KOMITE NASIONAL KESELAMATAN TRANSPORTASI
REPUBLIC OF INDONESIA

FINAL

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Aircraft Accident Investigation Report

PT Sriwijaya Air

Boeing 737-500; PK-CLC

Kepulauan Seribu District, DKI Jakarta

Republic of Indonesia

9 January 2021

2022

This Final Report was published by the Komite Nasional Keselamatan Transportasi (KNKT), Transportation Building, 3rd Floor, 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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Jakarta, 10 November 2022

KOMITE NASIONAL
KESELAMATAN TRANSPORTASI
CHAIRMAN

SOERJANTO TJAHJONO

Our sincerest condolences
for the families and relatives of the victims of the accident.
Wishing you peace, comfort, and courage at the time of sorrow.
Their sacrifice will not be in vain.
They will forever be missed and never forgotten.

To our beloved teacher, colleague and friend

Haryo Satmiko ATD, S.Sos, MPD

(6 May 1965 – 18 October 2022)

this will not be your last contribution

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ABBREVIATIONS AND DEFINITIONS

°C	:	Degree Celsius
A/P	:	Autopilot
A/T	:	Auto Throttle
A/T SPD	:	Autothrottle Speed
A/TC	:	Autothrottle Computer
AAIB	:	Air Accidents Investigation Branch
AAM	:	Autopilot Actuator Monitor
ACL	:	Authorization, Conditions and Limitation
AD	:	Airworthiness Directive
ADC	:	Air Data Computer
ADI	:	Attitude Director Indicator
ADS-B	:	Automatic Dependent Surveillance – Broadcast
Aeroplane	:	A power-driven heavier-than-air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight.
AFCS	:	Automatic Flight Control System
AFDS	:	Autopilot Flight Director System
AFML	:	Aircraft Flight Maintenance Log
AFS	:	Automatic Flight System
AIP	:	Aeronautical Information Publication
Aircraft	:	Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface
ALARP	:	As Low as Reasonably Practicable
ALERFA	:	The code word used to designate an alert phase
ALoS	:	Acceptable Level of Safety
ALT ACQ	:	Altitude Acquired
ALT HOLD	:	Altitude Hold
AML	:	Aircraft Maintenance Log
AMM	:	Aircraft Maintenance Manual
AMO	:	Approved Maintenance Organization
AMP	:	Aircraft Maintenance Procedure
AMPM	:	Aircraft Maintenance Procedure Manual
AOA	:	Angle of Attack
AOC	:	Air Operator Certificate
AOG	:	Aircraft on Ground
APM	:	Aircraft Procedure Manual

APP	:	Approach
APU	:	Auxiliary Power Unit
ARINC	:	Aeronautical Radio, Incorporated
ATC	:	Air Traffic Control
ATOs	:	Approved Training Organizations
ATP	:	Acceptance Test Procedure
ATPL	:	Airline Transport Pilot License
ATS	:	Air Traffic Services
AUPRTA	:	Airplane Upset Prevention & Recovery Training Aid
BITE	:	Built-in Test Equipment
BMKG	:	*Badan Meteorologi, Klimatologi, dan Geofisika*, is the Bureau of Meteorology, Climatology and Geophysics of Indonesia
BNPP	:	*Badan Nasional Pencarian dan Pertolongan* is the Indonesian Search and Rescue Agency
C of A	:	Certificate of Airworthiness
C of R	:	Certificate of Registration
CASR	:	Civil Aviation Safety Regulation
CB	:	Circuit Breaker
CBP	:	Compressor Bleed Pressure
CCA	:	Circuit Card Assemblies
CDL	:	Configuration Deviation List
CDU	:	Control Display Unit
CMD	:	Command
CMM	:	Company Maintenance Manual
COM	:	Company Operation Manual
CPC	:	Cabin Pressure Controller
CPL	:	Commercial Pilot License
CPL-A	:	Commercial Pilot License – Aeroplane
CRM	:	Crew Resource Management
CSMU	:	Crash Survivable Memory Unit
CTSM	:	Cruise Thrust Split Monitor
CVR	:	Cockpit Voice Recorder
CWS	:	Control Wheel Steering
DAA	:	Digital/Analog Adapter
DAAO	:	Directorate of Airworthiness and Aircraft Operations
DADC	:	Digital Air Data Computer
DAN	:	Directorate of Air Navigation

dBz	:	Decibel relative to Z. It is a logarithmic dimensionless technical unit used in radar, mostly in weather radar, to compare the equivalent reflectivity factor (Z) of a remote object (in mm6 per m3) to the return of a droplet of rain with a diameter of 1 mm (1 mm6 per m3)
DETRESFA	:	The code word used to designate a distress phase
DGCA	:	Directorate General of Civil Aviation
DMI	:	Deferred Maintenance Items
DQM	:	Departmental Quality Manager
E/A	:	Electronic & Avionic
EADI	:	Electronic Attitude Direction Indicator
EGPWS	:	Enhanced Ground Proximity Warning System
EGT	:	Exhaust Gas Temperature
ELBA	:	Emergency Locator Beacon-Aircraft
ERP	:	Emergency Response Planning
EWIS	:	Electrical Wiring Interconnection System
EZAP	:	Enhanced Zonal Analysis Procedure
F/D	:	Flight Director
FA	:	Flight Attendant
FAA	:	Federal Aviation Administration
FCC	:	Flight Control Computer
FCOM	:	Flight Crew Operating Manual
FCTM	:	Flight Crew Training Manual
FDA	:	Flight Data Analysis
FDAP	:	Flight Data Analysis Program
FDAPM	:	Flight Data Analysis Program Manual
FDM	:	Flight Data Manual
FDR	:	Flight Data Recorder
FIM	:	Fault Isolation Manual
FL	:	Flight Level
FMA	:	Flight Mode Annunciator
FMC	:	Flight Management Computer
FMC SPD	:	Flight Management Computer Speed
FO	:	First Officer
FOO	:	Flight Operation Officer
FOQA	:	Flight Operation Quality Assurance
FOTB	:	Flight Operation Technical Bulletin
GE	:	General Electric

GM	:	General Manager
GMF	:	Garuda Maintenance Facility
HDG	:	Heading
HDG SEL	:	Heading Select
HF	:	Human Factors
HIRA	:	Hazard Identification Risk Analysis
HHMPI	:	Handheld Multi-Purpose Interface
Hz	:	Hertz
IAS	:	Indicated Airspeed
IATA	:	The International Air Transport Association
ICAO	:	International Civil Aviation Organization
ILS	:	Instrument Landing System
INCERFA	:	The code word used to designate the uncertainty phase
INOP	:	Inoperative
IPC	:	Illustrated Part Catalog
IRS	:	Inertial Reference System
JATSC	:	Jakarta Air Traffic Services Center
JICT	:	Jakarta International Container Terminal
km	:	Kilo Meter
KNKT	:	*Komite Nasional Keselamatan Transportasi* is the Indonesia Independent Investigation Authority also known as National Transportation Safety Committee / NTSC)
lbs	:	A measuring unit in pound, which originates from the Latin libra
LLP	:	Life Limited Part
LMCR	:	Line Maintenance Control Report
LNAV	:	Lateral Navigation
LOC	:	Localizer
LOFT	:	Line Oriented Flight Training
LOSA	:	Line Operational Safety Audits
LRU	:	Line Replaceable Unit
LT	:	Local Time
LVDT	:	Linear Velocity Differential Transducer
LVL CHG	:	Level Change
MCC	:	Maintenance Control Center
MCP	:	Mode Control Panel
MEC	:	Main Engine Control
MEL	:	Minimum Equipment List

MIRS	:	Mechanical Interruption Summary Report
MMF	:	Merpati Maintenance Facility
MMO	:	Maximum Operating Mach Number
MOM	:	Multi Operator Message
MPD	:	Maintenance Planning Document
MPL	:	Multi-crew Pilot License
MSG	:	Maintenance Steering Group
NNC	:	Non-Normal Checklist
NTO	:	No Technical Objection
NTSB	:	National Transportation Safety Board
OTM	:	Operations Training Manual
P/N	:	Part Number
PCMCIA	:	Personal Computer Memory Card International Association
PF	:	Pilot Flying
PI	:	Portable Interface
PIC	:	Pilot in Command
PLA	:	Power Lever Angle
PM	:	Pilot Monitoring
PMC	:	Power Management Computer
PPC	:	Pilot Proficiency Check
QAR	:	Quick Access Recorder
QPM	:	Quality Procedure Manual
QRH	:	Quick Reference Handbook
QSS	:	Quality, Safety & Security
RCP	:	Reliability Control Program
RNAV	:	Area Navigation
ROV	:	Remotely Operated Vehicle
RPM	:	Rotation Per Minute
S/N	:	Serial Number
SB	:	Satisfactory with Briefing
SDR	:	Service Difficulties Report
SIC	:	Second in Command
SID	:	Standard Instrument Departure
SL	:	Service Letter
SMS	:	Safety Management System
SOP	:	Standard Operation Procedure
SPI	:	Safety Performance Indicators
SPM	:	Surface Position Monitor

SRB	:	Safety Review Board
SSFDR	:	Solid-State Flight Data Recorder
SSM	:	System Schematic Manual
SSMS	:	Sriwijaya Air Safety Management System
SSP	:	State Safety Program
T/O	:	Take Off
TAT	:	Total Air Temperature
TE	:	Terminal East
TOGA	:	Take Off Go Around
TPM	:	Training Program Manual
TSIB	:	Transport Safety Investigation Bureau
TSM	:	Torque Switch Mechanism
TSPM	:	Technical Services Procedure Manual
UK	:	United Kingdom
ULB	:	Underwater Locator Beacon
URT	:	Upset Recovery Training
UPRT	:	Upset Prevention and Recovery Training
US	:	United States
UTC	:	Universal Time Coordinate
V/S	:	Vertical Speed
VAC	:	Volt Alternating Current
VHF	:	Very High Frequency
VMO	:	Maximum Operating Speed
VNAV	:	Vertical Navigation
VOR	:	Very High Frequency Omnidirectional Range
VP	:	Vice President

SYNOPSIS

On 9 January 2021, a Boeing 737-500 aircraft, registration PK-CLC, was on a scheduled domestic flight, from Soekarno-Hatta International Airport (WIII), Jakarta, to Supadio International Airport (WIOO), Pontianak, and departed at 0736 UTC (1436 LT).

During climbing, the autopilot (A/P) directional control was changed from LNAV to HDG SEL and subsequently the vertical control changed to Pitch V/S and MCP SPD. These changes required less engine thrust therefore the engine power reduced. The FDR recorded that left thrust lever moved backward and the left engine thrust decreased, however the right engine remained at its climb power setting, resulting in an asymmetric thrust condition. The investigation concluded that the autothrottle (A/T) system command being unable to move right thrust lever was a result of friction or binding within the mechanical system except the torque switch mechanism. The maintenance record showed that the A/T problem was reported 65 times since 2013 and the problem was unsolved and still exist on the accident flight.

The Cruise Thrust Split Monitor (CTSM) system delayed to disengage the A/T and the thrust asymmetry continued to increase. The investigation believed that the delay of CTSM was due to an error in the spoiler signal value.

As the thrust asymmetry became greater, the aircraft turned to the left instead of to the right as intended. The aircraft entered an upset condition, and the pilot was unable to recover the situation. Inadequate of upset prevention and recovery training contributed to the inability of the pilot to prevent and recover from the upset condition.

The investigation concluded several contributing factors based on the safety issues identified following the accident.

The *Komite Nasional Keselamatan Transportasi* (KNKT) acknowledged that the safety actions taken by the related parties were relevant to improve safety, however there are safety issues that remain to be considered. The KNKT issued safety recommendations to address the safety issues identified in this report.

This investigation involved the participation of the National Transportation Safety Board (NTSB) of the United States of America as the State of Design and the State of Manufacture, the Air Accident Investigation Branch (AAIB) of the United Kingdom and the Transport Safety Investigation Bureau (TSIB) of Singapore as States providing assistance. All agencies have appointed their accredited representatives and advisers to assist in this investigation in accordance with the provisions in ICAO Annex 13.

1 FACTUAL INFORMATION

1.1 History of the Flight

On 9 January 2021, a Boeing 737-500 aircraft, registration PK-CLC, was being operated by PT Sriwijaya Air on a scheduled passenger flight from Soekarno-Hatta International Airport (WIII), Jakarta [1] with intended destination of Supadio International Airport (WIOO), Pontianak, on flight number SJY182.

At 0736 UTC (1436 LT[2]), in daylight conditions, Flight SJY182 departed from Runway 25R of Jakarta. On board the aircraft were two pilots, four flight attendants, and 56 passengers. The Pilot in Command (PIC) acted as Pilot Flying (PF) while the Second in Command (SIC) acted as Pilot Monitoring (PM).

At 07:36:46 UTC, the PM contacted the Terminal East (TE) controller (Air Traffic Controller/ATC) and the communication by the ATC was "SJY182 identified on departure, via SID (Standard Instrument Departure) unrestricted climb level 290". The instruction was read back by the PM.

At 07:36:51 UTC, the Flight Data Recorder (FDR) data recorded that the Autopilot (A/P) system engaged when the aircraft altitude was 1,780 feet. The A/P mode selected for directional control was selected LNAV and the vertical control was MCP SPD and LVL CHG[3].

At 07:38:00 UTC, the FDR recorded the A/P mode directional control was changed from LNAV to HDG SEL when the aircraft passed altitude about 5,400 feet and the aircraft speed was about 220 knots.

At 07:38:35 UTC, the A/P vertical control changed to V/S mode and the A/T changed from N1 mode to MCP SPD mode.

At 07:38:40 UTC, the FDR data recorded that as the aircraft climbed to an altitude of about 7,950 feet, the left thrust lever started decreasing from 47.5° thrust lever position and the N1[4] speed of the left engine decreased from 92.3%, while the right thrust lever position remained at 46° and the N1 speed of the right engine at 91.8%

At 07:38:41 UTC, the PM asked the PF whether the PF intended to turn to heading 070°.

The PM subsequently requested to the ATC for a heading change to 075° to avoid weather condition and at 07:38:50 UTC the ATC approved the request.

1 Soekarno-Hatta International Airport (WIII), Jakarta will be named as Jakarta for the purpose of this report.

2 The 24-hours clock in Local Time (LT) is used in this report to describe the local time as specific events occurred. Local time is Universal Time Coordinated (UTC) +7 hours.

3 LNAV, MCP SPD, LVL CHG are the autopilot modes, the detail description of the autopilot modes will be discussed in the chapter 1.6 of this report.

4 N1 refers to the rotational speed of the low speed spool which consists of the fan, the low pressure compressor and the low pressure turbine, all of which are connected by a concentric shaft.

At 07:39:01 UTC, the ATC instructed the pilots of SJY182 to stop climbing at 11,000 feet. The instruction was acknowledged by the PM. This altitude assignment was intended to avoid a conflict with another aircraft departing from Runway 25L with the same destination. The SJY182 aircraft was climbing to an altitude of about 8,800 feet and the left thrust lever position had decreased to 39° and the N1 speed of the left engine decreased to 86.4%, while the right thrust lever position and the N1 remained unchanged.

At 07:39:36 UTC, the altitude alert[5] tone sounded when the aircraft was passing through an altitude of about 10,100 feet, followed by the PM callout “Approaching 11,000”. The left thrust lever position had decreased to 25° and the N1 speed of the left engine decreased to 72.7%, while the right thrust lever position and the N1 remained unchanged.

At 07:39:40 UTC, the FDR recorded that the left thrust lever position had decreased to 22° and the N1 speed of the left engine decreased to 67.5%, while the right thrust lever position and the N1 remained unchanged. The control column wheel reached the recorded value of about 19° to the right and remained at this position until the A/P disengaged. The aircraft was turning to the right at a roll angle of about 15° to capture the commanded heading.

At 07:39:48 UTC, the FDR data recorded the aircraft’s altitude was about 10,450 feet, the roll angle was about 0°, with a heading of 046° and started decreasing (i.e., the aircraft started to turn to the left). The left thrust lever had decreased to 17.6° and the N1 speed of the left engine decreased to 59.3%, while the right thrust lever position and the N1 remained unchanged.

At 07:39:54 UTC, the aircraft was climbing through an altitude of about 10,500 feet when the PM called out “Set standard”[6]. The calculated rate of climb was about 950 feet/minute. The aircraft continued turning to the left with a roll angle of about 7°. The left thrust lever had decreased to 13° and the N1 speed of the left engine decreased to 49%, while the right thrust lever position and the N1 remained unchanged.

At 07:39:55 UTC, the ATC instructed the pilots of SJY182 to climb to Flight Level (FL) 130 (altitude of 13,000 feet). The instruction was acknowledged by the PM. This was the last recorded radio transmission from the accident flight.

At 07:40:01 UTC, the PF called out ”130” which might be the acknowledgement to the ATC instruction to climb to FL 130, and was responded “130” by the PM.

At the same time when the PM provided the response, at 07:40:03 UTC, the aircraft’s Enhanced Ground Proximity Warning System (EGPWS) alert “BANK ANGLE”[7] sounded. The aircraft was at an altitude of about 10,700 feet. The aircraft continued turning to the left with roll angle about 37°. The left thrust lever position had decreased to 9.3° and the N1 speed of the left engine decreased to 35.1%, while the right thrust lever position and the N1 remained unchanged.

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5 Altitude alert is an aural warning which active during climb or descend when the aircraft altitude reaches 900 feet to the intended altitude selected on the Mode Control Panel (MCP) or Flight Management Computer (FMC).

6 Callout ‘set standard’ is a reminder for pilots to set the altimeter barometric sub-dial to International Standard Atmospheric (ISA) of 1,013 millibars after passing the transition altitude, which within Indonesia airspace is 11,000 feet.

7 BANK ANGLE is EGPWS alert which on this flight condition active when the aircraft roll angle is 35° or greater.

At 07:40:05 UTC, the FDR data recorded the highest aircraft altitude of 10,700 feet, and the aircraft started to descend. The pilot activated stabilizer trim switch which disengaged the A/P system. The aircraft heading was 016°, and the aircraft rolled to the left at an angle of more than 45° with an accompanying by EGPWS bank angle alert. The left roll was further exacerbated by left roll pilot commands. The left thrust lever position had decreased to 8° and the N1 speed of the left engine decreased to 34%, while the right thrust lever position and the N1 remained unchanged.

At 07:40:10 UTC, the FDR data recorded the autothrottle (A/T) system disengaged and the aircraft pitch angle was more than 10° nose down.

At 07:40:28 UTC, the FDR stopped recording. The last aircraft coordinate recorded in the FDR was 5°57'56.21" S 106°34'24.86" E, which was in the vicinity of the accident location.

At 14:40 LT, the ATC called the pilot of SJY182 requesting for the aircraft heading but did not receive any response from the SJY182 pilot.

At 14:40:46 LT, the ATC called SJY182 pilot once again but did not receive any response from the pilot. At 14:40:48 LT, the radar target of the aircraft disappeared from the ATC radar screen.

At 14:41:09 LT, the ATC put a measurement vector of the last known position of SJY182 on the radar screen. The ATC then advised the supervisor of the disappearance of SJY182. The supervisor then reported the occurrence to the operation manager.

The ATC repeatedly called SJY182 and asked other aircraft pilots that flew near the last known location of SJY182 to call the SJY182 pilots. The ATC then activated the emergency frequency of 121.5 MHz and called SJY182 pilots on that frequency. All efforts were unsuccessful to get any responses from the SJY182 pilots.

1.2 Injuries to Persons

Injuries	Flight crew	Passengers	Total in Aircraft	Others
Fatal	6	56	62	-
Serious	-	-	-	-
Minor	-	-	-	-
None	-	-	-	-
TOTAL	6	56	62	-

All occupants were Indonesian citizens.

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

No other damage to property and/or the environment.

1.5 Personnel Information

1.5.1 Pilot-in-Command (PIC)

Gender	:	Male
Age	:	54 years old
Nationality	:	Indonesia
Marital status	:	Married
Date of joining company	:	24 November 2014
License	:	Airline Transport Pilot License (ATPL)
Date of issue	:	11 August 1997
Aircraft type rating	:	Boeing 737
Instrument rating validity	:	30 November 2021
Medical certificate	:	First class
Date of last medical	:	23 July 2020
Validity	:	23 January 2021
Medical limitation	:	Holder shall possess glasses that correct for near vision

Flying experience

Total hours	:	17,904 hours 12 minutes
Total on type	:	9,023 hours 22 minutes
Last 90 days	:	142 hours 40 minutes
Last 30 days	:	53 hours 24 minutes
Last 7 days	:	13 hours 6 minutes
Last 24 hours	:	Nil
This flight	:	about 22 minutes

Summary of Relevant PIC Trainings

On 6 May 2019, during the Pilot Proficiency Check (PPC), the upset recovery maneuver was assessed, and the result was satisfactory.

On 19 May 2019, the PIC underwent Line Check and the result was satisfactory.

On 10 November 2020, the PIC attended recurrent of Crew Resource Management (CRM) training with duration of 8 hours.

On 17 November 2020, the Line Oriented Flight Training (LOFT) was carried out and the result was satisfactory with remarks on the assessment items of Taxi and Non-normal Procedure (volcanic ash, loss of thrust both engines). The general comment for the PIC was “need improvement”. The corrective action for the remarks was made by briefing and the result was satisfactory.

On 18 November 2020, the PPC was conducted, and the result was satisfactory with general remark of required improvement on the standard callouts. Some assessment items were assessed as Satisfactory with Briefing (SB)[8]. Briefings were conducted on the SB items and the PIC was released for line operation. The SB were on the following assessment items:

- Knowledge (Non-Normal Checklist memory items and technical).
- CRM (standard callout and Flight Mode Annunciation (FMA) callouts).
- Non-Normal Procedure (cargo fire) with remark stating that evacuation initiated without executing cargo fire checklist.
- Approach (visual traffic pattern).
- Flight Management (FMC).

1.5.2 Second in Command

Gender	:	Male
Age	:	34 years old
Nationality	:	Indonesia
Marital status	:	Married
Date of joining company	:	8 November 2013
License	:	Commercial Pilot License (CPL)
Date of issue	:	23 November 2011
Aircraft type rating	:	Boeing 737
Instrument rating validity	:	31 July 2021
Medical certificate	:	First class
Date of last medical	:	3 July 2020
Validity	:	3 January 2021 with exemption[9]
Medical limitation	:	None
Flying experience		
Total hours	:	5,107 hours 39 minutes
Total on type	:	4,957 hours 39 minutes
Last 90 days	:	113 hours 44 minutes
Last 30 days	:	30 hours 10 minutes
Last 7 days	:	6 hours 29 minutes
Last 24 hours	:	Nil
This flight	:	about 22 minutes

8 Satisfactory with Briefing (SB) is an assessment criterion of performance which requires briefing to achieve the standard performance.

9 The SIC was included to have medical certificate validity exemption due to Covid-19 pandemic to the Directorate General of Civil Aviation.

Summary of Relevant SIC Trainings

On 15 July 2019, during the PPC, the upset recovery maneuver was assessed, and the result was satisfactory.

On 15 January 2020, the LOFT was carried out and the result was satisfactory without remarks.

On 14 February 2020, the SIC underwent line check and the result was satisfactory.

On 24 July 2020, the PPC was conducted, and the result was satisfactory. Some assessment items were assessed as SB. Briefings were conducted on the SB items and the SIC was released for line operation. The SB were on the following assessment items:

- Knowledge (NNC memory items),
- Non-normal Procedures (engine limit, engine severe damage), and
- Maneuvers (engine failure on takeoff). On this assessment item, the remarks were execution of memory items, heading deviation and wrong identification of engine problem.

On 8 December 2020, the SIC attended recurrent of CRM training with duration of 8 hours.

1.5.3 Flight Attendants

All flight attendants held valid Flight Attendant Certificates with rating of Boeing 737 and valid medical certificates.

1.5.4 Air Traffic Controller (Terminal East)

Gender	:	Male
Age	:	34 years
Nationality	:	Indonesia
Year of joining company	:	2013
License	:	Air Traffic Control License
Type rating	:	1. Tower Control
		2. Approach Control Surveillance
		3. Approach Control Procedural
Validity		30 June 2021
Medical certificate	:	Third class
Date of last medical	:	26 June 2018
Validity	:	26 June 2022
Medical limitation	:	None
ICAO English Language Proficiency	:	Level 4
Date of issue	:	15 November 2018
Validity	:	15 November 2021

Working time[10]

Last 7 days	:	19 hours 10 minutes
Last 24 hours	:	40 minutes

Duty time[11]

Last 7 days	:	9 hours 40 minutes
Last 24 hours	:	40 minutes

1.6 Aircraft Information

1.6.1 General

Registration mark	:	PK-CLC
Manufacturer	:	Boeing
State of manufacturer	:	United States of America
Type/Model	:	737-524
Serial Number	:	27323
Year of manufacture	:	31 May 1994
Date Indonesia registered	:	15 May 2012
Certificate of Airworthiness		
Issued	:	17 December 2020
Validity	:	16 December 2021
Category	:	Transport
Limitations	:	None
Certificate of Registration		
Number	:	3090
Issued	:	15 May 2019
Validity	:	14 May 2022
Time Since New	:	62,983 hours
Cycles Since New	:	40,383 cycles
Last Major Check	:	C06 (on 18 March 2019)
Last Minor Check	:	A05 (on 18 December 2020)

10 The working time is the time period when the person attends their particular working shift.

11 The duty time for Air Traffic Controller is the time period when the person performs their duty to provide air traffic control service.

1.6.2 Engines

Manufacturer	:	CFM International
Type/Model	:	CFM56-3B1
Serial Number-1 engine	:	859110
Serial Number-2 engine	:	858702

The summary record of the engines installed to the aircraft is as follow:

Year	Left Engine Serial Number	Right Engine Serial Number	Remarks
2012 - 2014	856876	859126	-
2015	721843	859126	On 4 February 2015, the left engine was replaced due to the expiry of a Life Limited Part (LLP).
2016	721843	856876	On 13 April 2016, the right engine was replaced due to the expiry of an LLP.
2017 - 2018	721843	856876	-
2019	721843	858702	The right engine was replaced due to the expiry of the LLP on 31 January 2019, during C06 Check.
2020	859110	856435	In March 2020, the aircraft was sent to Surabaya for maintenance and was grounded until December 2020. Both engines were replaced during the maintenance. The aircraft was released for service and flew back to Jakarta on 19 December 2020. Subsequently the right engine (serial number 856435) was replaced in Jakarta (with the engine serial number 858702 that was fitted on aircraft registration PK-CLK).
2021	859110	858702	-

1.6.3 Weight and balance

The aircraft weight and balance calculation of SJY182 flight based on the weight and balance sheet were as follows:

Dry operating weight	:	73,102 lbs
Total load	:	8,868 lbs

Total fuel on takeoff	:	19,118 lbs
Takeoff weight	:	101,088 lbs (maximum 116,448 lbs)
MAC takeoff	:	22.2%
Estimate trip fuel	:	6,488 lbs
Estimate landing weight	:	94,600 lbs (maximum 110,000 lbs)

1.6.4 Aircraft Maintenance Log Examination

1.6.4.1 Aircraft Maintenance Record

Since 24 March 2020 until 19 December 2020, Sriwijaya Air grounded the PK-CLC aircraft to perform several maintenance tasks, such as compliance with Airworthiness Directive (AD) number 2017-06-14, and 2013-04-05, engine borescope inspection on both engines, etc.

Since the aircraft was released to service on 20 December 2020 until the accident flight, there were 43 pilot reports recorded in the Aircraft Maintenance Log (AML). Issues with the A/T problem was reported 3 times during this period. The details of pilot reports from 20 December 2020 to 8 January 2021 are listed in the Appendices 6.1.

1.6.4.2 Deferred Maintenance Items (DMI)

The following DMI were recorded after the aircraft returned to service on 20 December 2020 until the accident flight.

DMI number 07953

On 20 December 2020 during the transit check, the engineer found that the right wing tip position light was not illuminate. The engineer replaced the bulb, but the problem still existed and transferred the problem into the DMI number 07953. On the same day the DMI was closed by rectifying the electrical wire.

DMI number 07954

On 20 December 2020 during the transit check, the engineer found that the A/T could not be engaged. The engineer transferred the problem into the DMI list number 07954.

On 22 December 2020, the engineer attempted to rectify the A/T system by replacing the A/T actuator assembly (A/T servo) of the right engine and the test result was satisfactory. The engineer did not close the DMI and considered to monitor the problem during the aircraft operation.

On 26 December 2020, during the daily inspection, the engineer performed the trouble shooting for the A/T system by conducting the BITE test and found that the “alpha vane DADC LH” and “A/T servo 2” failed. The engineer swapped the left and right Digital Air Data Computer (DADC), but the problem still existed and the DMI kept open.

On 30 December 2020, the engineer replaced the A/T computer. The BITE test result was satisfactory and the DMI was closed.

DMI number 07955

On 22 December 2020, a pilot reported that the auto mode of the pressurization system was unserviceable. The engineer cleaned up the Cabin Pressure Controller (CPC) computer connector, but the problem was still existed, and the engineer transferred the problem into the DMI list number 07955. On the same day, the CPC computer was replaced. The result of the test was satisfactory and the DMI was closed.

DMI number list 07956

On 25 December 2020 during a preflight check, the engineer found the first officer's Mach/Airspeed Indicator malfunctioned. The engineer then transferred the issue into the DMI list number 07956 due to unavailability of spare part. According to the Sriwijaya Air Boeing 737 Minimum Equipment List (MEL), the item was classified as repair category C[12].

On 4 January 2021, the first officer's Mach/Airspeed Indicator was replaced, and test result was satisfactory and the DMI was closed.

DMI number 07957

On 29 December 2020, a pilot reported that the cabin altitude selector on the Cabin Pressure Control Panel was unable to be set. The engineer replaced the Cabin Pressure Control Panel, but the outflow valve could not be manually controlled using the switch in the Cabin Pressure Control Panel. The engineer then transferred the defect into the DMI list number 07957. On the same day the Cabin Pressure Control Panel was replaced and the test result was satisfactory and the DMI was closed.

DMI number list 07958

On 3 January 2021, a pilot reported that A/T was unserviceable. The engineer attempted to resolve the problem by cleaning the A/T computer's electrical connector. After re-installation, the Built-in Test Equipment (BITE) test result was good.

On 4 January 2021, a pilot reported that A/T was unserviceable. The engineer tried cleaning the A/T computer's electrical connector, but the problem remained, and it was transferred to DMI number list 07958.

On 5 January 2021, the engineer again attempted to address the problem as stated in the DMI number 07958 by cleaning the A/T Takeoff and Go Around (TOGA) switch and conducted a BITE test on the A/T computer. The BITE test result was good and the DMI was then closed.

1.6.4.3 Autothrottle (A/T) Maintenance Record

The investigation reviewed the maintenance records for A/T and A/P systems which were derived from the AML since 2012 until the accident flight.

The first pilot report on the A/T related defect was recorded on 7 November 2013, which stated that the A/T switch was unable to hold in ARM position. Since the first report until the accident flight, there were a total of 65 pilot reports relating to the A/T, including 32 pilot reports of A/T disengagement. In addition to the 65 A/T pilot reports, the AML also recorded 69 pilot reports relating to problem of the A/P.

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12 According to the Sriwijaya Air Boeing 737 Minimum Equipment List (MEL), the MEL repair category C means the item must be repaired within 10 consecutive calendar-days (240 hours) excluding the day the malfunction was recorded in the Aircraft Maintenance Log (AML).

The 65 pilot reports related to the A/T system mainly consisted of the following:

- A/T system cannot be engaged
- A/T system disengage during flight
- A/T system could not hold in ARM position
- A/T unserviceable.

The reported A/T problems were troubleshooted and rectified by engineers. The breakdown of the rectification methods used by the engineers are summarized in the following table in percentage based on the total number of 65 reports.

Cleaning electrical connector	**Trouble shooting in accordance with AMM 22-04-10 (A/T System BITE)**	**Trouble shooting in accordance with AMM 22-31-00 (A/T System)**	**Other**
31	12	16	6
48%	18%	25%	9%

The table showed that most of the rectifications were conducted by cleaning of the electrical connector of the A/T system components followed by performing the Built in Test Equipment (BITE) procedure to clear faults.

The AML record showed that some of the reported problems appeared to be solved after the electrical connector cleaning was performed. The record also showed that after the engineer cleaned the electrical connector, the BITE tests were performed which showed the result of “no faults” and the rectification actions were stopped. The rectification utilized the maintenance manual which contained several FMC CDU pages for BITE test. The investigation was unable to find the FMC CDU page that was referred by the engineer during the BITE test as it was not clearly written in AML page.

The rectifications were also conducted by replacement of the suspected faulty components of the A/T system. The component replacements are summarized as follow:

1. On 3 October 2014, the N1 sensor of the right engine was replaced.
2. On 24 August 2015, the Flight Control Computer (FCC) B was replaced (the component removed was part number (P/N) 4051600-914 with serial number (S/N) 94033530, and the component installed was P/N 4051600-914 S/N 99044580).
3. On 17 December 2015, the Mode Control Panel (MCP) was replaced (the component removed was P/N 4051601-937 with S/N 96022554 and the component installed was P/N 4051601-938 with S/N 94102338,).
4. On 23 January 2016, the A/T computer was replaced (the component P/N 735SUE10-12 with S/N 5442 was removed, and the component P/N 735SUE10-12 with S/N 5501 was installed).
5. On 4 February 2017, the A/T computer was replaced (the component P/N 735SUE10-12 with S/N 5501 was removed and the component P/N 735SUE10-12 with S/N 5151 was installed).

6. On 18 March 2020, the FCC B was replaced (the component removed was P/N 4051600-914 with S/N 96083964, and the component installed was P/N 4051600-914 with S/N 90041943). The FCC A was also replaced (the component P/N 4051600-914 with S/N 94103655 was removed, and the component P/N 4051600-914 with S/N 90031936 installed).
7. On 22 December 2020, the right side A/T actuator assembly (A/T servo) was replaced. The AML recorded the component removed was P/N 763810-1 with S/N GK3895 which referred to cabin pressure controller. The correct component removed was P/N 111RAA3 with S/N 3480 and the component installed was P/N 111RAA3 with S/N 4448.
8. On 30 December 2020, the A/T computer was replaced (the component P/N 735SUE10-12 with S/N 5151 was removed, and the component P/N 755SUE2-4 with S/N 6952 installed). The A/T computer P/N 755SUE2-4 with S/N 6952 was installed in the aircraft during the accident flight.

In addition to the 65 A/T pilot reports, the AML entries also recorded 61 pilot reports relating to differences in engine parameters. The 53 out of the 61 reports occurred during descent. On 12 November 2013, a pilot reported that on initial descent the idle power of the right engine indicated higher than the left engine (the right engine N1 was at 71% while the left engine N1 was at 33%). This was the first reported engine problem related to A/T.

Some pilots reported that during descent, the low-pressure rotor assembly (N1) speed of the right engine indicated higher than the N1 speed of the left engine.

The summary of the pilot reports and the rectification actions related to difference in N1 speed during descent and the thrust lever movement are as follows:

1. On 12 November 2013, the engine N1 speed difference was reported. The engineer cleaned the electrical connectors of the Digital/Analog Adapter (DAA) and the Flight Management Computer (FMC).
2. Between November 2013 and August 2014, there were 19 pilot reports regarding the differences in N1 speeds and slow movement of the right engine thrust lever. The rectification was performed mainly by the cleaning of the electrical plug related to the engine system. The procedure for cleaning of the electrical plug available in Standard Wiring Practices Manual (SWPM) subject 20-60-01 Cleaning of electrical connector.
3. Between 3 to 30 September 2014, the AML recorded 12 pilot reports of the right engine N1 speed being higher than left engine N1 speed during descent. The rectification was performed by the cleaning of the electrical connector related to the engine system. On 30 September 2014, in response to the pilot report regarding the difference in N1 speeds during descent, the engineer performed lubrication of the right engine thrust lever control cable. The problem reappeared on 3 October 2014 and as part of the trouble shooting, the engineer replaced the right engine N1 sensor.
4. On 11 October 2014, a pilot reported that the right engine N1 speed was higher than left engine N1 speed during descent. The engineer adjusted the specific gravity setting in the Main Engine Control (MEC) and checking the Compressor Bleed Pressure (CBP) tube of the right engine.

5. On 18 October 2014, in response to a pilot report regarding the differences in N1 speeds, the engineer performed the right engine ground run.
6. From 22 October 2014 to 12 June 2015, the AML recorded 10 pilot reports regarding the difference in N1 speeds during descent. Rectifications carried by engineers on the right engine systems were cleaning of the electrical connectors of the Power Management Computer (PMC), cleaning the idle sensors, cleaning engine MEC electrical connectors, right engine low idle connectors, etc.
7. On 13 June 2015, a pilot reported the right engine low idle light illuminated. The low idle light indicated that the MEC on the respective engine was unable to achieved high idle engine RPM in flight. The engineer cleaned the electrical connector D2794 (the electrical connector of the engine idle light related to the ground flight relay).
8. On 17 June 2015, the MEC of the right engine was replaced and the problem of the differences in N1 speeds during descent disappeared.
9. On 10 December 2015, a pilot reported that both thrust levers were stiff and the engineer lubricated the thrust control cable.
10. On 13 April 2016, the right engine was replaced due to the expiry of an engine Life Limited Part (LLP). The removed engine was CFM56-3B1 with serial number of 859126, and the installed engine was CFM56-3B1 with serial number of 856876.
11. On 16 February 2018, a pilot reported that when the A/T was engaged, there was a slow response in the right engine thrust lever and resulted in the aircraft swaying due to asymmetric thrust. The engineer performed cleaning of the electrical connector of the A/T computer.
12. The thrust lever of the right engine was reported to be stiff on 10 July 2018 and the engineer performed the lubrication of the right engine thrust lever. Thereafter, from 10 July 2018 until the accident flight, there were 21 reports of A/T disengagements during flight due to system issues. Attempts to resolve the issue by engineers were mainly cleaning of the electrical connector of the A/T computer.
13. The aircraft was grounded for maintenance from 6 December 2018 until 18 March 2019. On 31 January 2019, the right engine CFM56-3B1 with serial number of 856876 was replaced by CFM56-3B1 with serial number of 858702 due to the expiry of engine Life Limited Part (LLP).
14. On 21 August 2019, a pilot reported that during initial descent the thrust lever of right engine retarded very slowly. The engineer performed a BITE test on the A/T computer in accordance with Aircraft Maintenance Manual (AMM) chapter 22-31-10 and the result was satisfactory.
15. On 19 March 2020, the right engine (serial number 858702) was removed and installed on another aircraft. Between March and December 2020, the aircraft was grounded in Surabaya for maintenance.
16. During the maintenance, the right CFM56-3B1 engine with serial number of 856435 was installed. On 19 December 2020, the aircraft flew from Surabaya to Jakarta. In Jakarta, this engine was replaced with an engine of serial number of 858702 until the accident.

From the beginning of the first reported A/T system defect to the day of the accident, the aircraft operator did not submit report to aircraft manufacturer regarding the A/T problems on PK-CLC.

The details of maintenance records for the A/T and A/P are available in Appendices 6.2 of this report.

1.6.5 Relevant Aircraft Systems

1.6.5.1 Automatic Flight Control System (AFCS)

The AFCS consists of the Autopilot Flight Director System (AFDS) and the A/T. These systems provide automatic aircraft stabilization about the pitch, roll, and yaw axis along with the engine management with selective guidance from radio altimeter, heading, flight management computer, attitude reference and air data computer inputs.

The AFDS and A/T are controlled using the Mode Control Panel (MCP) and the Flight Management Computer (FMC) to fly in an optimized lateral and vertical flight path throughout the flight.

The schematic diagram of the AFCS is shown below:

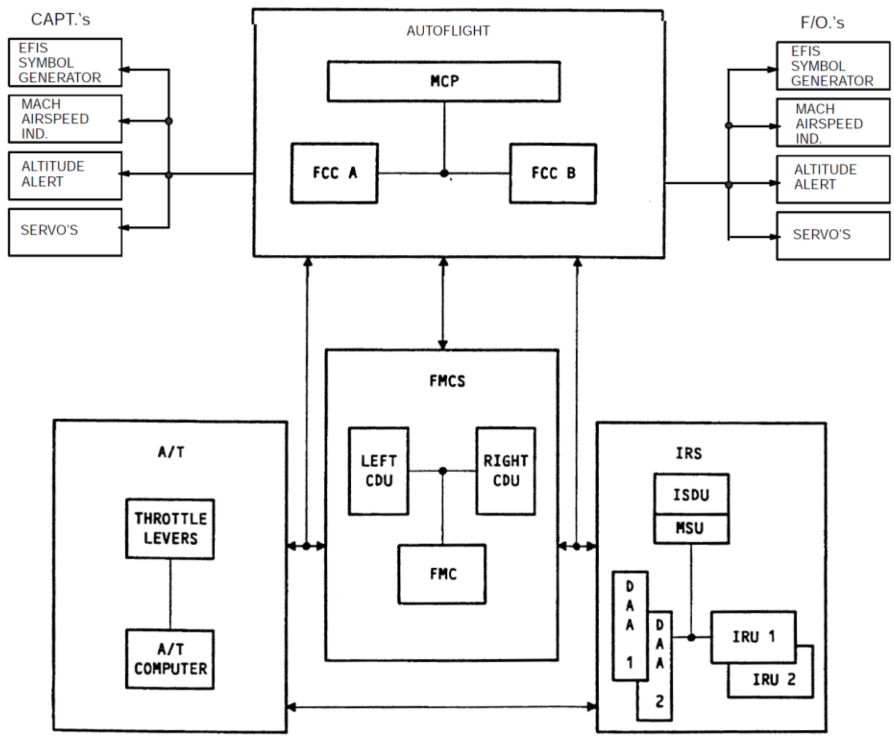


Figure 1: The schematic diagram of automatic flight control system (Image Copyright © Boeing. Reproduced with permission)

The MCP is shown in the figure below:

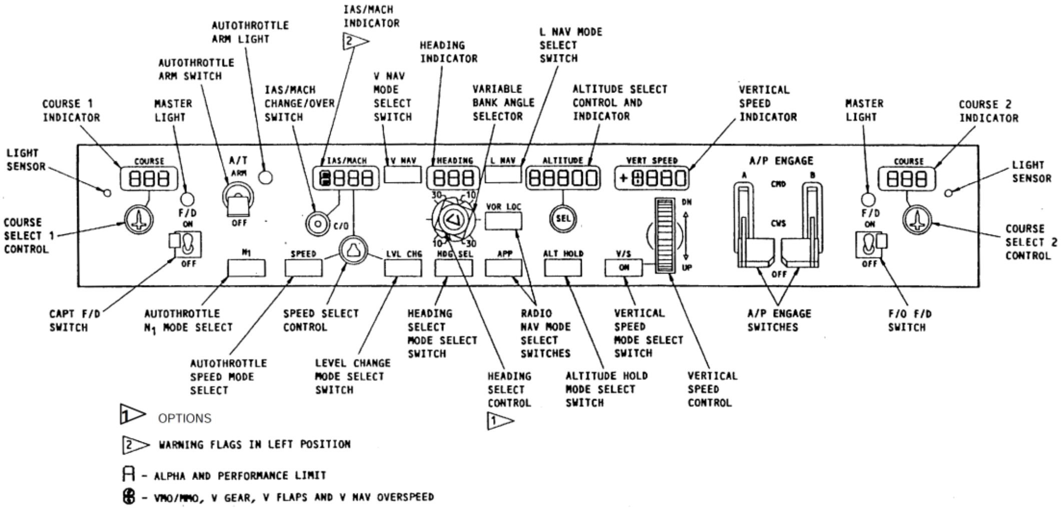


Figure 2: The Mode Control Panel (Image Copyright © Boeing. Reproduced with permission)

The autopilot (A/P) engagement

When all the components supporting the AFS are satisfy, the A/P can be engaged by selecting the paddle switch on the MCP from OFF to either Control Wheel Steer (CWS) or command (CMD). At aircraft altitude of 400 feet or above, the auto command can be selected in any mode. Only one A/P of A or B can be engaged at a time except when the approach (APP) mode is selected, and two Very High Frequency (VHF) navigations are tuned to a valid Instrument Landing System (ILS) frequency.

