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NATIONAL TRANSPORTATION SAFETY COMMITTEE

Aircraft Accident Investigation Report

PT. Merpati Nusantara Airlines
Xi 'An Aircraft Industry MA60; PK-MZK
Utarom Airport, Kaimana - Papua Barat
Republic of Indonesia

07 May 2011

NATIONAL TRANSPORTATION SAFETY COMMITTEE
MINISTRY OF TRANSPORTATION
REPUBLIC OF INDONESIA
2012

This Final Report was produced by the National Transportation Safety Committee (NTSC), Transportation Building 3rd Floor, Jalan Medan Merdeka Timur No. 5, Jakarta 10110, INDONESIA.

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

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GLOSSARY OF ABBREVIATIONS

AFIS	:	Aerodrome Flight Information Service
AGL	:	Above Ground Level
ALAR	:	Approach-and-Landing Accident Reduction
AOC	:	Air Operator Certificate
ATC	:	Air Traffic Control
ATPL	:	Air Transport Pilot License
ATS	:	Air Traffic Service
BMKG	:	*Badan Meteorologi Klimatologi dan Geofisika* / Meteorological Climatological and Geophysical Agency
°C	:	Degrees Celsius
CAAC	:	Civil Aviation Administration of China
CASR	:	Civil Aviation Safety Regulation
CCAR	:	China Civil Aviation Regulation
CPL	:	Commercial Pilot License
COM	:	Company Operation Manual
CRM	:	Cockpit Recourses Management
CSN	:	Cycles Since New
CVR	:	Cockpit Voice Recorder
DFDR	:	Digital Flight Data Recorder
DGCA	:	Directorate General Civil Aviation
EGPWS	:	Enhance Ground Proximity Warning System
ERS	:	Engine Regime Selector
FL	:	Flight Level
FDR	:	Flight Data Recorder
FOQA	:	Flight Operation Quality Assurance
fpm	:	feet per minute
FSS	:	Flight Station Service
hPa	:	Hecto-Pascals
Hr	:	Hours
ICAO	:	International Civil Aviation Organization
IFR	:	Instrument Flight Rules
IIC	:	Investigator in Charge
kg	:	Kilogram(s)
km	:	Kilometer(s)
kts	:	Knots (Nautical mile per hour)
LOSA	:	Line Operation Safety Audit
mb	:	Millibars

mm	:	Millimeter(s)
MSN	:	Manufacturer Serial Number
MTOW	:	Maximum Take-off Weight
Nm	:	Nautical mile(s)
KNKT / NTSC	:	*Komite Nasional Keselamatan Transportasi* / National Transportation Safety Committee
PF	:	Pilot Flying
PIC	:	Pilot in Command
PM	:	Pilot Monitoring
P/N	:	Part Number
QFE	:	Height above airport elevation (or runway threshold elevation) based on local station pressure
QNH	:	Altitude above mean sea level based on local station pressure
RPM	:	Revolution per Minute
SB	:	Service Bulletin
SCT	:	Scattered
SIC	:	Second in Command
S/N	:	Serial Number
TC	:	Type Certificate
TS/RA	:	Thunderstorm and rain
TAF	:	Terminal Aerodrome Forecast
TSB	:	Transport Safety Board (Canada)
TSN	:	Time Since New
TT/TD	:	Ambient Temperature/Dew Point
UTC	:	Universal Time Coordinated
VFR	:	Visual Flight Rules
VMC	:	Visual Meteorological Conditions
WIT	:	*Waktu Indonesia Timur* / Indonesia Eastern Standard Time (UTC +9 hours)
XAC	:	Xi 'An Aircraft Industry

INTRODUCTION

SYNOPSIS

On 7 May 2011, an Xi 'An MA60 aircraft, registered PK-MZK was being operated by PT. Merpati Nusantara Airline as a scheduled passenger flight MZ 8968, from Domine Eduard Osok Airport, Sorong, Papua Barat to Utarom Airport (WASK), Kaimana[1], Papua Barat.

The accident flight was part of series of flight scheduled for the crew. The aircraft departed from Sorong at 0345 UTC[2] and with estimated arrival time in Kaimana at 0454 UTC. In this flight, the Second in Command (SIC) was as Pilot Flying (PF) and the Pilot in Command (PIC) as Pilot Monitoring (PM). On board the flight were 2 pilots, 2 flight attendants, 2 engineers and 19 passengers consisting of 16 adults, 1 child and 2 infants.

The flight from Sorong was planned under the Instrument Flight Rules (IFR)[3]. The destination, Kaimana, had no published instrument approach procedure. Terminal area operations, including approach and landing, were required to be conducted under the Visual Flight Rules (VFR).

At about 0425 UTC, after passing waypoint JOLAM the crew of MZ 8968 contacted Kaimana Radio and informed that the weather at Kaimana was raining, horizontal visibility of 3 to 8 kilometers, cloud Cumulonimbus broken at 1500 feet, south westerly wind at a speed of 3 knots, and ground temperature 29°C.

The last communication with the crew of MZ 8968 occurred at about 0450 UTC. The flight crew asked whether there were any changes in ground visibility and the AFIS officer informed them that the ground visibility remained at 2 kilometer. The visual flight rules requires a visibility of minimum 5 km and cloud base higher than 1500 feet.

The evidence indicates that during the final segment of the flight, both crew member were looking outside the aircraft to sight the runway. During this period the flight path of the aircraft varied between 376 to 585 feet and the bank angle increased from 11 to 38 degree to the left.

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1 Utarom Airport (WASK), Kaimana is referred to as 'Kaimana' in this report.

2 The 24-hour clock in Universal Time Coordinate (UTC) is used in this report to describe the local time as specific events occurred. Indonesia Eastern Standard Time (*Waktu Indonesia Timur* / WIT) is UTC +9 hours

3 IFR (Instrument Flight Rules) Rules which allow properly equipped aircraft to be flown under Instrument Meteorological Condition (IMC).

The rate of descent then increased significantly up to about 3000 feet per minute and finally the aircraft impacted into the sea.

The accident site was about 800 meters south west of the beginning of runway 01 or 550 meters from the coastline. Most of the wreckages were submerged in the shallow sea between 7 down to 15 meter deep.

All 25 occupants were fatally injured. The aircraft was destroyed and submerged into the sea.

1 FACTUAL INFORMATION

1.1 HISTORY OF THE FLIGHT

On 7 May 2011, a Xi 'An MA60 aircraft, registered PK-MZK, was being operated by PT. Merpati Nusantara Airline as a scheduled passenger flight MZ 8968, from Domine Eduard Osok Airport, Sorong, Papua Barat to Utarom Airport (WASK), Kaimana, Papua Barat (Figure 1).

Figure 1: The Xi'An MA60 aircraft registration PK-MZK

The accident flight was part of series of flights scheduled for crew and aircraft which started from Jayapura to Nabire (MZ 8234), Nabire to Kaimana and Sorong (MZ 8967), Sorong to Kaimana and Nabire (MZ 8968), and finally from Nabire to Biak (MZ 8019).

The time of departure for the accident flight was from Sorong to Kaimana at 0345UTC and estimated arrival at 0454 with the Second in Command (SIC) as Pilot Flying (PF) and the Pilot in Command (PIC) as Pilot Monitoring (PM). On board the flight were 2 pilots, 2 flight attendants, 2 engineers and 19 passengers that consisted of 16 adults, 1 child and 2 infants.

The aircraft dispatch release from Sorong indicated that the flight was planned under the Instrument Flight Rules (IFR). The destination, Kaimana, had no published instrument approach procedure. Terminal area operations, including approach and landing, were required to be conducted under the Visual Flight Rules (VFR).

MZ 8968 operated on en-route airway W-67 at altitude 15,500 feet (FL 155) within controlled airspace, and subsequently left the controlled airspace and operated in un-controlled airspace until the arrival at Kaimana.

The flight crew was provided by Sorong dispatcher with the actual Kaimana weather information observed at 0300 UTC indicated that the weather was "precipitation near airport, horizontal visibility of 8 kilometers, cloud broken at 1400 feet, south easterly wind at speed of 6 knots and ground temperature 29°C". The observed weather report was issued by Meteorological Climatological and Geophysical Agency (BMKG), Kaimana.

The satellite weather image over Kaimana Airport at 0450 UTC provided to the investigation by BMKG Jakarta indicated that the weather was moderate rain.

At 0357, the crew of MZ 8968 established contact with Biak FSS (Flight Station Service).

At 0420, after passing waypoint JOLAM the crew of MZ 8968 contacted Kaimana Radio and informed that the estimated time of arrival would be 0454 UTC. The Kaimana AFIS (Aerodrome Flight Information Service) officer informed the crew that the weather at Kaimana was raining, horizontal visibility of 3 up to 8 kilometers, cloud Cumulonimbus broken at 1500 feet, south-westerly winds at a speed of 3 knots, and a ground temperature of 29°C.

At 0425, the flight crew reported that MZ 8968 was descending and was instructed to call when at a position 5 minutes from Kaimana.

At 0437, the flight crew reported that MZ 8968 was 7 Nm from the airport was descending and had passed 8,000 feet. The flight crew also asked about the rain and decided to fly to an area south of the airport.

At 0442, the Kaimana AFIS informed the crew that it was still raining at the airport and the ground visibility was 2 kilometers.

During the approach to Kaimana, the flight crew flew to the south of the airport in an attempt to make a visual approach. The auto-pilot was disengaged at 960 feet pressure altitude.

At 376 feet pressure altitude, the crew decided to discontinue the approach and climbed, turned to the left, opened the engine power, retracted flaps from 15 to 5 and subsequently to 0 position and retracted the landing gear.

The aircraft roll to the left with bank angle of 11 and continuously increased up to 38 degree. The rate of descend increased significantly up to about 3000 feet per minute and finally impacted into the shallow sea.

The accident site was about 800 meters south-west of the beginning of runway 01 or 550 meters from the coastline. The position of the main wreckage was 03° 39' 8" S; 133° 41' 15" E. Most of the wreckage was submerged in shallow sea between 7 to 15 meters deep (Figure 2).

Figure 2: Accident Site (red circle is the impact point)

The Kaimana AFIS officer who was off duty received a phone call from a witness informing them that there was an accident involving a Merpati aircraft. The Kaimana AFIS officer that was on duty could not see the accident site since it was blocked by trees.

There were four personnel of the airport rescue and fire fighting deployed to the coastline near the beginning of Runway 01, followed by one ambulance, eight security personnel and ten airport personnel.

All 25 occupants were fatally injured and the aircraft was destroyed.

A diagram of events during the final segment of flight is contained in Figure 3.

