light bars visible	"MINIMUMS - APPROACH LIGHTS / RED BARS" (if installed)
At DA(H) or MDA(H) - Suitable visual reference established, i.e., PM calls visual cues	PF: "CONTINUE"
At DA(H) or MDA(H)- Suitable visual reference not established, i.e., PM does not call any visual cues or only strobe lights	PF: "GO AROUND"
At minimums callout - If no response from PF	"I HAVE CONTROL_____" (state intentions)
Below DA(H) or MDA(H)- Suitable visual reference established	"THRESHOLD/RUNWAY TOUCHDOWN ZONE"
Below DA(H) or MDA(H)- Suitable visual reference established	PF: "LANDING"
Below DA (H) or MDA(H)- Suitable visual reference not established, i.e., PM does not call any visual cues	PF: "GO AROUND"

1.18.3 Aircraft Manual

Boeing B737 NG FCTM (page 5.77) Go Around and Missed Approach – All engines operating

During an automatic go-around initiated at 50 feet, approximately 30 feet of altitude is lost. If touch down occurs after a go-around is initiated, the go-around continues. Observe that the auto throttles apply go-around thrust or manually apply go-around thrust as the airplane rotates to go-around altitude.

***Note:** an automatic go-around cannot be initiated after touchdown.*

FCOM 4.20.2 March 31 2006

Only one A/P can be engaged at a given time unless the approach (APP) mode is engaged. Approach mode allows both A/Ps to be engaged at the same time. Dual A/P operation provides control through landing flare and touchdown or an automatic go-around.

In single A/P operation, full automatic flare and touchdown capability and A/P go-around capability are not available.

FCOM NP.21.54, revision September 27 2012

Go-Around and Missed Approach Procedure

Pilot Flying	***Pilot Monitoring***
At the same time: • *Push the TO/GA switch* • *Call "FLAPS 15"*	*Position the FLAP lever to 15 and monitor flap retraction.*
Verify: • *The rotation to go-around attitude* • *That the thrust increases*	
	Verify that the thrust is sufficient for the go-around or adjust as needed
Verify a positive rate of climb on the altimeter and call "GEAR UP"	*Verify a positive rate of climb on the altimeter and call "POSITIVE RATE."* *Set the landing gear lever to up.*

Boeing FCTM 737 NG (TM), page 1.2; June 30, 2012

Throughout this manual, techniques that help build good CRM habit pattern on the flight deck are discussed. For example, situational awareness and communication are stressed. Situational Awareness or the ability to accurately perceive what is going on in the flight deck and outside the airplane, requires ongoing monitoring, questioning, crosschecking, communication, and refinement of perception.

It is important that all flight deck crewmembers identify and communicate any situation that appears unsafe or out of the ordinary. Experience has proven that the most effective way to maintain safety of flight and resolve these situations is to combine the skills and experience of all crewmembers in the decision making process to determine the safest course of action.

1.18.4 Operator Safety Emergency Procedures

4.7. Flight Crew Task Card

4.7.1. B737-NG

When cockpit task completed:

- Terrain : Take along flash light when applicable
- Water : Put on life vest-shoes off

CAPTAIN	
TERRAIN	**WATER**
a. Proceed to forward doors, and assist evacuation, command: "JUMP-SLIDE-JUMP-SLIDE" b. After evacuation completed, check cabins to ensure that all occupants have evacuated. c. Leave the aircraft take along: Flash Light and Crash axe.	a. Proceed to forward doors, and assist evacuation, command : "INFLATE LIFE VEST HERE-JUMP" b. After evacuation completed, check cabins to ensure that all occupants have evacuated. c. Inflate life vest and leave the aircraft take along: Flash light and Crash axe.
FIRST OFFICER	
a. Take cockpit fire extinguisher b. Assist to open door 1R (coordinate with FA-4) c. Leave the aircraft immediately through forward doors d. Check around aircraft for possible fire e. Assist evacuation from the outside	a. Proceed to overwing exit windows and assist to open it. b. Assist evacuation command: "ONE LEG FIRST-THEN YOUR HEAD" c. After evacuation completed, check cabin to ensure that all occupants has evacuated. d. Leave the aircraft take along flash light
IF ADDITIONAL CREW (second officer) AVAILABLE	
a. Proceed to overwing exit windows and assist to open it. b. Assist evacuation command: "ONE LEG FIRST -THEN YOUR HEAD" c. After evacuation completed, check cabin to ensure that all occupants has evacuated. d. Leave the aircraft **Note**: If the first Officer is unable to fulfill his responsibilities, the Second officer will assume the duties.	a. Proceed to overwing exit windows and assist to open it. b. Assist evacuation command : "ONE LEG FIRST-THEN YOUR HEAD" c. After evacuation completed, check cabin to ensure that all occupants has evacuated. d. Leave the aircraft **Note**: Leave the aircraft and assist evacuation from the outside whenever the First Officer has take over the Task.

NOTE:

1. ON FERRY AND POSITIONING FLIGHTS WITH NO CREWMEMBERS IN THE CABIN, THE FLIGHT CREW EVACUATES THROUGH FORWARD DOORS. TAKE ALONG EMERGENCY EQUIPMENT.
2. IF EVACUATION THROUGH FORWARD DOORS IS NOT POSSIBLE, LEAVE THE AIRCRAFT THROUGH COCKPIT SLIDING WINDOWS.