The autopilot (A/P) disengagement

The A/P will disengage with the following condition:

1. Pressing the A/P Disengage push button on either control column.
2. Moving either A/P paddle switch to OFF on the Mode Control Panel (MCP).
3. Pressing either Take-off/Go-around push button when single A/P engages in Control Wheel Steer (CWS) or Command (CMD) and the aircraft altitude is below 2,000 feet Radio Altimeter.
4. Pressing either Take-off/Go-around push button after touchdown with both A/Ps engaged in CMD.
5. Activating either pilot's control wheel trim switch.
6. Moving the Stabilizer Trim Autopilot Cutout Switch to CUTOUT.
7. Loss of respective hydraulic system pressure.
8. Either left or right Inertia Reference System (IRS) failure or FAULT light illuminate.
9. Loss of electrical power or a sensor input which prevents proper operation of the engaged A/P and mode.
10. During approach, if the FLARE is not armed by approximately of 350 feet, both A/P automatically disengage.

11. An unsafe flight situation that may disconnects the A/P with the following condition:
    a. The A/P is in a speed mode and the aircraft should be gaining altitude but is not climbing and is approaching a stall.
    b. The A/P is engaged in a speed mode and should be descending but is not and at the same time is exceeding the Maximum Operating Speed / Maximum Maneuvering Speed (VMO/MMO) limits.
12. The Autopilot Actuator Monitor (AAM) which monitors the difference between the A/P roll command and the follow up Linear Velocity Differential (Displacement) Transducer (LVDT) of A/P.
13. The Surface Position Monitor (SPM) for pitch and roll, monitors the difference between the A/P actuator A/P LVDT and the surface position sensor.

The Boeing 737-500 A/P system is designed to maintain lateral control as the airplane roll increases; its maximum authority in a flap up configuration is limited by 5.75 degrees aileron input measured at the aileron control quadrant. The system is designed to remain engaged at its maximum authority (i.e. will not disconnect) provided there is no pilot intervention so as to ensure a roll upset is not further exacerbated when the pilots are not observing the aircraft attitude.

The Flight Director (F/D)

The Flight Director (F/D) is a dual system consisting of two individual Flight Control Computers (FCC) and MCP. The two FCCs are identified as A and B. For A/P operation, the FCC sends control commands to the respective pitch and roll hydraulic servos, which operate the flight control through two separate hydraulic systems. Each F/D provides the command bars to the Electronic Attitude Direction Indicator (EADI). The F/D provides pitch and roll command bars.

When the F/D selector on the MCP has been selected ON, the command bars become available. The F/D can be operated with or without the A/P or A/T. The F/D also can be combined with CWS.

The F/D take-off mode is engaged by pressing the TO/GA push button on either thrust lever. Initial F/D commands are 15 degrees nose up and HDG SEL mode for roll. The pitch command continues to command 15 degrees nose up until sufficient climb rate is achieved, then the pitch commands will move to an attitude to maintain the MCP speed plus 20 knots IAS which is set during preflight. The F/D roll mode is HDG SEL from take-off mode engagement through the take-off climb-out.

During takeoff, the F/D can be selected with the A/P CMD engaged. However during the takeoff the A/P CMD will be active when the altitude reaches 400 feet AGL or above.

The Control Wheel Steer (CWS)

The CWS will assist the pilot in controlling the aircraft similar to the manual flight. The CWS Pitch (P) or Roll (R) will be displayed in the EADI when the pilot makes a maneuver using the control column. When the pilot manipulates the roll, the pitch will be held by the A/P and if the pilot manipulates the pitch, the roll will be held by the A/P. During roll maneuver, the bank angle can be limited by the inner selector of the heading selector in the MCP.

The Autothrottle (A/T)

A/T system is a computer controlled electromechanical system which controls the engine thrust within engine design limit.

The A/T system controls the thrust lever positions of each engine to target either low pressure rotor assembly (N1) speed or an airspeed for all flight regimes. The A/T is also connected to the A/P system to support the automatic flight system.

The A/T system consists of a digital computer (the A/T computer), A/T servomechanisms, A/T torque switches, an A/T engage switch (on the MCP), A/T disengage switches, takeoff/go-around switches, two A/T warning lights on the DFCS Flight Mode Annunciators (FMA), and two power lever synchro. The system also uses external inputs from the N1 sensors, flap position synchro, DFCS (various inputs including flight spoiler angles), and Angle of Attack (AOA) sensor.

The Autothrottle (A/T) Engagement

When all conditions supporting the A/T system are satisfied, moving the A/T arm switch from OFF to ARM will arm the A/T for engagement in the N1, MCP Speed (MCP SPD) or FMC Speed (FMC SPD) modes. The A/T arm switch is magnetically held at ARM and releases to OFF when the A/T becomes disengaged followed by flashing red A/T Disengage lights.

The Autopilot (A/P) and Autothrottle (A/T) modes and annunciation

During the flight the AFDS and A/T will provide automatic aircraft stabilization in vertical and lateral axis. The standby (ARM) and active mode will be annunciated in different colors on the Flight Mode Annunciator (FMA) of the EADI. Four columns in the FMA are to represent the respective arm or active mode on top of the EADI display as shown in the figure below.

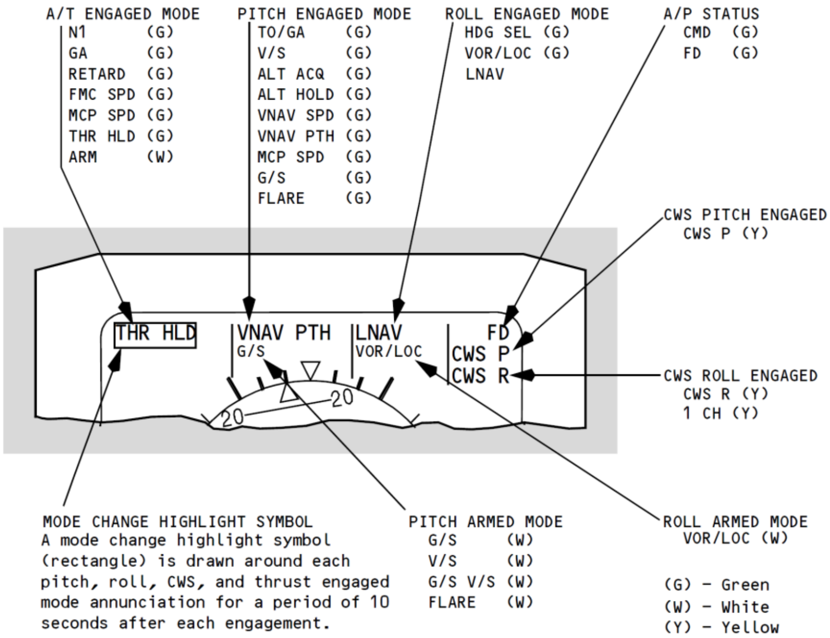


Figure 3: The Flight Mode Annunciator (FMA) in the Electronic Attitude Director Indicator (EADI) (Image Copyright © Boeing. Reproduced with permission)

The A/T mode is displayed in the far left of the FMA, and subsequent column displays vertical mode and the next column displays the lateral mode. A rectangle will be annunciated for 10 seconds after a mode engagement in these three columns. The far-right column displays the A/P status engagement either in F/D, CWS or CMD mode.

The AFDS and A/T can be controlled laterally and vertically by FMC or MCP. The FMC controlled directionally when the Lateral Navigation (LNAV) is selected and vertically when Vertical Navigation (VNAV) is selected. The FMA will displays LNAV and VNAV respectively. The AFDS and A/T are controlled by MCP when the respective mode on the MCP is selected. The A/P and A/T modes, and the respective FMA display are as follow:

1. The lateral control (roll engaged mode) can be selected by selecting the desired heading on the MCP and the FMA will display HDG SEL (Heading Select). During approach the VOR/LOC (Very High Frequency Omni Range / Localizer) button can be selected to provide lateral control including to intercept and maintain the selected course to valid VHF navigation.
2. The vertical control (pitch engaged mode) can be selected in the MCP by selecting the VERT SPEED (vertical speed) wheel to the desired rate of climb or descend and the FMA will display V/S. The vertical control can also be selected to maintain desired speed using the MCP by selecting the speed on the IAS/MACH knob and MCP SPD will be displayed on the FMA.

   The V/S (vertical speed) mode gives pitch command to hold the selected vertical speed. Pressing the V/S push button engages the V/S mode, except when engaged in ALT HOLD at the MCP altitude or after glide slope capture. When V/S mode is engaged, the vertical speed display in the MCP changes from blank to present the magnitude of the vertical speed and commanded vertical speed can be changed with the VERT SPEED wheel in the MCP.
3. The Autothrottle Speed (A/T SPD) or N1 mode controls the engine powers and will automatically engage when AFDS command pitch mode becomes engaged.
4. The LVL CHG (level change) mode coordinates pitch and thrust commands to make an automatic climb or descend to the altitude and at airspeed as selected on the MCP. Engaging LVL CHG mode in climb the FMA annunciators will display MCP SPD for pitch and N1 for the A/T. Engaging LVL CHG mode for descend automatically engages the A/T in RETARD and then ARM when thrust levers are at idle. The FMA annunciators will display MCP SPD for pitch and RETARD then ARM for the A/T.
5. When the AFDS is not in VNAV mode, engagement of altitude acquired (ALT ACQ) or altitude hold (ALT HOLD) will automatically engage the A/T in the MCP SPD mode.

   The ALT ACQ mode is the transition mode when the aircraft is approaching selected altitude and will be active automatically from V/S, LVL CHG or VNAV modes to the ALT HOLD mode.

   The ALT HOLD mode gives pitch commands to hold the MCP selected altitude or the altitude at which the ALT HOLD push button is pressed.

   The V/S mode is armed when the ALT HOLD mode is engaged and a new MCP altitude is selected. When V/S is armed, the V/S mode can be engaged by moving the VERT SPEED wheel in the MCP.

The A/T Thrust Lever Control Movement

In the take-off or go around, the engaged A/T system will advance 15° per second from the idle to the predicted thrust lever position and the FMA A/T will annunciate from ARM to N1.

In the normal climb, any change to the engine power or aircraft speed, the A/T system will command the thrust levers to move 6° per second.

The retard rate during cruise or descent or when the target altitude almost captured, the A/T system will move the thrust lever backward 2° per second.

When the engine fails during A/T engagement, the respective thrust lever will move to the forward stop in attempt to speed up the N1. If the N1 drop below 18%, the respective thrust lever will move backward to the idle position and the A/T system will not disengage. Nevertheless, the pilot checklist will instruct the pilot to disengage the A/T.

The A/T Disengagement

Any of the following conditions or actions disengages the A/T:

1. Moving the A/T Arm switch to OFF.
2. Pressing either A/T Disengage switch.
3. An A/T system fault is detected.
4. Two seconds have elapsed since touchdown. The A/T Disengage lights do not illuminate when the A/T automatically disengages after landing touchdown.
5. Thrust levers become separated more than 10 degrees during a dual channel approach after FLARE armed is annunciated. The thrust levers should normally be aligned to no more than one full knob width difference during all ranges of normal operation with symmetrical thrust.
6. Activation of the Cruise Thrust Split Monitor (see subchapter 1.6.5.2).

The A/T Torque Switch Mechanism

The Torque Switch Mechanism (TSM) consists of a gear driven shaft, carrying input and output quadrants for connection to the thrust lever controls with a mechanism to operate a switch. This arrangement permits pilot override of the A/T servo drive without disengagement of the A/T system. The illustrated TSM is shown below.

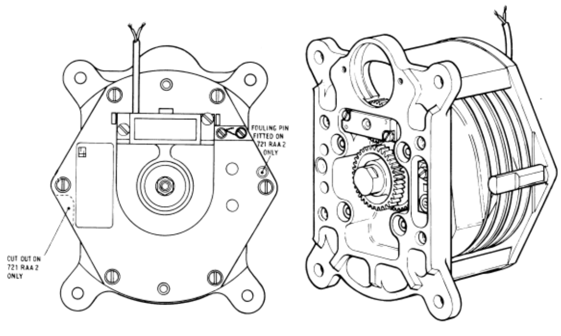


Figure 4: The illustrated Torque Switch Mechanism (TSM)

The TSM consists of a support frame with a top housing and a rotating mechanism. The rotating mechanism is carried on a main shaft driven by an input gear with an integral override mechanism which incorporates two double grooved pulley quadrants, the input and output quadrants. The input and output quadrants are connected to the forward (to the thrust lever in the cockpit) and aft throttle control cables (to the engine) respectively. The output quadrant embodies a friction brake. A switch assembly mounted on the top housing is operated by a mechanism within the input quadrant. A series of drain holes through the mechanism and frame components prevent collection of condensed moisture.

The support frame of the TSM provides the attachment for the associated A/T servo and potentiometer assemblies. The potentiometer assemblies provide the position feedback for the A/T system.

The location of the TSM installed and A/T Servo are in the equipment bay of the aircraft as shown in the figure below.

Figure 5: The location of TSM and A/T Servo

When the pilots override both or one of the thrust levers with the loads more than 2 pounds, the TSM activates the torque switch to open. In this condition the A/T system will let the pilot to move the thrust lever and the A/T system will not disengage.

The A/T will disengage when the pilots override either left or right thrust levers with a nominal load of more than 18 pounds. This condition also allows the pilots to override the A/T system in case of clutch failure in the TSM.

The Flight Spoiler

The flight spoiler control system supplements the ailerons in providing lateral control to the aircraft. The flight spoilers may also act as speed brakes. Both ground and flight spoilers are numbered 0 thru 9 from left to right as shown in Figure 6. The flight spoilers, 2, 3, 6, and 7 are located outboard of the engines. Spoiler position sensors are installed on spoiler numbers 2 and 7 to provide an electrical signal to indicate spoiler position.

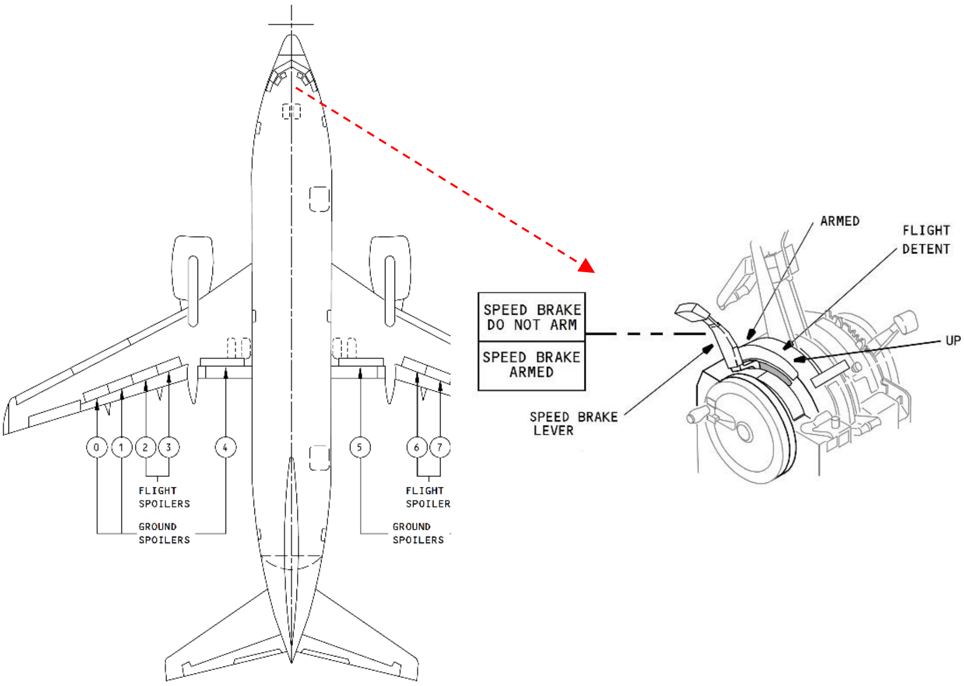


Figure 6: The spoilers and speed brake lever (Image Copyright © Boeing. Reproduced with permission)

Maximum flight spoiler deflection reaches an angle of 38±2° for a nominally rigged 737-500. In flaps up configuration with autopilot engaged, the flight control computer will limit roll authority via the left or right aileron angle to 5.75°, which corresponds to the associated flight spoiler 2 or 7 deflection of 6.5° for a nominally rigged 737-500.

Aileron and spoiler rigging maintenance is performed with control cable and/or sensor replacement. On-condition maintenance is performed when control anomalies are identified during operation.

The Sriwijaya Air Boeing 737-500 (MSG-3) Maintenance Program did not require periodic maintenance for spoiler sensor rigging. The Aircraft Maintenance Manual (AMM) stated that spoiler position sensor rigging is required when spoiler sensor is replaced or sensor removed as access when spoiler number 2 or number 7 is replaced. On-condition maintenance is performed when control anomalies are identified during operation. Aileron and spoiler rigging maintenance is performed with control cable and sensor replacement.

The Sriwijaya Air advised to the investigation that flight spoiler sensor rigging had never been performed on PK-CLC aircraft while being operated by Sriwijaya Air as it never met the requirement to do so.

1.6.5.2 Cruise Thrust Split Monitor

The Cruise Thrust Split Monitor (CTSM) disengages the A/T when A/P roll control requires significant spoiler deployment and a disparity of calculated thrust (in A/T computer) of both engines when at the same time, normally the thrust levers become separated. The CTSM is active when flaps are less than 12.5°, and the A/T is not engaged in the takeoff or go-around mode.

The CTSM function requires the following inputs: flap position, aircraft speed (in Mach), static pressure, total air temperature (TAT), flight spoiler angle of spoiler number 2 and 7 (left and right), both engine N1s or power lever angles if the N1 information is not available.

The CTSM monitors flight spoiler position and the net thrust difference between the two engines based on their N1 values. When the difference in the output thrusts (which is a function of static pressure, TAT, and aircraft speed) of the two engines exceeds a calculated limit for the flight conditions present, and the amount of flight spoiler deflection is greater than 2.5° for 1.5 seconds, the A/T will be disengaged.

During A/T disengagement, the A/T Arm switch will be released to OFF position followed by flashing red A/T Disengage lights. The A/T Disengage lights do not illuminate when the A/T automatically disengages after touchdown.

The CTSM activation depends on the availability of information from the related components as follows:

1. When flight spoiler position is not available, the flight spoiler position input will be ignored. If thrust asymmetry exceeds the thrust split limit, the A/T will disengage.
2. When N1 information is not available, the engine power lever angle will be used to compute the thrust asymmetry limit to maintain the CTSM. If either power lever angle is invalid, the A/T will not engage.
3. The CTSM uses aircraft speed (in Mach signal) and static pressure from ADC 1. If that ADC1is invalid, inputs for the CTSM will be referenced from ADC 2. If either aircraft speed or static pressure values from both ADC1 and ADC2 are invalid, the A/T will not engage. Static pressure from ADC 1 is recorded on the FDR.
4. The CTSM uses the higher TAT value from either ADC 1 or ADC 2. If both TAT values are invalid, the A/T will not engage. The TAT from ADC 1 is recorded on the FDR.
5. If the flap position information is not available, the CTSM will be inhibited.

The flap position is taken from the left flap transmitter which has three synchro, namely the A/P synchro (which provides data to the A/P and the FDR), flap position synchro (which provides data to flap position indicator and A/T computer), and the stall warning synchro (which provides data to stall management computer).

When the flap position synchro output is invalid, it will affect both the flap position indicator in the cockpit and the A/T computer. A failure in the flap position synchro will result in a non-responsive flap position indicator which should be apparent to the pilot.

A flap asymmetry comparator switch is located inside the flaps position indicator, and therefore a flap position synchro error may also result in a flap asymmetry alert. The flaps asymmetry alert will activate when there are 8° and 20° of synchro angle difference detected between the left and right flaps synchro. When an asymmetric flaps deployment is detected, it shuts a bypass valve and trips off hydraulic power to the flaps drive motor.

The flap position synchro sends the flap position information to A/T computer via a separated wiring (Vx, Vy and Vz wiring). An open Vx wiring to the A/T computer will not affect to the flap position indicator, but the A/T computer will interpret a 0° flaps position as 40°. In this condition the A/T system still can be engaged but the CTSM will be inhibited when the flaps position is at 0°.

The failure of the Vx wiring would only be identified by accessing the CURRENT STATUS page or LRU INTERFACE in the A/T BITE TEST of FMC CDU.

1.6.6 Autothrottle (A/T) Computer Modification

On 16 November 2000, the FAA issued Airworthiness Directive (AD) number FAA AD 2000-23-34 to replace the existing A/T computer with a new P/N. The FAA AD refers to the Boeing Service Bulletin number SB 737-22A1130 dated 24 September 1998.

The AD was applicable to all Boeing Model 737-300, -400, and -500 series airplanes was effective from 8 January 2001. The AD referred to Boeing Alert Service Bulletin number 737-22A1130 which required replacement of the previous A/T computer with improved A/T computer Boeing P/N 10-62017-30 or 10-62017-31.

The AD addressed the problem of split thrust lever movement caused by irregular A/T operation which results in asymmetric thrust conditions causing the airplane to bank excessively and going into a roll.

On 21 October 1998 Boeing issued a Service Letter (SL) number 737-SL-22-039 and on 30 April 2003 issued SL number 737-SL-22-039-A to advice the operator to incorporate the new A/T computer with P/N 10-62017-30 (Smiths P/N 735SUE9-12, 735SUE10-12 or 755SUE2-4) or 10-62017-31 (756SUE3-4).

The 10-62017-30/31 A/T computer has been modified to address in-service reports of asymmetric thrust events and A/T takeoff setting being oscillatory and overshooting the target N1.

The modification included the CTSM function and a revision to the takeoff N1 set logic. The CTSM function is enabled when the flaps are set at less than 15 degrees. The function will disengage the A/T when the net thrust difference between the two engines exceeds a limit, more than 2.5 degrees of spoiler deployment is used to control the roll attitude of the aircraft, and the aircraft is not on takeoff or go-around.

The A/T new P/N refers to the A/T computer manufacturer (Smiths) SB number 735SUE-22-1266 and 735SUE-22-1267 which is to be enhanced with the following:

- Thrust Split Monitor
- Improved T/O N1 Set-point Algorithm
- Output ARINC bus label 270, bit 27, changed to show internal disengagement.
- Power lever angle (PLA) sensor validity added to disconnect logic.
- Revised forward stop Built-In Test Equipment (BITE) test to improve reliability.

- Added the following in-flight BITE messages:

BITE Message		Cause
T/O SET LO	PERFORM LATE TOGA	Insufficient time to set thrust (possibly due to late TO/GA switch initiation).
FWD LOOP	TS 1 FAULT	Torque switch 1 failed to close.
FWD LOOP	TS 2 FAULT	Torque switch 2 failed to close.
THROT SPLIT	A/T DISC CRUISE	A/T disconnected in cruise due to a thrust split detected by the A/T.

- Improved torque switch bypass logic for thrust levers moving up from aft stop.
- Corrected several BITE nomenclature discrepancies.

The CTSM code was reviewed by Boeing and GE Aviation with no anomalies identified. The A/T computer manufacturer reviewed their historical documents which demonstrated satisfactory completion of required bench testing at the time of certification. The CTSM passed the operational test that was performed during a flight test. This flight test was historical data obtained during the certification program.

The FAA AD 2000-23-34 was performed when the aircraft was being operated in United States and prior to delivered to Sriwijaya Air on 2012 with the updated modification of the A/T computer with P/N 735SUE10-12 or 755SUE2-4.

1.7 Meteorological Information

The *Badan Meteorologi Klimatologi dan Geofisika* (BMKG – Bureau of Meteorology, Climatology and Geophysics) provided enhanced infrared satellite images. The enhanced infrared satellite images at 0730 UTC (1430 LT) and 0740 UTC (1440 LT) indicated that the cloud top temperature at the accident site (red circle) was from -34°C to -21°C.

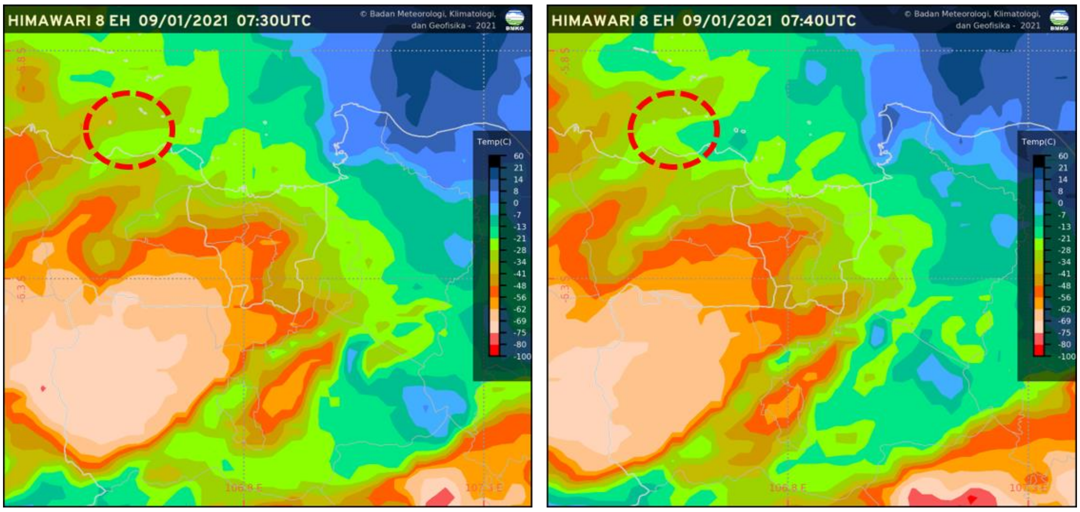


Figure 7: Enhanced infrared satellite image at 0730 UTC and 0740 UTC at accident site (red-dotted circle)

The superimposed ADS-B-based flight profile with radar weather image at 1438 LT provided by the BMKG indicated that the radar intensity level along the flight profile was not more than 25 dBz[13], which means that the flight path did not indicate any significant development of clouds.

Figure 8: The superimposed accident flight profile based on ADS-B- with BMKG radar weather image at 1438 LT

No.	Latitude	Longitude	Pressure Altitude (feet)	Reflectivity (dBz)	Potential Precipitation	Estimated Visibility (km)
1	-6.11740	106.64779	572	14.0	Very light /No Rain	>10
2	-6.11971	106.64164	1,040	14.5	Very light /No Rain	>10
3	-6.12390	106.62212	2,012	19.5	Very light /No Rain	>10
4	-6.11481	106.60121	3,012	18.5	Very light/No Rain	>10
5	-6.10885	106.58381	4,000	26.0	Light Rain	5.9 - 10
6	-6.10432	106.56866	4,984	28.0	Light Rain	5.9 - 10
7	-6.09940	106.55245	5,988	26.0	Light Rain	5.9 - 10
8	-6.09103	106.53724	6,996	17.5	Very light/No Rain	>10
9	-6.07534	106.52628	8,012	22.5	Very light/No Rain	>10

13 Decibel relative to Z. It is a logarithmic dimensionless technical unit used in radar, mostly in weather radar, to compare the equivalent reflectivity factor (Z) of a remote object (in mm^6 per m^3) to the return of a droplet of rain with a diameter of 1 mm (1 mm^6 per m^3).

No.	Latitude	Longitude	Pressure Altitude (feet)	Reflectivity (dBz)	Potential Precipitation	Estimated Visibility (km)
10	-6.04940	106.52291	9,012	31.5	Light Rain	5.9 - 10
11	-6.01885	106.53433	10,020	23.0	Light Rain	5.9 - 10
12	-5.97954	106.56723	10908	28.0	Light Rain	5.9 - 10

Based on the value of the reflectivity of the CAPPIZ system, the highest reflectivity was at 31.5 dBz when the aircraft reached altitude of about 9,000 feet at 1438LT. The reflectivity was within the range of light rain. The visibility during the light rain at altitude 9,000 feet was estimated between 5.9 to 10 km.

1.8 Aids to Navigation

1.8.1 ABASA 2D

Runway 25R utilized RNAV-1 Standard Instrument Departure (SID). The SID ABASA 2D given by ATC requires aircraft to climb on heading 247° after departure from Runway 25R. At or above 1,000 feet, the aircraft is then required to turn right to WINAR to AJUNA to NABIL to RATIH to LARAS to TOMBO to MULAN to ABASA (see Figure 9).

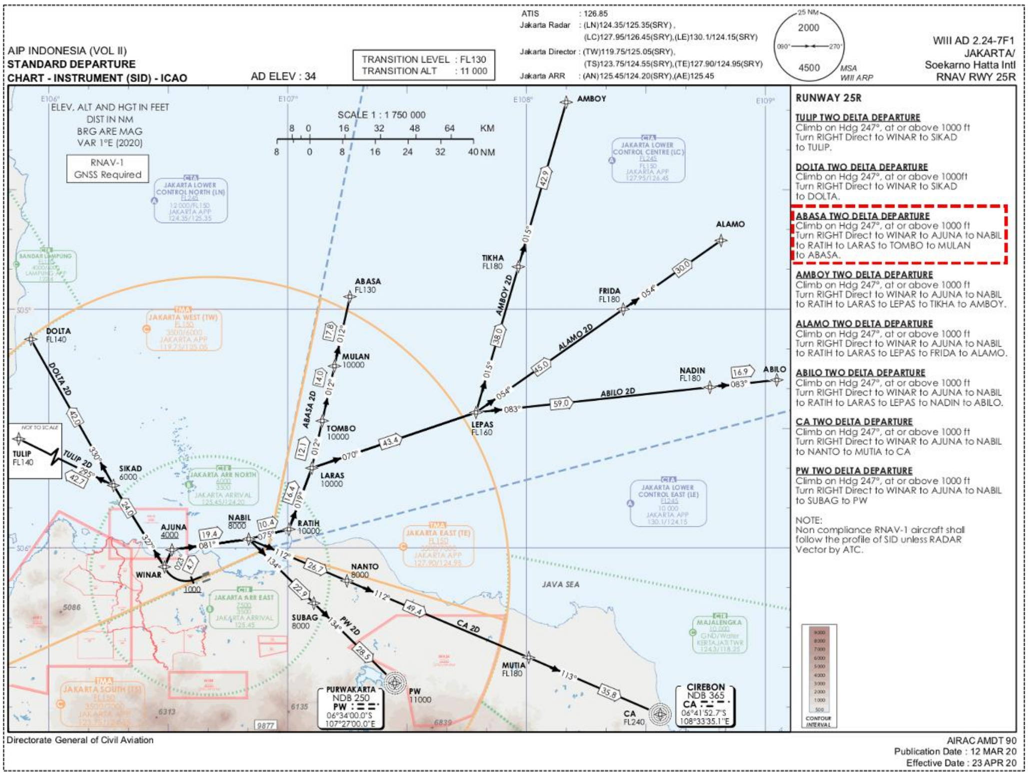


Figure 9: The RNAV-1 SID of Runway 25R

1.8.2 Automatic Dependent Surveillance – Broadcast

Automatic Dependent Surveillance – Broadcast (ADS–B) is a surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it, thereby enabling it to be tracked by ground receivers. The term "automatic" in the ADS-B means that the technology does not require flight crew or external input. The term "dependent" means its surveillance process relies on data from onboard aircraft systems to provide surveillance information to the receiver. The term "broadcast" means the originating source has no knowledge of who receives the data and there is no interrogation or two-way contact.

Several ADS-B receivers have been installed in several places including in the Jakarta Air Traffic Services Center (JATSC). The PK-CLC aircraft had ADS-B capability installed and the investigation retrieved the broadcasted aircraft data from the JATSC facility. The ADS-B recorded the last aircraft position on coordinate 05°57'50.20"S 106°34'28.30"E.

1.9 Communications

All communications between air traffic controllers and the pilots were recorded by ground based automatic voice recording equipment and the Cockpit Voice Recorder (CVR). The quality of the recorded aircraft transmissions was good. The excerpt of communications between the pilot and the controller will be discussed in the section 1.11.2 Cockpit Voice Recorder of this report.

1.10 Aerodrome Information

Soekarno-Hatta International Airport (WIII) is operated by PT Angkasa Pura II. The airport is located at Jakarta and aerodrome reference point is on coordinate 06°07'25" S 106°39'40" E. The airport has three paved aircraft landing surfaces designated as 25R-07L, 25L-07R, and 24-06.

1.11 Flight Recorders

1.11.1 Flight Data Recorder

The aircraft was fitted with a solid-state Flight Data Recorder (FDR) of P/N 980-4700-001 with S/N 4355, manufactured by Honeywell.

On 12 January 2021, the FDR Crash Survivable Memory Unit (CSMU) was recovered by the search team. The Underwater Locator Beacon (ULB) had detached from the FDR and was recovered.

The FDR CSMU was transported to the KNKT recorder facility for data downloading. The data download and read-out were performed by KNKT investigators with the participation of flight recorder specialists from the Transport Safety Investigation Bureau (TSIB) of Singapore and National Transportation Safety Board (NTSB) of United States of America as Accredited Representatives.

The FDR data was successfully downloaded and contain 370 parameters of approximately 27 hours of aircraft flight operation or 18 flights including the accident flight.

The FDR did not record the aircraft rate of climb/descend and the spoiler deflection angle. The data for these parameters in this investigation report were based on calculation. Boeing estimated the flight spoiler positions by correlating the spoilers to the control wheel positions recorded on the FDR. The calculation assumed nominal aircraft rigging and a neutral aileron trim setting, which could not be verified for the accident flight.

The FDR information are as follows.

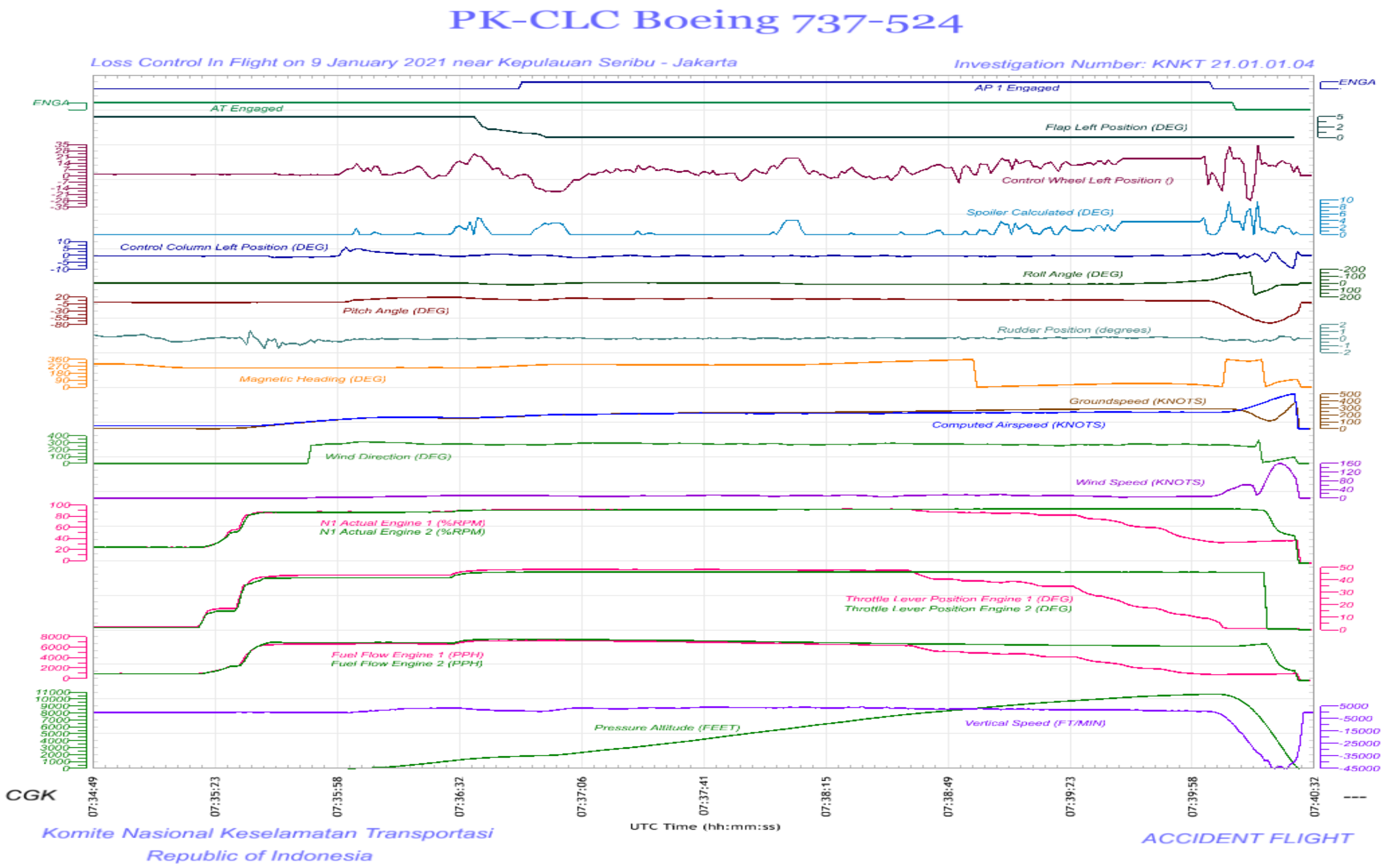


Figure 10: The significant FDR parameters of flight instrument of the accident flight

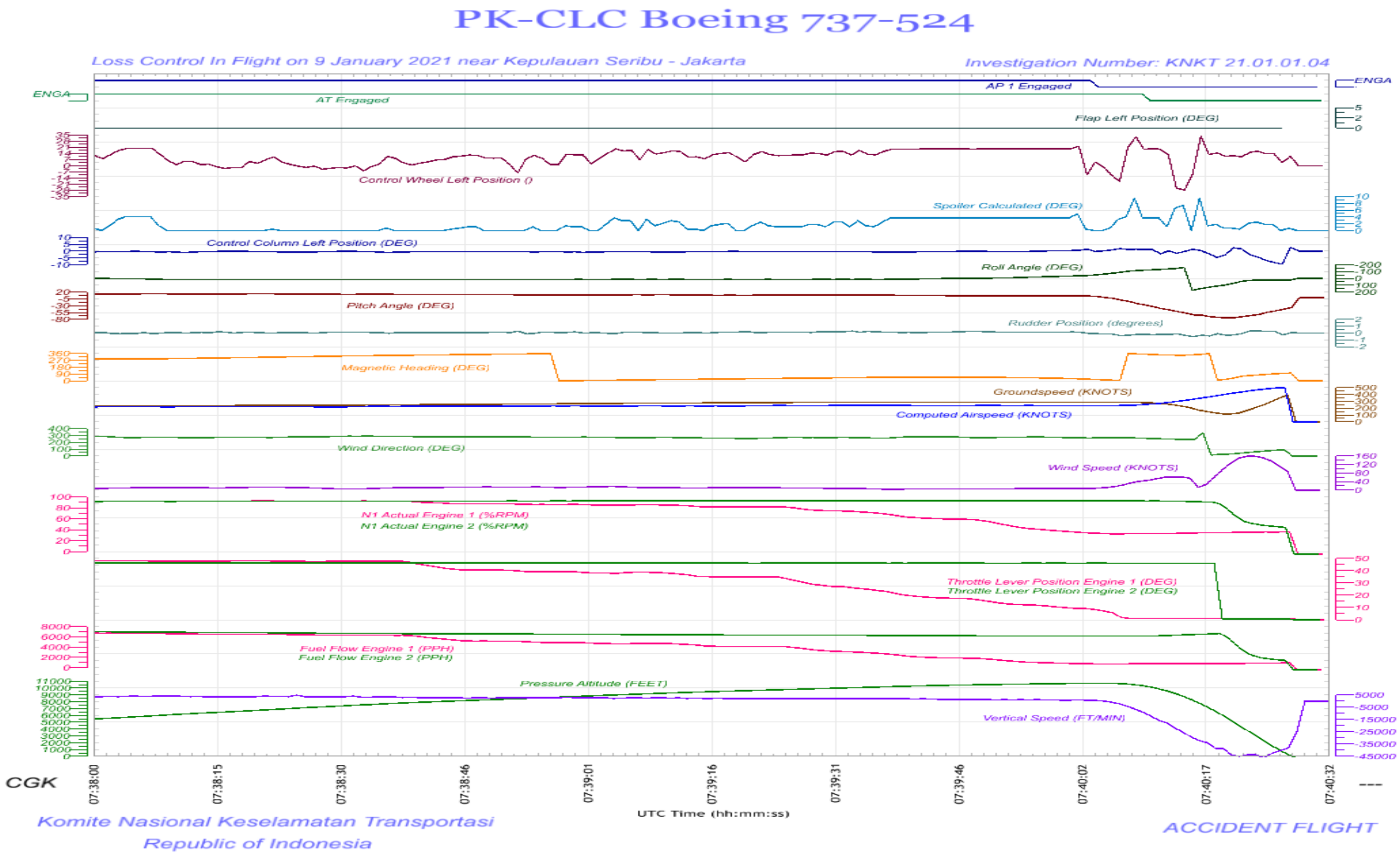


Figure 11: The significant FDR parameters of flight instruments of the accident flight prior to thrust levers split until the end of the flight

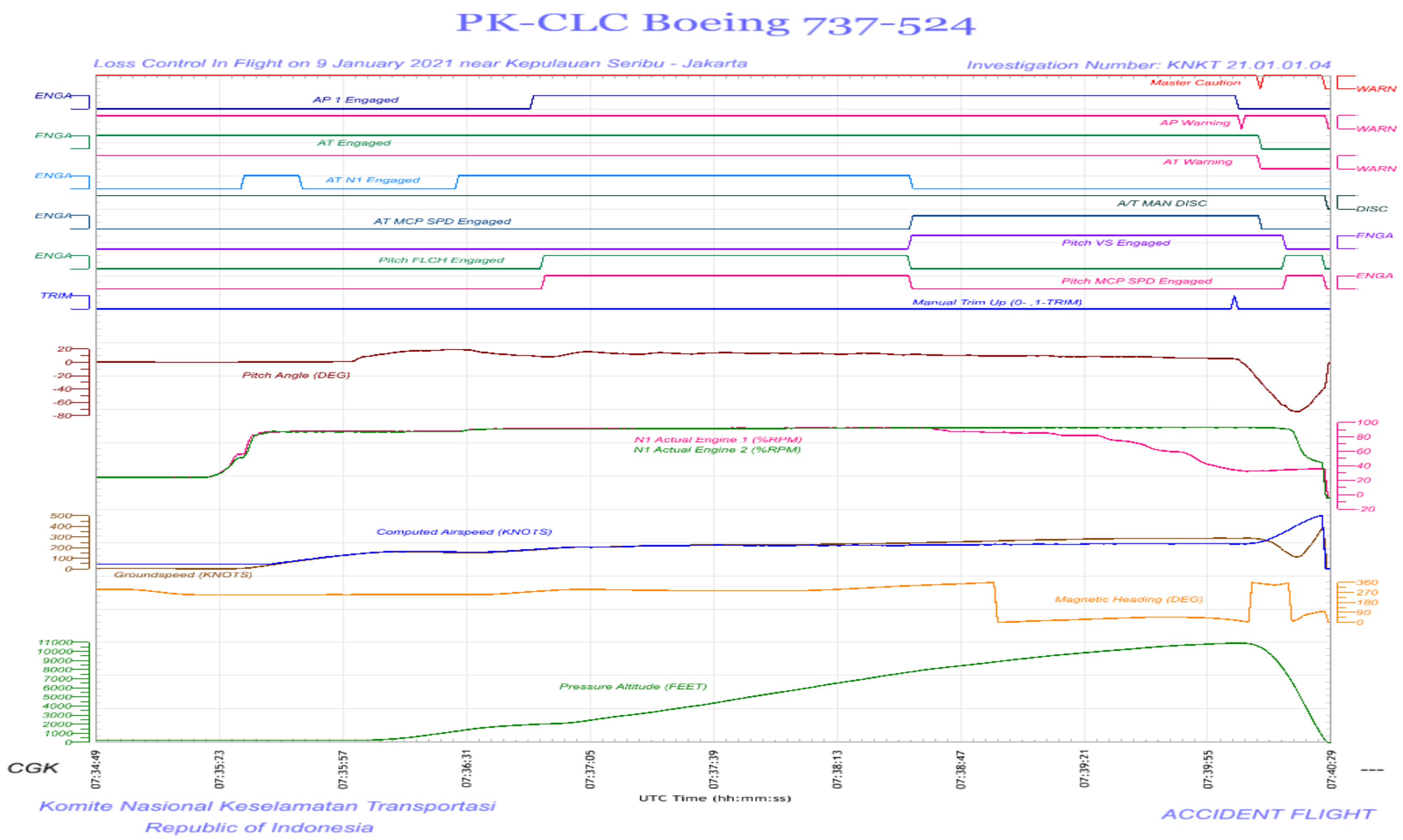


Figure 12: The significant FDR parameters of the autoflight of the accident flight

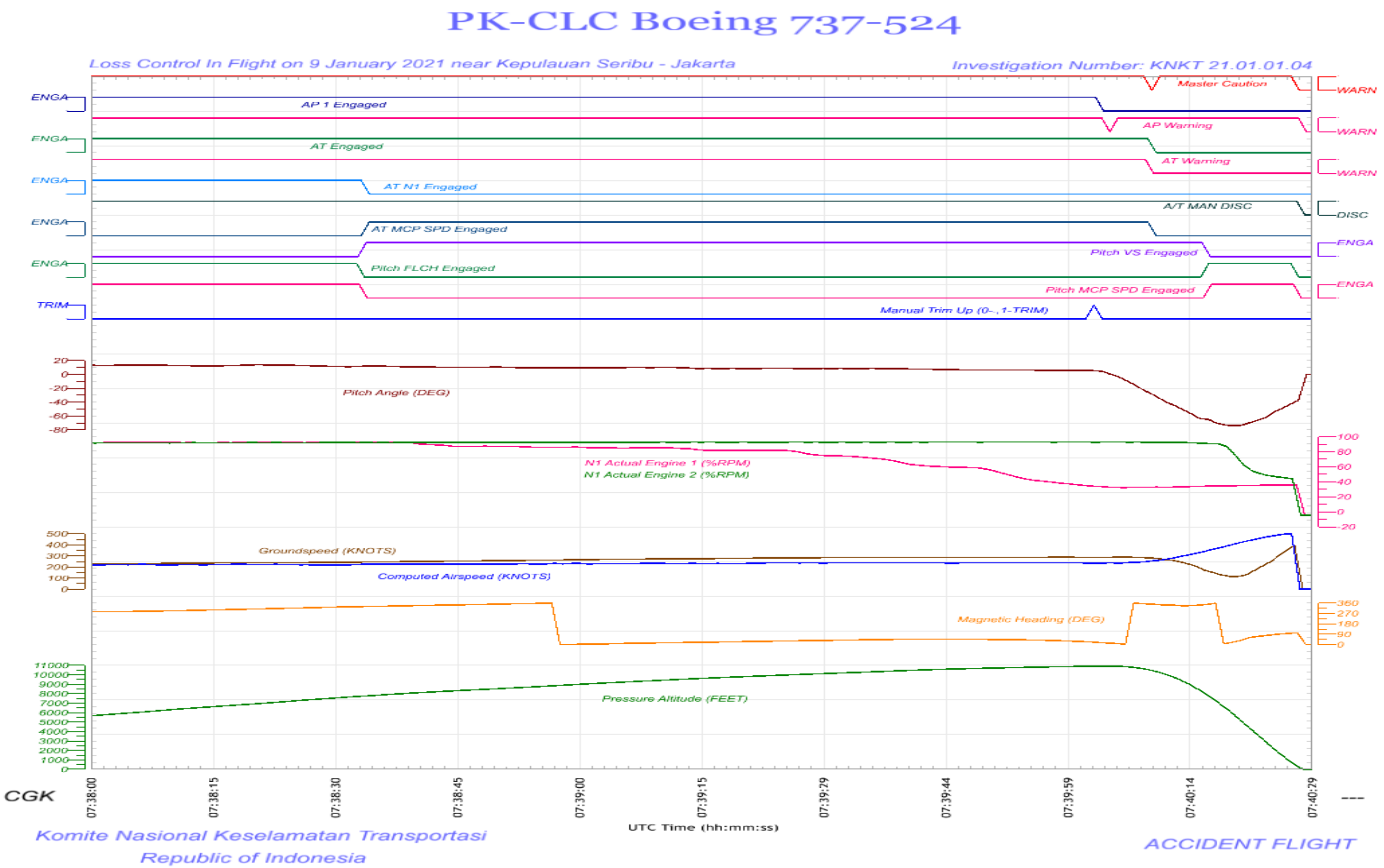


Figure 13: The significant FDR parameters of autoflight of the accident flight prior to thrust lever split until the end of the flight

The FDR data showed that:

1. At 07:35:21 UTC, the take-off was initiated, indicated by the increasing of the thrust levers position.
2. At 07:36:03 UTC, the aircraft was airborne and the A/T engaged in N1 mode;
3. 07:36:39 UTC, the flaps were retracted from 5 to 1.
4. At 07:36:51 UTC:
    - the aircraft altitude was about 1,780 feet,
    - the A/P mode directional control selected was LNAV and the vertical control was MCP SPD and LVL CHG.
5. At 07:36:58 UTC, flaps were retracted to 0.
6. At 07:38:00 UTC:
    - the A/P lateral control changed from LNAV to HDG SEL,
    - the aircraft climbed passed an altitude of about 5,400 feet, and
    - the aircraft speed was about 220 knots.
7. At 07:38:35 UTC:
    - the A/P vertical control changed to Pitch V/S and A/T changed from N1 to MCP SPD,
    - the aircraft climbed passed an altitude of about 7,600 feet, the calculated rate of climb was about 3,600 feet/minute, and
    - the aircraft speed was about 225 knots.
8. At 07:38:40 UTC:
    - the left thrust lever started to move backward from 47.5° position and the N1 speed of the left engine started to decrease from 92.3%,
    - the right thrust lever position remained at 46.2° and the N1 speed of the right engine remained at 91.8%,
    - the aircraft climbed passed an altitude of about 7,950 feet, the calculated rate of climb was 3,100 feet/minute, and
    - the aircraft speed was 225 knots.
9. At 07:39:01 UTC:
    - the aircraft climbed passed an altitude of about 8,800 feet,
    - the calculated rate of climb was about 2,600 feet/minute,
    - the aircraft was turning to the right with a roll angle of about 16° and passed heading of 002°,
    - the left thrust lever decreased to a position of 39° and the N1 speed of the left engine was 86.4% while the N1 speed for the right engine remained unchanged.
10. At 07:39:19 UTC:
    - the aircraft climbed passed an altitude of about 9,750 feet,
    - the calculated rate of climb decreasing to about 1,900 feet/minute,
    - the aircraft speed was about 230 knots,
    - the aircraft rolled to the right on an angle about 17°,

- the left engine thrust lever decreased to a position of 35° and the left engine N1 was at 81.5% and continued decreasing,
- the right thrust lever position and the N1 speed of the right engine remain unchanged,
- subsequently, the aircraft speed increased to about 238 knots, and
- the A/P remained engaged.