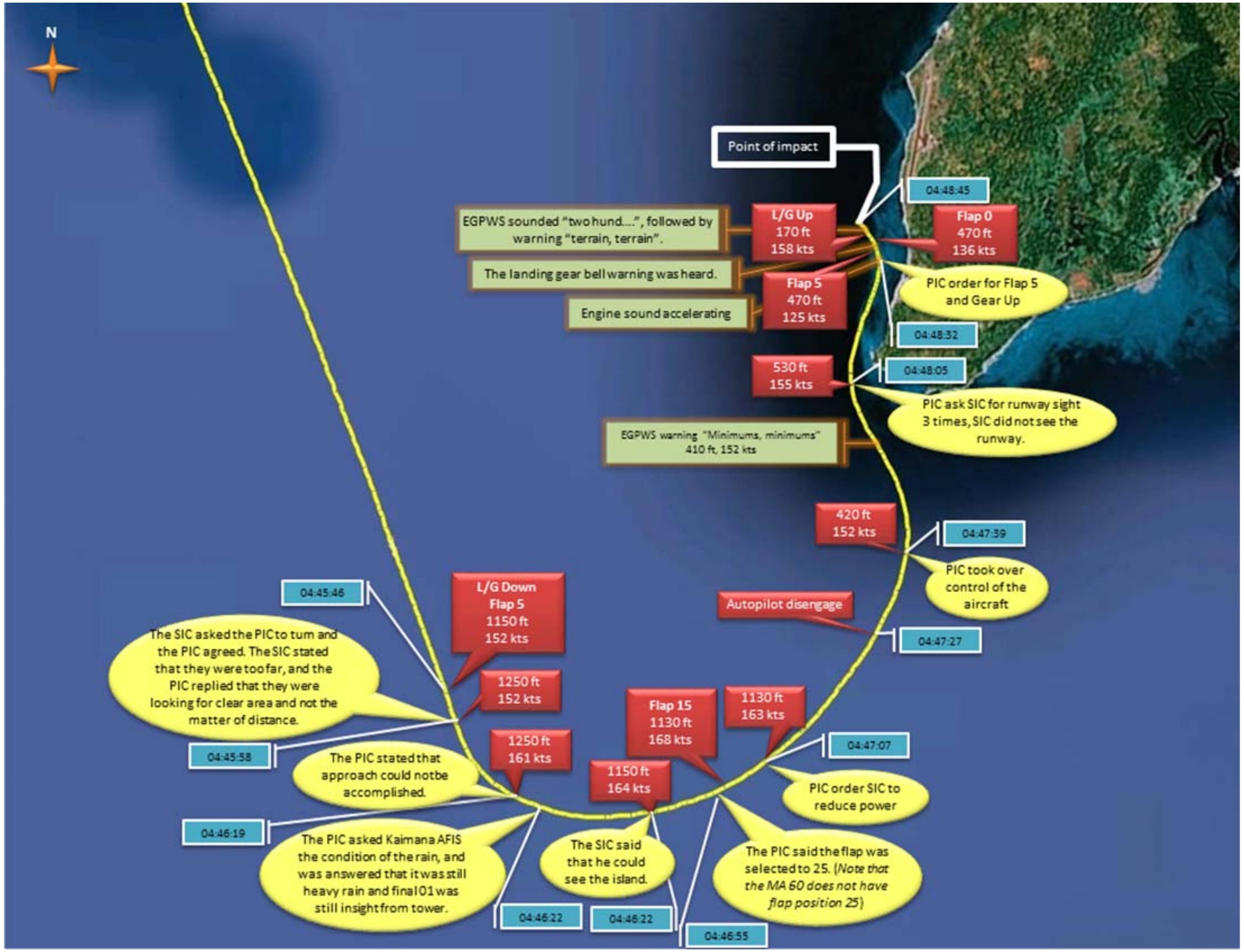


Figure 3: Events in the final segment of flight

1.2 INJURIES TO PERSONS

Injuries	Flight crew	Passengers	Total in Aircraft	Others
Fatal	4	21	25	-
Serious	-	-	-	-
Minor/None	-	-	-	Not applicable
TOTAL	4	21	25	-

1.3 DAMAGE TO AIRCRAFT

The aircraft was destroyed and submerged in the sea.

1.4 OTHER DAMAGE

There was no other damage.

1.5 PERSONNEL INFORMATION

1.5.1 Pilot in command

Gender	:	Male
Age	:	55 years
Nationality	:	Indonesia
License	:	ATPL
Date of issue	:	29 January 1983
Valid to	:	23 May 2011
Aircraft type rating	:	Fokker F-100 and MA-60
Medical certificate	:	Class 1, with limitation shall possess glasses that correct for near vision.
Date of medical	:	22 November 2010
Valid to	:	23 May 2011
Last proficiency check	:	12 March 2011
Total hours	:	24470 hours
Total on type	:	199 hours 5 minutes
Last 90 days	:	125 hours 1 minute
Last 7 days	:	17 hours 35 minutes
Last 24 hours	:	5 hours 45 minutes
This flight	:	1 hour 03 minutes

The PIC joined the company in 1977 as co-pilot for DHC 6 Twin Otter aircraft, operating in the Bali area. He was subsequently promoted to Fokker F27, Fokker F28 and Fokker F100 (since 1994). He had 6982 flight hours experience in the Fokker F100.

In 2010, the PIC commenced training on the MA60 aircraft and became a qualified pilot in command on 13 January 2011.

The flight to Kaimana with the MA 60 was his fourth flight of the day.

1.5.2 Second in Command

Gender	:	Male
Age	:	36 years
Nationality	:	Indonesia
License	:	CPL
Date of issue	:	30 July 2007
Valid to	:	31 December 2011
Aircraft type rating	:	MA 60
Medical certificate	:	Class 1, with limitation shall wear corrective lenses
Date of medical	:	20 December 2010
Valid to	:	20 June 2011
Last proficiency check	:	15 December 2010
Total hours	:	370 hours 15 minutes
Total on type	:	234 hours 25 minutes
Last 90 days	:	167 hours 30 minutes
Last 7 days	:	17 hours 35 minutes
Last 24 hours	:	5 hours 45 minutes
This flight	:	1 hour 03 minutes

The SIC joined the company in November 2007 and completed his type rating on the MA 60 aircraft in June 2008.

1.6 AIRCRAFT INFORMATION

1.6.1 General

Aircraft manufacturer	:	Xi ‘An Aircraft Industry (XAC), China
Aircraft model/type	:	MA 60
Serial number	:	0603
Year of manufacture	:	2007
Aircraft registration	:	PK-MZK
Certificate of Registration	:	2807
Valid to	:	03 March 2014
Certificate of Airworthiness	:	2807
Valid to	:	03 March 2012
TSN	:	615 hours
CSN	:	764 cycles
MTOW	:	21,800 kg

1.6.2 Engines

Engine type	:	Turbo propeller
Manufacturer	:	Pratt & Whitney, Canada
Model	:	PW 127 J
Serial Number Left	:	PCE-EA0077
TSN	:	615 hours
CSN	:	764 cycles
Serial Number Right	:	PCE-EA0076
TSN	:	615 hours
CSN	:	764 cycles

The operator was the first to operate this type of aircraft in Indonesia. The Type Certificate (TC No. 0015A) was issued by the Civil Aviation Administration of China (CAAC). The Indonesian Directorate General of Civil Aviation (DGCA) performed a TC validation in 2006 and issued the TC Validation number A066. The TC validation was to verify the implementation of Indonesia Civil Aviation Safety Regulation (CASR) Part 21, Part 25, Part 33, Part 34, Part 35, Part 36 and Part 121.

1.6.3 Weight and Balance

The aircraft takeoff weight was calculated by the flight crew at 18,344 kg and an estimated landing weight of 17,645 kg. Based on the estimated weights, the center of gravity was determined to be within the normal operating range for the entire flight.

1.7 METEOROLOGICAL INFORMATION

The weather report for Kaimana (WASK), issued on 7 May 2011indicated:

At 0400 UTC:

Surface wind	:	240 / 3 knots
Visibility	:	8 km
Present weather	:	precipitation insight
Cloud	:	Broken Cumulus and Cumulonimbus, cloud base at 1500 feet. Remark: Cumulonimbus to south west
Temperature	:	28° C
Dew Point	:	23° C
QNH	:	1008.9 mb
QFE	:	1008.0 mb

At 0500 UTC:

Surface wind	:	060 / 4 knots
Visibility	:	3 km
Present weather	:	intermediate moderate rain
Cloud	:	Broken, Cumulus and Cumulonimbus, cloud base at 1600 feet
Temperature	:	23° C
Dew Point	:	23° C
QNH	:	1009.2 mb
QFE	:	1008.1 mb

Day light conditions prevailed at the time of the accident.

1.8 AIDS TO NAVIGATION

There were no navigation aids for the approach and landing at Kaimana. Approach and landings must be conducted under the VFR.

1.9 COMMUNICATIONS

Air traffic communication services provided when operating into Kaimana were advisory only. Direct two-way communication between Kaimana AFIS and the crew was established when the flight was passing waypoint JOLAM. The two way communication between Kaimana AFIS and the crew was conducted normally and did not contribute to the accident.

1.10 AERODROME INFORMATION

Aerodrome Code	:	WASK / KNG
Airport Name	:	Utarom Airport
Airport Address	:	Jl. Bandara, PO. Box 10 Kaimana, Papua Barat 98654
Airport Class	:	III
Airport Authority	:	DGCA
Airport Service	:	AFIS
Type of Traffic Permitted	:	VFR
Coordinates	:	03° 38’ 00” S, 133° 41’ 00’’ E
Elevation	:	10 feet
Runway Length	:	1600 meters
Runway Width	:	30 meters
Azimuth	:	01 – 19

1.11 FLIGHT RECORDERS

The aircraft was equipped with a Digital Flight Data Recorder (DFDR) and Cockpit Voice Recorder (CVR). Both recorders were recovered from the accident site within three days after the accident.

1.11.1 Flight Data Recorder

1.11.1.1 Digital Flight Data Recorder (DFDR)

Manufacturer	:	Shaanxi Qianshan Avionics Co. Ltd., China
Type	:	Solid State
P / N	:	FB-30C
S / N	:	0509006

Directly after the recovery, the DFDR was washed by fresh water and stored in a container filled with fresh water. The DFDR was taken to the Civil Aviation Administration of China (CAAC) by NTSC investigator to download the data.

The DFDR contained more than 25 hours of excellent quality data comprising 84 parameters (including 36 discrete parameters).

The aircraft was not configured to record Lateral and Longitudinal acceleration on the DFDR.

An animated reconstruction of the FDR parameters and flight path was produced by NTSC recorder specialists at the NTSC flight recorder lab using Insight Animation and Google Earth images. The audio from the CVR was integrated into the accident flight animation to assist the investigation team.

Figure 4: Screenshot of flight animation

1.11.1.2 Situations at the final segment of the flight

At the final segment of the flight, the FDR recorded as the following:

- The aircraft descended to 376 feet pressure altitude (250 feet radio altitude) and climbed to 585 feet pressure altitude (454 feet radio altitude).
- During the climb from 376 feet pressure altitude, the aircraft was turning to the left and the bank angle from 11 deg increased up to 33 deg to the left.
- During the climb at 537 feet pressure altitude the crew opened the engines power. The torque of both engines increased up to 70% and 82% for the left and right engine respectively.
- The highest altitude recorded was 585 feet pressure altitude, at which the aircraft speed was 124 knots, and the pitch angle was at 1.8 deg nose down.
- While passing 570 feet pressure altitude, the flaps were retracted from 15 to 5 and subsequently to 0.
- While passing 550 feet pressure altitude (410 feet radio altitude), the crew retracted the landing gear.
- The bank angle continuously increased up to 38 degree to the left. This situation occurred at an altitude of 482 feet pressure altitude (212 feet radio altitude).
- The rate of descend increased significantly and finally the aircraft crashed into the shallow sea.