1.18.5 Frank Hawkins – "Human factor in flight"

Illusion in approach and landing

These are generally recognised as the most critical phases of flight and so visual illusions are potentially more dangerous than at other times. Crew members are most fatigued at the end of a flight, yet are then under the greatest pressure. Adverse weather conditions can have a greater influence on safety than during cruise. And time to make decisions is short and the consequences of error possibly catastrophic.

1.18.6 Pilot reaction time (ICAO Doc 8168)

Table I-2-3-1 Turn construction parameter summary

Segment or fix of turn location	*Speed (IAS)*[1]	*Altitude/height*	*Wind*	*Bank angle*[2]	*FTT (seconds)*			
					c (seconds)			
					Bank establishment time	Pilot reaction time	Outbound timing tolerance	Heading tolerance
Departure	Final missed approach IAS + 10%, see Table I-4-1-1 or Table I-4-1-2 [3]	Turn at altitude/height: Specified altitude/height Turn at turn point: A/D elevation + height based on 10% climb from DER	95% omnidirectional wind or 56 km/h (30 kt) for wind spirals	15° until 305 m (1°000 ft) 20° between 305 m (1 000 ft) and 915 m (3 000 ft) 25° above 915 m (3 000 ft)	3	3	N/A	N/A
En route	585 km/h (315 kt)	Specified altitude	95% probability wind or ICAO standard wind[4]	15°	5	10	N/A	N/A
Holding	Tables I-6-1-1 and I-6-1-2[5]	Specified altitude	ICAO standard wind[4]	23°	N/A	5	N/A	N/A
Initial approach – reversal and racetrack procedures	Table I-4-1-1 or Table I-4-1-2	Specified altitude	ICAO standard wind[4] or statistical wind	25°	5	0–6	10	5
Initial approach – DR track procedures	CAT A, B: 165 to 335 km/h (90 to 180 kt) CAT C, D, E: 335 to 465 km/h (180 to 250 kt)	CAT A, B: 1 500 m (5 000 ft) CAT C, D, E: 3 000 m (10 000 ft)	ICAO standard wind[4] DR leg: 56 km/h (30 kt)	25°	5	0–6	N/A	5
IAF, IF, FAF	See Tables I-4-1-1 and I-4-1-2 Use Initial approach speed for turn at IAF or IF Use maximum final approach speed for turn at FAF	Specified altitude	95% omnidirectional wind or 56 km/h (30 kt)	25°	3	3	N/A	N/A

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I-2-3-3

The ICAO Document 8168 shows that the pilot reaction time for the required control input is approximately 3 seconds.

1.19 Useful or Effective Investigation Techniques

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

2 ANALYSIS

The analysis part of this Final Report will discuss the relevant issues resulting in the collision with water involving a B737-800 aircraft, PK-LKS during the approach to Bali runway 09 on 13 April 2013. The investigation determined that there were no issues with the aircraft and all systems were operating normally. The analysis will therefore focus on the following issues:

- Flight path monitoring after changing from automatic to manual flight.
- Flight crew appreciation of external environment
- The Operator Standard Operating Procedure
- Observing and reporting of visibility

The other findings during the investigation that may not factors of this accident but these particular conditions are classified as safety issues

- Survivability
- Aerodrome category for fire-fighting and rescue

2.1 Flight path monitoring after changing from automatic to manual flight

2.1.1 Vertical profile

During the descent, at about 600 ft AGL, there was a wind shift that initially increased the aircraft airspeed, resulting in fluctuations to the approach profile and rate of descent (vertical speed). Approximately 20 seconds after the recorded wind shift, at an aircraft altitude of 486 feet, the autopilot was disengaged and the FDR recorded a continued steeper approach profile and increasing rate of descent.

Furthermore, during manual flight, the FDR recorded the rate of descent was up to more than 1000 feet per minute and the N1 indication varied between 41 to 45 %. At 30 feet AGL, the rate of descent was 1136 feet per minute.

The FDR recorded that the aircraft pitch angle varied between -1.1° to 1.8 ° and finally, just prior to impacting the water, was -1.6°.

According to Pilot Quick Reference Handbook (PI-QRH.20.2 Sep26.2013), *Flight with Unreliable/Turbulence Air, Penetration* with an estimated landing weight of 52,765 kg, the aircraft pitch angle should be between 0.0 to 0.5° and the N1 between 58 to 61 %.

The basic principles of jet aircraft flying for a steady approach profile states that to maintain the aircraft speed is by use of power and to maintain the aircraft vertical speed is by attitude or pitch angle. An examination of the pitch angle versus engine power on the FDR data indicated that the basic principle of jet aircraft flying was not adhered to.

2.1.2 Lateral profile

From figure 13 it was indicated that the flight from minimum descent altitude (MDA) still following the VOR approach lateral configuration (091°), rather than lining up to the runway lateral orientation (087°).

The four degrees difference was never corrected by the flying pilot.

2.2 Flight crew appreciation of external environment

At an aircraft altitude of approximately 900 feet AGL, the SIC commented that the runway was not in sight whereas the PIC commented that he could see the approach light and commanded to continue the approach. From the interview, the PIC stated that he saw a flashing light at the beginning of runway 09 which was also observed by the SIC later on.