11. At 07:39:36 UTC:
    - the aircraft climbed passed an altitude of about 10,100 feet,
    - calculated rate of climb was about 1,900 feet/minute,
    - the roll angle was about 16° to the right,
    - the left thrust lever decreased to position of 25° and the left engine N1 speed was 72.7%, and
    - the right thrust lever position and the N1 speed of the right engine remain unchanged.
12. At 07:39:40 UTC:
    - the control wheels deflected to the right about 19°,
    - the left aileron deflection down 3.3° and the right aileron deflected up 5.8°,
    - the calculated spoiler deflection was 3.7° and remained until the A/P disengaged,
    - the aircraft climbed passed an altitude of about 10,250 feet,
    - the calculated rate of climb was about 1,900 feet/minute,
    - the aircraft roll angle was 15° to the right,
    - the left thrust lever decreased to a position of 22° and the N1 speed of the left engine was 67.5%,
    - the right thrust lever position and the N1 speed of the right engine remain unchanged.
13. At 07:39:48 UTC:
    - the aircraft reached a heading of 046° and began to turn to the left with the initial roll angle of about 1°,
    - the aircraft climbed passed an altitude of about 10,450 feet,
    - the calculated rate of climb was about 1,200 feet/minute,
    - the left thrust lever decreased to 17.6° and the left engine N1 speed was 59.3%, and
    - the right thrust lever position and the N1 speed of the right engine remain unchanged.
14. At 07:39:54 UTC:
    - the aircraft continued its turn to the left with the roll angle about 7°,
    - the aircraft climbed passed an altitude of 10,570 feet,
    - the calculated rate of climb was about 950 feet/minute,
    - the left thrust lever decreased to 13° and the N1 speed of the left engine was 49%, and

- the right thrust lever position and the N1 speed of the right engine remain unchanged.

15. At 07:39:59 UTC:
    - the aircraft turned to the left passing a heading of 036°, with the roll angle about 24°,
    - the aircraft climbed to an altitude of about 10,650 feet and the calculated rate of climb was about 950 feet/minute,
    - the left thrust lever decreased to position of 11.2° and N1 speed of the left engine was 46.2%, and
    - the right thrust lever position and the N1 speed of the right engine remain unchanged.
16. At 07:40:03 UTC:
    - the aircraft was at an altitude of about 10,700 feet,
    - The aircraft turned to the left with roll angle about 37°,
    - The left thrust lever position had decreased to 9.3° and the N1 speed of the left engine was at 35.1%, and
    - the right thrust lever position and the N1 speed of the right engine remain unchanged.
17. At 07:40:04 UTC, the stabilizer trim switch activated for 1 second and the control wheel initially moved 10° to the left.
18. At 07:40:05 UTC:
    - the control wheel trim switch activated and A/P disengaged,
    - the aircraft rolled to the left with the roll angle of about 49°,
    - the highest aircraft altitude recorded was about 10,700 feet, thereafter the aircraft continued to descend until the end of FDR recording,
    - the left thrust lever decreased to a position of about 8° and the N1 speed of the left engine was at about 34%,
    - the right thrust lever position and the N1 speed of the right engine remain unchanged, and
    - after the A/P was disengaged, the control wheel was deflected to the left for four seconds and recorded deflection value up to 18°.
19. At 07:40:10 UTC:
    - the control wheel deflection recorded 33° to the right,
    - the left aileron deflection down at 5.8° and the right aileron deflected up at 6.4°.
    - the calculated flight spoiler deflection was 9.5°,
    - the A/T disengaged,
    - the left thrust lever decreased to idle position of 1.1°.
20. At 07:40:20 UTC, the right thrust lever was moved to idle position at 0.7°.
21. At 07:40:28 UTC, end of FDR recording.

1.11.2 Cockpit Voice Recorder

The aircraft was fitted with a FA2100 Cockpit Voice Recorder (CVR) with P/N 2100-1020-00 with S/N 000286507, manufactured by L3 Technologies.

On 30 March 2021, the CVR CSMU was recovered by the search team. The Underwater Locator Beacon (ULB) detached from the CVR CSMU and was recovered earlier on 12 January 2021, on the same day of the recovery of the FDR ULB and FDR CSMU.

The CVR CSMU was transported to the KNKT recorder facility for data downloading.

Upon receiving the CVR CSMU, several scratches were observed on the surface of the CVR CSMU and the flexible wire connector of the memory module (part of the CSMU) was damaged due to impact into the water. The CSMU was disassembled to recover the memory module. Thereafter the recovered memory module was cleaned by distilled water and alcohol (96% by volume). On completing the cleaning process, the memory module was dried using the vacuum oven at temperature between 60° and 65° for 3 hours. After 3 hours, the memory module was flipped and the drying process repeated for another 3 hours. Subsequently, the memory module was inspected under the digital microscope to examine if there is any damage to the memory chips and its circuitry. The examination found that the memory chips and its circuitry were in good condition.

The flexible wire connector was removed from the CVR CSMU due to damage and was replaced with a new 3 Volt L3 flex wire connector with P/N 1302-03XD8. The continuity test[14] was performed including the resistance value to the new flexible wire connector in accordance with the applicable L3 Technologies CVR manual.

A CVR unit with P/N 2100-1020-00 and S/N 000710304 which matches with the CVR that was installed on PK-CLC aircraft was prepared to download the CVR data on the memory module. Before attaching the memory module into the CVR unit, the CVR unit was programmed using the L3 loader software to match to the PK-CLC CVR memory module. Thereafter, the memory module was attached to the CVR unit. The CVR data was downloaded using the Portable Interface (PI) FA2100 Recorder Data Retrieval, and Handheld Multi-Purpose Interface (HHMPI) for backup.

The downloaded process successfully retrieved the raw voice file (.cvr file) and the file was decompressed using the L3 decompress application to generate voice files (.wav). The generated voice files contained four separated channels with two hours of audio data recorded.

The CVR contained audio recording from the time of the flight preparation and continued until the end of the accident flight.

14 Continuity test is a quick check to see if a circuit is open or close.

The download process was successfully. These were the observations on the recovered CVR data:

- Channel 1 and Channel 2 recorded all the SIC's voice communications throughout the flight.
- Channel 3 recorded the PIC's communication with the ground engineer. Throughout the flight, the PIC's voice was not recorded by Channel 3. The PIC's voice was recorded in Channel 2 when the voice was loud enough to be received in the SIC's headset microphone.
- Channel 4 recorded a prominent tone with a frequency of around 400 Hz which interfered all other audio and the recorded audio data was unintelligible.

The relevant excerpt of the CVR transcript are as follows:

Note: Other than specifically stated, the aural communications described in this CVR excerpt were from Channel 2.

Time (UTC)	Event
05:38:19	CVR started to record and the channel 4 recorded a tone with a frequency of around 400 Hz. This tone remained until the end of recording.
06:10:41	Sound similar to latched handle recorded in the Channel 3.
06:15:43	Sound similar to someone using headset was recorded in the Channel 2.
06:21:41	The SIC communicated with a female person.
06:33:08	The Channel 1, 2, and 3 recorded the communication on the Ground Control radio frequency.
06:35:18	Voice on the background of ground crew communication recorded on the Channel 3.
06:36:12	The SIC communicated with Ground controller requested to reposition of the aircraft.
06:49:35	Sound similar of someone heavy breathing in the Channel 3.
06:55:39	The SIC communicated with Delivery controller requesting departure clearance. The Delivery controller provided clearance for the SJY182 to fly to Pontianak via airway W14, with cruising level of FL240, using Standard Instrument Departure (SID) of ABASA 2D.
07:08:23	A Flight Attendant (FA) made a passenger announcement was recorded in Channel 3.
07:13:55	The SIC called the Ground controller and reported that the aircraft was ready for pushback and engine start. The Ground controller then provided pushback and start engine clearances to SJY182.
07:14:21	The PIC informed the ground personnel for push back. This was the only time that PIC's voice that was clearly heard in the Channel 3. Thereafter, the PIC voice was only recorded in low gain in the Channel 2.

Time (UTC)	Event
07:18:01	The SIC requested taxi clearance to the Ground controller and was instructed to taxi to Runway 25R via taxiway NC7 and NP2.
07:22:50	The Ground controller instructed the pilot of SJY182 to contact the Tower controller.
07:32:11	The PM reported to the Tower controller that the aircraft was on short Runway 25R and was responded to hold on short.
07:33:34	The Tower controller instructed the pilot of SJY182 to enter the runway after one aircraft on final had landed.
07:33:55	The SIC read out the before takeoff checklist.
07:35:20	The Tower controller issued takeoff clearance to the pilot of SJY182.
07:36:19	The SIC called "FOUR HUNDRED" and the PF responded with "LNAV".
07:36:37	The Tower controller instructed the pilot of SJY182 to contact the Terminal East (TE) controller.
07:36:46	The SIC contacted the TE controller who stated "SJY182 identified on departure, via SID unrestricted climb level 290".
07:38:07	The SIC called out "Heading SEL"
07:38:39	The SIC confirmed to the PIC that heading was 070 and was affirmed by the PIC.
07:38:50	The SIC requested to the TE controller for a heading change to 075° to avoid weather conditions and was approved.
07:39:01	The TE controller instructed the pilot of SJY182 to stop climb at altitude 11,000 feet. The SIC readback the instruction and thereafter advised the altitude change to the PIC.
07:39:36	A sound that is similar to altitude alert.
07:39:37	The SIC advised the PIC that the aircraft was approaching 11,000 feet, and the PIC response was unintelligible.
07:39:54	The SIC advised the PIC "Set standard", followed by the TE controller instructed the pilot of SJY182 to climb to altitude of 13,000 feet.
07:39:59	The SIC read back the TE controller instruction. This was the last recorded radio transmission of the pilots.
07:40:01	The PIC called out: "ONE THREE ZERO".
07:40:03	• The SIC responded to the PIC with "ONE THREE ZERO". • Enhanced Ground Proximity Warning System (EGPWS) alert "BANK ANGLE" was heard.
07:40:04	The PIC called out "eh" which then the SIC responded with "eh sorry", and followed by a EGPWS alert "BANK ANGLE".

Time (UTC)	Event
07:40:05	The SIC called “BANK ANGLE” followed by sound similar to A/P disengaged warning
07:40:08	The SIC called out “Capt… Capt…” followed by “upset, upset”.
07:40:20	A sound similar to an overspeed warning.
07:40:22	The SIC called out “Capt… Capt….” For three seconds.
07:40:30	End of recording.

1.11.3 CVR Test History

The CVR P/N 2100-1020-00 with S/N 000286507 data was downloaded in 2019 and 2020 for the renewal of the Certificate of Airworthiness (C of A) which in 2019, the CVR download was performed at the Garuda Maintenance Facility. The downloaded audio from the Channels 1, 2 and 3 were normal while the Channel 4 recorded a prominent tone with a frequency of about 400 Hz. The result of the download stated that the CVR was functioning correctly.

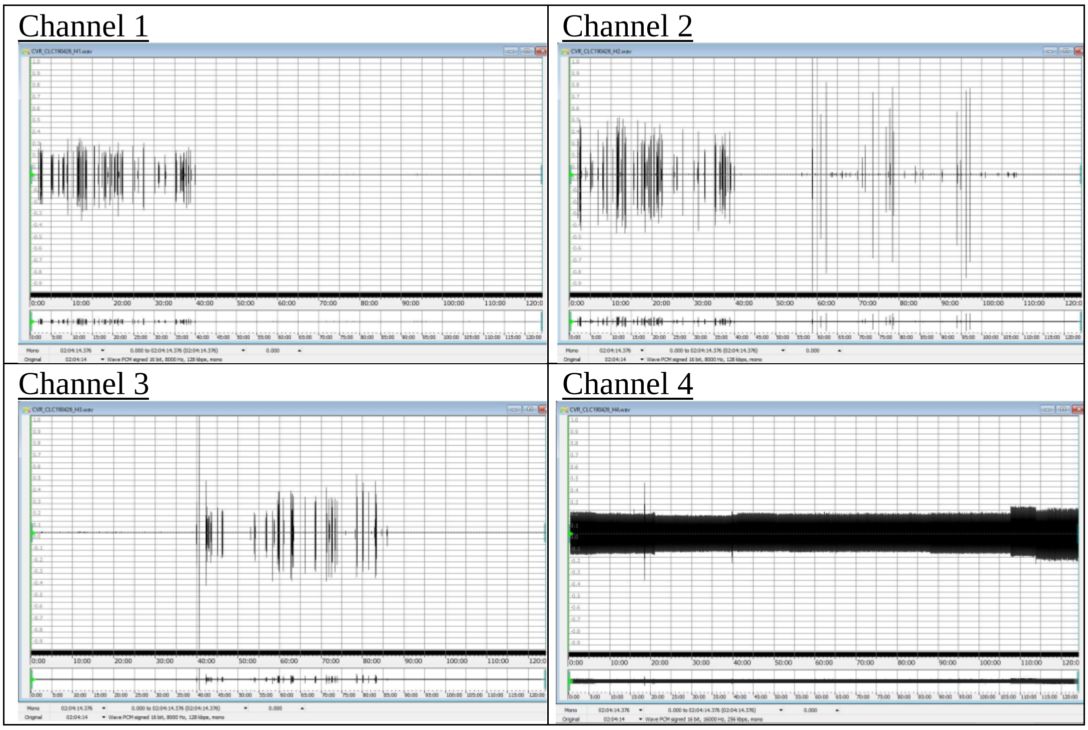


Figure 14: The downloaded CVR data in 2019

On 9 April 2020, the CVR was downloaded at the Sriwijaya Air facility while the aircraft was grounded for maintenance. There was no recording on Channels 1, 2 and 3, while Channel 4 recorded conversation between engineers while performing maintenance. The result of the download stated that the CVR was functioning correctly.

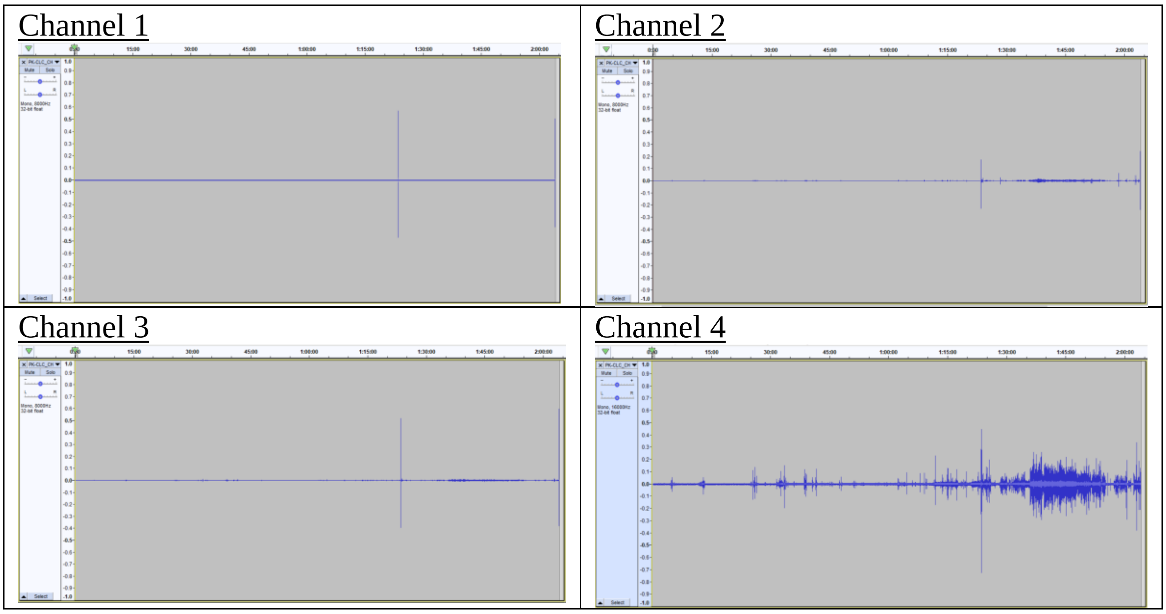


Figure 15: The downloaded CVR data in 2020

The investigation was unable to determine the reason on why Channel 4 recorded a prominent tone with a frequency of about 400 Hz in the downloaded CVR data in 2019 but was not in the downloaded CVR data in 2020.

1.12 Wreckage and Impact Information

The accident site was located about 11 Nm northwest of Jakarta, and about 80 meters southeast of the last known aircraft position recorded by the ADS-B. The wreckage distributed over an area of about 80 by 110 meters on the seabed at a depth of approximately 16 meters.

Figure 16: Aircraft flight track based on the FDR imposed to Google Earth

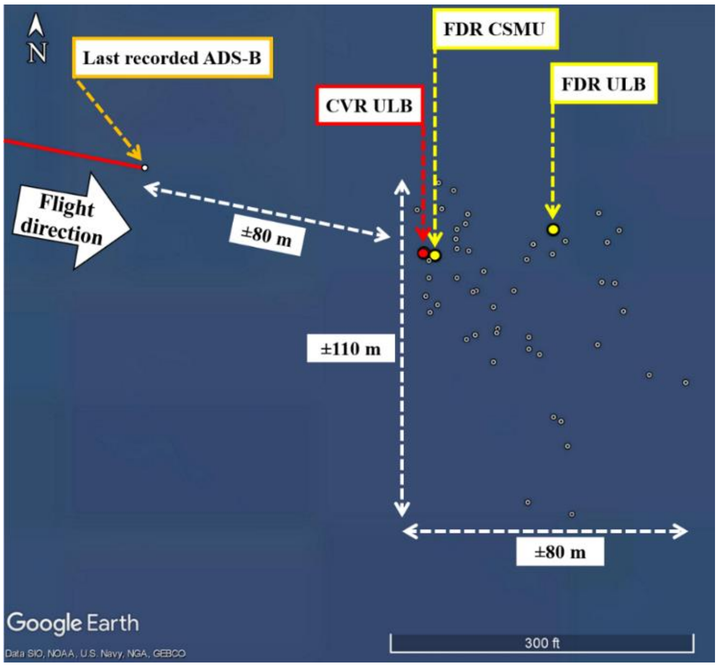


Figure 17: Location of FDR CSMU, FDR ULB and CVR ULB relative to the last ADS-B recorded data

The FDR's CSMU was found within the wreckage distribution area at coordinates 5°57'51.00" S 106°34'31.00" E. The ULBs were detached from both the FDR and the CVR[15]. The FDR's ULB was found at coordinates 5°57'50.76" S 106°34'32.10" E approximately 35 meters from the FDR's CSMU, and the CVR's ULB was found at coordinates 5°57'50.98" S 106°34'30.90" E.

Some other wreckages were recovered and transported to Jakarta International Container Terminal (JICT) for examination by the investigation team.

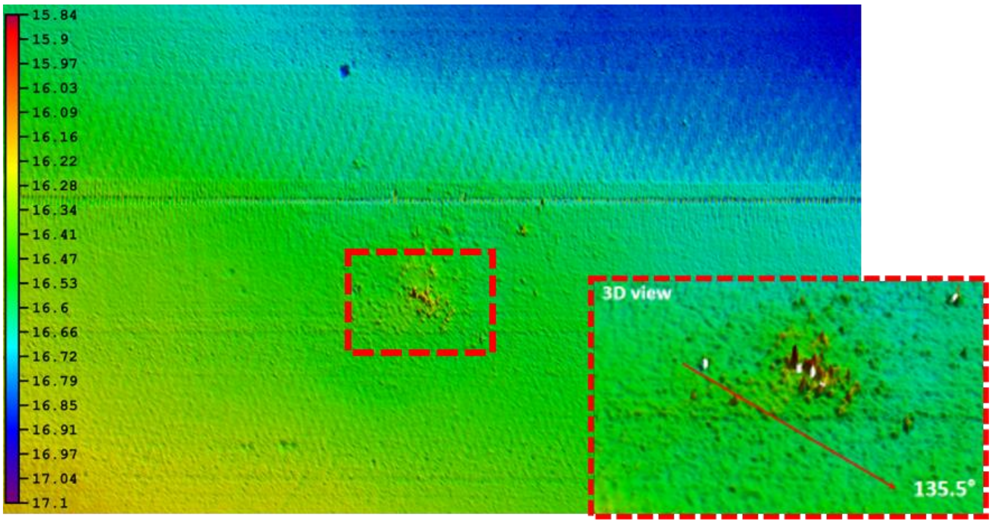


Figure 18: Scanning result from multibeam echosounder

15 Each flight recorder has a CSMU and an ULB.

1.13 Medical and Pathological Information

No medical and pathological information available for this investigation.

1.14 Fire

There was no evidence of fire.

1.15 Survival Aspects

After the radar target of the aircraft disappeared from the ATC radar screen and the attempts to contact the pilot were unsuccessful, about 1455 LT, the operation manager reported the occurrence to the Indonesian Search and Rescue Agency (*Badan Nasional Pencarian dan Pertolongan*/BNPP).

At 1542 LT, the Air Traffic Services (ATS) provider declared the uncertainty phase (INCERFA) of the SJY182. The distress phase of SJY182 (DETRESFA) was subsequently declared at 1643 LT.

On 10 January 2021, the wreckage was found on the seabed near Kepulauan Seribu District about 11 Nm Northwest of Jakarta. The accident was not survivable.

1.16 Tests and Research

1.16.1 The Test of Previously Installed Autothrottle Computer

The A/T computer was originally designed and manufactured by Smiths Aerospace which was later bought by General Electric. In 2016, General Electric sold the A/T computer product line to Ontic Engineering & Manufacturing United Kingdom (UK) Ltd (Ontic).

The A/T computer of P/N 735SUE10-12 with S/N 5151 (A/TC 5151) had been previously repaired in Aviation Instruments Repair Specialists Inc United States (US) in 2016. The teardown/inspection referred to the work order 134256 on 8 June 2016, which stated that the A/T computer experienced a computer fault. The Aviation Instruments Repair Specialists US replaced two transistors on the Engagement and Warning module to correct the fault. The unit was then released to service.

The A/T computer, serial number A/TC 5151, was installed on PK-CLC aircraft on 4 February 2017 and was removed on 30 December 2020 due to a pilot report on a defect that the A/T could not be engaged. There were 49 pilot reports which were related to the A/T system on PK-CLC prior to its removal.

On 22 January 2021, the A/T computer (A/TC 5151) was sent to Ontic for examination and testing. The A/T computer was received at Ontic facility in Cheltenham, UK on 11 February 2021 and was immediately transferred to a secure storage. On 15 February 2021, the A/T computer was then transported to Oakenhurst Aircraft Services Ltd. UK.

The test of A/T computer (A/TC 5151) was performed on 16 February 2021 in Oakenhurst Aircraft Services Ltd. UK with the assistance of the Air Accidents Investigation Branch (AAIB) UK in witnessing the test. The test plan was as follows:

1. To download any fault log data to assist the investigation in understanding the condition of the aircraft prior to the accident.

2. To identify if the unit has any fault history that could help to understand the operator maintenance and troubleshooting program.
3. To demonstrate the effect of a broken wire that is providing the flap position synchro input into the A/T system for the CTSM logic.

Participants were from KNKT, Boeing, NTSB, FAA, Ontic, GE, and the AAIB UK. The test results were as follows:

1. The physical inspection to the unit found no significant discrepancy.
2. The fault log data was downloaded successfully and retrieved faults corresponding to the 10 flights prior to removal of the A/T computer. The fault log history with the corresponding pilot reports is as follows:

Fault Log Number	**Date**	**Time (UTC)**	**Fault Log**	**Pilot Report**
1	29 December 2020	1224	throt 1 sync invalid	No report
2	29 December 2020	1101	throt 1 sync invalid	No report
3	29 December 2020	0843	throt 1 sync invalid	No report
4	29 December 2020	0635	throt 1 sync invalid	No report
5	29 December 2020	0157	throt 1 sync invalid	No report
6	28 December 2020	2314	throt 1 sync invalid	No report
7	28 December 2020	1244	throt 1 sync invalid	No report
	28 December 2020	1350	throt 1 sync fail enga	No report
8	28 December 2020	1013	throt 1 sync invalid	No report
	28 December 2020	1129	throt 1 sync fail enga	No report
9	28 December 2020	0416	throt 1 sync invalid	No report
10	28 December 2020	0227	throt 1 sync invalid	No report

The "throt 1 sync invalid" fault is logged when the thrust lever angle signal fails due to loss of 26 VAC excitation. This fault results in the Fast/Slow Flag coming in view on display.

The "throt 1 sync fail enga" fault is logged when an attempt is made to engage the A/T but the A/T will not stay engaged due to an invalid 26 VAC reference voltage. This fault results in the failure of the A/T to engage.

The "throt 1 sync invalid" and "throt 1 sync fail enga" faults will be logged if the internal fuse "FS1" is open.

3. The A/T computer of P/N 735SUE10-12 with S/N 5151 first underwent the Acceptance Test to ensure the condition of the unit before commencing further tests to the unit. The A/T computer failed multiple test steps during the Acceptance Test. An examination revealed that the cause of the failure was an open FS1 fuse located on the Filter Plate Assembly. A new fuse was soldered in parallel to the FS1 fuse and the Acceptance Test passed. There was no evidence of any failure within the A/T Computer that could have caused the FS1 fuse to fail. The AAIB determined that the fuse had blown normally due to overcurrent.
4. To demonstrate the effect of flap synchro wire problem, the comparison test was performed by using a serviceable A/T computer and a functional synchro from Ontic. The flap synchro inputs were directly fed to the A/T computer to help determine the effect of a broken wire and the resultant A/T calculation of the input angle. The testing confirmed that a broken wire Vx between the flap synchro and the A/T computer will cause the computer to interpret a flap position of 0° as 40°. This would inhibit the cruise thrust split monitor even when the flaps are physically at 0°.
5. The examination and testing of the A/T computer of P/N 735SUE10-12 with S/N 5151 that was previously installed on the accident aircraft did not reveal any discrepancies related to split thrust levers or CTSM logic.

1.16.2 The Test of Previously Installed Autothrottle Servo

The A/T servo P/N 111RAA3, was manufactured by Smiths Aerospace (now General Electric/GE). The A/T servo of P/N 111RAA3 with S/N 3480 was previously installed on the PK-CLC aircraft and was removed from the aircraft on 22 December 2020 for A/T problem troubleshooting. The maintenance records showed that the unit was installed on PK-CLC aircraft since 1994.

The A/T servo S/N 3480 was sent to Ontic facility in Chatsworth, California, United States of America on 22 January 2021 for testing. During the conduct of the test, it was revealed that the Ontic test bench was unserviceable and the test was rescheduled.

The A/T servo then was sent to Ontic Cheltenham UK and was received on 12 August 2021. The unit was immediately transferred to a secure store for a scheduled test on 9 December 2021.

On 9 December 2021, the test commenced and was witnessed by KNKT, NTSB, Boeing and AAIB UK. Testing was conducted in accordance with CMM Section 3. The test was performed as follow:

Sequence	Test Performance	Result
1	Resistance Checks	Passed
2	Tachometer Sensitivity test	Passed
3	Tachometer Datum test	Passed
4	Tachometer Sensing test	Passed
5	Rotation Direction test	Passed
6	Motor Threshold test	Passed
7	No Load Output Speed test	Passed

Sequence	Test Performance	Result
8	Motor Stall Torque test	Passed
9	Electromagnetic Clutch Operation test	Passed
10	Clutch Disengagement/Back drive Torque test	Passed
11	Backlash test	Passed

The test of the A/T servo part number 111RAA3 with serial number 3480 concluded no fault found on the unit.

1.16.3 The Test of installed EGPWS

The Enhanced Ground Proximity Warning System (EGPWS) computer of part number 965-0976-003-216-216 serial number 2126 was installed in the incident aircraft on 15 July 2017.

The EGPWS computer was recovered during the sea search on 16 January 2021. The unit was found with the front plate was missing and therefore the part number and serial number could not be determined.

The unit was examined at the Honeywell Aerospace facility in Redmond, Washington, USA on 8 April 2021. The examination revealed that the unit was severely damaged with sections of the chassis and circuit card assemblies missing, deformed, and scratched. The mounting tray was still in place with the unit and could not be removed by hand. To remove the unit from the tray, the rivets that held the mounting tray were removed, and a section of the tray was cut to remove the EGPWS computer.

The EGPWS Circuit Card Assemblies (CCA) were removed from the chassis of the computer and inspected. The EGPWS CCA condition is shown in the following figure.

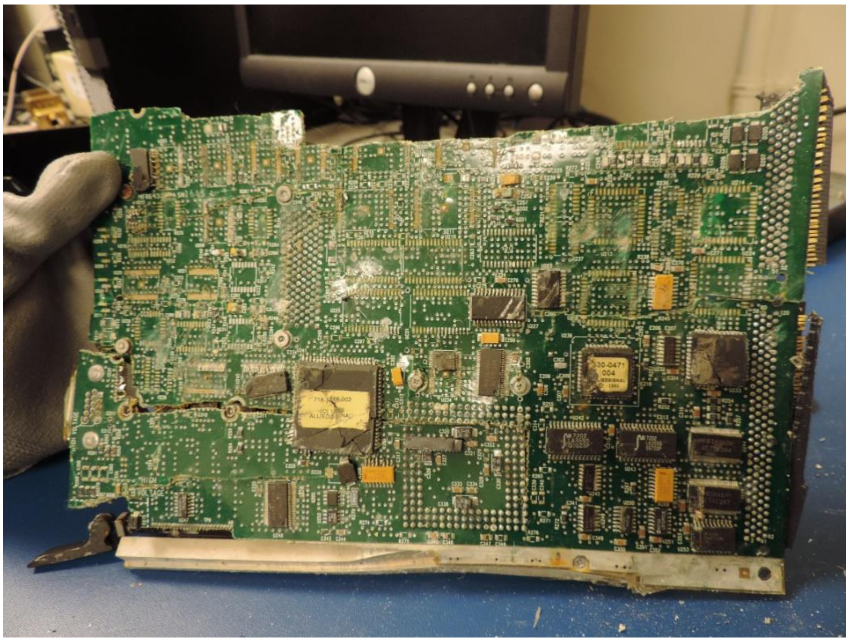


Figure 19: The EGPWS CCA

In this version of EGPWS computer, flight history data is stored in the memory chip on the controller A2 CCA. Some components were missing from the A2 CCA, including the memory chip. The location of the missing A2 CCA memory chip is shown in the following figure.

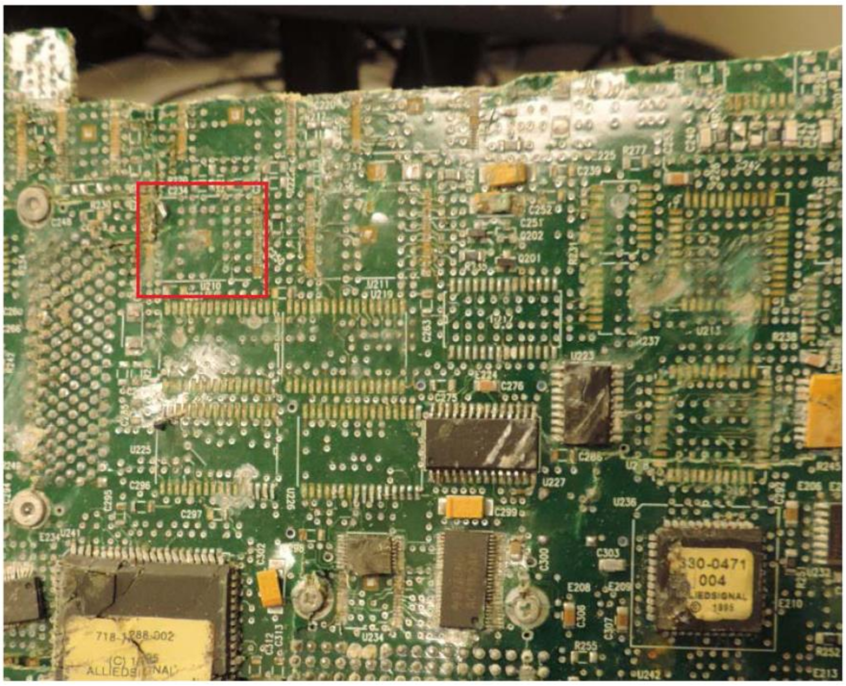


Figure 20: The red box is to identify the missing EGPWS A2 CCA chip

As the memory chip was not recovered, no further examination was conducted to the unit and no flight history data could be retrieved.

1.16.4 The Test of Previously Installed Flight Control Computers

The Flight Control Computer (FCC) of P/N 4051600-914 was manufactured by Honeywell International Inc.

The FCC of P/N 4051600-914 with S/N 96083964 (previously installed in the aircraft at the A/P B position) was removed from the aircraft on 18 March 2020 as it had a problem of A/P unserviceable since 16 March 2020.

The FCC of P/N 4051600-914 with S/N 94103655 (previously installed in the aircraft at the A/P A position) was removed from the aircraft on 18 March 2020 as it experienced the problem of A/P not being able to engage during transit check.

Both FCCs were transported to the Honeywell US in February 2021 for examination and downloading of stored faults to determine if there were any faults associated with the aircraft spoiler position signal used by the A/T computer. The examination of the FCCs took place at the Honeywell Deer Valley facility in Phoenix, Arizona, on 30 March and 14 June 2021.

The first test on 30 March 2021 was conducted on FCC of P/N 4051600-914 with S/N 94103655 to download the faults code. The download was unsuccessful as the process had to be terminated due to smoke emitting from the FCC during the download process.

After discussion with the investigation team, the memory card of FCC of P/N 4051600-914 with S/N 94103655 was removed on 14 June 2021 and placed in the serviceable FCC unit owned by Honeywell for data downloading purposes. The data download was successful and retrieved 7 inflight legs consisting of 3 fault codes.

The first fault code was a Pitch Bias out of View during cruise cockpit effect. The fault code diagnostic indicated the failed Line Replaceable Unit (LRU) as being Digital Air Data Computer (DADC) position 1, but there was no further detail of the source fault. This fault would have removed the pitch Flight Director (FD) command bar from the Electronic Attitude Display Indicator (EADI) and likely cancelled any active FD modes. The other 2 faults codes were power up faults with no diagnostics, that occurred on the ground, and would have resulted in restarts. There were no recorded fault codes related to the spoiler position signal.

Due to the anomalies noted when FCC P/N 4051600-914 with S/N 94103655 was initially powered on the test stand, the Acceptance Test Procedure (ATP) was not conducted on this unit.

FCC P/N 4051600-914 with S/N 96083964

The first test on 30 March 2021 was conducted to download the faults code.

FCC P/N 4051600-914 with S/N 96083964 was installed on the test stand. The test stand initiated and successfully performed the automated download process for fault codes from the unit. The data download was successful and retrieved 3 inflight legs consisting of 5 fault codes.

The first four fault codes occurred on the ground or during power up and provide no diagnostic information. Generally, a power up failure results in a restart of the power up cycle, which likely passed on the second try to allow the flight to proceed.

The final fault occurred on the ground and indicated there was a failure of a flight director command comparison monitor. Honeywell was unable to determine if this was due to a mis-comparison of pitch or roll.

There were no recorded fault codes related to the spoiler position signal.

On 14 June 2021, the Acceptance Test were performed and the unit failed on two tests associated with the Mach Trim position sensor. A failure of the Mach Trim Position Sensor during operation would trigger a Mach Trim System fault. Since this fault was not present in the fault history download, the investigation believed that the Mach Trim position sensor fault observed on the test bench did not occur during operation.

1.16.5 FCC Processing of the Spoiler Angle Examination

The analog spoiler position signal goes from the spoiler sensor to the FCC where it is converted into an ARINC signal. From the FCC, the ARINC signal goes to the Mode Control Panel (MCP) and then to the A/T computer. The FCC uses the spoiler position signal as feedback to define roll rate and will adjust the aileron command for roll rate when spoilers deflect.

The investigation team developed an on-aircraft test for verifying the processing of the spoiler signal from the spoiler sensor to the FCC and to the A/T computer. To conduct the exercise, NTSB, GE Aviation (UK) and AAIB sought the assistance of an air carrier in the United Kingdom.

The exercises were conducted on a Boeing 737-400 aircraft of an air carrier in the United Kingdom. The aircraft has an identical flight control system to the Boeing 737-500.

The purpose of the exercise was to correlate the relationship of the flight spoiler surface position to the flight spoiler position signal that is ultimately received by the AT computer. A secondary activity was to correlate the relationship of the control wheel deflection angle to the aileron and spoiler position system. The rigging of the flight spoiler position sensor was also considered in the exercise. The air carrier confirmed that the dedicated aircraft had been correctly rigged before the exercise.

On 4 August 2021, the investigation team agreed on the exercise plan as follows:

1. To place the inclinometers on each of the two control wheels, on flight spoiler 2 and on flight spoiler 7 surface along with both left and right ailerons. The inclinometer to be secured to the spoiler and aileron surfaces in the plane of movement so that true measurements of rotation can be made.
2. Connect pins 56 and 57 pins of A/T Computer D167A Plug to a handheld ARINC 429 receiver.
3. The aircraft would be electrically powered (either through battery, ground power or Auxiliary Power Unit/APU) so that the FCC, MCP and aileron trim switches were powered along with the spoiler position sensors. The 115 Volt AC would be required to ensure that the electrical hydraulic pump is available to power the flight control and spoiler system.
4. The flaps would be fully retracted and the aileron trim switches placed into central (neutral) position.
5. The control wheel would be rotated in both clockwise and counterclockwise directions and the reading of the inclinometers and the ARINC receiver will be recorded. The rotation of the control wheel would be in steps starting from 0°, 5°, 8°, 9°, 10°, 12°, 14°, 16°, 18°, 20°, 25° and 30° off center.
6. After completion of the steps, restore the aircraft back to original condition.

According to the aircraft maintenance manual chapter 27-61-00, the flight spoiler initiated to deflect when the control wheel moves (either clockwise or counterclockwise) at an angle of 11±1°. When the control wheel movement reached 87° , the flight spoiler deflection should be 38±2°.

On 15 August 2021 the test was witnessed by the KNKT, AAIB, NTSB, FAA, Boeing, GE and Ontic.

The aircraft setup is shown in the following figure.