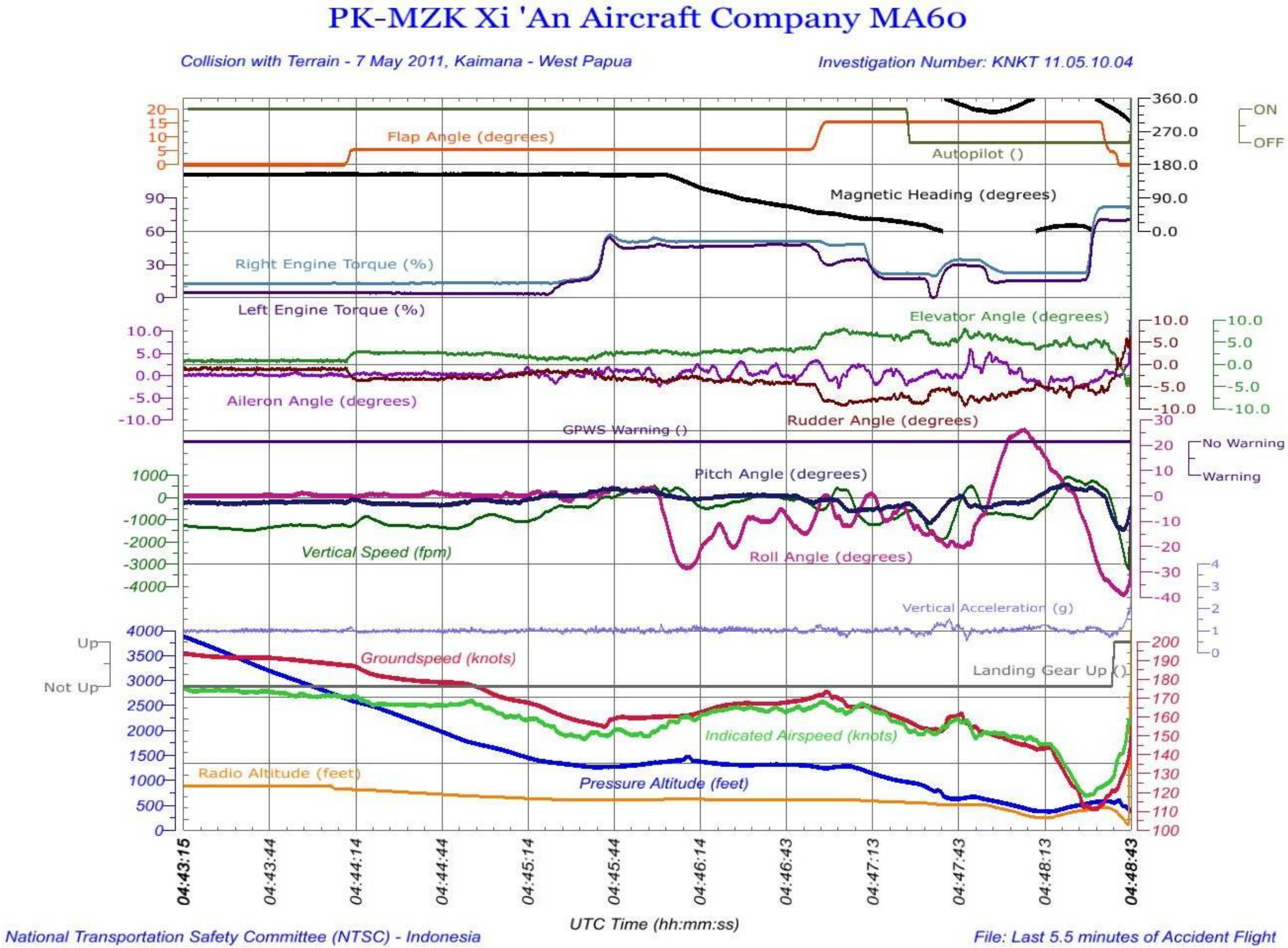


Figure 5: Selected FDR flight parameters from final 5 minutes of flight

1.11.2 Cockpit Voice Recorder (CVR)

Manufacturer	:	Honeywell, USA
Type	:	Solid State
P / N	:	980 – 6022 – 011
S / N	:	CVR 120-09559

1.11.2.1 Cockpit Communications

The CVR was taken to the NTSC laboratory in Jakarta. The CVR contained two hours of good quality recording starting from the final approach of the previous flight, transit time and the whole accident flight.

Limited communications were noted, only few conversation between the PIC and the SIC. When the PIC gave important commands to the SIC, he did not use standard phraseology as stated in the Company Operation Manual.

The CVR did not record any crew briefing and checklist reading consisted of Descent Checklist, Approach Checklist, and Landing Checklist were not heard on the CVR.

1.11.2.2 Sequence of events

A sequence of events based on the FDR and CVR data for the final segment of the flight is presented in the following table:

UTC Time	CVR	FDR
0429.18	The pilot reported descent from FL155 at about 62 miles to Kaimana.	
0430.00	The Kaimana AFIS reported that there was heavy rain at the airport.	
0431.47	The PIC asked which area of the airport was still clear, and was told that the area on the south of the airport was clear.	
0431.52	The PIC told the SIC to fly to the south of the airport.	
0432.44	Both pilots discussed flying to the clear area.	
0435.36	The PIC asked the SIC to reduce the aircraft speed.	
0437.00	The pilot reported to Kaimana AFIS that they were in position seven miles to Kaimana and passed 8000 feet.	
0437.10	Kaimana AFIS reported that the surface wind was from 060 degrees 4 knots, visibility 2 km and the cloud base 450 up to 550 meters.	

UTC Time	CVR	FDR
	The PIC asked about the conditions on final to runway 01, Kaimana AFIS informed them that the visibility in that direction was about 2 km.	
0440.08	The PIC ordered the SIC to reduce power.	
0441.53	The PIC ordered the SIC to reduce power further. The PIC then asked about the rain, and Kaimana AFIS informed the crew that it was still raining heavily.	
0443.46	The PIC asked if the runway 01 could be seen from the tower and the AFIS replied that the runway 01 could be seen from the tower.	
0444.01	The SIC asked for further descent and the PIC agreed.	
0444.08	The PIC continued the approach, and ordered the SIC to descend to circuit altitude and selected the flap.	
0445.32	The Flight Attendant reported “Cabin ready”.	
0445.38	The PIC ordered the SIC to increase the engine power.	
0445.46	The PIC asked to select the landing gear to down.	
0445.49		L/G down, 1274 feet pressure altitude, 151 knots airspeed.
0445.58	The SIC asked the PIC to turn and the PIC agreed. The SIC stated that they were too far, the PIC replied that they were looking for clear area and not the matter of distance.	
0446.16	The PIC stated that approach could not be accomplished.	1357 feet pressure altitude.
0446.22	The PIC asked Kaimana AFIS the condition of the rain, and was answered that it was still heavy rain and final 01 was still insight from tower.	
0446.43	The SIC said that he could see the island.	
0446.55	The PIC said the flap was selected to 25. (Note that the MA 60 does not have flap position 25)	Flap travelled to 15.
0447.07	The PIC ordered the SIC to reduce the power.	
0447.26		Autopilot disengaged, 960 feet pressure

UTC Time	CVR	FDR
		altitude, 153 knots airspeed, bank angle 8° to the left, 17% left and 22% right engine torque, 238º heading.
0447.39	The PIC took over control of the aircraft.	654 feet pressure altitude, 155 knots airspeed, bank angle 20 degree to the left, heading 360 degree.
0447.56	EGPWS warning “minimum, minimum” sounded	580 feet pressure altitude (456 feet radio altitude), 152 knots airspeed, bank angle 7 degree to the right, heading 322 degree.
0448.05	The PIC asked whether the SIC could see the runway three times and was answered that the SIC did not see the runway.	456 feet pressure altitude, 149 knots airspeed, bank angle 26 degree to the right, heading 340 degree.
0448.32	The engine sound accelerating was heard and followed by the PIC ordered for flap 5 and gear up.	537 feet pressure altitude, 123 knots airspeed, bank angle 29° to the left, engine torque were increasing to 70% on the left and 82% on the right engine, heading 357 degree.
0448.34		bank angle 33° to the left, at 585 feet pressure altitude, 125 knots airspeed, 70% left and 82% right engine torque, heading 343degree.
0448.36	The landing gear bell warning sounded.	550 feet pressure altitude, 125 knots airspeed, bank angle 35 degree to the left, heading 339 degree.
0448.37		Flap reached position 5 at 547 feet pressure altitude, 129 knots airspeed, bank angle 36° to the left, engine torque were at 70% on the left and 82% on the right engine, heading 335 degree.
0448.39		Flap reached position 0, bank angle 38 degree to the left, 482 feet pressure altitude, 140 knots airspeed, engine torque were at 70% on the left and 82% on the right engine, heading 326 degree.
0448.43	EGPWS sounded “two hund….” followed by warning “terrain, terrain”.	151 feet radio altitude, 158 knots airspeed, bank angle 28° to the left,70% left and 82% right engine torque, heading 301 degree, vertical speed 2944 fpm down.
0448.45	End of recording.	End of recording.

1.12 WRECKAGE AND IMPACT INFORMATION

The accident site was about 800 meters south west of the beginning of runway 01 or 550 meters from the coastline. Most of the wreckage was submerged into the sea between 7 to 15 meters deep (Figure 6).

The wreckage was spread over an area around 100 m x 200 m on the sea floor.

The wreckage distribution was as follows:

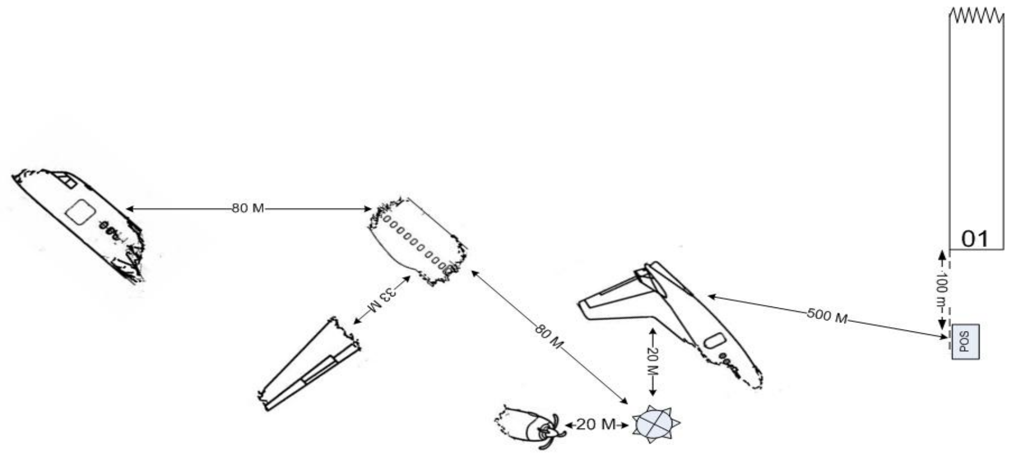


Figure 6: Wreckage distribution (not to scale)

Light parts of the aircraft such as seat cushions and pieces of propeller blades were immediately recovered, while large parts such as two broken fuselage pieces, the left wing, center section, the left engine gearbox, landing gears, and the empennage were later salvaged from the sea.

The recovery of the aircraft wreckage was initiated on 20 May 2011 and ended on 31 May 2011. Most of the aircraft components, including the forward fuselage and cockpit were recovered.

The landing gear handle was found in the up position. The condition levers (propeller control levers) were in the maximum forward position. The engine power levers were in the forward position. The flap selector was in the 0 position (Figure 7).

Figure 7: Recovered Pedestal

The aircraft had three flap screw jacks on each wing. Four of the six flaps screw jacks were recovered and found in the fully retracted position.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

All aircraft occupants were fatally injured as result of impact forces.

There was no evidence that physiological factors or incapacitation affected the performance of flight crew members.

1.14 FIRE

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

1.15 SURVIVAL ASPECTS

The accident was not survivable.

1.16 TESTS AND RESEARCH

The aircraft was fitted with an Engine Regime Selector (ERS) to manage engine power and to select the required torque settings for various phases of flight. The ERS selections consisted of TOGA (Take Off/Go Around), MAXCONT (Maximum Continuous), CLIMB, CRUISE and a TEST function. The equipment was manufactured by Xian Qing An Electric Control Ltd., with part number EZX-1A or Y7III-CP72-057A.

The engine power ranges controlled by ERS, as detailed in the MA60 FCOM Limitation chapter 1-10, are as follows:

POWER SELECTION	*JET THRUST*	*PERCENT TORQUE*
TOGA	*325 lbs*	*106.3%*
MAX CONT	*325 lbs*	*106.3%*
MAX CLIMB	*268 lbs*	*87.6%*
MAX CRUISE	*262 lbs*	*85.6%*

This ERS only permits one button selection at a time. The respective light will illuminate to indicate the selected button.

During an approach, the approach checklist requires that the ERS is set to TOGA. The investigation conducted several flight observations using a sister aircraft of the MA60 as well as several exercises using a flight simulator. Based on engine power readings at various ERS settings, it showed that in the final segment of flight, the ERS position was more likely to be selected to the CRUISE mode.

1.17 ORGANISATIONAL AND MANAGEMENT INFORMATION

Aircraft Owner	:	PT. Merpati Nusantara Airlines
Address	:	Jl. Angkasa Blok B-15 Kav 2-3
		Kemayoran, Jakarta 10720
AOC Number	:	AOC 121/002

PT. Merpati Nusantara Airlines is a state owned enterprise that provides domestic flight services throughout the region. The operator operates 5 types of aircraft consisting of B 737, Fokker F100, Xi ‘An MA60, Casa C 212 and De Havilland DHC 6 Twin Otter. The fleet of Xi ‘An MA60 consisted of fifteen aircrafts.

The Aviation Safety, Security & Quality Division of Merpati issued an Aviation Safety Recommendation Number: DS/IV/2011/R010 dated 14 April 2011, related to pilot classification. A pilot is classified as an experienced pilot after reaching 250 hours on type. It was recommended not to pair schedule a non-experienced PIC with non-experienced SIC.

The investigation found that a LOSA (Line Operation Safety Audit) had been performed by the operator. However, a FOQA (Flight Operation Quality Assurance) had not been implemented and the operator had not been effectively implementing the Safety Management System (SMS) at all management levels.