During interview, the Ngurah Rai Tower controller stated that during that period, there was no runway lighting system illuminated other than the Precision Approach and Path Indicator (PAPI) lights.

Both pilots stated that the weather conditions at that time were hazy. The PIC stated that while on final approach, he noticed that it was dark on the right side of the short final area. This statement was confirmed by the CCTV recording which showed that the rain moved to the north toward the final track of runway 09 prior to the accident.

Refer to the thunderstorm formation: which known that all thunderstorms, regardless of type, go through three stages: the developing stage of the cumulonimbus clouds, the mature stage, and the dissipation stage. The average thunderstorm has a 24 km (15 mi) diameter. Depending on the conditions present in the atmosphere, these three stages take an average of 30 minutes to go through.

The mature stage indicated by initiation of precipitation. The thunderstorm has a specific wind velocity and the direction of water drop may impact and limiting the pilots vision.

The moving rain area as shown on the CCTV was an indication of mature stage of thunderstorm. The rain intensity was increasing as indicated by an aircraft that was on approach five miles behind the accident aircraft performing a go-around at MDA. Furthermore, the ATIS published at 07.30 UTC stated that there was a cumulonimbus cloud in the vicinity of the airport.

After the EGPWS called “THREE HUNDRED”, the CVR recorded sound similar to rain hitting the windshield. The CVR did not record the sound of windshield wiper operation.

During the interview the PIC stated that he expected that he would see the runway after passing the moving rain area as he observed only a narrow dark area on the right side of the short final track of runway 09.

At an aircraft altitude of approximately 150 feet AGL, the PIC took over control and the SIC handed control to the PIC and called that he could not see the runway.

Based on all particular statements above, the investigation identified a series of errors classified as threats as follows:

The PIC's expectation that he would be able to see the runway after the rain can be considered as inability to accurately perceive what was going on in the flight deck and outside the aircraft, including the thunderstorm formation that was observed at an aircraft altitude below 900 feet. This might be due to unutilized resources available in the flight deck and the limited visibility due to the hazy conditions which made the pilot unable to see the all thunderstorm formation properly.

An unresolved discrepancy which occurred at 300 feet and 150 feet while the SIC had clearly said that he could not see the runway, however the PIC continued the approach.

The PIC's expectation that he would be able to see the runway after the rain was not achieved, while the COM required that an immediate go-around should be executed after descent below MDA if the PF cannot maintain any visual reference.

At approximately 150 feet, the SIC called that he could not see the runway but the approach was continued until after the EGPWS called "TWENTY".

Situational awareness refers to the pilot's "perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1995, p. 36). According to Endsley, SA can be considered as knowledge of what is happening now, knowledge of what has happened previously, and knowledge of what is expected to occur in the future.

At about 900 feet, the PIC noticed that there was dark area on the short final meanwhile the flashing light was still visible. Based on this information, the PIC predicted that the dark area was narrow and the runway would be visible after a short time. This was an incorrect assessment of the weather conditions at the time.

After the aircraft entered the rain, the runway was not visible until the aircraft impacted the water. The PIC's expectation that the runway would become visible in the near future did not occur. The PIC may not have been aware of the thunderstorm characteristics, especially the mature state of cumulonimbus. The conditions stated above can be concluded as inadequate situational awareness.

2.3 The Operator's Operating Procedure

2.3.1 Go-around procedure

The (EGPWS) aural alert called out "MINIMUM" at an aircraft altitude approximately 550 feet AGL, the SIC disengaged the autopilot and the auto-throttle, and continued the approach using manual flight.

The MDA (Minimum Descent Altitude) published for the VOR/DME approach to runway 09 was 465 feet and this indicated that the EGPWS "MINIMUM" call was consistent with the aircraft altitude.

The PIC decided to continue the approach, by stating that he could see the flashing light.

After the EGPWS called “THREE HUNDRED”, the CVR recorded a sound similar to rain hitting the windshield. The PIC stated that he entered the cloud and then at 200 feet the outside environment was “totally dark” and he added that this was his first experience flying into such conditions. After the EGPWS called “TWO HUNDRED”, the PIC took over control of the aircraft. The SIC handed control to the PIC and called that he could not see the runway. The CVR did not record the sound of windshield wiper operation. Subsequently, the pilots could not see the flashing light due to decreased visibility as a result of rain hitting the windshield and the absence of windshield wiper operation.

The company operations manual stated that whenever visual reference was lost during an approach, the pilot flying should initiate a go-around procedure by pushing the TO/GA switch and calling “FLAPS 15”, while the pilot monitoring positions the flap lever to 15 and monitors flap retraction.

According to the Operator’s COM, Below DA (H) or MDA (H)- Suitable visual reference not established, i.e, PM does not call any visual cues PF should initiate Go Around. The CVR did not record any call out of visual cues by the PM.

The COM required that the PIC should immediately initiate a go-around at any time below the MDA/DH if the pilots lost visual reference with the ground.

During the subsequent interview, the PIC stated that the decision to continue the approach while it was raining, was based on his observation of the dark area on the right side of the final track was relatively narrow. The PIC expected to be able to see the runway shortly after.

Four minutes prior to the accident, the airport CCTV recorded that the final approach area was clear. During the final approach of the aircraft, the CCTV recorded that the final approach area was raining. This indicated that the dark side that was initially observed by the PIC to the right of the aircraft had moved across the final approach path.