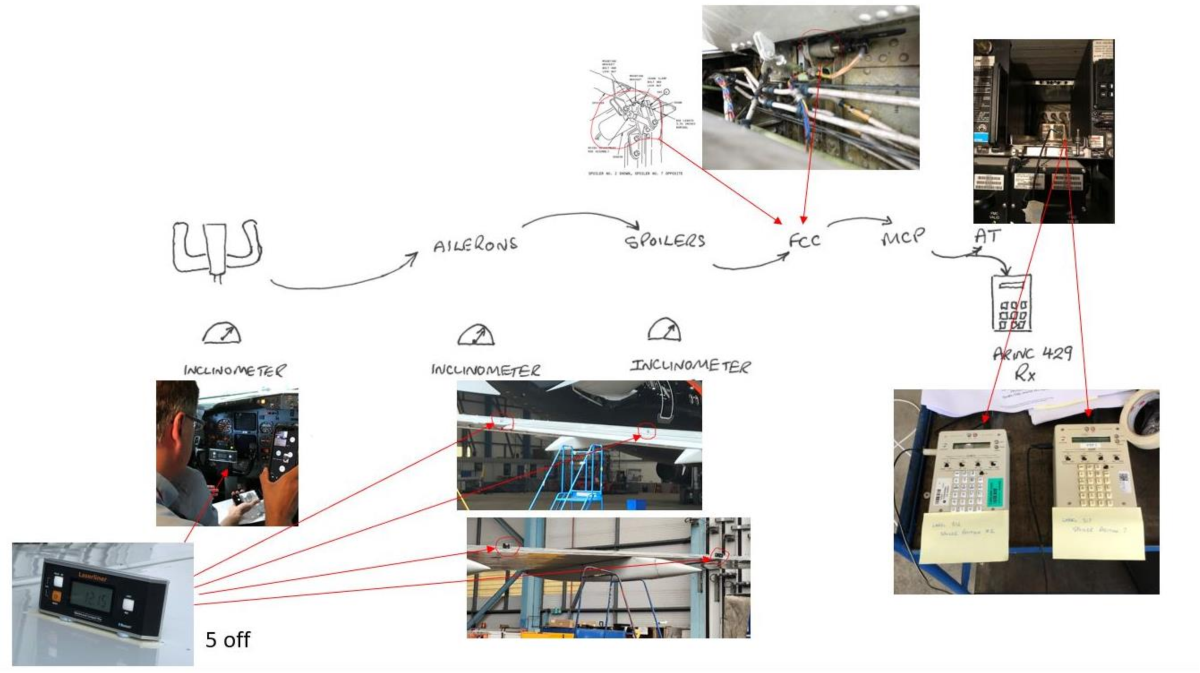


Figure 21: The aircraft setup illustration to conduct the exercise

The test result is as follows:

The test verified that the spoiler position angle matched to the spoiler position output from the FCC. The relationship chart of the aileron and flight spoiler deflection is shown in the figure below.

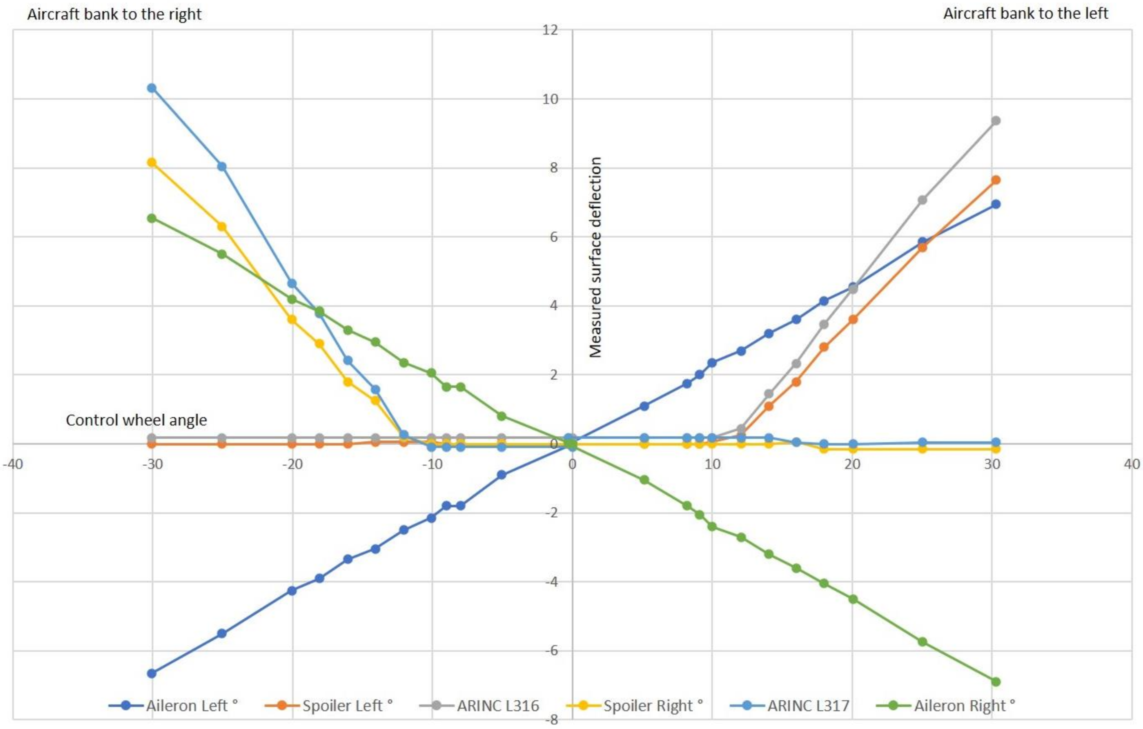


Figure 22: Aileron and spoiler deflection test result (surface deflect up = positive value)

1.16.6 Aircraft Simulations

The investigation conducted simulations of the accident flight, based on the FDR and CVR data, utilizing flight training simulator facilities. The simulation scenario referred to the FDR and CVR data of the accident flight.

The objectives of the simulation were to understand:

1. The activation of cruise thrust split monitor (if applicable);
2. Information available to the flight crew related to the asymmetric thrust condition;
3. The pilot activities and workload during flight;
4. The recovery of the upset condition.

The simulation attempt conducted in Las Vegas Flight Academy in Henderson, Nevada, USA and was attended by KNKT, NTSB, FAA, and Boeing. It was found that the simulator did not react similarly to the accident flight during asymmetric thrust event.

The investigation team repeated the simulation on 7 December 2021, in NAM Training Centre flight training simulator facility in Jakarta, with an aircraft type of Boeing 737-300/400/500 and was attended by KNKT and Sriwijaya Air which was represented by three pilots. One pilot acted as simulator operator on the instructor panel and two pilots acted as active flight crew.

The second simulation used similar scenario as the first simulation. The flight sequence was as follows:

1. Take off from Runway 25R of the Soekarno-Hatta International Airport.
2. Climb out by following the RNAV-1 Standard Instrument Departure (SID) of ABASA 2D.
3. Changes of A/P and A/T mode.
4. Communication with Air Traffic Control (ATC) at altitude as recorded in the FDR and CVR.
5. Retarding the left thrust lever to simulate power asymmetry, and up to the point of aircraft upset.

To recreate asymmetric power, a fishing line was tied to the left thrust lever to manually retard the thrust lever.

The simulation was conducted in two sessions; on the first session KNKT investigators acted as active flight crew and on the second session, two Sriwijaya Air pilots acted as flight crew. Each session has three simulator runs.

<u>First Session</u>

The first session was conducted according to the scenario. The simulation successfully recreated the accident flight and was able to make a similar path to the accident flight. The recovery was made while the aircraft rolled to the left about 35°. The recovery was initiated by disengaging the A/P by means of activating electric stabilizer trim. The recovery was successful by operating aileron only, no rudder application and no correction to the thrust lever position were made.

The simulator was not equipped with Cruise Thrust Split Monitor (CTSM) therefore A/T disengagement did not occur when the asymmetric thrust occurred. It was also noted that while the left thrust lever at a neared idle position, the landing gear unsafe light (3 red lights) illuminated. The simulator also was not equipped with BANK ANGLE alert of the EGPWS, therefore the alert did not activate. The stick shaker was active prior to the recovery being initiated.

The second simulation run was conducted with a similar scenario. The difference was on the initiation of recovery action that was performed when the A/P automatically disengaged. The A/P automatically disengaged when the aircraft roll angle was about 90° to the left. The recovery to the upset was successfully conducted by the activation of aileron only.

The third simulation run was conducted with the similar scenario and the recovery action that was performed about two seconds after the A/P disengaged. This is intended to understand the effect of asymmetric power on the aircraft roll after the A/P disengaged. During the simulation, the recovery was initiated when the aircraft roll was about 120° to the left. The A/P disengagement did not result in significant aircraft roll or yaw. The recovery to the aircraft upset was successful due to the activation of aileron only.

Second Session

The second session of the simulation was conducted with the same scenario with two qualified Boeing 737-500 pilots of Sriwijaya Air acting as flight crew. Both pilots reenacted the accident flight by performing activities such as checklist reading, ATC communication read back, standard call out, and upset recovery at the instructions of the KNKT.

The first simulation run on the second session successfully recreated the accident flight and was able to simulate a similar path to the accident flight. The recovery was initiated when the aircraft rolled to the left about 35°. The first simulation run revealed that:

1. Among the activities of changing the A/P modes, communicating to the ATC and executing other standard flying activities, there were some significant periods of time available to monitor the progress of the flight path.
2. The flight crew realized about the asymmetric power condition after noticing the different indications on the engine instruments. The flight crew checked the throttle quadrant and found that the thrust lever difference was about two knobs or approximately 6 cm or 2 1/2 inches.
3. During the recovery, the flight crew disengaged the A/P and simultaneously retarded both thrust levers to idle.
4. The flight crew successfully recovered the aircraft from the upset condition.

The second simulation run was conducted with a similar scenario but the initiation of the recovery was performed only after the A/P disengaged. The flight crew successfully recovered from the upset condition by the activation of aileron only.

The third simulation run was performed with a similar scenario but the recovery of upset condition was initiated 2 seconds after the A/P disengaged. The flight crew successfully recovered from the upset condition by the activation of aileron only.

1.17 Organizational and Management Information

1.17.1 Aircraft Operator

The Boeing 737-500 aircraft was registered as PK-CLC and was owned and operated by PT. Sriwijaya Air. The aircraft operator held a valid Air Operator Certificate number 121-035.

The Sriwijaya Air operated a total of 2 Boeing 737-900Ers, 13 Boeing 737-800s, and 6 Boeing 737-500s which includes the PK-CLC aircraft.

1.17.1.1 Pilot Duties and Responsibilities

Sriwijaya Air Company Operation Manual (COM) subchapter 1.4.1 described the responsibility and authority of Pilot in Command as follow:

- *The pilot in command of an aircraft is directly responsible for, and is the final authority as to, the operation and security of the aircraft.*
- *In an in-flight emergency requiring immediate action, the pilot in command may deviate from any rule of part 91 to the extent required to meet that emergency.*
- *The pilot in command must comply with this Company Operations Manual, Company directives, Standard Operating Procedures, and CASR.*

The following guidance on crew duties was provided to Sriwijaya's pilot which was listed in the Sriwijaya Air version of the Boeing 737-300/-500 Flight Crew Operations Manual (FCOM), "Normal Procedure" page NP 11.2 thru 11.4, dated March 18, 2016.

Crew Duties

The general PF phase of flight responsibilities are:

- *taxiing*
- *flight path and airspeed control*
- *airplane configuration*
- *navigation*

The general PM phase of flight responsibilities are:

- *checklist reading*
- *communications*
- *tasks asked for by the PF*
- *monitoring taxiing, flight path, airspeed, airplane configuration, and navigation*

PF and PM duties may change during a flight. For example, the captain could be the PF during taxi but be the PM during takeoff through landing.

The mode control panel is the PF's responsibility. When flying manually, the PF directs the PM to make the changes on the mode control panel.

The captain is the final authority for all tasks directed and done.

The crew must always monitor:

- *airplane course*
- *vertical path*
- *speed*

When selecting a value on the MCP, verify that the respective value changes on the flight instruments, as applicable.

The crew must verify manually selected or automatic AFDS changes. Use the FMA to verify mode changes for the:

- *autopilot*
- *flight director*
- *A/T*

During LNAV and VNAV operations, verify all changes to the airplane's:

- *course*
- *vertical path*
- *thrust*
- *speed*

Announcing changes on the FMA and thrust mode display when they occur is a good CRM practice.

The COM subchapter 8.1.10.6 also required PIC to report and record of mechanical irregularities as follows:

Whenever a pilot finds a defective equipment, the PIC will:

1. *Check the Aircraft Maintenance Log to see if the item has been previously reported and properly deferred. If the item has not been previously written up, the PIC will record the pertinent information on the Aircraft Maintenance Log.*
2. *Check the approved Minimum Equipment List to determine if the defective equipment may be deferred and the conditions that must be met.*
3. *If the defective equipment is not deferrable, the PIC will not allow the aircraft to take off until mechanical irregularity is corrected or acceptable Dispatch Authorization has been issued.*

1.17.1.2 Policy on the Use of Automation

The COM subchapter 8.3.18 described the policy on the use of automation as follow:

Automatic flight systems are designed to enhance flight safety and efficiency and must be used to their fullest extent.

- *Company's policy that the highest level of automation appropriate to the task should be used.*
- *The Flight Crew must not allow automation to detract from the overall management of the flight.*

The Sriwijaya Air version of the Boeing 737 CL Flight Crew Training Manual (FCTM), page 1.38 described that during all phases of flight, the use of A/T is recommended when the A/P is engaged.

1.17.1.3 Normal Procedure on Climb and Pass 10,000 feet

The following guidance on climb and cruise was provided to Sriwijaya's pilot which is listed in the Sriwijaya Air version of the Boeing 737-300/-500 FCOM, page NP 21.39 dated June 15, 2020:

Climb and Cruise Procedure

Complete the After Takeoff Checklist before starting the Climb and Cruise Procedure.

Pilot Flying	***Pilot Monitoring***
	During climb and cruise, verify the RNP as needed
	At or above 10,000 feet MSL, set the LANDING light switches to OFF.
	Set the passenger signs as needed.
When climbing above transition altitude, set and crosscheck the altimeters to standard.	

1.17.1.4 Flight Deck Philosophy

The following guidance on flight deck philosophy was listed in the Sriwijaya Air version of the Boeing 737 CL Flight Crew Training Manual (FCTM).

Flight Deck Philosophy

Boeing flight decks are designed to support the priorities of aviate, navigate, communicate and manage airplane systems.

The Captain is ultimately responsible for the safe operation of the airplane. Both flight crew members are responsible for the safe conduct of the flight. Automation assists the flight crew in the efficient operation of the airplane. If the airplane is not performing as needed, or expected, the flight crew must assume positive control of the airplane.

The flight deck design assumes the pilot will:

- *Respond correctly and safely to alert conditions.*
- *Prioritize warnings over cautions.*
- *Maintain situational awareness at all times. Both pilots should check the flight instruments and flight mode annunciations and verify that the airplane is responding appropriately. Both pilots need to anticipate what needs to be done next and how the airplane should respond.*
- *Use the appropriate level of automation for the situation. Hand off a task to automation in the state needed. Engage automation when the workload increases and take over manual control of the airplane when needed.*
- *Apply critical thinking and judgment. If indications are not as expected seek verifying information and take appropriate action.*

Operational Philosophy

The normal procedures are designed for use by trained flight crewmembers. The procedure sequence follows a definitive panel scan pattern. Each crewmember is assigned a flight deck area to initiate action in accordance with Normal and Supplementary Procedures. Non-normal procedural actions and actions outside the crewmembers' area of responsibility are initiated at the direction of the captain.

Non-normal checklists are provided to cope with or resolve non-normal situations on the ground or in flight.

Callouts

Both pilots should check the flight instruments and Flight Mode Annunciations (FMAs) at regular intervals to verify the selections made are correct for the phase of flight. Both pilots should crosscheck their MCP selections with the FMAs to ensure the airplane is responding as expected. Unexpected FMAs should be announced, evaluated and addressed appropriately.

1.17.1.5 Upset Recovery Procedure

The Sriwijaya Air version of the Boeing 737 CL FCTM, page 7.33, described upset recovery as follows:

For detailed information regarding the nature of upsets, aerodynamic principles, recommended training and other related information, refer to the Airplane Upset Prevention & Recovery Training Aid (AUPRTA) available through your operator and on the ICAO website.

Historically, an upset has been defined as unintentionally exceeding any one or more of the following conditions:

- *pitch attitude greater than 25° nose up*
- *pitch attitude greater than 10° nose down*
- *bank angle greater than 45°*
- *less than the above parameters but flying at an airspeed inappropriate for the conditions.*

The latest revision of AUPRTA concludes that an upset condition exists any time that an airplane is deviating from the intended airplane state. The AUPRTA has been updated to emphasize the importance of recognition and avoidance of situations that can lead to airplane upsets and to improve a pilot's ability to recover control of an airplane that deviates from the intended airplane state. An airplane upset can involve pitch or roll angle deviations as well as inappropriate airspeeds for the conditions.

With the focus on upset recognition and avoidance, pilots should understand how to operate the airplane throughout the entire operational flight envelope. Pilots should have practical knowledge of and demonstrate proficiency in airplane performance and handling characteristics.

Upset prevention and recovery training should emphasize the entire operational flight envelope to develop pilot awareness and handling skills in both manual and automated flight.

Upset Recovery Maneuvers

If an upset situation is recognized, immediately accomplish the Upset Recovery maneuver found in the non-normal maneuvers section in the QRH.

It is possible to consolidate upset recovery maneuvers into two basic scenarios, nose high and nose low, and to acknowledge the potential for high bank angles in each scenario. Recognizing and confirming the upset, reducing automation, and completing the recovery are included in the Upset Recovery maneuvers in the QRH. The maneuvers provide a logical progression for recovering the airplane.

To recognize and confirm the situation the crew must assess the airplane attitude, airspeed, altitude and trend information through instrument crosscheck.

The ADI[16] *should be used as the primary reference in assessing airplane attitude. The pitch scales and color coding above/below the horizon (blue/brown) should be used when making the pitch assessment.*

For any pitch attitude, the bank pointer stays perpendicular to the horizon. When completing the upset recovery maneuver, roll the shortest direction to wings level (toward the bank pointer).

Though flight crews in line operation rarely, if ever, encounter an upset situation, understanding how to apply aerodynamic fundamentals in such a situation helps them control the airplane. Several techniques are available for recovering from an upset. In most situations, if a technique is effective, it is not recommended that pilots use additional techniques. Several of these techniques are discussed in the example scenarios below:

- *stall recovery*
- *nose high, wings level*
- *nose high, high bank angles*
- *nose low, wings level*
- *nose low, high bank angles*
- *high bank angles*

Note*: Higher than normal control forces may be required to control the airplane attitude when recovering from upset situations. Be prepared to use a firm and continuous force on the control column and control wheel to complete the recovery.*

...

16 ADI is Attitude Director Indicator.

Nose Low, High Bank Angles

The nose low, high angle of bank upset requires prompt action by the pilot as altitude is rapidly being exchanged for airspeed. Even if the airplane is at a high enough altitude that ground impact is not an immediate concern, airspeed can rapidly increase beyond airplane design limits. Simultaneous application of roll and adjustment of thrust may be necessary. It may be necessary to apply nose-down elevator to limit the amount of lift, which will be acting toward the ground if the bank angle exceeds 90°. This also reduces wing angle of attack to improve roll capability. Full aileron and spoiler input should be used if necessary to smoothly establish a recovery roll rate toward the nearest horizon. It is important to not increase g force or use nose-up elevator or stabilizer until approaching wings level. The pilot should also extend the speed brakes as needed.

High Bank Angles

If the airplane is not in "zero-angle-of-bank" flight, lift created by the wings is not being fully applied against gravity, and more than 1 g is required for level flight. At bank angles greater than 67°, level flight cannot be maintained within AFM load factor limits. In high bank angle increasing airspeed situations, the primary objective is to maneuver the lift of the airplane to directly oppose the force of gravity by rolling in the shortest direction to wings level. Applying nose-up elevator at bank angles above 60° causes no appreciable change in pitch attitude and may exceed normal structure load limits as well as the wing angle of attack for stall. The closer the lift vector is to vertical (wings level), the more effective the applied g is in recovering the airplane.

A smooth application of up to full lateral control should provide enough roll control power to establish a very positive recovery roll rate. If full roll control application is not satisfactory, it may even be necessary to apply some rudder in the direction of the desired roll.

Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control or structural failure.

The Sriwijaya Air version of the Boeing 737 Quick Reference Handbook (QRH), page MAN.1.7, described the upset recovery procedure as follows:

Historically, an upset has been defined as unintentionally exceeding any one or more of the following conditions:

- *pitch attitude greater than 25° nose up*
- *pitch attitude greater than 10° nose down*
- *bank angle greater than 45°*
- *less than the above parameters but flying at an airspeed inappropriate for the conditions.*

An upset condition is now considered any time an airplane is diverting from the intended airplane state. An airplane upset can involve pitch or roll angle deviations as well as inappropriate airspeeds for the conditions.

The following actions represent a logical progression for recovering the airplane. The sequence of actions is for guidance only and represents a series of options to be considered and used dependent on the situation. Not all actions may be needed once recovery is under way. If needed, use minimal pitch trim during initial recovery. Consider careful use of rudder to aid roll control only if roll control is ineffective and the airplane is not stalled.

These actions assume that the airplane is not stalled. A stall condition can exist at any attitude and can be recognized by one or more of the following:

- *Stick shaker*
- *Buffet that can be heavy at times*
- *Lack of pitch authority*
- *Lack of roll control*
- *Inability to stop a descent.*

If the airplane is stalled, first recover from the stall by applying and maintaining nose down elevator until stall recovery is complete and stick shaker stops.

…

Nose Low Recovery

Pilot Flying	***Pilot Monitoring***
Recognize and confirm the developing situation	
• *Disengage autopilot* • *Disengage autothrottle* *Recover:* • *Recover from stall, if needed* • *Roll in the shortest direction to wings level. If bank angle is more than 90 degrees, unload and roll. ** *Complete the recovery:* • *Apply nose up elevator* • *Apply nose up trim, if needed ** • *Adjust thrust and drag, if needed.*	• *Call out attitude, airspeed and altitude throughout the recovery* • *Verify all needed actions have been done and call out any continued deviation.*

WARNING: * Excessive use of pitch trim or rudder can aggravate an upset, result in loss of control, or result in high structural loads.

1.17.1.6 Upset Recovery Training

Sriwijaya Air Operations Training Manual (OTM), subchapter 4.3, described that the upset recovery training is included as part of the mandatory training program along with three other trainings (windshear, ALAR/CFIT and TCAS). The required recurrency for the upset recovery training is every 24 months.

The OTM described in details training program for the mandatory training including the details program and guidelines to conduct the training except the training for upset recovery.

The OTM subchapter 4.13, described that upset recovery maneuver is one of the training modules that is conducted during proficiency check. The proficiency check is described as follows:

> *Sriwijaya Air may not use any person nor may any person serve as a required pilot unless that person has satisfactorily completed a proficiency check in approved airplane simulator within the preceding 6 calendar months in which he satisfactorily performs the duties and responsibilities, and must be carried out in that type of aircraft he is to fly.*
>
> *Pilot proficiency check is renewed within the last 60 days of its validity period, such check is deemed to have taken place on the last day of the validity period.*

In the OTM subchapter 4.13.3, the curriculum of the proficiency check is as follows:

CURRICULUM SEGMENT	*DELIVERY METHODS*	*FACILITY*	*DURATION*	*DAYS*
FLIGHT TRAINING				
Pilot Proficiency Check	*Check Ride*	*FFS**	*1 Session*	*1*

*FFS: full flight simulator

Sriwijaya Air has developed Training Aid document for upset recovery training. The document described the training preparation guidelines for aircraft upset recovery in a variety of situations, including recovering an aircraft in a nose low situation.

UPSET RECOVERY		
PF	**PM**	**REMARKS**
Recognize and confirm the situation		
NOSE LOW RECOVERY		
	▶ Call **"UPSET BROWN"** ▶ Inform ATC: **"MAY DAY 3X, SJY___UPSET"**	**Note:** The term Nose Low is replaced by **"Upset Brown"**
▶ Disconnect autopilot and autothrottle ▶ Recover from stall, if required ▶ * Roll in shortest direction to wings level (unload and roll if bank angle is more than 90 degrees) ▶ Recover to level flight: ✓ Apply nose up elevator ✓ *Apply nose up trim, if required ▶ Adjust thrust and drag as required (Thrust Lever and/or speedbrakes)	▶ Call out attitude, airspeed and altitude throughout the recovery ✓ Verify all required actions have been completed and call out any omissions.	If captured into High Speed Stall; keep stick shaker until reaching horizon and keep pitch at horizon **WARNING:** * Excessive use of pitch trim or rudder may aggravate an upset situation or may result in loss of control and/or high structural loads.
Complete the recovery		
▶ When approaching the horizon, roll to wings level ▶ Check airspeed and adjust thrust ▶ Establish pitch attitude.		
When Upset is recovered check MSA		
▶ Return to initial altitude or MSA as required	▶ Call " **MSA IS ___ FEET".** ▶ Inform ATC: **"SJ___REQUEST MAINTAIN/CLIMB/DESCEND TO FL___/___FEET".**	
▶ Call **"SET MCP ALTITUDE"** ▶ Call **"CYCLE FLIGHT DIRECTOR "** ▶ Engaged A/P and A/T, reset speed.	▶ Cycle flight director	
Post recovery		
▶ **Assess:** ✓ Aircraft condition ✓ crew and passenger condition ▶ **Make a decision and inform:** ✓ ATC ✓ Cabin crew ✓ Passengers ✓ Company		

Figure 23: Training preparation guideline for upset recovery – nose low

The training preparation guideline for upset recovery described that the term Nose Low is replaced by UPSET BROWN and followed by requirement to inform ATC "May Day 3x, SJY___Upset". The Sriwijaya Air did not ask for a NTO (No Technical Objection) from the aircraft manufacturer nor was the DGCA consulted for this modification.

1.17.1.7 Upset Recovery Training Observation

The investigation team observed a demonstration of Sriwijaya upset recovery training during pilot recurrent training that was conducted after the accident. The observation found that the pilots implemented the additional task to call UPSET BROWN (for nose low condition) or UPSET BLUE (for nose up condition) and followed by requirement to inform ATC "May Day 3x, SJY___Upset".

In the upset recovery exercises observed, the aircraft entered an overspeed situation and subsequently, entered an accelerated stall. The additional tasks impeded the PM from communicating the aircraft state, including attitude, airspeed, altitude, or other deviations during the recovery, or assisting the PF in the recovery process to the PF, such as verifying all needed actions had been performed.

The detail of the observation result is available in appendices 6.3.

1.17.1.8 Safety Management System

Sriwijaya Air Quality, Safety, and Security (QSS) Directorate is led by the Director of Quality, Safety, & Security and assisted by the Vice President (VP) of Quality & Safety and VP Security. The VP Quality & Safety is responsible to manage the implementation of company quality and Safety Management System (SMS) including Quality & Safety Internal Audit.

Sriwijaya Air SMS utilizes reactive, proactive, and predictive approaches for safety data collection as stated in the SMS manual. The safety management process includes, but not limited to safety reporting system and flight data monitoring program for identifying operational exceedances and confirming normal operating procedures.

Hazard Report

Sriwijaya Air SMS Manual Chapter 3.6 "Safety Reporting System" described the process of safety reporting system below:

> *Sriwijaya Air is having an operational safety reporting system that is implemented throughout the organization in a manner that:*
>
> *1. Encourages and facilitates personnel to submit reports that identify safety hazards, expose safety deficiencies and raise safety concerns;*
>
> *2. Ensures mandatory reporting in accordance with applicable regulations*
>
> *3. Includes analysis and management action as necessary to address safety issues identified through the reporting system.*
>
> *Sriwijaya Air Safety management systems involve the reactive, proactive and predictive identification of safety hazards. Reporting systems is not just restricted to incidents but include provision for the reporting of hazards, i.e. unsafe conditions that have not yet caused an incident.*

Sriwijaya Air maintains a "Just culture" non-punitive reporting policy and encourages the utilization of the reporting system for the purpose for which it is intended. To identify and reduce the hazards associated within the aviation industry. It is everyone's responsibility to report hazards, occurrences, or incidents that may become an accident.

Safety reporting system will facilitate and encourages the reporting of hazards, deficiencies and safety concerns from personnel at all levels of the organization. Sriwijaya Air recognize that an acknowledgement for each report is essential to build and maintain confidence in the process and encourage more reporting from all personnel within the company.

All personnel may report any hazard that has the potential to cause damage or injury or that threatens the organizations viability. Hazards and incidents should be reported if it is believed that something can be done to improve safety, other aviation personnel could learn from the report, the system and its inherent defenses did not work "as advertised".

Formal means of safety reporting as a safety data collecting system in Sriwijaya Air include:

1. *Mandatory Reporting System*

   Mandatory reporting system shall facilitate the reporting of events or conditions mandated by the authority, customers, service providers and subcontractor as appropriate if required. Occurrence which may represent a significant risk to aviation safety as listed in CASR 19 Appendix B "List Classifying Occurrence in Civil Aviation To Be Mandatorily Reported".

2. *Voluntary Reporting System*

   The objective of the Sriwijaya Air Voluntary Reporting System is to enhance aviation safety through the collection of reports on actual or potential safety deficiencies that would otherwise not be reported through other channels. Such reports may involve occurrences, hazards or threats relevant to aviation safety.

   Voluntary Reporting Systems shall conform to the Non-Punitive Reporting Policy, unless the action is resulted from illegal activity, willful misconduct or against company code of conduct.

   The objective Voluntary Reporting System is to encourage all personnel and company service provider employees to voluntarily report safety information that may be critical to identifying potential precursors to accidents and incidents. Identifying these precursors helps to prevent accidents and incidents, and is a critical element of the Company Accident and Incident Prevention Program.

   The report may be submitted on DGCA Form No. 830-02 "Voluntary Occurrence Report" that can be downloaded from the https://imsis-djpu.dephub.go.id/hubud/web/ and Company Reporting System – Sriwijaya Air Safety Management System (SSMS).

3. *Confidential Reporting System*

   Confidential reporting systems aim to protect the identity of the reporter. This is one way of ensuring that voluntary reporting systems are non-punitive. Confidentiality is usually achieved by de-identification, often by not recording any identifying information of the occurrence. One such system returns to the user the identifying part of the reporting form, and no record is kept of these details.

   Confidential incident reporting systems facilitate the disclosure of human errors, without fear of retribution or embarrassment, and enable others to learn from previous mistakes.

   Confidential report using safety / hazard report form, the differences are the reporter giving tick "" of "X" on right the upper corner of safety / hazard report form.

   Sriwijaya Air is having a confidential safety reporting system that is implemented throughout the organization in a manner that encourages and facilitates the reporting of events, hazards and/or concerns which resulting from or associated with human performance in operations.

SMS Manual Subchapter 3.6.5 "Reportable Events" describe the event that required to be reported such as accident, serious incident, incident, service difficulty reports, flight occurrences, ground accident and hazard observation.

The detail description of accident, serious incident, incident, service difficulty reports, flight occurrences, ground accident including definition, criteria and/or sample of the events were described on that subchapter. The detail description or criteria related to the hazard observation shall be reported was not described in the SMS manual.

The investigation reviewed samples of recorded hazard report from the hazard reporting system. In 2020, the QSS Department received 565 hazard reports consisted of 18 reports submitted by flight attendant, 243 reported by ground personnel, 39 reported by pilot, 13 reported by maintenance personnel, 5 reported by management personnel and 247 reported by security.

Safety Performance Monitoring and Measurement:

Sriwijaya Air Safety Management System Manual Section 3.1 Safety Performance Monitoring and Measurement stated:

Safety performance monitoring and measurement is a means of evaluating the effectiveness of Sriwijaya Air in preventing accidents and incidents, also maintaining compliance with regulations and other requirements relevant to the operational safety.

Safety performance is monitored continuously by QSS Directorate utilizing the collation of data and analysis sourced from the Occurrence Reporting System, Incident Investigation, Safety Surveillance/Inspection, and Flight Data Analysis Program. This data is published, distributed and reviewed at the Sriwijaya Air SRB[17] *meeting. Actions arising from this SRB are allocated to parties who are responsible for their close-out.*

17 SRB is Safety Review Board.

To verify the safety performance and validate the effectiveness of safety risk controls requires the use of a combination of internal audits and the establishment and monitoring of Safety Performance Indicators (SPI). Assessing the effectiveness of the safety risk controls is important as their application does not always achieve the results intended.

The safety performance of Sriwijaya Air shall be verified in reference to the safety performance indicators and safety targets of the SMS. Information sources for Sriwijaya Air safety performance monitoring and measurement include.

a. Safety Reporting;

b. Safety Audits;

c. Safety Surveys;

d. Safety Reviews;

e. Safety Studies; and

f. Internal Safety Investigations.

Lagging and leading indicators are used to classify Sriwijaya SPIs18.

Leading SPIs measure processes and inputs being implemented to improve or maintain safety. These are also known as "activity or process SPIs" as they monitor and measure conditions that have the potential to become or to contribute to a specific outcome. Leading SPIs may also inform the organization about how their operation copes with change, including changes in its operating environment. The focus will be either on anticipating weaknesses and vulnerabilities as a result of the change or monitoring the performance after a change.

Lagging SPIs help the organization understand what has happened in the past and are useful for long-term trending. They can be used as a high-level indicator or as an indication of specific occurrence types or locations, because lagging SPIs measure safety outcomes, they can measure the effectiveness of safety mitigations. They are effective at validating the overall safety performance of the system. Lagging SPIs measure events that have already occurred. They are also referred to as "outcome-based SPIs" and are normally (but not always) the negative outcomes the organization is aiming to avoid.

Safety Performance Indicator are generally data based expressions occurrence of some events, incidents or reports. The indicator(s) chose should correspond to the relevant safety goals and defined during Safety Review Board (SRB). Detail procedure regarding Safety performance indicators will be describe on SJ-QP-DV-020 – Safety Performance Monitoring and measurements.

18 SPI is Safety Performance Indicator.

Hazard Identification Risk Analysis (HIRA)

Sriwijaya Air QSS Directorate conducted and issued a Hazard Identification Risk Analysis (HIRA) report number-20191108-036, on 8 November 2019, regarding the Company Contingency Plan during termination of a joint management with another aircraft operator and approved maintenance organization. There were 9 hazards identified with risk index 4B which were unacceptable under the existing circumstances, and one hazard with risk index 3B which was acceptable based on risk mitigation. The document including the risk analysis and mitigations that required to be completed by responsible departments as stated in the HIRA report. The investigation was unable to find the further risk management to ensure the hazards were effectively controlled and not created any new hazards.

The detailed HIRA report is available on the appendices 6.4 of this report.

Sriwijaya Air defined the acceptability criteria of risk acceptable/mitigation control as stated on the SMS manual chapter 2.2.7 based on risk index matrix of likelihood and severity or potential consequences of the projected risk. The detail of the risk acceptable/mitigation and control was as follows:

2.2.7 RISK ACCEPTABLE / MITIGATION & CONTROL

Where risk is concerned, there is no such thing as absolute safety. Risks have to be managed to a level "as low as reasonably practicable" (ALARP). This means that the risk must be balanced against the time, cost and difficulty of taking measures to reduce or eliminate the risk

TOLERABILITY DESCRIPTION	ASSESSED RISK INDEX	SUGGESTED CRITERIA	DESCRIPTION
INTOLERABLE REGION	5A, 5B, 5C 4A, 4B, 3A	Unacceptable under the existing circumstances	HIGH RISK
TOLERABLE REGION	5D, 5E, 4C, 4D 4E, 3B, 3C, 3D 2A, 2B, 2C, 1A	Acceptable based on risk mitigation. It may require management decision.	MODERATE RISK
ACCEPTABLE REGION	3E, 2D, 2E, 1B, 1C,1D, 1E	Acceptable	LOW RISK

Recommended Action:

***High risk**:* *Cease or cut back operation promptly if necessary. Perform priority risk mitigation to ensure that additional or enhanced preventive controls are put in place to bring down the risk index to the moderate or low range.*
***STOP: UNACCEPTABLE** under the existing circumstances. DO NOT PERMIT any operation until sufficient control measures have been implemented to reduce risk to an acceptable level*

***Moderate Risk**:* *Schedule performance of a safety assessment to bring down the risk index to the low range if viable.*
*Management attention and approval of risk control / mitigation actions required. **ACCEPTABLE** after review of operation.*

***Low Risk**:* ***ACCEPTABLE** as is. No further risk mitigation required.*

Following the mitigation of an identified hazard and reducing its risk level to the tolerable region, continual monitoring and review must be conducted as required by the SMS Manual chapter 2.5 to ensure that the mitigating measure did not create any new hazards:

2.5 MONITOR AND REVIEW DEFENSES

Defences is specific mitigating actions, preventive controls or recovery measures put in place to prevent the realization of a hazard or its escalation into an undesirable consequence. When any change is made, further risk management must be carried out to ensure the hazard is effectively controlled and the defense has not, in itself, created any new hazards.

The SMS record management described in the SMS Manual chapter 3.5 as follows:

3.5 SMS RECORD MANAGEMENT

The method of storing all SMS-related records and documents, Sriwijaya Air conducts recording by soft and hard copy. This method used to maintain and analyze hazards if any. Many kind of Safety Management System Record as result of hazard identification and hazards as mitigation.

The other objective in the safety management system are:

1. *To collect and record safety information through various sources of hazard identification, and process into meaningful conclusions that can be reached only through analysis of that information, statistical measurement as a basis for continuous improvement.*
2. *To establich safety databases and reporting systems, that can be analyzed to determine any safety actions required.*
3. *The record retentions of those all database are decided two years.*

3.5.1 RECORDING SYSTEM

Sriwijaya Air has the recording system to ensures the generation and retention of all records necessary to document and support the SMS, such as:

1. *Identifying what is relevant;*
2. *Collecting current and applicable information;*
3. *A procedure for receiving and actioning reports;*
4. *A reliable method of accurately recording, storing, retrieving and maintaining safety reports*
5. *A procedure for distributing relevant /appropriate information to staff/ contractors);*
6. *Able to be audited.*

The records management for safety management system (SMS) records, the organization shall establish and maintain procedures for their: identification; maintenance; and disposition.

The records management for (SMS) shall be: legible; identifiable; and traceable to the activity involved. The records management for Safety Management System shall be maintained in such a way that they are:-readily retrievable; and protected against: damage, deterioration, or loss.

Flight Data Analysis Program

The QSS Directorate has established Flight Data Analysis Program (FDAP) since June 2011 which had the capability to download and analyze the flight data from the most of Sriwijaya Air aircraft fleet (28 aircraft in total).

Before the joint management program with another aircraft operator and approved maintenance organization, the flight recorder data download was conducted by the engineers from Sriwijaya Air. During the joint management program, the responsibility to retrieve flight recorder data was transferred to another approved maintenance organization since October 2018. After the termination of the joint management in December 2019, Sriwijaya Air resumed the responsibility of retrieving the flight recorder data for its FDAP.

The Sriwijaya Air FDAP utilized the flight data by the means of Quick Access Recorder (QAR), or Solid-State Flight Data Recorder (SSFDR) depend on the available system on the aircraft. The download was conducted periodically to monitor the safety performance.

The following is the table of percentage flight data retrieved by FDAP between 2018 and 2020.

	Data retrieval (%)		
	2018	**2019**	**2020**
January	25.3	49	24
February	6.6	21	46
March	11.8	23	36
April	20.3	6	54.8
May	24.2	36	13
June	34.8	25	27
July	36.5	40	36
August	23.2	40	28
September	30.5	41	41
October	21.9	0	36
November	33.9	0	35
December	33.6	0	52

The FDAP did not involve the PK-CLC aircraft since the QSS directorate did not have the correct aircraft data frames which was required to define the value of each recorded parameters to be analyzed by the flight data analysis software. The flight recorder data of PK-CLC were downloaded but the analysis could not be performed.

The FDAP monitors several safety events including condition of excessive bank angle. The excessive bank angle event for very high altitude would be triggered when the aircraft roll angle more than 31° at altitude greater than 1,000 feet above runway elevation and the flight phase was from climb to go-around.

Thrust asymmetric condition was also monitored by the FDAP for flight phases of approach or engine thrust reverse application. The triggering condition was the difference in the N1 speeds of left and right engines for more than 10% RPM.

1.17.1.9 Maintenance Management

The aircraft maintenance of the Sriwijaya Air fleet is organized under the technical directorate which led by Technical Director as described in the Company Maintenance Manual (CMM) document number SJ-QM-DT-01.

The technical directorate consist of Aircraft Maintenance department, Aircraft Technical Services department and Quality Maintenance department. The organization structure of the technical directorate is shown in the figure below.The technical directorate was eligible to conduct the aircraft maintenance as described in the Authorization, Conditions and Limitation (ACL) of Air Operator Certificate (AOC) number 121-035 document. On part D71 of the ACL document, the Sriwijaya Air eligible to conduct the aircraft maintenance includes the airframe, aircraft engines, appliances, and parts, including minor modification and unscheduled repair, engines, and its component. The heavy maintenance performance such as A Check or phase A and higher was subcontracted to the Approved Maintenance Organization (AMO).

The maintenance operation including the line and base maintenance activities were conducted by the Aircraft Maintenance department which led by the General Manager (GM) Aircraft Maintenance.

The Aircraft Maintenance department consists of Maintenance Operation department, Maintenance Control Center (MCC) department and Material Management department. The detail description in regard the aircraft maintenance is described in the Aircraft Maintenance Procedure (AMP) document number of SJ-QP-DT-02.

The Sriwijaya Air operation covers several cities in Indonesia. To provide the aircraft maintenance services, maintenance staffs were positioned at different stations throughout the Sriwijaya Air operation area. The table below shows the engineer distribution and their qualification.

	A/P	**E/A**	**Mechanic**	**Cabin**	**Repair**	**MCC**
Jakarta (CGK)	19	3	14	8	1	9
Ujung Pandang (UPG)	8	0	2	0	0	0
Surabaya (SUB)	3	1	0	0	0	0
Yogyakarta (YIA)	2	0	0	0	0	0
Balikpapan (BPN)	1	0	1	0	0	0
Pontianak (PNK)	1	0	0	0	0	0
Tanjung Pandan (TJQ)	1	0	0	0	0	0
Ternate (TTE)	1	0	0	0	0	0
Biak (BIK)	0	0	1	0	0	0
Jayapura (DJJ)	1	0	0	0	0	0
TOTAL	37	4	18	8	1	9

Note:

A/P : The engineer with qualification of Airframe and Powerplant

E/A : The engineer with qualification of Electronic and Avionic

Mechanic : The personnel who has no qualification of A/P or E/A

Cabin : The cabin maintenance engineer

Repair : The repairman

MCC : Maintenance Control Center department personnel including 1 (one) trouble shooter who has the qualification of A/P

The Sriwijaya Air fleet technical services are provided by the Aircraft Technical Services department which was led by the GM Aircraft Technical Services. The Aircraft Technical Service department consists of Fleet Planning & Control department, Engineering Service department and Maintenance Planning department. The Engineering Service department is also responsible to conduct the personnel training control and management. The detail description of the technical service of the Sriwijaya Air fleet is described in the Technical Services Procedure Manual (TSPM).

The quality system of the Sriwijaya Air fleet managed was by the Quality Maintenance department which was led by the GM Quality Maintenance. The Quality Maintenance department consists of the Quality Standard & Airworthiness Certification department and Quality Audit & Control department. The overall maintenance oversight is conducted by the Quality Audit and Control department. The detail description of the quality system is described in the Quality Procedure Manual (QPM).

The investigation noted inconsistencies in manual controls and updates such as for example the title position of the GM Aircraft Maintenance and its subordinates in the CMM was different with those title positions as described in the AMP.

Management of Repetitive Defect and Deferred Maintenance Item (DMI)

The aircraft defect that was reported by the pilot is recorded in the Aircraft Maintenance Log (AML). According to the Sriwijaya Air Aircraft Procedure Manual (APM) chapter 2.3, the rectification of the aircraft defect must include the AMM reference in the AML.

Referring to the TSPM, the Maintenance Planning department is responsible to handle the archiving of the AML as described in the chapter 17.3 as follow:

TECHNICAL RECORD

17.3 PROCEDURE

F. The Technical Records section will make digitally available for pilot reports, and necessary information required by other Departments for evaluation or investigation.

17.3.2 UPDATING TECHNICAL RECORD

B. The pilot reports, and all necessary information listed in Aircraft Maintenance Logbook should be digitally entered on daily basis to ensure that the critical information is captured and readily available.

The repetitive defect definition is mentioned in the CMM, chapter 3.2.6 which was described as follow:

3.2.6 CONTROL OF REPETITIVE DEFFECT

The repetitive defect are technical problem of the system which occurs three times on the same aircraft during any 15-flight segment or less of operation be identified as a "repetitive defect'', and a positive plan of corrective action be pursued to preclude further reoccurrence.