1.18 ADDITIONAL INFORMATION

The investigation found that the aircraft was not configured to record the lateral and longitudinal acceleration data on the aircraft DFDR.

In accordance with Indonesian Civil Aviation Safety Regulation parts 121.343 and 121.344, it is mandatory to include parameters of lateral and longitudinal acceleration in the flight data recorder. However, at the time of CAAC certification for the MA 60 aircraft, the China Civil Aviation Regulation (CCAR) 121 did not require the two items as mandatory.

The EGPWS, Mark VIII Part number 965-1206-003 was manufactured by Honeywell and was installed in the accident aircraft with data base identification 446.

There was a Service Bulletin Number MA60-34-SB238 issued on 4 April 2011 related to the initialization of the EGPWS regarding configuration data for eight aircraft of which five of them were operated by Merpati (aircraft MSN 0505, 0506, 0601, 0603 and 0608). Note that the PK-MZK was the MSN 0603, aircraft.

The SB MA60-34-SB238 related to false warning flaps. If the configuration data input into EGPWS is wrong, there will be a false warning of flaps not extended when the flaps are extended during each normal landing. There was no problem reported that PK-MZK aircraft (MSN 0603) had problem of flaps false warning.

1.18.1 Aircraft Manuals

The investigation found that the Flight Crew Operation Manual (FCOM) and Aircraft Maintenance Manual (AMM) used non-standard English Aviation Language. It was supported by a review performed by the Australian Transport Safety Bureau (ATSB).

1.18.2 Pilot Training

The pilot training syllabus in Merpati for the MA 60 consisted of 146 hours ground training, 8 simulator sessions for transition training or 15 simulator sessions training for first joining pilot (ab-initio) and 100 hours line training, while the standard simulator training sessions in Xi ‘An Aircraft industry consist of 22 simulator sessions.

The first three batches of pilot training was performed at Xi ‘An, China and was mentored by manufacturer instructors with interpreter using the aircraft manufacturer syllabus which was approved by DGCA of Indonesia. The subsequent pilot training was conducted by Merpati instructor using modified syllabus which was also approved by the DGCA.

The SIC was trained in the first three batches, while the PIC was trained using the modified syllabus.

The company uses three grades for initial training and recurrent training. These were: Satisfactory (S), Satisfactory with Briefing (SB), and Unsatisfactory (US).

About 30% of the trainees were graded as Satisfactory with Briefing (SB) and they had a remedial briefing. There was no trainee having US grade, so that the rate of failure in training was zero.

There was no formal evidence that the EGPWS initial and recurrent training package was given to the crew.

1.18.3 Go around procedure

The aircraft FCOM chapter 2.15 Go-Around procedure stated:

Complete the "Go Around" procedure under the following conditions:

- *Runway is invisible at the decision altitude or minimum descent altitude;*
- *Position deviation of aircraft is too large when 1000 ft below instrument approach or 500 ft below visual approach;*
- *Or other requires go around conditions.*

PF	***PM***
Order "Go around", meanwhile	
ERS ……………………………………ON *Press down the go around button and push forward power lever to 80^0* *Order "Flap 15^0 "* *Add the pitch attitude to go around attitude with following the flight director.* *Verify the positive rate of climb.* *Order "Gear up"*	*Verify the go around power has been set.* *Retract the flap to 15^0* *Verify the positive rate of climb occurs and report "Positive Climb".* *Put the landing gear control handle at UP position.* *Verify the go around altitude has been set.*
Above 400 ft :	
Select the heading mode, climb mode and verify that mode display is correct. *Verify the aircraft flies along the go around path.* *When the speed is above 135 kn. Order "flap 5^0".* *Order "Retract flap".*	*Verify the mode display* *Retract flap to 5^0 and monitor the flap position indicator.* *Retract flap to 0^0 and monitor the flap position indicator.*

Above 1000 ft	
Switch the autopilot on. *Order "After Takeoff Checklist"*	*Verify the go around altitude is captured.* *Complete "After Takeoff Checklist"*

1.18.4 Flight Simulation

During the investigation the NTSC conducted a flight simulation in the MA 60 Flight Simulator in the Xi 'An Aircraft Manufacturer Facility. The simulation exercises were performed by two Merpati MA 60 qualified pilots and monitored by Xi 'An instructor pilots. The exercises were supervised by NTSC and observed by CAAC.

The flight simulation exercises were simulated the situation as close as possible to the parameters as recorded in the FDR and several variations in flight scenario. The flight scenario consisted of variations of flaps configuration, roll angle and engine torque.

The exercises in the flight simulator showed that with a set of flight parameters close to the situation in the final segment of the flight, the aircraft could be slowly recovered if appropriate action in correcting the bank angle.

The result of the flight simulations exercises is shown in appendix A.

1.18.5 Emergency Locator Transmitter

The aircraft was equipped with an Emergency Locator Transmitter (ELT) part number 452-0133, serial number 04629. Due to the level of destruction as a result of impact with the sea, the ELT did not transmit an emergency signal.

1.19 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

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

2 ANALYSIS

2.1 GENERAL INFORMATION

This analysis will discuss the factors associated with the collision with water by the Xi ‘An MA 60 aircraft operating on flight MZ 8968 from Sorong to Kaimana on the 7 May 2011. The investigation found that the aircraft was serviceable at the time of the accident. This analysis will discuss issues on the crew operating procedures, the weather at the time of the accident, the crew pairing and the management of the operation.

2.2 SITUATIONS AT THE FINAL SEGMENT OF THE FLIGHT

Kaimana did not have an instrument approach procedure and an approach should be conducted in visual approach under Visual Meteorological Condition (VMC). At the time of the accident, the weather at Kaimana was raining with the visibility of two kilometers and did not meet the DGCA and operator requirements for a visual approach having visibility of more than five kilometers.

Figure 8: Screenshot of flight animation

The crew did not conduct an approach briefing. During the final segment of the flight the crew became preoccupied by looking outside the aircraft to find the runway.

When the aircraft turned for the final approach, the PIC took over control of the aircraft from the SIC. Based on the available information, the investigation was not able to determine the reason for this change of crew roles. It may have had the effect of increasing crew workload at a critical phase of flight.

Approximately 17 seconds after the PIC took over the control, the EGPWS alert “minimum, minimum” was heard. The aircraft was at approximately 580 feet pressure altitude (456 feet radio altitude) as recorded on the aircraft FDR, the approach was continuing. According to company operation manual (COM), in a VMC (Visual Meteorological Condition), a “minimum, minimum” alert while the approach was not stabilized should be followed by the action of abandoning the approach.

In the next few seconds, the PIC asked whether the SIC could see the runway three times and was answered that the SIC did not see the runway. The engine sound accelerated and was followed by the PIC ordered for flap five and gear up. The flaps were retracted from 15 to 5 and subsequently to 0 position. The landing gear was retracted. Shortly afterwards, the EGPWS sounded “two hund….”, followed by warning “terrain, terrain” just before the aircraft impacted the water.

The FCOM procedure stated that for a Go Around the flap should be maintained at 15.

The situations at the final segment of the flight were as follows:

As it was recorded in the CVR, during the final segment of the flight, both crews member were preoccupied to look for the runway as there were checking three times whether the runway was insight.

At that time the FDR recorded as follows:

- The aircraft descended to 376 feet pressure altitude (250 feet radio altitude) and climb to 585 feet pressure altitude (454 feet radio altitude).
- While passing 537 pressure altitude, the torque of both engines was increased to 70% and 82% for the left and right engine respectively and the aircraft was turning to the left, banking from 11 degree to the left, and increasing up to 33 degree. The bank angle even reached 38 degree at 482 feet pressure altitude (370 feet radio altitude).
- The situations above indicated that the pilot intended to discontinue the approach by climbing and turning to the left to an area above the sea in order avoiding hilly terrain on the right side.
- At the highest altitude of 585 feet, the aircraft speed was 124 knots, and the pitch angle was at 1.8 degree nose down.
- While passing 570 feet altitude, the flaps were retracted from 15 to 5 position and subsequently to 0.
- While passing 550 feet pressure altitude (410 feet radio altitude), the crew retracted the landing gear.

- The bank angle continuously increased up to 38 degree to the left. This situation occurred at an altitude of 482 feet pressure altitude (212 feet radio altitude).
- The rate of descend increased significantly and finally the aircraft impacted into the shallow sea.

The rapid descent was mainly a result of a combination of situations such as high bank angle (up to 38 deg to the left) and the flaps retracted to 5 and subsequently to 0 position, and also the combination of other situations such as; engine torque, airspeed, and nose-down pitch.

The situation above arose from loss of situational awareness due to a strong intention of the crew to find the runway in poor visibility.

There were actions which deteriorated the lift as a result of flaps retraction in high degree of bank. The flaps retraction to 5 was contrary to the go-around procedure in which the flaps should be maintain at 15 until above 400 feet and airspeed above 135 knots.

The exercises in the flight simulator showed that with a set of flight parameters close to the situation in the final segment of the accident flight, the aircraft could be slowly recovered if appropriate action particularly in correcting the bank angle.

2.3 COCKPIT DISCIPLINE

An approach to Kaimana should be conducted in visual approach and require visibility greater than 5 kilometers. At the time of the accident, the weather at Kaimana was raining and the visibility was 2 kilometers. In such condition a visual approach should not be performed.

From the CVR it was revealed that during the flight, the crew did not perform crew briefing and checklist reading. In absence of crew briefing, the crew could not synchronize the plan to conduct the approach, and what actions they would take if the situation deviates from the normal situation.

As a result of the crew did not complete the approach checklist was an action to change the Engine Regime Selector (ERS) from CRUISE to TOGA mode was not carried out. During the course of investigation, it was found that the ERS button could be determined in the CRUISE mode. As a result, the torque only reached 70% and 82% during the discontinued approach, instead of around 95% if the ERS button was in TOGA mode. The lower power would have significantly affected the performance of the aircraft.

During go around the PIC commanded to retract the flaps to 5. The FCOM stated a go around with two engines operation initiated from flaps 30, in which the flaps should be set to 15, and remain at 15 until above 400 feet and the speed reaches 135 knots.

There is a strong indication that the PIC reverted to a procedure for a previous aircraft type he had flown when he asked for “Flap 25”, which does not exist on the MA60 aircraft type. Another action was to set flaps position to 5 during go around. This procedure was a typical action in the Fokker aircraft type. The PIC had 6,982 hours flying time of the Fokker 100 aircraft type, which does have a Flap 25 setting. In contrast, he had flown the MA60 for only 199 hours. Stress and workload can increase the likelihood of regressing to earlier well-learned habit patterns.

2.4 CREW TRAINING

The crew performance may have been related to the training.

The investigation found a number of deficiencies in the training program performed in the company. Several cases in training are as follows:

- The company used three grades for initial training and recurrent training. These were: Satisfactory (S), Satisfactory with Briefing (SB), and Unsatisfactory (US). About 30% of the trainee was graded as Satisfactory with Briefing (SB) and they have a remedial briefing. There was no trainee having US grade, so that the rate of failure in training was zero.
- There was no formal evidence that the crews received EGPWS training for initial and recurrent training.
- The Flight Crew Operation Manual (FCOM) and Aircraft Maintenance Manual (AMM) used non-standard English Aviation Language. It was also supported by a review performed by the Australian Transport Safety Bureau (ATSB). Although the issue on the language used in the manuals could not be directly contributed to the development of the accident, it had the potential to cause confusion.

There is a strong indication that the PIC reverted to a procedure for a previous aircraft type he had flown when he asked for “Flap 25”, which does not exist on the MA60 aircraft type. The PIC had 6982 hours flying time of the Fokker 100 aircraft type, which does have a Flap 25 setting. In contrast, he had flown the MA60 for only 199 hours. Stress and workload can increase the likelihood of regressing to earlier well-learned habit patterns.

Inadequacy in training may lead to regression toward earlier well learned habit pattern.

2.5 CREW PAIRING

Both the PIC and the SIC had low time on type on the MA60. The PIC had a total time of 199 hours in MA60, and the first officer had a total time of 234 hours. This pairing of two low time-on-type crew was contrary to the Company Aviation Safety recommendation dated 14 April 2011 in which an experience pilot requires a minimum of 250 flight hours on type. This situation may have contributed to the accident.