After the autopilot was disengaged at an aircraft altitude of 486 feet, the FDR recorded a steeper rate of descent compared to when the autopilot was engaged. With the autopilot engaged, the rate of descent was approximately 850 feet per minute. When the autopilot was disengaged the aircraft was above the glide slope but subsequently descended below glide slope. At a height of 30 feet, the FDR recorded the rate of descent of 1,136 feet per minute.

After the EGPWS called out “TWENTY”, the PIC commanded a go-around. The FDR did not record the activation of TO/GA button, nor any changes of aircraft pitch angle and/or configuration as an indication of a go-around. The FDR recorded that the N1 of engine 1 increased from 63.2 %, and N1 of the engine 2 increased from 60.5 %. However within one second of commanding the go-around, the aircraft hit the water. The last FDR recorded data indicated that the N1 of engine 1 was 66.2 %, and the N1 of the engine 2 was 64.9 %.

The B737 NG FCTM 5.77 stated that during an automatic go-around initiated at 50 feet, approximately 30 feet of altitude is lost.

According to ICAO Document 8168, the pilot reaction time for the required control input is approximately 3 seconds.

In this accident, the go-around was initiated at 20 feet AGL while the rate of descent was 1136 feet per minute or 18 feet per second, which means that the impact would occur at approximately 1 second after the initiation of go-around.

Given the low height, pilot reaction time to change the aircraft configuration and the aircraft inertia, the investigation considered that a successful go-around from this position would not be able to be accomplished.

2.3.2 CRM Practices

It was stated clearly in the operator's operation manual and emphasized in the operator's flight crew operation manual that good CRM habit pattern or practice on the flight deck was paramount to achieve safe and efficient flight.

The operator's performance evaluation for the flight crew included the assessment of CRM/Threat & Error Management, however from number of training records of the PIC; it was only recorded once in the aspect of CRM/Threat & Error Management and his workload management item was graded as minimum standard. Whereas for the SIC training records, he received grading in the aspect of CRM/Threat & Error Management during his line training which consisted of 54 sectors, and generally was graded as satisfactory.

The investigation data showed that series of errors occurred during approach, among other thing such as the absence of callouts, lack of monitoring and crosschecking both lateral and vertical path especially below MDA combined with the additional factor of adverse weather conditions at low altitude, were potentially more dangerous as time to make decision was short and the consequences of these events possibly catastrophic; however these errors were not corrected timely by the flight crew in accordance with operator's CRM principles in managing threat and error.

During the final approach phase the crew was faced with a high workload. In this situation, a good CRM habit pattern, and good situational awareness was needed to identify and communicate any situation that appears unsafe or out of the ordinary, as clearly stated in the operator's COM.

Although the PIC and SIC had completed the operator CRM training and had been assessed as satisfactory, however, the crew actions during the approach indicated that their CRM practices was not effective to identify and manage the flight risk.

2.4 Observing and reporting of visibility

On 13 April 2013 at 0700 UTC, the Bali Aerodrome Terminal Information Services (ATIS) broadcast the weather: visibility 10 km, cloud broken 1,700 feet and NOSIG (no significant changes within two hours).

The pilot of an aircraft holding near the threshold of runway 09 reported that, while the accident flight made the approach, the weather on the final area until the runway threshold was raining and he could not see the aircraft, when the accident flight was at 3 nm to the runway as indicated on the Traffic Collision Avoidance System (TCAS).

The ATIS information reported that the visibility was 10 km was contrary to the condition that the aircraft could not be seen at approximately 3 nm (5 km) and that both pilots could not see the runway at an altitude of less than 300 feet. The ICAO Annex 3 recommends that visibility observation for arriving aircraft should represent the approach/landing area.

4.6 Observing and reporting of visibility

4.6.3 ***Recommendation****- ……..when local routine and special reports are used for arriving aircraft, the visibility observations for these reports should be representative of the approach/landing area.*

The weather observation was performed ten minutes prior to the issuance of weather information at an interval of 30 minutes. Based on this condition, the last weather observation prior to the accident was performed at 0650 UTC (20 minutes prior to the accident) and the next observation would be at 0720 UTC.

Referring to the CCTV footage those 4 minutes prior to the accident the rain area was on the south side of the final track and rapidly changing until after the accident. The rain might have not been observed at 0650 UTC. The rapid change of the weather phenomenon of raining and deterioration of visibility in the final approach area was not observed and reported to the pilots.

2.5 Aerodrome fire-fighting and rescue category

The Bali Ngurah Airport (WADD) aerodrome category published in the AIP on 15 November 2006 was category IX and included six foam tender units.

The CCTV recorded the ARFF units arrived near to the accident site at 0715 UTC, consisting of four foam tenders, one ambulance and one rescue tender unit.

Between 0724 UTC to 0745 UTC, three aircraft took off (an Airbus 330-300, an MA60 and a Boeing 737-900) and six aircraft landed (a Boeing 737-800, a Boeing 737-300, 2 Airbus 320, an Airbus 330-200 and a Cessna 208) using runway 09.

At 0713 UTC, the ARFF deployed four units foam tender to the accident site and two units foam tender stand by at fire station.

Referring to table 3 of this report that two foam tender units are available equal to ARFF category VI or VII. In this condition the operation of the A330 was not supported with the minimum ARFF required category IX while four units foam tender were deployed from the fire station.