The MCC department is responsible to handle the repetitive defect. The detail of repetitive handling which performed by the MCC department is described in the AMP in the chapter 3.3.6 as follow:

3.3.6 CONTROL OF REPETITIVE DEFECT

1. *One or more MCC personnel are assigned to serve as repeat analysis. The after are responsible for maintaining an oversight over discrepancies, reported on operating airplanes and identifying repeat program, reviewing and follow-up to determine the effectiveness of the rectification program.*
2. *The Sriwijaya Air Repetitive Defect Control System is designed to identify and correct any discrepancies that recur three times on the same aircraft during any 15-flight segment or less of operation be identified as a "repetitive defect'', and a positive plan of corrective action be pursued to preclude further recurrence.*
3. *The MCC & Engineering therefore continuously reviews maintenance records of the previous 5 (five) days. The review include:*
   a. *Corrected and redirected pilot and ground write-ups from the computer databases for Boeing 737 aircrafts;*
   b. *Deferred maintenance Items recorded and tracked by MCC;*
   c. *Daily activity logs recorded by MCC; the logs are records of discrepancies reported by flight crew and line stations*
   d. *Daily maintenance activities at home base and outstations.*
4. *When an item has been identified as a repetitive defect the Engineer coordinates its rectification:*
   a. *If the repetitive defect can be rectified during line maintenance at the home base line station or at an out-station, the Engineering coordinates the rectification with the Maintenance Controller on duty.*
   b. *If the repetitive defect can only be rectified during home base hangar maintenance, the Engineer will coordinate rectification with Engineering.*
5. *All items identified as repetitive defect are brought to the attention of the S.M Maintenance Planning, S.M Aircraft Maintenance Operation and S.M Quality Maintenance, on a daily basis*
6. *The Maintenance Support a log of all identified repeat discrepancies for tracking and follow-up purposes.*

The investigation noted that the involvement of the Engineering department to handle the repetitive defect was not defined in the Technical Services Procedure Manual (TSPM).

The handling of the repetitive defect as described in the in the AMP in the chapter 3.3.6 point 3, involving the review of the Deferred Maintenance Item (DMI) of the respective aircraft having the problem. The Quality Procedure Manual (QPM) defined the arrangement of the DMI as follow:

5.5 DEFERRED MAINTENANCE ITEM

5.5.1 GENERAL

In order to maintain flight schedule integrity, it occasionally becomes necessary to defer the rectification of minor discrepancies to a more convenience time. Deferral shall be permitted under controlled conditions defined in the MEL (Minimum Equipment List, Operation Procedures, Maintenance Procedure and Configuration Deviation List).

The purpose of Deferred Maintenance Procedures is to control deferred discrepancy rectification, to avoid deferred discrepancy overdue according to MEL Repair Interval.

The Deferred Maintenance Procedures is documented with the use of:

- *a. The Deferral Maintenance Item (DMI) Control Sheet Form (TP-005R1), which is used by Maintenance Control to defer a discrepancy and to assign them to maintenance for corrective action.*
- *b. The DMI List Extension Monthly Report (TP-005R1), which is used by Maintenance Control to report status of deferred items and extension due.*
- *c. The DMI List Extension Application (TP-005R1), which is use by Maintenance Control to request approval to Quality Maintenance for extending repair interval of the DMI.*

The Maintenance Control has the authority to defer an item, which meet one or more of the following criteria:

- *a. The malfunction system or component is specially addressed in the Minimum Equipment List (MEL) or Configuration Deviation List (CDL).*
- *b. The limitations for continued safe for operation with the inoperative item are provided in the MEL.*
- *c. The item is of a non-airworthy nature. Non-airworthiness items do not affect the continued for safe operation of an airplane, and may therefore be deferred until the next maintenance opportunity.*

If the item does not meet the above criteria, the Quality Maintenance must be contacted for deferral authority.

As the follow up of the DMI which described in the QPM, the management of the DMI was managed by the MCC as described in the AMP in the chapter 3.7 as follow:

3.7 DEFERRED MAINTENANCE ITEM MANAGEMENT

Deferred Maintenance Item (DMI) is outlining any discrepancy found by Cockpit Crew and as reference to the MEL/CDL item will be deferred with repair interval duration requirement on the MEL/CDL to any station where the resources can be arranged to solve the problem.

1. *Source of DMI's:*
   a. *Deferred items are reported aircraft discrepancies that have not been corrected and are being controlled by Technical section using MCC as a focal point. Only items that do not affect safety or airworthiness may be deferred, except as provided for in the MEL/CDL or Maintenance Manual.*
   b. *Deferrals are authorized when operational and other constraints back of downtime, spares, manpower, facilities and equipment, etc.*
   c. *For Items of an airworthy nature and beyond MEL/CDL limits, MCC must obtain Quality Maintenance concurrence prior to authorizing deferral.*
   d. *If any Repetitive Defects occurred during operational which are deferrable & permissible as per MEL or CDL*
2. *DMI Procedures:*
   a. *AML is used for all maintenance action performed on the aircraft (defect & its rectification)*
   b. *DMI Log is used to defer the defect and repetitive defect accordance the approved MEL or CDL.*
   c. *All performance limitation of deferred defect must be stated in the technical log and clearly informed to flight crew (altitude, runway, fuel uplift, etc.)*
   d. *The Deferred Maintenance Items sheet need to be reviewed, record and keep in the folder as record. The DMI log as per instruction procedure in the Form Manual, TP-003.*
   e. *The DMI based on Minimum Equipment List (MEL) and the Configuration Deviation List (CDL) for the Boeing 737 aircrafts type need to be recorded and monitored using DMI Control / Summary.*
   f. *Practice re-rack/re-position, connector cleaning, etc. are allow at aircraft transit only, when facing time constrain to OTP and defects are deferrable as per MEL or CDL, defer procedure should applied.*
   g. *Before DMI rised Engineer must be performed trouble shoot as soon as practicable. Progress trouble shooting on DMI should be performed at every aircraft overnight stop or maintenance day as per applicable reference manual, and must be transferred to AML as well as record and report to MCC.*
   h. *Clearing DMI must be transferred back to AML for certification purposes.*

i. DMI defect caused troubleshooting should be defined within 3 days since raised for giving time of supporting unit to provide the need.

j. In case of insufficient time within 3 days, LM/MCC on duty inform to Manager MCC for further arrangement & coordination within S.M. Maintenance Control.

k. Please DO NOT troubleshoot any system unless having a clear understanding and its operation

l. Please DO NOT to swap any units between the pneumatic systems.

Should the repetitive defect or the DMI required the trouble shooting, the MCC is responsible to assign the trouble shooter as described in the AMP in the chapter 3.2.4 as follow:

3.2.4 TROUBLE SHOOTER

The Trouble Shooter reports to Manager of Maintenance support to implement Maintenance Control Center functions covered / included: operational and maintenance in daily basis.

a. Report to Manager of Maintenance Support or the person as delegation for that purpose.

c. Aircraft system troubleshooting coordination and advise to the Line Maintenance.

d. Production tracking to ensure availability of aircraft for daily operations.

*e. Technical Delay and AOG (*Aircraft on Ground) *coordination and also reporting it.*

f. Deferred Maintenance Item and repetitive defect monitoring, coordination in terms of spares, equipment, tooling, special test equipment, manpower, time, operational limitation and generate Maintenance support job order.

g. Aircraft system troubleshooting coordination and advise to the Line Maintenance.

h. Collect supporting data for reports related to Technical Delay, Service Difficulties Report (SDR), Daily and Weekly DMI records and monitoring.

i. Close Liaison with Material Management on spares required for line maintenance Main Base and Outstations operations.

j. Assist Material Management in filing warranty claims and reports.

k. Help prepare trouble shooting chronology for submitting DMI Extension requests to the SJ Quality Maintenance.

1. Ensure shift turn over report changes are carried out to prevent lack of communication between shifts.

l. Any other duties as assigned by Manager of Maintenance Support or his delegates.

Reliability Control Program

As part of the compliment of the Civil Aviation Safety Regulation (CASR) part 121.367 about the Maintenance Program, Sriwijaya Air utilized the Reliability Control Program (RCP) as part of the maintenance performance monitoring.

The reliability monitoring is described in the CMM chapter 12.2 as follow:

12.2 MONITOR MECHANICAL PERFORMANCE FUNCTION

This function must provide for collecting and analyzing operational data. The intent here is to identify deficiencies that require corrective action. This monitoring is done through emergency response, day-today monitoring, and long term monitoring.

1. *EMERGENCY RESPONDING*

   Emergency responding includes identifying emergency/critical situations, determining causes, and formulating a plan to ensure that similar conditions do not exist in like equipment. Emergency/critical situations include:

   a) In-flight engine shutdowns;

   b) Critical structural failures; and

   c) Any life-limited part failure.

2. *DAY TO DAY MONITORING*

   Sriwijaya Air conduct daily maintenance operational meetings to discuss morning launch delays and activities of the previous day. Daily maintenance operational meetings discussed include:

   a. *Daily mechanical problems of each aircraft;*
   b. *Non-availability of spare parts;*
   c. *Inadequate manpower to perform maintenance;*
   d. *Deferred maintenance items and time;*
   e. *Safety-related failures;*
   f. *Repetitive defect;*
   g. *Maintenance delays/cancellations;*
   h. *Scheduled inspection results, including sufficient time to complete the check, unusual/critical findings, recurring problems, and parts/equipment/manpower availability.*
   i. *Mechanical Interruption Summary Report (MIRS).*

3. *LONG TERM MONITORING*

   This system should include charting or some appropriate means of reporting and accounting operational data at specified intervals to reveal trend-related information.

   Operational data used by Sriwijaya Air to monitor mechanical performance are:

   a. *Pilot reports compiled*
   b. *Component replacement rate;*
   c. *Engine & APU unscheduled removal rate;*
   d. *Service Difficulty Reports (SDR).*

Emergency Responding & Long Term Monitoring as a part of maintenance control by reliability method (RCP) and Day to Day Monitoring as a part of maintenance control system section.

Maintenance Personnel Training

The engineer training is managed and controlled by the Engineering Service department in reference to the CMM.

The detail training program is described in the Training Program Manual (TPM) which described the training program for the technical personnel:

1. Initial training

   The initial training consists of Basic Training, Maintenance/Inspection Technical Training, and Specialized Training.

2. Recurrent training

   The recurrent training consists of Human Factors, Safety Management System and Non-Destructive Test (NDT). The recurrent training also applied to the holder of Airframe & Powerplant (A/P) and Electronic & Avionic (E/A) type rating in the Aircraft Maintenance Engineer (AME) license when the holder does not perform the approval and return to service within their privileges on specific aircraft type in preceding 24 months.

3. Remedial training

   The remedial training is to resolve the maintenance personnel who demonstrated lack of knowledge and skill.

   The investigation did not find any information on how such personnel are identified and how the remedial training is performed to resolve the issue.

4. Additional training

   The additional training is the training related to the personnel development that was not covered in the Initial, Recurrent and Remedial training.

   The training schedule was developed annually by the Engineering Service department and will be updated monthly based on the training need that was supplied to the Engineering Service department from another department within the Technical Directorate.

   The training program will be conducted by instructors from within the organization.

The Reliability Report Between January and April 2020

Referring to the Company Maintenance Manual (CMM) chapter 12.4, Sriwijaya Air has implemented the Reliability Control Program (RCP) in compliance to the Civil Aviation Safety Regulation (CASR) Part 121 (121.367).

The implementation of RCP was described in the Reliability Control Program Manual. The Engineering Service department was responsible to issue the RCP.

The RCP is intended to compare the aircraft including its system performance to the established standard for identifying the problems and initiating the corrective actions.

The summary of the RCP on Boeing 737-500 fleet related to the autoflight system as published between January and April 2020 are shown below.

1. In January 2020, there was no report regarding the autoflight.
2. In February 2020, the RCP recorded 18 pilot reports of autoflight defects within the aircraft fleet except for the accident aircraft.
3. In March 2020, the RCP reported 24 pilot reports regarding autoflight. 12 out of 24 pilot reports were from the accident aircraft. Out of these 12 pilot reports on the accident aircraft 2 pilot reports were related to the A/T system and one report was on the slow response of the right engine thrust lever during take-off roll.
4. In April 2020, the RCP reported 4 pilot reports regarding autoflight system. These reports did not involve the accident aircraft as it was grounded for maintenance during that time.

The details of the RCPs issued in March and April 2020 are in the following figure.

Sriwijaya Air

PILOT REPORT FOR MONTH OF MAR 2020
B737 - 500

ATA			SYSTEM	No. Pirep for Month 2020			Rate for Month 2020			3 Mths PIREP 2020	CUMLTV 3 Mths RATE 2020	12 Mths PIREP 2020	CUMLTV 12 Mths RATE 2020	UPPER ALERT LEVEL	RED ALERT 2020	TREND 2020
				JAN	FEB	MAR	JAN	FEB	MAR	MAR	MAR	MAR	MAR		MAR	MAR
21	00	2100	Air Conditioning and Pressurization	3	2	10	6.9	4.1	18.4	15	10.2	107	12.5	41.0		
22	00	2200	Auto Flight	0	18	24	0.0	37.0	44.2	42	28.6	101	11.8	32.9	RED-2	UP
23	00	2300	Communications	6	2	4	13.7	4.1	7.4	12	8.2	41	4.8	15.7		
24	00	2400	Electrical Power	0	0	1	0.0	0.0	1.8	1	0.7	16	1.9	6.1		
25	00	2500	Equipment/Furnishing	0	0	2	0.0	0.0	3.7	2	1.4	22	2.6	9.5		
26	00	2600	Fire Protection	7	10	11	16.0	20.6	20.3	28	19.1	67	7.9	25.1		
27	00	2700	Flight Controls	10	9	6	22.9	18.5	11.0	25	17.1	72	8.4	16.7		DOWN
28	00	2800	Fuel	0	2	2	0.0	4.1	3.7	4	2.7	10	1.2	4.2		
29	00	2900	Hydraulics	3	0	1	6.9	0.0	1.8	4	2.7	16	1.9	8.5		
30	00	3000	Ice and Rain Protection	16	3	1	36.6	6.2	1.8	20	13.6	37	4.3	9.9		DOWN
31	00	3100	Indicating and Recording Systems	0	0	10	0.0	0.0	18.4	10	6.8	22	2.6	5.3	RED-1	
32	00	3200	Landing Gear	15	21	36	34.3	43.2	66.3	72	49.1	257	30.1	69.5		UP
33	00	3300	Lights - General	16	16	12	36.6	32.9	22.1	44	30.0	133	15.6	40.7		DOWN
34	00	3400	Navigation - General	16	17	34	36.6	35.0	62.6	67	45.7	181	21.2	41.9	RED-1	
35	00	3500	Oxygen	7	8	2	16.0	16.5	3.7	17	11.6	49	5.7	17.1		
36	00	3600	Pneumatic	0	1	1	0.0	2.1	1.8	2	1.4	32	3.8	12.6		
38	00	3800	Water/Waste	0	0	1	0.0	0.0	1.8	1	0.7	2	0.2	2.4		
49	00	4900	Airborne Auxiliary Power	3	3	0	6.9	6.2	0.0	6	4.1	76	8.9	32.9		DOWN
52	00	5200	Doors - General	1	3	1	2.3	6.2	1.8	5	3.4	27	3.2	9.1		
53	00	5300	Fuselage	0	0	0	0.0	0.0	0.0	0	0.0	1	0.1	2.0		
54	00	5400	Nacelles/Pylons	0	0	0	0.0	0.0	0.0	0	0.0	7	0.8	4.6		
55	00	5500	Stabilizers	0	0	0	0.0	0.0	0.0	0	0.0	0	0.0	0.0		
56	00	5600	Windows	0	1	1	0.0	2.1	1.8	2	1.4	7	0.8	4.2		
57	00	5700	Wings	0	0	0	0.0	0.0	0.0	0	0.0	2	0.2	1.3		
71	00	7100	Power Plant	0	0	3	0.0	0.0	5.5	3	2.0	11	1.3	7.5		
72	00	7200	Engine	0	0	0	0.0	0.0	0.0	0	0.0	4	0.5	2.8		
73	00	7300	Fuel/Control	0	1	4	0.0	2.1	7.4	5	3.4	26	3.0	12.1		UP
74	00	7400	Ignition	1	2	0	2.3	4.1	0.0	3	2.0	10	1.2	6.1		
75	00	7500	Air	0	0	0	0.0	0.0	0.0	0	0.0	1	0.1	0.7		
76	00	7600	Engine Controls	0	0	0	0.0	0.0	0.0	0	0.0	0	0.0	17.2		
77	00	7700	Engine Indicating	5	0	2	11.4	0.0	3.7	7	4.8	46	5.4	18.9		
78	00	7800	Exhaust	0	1	0	0.0	2.1	0.0	1	0.7	10	1.2	7.5		
79	00	7900	Engine Oil	1	0	0	2.3	0.0	0.0	1	0.7	12	1.4	10.5		
80	00	8000	Engine Starting	0	1	0	0.0	2.1	0.0	1	0.7	15	1.8	10.7		

NOTE:
The Alert Level (AL) is based on monthly unschedule removal Rate of last years (Average + (2.5xStd. Dev.))

Figure 24: Reliability Report March 2020

PILOT REPORT FOR MONTH OF APR 2020
B737 - 500

ATA			SYSTEM	No. Pirep for Month			Rate for Month			3 Mths PIREP	CUMLTV 3 Mths RATE	12 Mths PIREP	CUMLTV 12 Mths RATE	UPPER ALERT LEVEL	RED ALERT	TREND
				2020			2020			2020	2020	2020	2020		2020	2020
				FEB	MAR	APR	FEB	MAR	APR	APR	APR	APR	APR		APR	APR
21	00	2100	Air Conditioning and Pressurization	2	10	2	4.1	18.4	8.9	14	11.2	92	11.6	41.0		
22	00	2200	Auto Flight	18	24	4	37.0	44.2	17.8	46	36.7	99	12.5	32.9		
23	00	2300	Communications	2	4	0	4.1	7.4	0.0	6	4.8	38	4.8	15.7		
24	00	2400	Electrical Power	0	1	2	0.0	1.8	8.9	3	2.4	17	2.2	6.1	RED-1	UP
25	00	2500	Equipment/Furnishing	0	2	3	0.0	3.7	13.3	5	4.0	23	2.9	9.5	RED-1	UP
26	00	2600	Fire Protection	10	11	0	20.6	20.3	0.0	21	16.7	61	7.7	25.1		DOWN
27	00	2700	Flight Controls	9	6	4	18.5	11.0	17.8	19	15.2	63	8.0	16.7	RED-1	
28	00	2800	Fuel	2	2	5	4.1	3.7	22.2	9	7.2	14	1.8	4.2	RED-1	
29	00	2900	Hydraulics	0	1	1	0.0	1.8	4.4	2	1.6	16	2.0	8.5		UP
30	00	3000	Ice and Rain Protection	3	1	0	6.2	1.8	0.0	4	3.2	34	4.3	9.9		DOWN
31	00	3100	Indicating and Recording Systems	0	10	0	0.0	18.4	0.0	10	8.0	19	2.4	5.3		
32	00	3200	Landing Gear	21	36	11	43.2	66.3	48.9	68	54.2	249	31.5	69.5		
33	00	3300	Lights - General	16	12	3	32.9	22.1	13.3	31	24.7	121	15.3	40.7		DOWN
34	00	3400	Navigation - General	17	34	5	35.0	62.6	22.2	56	44.7	171	21.6	41.9		
35	00	3500	Oxygen	8	2	0	16.5	3.7	0.0	10	8.0	48	6.1	17.1		DOWN
36	00	3600	Pneumatic	1	1	0	2.1	1.8	0.0	2	1.6	31	3.9	12.6		DOWN
38	00	3800	Water/Waste	0	1	0	0.0	1.8	0.0	1	0.8	2	0.3	2.4		
49	00	4900	Airborne Auxiliary Power	3	0	4	6.2	0.0	17.8	7	5.6	77	9.7	32.9		
52	00	5200	Doors - General	3	1	1	6.2	1.8	4.4	5	4.0	27	3.4	9.1		
53	00	5300	Fuselage	0	0	2	0.0	0.0	8.9	2	1.6	3	0.4	2.0	RED-1	
54	00	5400	Nacelles/Pylons	0	0	0	0.0	0.0	0.0	0	0.0	7	0.9	4.6		
55	00	5500	Stabilizers	0	0	1	0.0	0.0	4.4	1	0.8	1	0.1	0.0	RED-1	
56	00	5600	Windows	1	1	0	2.1	1.8	0.0	2	1.6	7	0.9	4.2		DOWN
57	00	5700	Wings	0	0	0	0.0	0.0	0.0	0	0.0	2	0.3	1.3		
71	00	7100	Power Plant	0	3	0	0.0	5.5	0.0	3	2.4	11	1.4	7.5		
72	00	7200	Engine	0	0	0	0.0	0.0	0.0	0	0.0	3	0.4	2.8		
73	00	7300	Fuel/Control	1	4	1	2.1	7.4	4.4	6	4.8	27	3.4	12.1		
74	00	7400	Ignition	2	0	0	4.1	0.0	0.0	2	1.6	10	1.3	6.1		
75	00	7500	Air	0	0	0	0.0	0.0	0.0	0	0.0	1	0.1	0.7		
76	00	7600	Engine Controls	0	0	0	0.0	0.0	0.0	0	0.0	0	0.0	17.2		
77	00	7700	Engine Indicating	0	2	2	0.0	3.7	8.9	4	3.2	44	5.6	18.9		UP
78	00	7800	Exhaust	1	0	0	2.1	0.0	0.0	1	0.8	6	0.8	7.5		
79	00	7900	Engine Oil	0	0	0	0.0	0.0	0.0	0	0.0	12	1.5	10.5		
80	00	8000	Engine Starting	1	0	0	2.1	0.0	0.0	1	0.8	15	1.9	10.7		

NOTE:
The Alert Level (AL) is based on monthly unschedule removal Rate of last years (Average + (2.5xStd. Dev.))

Figure 25: Reliability Report April 2020

1.17.2 Air Traffic Services Provider

The *Perusahaan Umum Lembaga Penyelenggara Pelayanan Navigasi Penerbangan Indonesia* (AirNav Indonesia) is the ATS provider within Indonesia. The ATS in Jakarta is provided by AirNav Indonesia branch office located at the Jakarta Air Traffic Service Center (JATSC) which held a valid ATS provider certificate. The services provided were aerodrome control, approach control, aeronautical communications, and flight information services.

The approach control services for SJY182 flight were provided by the Terminal East controller utilizing surveillance control (radar service).

1.17.2.1 Procedure of Aircraft Lost Contact

The JATSC Standard Operation Procedure (SOP) for Approach Control Services subchapter 6.2.1 contained guidance in declaring an aircraft, which was suspected or deemed to be in an emergency situation, in the event that the pilot of the aircraft could not be contacted or a loss of communication with the aircraft. The subchapter 6.2.2 described the different states of emergency as follows:

a. Uncertainty Phase (INCERFA)
   i. No information has been received from an aircraft within a period of thirty minutes or since the first attempt to establish communication with such aircraft;
   ii. An aircraft fails or has not arrived within thirty minutes of the estimated time of arrival.

b. Alert Phase (ALERFA)
   i. Subsequent attempts to establish communication with the aircraft and enquiries with other relevant sources have failed to reveal any news of the aircraft;
   ii. Information has been received which indicates that the aircraft has experienced system malfunction, but not to the extent that a forced landing is likely;
   iii. An aircraft is known or believed to be the subject of unlawful interference;
   iv. An aircraft has been cleared to land but fails or have not land within five minutes of the estimated time of landing, and that communication has not been re-established with the aircraft.

c. Distress Phase (DETRESFA)
   i. Further unsuccessful attempts to establish communication with the aircraft and unsuccessful enquiries with other sources point to the probability that the aircraft is in distress;
   ii. The fuel on board is considered to be exhausted, or to be insufficient to enable the aircraft to reach the destination or alternate destination;
   iii. When information is received which indicates that the aircraft has experience system malfunction to the extent that a forced landing is likely;
   iv. Information is received or it is reasonably certain that the aircraft is about to make or has made a forced landing, except when there is reasonable certainty that the aircraft and its occupants are not threatened or in imminent danger and do not require immediate assistance.

The subchapter 6.2.3.2 described the procedures to be followed in handling an emergency:

- Immediately report the situation to the supervisor.
- Obtain from the operator or the flight crew information that may be relevant such as: number of persons on board, amount of fuel remaining, possible presence of hazardous materials and the nature thereof.
- Notify the appropriate ATS units and authorities.
- Inform all aircraft who operate near the emergency aircraft.
- Instruct all other aircraft to fly near the location of emergency aircraft and relay controller instruction if the emergency aircraft is unable to receive the instruction and to monitor the Emergency Locator Beacon-Aircraft (ELBA).

According to the subchapter 6.2.7, the ATS personnel can escalate the emergency phase on receiving information that increase the likelihood of the emergency condition, and coordinate with the Search and Rescue Agency in the escalation of the condition.

1.17.3 Indonesia Directorate General of Civil Aviation (DGCA)

The safety oversight on civil aviation in Indonesia is administered by the Directorate General of Civil Aviation (DGCA) which is part of the Ministry of Transportation. The requirement standards for civil aviation safety in Indonesia are published in the Civil Aviation Safety Regulation (CASR).

The DGCA has several directorates which includes

- the Directorate of Airworthiness and Aircraft Operations (DAAO) that is responsible for formulating policies and standards including the regulatory oversight of the civil aircraft operators; and
- the Directorate of Air Navigation (DAN) that is responsible for formulating policies and standards including the regulatory oversight of the ATS providers and aviation meteorological providers.

1.17.3.1 Indonesia Regulation of Upset Prevention and Recovery Training

The CASR Part 121 subpart 121.404 requires aircraft operators to have several training components which included initial and recurrent for Aircraft Flight Training. The detail content of the “Aircraft Flight Training” component in the CASR Part 121 Appendix C included upset recovery training that may be accomplished in an aircraft or aircraft type simulator.

The CASR Part 121 Appendix C also required recurrent training for the “Aircraft Flight Training” component to be conducted every 12 months.

In 2018, the DGCA published Safety Circular number *SE.003 Tahun 2018* that required aircraft operators to conduct upset recovery training as follows:

> *The Operator shall ensure flight crew members complete training in procedures for aircraft upset recovery during initial ground training and subsequently during recurrent training either once every 36 months or, if applicable, in accordance with the continuing qualification schedule as defined in the Operator's Advanced Qualification Program.*
>
> *Note: Training is applicable to all pilot crew members and typically addresses pilot flying (PF) and pilot monitoring (PM) duties.*
>
> *Aircraft upset recovery training typically includes:*
>
> - *Upset prevention;*
> - *Factors leading to an upset or loss of control situation;*
> - *Upset situation identification;*
> - *Recovery techniques;*
> - *Emphasis on aerodynamic factors present during the upset and the recovery.*
>
> *Acceptable means of ground training may include video presentation(s), verbal instruction and/or group discussion.*

The investigation was unable to find procedures pertaining to the delivery of upset prevention and recovery training, and guidance from the DGCA to aircraft operators and/or approved training organizations (ATOs).

1.17.3.2 Indonesia Regulation of Notification of Rescue Coordination Center

The Civil Aviation Safety Regulation Part 170 subpart 5.2 described the different states of emergency as follows:

a. Uncertainty phase, when:
   1) air traffic services unit has not received communication from an aircraft within a period of thirty minutes after the time a communication should have been received, or from the time an unsuccessful attempt to establish communication with such aircraft was first made;
   2) an aircraft fails to arrive within thirty minutes of the estimated time of arrival last notified to or estimated by air traffic services unit, except when no doubt exists as to the safety of the aircraft and its occupants.

b. Alert phase, when:
   1) following the uncertainty phase, subsequent attempts by air traffic services unit to establish communication with the aircraft or inquiries to other relevant sources have failed to reveal any news of the aircraft;
   2) an aircraft has been cleared to land and fails to land within five minutes of the estimated time of landing and communication has not been re-established with the aircraft;
   3) air traffic services unit has been received information which indicates that the operating efficiency of the aircraft has been impaired, but not to the extent that a forced landing is likely, except when evidence exists that would allay apprehension as to the safety of the aircraft;

4) air traffic services unit has received information and believed the aircraft is to be the subject of unlawful interference.

c. Distress phase when:

1) air traffic services unit has unsuccessful attempts to establish communication with the aircraft and more widespread unsuccessful inquiries point to the probability that the aircraft is in distress;
2) air traffic services unit has received information that the fuel on board is considered to be exhausted, or to be insufficient to enable the aircraft to reach the destination;
3) air traffic services unit has received information which indicates that the operating efficiency of the aircraft has been impaired to the extent that a forced landing is likely;
4) air traffic services unit has received information that the aircraft has made a forced landing, and the aircraft and its occupants are not threatened by grave and imminent danger and do not require immediate assistance.

The subpart 5.2 also described that the notification to the rescue coordination center must contain the information as follows:

a. the phases/states of the emergency (INCERFA, ALERFA or DETRESFA);
b. agency and person calling;
c. nature of the emergency;
d. significant information from the flight plan;
e. unit which made last contact, time and means used;
f. last position report and how it was determined;
g. color and distinctive marks of aircraft;
h. dangerous goods carried as cargo;
i. any action taken by reporting office; and
j. other pertinent remarks.

1.17.4 ICAO Standards and Recommended Practices

1.17.4.1 Upset Prevention and Recovery

The ICAO Annex 6 Part I (International Commercial Air Transport – Aeroplanes) subchapter 9.3 required aircraft operators to establish and maintain a ground and flight training program, approved by the civil aviation authority, which included upset prevention and recovery training (UPRT). The ICAO Document 9868 (Procedure for Air Navigation Services – Training) provided procedures in the delivery of UPRT for aeroplane pilots. This was supported by the ICAO Document 10011 (Manual on Aeroplane Upset Prevention and Recovery Training), which provided guidance to civil aviation authorities, aircraft operators and approved training organizations (ATOs) for instituting best practices into the UPRT.

The ICAO Document 10011 described that the UPRT should focus to the following areas:

- *a. heightened awareness – of the potential threats from events, conditions or situations;*
- *b. effective avoidance – at early indication of a potential upset-causing condition; and*

} *Prevention*

- *c. effective and timely recovery – from an upset to restore the aeroplane to safe flight parameters.*

The ICAO Document 10011 subchapter 2.1.2 described the following:

Effective UPRT programme development and supporting regulatory frameworks require an integrated comprehensive approach to ensure standardization in the levels of knowledge and skill sets within the pilot community.

This integration effort should comprise the following UPRT components:

a) academic training — designed to equip pilots with the knowledge and awareness needed to understand the threats to safe flight and the employment of mitigating strategies; and

b) practical training — designed to equip pilots with the required skill sets to effectively employ upset avoidance strategies and, when necessary, effectively recover the aeroplane to the originally intended flight path. The practical training component is further broken down into two distinct subcomponents involving:

1) on-aeroplane training — during CPL(A)[19] *or MPL*[20] *training in suitably capable light aeroplanes to be conducted by appropriately qualified instructors to develop the knowledge, awareness and experience of aeroplane upsets and unusual attitudes, and how to effectively analyse the event and then apply correct recovery techniques; and*

2) FSTD training — on specific or generic aeroplane types to build on knowledge and experience and apply these to the multi-crew crew resource management (CRM) environment, at all stages of flight, and in representative conditions, with appropriate aeroplane and system performance, functionality and response. Once again, this instruction should only be provided by appropriately qualified instructors.

ICAO also provided Airplane Upset Prevention and Recovery Training Aid (AUPRTA), available on the ICAO website, as an effort to increase the ability of pilots to recognize and avoid situations that can lead to aircraft upsets, and to improve their ability to recover control of an aircraft that diverges from a pilot's desired aeroplane state.

19 Commercial Pilot License – Aeroplane (CPL-A).

20 Multi-crew Pilot License.

1.17.4.2 Notifications to Rescue Coordination Center

The standards on notification to rescue coordination center are described in the ICAO Annex 11 Standard 5.2 as follows:

5.2.1 Without prejudice to any other circumstances that may render such notification advisable, air traffic services units shall, except as prescribed in 5.5.1, notify rescue coordination centres immediately an aircraft is considered to be in a state of emergency in accordance with the following:

a) Uncertainty phase when:

1) no communication has been received from an aircraft within a period of thirty minutes after the time a communication should have been received, or from the time an unsuccessful attempt to establish communication with such aircraft was first made, whichever is the earlier, or when

2) an aircraft fails to arrive within thirty minutes of the estimated time of arrival last notified to or estimated by air traffic services units, whichever is the later,

except when no doubt exists as to the safety of the aircraft and its occupants.

b) Alert phase when:

1) following the uncertainty phase, subsequent attempts to establish communication with the aircraft or inquiries to other relevant sources have failed to reveal any news of the aircraft, or when

2) an aircraft has been cleared to land and fails to land within five minutes of the estimated time of landing and communication has not been re-established with the aircraft, or when

3) information has been received which indicates that the operating efficiency of the aircraft has been impaired, but not to the extent that a forced landing is likely,

except when evidence exists that would allay apprehension as to the safety of the aircraft and its occupants, or when

4) an aircraft is known or believed to be the subject of unlawful interference.

c) Distress phase when:

1) following the alert phase, further unsuccessful attempts to establish communication with the aircraft and more widespread unsuccessful inquiries point to the probability that the aircraft is in distress, or when

2) the fuel on board is considered to be exhausted, or to be insufficient to enable the aircraft to reach safety, or when

3) information is received which indicates that the operating efficiency of the aircraft has been impaired to the extent that a forced landing is likely, or when

4) information is received or it is reasonably certain that the aircraft is about to make or has made a forced landing,

except when there is reasonable certainty that the aircraft and its occupants are not threatened by grave and imminent danger and do not require immediate assistance.

1.17.5 Maintenance Trouble Shooting

The basic troubleshooting of electrical and avionics definition can be adopted from the FAA handbook number FAA-8083-30 in Chapter 10. The Basic Circuit Analysis and Troubleshooting in FAA-8083-30 Chapter 10 page 10-82 stated as follows:

> ***Basic Circuit Analysis and Troubleshooting***
>
> *Troubleshooting is the systematic process of recognizing the symptoms of a problem, identifying the possible cause, and locating the failed component or conductor in the circuit. To be proficient at troubleshooting, the engineer must understand how the circuit operates and know how to properly use the test equipment.*

In the same chapter, it is also stated that the basic circuits and troubleshooting involves the identification of short circuit, open circuit, continuity, and discontinuity.

To perform the appropriate troubleshooting of the problem that occurred in the aircraft, the engineer should refer to the correct manual that is effective for the aircraft. The effective Boeing manual identification for the aircraft model is as follow:

Customer/ Model Series	Operator		Manufacturer			Registration Number
	Identification Code	Effectivity Code	Block Number	Serial Number	Line Number	
737-524	CAL	610	PT810	27323	2616	PK-CLC

Before conducting the troubleshooting, the engineer must identify the correct manual and chapter in the AMM to refer to. The System Schematic Manual (SSM) also provides the schematic diagram of the respective system to the engineer.

The inspection of the electrical connector and wire is part of the Electrical Wiring Interconnection System (EWIS). The effective Boeing 737-500 Aircraft Maintenance Manual (AMM), Chapter 20 identifies the standard maintenance procedure to conduct the inspection of electrical wiring as part of EWIS in task 20-60-03-102-005.

The definition of the EWIS in the AMM task 20-60-03-102-005 stated:

> *B. Definitions:*
>
> *(1) Electrical Wiring Interconnection System (EWIS): means any wire, power feeder, wiring device, or combination of these, including termination devices, installed in any area of the airplane for the purpose of transmitting electrical energy, including data and signals, between two or more intended termination points. EWIS is defined in full by 14 CFR section 25.1701.*

The inspection, cleaning and reposition of the suspected electrical connector are also parts of the Electrical Wiring Interconnection System (EWIS) inspection.

Based on the identification of the aircraft, the trouble shooting procedure for the A/T will be AMM chapter 22-04-10 (A/T System BITE Trouble Shooting) and 22-31-00 (A/T System – Description and Operation).

The AMM Chapter 22-04-10 described that the A/T system problem could be interrogated via a BITE function that is integrated in the Flight Management Computer (FMC) Control Display Unit (CDU).

The BITE test is intended to provide the engineer with a convenient means of isolating the A/T system faults to the Line Replacement Unit (LRU). The A/T BITE is divided into a CURRENT STATUS test, an INTERACTIVE TEST, INFLIGHT FAULT test, LRU INTERFACE test, RIGGING ADJUST test and a RANGE CHECK.

The BITE test can be requested from a manual input to the FMC CDU and will be entered if the prerequisite conditions are present. These prerequisite conditions are gear down, squat, and N1 less than 12.5% and FMC A/T BITE test request which ensure that the BITE program cannot be entered while the aircraft is in the air or while the engines are running.

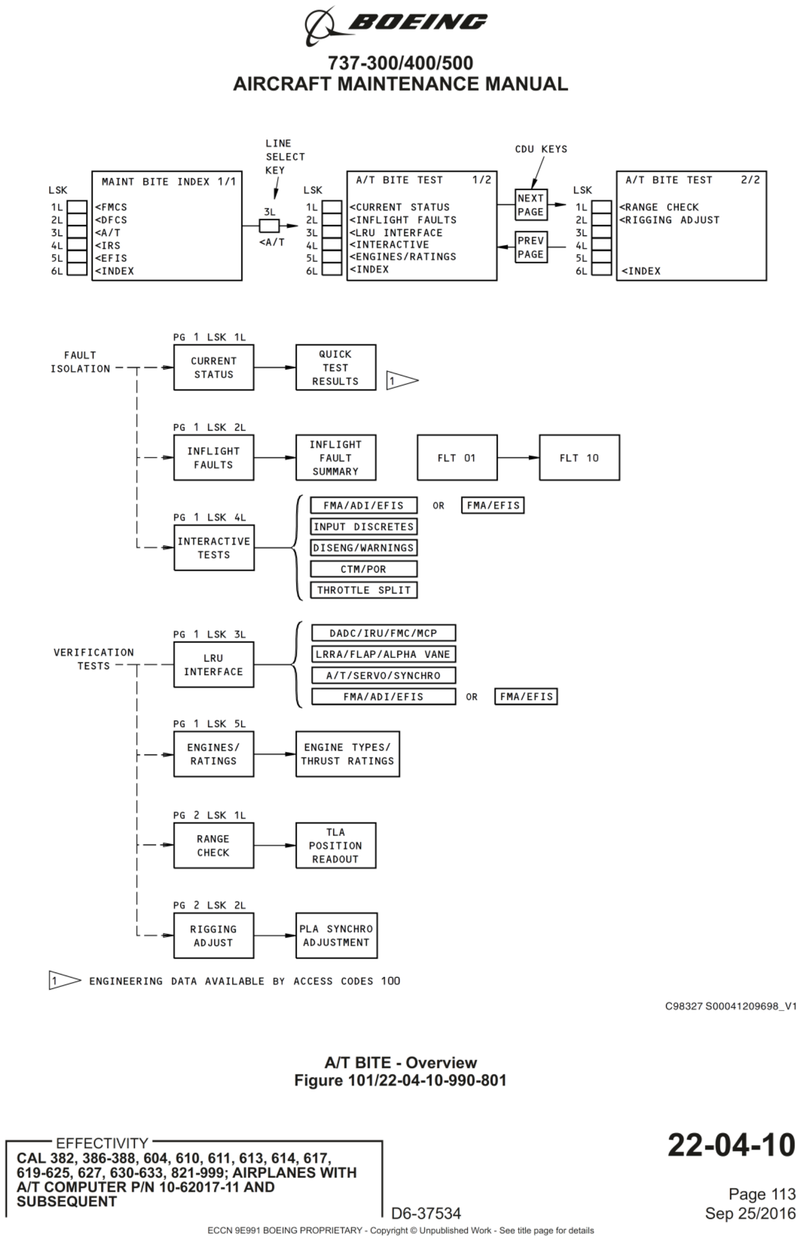


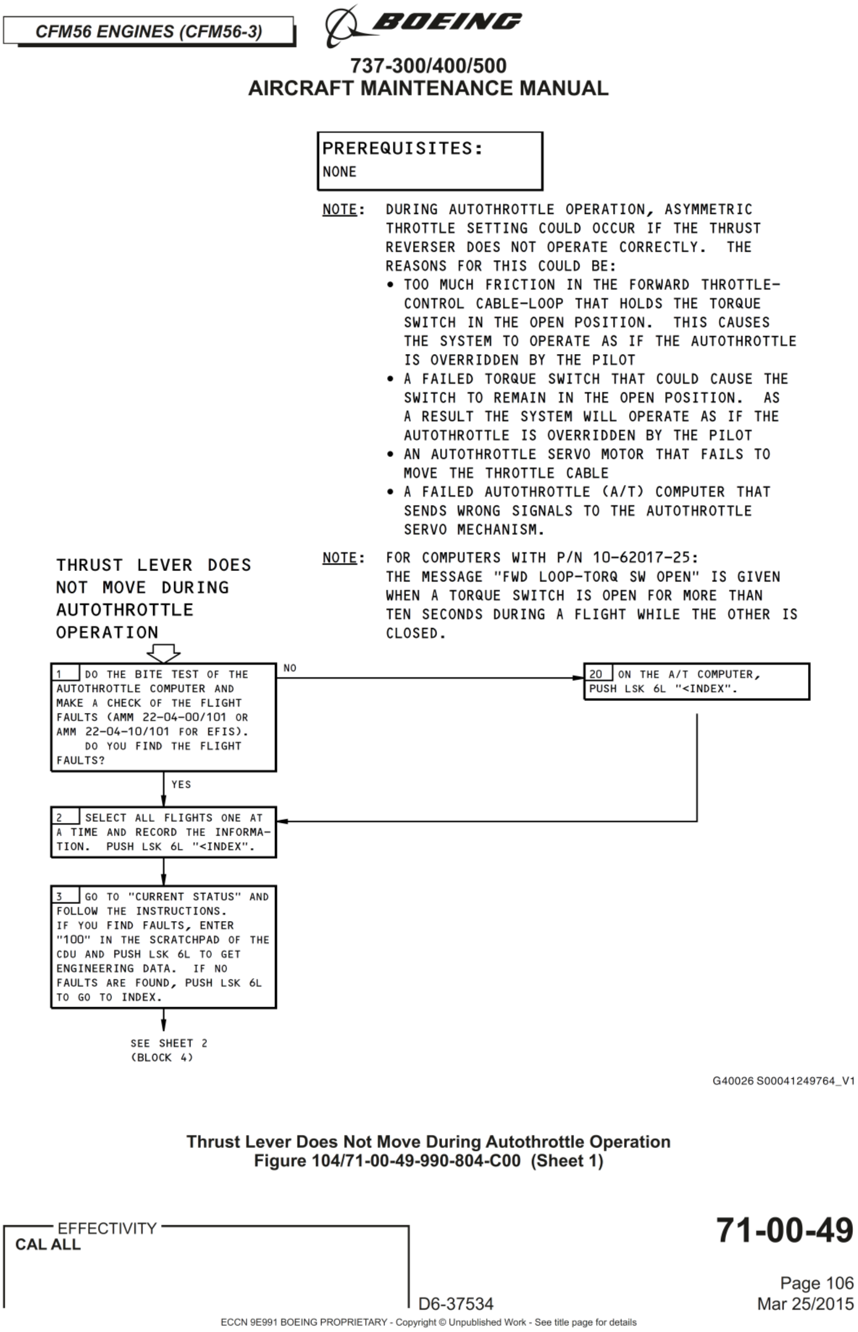
Figure 26: The A/T BITE flow in the Control Display Unit (Image Copyright © Boeing. Reproduced with permission)

In any step directed by the BITE test to check component which involving the electrical connector including the LRU, it is a common practice to check the electrical connector of the related LRU or component, even though the AMM do not mention any electrical plug inspection. The Standard Wiring Practice Manual (SWPM) chapter 20-60-01 provides the procedure for cleaning of the electrical connector and suggested to conduct a relevant operational test or BITE test.