2.6 CREW RESOURCE MANAGEMENT

The CVR revealed limited conversation between the PIC and the SIC. This situation is uncommon in a good cockpit environment. It was known that the PIC had served the company for more than 30 years while the SIC was a newly recruited pilot.

As the aircraft approached Kaimana, the PIC gave several instructions to the SIC related to the direction, speed, altitude and power setting of the aircraft. This type of interaction between the PIC and the SIC suggested a steep trans-cockpit authority gradient in which the SIC may not challenge the decisions and actions of the PIC.

The PIC may have lack of trust to the SIC, as indicated by giving the SIC handling instructions and took over the control during the final phase of the approach. The action of the PIC may have created additional workload to the PIC and reduced his situational awareness.

For more detail on crew resource management, situational awareness and schema/behavior see Appendix B.

2.7 OPERATOR MANAGEMENT

The investigation found that a LOSA (Line Operation Safety Audit) had been performed in the operator. However, a FOQA (Flight Operation Quality Assurance) had not been implemented and the operator had not been effectively implementing the Safety Management System (SMS) in all management levels.

As a result, management may not have adequate tools to monitor the quality of the line crew performance during line operations.

2.8 EGPWS

The EGPWS sounded aural alerts “Minimum-Minimum” at about 500 feet AGL, call out “Two hund……..” and finally superseded with “terrain-terrain” warning.

According to ompany operation manual (COM), in a VMC (Visual Meteorological Condition), a “minimum, minimum” alert while the approach was not stabilized should be followed by the action of abandoning the approach.

2.9 SUMMARY OF ANALYSIS

The investigation determined that the aircraft was being flown under visual flight in condition that was not suitable for a visual approach. The crew did not follow standard operating procedures and did not conduct an approach briefing or complete the landing checklist.

The crew were continually seeking to establish visual reference with the runway but were unsuccessful. Following the decision to discontinue the approach, the PIC deviated from the standard go-around procedures while the aircraft was in close proximity to the water.

The rapid descent was mainly a result of a combination of situations such as high bank angle (up to 38 deg to the left) and the flaps retracted to 5 and subsequently to 0 position, and also the combination of other situations such as; engine torque, airspeed, and nose-down pitch.

3 CONCLUSION

3.1 FINDINGS

1. The aircraft was airworthy prior the accident. There is no evidence that the aircraft had malfunction during the flight.
2. The crew had valid flight license and medical certificate. There was no evidence of crew incapacitation.
3. In this flight the SIC acted as Pilot Flying until the PIC took control of the aircraft at the last part of the flight.
4. According to company operation manual (COM), in a VMC (Visual Meteorological Condition), a “minimum, minimum” EGPWS alert while the approach was not stabilized should be followed by the action of abandoning the approach.
5. The cockpit crew did not conduct any crew approach briefing and checklist reading.
6. As it was recorded in the CVR during the final segment of the flight, both crews member were looking out-side to look for the runway. It might reduce the situational awareness.
7. At the final segment of the flight, the FDR recorded as follows:
   - The approach was discontinued started at 376 feet pressure altitude (250 feet radio altitude) and reached the highest altitude of 585 feet pressure altitude. While climbing the aircraft was banking to the left reaching a roll angle of 38 degree. The torque of both engines was increased reaching 70% and 82% for the left and right engine respectively.
   - During the go-around, the flaps were retracted to 5 and subsequently to 0 position, and the landing gears were retracted. The aircraft started to descend, and the pitch angle reached 13 degree nose down.
   - The rate of descend increased significantly reaching about 3000 feet per minute, and finally the aircraft crashed into the shallow sea.
8. The rapid descent was mainly a result of a combination of situations such as high bank angle (up to 38 deg to the left) and the flaps retracted to 5 and subsequently to 0 position, and also the combination of other situations: engine torque, airspeed, and nose-down pitch.
9. The ERS button was determined in the CRUISE mode instead of TOGA mode. This had led the torque reached 70% and 82% during discontinuing the approach.
10. The flaps were retracted to 5 and subsequently to 0, while the MA-60 standard go-around procedure is to set the flaps at 15.

11. There was limited communications between the crew along the flight. This type of interaction indicated that there was a steep trans-cockpit authority gradient.
12. The SIC was trained in the first three batches which was conducted by the aircraft manufacturer instructor and syllabus, while the PIC was trained by Merpati instructor using modified syllabus. Inadequacy/ineffectivity in the training program may lead to actions that deviated from the standard procedure and regression to the previous type.
13. The investigation found that the Flight Crew Operation Manual (FCOM) and Aircraft Maintenance Manual (AMM) used non-standard English Aviation Language. This finding was supported by a review performed by the Australian Transport Safety Bureau (ATSB).

3.2 OTHER FINDINGS

1. The DFDR does not have the Lateral and Longitudinal acceleration. These two parameters which were non safety related items were mandatory according to the CASR parts 121.343 and 121.344, and at the time of the MA 60 certification, the CCAR 121 did not require those two parameters.
2. Due to impact forces and immersion in water, the Emergency Locator Transmitter (ELT) did not transmit any signal.

3.3 FACTORS

Factors contributed to the accident are as follows:

1. The flight was conducted in VFR in condition that was not suitable for visual approach when the visibility was 2 km. In such a situation a visual approach should not have been attempted.
2. There was no checklist reading and crew briefing.
3. The flight crew had lack of situation awareness when tried to find the runway, and discontinued the approach.
4. The missed approach was initiated at altitude 376 feet pressure altitude (250 feet radio altitude), the pilot open power to 70% and 82% torque followed by flap retracted to 5 and subsequently to 0. The rapid descent was mainly caused by continuously increase of roll angle up to 38 degree to the left and the retraction of flaps from 15 to 0 position.
5. Both crew had low experience/flying time on type.
6. Inadequacy/ineffectivity in the training program may lead to actions that deviated from the standard procedure and regression to the previous type.

4 SAFETY ACTIONS

At the time of issuing this Final Report, the National Transportation Safety Committee had been informed concerning several safety actions performed:

4.1 DIRECTORATE GENERAL OF CIVIL AVIATION

Directorate General of Civil Aviation (DGCA) conducted a special safety audit for PT. Merpati Nusantara Airlines on 13 - 15 May 2011.

4.2 PT. MERPATI NUSANTARA AIRLINES

PT. Merpati Nusantara Airlines issued safety recommendations on 11 May 2011, as follows:

a. To pilots; to abandon the approach/to Go-Around if safe landing cannot be made.

b. To comply the Visual Flight Rules (VFR) and for the instrument approach minima;

c. To emphasis all nine “stabilized approach” criteria;

d. To include wind shear, Crew Resources Management (CRM), Approach Landing Accident Reduction (ALAR) and go-around indoctrination in the mandatory and simulator training;

e. For dispatcher: To provide up-dated weather information and anticipate the possibility of Return To Base (RTB);

f. For line maintenance: Preflight, transit and daily inspection should be conducted in accordance with the checklist and immediately reports any finding to the Maintenance Control Centre;

PT. Merpati Nusantara Airlines had implemented Safety Management System (SMS) in all management levels in October 2011.

4.3 AIRCRAFT MANUFACTURER

The Xi’An aircraft manufacturer informed that they are currently revising the aircraft operation and maintenance manuals into standard aviation English.

5 RECOMMENDATION

As a result of the investigation, the National Transportation Safety Committee issues the following recommendations:

5.1 RECOMMENDATION TO PT. MERPATI NUSANTARA AIRLINES

The National Transportation safety Committee recommends that the PT. Merpati Nusantara Airlines should:

a. Review the training management system to meet the standard requirements.

b. Improve the aircraft acceptance including documentation and manuals, related to the CASR requirements.

5.2 RECOMMENDATION TO DIRECTORATE GENERAL OF CIVIL AVIATION

The National Transportation safety Committee recommends that the Directorate General Civil Aviation should:

a. Emphasis the aircraft inspection including documentation and manuals, prior to issuance of an initial airworthiness certificate related to the CASR 121 requirements including the DFDR parameters.

b. Review the adequacy of training syllabus in order to meet the qualification requirements.

c. Review the crew pairing policy.

d. Review implementation of the Safety Management System (SMS) to all operators.

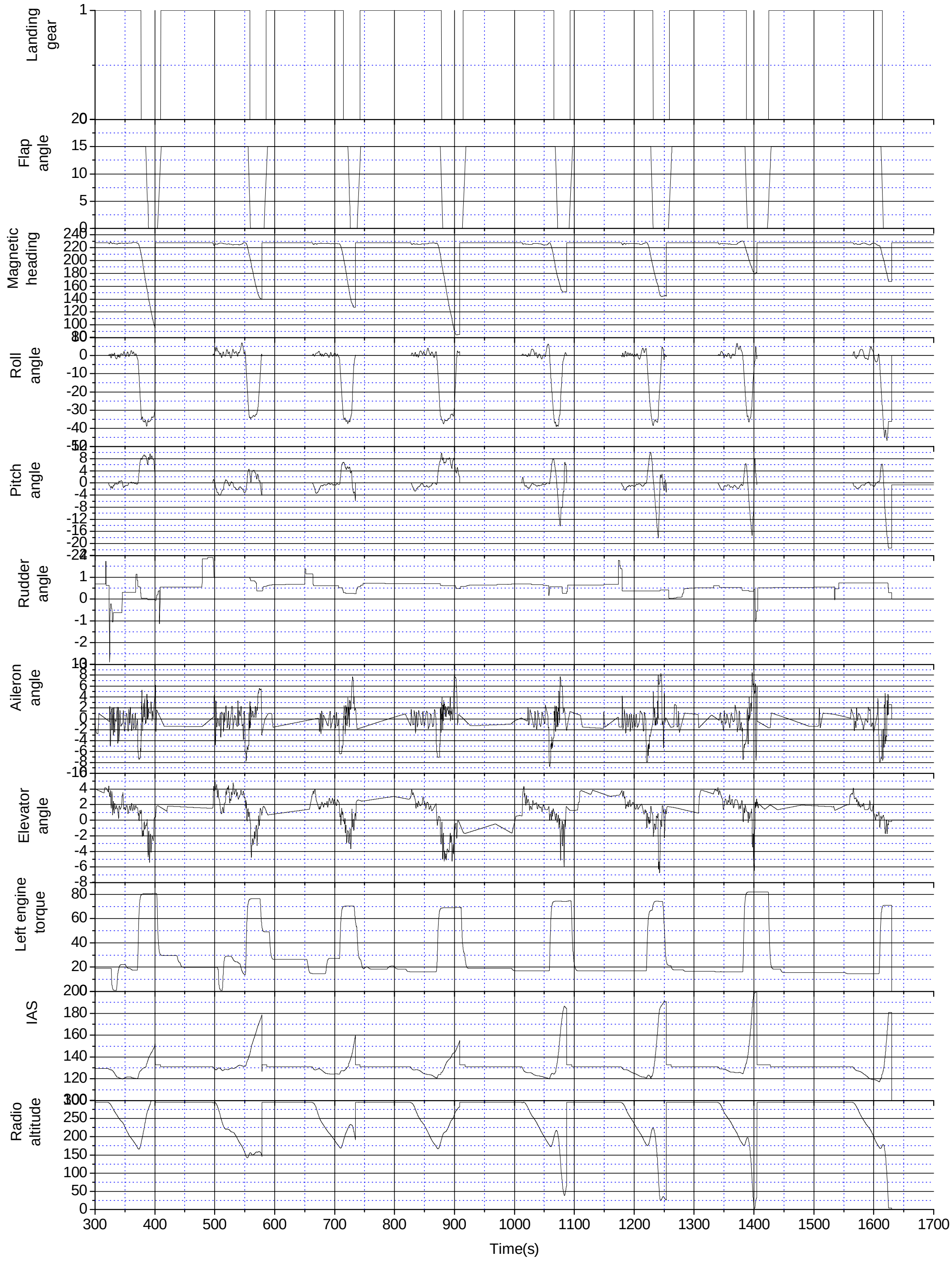
APPENDIX A

Simulator Exercises (8 sessions)