While four of foam tenders units were deployed from the fire station it is probable that the response time as required by ICAO Annex 14 9.2.21 would not be achieved, when required.

3 CONCLUSIONS

3.1 Findings

The National Transportation Safety Committee findings on the accident flight are as follows:

1. The aircraft was airworthy prior to impact and has an item on the DMI (deferred maintenance item) category C (right engine oil filter).
2. The simulation showed that the airplane was performing as expected given the flight control inputs (either via autopilot or manual) and any external influences on the flight path such as wind. The investigation determined that there were no issues with the aircraft and all systems were operating normally.
3. All crew has valid licenses and medical certificates.
4. The SIC acted as Pilot Flying (PF) until taken over by the PIC on final approach at approximately 150 feet AGL.
5. The flight performed a VOR DME approach runway 09, and the published Minimum Descent Altitude (MDA) was 465 feet AGL.
6. During the approach, the CVR did not record any call out by the PM as stated in the company procedure regarding to visual reference.
7. At 900 feet AGL the PF did not have the runway in sight, while the PIC stated that he saw flashing light at the beginning of runway 09 which was also observed by the SIC latter on. The PIC commanded to continue approach.
8. Approach guidance facilities such as Precision Approach Path Indicator (PAPI) and runway lights were all serviceable. At the time of accident, only the PAPI lights were ON.
9. The FDR data showed that the aircraft crossed the extended runway centerline and continued on radial 091° BLI VOR.
10. When the EGPWS aural alert “MINIMUM” sounded at aircraft altitude of approximately 550 feet AGL, the SIC disengaged the autopilot and the auto-throttle and continued the approach manually.
11. After the EGPWS called “THREE HUNDRED” the CVR recorded sound similar to rain hitting the windshield and the PIC stated that outside environment was ”totally dark”. The CVR did not record the sound of windshield wiper operation. The airport CCTV recorded that the final area was raining.
12. The PIC took over the control of the aircraft at about 150 feet radio altitude when both pilots did not have visual references.
13. The CVR recorded that the PIC commanded to go-around at 20 feet, while the FDR did not show any changes required for go-around activation such as: Throttle Lever Angle, TOGA button, aircraft pitch up, and changing of engine parameters.
14. Before reaching the MDA the aircraft was flown with autopilot and auto-throttle engaged. After the auto-pilot and auto-throttle disengaged, the FDR recorded steeper rate of descent of which at 30 feet the rate of descend was recorded at 1136 feet per minute.

15. An examination of the pitch angle versus engine power on the FDR data indicated that the basic principle of jet aircraft flying was not adhered to.
16. The pilot of an aircraft who made an approach 5 Nm behind the accident aircraft reported that the runway was not sighted at the published minima.
17. The pilots of arriving aircrafts were not provided with timely and accurate weather condition information when the weather on final area runway 09 was changing rapidly.
18. During interview the PIC stated that the decision to continue approach during raining was based on his expectation to be able to see the runway shortly.
19. The periodic CRM assessment and performance had been conducted for the PIC and SIC, however the crew actions during the approach indicated the CRM practices were not effective in identifying and managing flight risk.
20. The SIC attempted to evacuate the aircraft through the right cockpit window without success. He then evacuated the aircraft through the forward right service door.
21. The FA1 was unable to release the slide that has been inflated from the left passenger door in attempt to use the slide as floating device. During interview FA1 said that the training for this particular task was done through video presentation.
22. The actual response time performed by the ARFF was 4 minutes after the crash bell pressed by controller.
23. The current weather observation especially in regard of the visibility did not represent the approach/landing area as required by ICAO Annex 3 standard.
24. Between 0724 UTC to 0745 UTC, there were three aircrafts took off and six aircrafts landed using runway 09, including two Airbus A330. During this period 4 units of foam tender were absence from the fire station. It was possible that the response time as recommended by the ICAO Annex 14, Para 9.2.21 would not be achieved.

3.2 Contributing Factors[6]

- The aircraft flight path became unstable below minimum descends altitude (MDA) with the rate of descend exceeding 1000 feet per minute and this situation was recognized by both pilots.
- The flight crew loss of situational awareness in regards of visual references once the aircraft entered a rain cloud during the final approach below minimum descends altitude (MDA).
- The PIC decision and execution to go-around was conducted at an altitude which was insufficient for the go-around to be executed successfully.
- The pilots of accident aircraft was not provided with timely and accurate weather condition despite the weather around the airport and particularly on final approach to the airport was changing rapidly.

6 "Contributing Factors" is defined as events that might cause the occurrence. In the case that the event did not occur then the accident might not happen or result in a less severe occurrence.

4 SAFETY ACTION

4.1 Operator Safety Action

At the time of issuing this Draft Report, the National Transportation Safety Committee had received safety actions following this accident. The Chief Pilot issued notice to pilot with subject reminder go around as new Go Around policy on 23 April 2013 stated as follows:

1. In the situation of flying below minima (altitude), GO AROUND shall be performed if:
   - Any taking over control (PF to PM), and /or
   - Any reduced visual reference.
2. Prepared for GO AROUND call out procedure should be emphasized to your flight, especially below 1000 feet.

The Lion Air has conducted safety briefing to pilots which was an additional program post accident of PK-LKS, initiated since December 2013. The briefing informs issues related to the operational aviation safety of the company included stabilized approach criteria and go around.