The troubleshooting process of the A/T system using the BITE function is described as follows:

1. When a A/T problem is reported, the first action is to verify the problem by interrogating the FMC CDU using BITE function (see AMM chapter 22-04-10 page 101) as shown in the Figure 27.
2. If the LRU which supporting the A/T had a problem and the A/T BITE TEST could not be conducted, the system would show a page with two options of A/T BITE INOP or CHECK A/T OR INTERFACE. These options indicate following:
    - The A/T BITE INOP means that the FMC does not receive any input from the A/T computer or the A/T computer failure.
    - The CHECK A/T OR INTERFACE means that the BITE test logic is not satisfied. For example, the Circuit Breaker (CB) may have tripped, or the landing gear switch is faulty, or the A/T computer is faulty.
3. If the A/T BITE INOP or CHECK A/T OR INTERFACE is not indicated, the A/T BITE is functional. The A/T troubleshooting flow is as such:
    - IDENT→POS INIT→INDEX→MAINT
    - On <MAINT> page, select<A/T>
    - On <A/T> page, select<A/T BITE TEST>
4. On <A/T BITE TEST> page, the system will then provide several options of selection (CURRENT STATUS, INFLIGHT STATUS, LRU INTERFACE, INTERACTIVE, ENGINES/RATING, RANGE CHECK and RIGGING ADJUST).
5. The manual also stated that the engineer had to ensure that the engine showed the correct engine rating (in this case CFM56-3B1 with the thrust 20,100 lbf) via the selection of <ENGINES/RATINGS> option.
6. The <CURRENT STATUS> will pull out the <QUICK TEST RESULTS> which provide the status of the A/T computer or any other affected LRU. The affected LRU can be further accessed by entering "100" into the FMC CDU scratch pad and the FMC CDU will display the affected LRU.
7. For further troubleshooting, the <INTERACTIVE TEST> page can be accessed to test the LRUs that are connected to the A/T system. This function will enable engineers in identifying the faulty LRU for rectification.
8. The split thrust lever can be detected through the <INTERACTIVE TEST> page by accessing the THROTTLE SPLIT selection. The THROTTLE SPLIT page contains the procedure for testing the thrust levers movement. Any problem that is found during the test, the FMC CDU will provide an error message either "THROT SPLIT" or "FWD LOOP".

9. The <INTERACTIVE TEST> page for “THROT SPLIT” or “FWD LOOP” contained the procedure to test the function of the Torque Switch Mechanism (TSM). The test is to verify whether the torque switch is in open or close circuit by manipulating the thrust lever during test. The test also verifies the integrity of the thrust lever cable connecting from the thrust lever control box in the cockpit to the torque switch mechanism.
10. With the reference of THROT SPLIT or FWD LOOP error messages generated by the FMC CDU or there was a thrust lever movement problem is encountered during the A/T system engage, the trouble shooting steps contained in the AMM chapter 71-00-49 (Power Plant–- Trouble Shooting (Engine Controls)) shown on figure 28 contain the procedure in performing the detail trouble shooting of the thrust lever cable, which include the examination for friction or mechanical binding.
11. If the pilot reported of the engine experiencing slow response during the descent, and it was proved that the engine did not have any other problem (by the evidence of run up or any other evidence), the step described in the point 7 can be performed.
12. If the thrust lever hard to move or slow response during the A/T engagement was reported, the procedure to verify the existing load of the thrust lever is described in the AMM chapter 76-11-00 (Engine Control System – Adjustment/Test). The AMM chapter 76-11-00 is to verify the load test of the thrust lever by applying the load of 4 to 8 lbs. If the thrust lever required more than 8 lbs., the thrust lever may be experiencing high friction due to the binding within the mechanism system of the engine thrust cable system. The procedure also required to examine the correct thrust lever cable routing using the AMM chapter 76-11-04 (Engine Control Cables – Maintenance Practices).
13. In 1994, Boeing issued Service Letter (SL) number 737-SL-76-016-A to recommend troubleshooting procedures for intermittent thrust lever response during A/T operation which refer to AMM 22-04-01 (Non–EFIS Airplanes), AMM 22-04-11 (EFIS Airplanes), AMM 76-11-00, AMM 76-11-04, AMM 76-11-01.


CFM56 ENGINES (CFM56-3)

BOEING

737-300/400/500
AIRCRAFT MAINTENANCE MANUAL

PREREQUISITES:
NONE

NOTE: DURING AUTOTHROTTLE OPERATION, ASYMMETRIC THROTTLE SETTING COULD OCCUR IF THE THRUST REVERSER DOES NOT OPERATE CORRECTLY. THE REASONS FOR THIS COULD BE:
- TOO MUCH FRICTION IN THE FORWARD THROTTLE-CONTROL CABLE-LOOP THAT HOLDS THE TORQUE SWITCH IN THE OPEN POSITION. THIS CAUSES THE SYSTEM TO OPERATE AS IF THE AUTOTHROTTLE IS OVERRIDDEN BY THE PILOT
- A FAILED TORQUE SWITCH THAT COULD CAUSE THE SWITCH TO REMAIN IN THE OPEN POSITION. AS A RESULT THE SYSTEM WILL OPERATE AS IF THE AUTOTHROTTLE IS OVERRIDDEN BY THE PILOT
- AN AUTOTHROTTLE SERVO MOTOR THAT FAILS TO MOVE THE THROTTLE CABLE
- A FAILED AUTOTHROTTLE (A/T) COMPUTER THAT SENDS WRONG SIGNALS TO THE AUTOTHROTTLE SERVO MECHANISM.

NOTE: FOR COMPUTERS WITH P/N 10-62017-25: THE MESSAGE "FWD LOOP-TORQ SW OPEN" IS GIVEN WHEN A TORQUE SWITCH IS OPEN FOR MORE THAN TEN SECONDS DURING A FLIGHT WHILE THE OTHER IS CLOSED.

THRUST LEVER DOES NOT MOVE DURING AUTOTHROTTLE OPERATION

1 DO THE BITE TEST OF THE AUTOTHROTTLE COMPUTER AND MAKE A CHECK OF THE FLIGHT FAULTS (AMM 22-04-00/101 OR AMM 22-04-10/101 FOR EFIS). DO YOU FIND THE FLIGHT FAULTS?

NO

20 ON THE A/T COMPUTER, PUSH LSK 6L "<INDEX".

YES

2 SELECT ALL FLIGHTS ONE AT A TIME AND RECORD THE INFORMATION. PUSH LSK 6L "<INDEX".

3 GO TO "CURRENT STATUS" AND FOLLOW THE INSTRUCTIONS. IF YOU FIND FAULTS, ENTER "100" IN THE SCRATCHPAD OF THE CDU AND PUSH LSK 6L TO GET ENGINEERING DATA. IF NO FAULTS ARE FOUND, PUSH LSK 6L TO GO TO INDEX.

SEE SHEET 2 (BLOCK 4)

G40026 S00041249764_V1

Thrust Lever Does Not Move During Autothrottle Operation
Figure 104/71-00-49-990-804-C00 (Sheet 1)

EFFECTIVITY
CAL ALL

71-00-49

D6-37534

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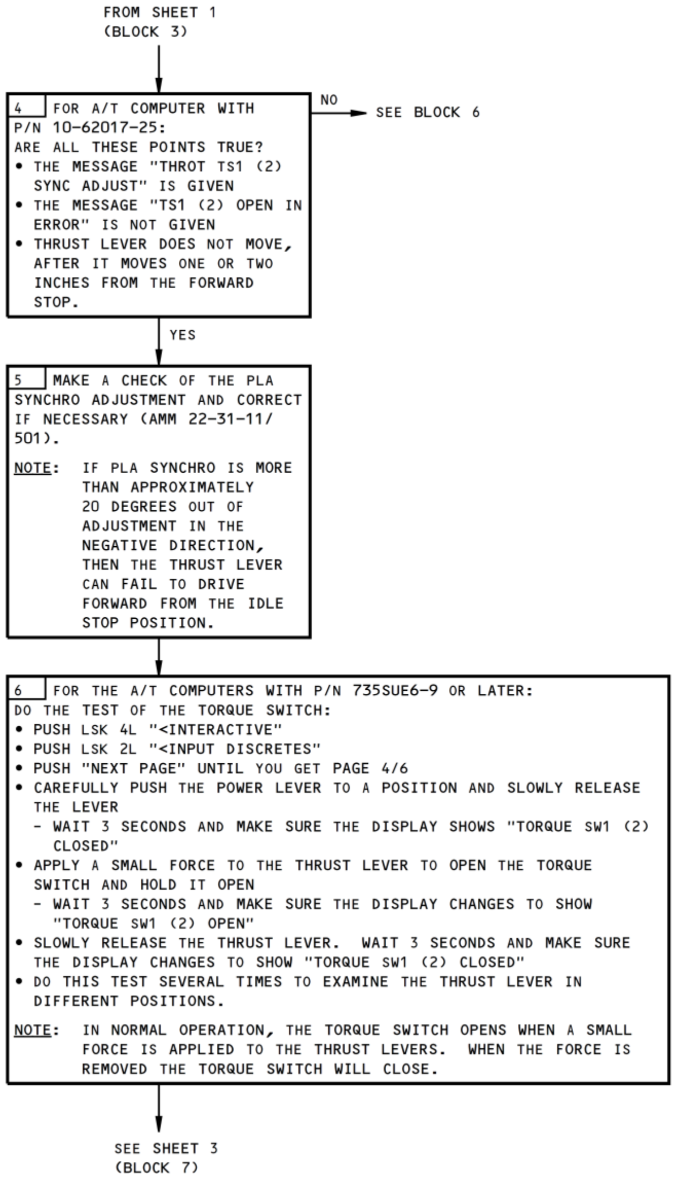
ECCN 9E991 BOEING PROPRIETARY - Copyright © Unpublished Work - See title page for details

Figure 27: The trouble shooting of the thrust lever movement problem sheet 1 (Image Copyright © Boeing. Reproduced with permission)

CFM56 ENGINES (CFM56-3)

BOEING

737-300/400/500
AIRCRAFT MAINTENANCE MANUAL



G40027 S00041249765_V1

Thrust Lever Does Not Move During Autothrottle Operation
Figure 104/71-00-49-990-804-C00 (Sheet 2)

EFFECTIVITY
CAL ALL

71-00-49

D6-37534

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Figure 28: The trouble shooting of the thrust lever movement problem sheet 2 (Image Copyright © Boeing. Reproduced with permission)

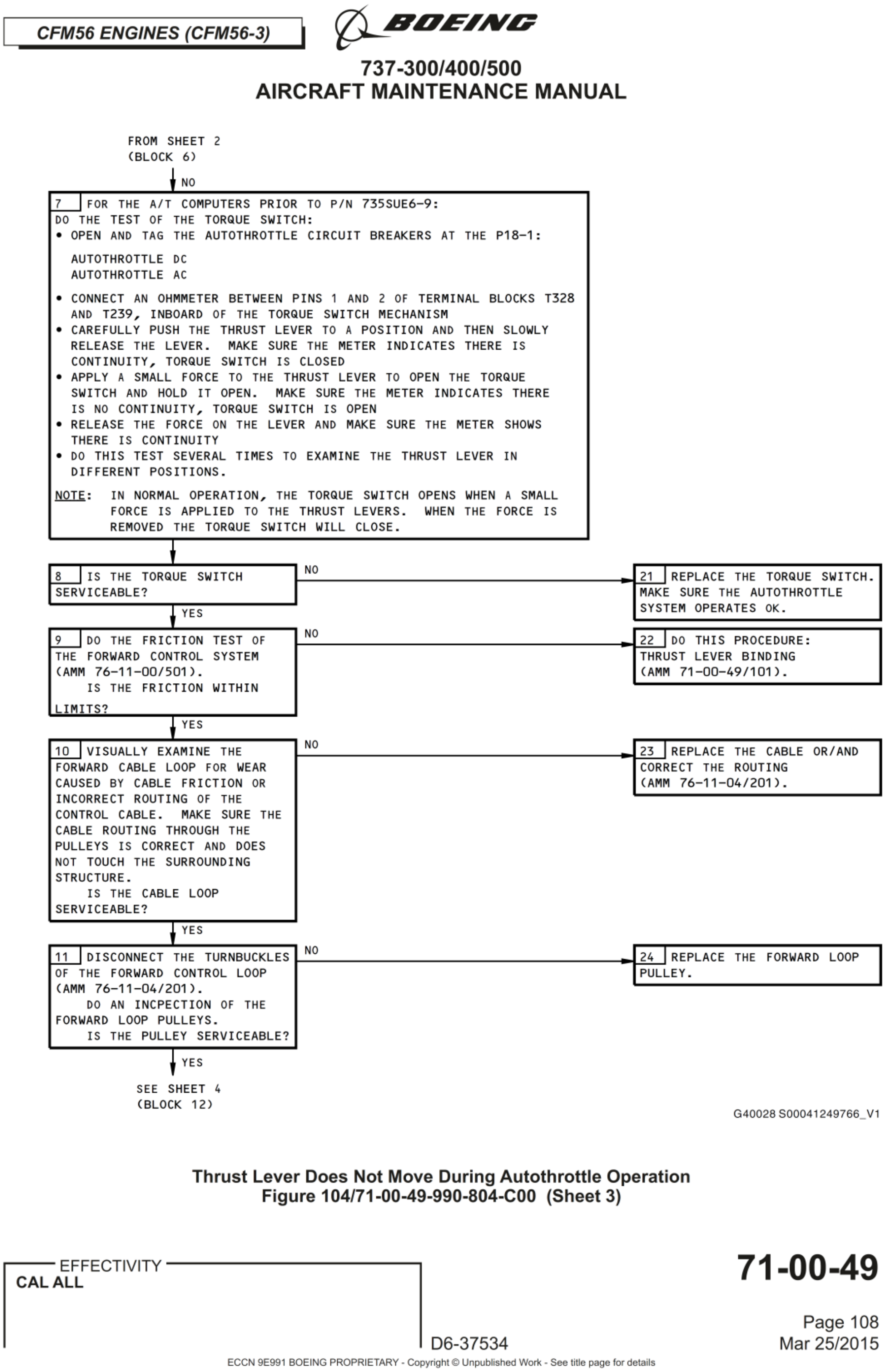

Figure 29: The trouble shooting of the thrust lever movement problem sheet 3 (Image Copyright © Boeing. Reproduced with permission)

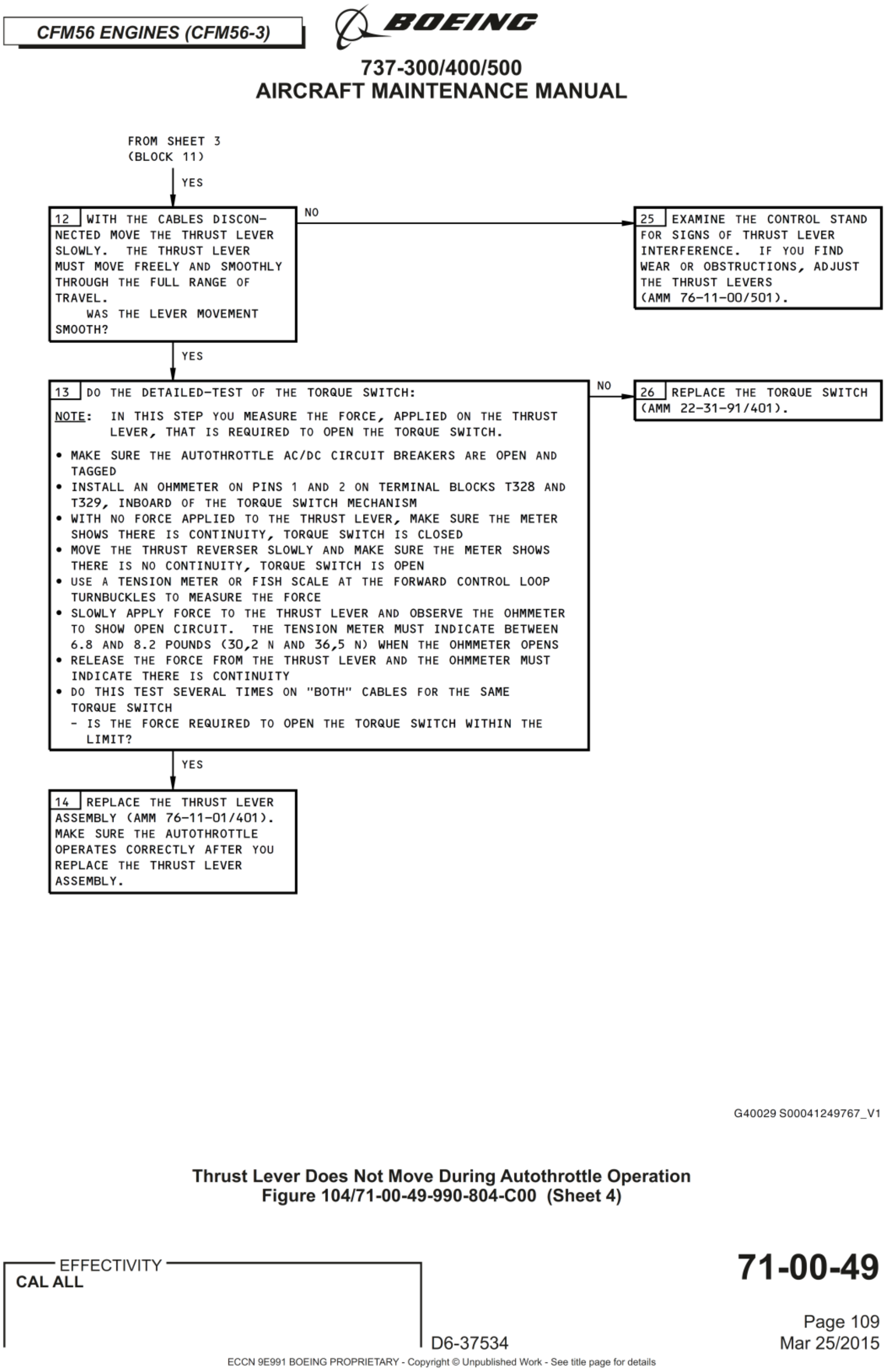

Figure 30: The trouble shooting of the thrust lever movement problem sheet 4 (Image Copyright © Boeing. Reproduced with permission)

In troubleshooting of the A/T system in relation to the spoiler position input logic for the CTSM, the spoiler position (sensor value) can be accessed via the FMC CDU through the DFCS BITE TEST function on the OVERNIGHT MAINT page. The OVERNIGHT MAINT provides the engineer to verify the SENSOR VAL page of the test 56.11.

1.18 Additional Information

1.18.1 Thrust Asymmetry Events on PK-CLC Aircraft

The aircraft operator has an establish system which periodically downloads the Quick Access Recorder (QAR) data for Flight Data Monitoring (FDM). The aircraft operator has downloaded the PK-CLC aircraft's flight data from the QAR.

The investigation retrieved the downloaded QAR data of PK-CLC aircraft from the aircraft operator. The QAR data of PK-CLC recorded several flights that experienced abnormal movement of thrust levers and the first occurrence of abnormal movement of thrust levers was on 7 March 2020.The QAR data are as follows:

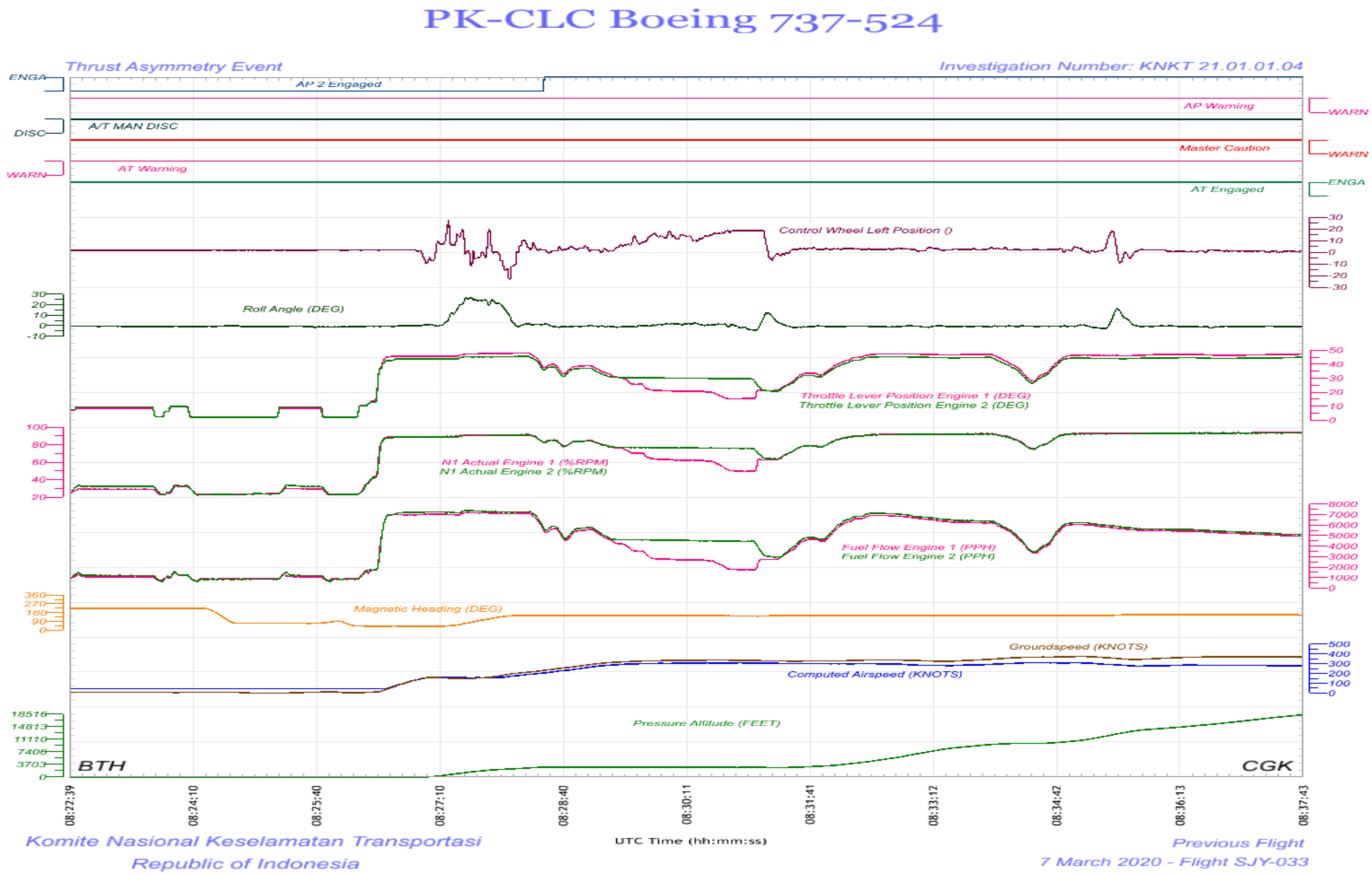

Figure 31: The QAR data of a flight on 7 March 2020

The QAR data of a flight on 7 March 2020 showed that:

1. At 08:26:13 UTC, the take-off initiated and became airborne at 08:26:58 UTC.
2. At 08:28:16 UTC, the A/T mode changed from N1 to MCP SPD.
3. At 08:28:25 UTC:
   - both thrust levers moved backward from position about 45° to about 40°,
   - the aircraft was maintaining a heading of 150°,
   - the aircraft altitude was at 3,060 feet, and
   - the aircraft speed was about 200 knots and increasing.
4. At 08:28:28 UTC the A/P 2 engaged.
5. At 08:28:32 UTC:
   - the aircraft altitude maintained at 3,100 feet, and
   - the aircraft speed was 235 knots and was increasing.
6. At 08:29:05 UTC:
   - both thrust levers moved backward from position about 37°,
   - the aircraft altitude was about 3,100 feet,
   - the heading maintained at 150°, and
   - the aircraft speed was about 270 knots and increasing.
7. At 08:29:16 UTC:
   - the left thrust lever continued moving backward while the right thrust lever stopped about 31°,
   - the N1 speed of the left engine was 78.2% and decreasing while the N1 speed of the right engine stopped at 77.4%,
   - the aircraft was maintaining altitude of 3,100 feet and heading of 150°, and
   - the aircraft speed was accelerating passed 285 knots.
8. At 08:30:01 UTC:
   - the left thrust lever stopped at a position about 21° while the right thrust lever position remained at 31°.
   - the N1 speed of the left engine was 62.7% while the N1 speed of the right engine was 76.6%.
   - the aircraft altitude and heading still maintained and the aircraft speed maintained at 303 knots.
   - the control wheels deflected 17° to the right, and
   - the left aileron deflected down 1.6° and the right aileron deflected up 4.2°.
9. At 08:30:41 UTC:
   - the left thrust lever moved backward to 15.5° while the right thrust lever remained at 31°,
   - the N1 speed of the left engine was 52.8% while the N1 speed of the right engine was 76%,

- the aircraft altitude and speed maintained while the heading changed from 150° to 146°,
- the control wheel deflected to the right 18°, and
- the left aileron deflected down 2.7° and the right aileron deflected up 5°.

10. At 08:31:03 UTC:
    - the left thrust lever moved forward from position of 15° and the right thrust lever moved backward from position of 31°.
    - the A/P and A/T remained engaged.
11. At 08:31:08 UTC, both thrust levers become equal at position about 21°.
12. At 08:31:14 UTC, the aircraft maintained at an altitude of 3,100 feet, heading on 146°, and speed at 303 knots. The control wheel moved to neutral (0°) position.
13. The aircraft continued the flight without further abnormality.

The investigation team has interviewed both pilots of this flight. None of the pilots recalled the asymmetric power event. No pilot report was filed into the AML for this flight.

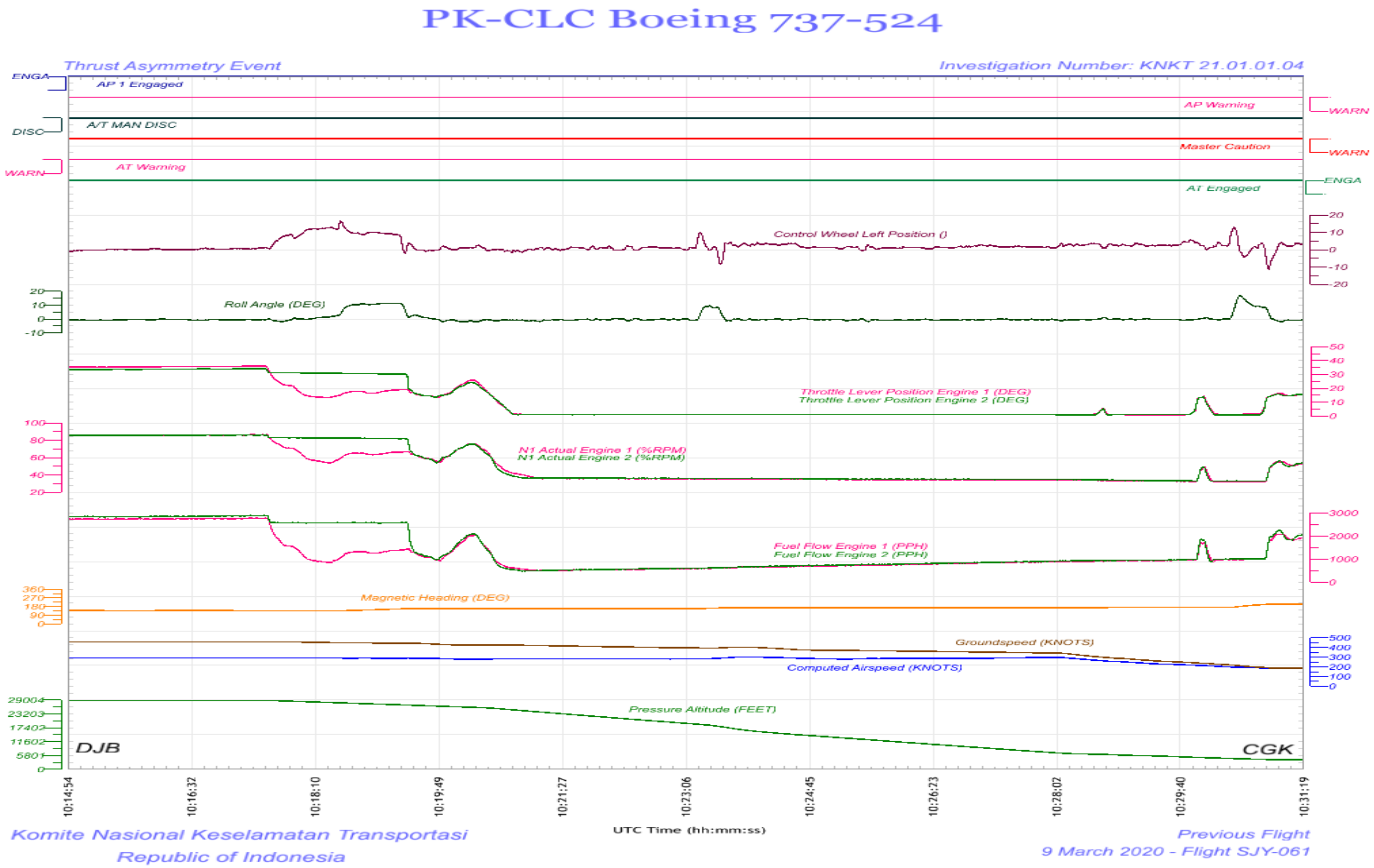

Figure 32: The QAR data of a flight on 9 March 2020

The QAR data of a flight on 9 March 2020 showed that:

1. The aircraft was cruising at an altitude of 29,000 feet, on heading 137°, the aircraft speed was 292 knots. Both thrust levers were on equal position about 35° and the N1 speed of both engines were equal about 86%. The A/P and A/T were engaged.
2. At 10:17:26 UTC, the aircraft started to descend. Both thrust levers moved backward about equally. At 10:17:36 UTC, the right thrust lever stopped at 31.3° and the N1 speed of the right engine was 82.9%, while the left thrust lever continued moving backward.
3. At 10:18:12 UTC:
   - the left thrust lever position was 13.5° while the right thrust lever position was 31°,
   - the N1 speed of the left engine was 56.5% while the N1 speed of the right engine was 82.7%,
   - the aircraft was descending passing 28,400 feet,
   - the heading maintained at 136°, and
   - the control wheel deflected to the right about 12°.
4. At 10:19:26 UTC:
   - the right thrust lever moved backward and was at the equal position to the left thrust lever at 15°, 6 seconds later,
   - the A/P and A/T were engaged, and
   - subsequently, the control wheel moved to neutral (0°).

The aircraft continued the flight without further abnormalities.

The investigation team has interviewed both pilots of this flight. None of the pilots recalled the asymmetric power event. No pilot report was filed into the AML for this flight.

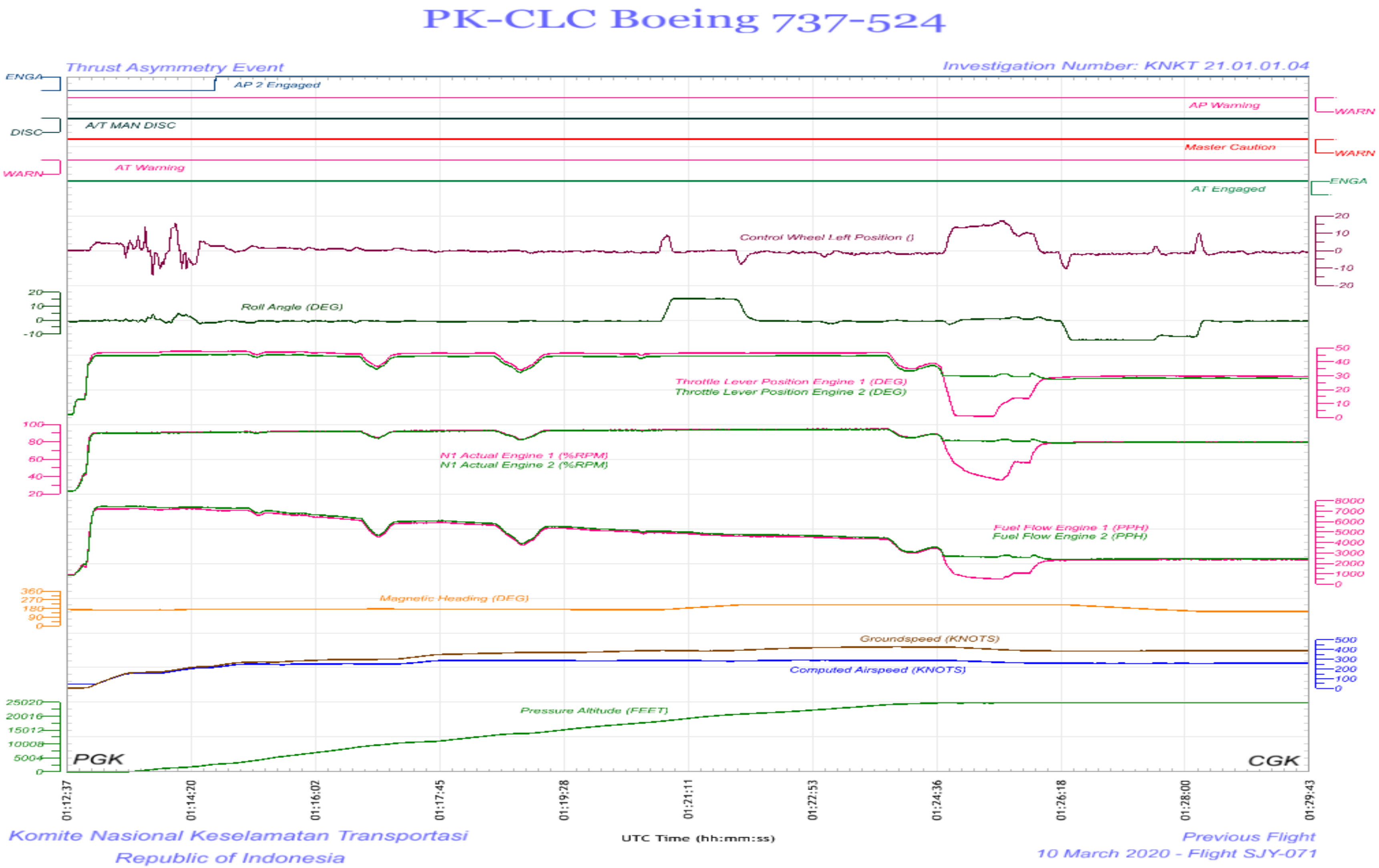

Figure 33: The QAR data of a flight on 10 March 2020

The QAR data of a flight on 10 March 2020 showed that:

1. The aircraft was climbing to a cruising altitude:
   - the aircraft was on a heading of 220°,
   - the aircraft speed was 288 knots,
   - the left thrust lever position was 39° and the N1 speed of the left engine was 88.9% while the right thrust lever position was 37.3° and the N1 speed of the right engine was 88.4%, and
   - the A/P and A/T were engaged.
2. At 01:24:42 UTC:
   - the aircraft reached the cruising altitude of 25,000 feet,
   - the heading was 220°,
   - the aircraft speed was 288 knots,
   - both thrust levers moved backward, and
   - the right thrust lever stopped at 30° while the left thrust lever continued moving backward.
3. At 01:24:53 UTC:
   - the left thrust lever reached to idle position of 1.1° while the right thrust lever position remained at 30°,
   - the N1 speed of the left engine was 53.7 % while the N1 speed of the right engine was 81%,
   - the aircraft was maintaining heading of 218°, and
   - the control wheel deflected to the right at an angle of 13°.
4. At 01:25:26 UTC,
   - the A/P and A/t remained engaged,
   - the left thrust lever gradually moved forward,
   - the aircraft was maintaining the altitude of 25,000 feet and heading of 218°, and
   - the aircraft speed was 270 knots.
5. At 01:26:05 UTC, both thrust levers were about equal position of 28°.

The A/P and A/T remained engaged during this event. The flight continued without any further abnormality.

The investigation team has interviewed both pilots of this flight. None of the pilots recalled the asymmetric power event. No pilot report was filed into AML for this flight.

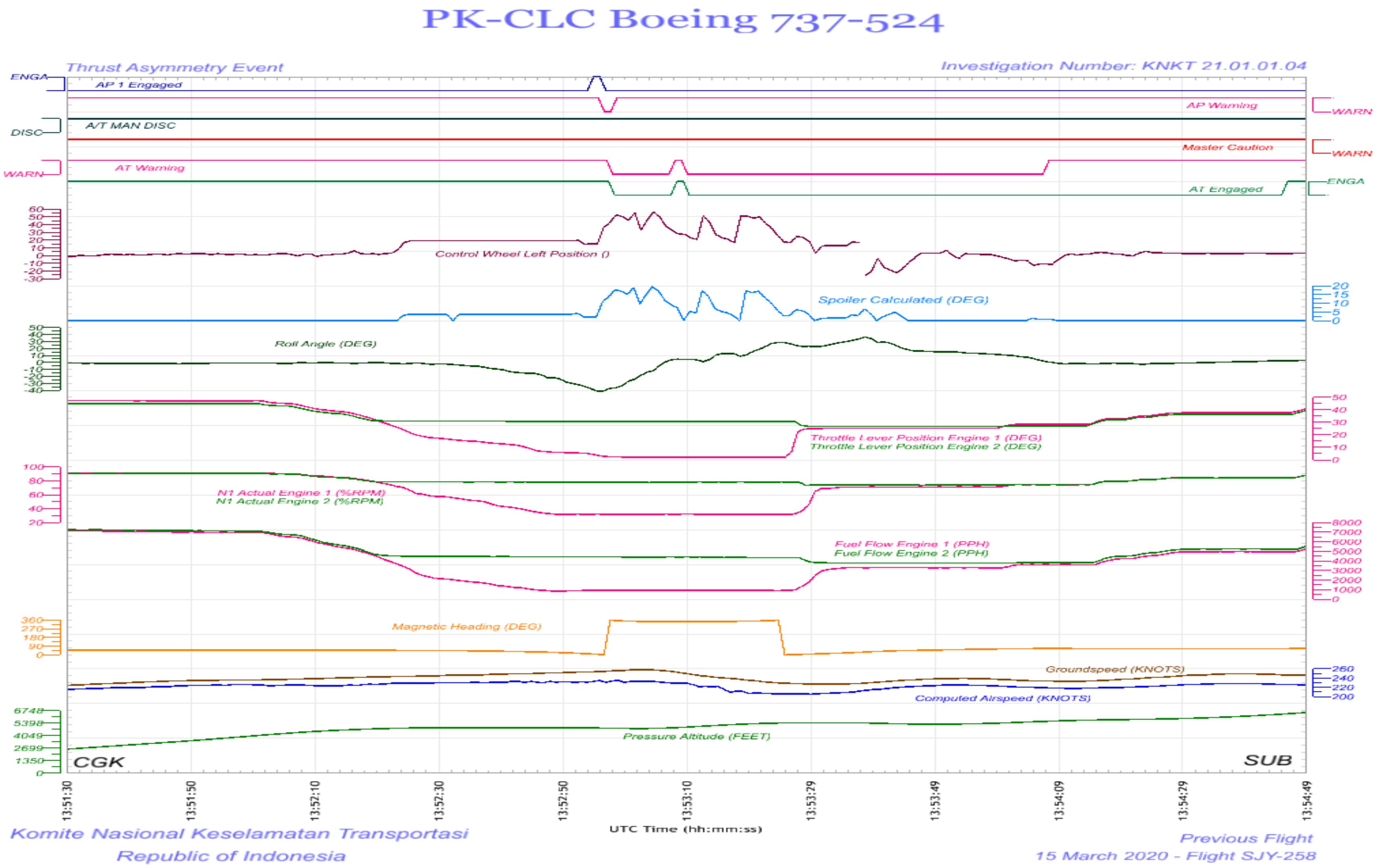

Figure 34: The QAR data of a flight on 15 March 2020 with additional parameter of spoiler deployment calculation

The QAR data of a flight on 15 March 2020 showed that:

1. The aircraft departed and climbed to an initial altitude of 5,000 feet.
2. At 13:51:56 UTC:
   - the aircraft was climbing past an altitude of 4,000 feet,
   - the aircraft was maintaining a heading of 047°,
   - the aircraft speed was about 225 knots,
   - the N1 speed of the left engine was 91% while the N1 speed of the right engine was 90.5%, the left thrust lever position was 47°,
   - the right thrust lever position was 45°, and
   - the A/P and A/T were engaged.
3. At 13:52:04 UTC, the aircraft was climbing passing altitude of 4,400 feet, both thrust levers moved backward.
4. At 13:52:20 UTC:
   - the aircraft reached the altitude of 5,000 feet,
   - the heading was maintaining at 047°,
   - the aircraft speed was accelerating passing 227 knots, and
   - the right thrust lever stopped about 34°, while the left thrust lever continued moving backward.
5. At 13:52:27 UTC:
   - the control wheel deflected 19° to the right until the A/P disengaged.
   - the left aileron deflected down at 3.8° and the right aileron deflected up at 5.8°.
   - the calculated flight spoiler deployment was 3.7° and remained until the A/P disengaged.
   - the aircraft was maintaining a heading of 46°.
   - the left thrust lever position was 21° while the right thrust lever position was 31°, and
   - the N1 speed of the left engine was 66% while the N1 speed of the right engine was 78.5%.
6. At 13:52:31 UTC:
   - the aircraft turn to the left,
   - the control wheel remained deflected to the right 19°,
   - the left aileron deflected down at 3.8° and the right aileron deflected up at 5.8°,
   - the calculated flight spoiler deflection remained at 3.7°,
   - the left thrust lever position was 17.4° while the right thrust lever position was 31°, and
   - the N1 speed of the left engine was 57.6% while the N1 speed of the right engine remained at 78.5%.

7. At 13:52:58 UTC:
    - the A/P disengaged followed by the A/T disengaged.
    - the aircraft was on heading of 003°,
    - the aircraft rolled to the left with an angle of 41°,
    - the control wheel deflected to the right 36°,
    - the left aileron deflected down 5.9° and the right aileron deflected up at 10.5°, and
    - the calculated flight spoiler deflection was 10.8°.
8. At 13:53:29 UTC, the left thrust lever moved forward and afterward became equal to the right thrust lever about 25° position. The aircraft heading was 005° and the altitude was 5,600 feet.
9. Between the A/T disengaged until the left thrust lever moved forward, the aircraft roll angle varied between 37° roll to the left and 28° roll to the right. The control wheel movement to the right varied between 17° to 55°. The rudder remained about neutral (0°) position.
10. At 13:54:40 UTC, the A/P engaged followed by the A/T engaged 7 seconds after. The aircraft altitude was about 6,300 feet, on heading of 064° and aircraft speed of 228 knots.

The PIC of this flight was the PF of the accident flight. The investigation conducted an interview with the SIC of this flight.

The SIC recalled that during the flight, he acted as PF and while maintaining altitude of 5,000 feet, the ATC provided clearance to turn to the right. The SIC turned the heading selector on the MCP and noticed that the aircraft was unable to turn to the right. The SIC reported the condition to the PIC. The SIC then disengaged the A/P and turned the aircraft manually. After few moments the PIC realized that asymmetric thrust occurred, and the left thrust lever was at the idle position. Thereafter, both thrust levers restored to about 25° position, the aircraft returned to normal condition and no further anomalies occurred until landing. The SIC did not recall any additional details of the flight. Investigators were unable to determine how the PIC diagnosed the asymmetric thrust condition.

No pilot report of aircraft system malfunction was filed into the AML nor safety occurrence report to the operator safety reporting system.