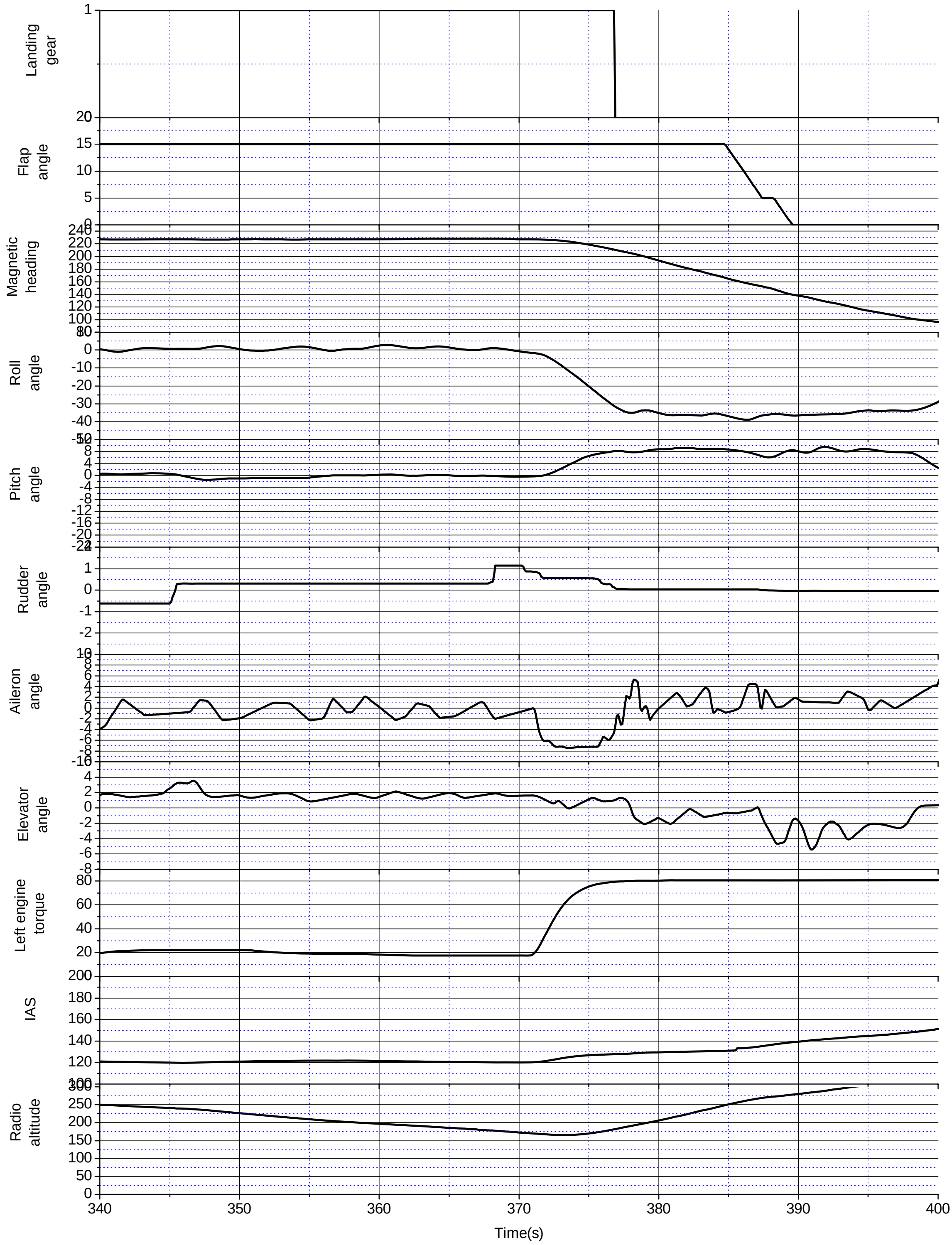
Plots of “flight parameter”

Legend:

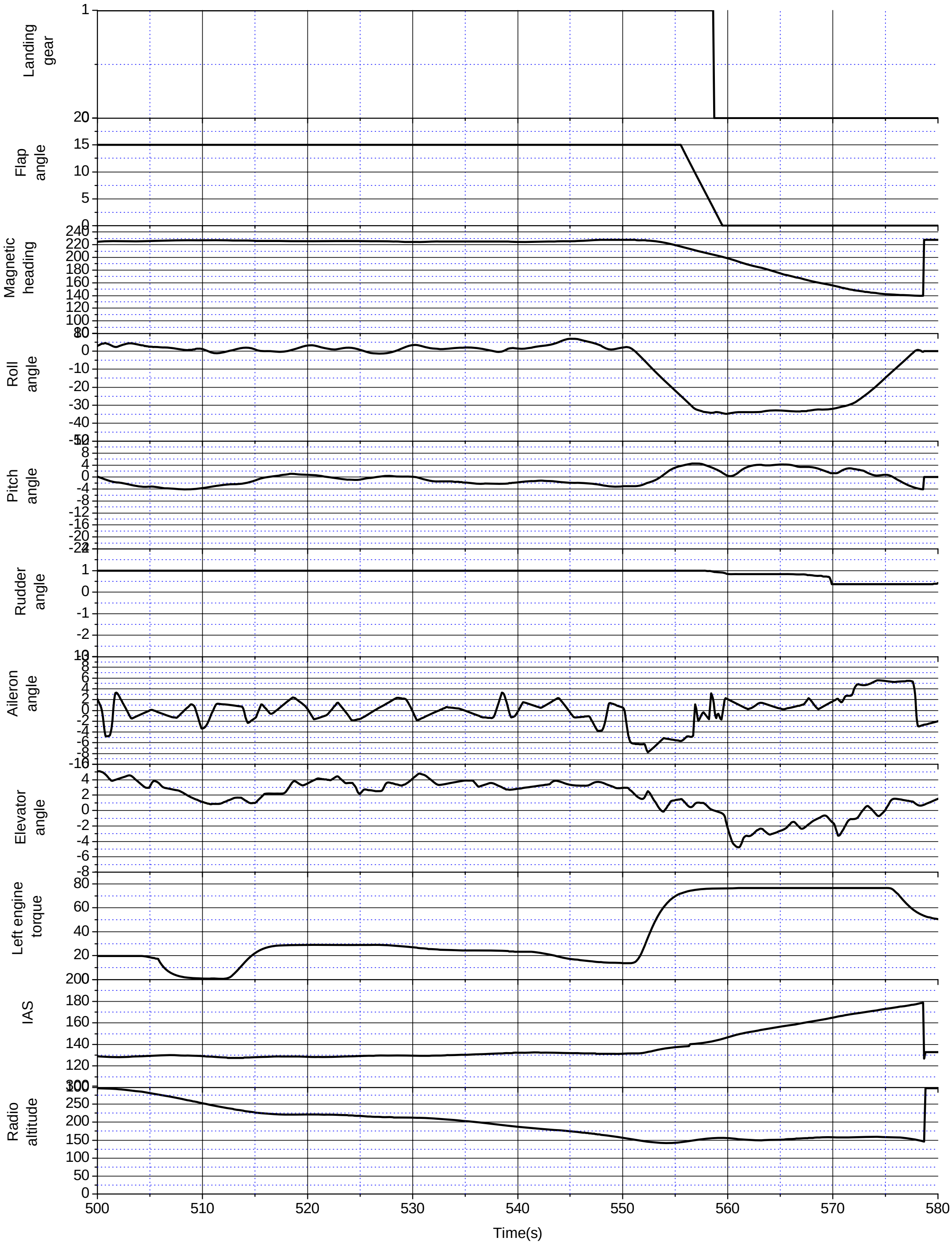
Time	:	s
Radio altitude	:	m
IAS	:	knots
Engine torque	:	%
Elevator angle	:	º
Rudder angle	:	º
Aileron angle	:	º
Pitch angle	:	º
Roll angle	:	º
Magnetic heading	:	º
Flap angle	:	º
Landing gear	:	1—down
		0—up