4.2 ARFF Safety Action

On 26 April 2013, the ARFF performed meeting to evaluate the ARFF response to the accident on 13 April 2013. This meeting agreed that the ARFF will perform several improvements on the airport and conduct the rescue. The improvements will include establishing gates area and launching boats on the beginning runway 09.

5 SAFETY RECOMMENDATIONS

Base on the examination of the factual data and the findings that contributed to the accident such as, Observing and reporting of visibility, Descent Profile Changed from Automatic to Manual Flight, Situational Awareness and Go around procedure.

The safety issues related to Survivability and Aerodrome category for fire-fighting and rescue were also found during the investigation.

Refer to the findings; the National Transportation Safety Committee issued several safety recommendations addressed to:

5.1 PT. Lion Mentari Airlines

The KNKT considers that the safety actions Number 019/NTP/IV/2013, subject Reminder Go Around, and Lion Air letter Number 014/JKTDSJT/EXT/V/2014 on 22 May 2014 which included Lesson Plan Recurrent and LOFT for Instructor and Trainee, Safety Meeting Group Result, Flight Data Monitoring result on High Energy Approach, Simulator Refreshing Program based of FOQA, and Simulator Pilot Proficiency Check and Recurrent Program were acceptable for improvement of the particular conditions, however KNKT considers issuing safety recommendations in addition as follows:

a. The operator should ensure that all pilots must be competent in hand flying and covered during pilot initial and recurrent training program.

b. The operator should emphasize and ensure pilot monitoring skills are embedded in the pilot training program and SOP.

c. The operator should review and ensure the effectiveness of current CRM training program and CRM practices.

d. The operator should review and ensure the effectiveness of current Safety Emergency Procedure particularly evacuation procedure.

5.2 PT Angkasa Pura I

The rescue was not factor contribute to an accident however, compliances to the requirements could minimized the severity of the occurrence to the fatality, damage to property and possibly liability.

The KNKT recommends:

a. In regard to the actual time of the ARFF arrival at the accident site and the ICAO Annex 14 Para 9.2.23 recommended response time indicated that the actual response time performed by the ARFF was 4 minutes instead of 3 minutes after the crash bell pressed by controller. Following to this finding the PT Angkasa Pura I requires to evaluate the ARFF response time capability based on the involvement of the ARFF Ngurah Rai to this rescue operation.

b. While foam tender(s) absence from the fire station, the requirement of ICAO for the response time and firefighting category should be complied therefore requires

specific strategy. If the response time could not be achieved, the airport operation should be reduce or stop for evaluating purposes.

5.3 Badan Meteoorologi Klimatologi dan Geofisika (BMKG)

The ATIS information of the visibility was 10 km contrary to the actual condition that the pilots could not see the runway. Considered to this finding KNKT recommends that:

a. The ICAO Annex 3 4.6, Observing and reporting of visibility, should be implemented.

b. The BMKG and AP I should evaluate the current information distribution system to ensure the latest weather information distributes to the pilots representing the ICAO Recommendation.

5.4 AirNav Indonesia

Refer to Analysis sub chapter 2.5.and President Decree number 77/year of 2012 sub chapter 1.10 in Chapter 3 article 3 stated that the AirNav Indonesia provides Air Traffic Services (ATS).

The ATIS information of the visibility was 10 km contrary to the actual condition that the pilots could not see the runway. Considered to this finding KNKT recommends that the AirNav Indonesia should adjust the airport operation according to the current firefighting and rescue category, declared by airport authority.

5.5 Directorate General of Civil Aviation

a. The DGCA should oversight all air operators in achieving the effectiveness of training programs for the pilots to be competent in hand flying and covered during pilot initial training and recurrent program.

b. The DGCA should oversight all air operators to ensure pilot monitoring skills are embedded in the pilot training program and SOP.

c. The DGCA should oversight all air operators to ensure the effectiveness of current CRM training program and CRM practices.

d. The DGCA should oversight all air operators in reviewing the effectiveness of current Safety Emergency Procedure particularly evacuation procedure.

e. The DGCA should oversight the ARFF response time capability, including in the case of the firefighting and rescue category downgraded due to firefighting and rescue activities.

6 APPENDICES

6.1 Lion air Reminder Go Around

Lion air	NOTICE TO PILOT		
SUBJECT: REMINDER GO AROUND	Notice Number	:	019/NTP/IV/2013
	Applicability	:	**All Pilots**
	Date of issued	:	April 23th, 2013
	Date of effectiveness	:	April 23th, 2013
	Distribution List	:	DO, DS, OF, OFC

Dear All Pilots,

With reference to the new flight crew policies as stated in **Notice to Pilot No.013/NTP/III/2013** date **21st March 2013, point 5:**

As a part of its oversight function, herewith SSQ would like to deliver additional recommendation of new **GO AROUND policy** to all flight crews as follows:

1. In the situation of flying below minima (altitude), GO AROUND shall be performed if:
   - Any taking over control (PF to PM), and/or
   - Any reduced visual reference.
2. Prepare for GO AROUND call out procedure should be emphasized to your flight, especially below 1000 feet.

Flying an aircraft is precise, demanding, and unforgiving endeavor. It is proven that compliance with regulations and procedures in most cases helps to lower the risk of identified hazards.
DO NOT HESITATE TO GO AROUND OR WAVE OFF.