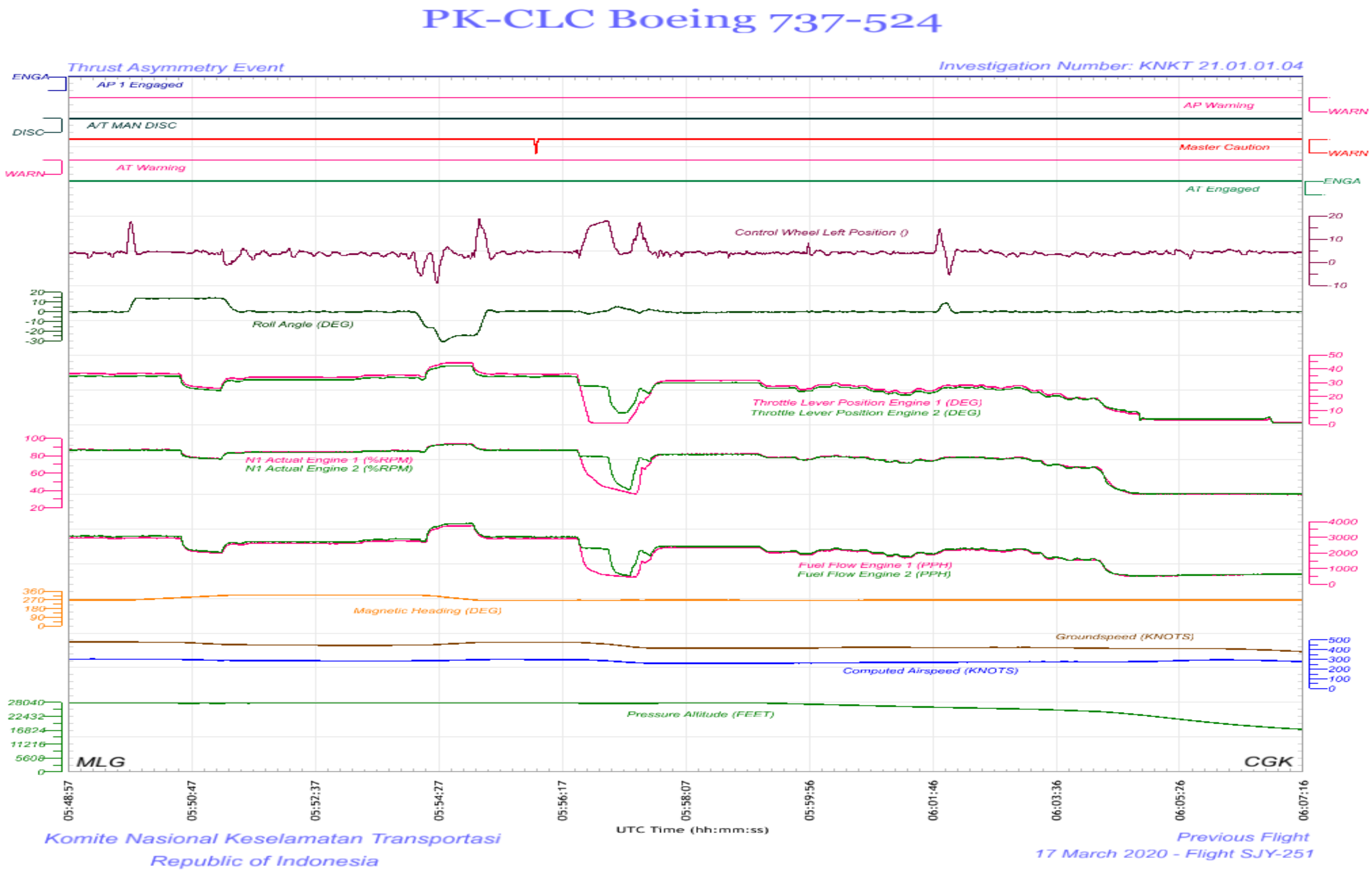

Figure 35: The QAR data of a flight on 17 March 2020

The QAR data of a flight on 17 March 2020 showed that:

1. The aircraft was cruising at an altitude of 28,000 feet and was maintaining a heading of 266°.
2. At 05:56:31 UTC:
    - the aircraft initiated its descent,
    - both thrust levers moved backwards, and
    - the A/P and A/T were engaged.
3. At 05:56:35 UTC:
    - the left thrust lever continued to move backwards passed 22.9°, while the right thrust lever stopped at 27.8°, and
    - the N1 speed of the left engine was 75% and decreasing while the N1 of the right engine stopped at about 79.5%.
4. At 05:56:45 UTC:
    - the left thrust lever reached the idle position of 1.1° and the N1 speed of the left engine was 54%,
    - the right thrust lever remained at 27.8° and the N1 speed of the right engine was 79.2%, and
    - the aircraft was maintaining a heading of 266°, the roll angle was 2° to the left,
    - the control wheel deflected 16° to the right.
5. At 05:56:54 UTC:
    - the right thrust lever started to move backwards,
    - the left thrust lever position was 0.9° and the N1 speed of the left engine was 44.7%,
    - the aircraft heading was 265°, the roll angle was 0°, and
    - the control wheel deflected 17.4°.
6. At 05:57:07 UTC:
    - the right thrust lever stopped at a position of 8.8° while the left thrust lever position was 0.9°,
    - the N1 speed of the right engine was 47.7% and the N1 speed of the left engine was 40.9%,
    - the aircraft was maintaining heading of 266° while the aircraft rolled 5° to the right, and
    - the control wheel deflected 5° to the right.
7. At 05:57:18 UTC, both thrust levers moved forward. The left thrust lever position was 1.9° and the right thrust lever position was at 10.7°.
8. At 05:57:30 UTC, the right thrust lever stopped at 24.4°, while the left thrust lever continued moving forward.

9. At 05:57:39 UTC:
    - the left thrust lever position was 25.5° and the right thrust lever position was 26.5°,
    - the N1 speed of the left engine was 75.4% and the N1 speed of the right engine was 77.8%,
    - the aircraft was maintaining a heading of 268°, and
    - the control wheel deflected 3.5°
10. Thereafter, both thrust levers moved relatively equal and no further asymmetric thrust levers event occurred until the aircraft landed safely.
11. The A/P and A/T remained engaged during the asymmetric thrust levers occurred.

The investigation team has interviewed both pilots of this flight. Neither pilot recalled an asymmetric thrust condition during the flight.

No pilot report was filed into the AML after this flight.

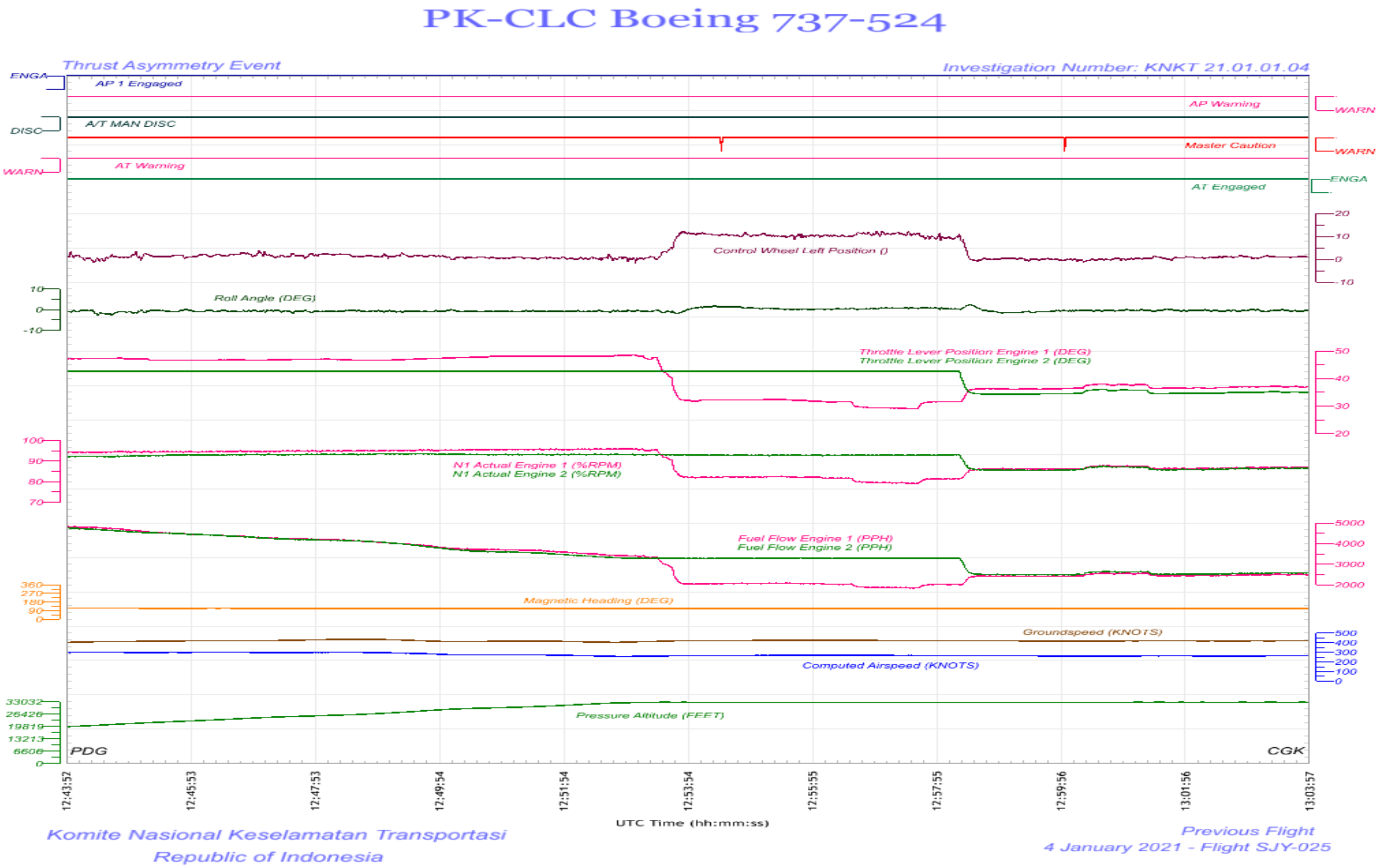

Figure 36: The QAR data of a flight on 4 January 2021

The QAR data of a flight on 4 January 2021 showed that:

1. At 12:53:14 UTC:
    - the aircraft reached the cruising altitude of 33,000 feet and maintaining a heading of 113°,
    - the left thrust lever position was at 47.8° and decreasing while the right thrust lever position was at 42.7° and remained,
    - the N1 speed of the left engine was 95.6% while the N1 speed of the right engine was 92.9%, and
    - the A/P and AT engaged.
2. At 12:53:54 UTC:
    - the left thrust lever stopped at the position of 32° while the right thrust lever remained at 42.7°,
    - the N1 speed of the left engine was 82.5% while the N1 speed of the right engine was 92.8%, and
    - the aircraft heading was 111°, the roll angle was 0° and the control wheel deflected 11.5° to the right.
3. At 12:58:19 UTC, the right thrust lever position was 42° and started to move backward while the left thrust lever was at the position of 31.6°.
4. At 12:58:27 UTC, both thrust levers positions were about equal at 35°.
5. The A/P and A/T remained engaged during this event.

The investigation has interviewed both pilots of this flight. None of the pilot recalled or identified asymmetric thrust levers during the flight. No pilot report was filed into the AML after this flight.

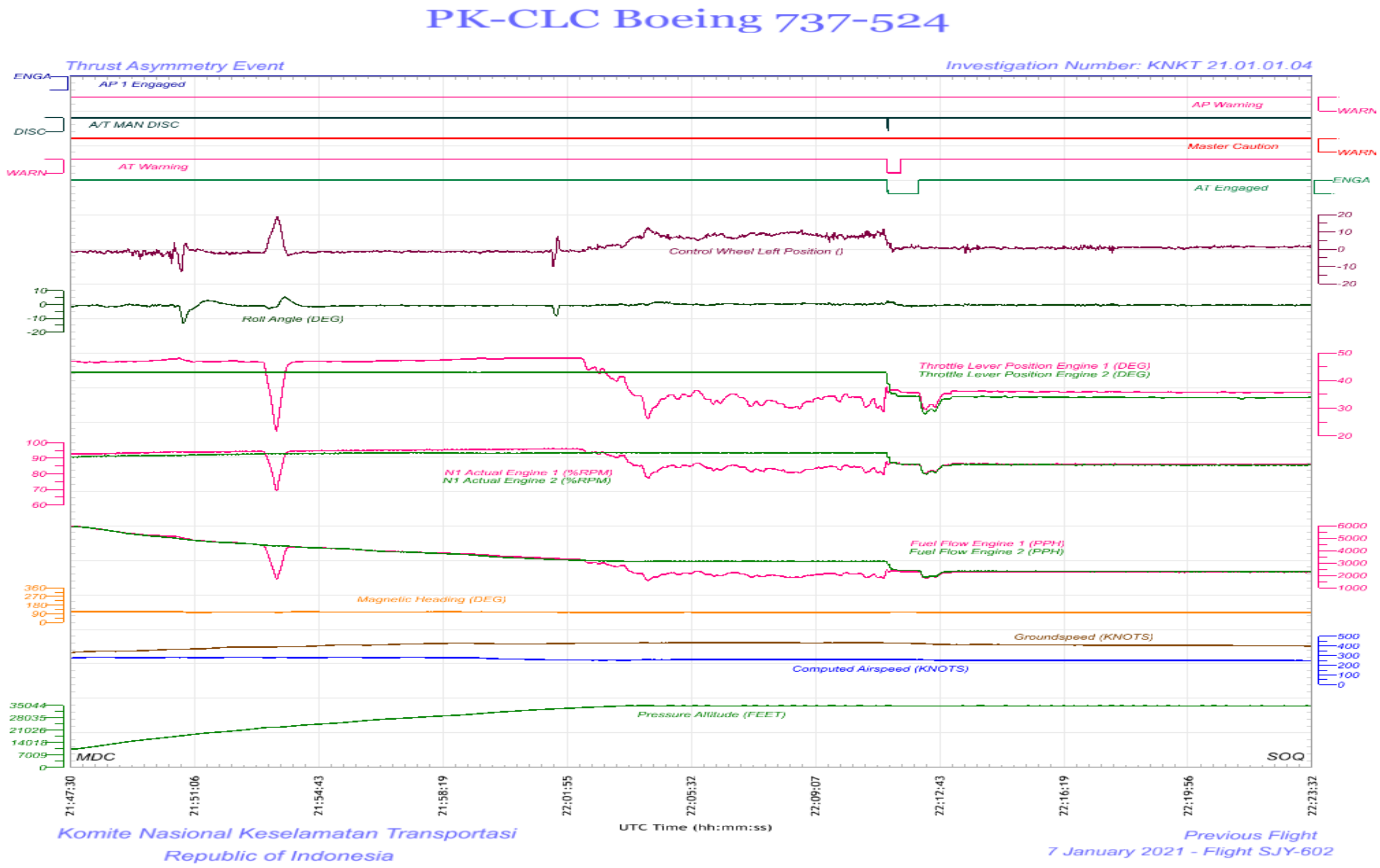

Figure 37: The QAR data of a flight on 7 January 2021

The QAR data of a flight on 7 January 2021 showed that:

1. The aircraft was climbing to its cruising altitude of 35,000 feet, on a heading 105°. The right thrust levers did not move from its position of 42.9° and the N1 speed of the right engine remained at 93%. The left thrust lever moved varied between 22° to 46° and the N1 speed of the left engine varied between 69% to 94%.
2. At 22:02:48 UTC:
   - the aircraft was climbing passing altitude about 34,300 feet,
   - the right thrust lever position was 42.9° and the N1 speed of the right engine was 93%,
   - the left thrust lever position was at 44.6° and started to move backwards while the N1 speed of the left engine was 93.8% and decreasing, and
   - the A/P and AT engaged.
3. At 22:03:39 UTC:
   - the aircraft reached the cruising altitude of 35,000 feet and maintaining a heading of 105°,
   - the left thrust lever position continued moving backwards and was passing 39.4°, while the right thrust lever position remained at 42.9°, and
   - the N1 speed of the left engine was 90.4% while the N1 speed of the right engine was 93%.
4. At 22:04:16 UTC:
   - the left thrust lever stopped at a position of 26.7° while the right thrust lever position remained at 42.9°,
   - the N1 speed of the left engine was 77.8% while the N1 speed of the right engine remained,
   - the aircraft was on heading of 104° and the roll angle was 0° and
   - the control wheel deflected to 11° to the right.
5. Thereafter the left thrust lever moved varied between 33° and 36° and the N1 speed of the left engine varied between 84% and 87%. The right thrust lever remained at 42.9°.
6. At 22:11:14 UTC:
   - the A/T disengaged, and
   - the right thrust lever moved backward and the left thrust lever moved forward.
7. AT 22:11:23 UTC, both thrust lever positions became equal about 36° and the N1 speed of both engines equal about 87%. The control wheel deflection moved to 0°.
8. At 22:12:08 UTC, the A/T was engaged. The aircraft continued the flight without any further asymmetric event and landed safely.

The investigation team has interviewed both pilots of the flight. Both pilots stated that they noticed fuel unbalance and thereafter noticed thrust lever asymmetry. The pilots disengaged the A/T, adjusted the thrust levers manually to about equal position and re-engaged the A/T. The A/P remained engaged during the asymmetric event occurred.

No pilot report was filed into the AML after this flight.

1.18.2 Guidance Material for Improving Flight Crew Monitoring

The International Air Transport Association (IATA) published the Guidance Material for Improving Flight Crew Monitoring in 2016. The guidance stated that monitoring is an overarching process requiring knowledge, skills and attitudes that enables flight crews to perform safely, effectively and efficiently. Monitoring includes the process of observing and creating a mental model, by seeking out available information to compare actual and expected aircraft state.

The monitoring consists of:

- Predictive monitoring supports anticipation of expected threats and the mitigation of consequences.
- Reactive monitoring supports:
  - identification of unexpected/pop-up threats and the mitigation of consequences
  - detection and correction of errors
  - recognition and recovery of undesired aircraft states.

Monitoring is performed during all phases of flight, from aircraft ground and pre-flight operations to take-off until landing, to after landing and post flight operations, and should be adapted to each phase of the flight.

Monitoring requires a combination of cognitive resource allocation such as attention, and a link to previously acquired knowledges (scripts and scenarios), which allow a pilot to detect, understand, project into the future, and then take the right decision/action. Monitoring includes comparing desired state against actual state, identifying deviations, proposing solutions, correcting, or intervening if necessary. When monitoring in a multi-crew environment, effective crew monitoring requires maintaining a shared mental model between flight crew members and communicating any changes or intentions with other flight crew members.

Flight crews must understand the two fundamental aspects of monitoring as a “role” versus monitoring as a “task”.

Monitoring as a “role”, describes the assignment of monitoring to the designated functional roles of the pilot, such as captain/first officer/relief pilot, and to the assigned roles as Pilot Flying and Pilot Monitoring during different phases of flight. Each operator should clearly define the roles of Pilot Flying and Pilot Monitoring and integrate operational policy, procedures and training in order to enhance a flight crew’s monitoring for both tasks and roles.

Monitoring as a “task” consists of:

- Requires the flight crew to observe, interpret and understand all relevant data (i.e., configuration, energy state, parameters, automation modes, automated systems, behavior of flight crew and information) related to the phase of flight,
- Involves a cognitive comparison against expected values, modes and procedures,

- Requires flexibility to allow flight crew to adapt and handle variability in the changing conditions of flight,
- Requires communication, including means to alert when significant deviations occur, and
- Includes intervention in a timely manner when the situation requires it.

While flight path management has the highest priority, the flight crew is required to monitor everything related to the flight, not just the flight path. Some of the issues that can contribute to the complexity of monitoring include:

- Workload management to
  - prioritize and perform tasks effectively and efficiently, and
  - manage and recover from interruptions, distractions, variations and failures
- Different types of monitoring based on the action itself (e.g., different monitoring required for a call out versus monitoring the weather ahead of aircraft)
- Prioritization based on desired outcomes
- Conditions requiring modifying monitoring goals when conditions change.

Another cause of the complexity of monitoring might be called "ironies of automation". Advanced aircraft systems are very reliable and flight crews rarely deal with malfunctions. The high reliability of systems may result in expectation of normalcy amongst flight crews, which can create trust or over-reliance in the automated systems which then can result in breakdowns in the monitoring process.

Flight crews need to actively manage mental processes to build their situation awareness. Monitoring involves effective management of attention, vigilance, memory, prioritizing, information processing, communication and adaptability. Its dependence on mental processes along with the limitations of the human capabilities, make monitoring a highly complex process in today's advanced flight decks and ATC environment. In addition, human factors such as memory, vigilance, and focus of attention bring complexity into monitoring.

Good monitoring requires knowledge, skills and attitudes as well as experience and communication; none of these can be taken in isolation.

Knowledge is provided through training. Experience is the application of knowledge, and skill is the product of both knowledge and experience.

Communication is fundamental to monitoring to ensure that the flight crew maintains the same complete mental model of presence and anticipation; "both as output and as input". Interactive briefings and facilitated (self-) debriefings used in daily operations may also be used to review and discuss mental models and behaviors that affected monitoring during the flight.

1.18.3 Human Factors References

1.18.3.1 Startle and Surprise

European Union Aviation Safety Agency (EASA)[21] described startle and surprise as follows:

The Theory of Startle and Surprise

By definition, unexpected events and/or intense stimuli always cause surprise and/or startle. However, not all unexpected events lead to large physiological and emotional reactions. An Air Traffic Controller asking for a slightly different airspeed than expected on approach is a surprise but, hopefully, will not lead to large physiological and emotional reactions. The focus of this project is startle and surprise reactions that are large enough to have an impact on performance and can negatively influence safety. Reactions may be large due to their high level of unexpectedness or because they take place in a safety critical and, at least perceived, time critical environment.

It is clear that startle and surprise play important roles in many aircraft incidents and accidents (see the accident and incident analysis in (NLR-CR-2016-620). However, definitions of startle and surprise vary and are even used interchangeably within the domain of aviation. This review starts with providing insight into these differences, mainly based on a comprehensive review by Rivera, Talone, Boesser, Jentsch, & Yeh, 2014.

Startle

The startle reflex is the first response to a sudden, intense stimulus. It triggers an involuntary physiological reflex, such as blinking of the eyes, an increased heart rate and an increased tension of the muscles. The latter are necessary to prepare the body for the fight-flight response (Koch, 1999). The startle response is accompanied by an emotional component which for a large part influences how a person responds to the unexpected event (Lang, Bradley, & Cuthbert, 1990).

The duration of the startle reflex, as with most reflexes, is very short and depends on the severity of the reflex. A mild reflex lasts less than one second and a high-intensity response can last up to 1.5 seconds. Startle reflexes are more severe during very low or very high arousal levels. In addition to the involuntary physiological reflexes, startle inhibits the muscular activity, thus a startled person stops doing what he was doing (Koch, 1999). The disruption can last from 100ms to 3 seconds for simple tasks and up to 10 seconds for more complex motor tasks (Rivera et al, 2014).

On the flight deck the disruption caused by the startle reflex can have detrimental effects, particularly when the startle is elicited when the pilot is performing flight essential tasks. A pilot can lose part of the situational awareness, due to distraction which might cause cognitive tunneling. And pilots might be interrupted in a difficult cognitive process, such as making a decision (Rivera, et al, 2014).

21 EASA. (2022). Startle Effect Management. The article can be found in the following link https://www.easa.europa.eu/document-library/research-reports/easarepresea20153.

Anatomy of the startle

When a person perceives a startling stimulus, the brain processes this in two ways (LeDoux, 1997); the 'quick and dirty' and the neocortex pathways. In the quick and dirty pathway, the perceived stimulus (see orange arrow in Figure 2-1) is first crudely analysed by a brain structure called the thalamus. This information is almost immediately sent to the amygdala (top white arrow) which will trigger a first response to the possible danger (bottom white arrows towards the body). In the neocortex pathway, the thalamus simultaneously sends a signal to the neocortex where it is further analysed (grey arrows in Figure 2-2. This path is slower than the 'quick and dirty' path directly from the thalamus to the amygdala, but processes the information deeper. The result from this analysis can be either that the threat is dangerous and that immediate action is indeed necessary, or that there is a false alarm and no actions are required.

From an evolutionary, survival perspective it makes sense to have an over-cautious, 'better safe than sorry' system in place when dealing with unexpectedness; an automatic and fast threat attribution to a Startle or Surprise. Afterwards, a slower and deliberate analysis of the situation takes place, possibly leading to a 'false threat' assessment. By then, all the physiological (increased heart rate, muscle tension and breathing, adrenaline secretion, etc.) and psychological (fear, possibly leading to anxiety and uncertainty) responses are taking place. If enough information is available to make this assessment rapidly, these responses fade away. However, in an unclear or ambiguous situation these high levels of physiological and psychological stress can persist. We assume this is what the flight crew of AF447 experienced, possibly leading to non-deliberate muscle activity (applying back pressure without being aware) and decreased cognitive capacity for situation assessment (not realizing the aircraft was in a stalled state). The slower and deliberate analysis of the situation sometimes takes place hours after the unexpected event. This happens when the fight or flight response is strong and creates a sense of urgency to take action, perceived time pressure. This action-mode inhibits slow and deliberate analysis.

Surprise

The psychology of surprise is about how people respond to unexpected events (Wickens, 2001). Surprise results from a disparity between a person's expectations and what is actually perceived (Horstmann, 2006). This implies that surprise can be elicited by the presence, but also by the absence of stimuli (e.g. Rivera et al. (2014); Bürki-Cohen (2010)). This contrasts with startle, because startle is always triggered by a sudden highly intensive stimulus and cannot be triggered by the absence of a stimulus. The effects of surprise are in part comparable to those of startle. Physiological responses to surprise include increased heart rate and blood pressure, cognitive responses include confusion and loss of situational awareness, and may involve the inability to remember the current operating procedures (Rivera et al. (2014)).

Even though startle and surprise often occur together, the startle reflex can be triggered without the notion of surprise. For example under anticipated circumstances when a person is told that a loud noise will be audible and when, this person will usually still have a startle reflex resulting from the loud noise (Ekman, Friesen, & Simons, 1985).

The duration of the surprise response is typically longer than that of the startle reflex. The discrepancy between expected and actual circumstances requires the person experiencing the surprise to reevaluate the situation to continue with the task. Larger discrepancies usually require more time for reevaluation than smaller discrepancies. Furthermore, the surprise also takes more time when the discrepancy requires an update of the expectations of the person experiencing the surprise (Horstmann, 2006).

The physiological response to surprise causes the attentional system to become more focused and impairs the working memory (Martin et al, 2012). The focus can help in evaluating the situation, especially when this is a dangerous situation in which you have to make choices quickly (Sapolsky, 1994). However, people tend to focus on the most salient information, which may not be the most important information at that moment (Rivera et al, 2014). Also, the combination of focused attention with the impaired working memory can cause problems for the person experiencing the surprise regarding his main tasks.

Startle versus Surprise

In contrast to startle, which always occurs as a response to the presence of a sudden, high-intensity stimulus, surprise can be elicited by an unexpected stimulus or by the unexpected absence of a stimulus. For a startle on the flight deck to occur according this definition a loud noise, a flash of light or a substantial displacement of the aircraft, or pilot seat is required.

Unexpected events can cause startle, they can cause surprise or they can cause startle and surprise combined. Only startle (e.g. you expected the balloon to explode and it does) is very rare in an aviation context and usually only creates very short term physiological reactions reaction. Startle combined with surprise (e.g. a lightning strike) is more common and only surprise (Expectations ≠ Reality) is the most common. The focus of the current project is on these last two, in a flight deck situation: startle combined with surprise and surprise only.

1.18.3.2 Confirmation Bias and Complacency

Confirmation bias is described as making a decision based on faulty information or incorrect reasoning which favors one understanding of an event (Harrivel et al., 2016) [22]. Parasuraman and Manzey (2010)[23] stated that when there was an automatically warning generated, pilot often ignore the contradicting information available or to believe as a result of confirmation bias effect.

The complacency is defined by the SKYbrary[24] as a state of self-satisfaction with one's own performance coupled with an unawareness of danger, trouble, or controversy. Parasuraman and Manzey (2010) described complacency might have made an operator in aviation (e.g., pilot) not to conduct sufficient checks of system state and assumed "all was well" when in fact a dangerous condition was developing.

22 Harrivel et al., (2016). Psychophysiological sensing and state classification for attention management in commercial aviation. The article can be found in the following link https://arc.aiaa.org/doi/pdf/10.2514/6.2016-1490

23 Parasuraman and Manzey, (2010). *Complacency and Bias in Human Use of Automation: An Attentional Integration*. The article can be found in the following link https://journals.sagepub.com/doi/10.1177/0018720810376055.

24 SKybrary. (2022). Complacency. The full article of complacency can be found in the following link https://skybrary.aero/articles/complacency.

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 ICAO Annex 13 to the Chicago Convention.

2 ANALYSIS

The investigation found that during the flight, there was a thrust lever anomaly. The thrust levers became asymmetry and the aircraft entered an upset condition. Thorough analysis of the pilots coordination could not be performed as throughout the flight, the PIC voice was only recorded when the voice was loud enough to be received in the in the SIC's headset microphone, and the channel of cockpit area microphone only recorded a prominent tone with a frequency of around 400 Hz which interfered with all other audio. The investigation was unable to determine the reason for the recorded a prominent tone in Channel 4.

The analysis of the investigation will discuss on the following topics:

- How the asymmetric power occurred and the likely reasons the CTSM on the subject aircraft did not disengage before the aircraft entered an upset condition.
- How the pilot could recognize the aircraft anomaly;
- How the aircraft entered the upset condition and the pilot recovery action;
- The pilot Upset Prevention and Recovery Training (UPRT);
- The aircraft maintenance management;
- The implementation of the Safety Management System.

2.1 The Autothrottle (A/T) Issue

2.1.1 Thrust Levers Asymmetric

During takeoff, the A/T was engaged in TO/GA mode and after the aircraft was airborne, at altitude of about 2,000 feet, the A/P was engaged in MCP SPD for vertical control and LNAV for lateral control. On these modes, the aircraft automation managed the speed, altitude and track by the preset programmed while on the ground. When the altitude was about 5,400 feet, the calculated rate of climb was about 3,500 to 4,000 feet/minute and the aircraft speed was about 220 knots, the lateral control was changed from LNAV to HDG SEL. The HDG SEL mode indicated that the aircraft flight path was controlled by selecting the heading on the Mode Control Panel (MCP) by the pilot.

At 07:38:35 UTC, at the altitude of about 7,800 feet, the A/P changed from MCP SPD to V/S mode, and the A/T changed from N1 to MCP SPD. These indicated that the A/T control would be adjusted according to the aircraft speed and the rate of climb value selected by the pilot on the MCP. The calculated rate of climb was about 3,600 feet/minute while the aircraft speed was about 225 knots.

Five seconds after, the calculated rate of climb was reducing to 3,100 feet/minute and the aircraft speed was accelerating. The left thrust lever started to move backwards from 47.5° and the N1 speed of the left engine started to decrease from 92.3%. The right thrust lever remained at 46.2° and the N1 speed of the right engine at 91.8%.

At 07:38:50 UTC, the PM requested a right turn to heading 075° to avoid a weather condition; the request was approved by the Terminal East controller (Air Traffic Control/ATC). With the HDG SEL mode engaged, it was most likely that the PF selected the heading to 075° on the MCP and the A/P responded properly as the aircraft continued to roll to the right.

At 07:39:01 UTC, ATC advised the flight to stop climb at an altitude of 11,000 feet and was acknowledged by the PM. It was most likely that the PF would select the MCP altitude to 11,000 feet.

At 07:39:19 UTC, when the aircraft altitude was about 9,800 feet, with the calculated rate of climb was decreasing to about 2,000 feet/minute, the aircraft speed indicated 230 knots, and the aircraft rolled to the right at an angle of about 15°. The aircraft speed increased to about 238 knots and thereafter remained about 238 knots until the A/P disengaged. The left thrust lever position was on 35° and the N1 speed of the left engine was at 81.5% and continued decreasing while the right thrust lever and N1 speed of the right engine remain unchanged.

In V/S mode, the aircraft automation (A/P and A/T) would control the aircraft according to the selection of aircraft speed and rate of climb on the MCP. The calculated rate of climb maintained about 2,000 feet/minute which most likely due to the selection of the rate of climb on the MCP was 2,000 feet/minute. The aircraft speed being maintained about 238 knots indicated that most likely the speed was selected to 240 knots.

When the aircraft has reached the selected targets of rate of climb and aircraft speed, the aircraft automation system normally would respond by maintaining the rate of climb and aircraft speed by coordinating with the A/T. During the initial climb, the rate of climb was between 3,500 and 4,000 feet/minute and the speed was about 225 knots. The engine thrust required during the initial climb was higher than the engine thrust during climb with HDG SEL and V/S mode, therefore the engine thrust decreased.

Since the right thrust lever position did not move backwards, the left thrust lever decreased more than normal to compensate the engine thrust required in capturing the selected speed and rate of climb. The thrust levers diverged and a thrust asymmetry occurred. Furthermore, the asymmetry became greater over time and eventually resulted in un-commanded roll to left instead of to the right.

The aircraft was delivered to the Sriwijaya Air in 2012. The investigation noted that the since 2013 until the accident flight, there were 65 problems related to the A/T system reported

The engineer's actions in attempting to address the reported A/T problem were dominated by cleaning the connectors (48%). Replacements of several components were also performed. The AML recorded replacement of right engine, however the A/T problems still occurred, this showed that the problem was not related to the engine. The engineer actions did not solve the problem.

The examination to the A/T system related components that were removed from the accident aircraft such as A/T servo and A/T computer, found that the problem was not caused by the failure of these components.

The AML also recorded 61 problems related to the difference of engine parameters between left and right engines, including 32 times of A/T disengagement. Most of the differences in the engine parameters were reported during the aircraft on descent. The AML also recorded the lack of thrust lever movement of the right engine as follow:

- Six pilot reports related to slow response of the right thrust lever to flight idle during descent.
- Two pilot reports related to the right thrust lever hard to move.

The lack response or hard to move the right thrust lever indicated that the thrust control cable experienced friction or binding within the mechanical system.

According to the AML and referring to the AMM, the rectification actions that had not been performed were the examination of the thrust lever control system extending from the throttle control box (in the cockpit) to the torque switch mechanism (in the electronic and equipment bay).

The torque switch mechanism was installed in-line with the engine control cables and servo mechanism. Whenever a problem such as high friction is experienced in the engine control cable, the torque switch will open.

This high friction could be due to the pilots intervening on the thrust lever and the torque switch will then open to allow the pilots' input on the thrust lever. When the pilots released the thrust lever, the friction will then reduce, and the torque switch will close and A/T control resumes. Similarly, a high enough friction force occurring in the throttle control cable can cause the torque switch to open and the throttle lever stopped being moved by the A/T system until the friction force is reduced.

In the accident flight, the right thrust lever did not move to capture the targets selected on the MCP therefore the left thrust lever continued move backwards to compensate the engine thrust required to capture the selected speed and rate of climb. This condition resulted in the thrust lever asymmetry.

Referring to the previous reported A/T problems, the rectification attempts, and the examination of the removed components, it can be concluded that the A/T system command being unable to move right thrust lever was a result of friction or binding within the mechanical system except the torque switch mechanism.

2.1.2 A/T Automatic Disengagement

The accident aircraft's A/T Computer (P/N 10-62017-30) complied with the United States Federal Aviation Authority (FAA) Airworthiness Directive (AD) number FAA AD 2000-23-34, dated December 4, 2000. This AD required compliance with Boeing Alert Service Bulletin 737-22A1130, dated September 24, 1998, which added a function to the A/T Computer called a Cruise Thrust Split Monitor (CTSM). The AD was prompted by reports of irregular A/T operation in which the thrust levers slowly moved apart resulting in an asymmetric thrust condition that caused the airplane to bank excessively and go into an un-commanded roll.

The CTSM monitors engine thrust and airplane roll input which was designed to disengage the A/T prior to the aircraft reaching a significant asymmetrical thrust condition that could compromise continued safe flight. The CTSM logic requires a left or right flight spoiler position input value of 2.5° or greater for 1.5 seconds or more to disengage the A/T to prevent further thrust asymmetry.

The A/T can be disengaged manually by using a disconnect button located on either thrust lever or by selecting a switch located on the MCP. Once disengaged the A/T is not able to move the throttle levers; however, the throttle levers can still be moved manually. The A/T disengagement is followed by the "A/T Arm" switch on the MCP releasing to off and flashing red A/T disengage lights.

The CTSM code was reviewed by both Boeing and the A/T Computer manufacturer with no anomalies identified. The A/T Computer manufacturer reviewed their historical documents which demonstrated satisfactory completion of required bench testing at the time of certification.

As the flight spoiler position was not recorded in the FDR, Boeing calculated the flight spoiler positions on the accident flight and the 15 March 2020, flight by correlating the spoilers to the control wheel positions recorded on the FDR. These calculations assumed nominal aircraft rigging and a neutral aileron trim setting, which could not be verified for the accident flight.

The FDR recorded at 07:39:40 UTC, the control wheels deflected to the right about 19°, the left aileron deflection down 3.3° and the right aileron deflected up 5.8°, the calculated spoiler deflection was 3.7°, and the aircraft roll angle was 15° to the right. Based on the CTSM design, the A/T should have been disengaged at this time as all requirements were met.

At 07:40:10 UTC, the A/T disengaged. The control wheel deflection recorded on the FDR around the time of A/T disengagement was between 20° and 33° to the right, which corresponds to a calculated spoiler deflection of between 4.14° and 9.47°.

The FDR did not record A/T manual disconnection at the time of the A/T disengaged, meaning that the disengage button on either thrust lever was not used by the crew to disengage the system. While it is possible for the A/T to be manually disengaged using a switch on the MCP, this would not be an expected technique during an upset recovery event. In addition, during the accident flight the thrust levers were not manually moved until 9 seconds after the A/T disengaged. It would seem unlikely that the crew would disengage the A/T manually but then waited 9 seconds to move the thrust levers.

The QAR data of the flight on 15 March 2020, revealed the same A/T disengagement signature as the accident flight. On this flight the control wheel deflection recorded on the FDR around the time of the first A/T disengagement was between 15° and 36° to the right, which corresponds to a calculated spoiler deflection of between 2.15° and 10.88°. The control wheel deflection recorded around the time of the second A/T disengagement was between 32° and 28° to the right, which corresponds to a calculated spoiler deflection was between 9.22° and 7.38°. In both the 15 March 2020 event and the accident event the disconnect occurred at the time when the control wheel first moved beyond the autopilot saturation position.. The QAR also did not record A/T manual disconnection and it would be even less likely that the MCP disconnect switch would be used in both upset events.

In both the 15 March 2020 event and the accident event the A/T disengaged timing showed that, the disengagement occurred at the time when the control wheel moved beyond the A/P saturation position of 5.75° deflection.

At this time, the aircraft had experienced asymmetric thrust that created an un-commanded roll. For these reasons it is unlikely that the A/T disengagement that occurred during the accident sequence was manually performed by the pilot. The analysis of the events found that the CTSM was active to disengage the A/T, however, it occurred late during the accident sequence after the un-commanded roll occurred due to the asymmetrical thrust.

Maintenance records indicated that the previous A/T Computer which was installed on the aircraft during the 15 March 2020 flight, also had a split thrust lever and roll event that was not prevented by the CTSM.

Examination and testing of the A/T Computer that was previously installed on the accident aircraft did not reveal any discrepancies related to split thrust levers or the CTSM logic.

In view that the logic review did not identify any anomaly with the CTSM code and the same non-activation of CTSM occurred on two different A/T Computers that were installed on the accident aircraft, the investigation determined that the A/T Computer is unlikely to be the cause of the CTSM not activating as expected during the accident flight.

The CTSM logic require inputs from the following aircraft sources: N1 left and right, power lever angle left and right, Mach, total air temperature (TAT), static pressure, flaps position, and flight spoiler position left and right. Of these inputs, only static pressure and N1 left and right values can be ruled out directly from FDR data.

The left and right power levers angle is used to derive thrust lever angle to calculate thrust when N1 is invalid. Thrust lever angle is recorded on the FDR.

Since power lever angle is only used if N1 left or right is invalid, and the FDR showed N1 left and right were both valid, the investigation determined it was unlikely that the power lever angle sensing was the reason the CTSM did not activate when expected.

The Mach and TAT signals are both digital signals. Mach is from ADC1, or if invalid, from ADC 2. TAT uses the higher of the two values from ADC1 or ADC2. If both signals are invalid, then the A/T computer will disengage. Mach is not recorded on the FDR. Other data provided by ADC1 that is recorded on the FDR appeared to be reasonable, suggesting that ADC1 was functioning normally. In addition, the Captain's Mach (left side) indicator, which uses the Mach signal from ADC1, had no recent maintenance writeups, suggesting that the Mach value from ADC1 was reasonable on recent flights. TAT was recorded on the FDR and appeared reasonable on the accident flight. For these reasons it was unlikely that the Mach and TAT input were the reason the CTSM did not activate when expected on the accident flight.

The flaps position signal input to the A/T Computer must be less than 12.5° (corresponds to a flaps operational setting of 10 or less) for the CTSM to operate. The synchro that provides the flaps signal to the A/T Computer is also used by the flaps indicator in the cockpit to position the left flaps needle and to activate the flaps asymmetry alert. Maintenance records do not indicate any recent pilot reports of a flap indicator problem nor flaps asymmetry. For these reasons, the investigation believes it is unlikely that the flaps signal sent from the left flap transmitter was an incorrect value.

The FDR revealed that the flap surfaces were positioned between 0 and 5 degrees for the entirety of the flight. Analysis by the A/T Computer manufacturer revealed that for this flap position range, there is only one flap-related wiring fault that could lead to a condition where the A/T Computer could be engaged but the CTSM function would be inhibited. If wire Vxz to the A/T Computer input was open (not connected), the computer interprets a 0° flap position as 40°. This would inhibit the CTSM when the flaps are at 0°. This failure would only be identified by performing the on-condition "CURRENT STATUS" or "LRU INTERFACE LRRA/FLAP/ALPHA VANE" ground maintenance A/T BITE tests. Maintenance records show that recent A/T Computer ground BITE tests (including on 4 January 2021 and 5 January 2021) were performed and the results were good. Also, the AML recorded that on 26 December 2020, stated "After Bite test L Alpha vane, L DADC & A/T #2 Failure" with no mention of a flaps related failure. It is likely that one of the two A/T BITE tests capable of detecting the open wire condition would have been performed during these recent maintenance activities, and there is no documentation from these maintenance activities that identifies a flap related failure.

If the open wire condition was present on both the accident flight and the 15 March 2020 flight, the CTSM would not have triggered on these flights. If the open wire condition was intermittent, it would seem unlikely that the CTSM activation would occur during such similar circumstances of high deflection of flight spoilers.

The investigation believes that flaps related failure or flaps open wire condition were unlikely to have been present on the accident flight.

The CTSM logic requires a left or right flight spoiler position input value of 2.5° or greater to activate. If either left or right flight spoiler position signals are invalid the logic will assume the spoiler position is greater than 2.5° and will allow the CTSM to activate if the remaining logic is met. The flight spoiler positions were not recorded on the FDR. The flight spoiler positions were calculated based on it being nominally rigged at a neutral aileron trim setting, though it could not be verified for the accident aircraft. Regardless, the results showed that the CTSM did not activate when the A/P aileron input reached saturation position, but likely did activate when control wheel input was manually increased beyond the A/P aileron saturation position. The additional control wheel input increased both the aileron and associated spoiler deflection. The only input to the CTSM that would be affected by the change in the control wheel position is the spoiler position signal magnitude. The possibility that the right flight spoiler position signal value read by the A/T Computer was too low to activate the CTSM and resulted in the delay of the A/T disengagement while the A/P was engaged. Therefore, the investigation believes it is possible that the right flight spoiler position signal value read by the A/T Computer was less than 2.5° and resulted in the delay of the A/T disengagement while the A/P was engaged.

The investigation could not determine the cause of the flight spoiler signal value being too low. The multiple sources that possibly caused a too low of the flight spoiler signal value, including a mis-rigged or erroneous spoiler sensor, mis-rigged spoiler actuator, or a sheared or damaged spoiler linkage.

The Sriwijaya Air advised to the investigation that flight spoiler sensor rigging had never been performed on PK-CLC aircraft while being operated by Sriwijaya Air as it never met the requirement to do so.

2.2 Factors Affected Pilot Action

In this subchapter, the analysis will discuss the factors that affected the pilot action during the accident flight. The discussion covers several topics as follows:

- Pilot Recognition of the Aircraft Problem;
- Upset Recovery After Bank Angle Warning;
- Upset Prevention and Recovery Training.

2.2.1 Pilot Recognition of the Aircraft Problem

At 07:38:40 UTC, when the aircraft was climbing through an altitude of about 8,100 feet in a right roll of about 20° following the pilot heading selection and passing a heading of 348°, the left thrust lever started to move backward while the right thrust lever remained unchanged on climb power. Subsequently, the thrust levers split resulted in the asymmetric engine power and the aircraft was unable maintain the right turn as commanded by the A/P.

Because the thrust levers are back driven by the A/T system, the thrust lever positions were not physically symmetrical and the engine instruments such as N1, EGT, N2, and Fuel Flow of the left and the right engines indicated differences. Had the crew noticed the engine parameters displayed on the Engines Instrument Primary Panel and at the physical thrust levers, it should have been a cue for the pilots to identify that the asymmetric power occurred.

The QAR data showed 7 occurrences of thrust levers split prior to the accident and based on the interviews none of the pilots noticed these until other indications were detected. The simulations performed in Jakarta and Las Vegas showed that the pilots did not realize the thrust levers split, until they noticed the engine parameters when they scanned the instrument panels. The thrust levers positions that were split might not have been monitored by the pilots as no engine power change required during this phase of the flight.

At 07:39:48 UTC, when the aircraft was climbing past altitude about 10,450 feet, on heading 046°, the aircraft was approximately wings level. Thereafter, the aircraft rolled to the left and reached a roll angle of 7° to the left at 07:39:54 UTC. The A/P remained engaged on V/S and HDG SEL mode, which was based on the last ATC clearance, and the intended heading was 075°.

The reduction in aircraft roll angle to wings level and continued to roll to the left would have been displayed on the EADI. The roll attitude of less than 5° would have attracted the pilot’s attention as it was much shallower than normal roll angle of about 20°.

The FCOM stated that at or above 10,000 feet, the pilot should set the landing light off and set the passenger sign as needed. When the aircraft climbed through an altitude of about 10,100 feet, the altitude alert activated followed by the PM called out “approaching 11,000”, at 07:39:37 UTC, which was a callout to remind the PF that the aircraft was about to reach the assigned altitude. The CVR also recorded that at 07:39:54 UTC, the PM called out “set standard” which was a call out to change the altimeter window from the aerodrome air pressure to standard barometric pressure. One second later, the ATC issued clearance for the aircraft to continue its climb to FL130 and this was acknowledged by the PM.