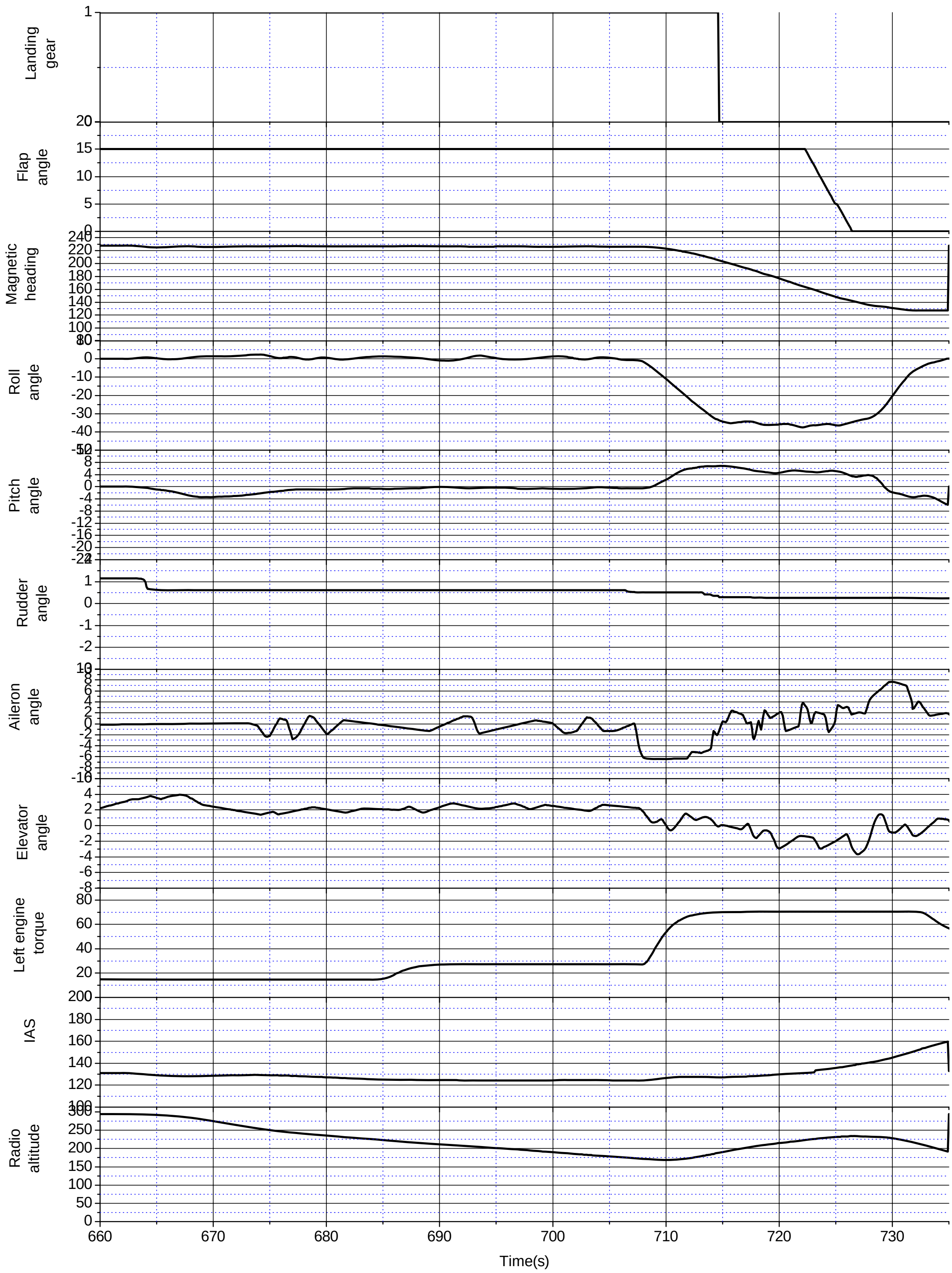
1. All movement



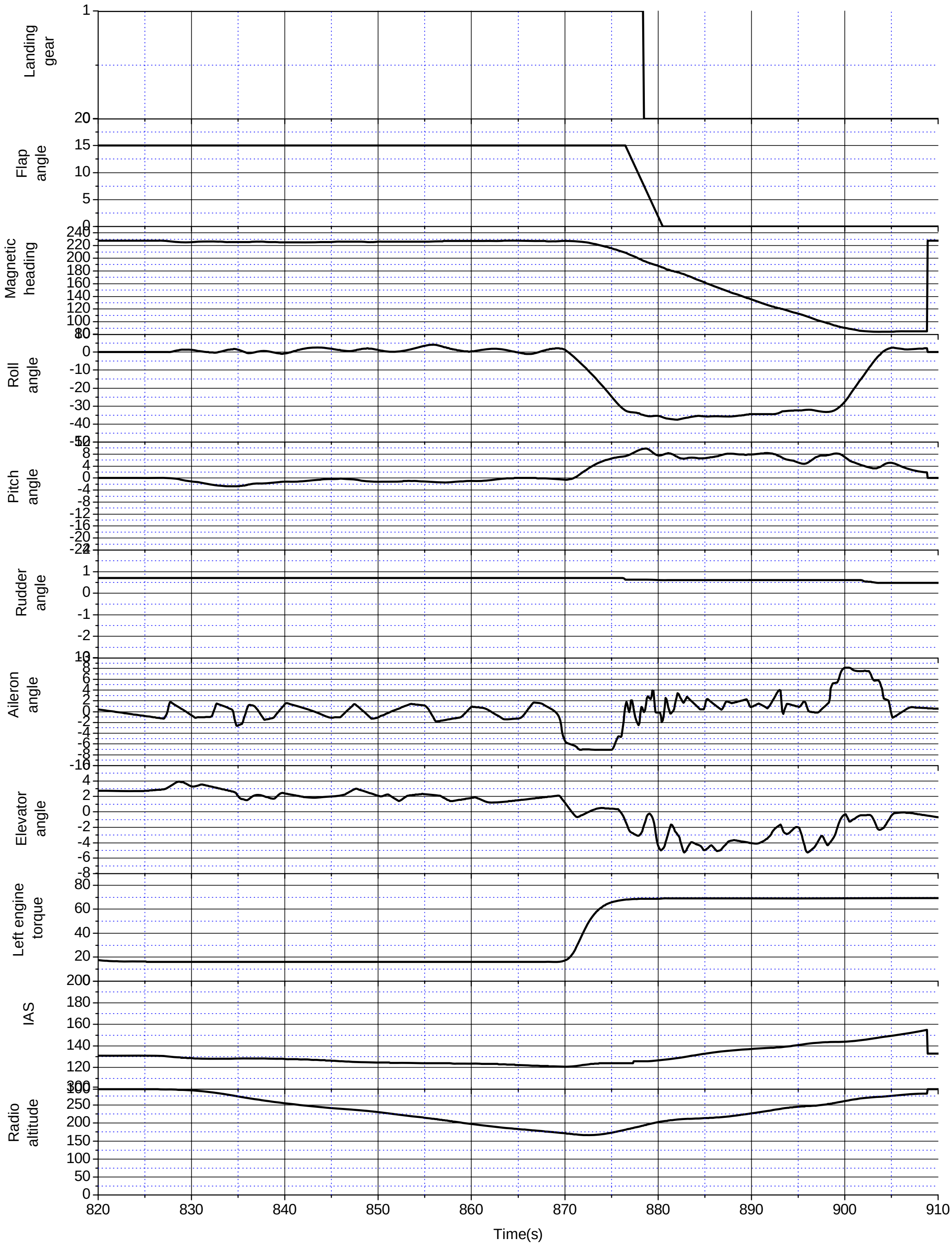
2. 1st movement



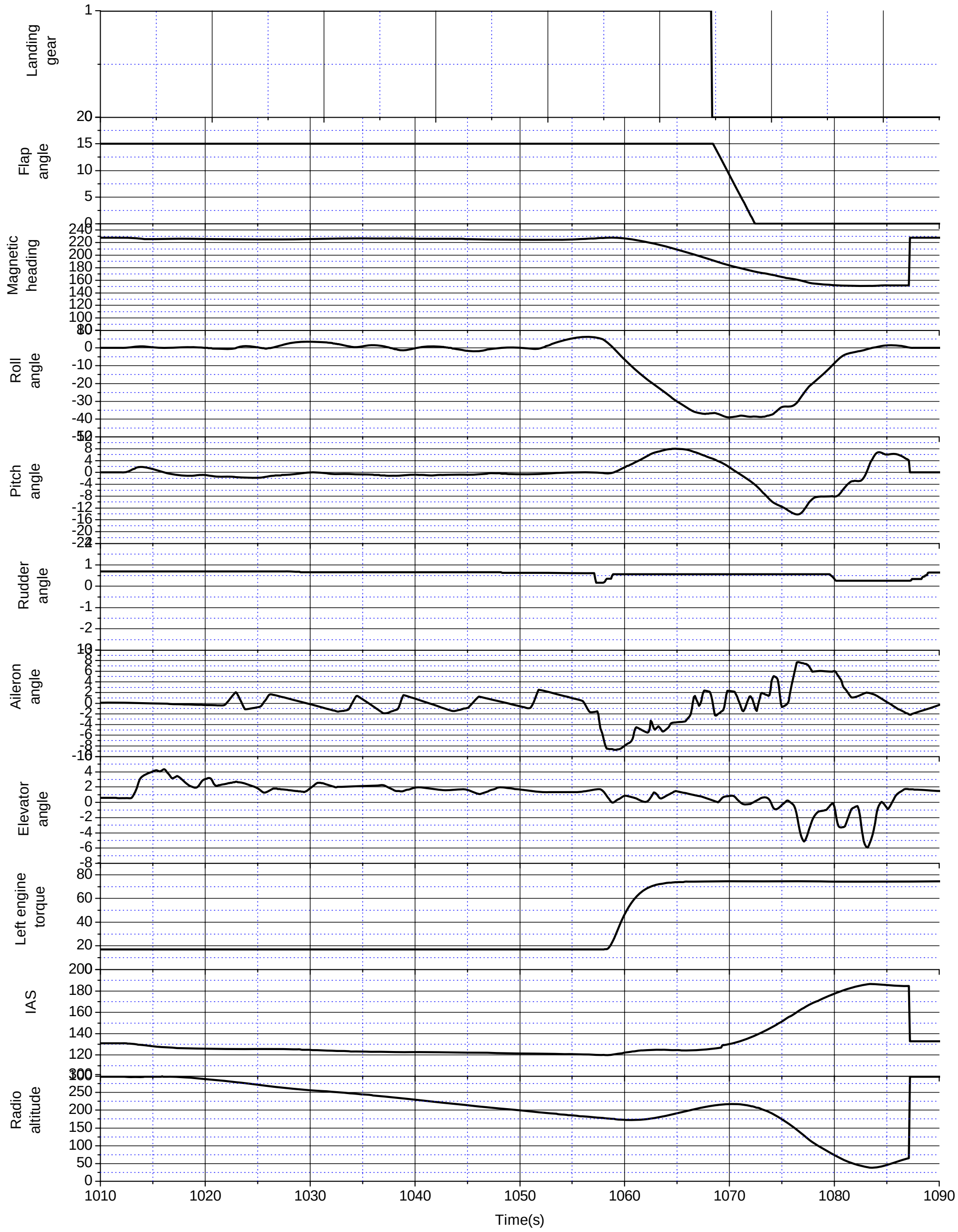
3. 2nd movement



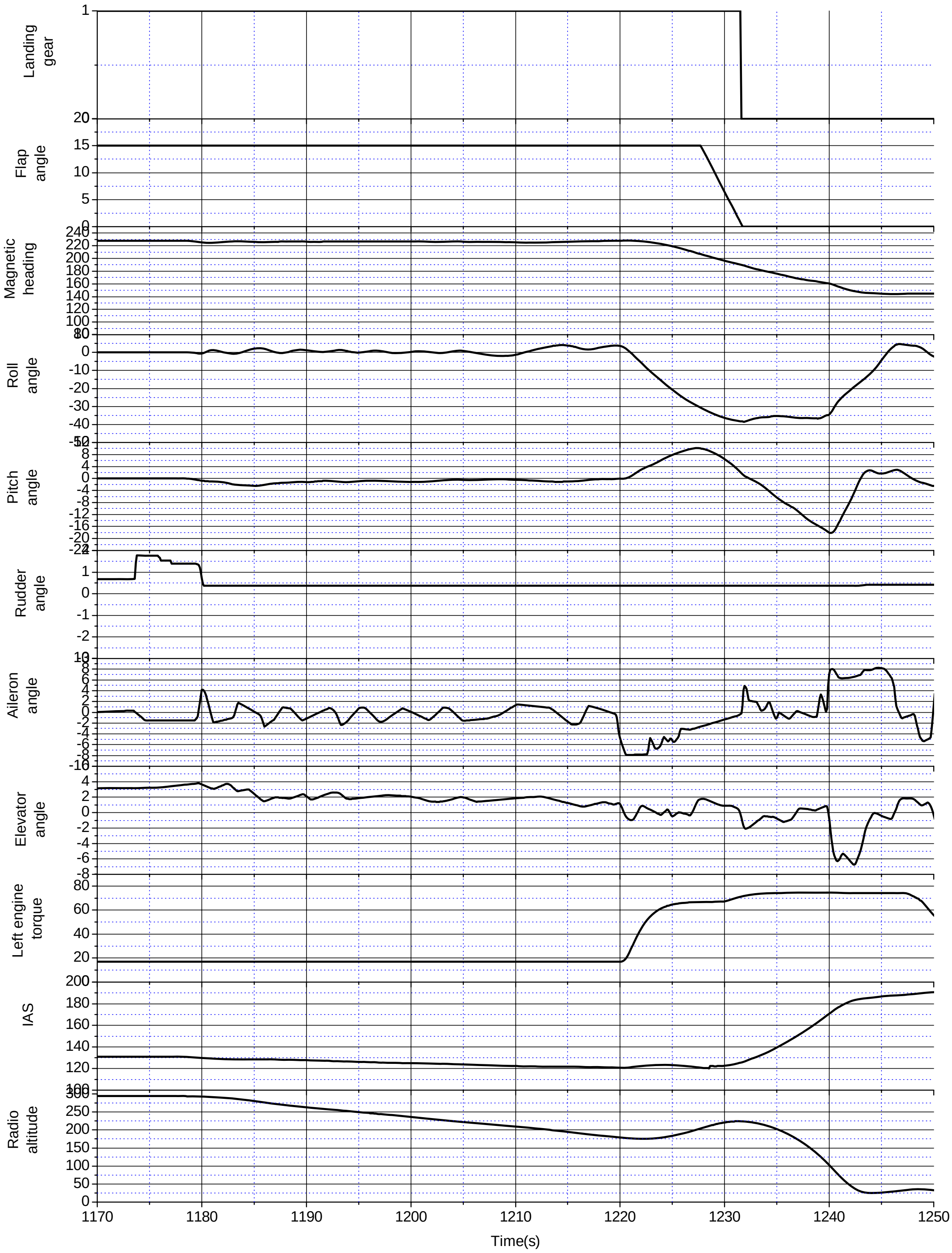
4. 3rd movement



5. 4th movement

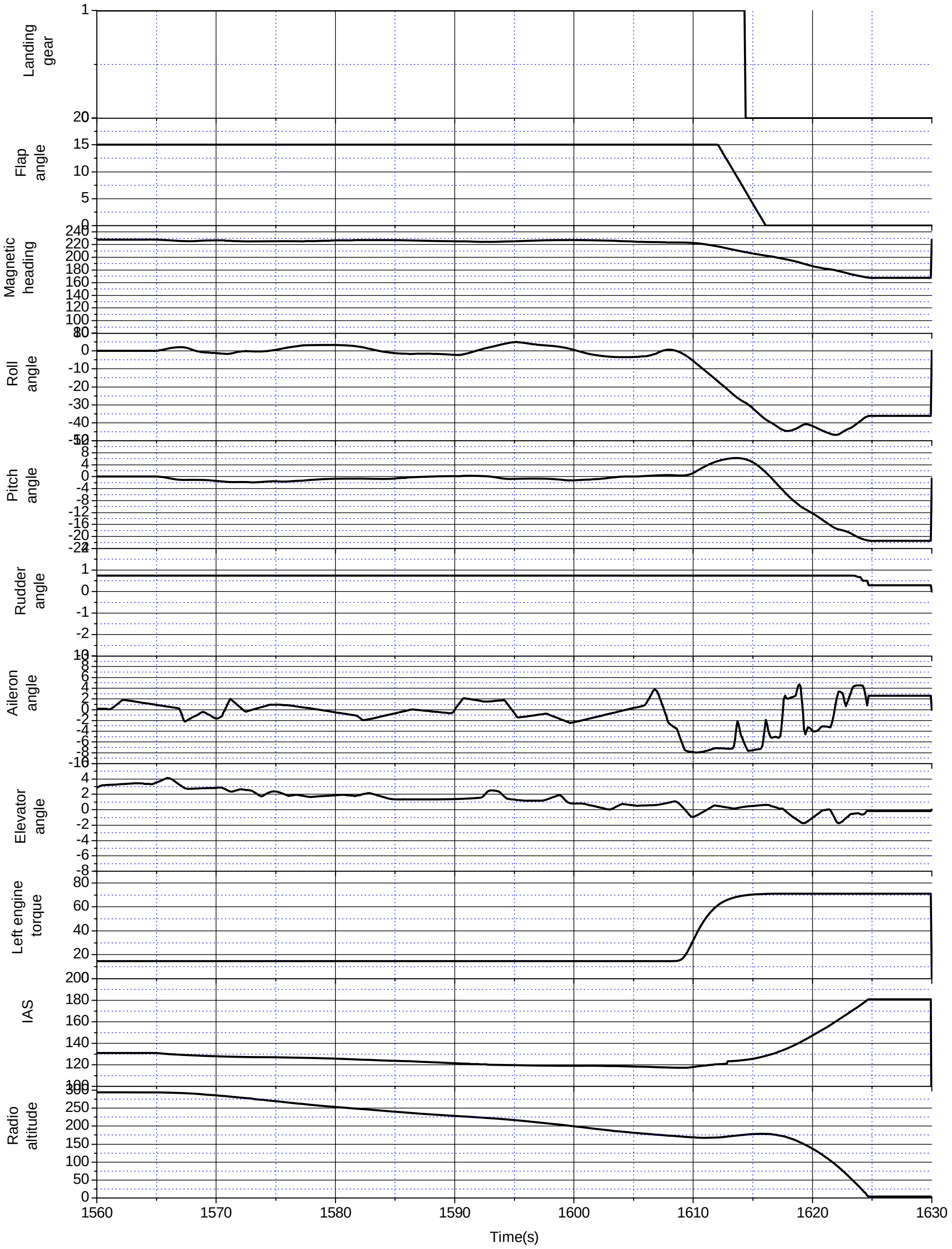


6. 5th movement



7. 6th movement

8. 7th movement



9. 8th movement

APPENDIX B

Situational awareness

Situational Awareness (SA) is a term that has been very difficult for researchers and practitioners to define. Nevertheless, it is a term that is often used to explain the causes of system failures. Typically, these failures involve a breakdown in the process of acquiring and processing task-related information such that valuable cues are either overlooked (lapse) or misinterpreted (mistake). To that end, SA relates primarily to the initial stages of information processing where information is acquired and examined, and on which subsequent decisions are made.

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 (Level 1 SA), knowledge of what has happened previously (Level 2 SA), and knowledge of what is expected to occur in the future (Level 3 SA).

An example of the impact of system design on SA can be drawn from the Xian M 60 accident. The sound of minimum reminding sign was not salient enough to aware the flight crew's attention during their effort to recognize the run way although the pilot already conducted training the event in the simulator. This is colloquially referred to as 'the out of the loop' syndrome.

Level 1 SA

The 'out of the loop' syndrome or a breakdown in Level 1 SA is said to occur when an automated system performs functions that are not anticipated by the operator. This tends to be the most common type of error that occurs as a result of interactions with advanced technology. Part of the difficulty appears to lie in both the accuracy and the reliability of such systems, to the extent that operators may become complacent regarding the potential system failures that may occur.

From an information processing perspective, the likelihood that a system will perform functions that are unanticipated by the operator is related to both the inherent behaviour of the automated system and the factors that impact upon the operator. Where a system is relatively unreliable, operators tend to maintain a relatively high level of vigilance, thereby decreasing the reaction time in response to an unexpected change in the system state. However, where a system is relatively reliable, operators may develop a level of trust in the system, the consequence of which may be an increase in the reaction time in response to an unexpected change in the system state.

Irrespective of issues such as design and training, the notion of advanced technology itself has implications for SA, especially in terms of failure detection and diagnosis. For example, evidence arising from research suggests that a lack of direct involvement in the performance of a task increases the time required to establish control of a system in the event of failure. Therefore, it might be asserted that the difficulty associated with advanced technology appears to arise due to the lack of cognitive involvement in the performance of a task. In the absence of such involvement, the cues arising from changes that occur within the operational environment are no longer evident, except through secondary sources such as instrumentation.

Level 2 SA

Rather than simply being aware of events that are occurring, SA also involves the interpretation and comprehension of the information arising from the environment, to the extent that some sort of meaning is derived in terms of the nature of the system (Level 2 SA). The skills necessary to derive an accurate interpretation are dependent upon a number features including the previous experience of the operator ***as well as in simulator training*** and the nature of the representation of the domain **in long-term memory**. It is only by understanding the interaction between the various features that constitute the environment that a person is able to integrate relatively disparate pieces of information to form a coherent understanding of the current state of the system.

Ultimately, the accurate interpretation of the information arising from the operational environment is dependent upon the development and maintenance of a mental model. A mental model is a representation in the mind, of the structure and operation of a system. **Mental models are developed largely through experience and active interaction with the environment**. They involve the interpretation of the perceived actions of a device and the mental representation of its structure.

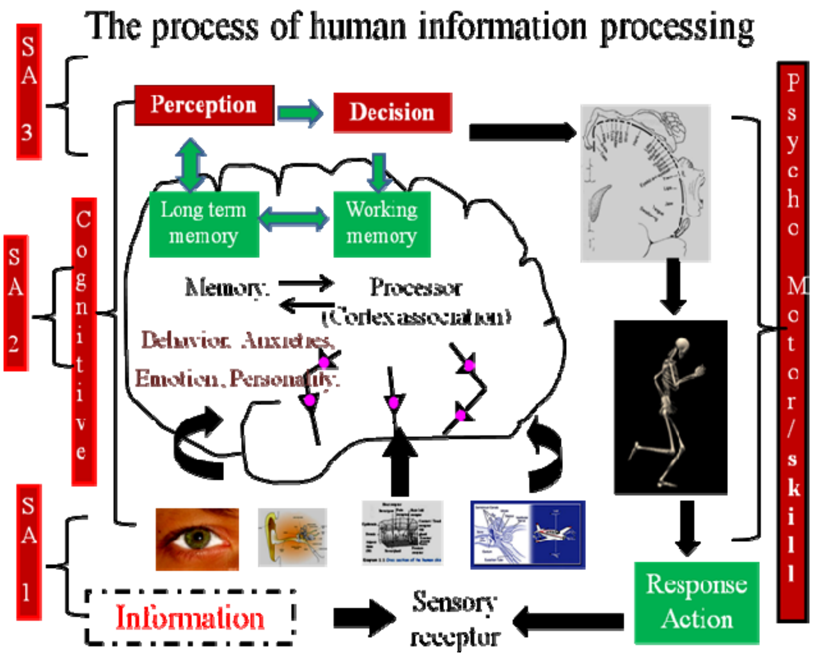
An inaccurate representation of the system may lead to difficulties in operating performance, particularly under conditions of high workload and/or stress. Important information that is pertinent to a problem may be overlooked or disregarded as unimportant if an operator is unable to integrate this information into a mental model of operation of the system.

One of the most important prerequisites for effective and efficient SA in a group environment involves the development and maintenance of a consistent mental model within the group. This is particularly significant during non-normal situations, as it enables the group as a team to increase the probability that subtle changes in the system state will be identified and processed.

Level 3 SA

In establishing an accurate and reliable mental model, pilots also develop the capability to anticipate the outcomes of the various actions. The capability to anticipate the impact of future events on human performance enables strategies to be devised that will minimize the potential impact of system failures. In the terms of the ‘Reason’ model, anticipation represents an opportunity to develop and implement a system defence to mitigate against a system failure.