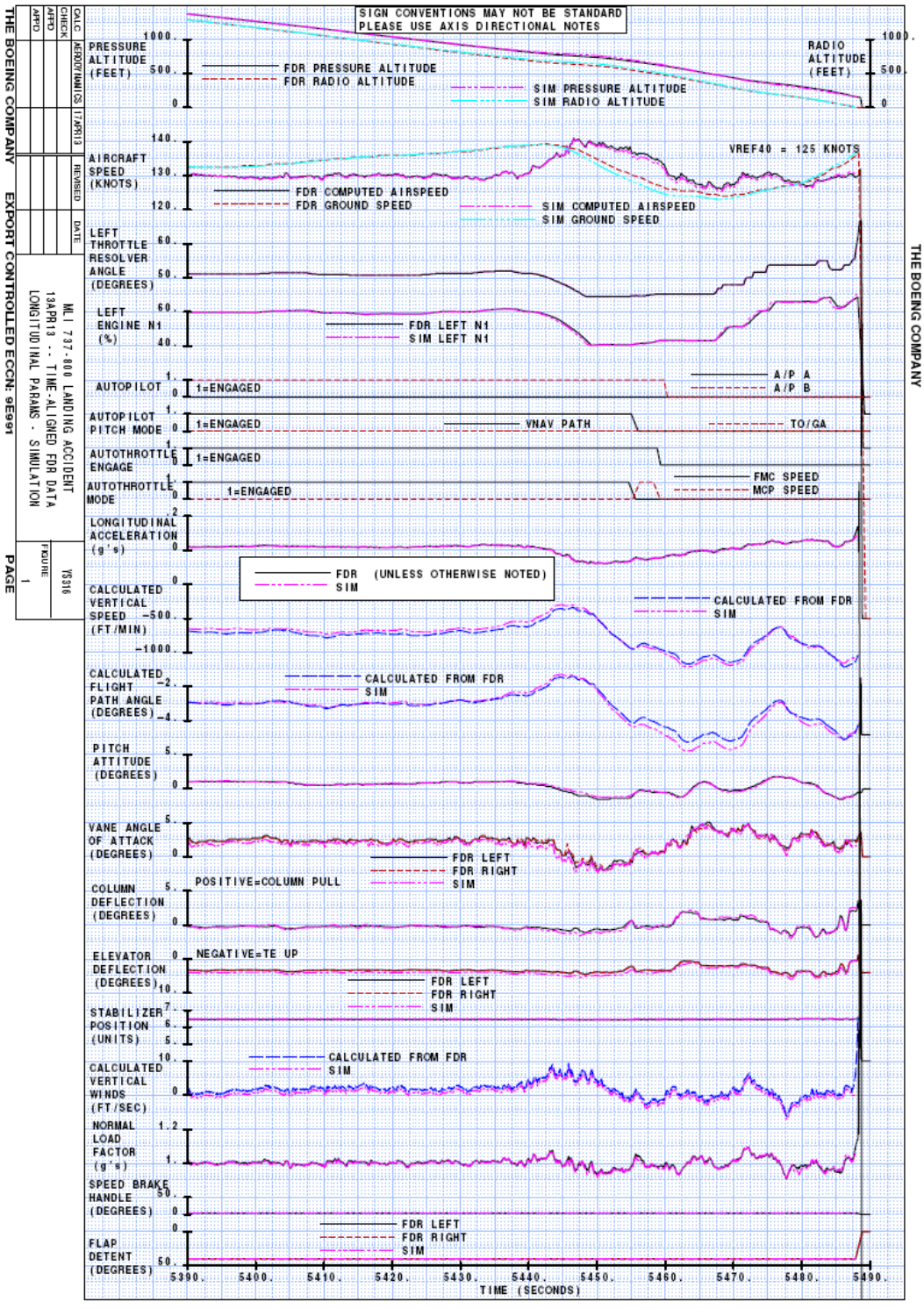
Thank you for your kind attention and Have a nice flight.