Developing the skills necessary to anticipate the consequences of events is particularly difficult for less experienced people, and it is often developed ad hoc within the operational environment. However, the capacity to anticipate events is extremely important in complex dynamic systems, where the effectiveness of interventions is likely to diminish with time.



Crew Resource Management

Crew Resource Management (CRM) is generally defined as "the effective use of all available resources, such as equipment, procedures and people, to achieve safe and efficient operations" [10]. **It is associated with principles such as communication skills, interpersonal skills, stress management, workload management, leadership and team problem solving.** These principles have been taught in major airlines since the late 1970s.

CRM training programs generally consist of initial awareness training, recurrent awareness training, knowledge acquisition, skill acquisition, practical training exercises, and the incorporation of CRM elements in normal check and training activities. These courses are predominantly awareness based rather than skill acquisition courses.

Issues associated with the authority relationship between an aircraft captain (pilot in command) and the first officer (co-pilot) have been cited in a number of accidents and incidents. Research has shown that there is an optimum trans-cockpit authority gradient to allow an effective interface between pilots on the flight deck. The gradient may be too flat, such as two equally qualified individuals occupying the flight deck***, or it may be too steep, as with a dominating senior captain and an unassertive and less experienced first officer*****. In these cases, the likelihood of errors going undetected and/or uncorrected increases**. A study of 249 airline pilots found that nearly 40% of first officers reported that they had, on several occasions, failed to communicate their doubts to the captain about the operation of the aircraft. Reasons appeared to be a desire to avoid conflict and deference to the experience and authority of the captain. Those reasons were more consistent with or indicative of a steep trans-cockpit authority gradient.

Distraction

The problem of distractions exists in multi-crew aircraft. In this environment, the handling pilot must focus on flying the aircraft and must guard against allowing too much of his attention to be diverted by the tasks being performed by the support/monitoring pilot. In the Xi'An M60 accident, neither crewmember was monitoring the aircraft instruments. For some further information on the hazards associated with pilot distraction see ATSB aviation research investigation report B2004/0324

(http://www.atsb.gov.au/publications/2005/distraction_report.aspx).

Schema/Schemata Theory

Type of error of commision (doing the wrong thing) are slips, in which the operator has the correct intention, but carries out the wrong execution (sequence or wrong order of execution). This type of error can occure because of errors based in long term memory pattern encoded by previous repeated or impressed experience in which called schema/schemata or mental model. Errors based in *schema /long term memory pattern* is sensory-motor knowledge structures stored in memory used to guide behavior (Bartlett's Schema Theory, 1886–1969). Self-schemas/long term memory pattern are stable and fixed in adults (Markus, 1977). Schemas can contribute to stereotypes and make it difficult to retain new information that does not conform to our established schema. According to this theory, *schemata* represent knowledge about concepts: objects and the relationships they have with other objects, situations, events, sequences of events, actions, and sequences of actions.

If someone do learning the new knowledge and training others skill, the new schemata will pile up on the older or previous schema.

Regression of Skills

Regression is the loss of learned skills; usually after breaks ~~in~~ or did not in full concentration nor attention to the situation or instruction. These operators may be unable to retrieve from their long-term memory in a way that normally can be easily recalled and they refer to their older or previous long term memory pattern or schema. The amount of information they need to recover or "recoup" their abilities may be longer one to other operators and they may need additional information to catch up.

Analogy with Dreyfus Stages to Experience Levels of GA Aviators [*)]

Stage	Features	GA Pilot Experience Level
Novice	actions based on adherence to rules and procedures	student pilot
Advanced Beginner	actions based on both adherence to rules and recognition of previous experiences	licensed pilots who have acquired a minimum of 100 hours of total flying time
Competent	actions based on analysis of facts in which pilot begins to associate key facts with specific actions	licensed pilots who fly frequently (a minimum of 10 hours/month) and who have acquired a minimum of 250 hours of flying time
Proficient	actions based primarily on intuitive knowledge developed from past experiences but relies also on analytical skills	pilots with a variety of flight experiences who fly regularly (a minimum of 25 hours/month) and have acquired of 1,000 hours of flying time
Expert	actions based on intuitive knowledge and wisdom of relevant, context-based experiences – analysis is primarily concerned with identification of proper context	pilots with a variety of flying experiences who fly regularly (a minimum of 25 hours/month) and have acquired of 3,000 hours of flying time

[*)] Dreyfus, H.C. & Dreyfus, S.E. (1980). A five-stage model of the mental activities involved in directed skill acquisition ORC 80-2 (F49620-79-C-0063). Bolling, AFB, Washington, DC. Air Force Office of Scientific Research. United States Air Force.