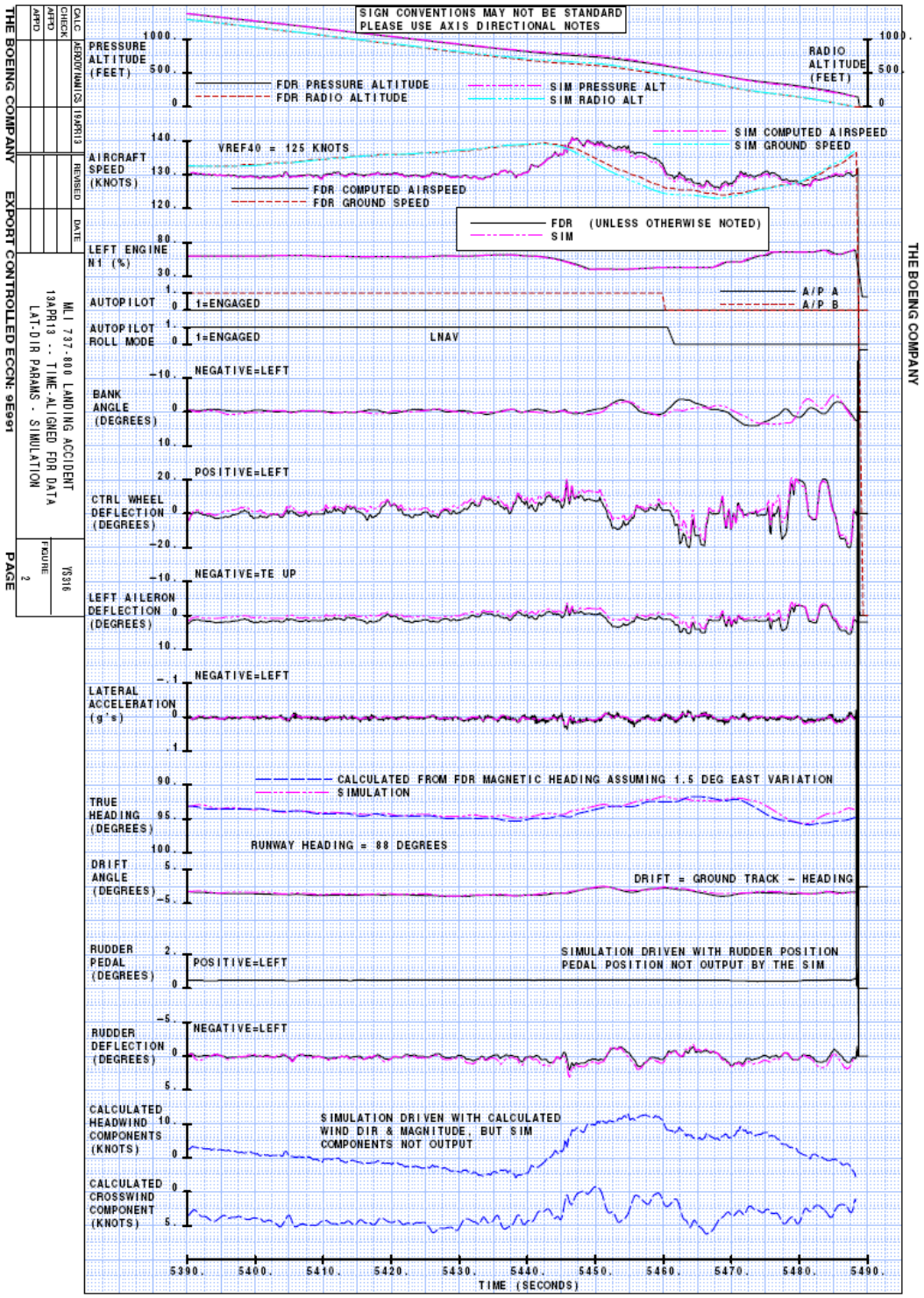
Regards,

Capt. Destyo Usodo
Chief Pilot B737 - Lion Air

6.2 Flight Data Simulation Match- Lion Air 737-800 PK-LKS Landing Accident

Enclosure to 66-ZB-H200-ASI-18730




THE BOEING COMPANY
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PAGE 2
FIGURE 2
YS316
MLI 737-800 LANDING ACCIDENT
13APR13 -- TIME-ALIGNED FDR DATA
LAT-DIR PARAMS - SIMULATION
CALC
CHECK
AFTD
APTD
AERODYNAMICS
19APR13
REVISED
DATE
SIGN CONVENTIONS MAY NOT BE STANDARD
PLEASE USE AXIS DIRECTIONAL NOTES
PRESSURE ALTITUDE (FEET)
FDR PRESSURE ALTITUDE
FDR RADIO ALTITUDE
SIM PRESSURE ALT
SIM RADIO ALT
RADIO ALTITUDE (FEET)
AIRCRAFT SPEED (KNOTS)
VREF40 = 125 KNOTS
SIM COMPUTED AIRSPEED
SIM GROUND SPEED
FDR COMPUTED AIRSPEED
FDR GROUND SPEED
FDR (UNLESS OTHERWISE NOTED)
SIM
LEFT ENGINE N1 (%)
AUTOPILOT
1=ENGAGED
A/P A
A/P B
AUTOPILOT ROLL MODE
LNAV
BANK ANGLE (DEGREES)
NEGATIVE=LEFT
CTRL WHEEL DEFLECTION (DEGREES)
POSITIVE=LEFT
LEFT AILERON DEFLECTION (DEGREES)
NEGATIVE=TE UP
LATERAL ACCELERATION (g's)
TRUE HEADING (DEGREES)
CALCULATED FROM FDR MAGNETIC HEADING ASSUMING 1.5 DEG EAST VARIATION
SIMULATION
RUNWAY HEADING = 88 DEGREES
DRIFT ANGLE (DEGREES)
DRIFT = GROUND TRACK - HEADING
RUDDER PEDAL (DEGREES)
SIMULATION DRIVEN WITH RUDDER POSITION
PEDAL POSITION NOT OUTPUT BY THE SIM
RUDDER DEFLECTION (DEGREES)
CALCULATED HEADWIND COMPONENTS (KNOTS)
SIMULATION DRIVEN WITH CALCULATED
WIND DIR & MAGNITUDE, BUT SIM
COMPONENTS NOT OUTPUT
CALCULATED CROSSWIND COMPONENT (KNOTS)
TIME (SECONDS)
5390.
5400.
5410.
5420.
5430.
5440.
5450.
5460.
5470.
5480.
5490.
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