These pilot activities after the aircraft climbed through a passed altitude of 10,000 feet, might have diverted the pilot attention from monitoring the flight path. The CVR recorded an interval of 17 seconds between the callouts of "approaching 11,000" and "set standard". During the 17 second interval, the aircraft roll angle was decreasing to wings level and continued rolling to 7° to the left over a period of 6 seconds. The investigation could not determine the pilot activity during this 17 second interval however, this period should provide sufficient time for the pilots to revert to monitoring the flight path.

During the departure, at 07:38:50 UTC, the PM requested heading deviation for weather avoidance. The BMKG weather information stated that the visibility along the flight track was between 6 and 10 km. These indicated that the weather surrounding the flight path was cloudy. The weather condition might have made the pilot visual horizon which also can be used as a cue of the aircraft roll attitude to the pilot was not available.

According to the FCOM, the duty of the PF included flight path control and navigation, while the duty of the PM included monitoring flight path and navigation. The FCOM also stated that the pilot must always monitor aircraft course, vertical path and speed.

The PF's duty was to control the flight path and the PM's duty was to monitor it. The condition of the roll angle decreased to wings level and continued to roll to the left, was not monitored by the pilots even when sufficient time was available. The available cues were thrust lever position, engine instrument indications, and the aircraft attitude displayed on the EADI. The visual horizon which could be used as a cue was not available. The investigation could not determine the pilots attention during 17 seconds interval.

The simulation performed in Jakarta showed that the pilots performing the simulation had enough time to monitor the progress of the flight path and recognized the deviation of the flight.

The undetected roll angle indicated that both PM and PF of the accident flight did not perform their duties of monitoring flight path accordingly.

On 15 March 2020, the PF had experienced of asymmetric power which resulted in the aircraft deviating from the desired flight path. This event was successfully recovered and the aircraft continued its flight safely. There was no pilot report to the company and maintenance log write up after this event. It is unknown why the pilots did not report this to the company or write it up in the maintenance log but an event like this should have been reported.

During the accident flight, the pilots had adequate time to identify the aircraft roll angle which displayed on the EADI. However, the pilots did not identify that the aircraft was unable maintain the right turn as commanded by the A/P. This might be an indication that the pilots decreased their active monitoring of the flight path.

The pilot might have considered that monitoring the flight path was not so significant as the aircraft was in automation with the A/P and the A/T engaged and the aircraft automation system was reliable. The experience on 15 March 2020 flight might not change the pilot perception that the aircraft automation was reliable.

During the aircraft climbed passing 10,300 feet, the control wheels were deflected to the right which might be assumed by the pilot that the aircraft was turning to the right. This might have strengthened the pilot's belief that the aircraft was on the intended flight path. Under normal circumstances, the control wheel would have returned to a neutral position after the turn was initiated. The control wheel remaining deflected should have alerted the crew that an anomaly was present. However, because the aircraft was turning to the right and the control wheel was positioned to the right, this could have led to the pilots assuming the aircraft was performing the right turn as commanded and there was no anomaly. This phenomenon is known as confirmation bias when a person seeks information that confirms one's belief and disregards information that does not confirm one's belief.

The confirmation bias might have also contributed to the decreasing of active monitoring by the pilot.

The complacency that the aircraft automation system was reliable and the confirmation bias assuming that the aircraft was performing the right turn as commanded might have decreased the pilot active monitoring.

2.2.2 Upset Recovery After Bank Angle Warning

At 07:39:48 UTC, the A/P remained engaged on HDG SEL mode, which was based on the last ATC clearance, and the intended heading was 075°. The aircraft was climbing passing altitude about 10,450 feet, on heading 046°, the aircraft wing was about at level position thereafter, the aircraft rolled to the left.

According to the QRH, the definition of upset condition was any time when an airplane is deviating from the intended aircraft state. An aircraft upset can involve pitch or roll angle deviations as well as inappropriate airspeeds for the condition. In this case, the aircraft's wings level and began turning to the left is considered deviation from its intended heading was an indication of an aircraft upset condition. There was no pilot action taken in response to this aircraft upset condition.

At 07:39:59 UTC, the PM read back the ATC instruction to climb to FL130 (altitude of 13,000 feet). At this time the aircraft was passing the altitude of 10,550 ft, the rate of climb was about 950 feet/minute, the aircraft heading was on 036°, and it already rolled to the left with an angle of 24° bank, instead of banking to the right. The control wheel position was deflected to the right at an angle of 19,2°.

The ATC instruction to climb to FL130 was confirmed by the PF and reconfirmed by the PM at 07:40:03 UTC. At the time when the PM reconfirmed climb instruction to the PF, the EGPWS Bank Angle warning activated. This warning was triggered by the aircraft roll angle that was 37° to the left.

In order for the aircraft able to fly to FL130, the PF should change the altitude window on the MCP from the previous altitude clearance of 11,000 feet to 13,000 feet. The PF confirmation of the ATC clearance should have been followed by the PF action to select the altitude window on the MCP. Therefore, the PF most likely was looking to the MCP when the Bank Angle warning was active.

At 07:40:05 UTC, the A/P was disengaged by the activation of stabilizer trim switch as recorded on the FDR and the A/P disengage aural warning on the CVR. After the A/P disengaged, the control wheel position moved to the left on an angle between 10° to 18° for four seconds as the aircraft continued to roll to the left. As the A/P was no longer engaged and controlling the aircraft, therefore, the control wheel movement was likely induced by the pilot.

Based on the previous analysis topic (subchapter 2.2.1), it is unlikely the pilots were performing active monitoring prior to the upset where the EADI provided the necessary indications to roll right to level wings, the pilot might have decreased their active monitoring. Also, the PF might be focusing on the MCP to make input changes in the altitude window which might have altered the pilot's attention from the EADI resulting in the PF not being able to identify the aircraft roll attitude. While disengaging the A/P by activation of the manual electric trim, the PF hands might have felt that the control wheel was deflecting to the right.

These conditions might have created false assumption to the PF that the aircraft was still turning to the right and having not monitored the EADI, the PF might not be aware that it was the aircraft roll attitude that triggered the warning.

The condition of engine asymmetric power that led to the yaw and roll to the left was countered by the aileron and flight spoiler that were commanded by the A/P to turn the aircraft to the right. Disengaging the A/P has eliminated the aileron and flight spoiler forces to counter the asymmetric power therefore, the yaw and roll forces of the power asymmetric had become greater to roll the aircraft to the left. Four seconds of pilot action to turn the control wheel to the left increased the roll tendency of the aircraft to the left.

The Bank Angle warning, which is an indication of excessive roll angle, is an abnormal or hazardous condition that required to be corrected immediately. The sudden audible alert of the Bank Angle warning might surprise the pilots and followed by the immediate PF disengaging the A/P suggested that the PF could have been startled.

The PF might not be aware of the correct aircraft roll angle and the asymmetric power that caused the abnormal roll condition. The deflection of control wheel to the right and having not monitored the EADI might have made the pilot assumed that the aircraft was rolling excessively to the right and in response, the PF deflected the control wheel to the left to counter it. The initial four seconds of the pilot action after the disengagement of the A/P was not an appropriate response to the condition. The control wheel activation to the left created more rolling tendency to the left and it was contrary to restore the aircraft to safe flight parameters.

The Sriwijaya Air version of the Boeing 737 Quick Reference Handbook (QRH) on Upset Recovery required both PF and PM to recognize and confirm the developing situation by assessing the airplane attitude, airspeed, altitude and trend information through instrument crosscheck. According to the Sriwijaya Air version of the Boeing 737 CL FCTM, the ADI should be used as the primary reference in assessing the aircraft attitude and in this case the EADI. If the EADI was used as the primary reference, the anomaly of the control wheel deflection should not have affected the PF understanding of the aircraft attitude and the PF should be able to apply correct input for recovery.

2.2.3 Pilot Upset Prevention and Recovery Training

The ICAO Annex 6 requires pilot to be trained for Upset Prevention and Recovery Training (UPRT), which describes in detail on the ICAO Document 10011. The document requires UPRT to be conducted on academic and practical training, which should focus to areas of:

- heightened awareness – of the potential threats from events, conditions or situations;
- effective avoidance – at early indication of a potential upset-causing condition; and
- effective and timely recovery – from an upset to restore the aeroplane to safe flight parameters

The Indonesia CASR Part 121 has required pilot to be trained for upset recovery training since 2017. The regulation described that the upset recovery training was part of the Aircraft Flight Training requirements.

However, the CASR or other DGCA publication did not describe in detail the training requirement and has not included the prevention training on an upset condition.

Sriwijaya Air provided upset recovery training to its pilots which consisted of simulator training to perform an upset recovery maneuver every 24 calendar months during Pilot Proficiency Check. However, there was no detailed training program nor guidelines to conduct the upset recovery training.

The lack of detail of the upset recovery training program indicates the implementation of the upset recovery training inadequate in ensuring that pilots have enough knowledge to perform effective and timely recovery of an upset condition. This condition was supported by the fact that on the accident flight, the EADI as primary reference was not adequately monitored resulting in incorrect input for recovery.

The absence of the guidance of the national standard for the UPRT, might have made the Sriwijaya Air was unable to have adequate implementation of the UPRT.

2.2.4 Summary of the Factors that Affected Pilot Action

The investigation concluded that during the accident flight, the pilots should have enough time to monitor the thrust lever asymmetry and able to recognize deviation of the flight path. However, the pilots did not identify the flight anomaly before it developed into an upset condition. This lapse of not identifying the anomaly could be due to reduced active monitoring because of pilot automation complacency and confirmation bias that aircraft was performing the right turn as commanded.

Without using the EADI as primary reference in assessing the aircraft attitude, the pilot was not able to apply correct recovery inputs.

An effective UPRT should increase the ability of pilots to recognize and avoid situations that can lead to aircraft upsets, and to improve their ability to recover control of an upset aircraft. However, the absence of the guidance of the national standard for the UPRT have resulted in inadequate implementation of the UPRT.

2.3 Aircraft Maintenance Management

2.3.1 Autothrottle (A/T) Trouble Shooting

Since 2013 until the accident flight, the AML data recorded 65 pilot reports related to the A/T system and 61 problems related to the differences in engine parameters. The AML record showed that 48% of the A/T system maintenance actions involved cleaning of the electrical connectors.

The connector cleaning is part of the Electronic Wiring Interconnection System (EWIS) preliminary action however, the connector cleaning might have become a habit during the rectification as it is the easiest rectification action and appeared to be successful. Some of the reported problem appeared to be solved after the connector cleaning performed. The AML record showed that after the engineer had cleaned the electrical connector, the BITE test was performed which showed the result of "no faults". The engineers' entry into the AML did not indicate the page of the FMC/CDU which they accessed to perform the BITE test.

If the cleaning of the electrical connectors did not solve the A/T system problem, the Flight Management Computer (FMC) Control Display Unit (CDU) provides tools for thorough trouble shooting as directed by the Aircraft Maintenance Manual (AMM).

The use of FMC CDU is part of AMM trouble shooting therefore, the AMM reference must be included in the AML as required in the Sriwijaya Air Aircraft Maintenance Procedure (AMP). The "no faults" results might had been generated by the A/T computer that did not find any fault in the computer nor any electrical power connection to the A/T computer and not considered the reliability of the information from each component of the A/T system.

The maintenance actions were stopped after the BITE test resulted "no faults". Additional actions, based on pilots write ups, were available, as discussed in section 1.17.5. These included the subsequent FMC CDU test as described in the AMM 22-04-10 or 22-31-00, such as the guidance in the INTERACTIVE TEST page in the FMC CDU. Not performing these additional actions based on the specific maintenance issue might prevent the problem from being resolved. If the problem reappeared, the INTERACTIVE TEST page in the FMC CDU might have showed the identification of any BITE messages that generated by the erroneous system captured by the FMC CDU, that maybe FWD LOOP (torque switch fail to close) or THROT SPLIT (A/T disconnected in cruise due to a thrust split detected by the A/T).

Among the 61 pilot reports relating to the differences in engine parameters, more than 53 reports occurred during the aircraft descent.

According to the Sriwijaya Air version of the Boeing 737 CL Flight Crew Training Manual (FCTM), the use of A/T is recommended when the A/P is engaged for all phase of flight. Accordingly, the pilots would maintain the A/T engaged during the descent. On 7 March 2020, the pilot also reported that the right thrust lever was late to response during take-off roll after executing the TOGA switch. The differences in engine parameters during aircraft descent and the right thrust lever late on the take-off roll while the A/T engaged, most likely might have resulted in the thrust levers split.

The Quick Access Recorder (QAR) data recorded 7 thrust levers split occurrences between 2020 and 2021. No pilot reported on these occurrences in the AML. Most of the pilots stated that they did not recall the occurrences.

Based on the maintenance history the engineer referring to the AMM chapter 22-04-10 (A/T System BITE Trouble Shooting) showed a frequency of 18%, while the engineers referring to the AMM chapter 22-31-00 (A/T System – Description and Operation) was 25%. None of the maintenance history recorded the performance of the AMM chapter 71-00-49 (Power Plant – Trouble Shooting (Engine Controls)) trouble shooting procedure for aircraft experiencing thrust lever that is unable to move during A/T engagement.

If the FMC CDU INTERACTIVE TEST was performed for thrust lever movement problem during the A/T system engagement will result to FWD LOOP or THROT SPLIT fault messages. The subsequent trouble shooting steps would use procedure contained in the AMM chapter 71-00-49 (Power Plant–- Trouble Shooting (Engine Controls)). Similarly, for pilot report of thrust lever split event, the same troubleshooting step should also be in accordance with the procedure in AMM chapter 71-00-49, which contained maintenance steps to check the friction of the engine control cable.

Therefore, the termination of the trouble shooting after the BITE test result of "no faults" and without the pilot report of thrust lever split, resulted in the engineers stopped the trouble shooting steps and not proceed to examine the engine thrust control as required in AMM chapter 71-00-49. This is likely the reason why the defect prolonged.

2.3.2 Maintenance Management

On 20 December 2020, the reported A/T problem was entered in the Deferred Maintenance Item (DMI). The DMI was closed on 30 December 2020 after replacement of the A/T computer. On 3 January 2021, the A/T was reported as unserviceable. The engineer rectified the problem by cleaning the A/T computer and the BITE test result showed "no fault". On 4 January 2021, the A/T problem was again reported and entered in the DMI which was closed on 5 January 2021 after cleaning the TOGA (Takeoff/Go Around) switch. The flight data of the flights on 7 January 2021 and the accident flight, showed asymmetric thrust power events which indicated that the A/T system problem remained after the rectification on 5 January 2021.

The reported A/T problem was repeatedly deferred as DMI from 20 December 2020 to 4 January 2021. The DMI was first raised on 20 December 2020 and was rectified and closed on 30 December 2020. But the defect was reported again on 3 and 4 January 2020 and DMI raised again which indicated that the A/T problem was not properly rectified.

Maintenance records indicated that rectifications performed by line maintenance engineers of similar problem since 2013 were by carrying out a BITE test. After the BITE test result showed "no faults", the engineers stopped the trouble shooting process and signed off the defect without progressing to the steps of carrying out the "INTERACTIVE TEST" in the FMC CDU menu.

The Sriwijaya Air maintenance management established the MCC which has responsibilities including monitoring the defect and DMI rectification. The progress of DMI rectification was recorded and monitored through DMI control/summary. The DMI control/summary was collected and review by the MCC on daily and weekly basis. MCC should have a process in place to identify and definitively resolve recurring maintenance issues

It is likely that line maintenance engineers were not made aware of the recurring A/T problem on this aircraft and have been performing the BITE test to clear the defect. As such further trouble shooting efforts should be initiated by MCC who has been monitoring for recurring defects under its maintenance management program. However, the monitoring efforts by MCC did not appear to have raised awareness amongst the line maintenance engineers of the recurring A/T defect and the additional trouble shooting steps in the “INTERACTIVE TEST” function in the FMC CDU menu.

It is evident that the recurring defect monitoring efforts under the maintenance management program has not been implemented effectively given the prolonged unsolved A/T defect on the accident aircraft.

2.4 Safety Management System

Sriwijaya Air has established Safety Management System (SMS) managed by Quality, Safety and Security Department (QSS). The safety management process includes, but not limited to the management of the safety reporting system and flight data monitoring program for monitoring safety performance continuously.

Sriwijaya Air has established the Flight Data Analysis Program (FDAP) as one of several methods to identify operational exceedances and confirming normal operating procedures. The FDAP monitors safety events including excessive bank angle throughout the flight and thrust asymmetric condition during approach or engine thrust reverse application on landing. The data retrieval of the FDAP showed that since 2018 until 2020, the average data retrieval was 28.1% with the maximum data collected was 54.8% on April 2020. The less FDAP data analysis reduced the ability to monitor flight operation safety performance.

The QAR data of PK-CLC was downloaded, however Sriwijaya Air was unable to analyze the data as it did not have the correct data frame file to process the PK-CLC QAR data. As a result, the excessive bank angle event due to thrust asymmetry during the flight on 15 March 2020 was not detected. For subsequent thrust asymmetry events, the event conditions did not meet the triggering value set in the FDAP and were not captured.

The investigation received samples of hazard reporting in the period of 2020 which consisted of 565 hazard reports. The evaluation of these data showed that majority of the hazard were reported by ground personnel. Few hazards were reported by pilots and maintenance personnel and there was no hazard report by dispatchers. This unbalance composition of the hazard reporters is likely an indication that the hazard reporting program has not been emphasized to all employees which could result in hazards not identified and properly mitigated.

In November 2019, the QSS carried out the Hazard Identification Risk Analysis (HIRA) of the hazard identified following the termination of the joint operation and maintenance with another aircraft operator and approved maintenance organization which terminated in December 2019. The HIRA stated that 9 of 10 hazards were within the intolerable region with the risk index of 4B (high risk). The 9 hazards that were classified as 4B were assessed and the mitigations were proposed which reduced to tolerable region with risk index of 3B (moderate risk). The Sriwijaya Air Safety Management System Manual stated that hazard in tolerable region would still require further risk management to ensure that the hazards were effectively controlled and that the mitigation action did not create any new hazard. The investigation did not find any evidence of further risk management for the 9 hazards which were reduced to the tolerable region.

The list of hazards in the HIRA that was made during the termination of the joint cooperation, did not include the ability to maintain FDAP, that was performed by another approved maintenance organization. The FDAP data retrieval showed there were no QAR data retrieved during the period of October to December 2019 which was due to lack of human resources and equipment. The investigation noted that the HIRA did not describe the details of the hazards that may have exist.

The evidence of low rate of FDAP data analysis, unbalance composition of hazard reporters, and the lack of detail in the hazard identification suggested that Sriwijaya Air safety management system (SMS) has not been implemented effectively.

3 CONCLUSIONS

3.1 Findings

The findings are statements of all significant conditions, events or circumstances in the accident sequence. The findings are significant steps in the accident sequence, but they are not always causal, or indicate deficiencies. Some findings point out the conditions that pre-existed the accident sequence, but they are usually essential to the understanding of the occurrence, usually in chronological order.

1. Boeing 737-500 aircraft registered PK-CLC started to be operated by Sriwijaya Air since 2012.
2. PK-CLC aircraft complied with the FAA Airworthiness Directive (AD) 2000-23-34 to address asymmetric thrust events, by the incorporation of the Cruise Thrust Split Monitor (CTSM), prior to delivery to Sriwijaya Air.
3. The CTSM monitors flight spoiler position and the net thrust difference between the two engines based on their N1 values. When the difference in the output thrusts exceeds a calculated limit for the flight conditions present, and the amount of flight spoiler deflection is greater than 2.5° for 1.5 seconds, the A/T will be disengaged.
4. Since 2013, the AML recorded 65 pilot reports relating to the A/T, including 32 pilot reports of A/T disengagement. In addition to the 65 A/T pilot reports, the AML also recorded 61 pilot reports relating to differences in engine parameters which 53 out of the 61 reports occurred during descent. The AML also recorded 69 pilot reports relating to the problem of A/P.
5. The AML record showed that 48% the A/T system maintenance actions taken involved cleaning of the electrical connectors. Additional maintenance actions taken involved the replacement of the suspected faulty components of the A/T system. The investigation conducted examination of the previously installed components and did not find any abnormality of the component examined.
6. The AML recorded replacement of engine, however the A/T problems still occurred, this showed that the problem was not related to the engine.
7. Since 24 March 2020 until 19 December 2020, Sriwijaya Air grounded the PK-CLC aircraft for several maintenance performances. Since the aircraft was released to service until the accident flight, the AML recorded 43 pilot reports, including 3 pilot reports of A/T problem. Among the pilot reports, 6 were entered as DMI of which 2 were related to A/T problem.
8. The Quick Access Recorder (QAR) data recorded 7 asymmetric thrust lever events between 2020 and 2021. There was no pilot report of these occurrences in the AML. Most of the pilots stated that they did not recall the occurrences.
9. One of the asymmetry thrust lever events occurred on 15 March 2020, which resulted in the aircraft rolled to the left up to 41º. The A/T disengaged when the calculated flight spoiler deflection was 10.8°. It was most likely that the A/T disengaged by the activation of CTSM. The accident flight PF was the PIC on this flight.

10. The accident flight of PK-CLC was on 9 January 2021, when the aircraft was being operated on a scheduled passenger flight from Jakarta with intended destination of Pontianak, on flight number SJY182. On board the flight was 6 crew and 56 passengers.
11. The pilots and the flight attendants held valid licenses and medical certificates.
12. The air traffic controller on duty held valid license and medical certificate.
13. The aircraft had valid Certificate of Airworthiness (C of A) and Certificate of Registration (C of R). The aircraft was operated within the weight and balance envelop.
14. The Flight Data Recorder (FDR) equipped in the aircraft did not record the aircraft rate of climb/descend and the spoiler deflection angle. The data for these parameters in this investigation report were based on calculation.
15. The Cockpit Voice Recorder (CVR) equipped in the aircraft only recorded the PIC voice when the voice was loud enough to be received in the in the SIC's headset microphone, and the channel of cockpit area microphone only recorded a prominent tone with a frequency of around 400 Hz which interfered all other audio.
16. The CVR downloaded in 2019 for renewal of the C of A, found the Channel 4 recorded a tone with a frequency of 400 Hz. The CVR download in 2020 found that the Channel 4 recorded conversation between engineers. The result for both downloads stated that the CVR was functioning correctly. The investigation was unable to determine the reason of why Channel 4 recorded a prominent tone with a frequency of about 400 Hz in 2019 and the accident flight while the recording that were downloaded in 2020 were normal.
17. At 0736 UTC (1436 LT) in daylight conditions, flight SJY182 departed from Runway 25R of Jakarta, and the FDR data recorded that the A/T was engaged in N1 mode after airborne and the A/P system engaged at altitude of 1,800 feet.
18. At 07:38:00 UTC, the A/P lateral control changed from LNAV to HDG SEL and five seconds after, the A/P vertical control changed to Pitch V/S and A/T changed from N1 to MCP SPD. The change in A/P mode required less engine thrust.
19. The SJY182 pilot requested to the Terminal East controller (Air Traffic Controller/ATC) for a heading change to 075° to avoid weather conditions and was approved. The ATC predicted that the heading change would make the flight path of SJY182 conflict with another aircraft that was departing from Runway 25L to the same destination. Therefore, the ATC instructed the SJY182 pilot to stop climbing at 11,000 feet.
20. The weather radar provided by the *Badan Meteorologi Klimatologi dan Geofisika* (BMKG – Bureau of Meteorology, Climatology and Geophysics), did not indicate any significant development of clouds along the accident flight path.
21. The change in A/P mode required less engine thrust and the FDR data recorded when the left thrust lever and the N1 speed of the left engine started continuously reducing, while the right thrust lever and N1 speed of the right engine remained fixed until the aircraft entered an upset condition.

22. The investigation assumed that the A/T system command was unable to move right thrust lever as a result of friction or binding within the mechanical system, except the torque switch mechanism

23. Since the right engine thrust lever position did not move backwards, the left engine thrust lever decreased more than normal to compensate the engine thrust required in capturing the selected speed and rate of climb, and the thrust levers became asymmetry.

24. The design of the CTSM described that the CTSM should disengage the A/T when the flight spoiler deflects greater than 2.5° for a minimum of 1.5 seconds.

25. At 07:39:40 UTC, the aircraft climbed passed an altitude of about 10,250 feet and was turning to the right at a roll angle of 15º, with the control wheels deflected to the right about 19°, the left aileron deflection down 3.3° and the right aileron deflected up 5.8°, the calculated spoiler deflection was 3.7°. These conditions met the requirement of the CTSM activation to disengage the A/T however it was delayed. Should the CTSM activated timely, the further thrust asymmetry could be prevented.

26. The QAR data of a flight on 15 March 2020 showed that the CTSM disengaged the A/T when the control wheel deflection was between 15° and 36° to the right, which corresponds to a calculated spoiler deflection of between 2.15° and 10.88° and on the accident flight the CTSM disengaged the A/T when control wheel deflection was between 20° and 33°, which corresponds to a calculated spoiler deflection of between 4.14° and 9.47°. In both events the A/T disengaged at the time when the control wheel moved beyond the A/P saturation position.

27. The investigation believes that the delay of CTSM activation was possibly due to the right flight spoiler position signal value read by the A/T Computer was too low to activate the CTSM. The investigation could not determine the cause of the flight spoiler signal value being too low. The multiple sources that possibly caused a too low of the flight spoiler signal value, including a mis-rigged or erroneous spoiler sensor, mis-rigged spoiler actuator, or a sheared or damaged spoiler linkage.

28. The Sriwijaya Air advised to the investigation that flight spoiler sensor rigging had never been performed on PK-CLC aircraft while being operated by Sriwijaya Air as it never met the requirement to do so.

29. At 07:39:48 UTC, the FDR data recorded that when the aircraft's altitude was about 10,450 feet and the heading was 046º. The aircraft began turning to the left instead of to the right as a result of the thrust lever asymmetry.

30. At 07:39:54 UTC, the ATC instructed SJY182 to climb to an altitude of 13,000 feet, and the instruction was read back by the SIC at 07:39:59 UTC. This was the last known recorded radio transmission by the flight.

31. At 07:40:05 UTC, the A/P disengaged when the aircraft altitude was about 10,700 feet due to the pilot's activation of the stabilizer trim switch. Thereafter the aircraft continued to descend until the end of FDR recording.

32. There were several indications available that the pilots could have checked to identify the aircraft anomalies, such as engine parameters, thrust levers position, and roll angle displayed on the EADI. The FCOM stated that the pilot must always monitor aircraft course, vertical path and speed.

33. The aircraft's wings level and began turning to the left is considered a deviation from its intended heading and was an indication of an aircraft upset condition. There was no pilot action taken in response to this aircraft upset condition. The absence of pilot action suggested that both PF and PM were not adequately performing their duties in monitoring the aircraft in a proper flight path.

34. The condition of engine asymmetric power that led to the yaw and roll to the left was countered by the aileron and flight spoiler that were commanded by the A/P to turn the aircraft to the right. When the A/P was disengaged, the aileron and flight spoiler forces that countered the asymmetric power were removed and as a result, the yaw and roll forces of the asymmetric power rolled the aircraft to the left. Four seconds of pilot action to turn the control wheel to the left increased the roll tendency of the aircraft to the left.

35. The EGPWS Bank Angle warning activation was triggered by the aircraft roll angle of 37° to the left. The deflection of control wheel to the right and inadequate monitoring of the EADI might have made the pilot assumed that the aircraft was rolling excessively to the right and deflected the control wheel to the left to recover it. The control wheel activation to the left created more roll tendency to the left which was counter to restoring the aircraft to safe flight parameters.

36. The investigation concluded that during the accident flight, the pilots should have enough time to monitor the thrust lever asymmetry and able to recognize deviation of the flight path. However, the pilots did not identify the flight anomaly before it developed into an upset condition. This lapse of not identifying the anomaly could be due to reduced active monitoring because of pilot automation complacency and confirmation bias that aircraft was performing the right turn as commanded. Without using the EADI as primary reference in assessing the aircraft attitude, the pilot was not able to apply correct recovery inputs.

37. An effective UPRT should increase the ability of pilots to recognize and avoid situations that can lead to aircraft upsets, and to improve their ability to recover control of an upset aircraft.

38. The ICAO Annex 6 requires pilot to be trained for Upset Prevention and Recovery Training (UPRT), which describes in detail on the ICAO Document 10011. The document requires UPRT to be conducted on academic and practical training.

39. The Indonesia CASR Part 121 has required pilot to be trained for upset recovery training since 2017. The CASR or other DGCA publication did not describe in detail the training requirement and has not included the prevention training of an upset condition.

40. Sriwijaya Air provided upset recovery training to its pilots which consisted of simulator training to perform an upset recovery maneuver every 24 calendar months during Pilot Proficiency Check. However, there was no detailed training program nor guidelines to conduct the upset recovery training.

41. The lack of detail of the upset recovery training program of Sriwijaya Air indicates the implementation of the upset recovery training inadequate in ensuring that pilots have enough knowledge to prevent and recover an upset condition effectively and timely.

42. The absence of the guidance of the national standard for the UPRT, might have made the Sriwijaya Air was unable to have adequate implementation of the UPRT.

43. The procedure on the Sriwijaya Air version of the Boeing 737 QRH required the PM to call out attitude, airspeed and altitude throughout the recovery. The Sriwijaya Air modified the procedure described in the Sriwijaya Air Training Aid that required the PM to callout "upset brown", for an upset in nose down position, followed by the requirement to inform the ATC "May Day 3x, SJY___ Upset".

44. The Sriwijaya Air did not ask for a NTO (No Technical Objection) from the aircraft manufacturer nor was the DGCA consulted for this modification.

45. During an observation of the Sriwijaya Air upset recovery training after the accident, this additional task impeded the PM from communicating the aircraft state, including attitude, airspeed, altitude, or other deviations during the recovery, or assisting the PF in the upset recovery process to the PF, such as verifying all required actions have been accomplished. In the upset recovery exercises observed, it was noted that due to this additional non-pertinent task by the PM, the aircraft entered an over speed situation and which subsequently, entered developed into an accelerated stall.

46. At 07:40:48 UTC, the radar target of the aircraft disappeared from the ATC radar screen. About 0755 UTC, the Air Traffic Services (ATS) provider reported the occurrence to the Indonesian Search and Rescue Agency (*Badan Nasional Pencarian dan Pertolongan*/BNPP), and at 0842 UTC, declared the uncertainty phase (INCERFA) of the SJY182. The distress phase of SJY182 (DETRESFA) was subsequently declared at 0943 UTC.

47. The search team identified that the wreckage was about 80 meters Southeast from the last known aircraft position recorded by the Automatic Dependent Surveillance – Broadcast (ADS-B). The wreckage was distributed across an area of about 80 by 110 meters on the seabed at a depth of approximately 16 meters.

48. The ATS in Jakarta is provided by AirNav Indonesia branch office Jakarta Air Traffic Service Center (JATSC) which held a valid ATS provider certificate.

49. The JATSC Standard Operation Procedure (SOP) for Approach Control Services contained guidance in declaring an aircraft which was suspected or deemed to be in an emergency in the event that the pilot of the aircraft could not be contacted or a loss of communication with the aircraft.

50. The JATSC SOP also mentioned several states of emergency that are in accordance with the standard requirement in Civil Aviation Safety Regulation (CASR) Part 170.

51. The determination of the states of emergency in the CASR Part 170 was adopted from ICAO Annex 11 subchapter 5.2 without including the alternative conjunction (or) on each state of the emergency. This was not in accordance with the standard described in the ICAO Annex 11.

52. Since 2013 until the accident flight, the AML data recorded 65 pilot reports related to the A/T system and 61 problems related to the differences in engine parameters. The AML record showed that 48% of the A/T system maintenance actions involved cleaning of the electrical connectors.

53. The maintenance actions were stopped after the BITE test resulted “no faults”. Additional actions, based on pilot write ups, were available, including the subsequent FMC CDU test as described in the AMM 22-04-10 or 22-31-00, such as the guidance in the INTERACTIVE TEST page in the FMC CDU. The subsequent trouble shooting steps would use procedure contained in the AMM chapter 71-00-49 (Power Plant–- Trouble Shooting (Engine Controls)).

54. The troubleshooting step for pilot report of thrust lever split event, should also be in accordance with the procedure in AMM chapter 71-00-49, which contained maintenance steps to check the friction of the engine control cable.

55. The termination of the trouble shooting after the BITE test result of “no faults” and without the pilot report of thrust lever split, resulted in the engineers stopped the trouble shooting steps and not proceed to examine the engine thrust control as required in AMM chapter 71-00-49. This is likely the reason why the defect prolonged.

56. The reported A/T problem was repeatedly deferred as DMI from 20 December 2020 to 4 January 2021. The DMI was first raised on 20 December 2020 and was rectified and closed on 30 December 2020. But the defect was reported again on 3 and 4 January 2020 and DMI raised again which indicated that the A/T problem was not properly rectified.

57. The Sriwijaya Air maintenance management established the MCC which has responsibilities including monitoring the defect and DMI rectification. The progress of DMI rectification was recorded and monitored through DMI control/summary which review by the MCC on daily and weekly basis.

58. The monitoring efforts by MCC did not appear to have raised awareness amongst the line maintenance engineers of the recurring A/T defect and the additional trouble shooting steps in the “INTERACTIVE TEST” function in the FMC CDU menu.

59. It is evident that the recurring defect monitoring efforts under the maintenance management program has not been implemented effectively given the prolonged unsolved A/T defect on the accident aircraft.

60. The Flight Data Analysis Program (FDAP) established by the Sriwijaya Air retrieved an average data of 28.1%. The low rate of FDAP data analysis reduced the ability of the program in monitoring flight operation safety performance.

61. The QAR data of PK-CLC was downloaded, however Sriwijaya Air was unable to analyze the data as it did not have the correct data frame file to process the PK-CLC QAR data. As a result, the excessive bank angle event due to thrust asymmetry during the flight on 15 March 2020 was not detected. For subsequent thrust asymmetry events, the event conditions did not meet the triggering value set in the FDAP and were not captured.

62. The samples of the hazard reporting of the Sriwijaya Air on the period of 2020 showed that majority of the hazard were reported by ground personnel. Few hazards were reported by pilots and maintenance personnel and there was no hazard report by dispatchers. This unbalance composition of the hazard reporters is likely an indication that the hazard reporting program has not been emphasized to all employees which could result in hazards not identified and properly mitigated.
63. The list of hazards in the HIRA that was made during the termination of the joint cooperation, did not include the ability to maintain FDAP, that was performed by another approved maintenance organization. The FDAP data retrieval showed there were no QAR data retrieved during the period of October to December 2019 which was due to lack of human resources and equipment. The investigation noted that the HIRA did not describe the details of the hazards that may have exist.
64. The evidence of low rate of FDAP data analysis, unbalance composition of hazard reporters, and the lack of detail in the hazard identification suggested that Sriwijaya Air safety management system (SMS) has not been implemented effectively.

3.2 Contributing Factors

Contributing factors is defined as actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident or incident occurring, or mitigated the severity of the consequences of the accident or incident.

The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability. The presentation of the contributing factors is based on chronological order and does not show the degree of contribution.

The KNKT concluded the contributing factors as follows:

- The corrective maintenance processes of the A/T problem were unable to identify the friction or binding within the mechanical system of the thrust lever and resulted in the prolonged and unresolved of the A/T problem.
- The right thrust lever did not reduce when required by the A/P to obtain selected rate of climb and aircraft speed due to the friction or binding within the mechanical system, as a result, the left thrust lever compensated by moving further backward which resulted in thrust asymmetry.
- The delayed CTSM activation to disengage the A/T system during the thrust asymmetry event due to the undervalued spoiler angle position input resulted in greater power asymmetry.
- The automation complacency and confirmation bias might have led to a decrease in active monitoring which resulted in the thrust lever asymmetry and deviation of the flight path were not being monitored.
- The aircraft rolled to the left instead of to the right as intended while the control wheel deflected to the right and inadequate monitoring of the EADI might have created assumption that the aircraft was rolling excessively to the right which resulted in an action that was contrary in restoring the aircraft to safe flight parameters.
- The absence of the guidance of the national standard for the UPRT, may have contributed to the training program not being adequately implemented to ensure that pilots have enough knowledge to prevent and recover of an upset condition effectively and timely.

4 SAFETY ACTION

At the time of issuing this report, the *Komite Nasional Keselamatan Transportasi* (KNKT) had been informed of safety actions resulting from this occurrence.

4.1 Directorate General of Civil Aviation

On 11 January until 3 February 2021, the Directorate General of Civil Aviation (DGCA) conducted special inspection on all Boeing 737-300/400/500 aircraft in Indonesia. The areas of the inspection were as follow:

- Airworthiness Directive (AD) compliances;
- routine and major inspection implementations;
- continuing analysis surveillance program implementation including the management of repetitive defects;
- pilot training program implementation, including weather avoidance and upset recovery training program;
- pilot proficiency check implementation;
- flight duty time limitation and pilot recent experience;
- implementation of DGCA Circular regarding COVID-19 pandemic.

On 28 January 2021, the DGCA initiated a discussion with aircraft operators on the implementation of upset prevention and recovery training (UPRT) program.

On 29 January and 4 February 2021, the DGCA initiated a discussion with aircraft operators and approved maintenance organizations related to the handling of repetitive problem.

On 10 February 2021, KNKT issued two safety recommendations addressed to the DGCA which had been responded by several corrective actions as follows:

- ***04.R-2021-01.01***

  The ICAO Annex 6 (Part I – International Commercial Air Transport – Aeroplanes) required the aircraft operators to establish and maintain upset prevention and recovery training (UPRT) program. The ICAO Doc 9868 (Procedure for Air Navigation Services – Training) provided procedures in the delivery of upset prevention and recovery training for aeroplane pilots.

  The ICAO Doc 10011 (Manual on Aeroplane Upset Prevention and Recovery Training) also provided guidance to civil aviation authorities, aircraft operators and approved training organization (ATOs) for instituting best practices into the UPRT. The ICAO Doc 10011 described that the UPRT should focus on the areas of heightened awareness of the potential threats from events, conditions or situations; effective avoidance at early indication; and effective and timely recovery.

  ICAO also provided Airplane Upset Prevention & Recovery Training Aid (AUPRTA), as an effort to increase effectiveness of UPRT.

The CASR Part 121 required aircraft operators to have initial and recurrent for "Aircraft Flight Training" which included upset recovery training that might be accomplished in an aircraft or aircraft type simulator, as described in the Appendix C.

In 2018, the DGCA published a safety circular that required an aircraft operator to conduct upset prevention and recovery training. The requirement for upset prevention training has not been included in CASR Part 121.

The investigation was unable to find guidance from the DGCA to aircraft operator and/or approved training organization (ATO) to enable and support the implementation of effective upset prevention and recovery training.

Therefore, KNKT recommends the DGCA to include a requirement of UPRT in the CASR and to develop guidance to increase the effectiveness of UPRT.

Responding to the safety recommendation above, the DGCA had accelerated the UPRT program by assigning a special task force to implement the UPRT on 25 June 2021. The UPRT task force included the participation of DGCA Inspectors, DGCA Test Pilot, aircraft operator flight instructors, and aircraft operator UPRT instructors. The UPRT task force has duties as follows:

1. Review and develop guidance for UPRT implementation in Indonesia,
2. Review and develop regulations related to UPRT in Indonesia,
3. Implement UPRT program in Indonesia,
4. Develop a technical guidance and accelerate UPRT implementation in Indonesia,
5. Arrange agreement with internationally recognized UPRT expert.

The UPRT task force has completed several actions as follows:

1. On 17 June 2021, completed the draft Advisory Circular for UPRT,
2. On June 2021, completed the draft of amendment of the CASR Part 121 including the provision related to UPRT,
3. On 8 September 2021, completed initial review of UPRT Implementation Plan proposed by an international UPRT expert,
4. On 21 October 2021, completed reviewing of international UPRT expert proposal.

- ***04.R-2021-01.02***

  The ICAO Annex 11 subchapter 5.2 described the state of emergency that requires notification to the rescue coordination center, this standard was adopted in the CASR Part 170 subpart 5.2. However, the adoption of determination of the state of emergency did not include the alternative conjunction (or), which was not in accordance with the Standard 5.2 described in the ICAO Annex 11. The absence of the conjunction may confuse the determination of the state of emergency and may delay the activation the search and rescue activity.

  Therefore, KNKT recommends the DGCA to review the requirements of notification of rescue coordination center in the CASR Part 170 to ensure that the requirement is in accordance with the standards in ICAO Annex 11.

Responding to the safety recommendation above, the DGCA had reviewed and amended the CASR Part 170 refer to ICAO Annex 11 subchapter 5.2.

4.2 Sriwijaya Air

The KNKT had been informed by Sriwijaya Air related to the safety actions taken prior to publishing the interim investigation statement as follows:

1. Issued a quality notice on 18 January 2021 to maintenance control center and engineers for ensuring:
   a. the repetitive defect handling must be conducted in accordance with the Safety Circular from the DGCA and Company Maintenance Manual;
   b. to follow the procedure described on the Aircraft Maintenance Manual (AMM), Fault Isolation Manual (FIM) and Illustrated Part Catalog (IPC) for troubleshooting;
   c. to fill the Aircraft Maintenance Log in accordance with the Quality Procedure Manual (QPM);
   d. to follow part robbing procedure as describe in the QPM and Aircraft Maintenance Procedure Manual (AMPM).
2. Issued the following notice to pilots on 20 January 2021:

   This notice reach you as a call toward the safe flight. With recent tragedy, we urge all pilots to raise awareness and keep the highest professionalism and discipline on your duty. This can be fulfilled with many guidance that we had:
   - *Follow Operating Experience guidance.*
   - *Review Training Aid.*
   - *Awareness of aircraft position, attitude, aircraft systems by active monitoring the state of aircraft on every phase of flight.*
   - *Awareness of aircraft configuration, thrust lever position/power setting and flight control system modes, anytime airplane deviate from its intended state must be corrected immediately.*
   - *Cockpit crew is responsible for entering clear and accurate write-ups of any discrepancies, including any incident or anomaly observation in AML, use of FRM (737NG) and/or describe discrepancy information comprehensively.*
3. Included the upset recovery training as part of the training syllabus in the next Line Oriented Flight Training (LOFT) – Pilot Proficiency Check (PPC).
4. Issued Quality Notice to maintenance personnel on 1 February 2021 to remind:
   a. the handling of repetitive problem to be performed in accordance with the company procedures as stated in the Company Maintenance Manual (CMM) and Aircraft Maintenance Procedure Manual (AMPM),
   b. the troubleshooting to be performed in accordance with the current Aircraft Maintenance Manual (AMM), Fault Isolation Manual (FIM) and Illustrated Part Catalogue (IPC),
   c. filling the Aircraft Maintenance Log (AML) correctly in accordance with the AMPM,
   d. the robbing part to be performed in accordance with the AMPM.

5. Reviewed the existing Upset Recovery Training (URT) and initiated the implementation of Upset Prevention Recovery Training (UPRT) program on 11 February 2021. The UPRT for all pilots started on 18 November 2021 in cooperation with a consultant. The UPRT program involved the DGCA.
6. Disseminated the Boeing Flight Operation Technical Bulletin (FOTB) related to UPRT on 22 February 2021.
7. Issued Notice to Pilots on 21 May 2021 to remind the pilots of the handling and monitoring of the automation systems.
8. Reviewed the Crew Resources Management (CRM) training program to include operational events taken from Sriwijaya Air reporting system.
9. Quality Safety and Security Directorate conducted special audit on the Operation and Maintenance Directorates to identify safety deficiencies.
10. Revised the Flight Data Analysis (FDA) event to include thrust asymmetry and Loss of Control in flight events.
11. Issued Security Notices to remind the aviation security personnel related to the procedure of passenger identification and to improve the security on the check in counter and boarding process.
12. Amended the CMM and AMPM related to the repetitive defect including the definition, management, control and record, and issuance of special task.
13. Conducted special weekly meeting to discuss the significant problems, DMI, repetitive defect, availability of spare part, manpower and operational issues.
14. Improved the engineer training to include Enhanced Zonal Analysis Procedure (EZAP) and Electrical Wiring Interconnection System (EWIS), and Principle of Troubleshooting during the engineer recurrent training in 2022.
15. Amended the approved maintenance program to include fidelity test during annual CVR test in accordance with ICAO Document 10104.
16. Implemented maintenance software for the maintenance management which included enhancement of reliability control program and repetitive defect control. During the issuance of the Final Report the program was on final stage of implementation.
17. Performed A/T System Bite Test in accordance with AMM on all Boeing 737CL aircraft and no faults were found.
18. Issued Engineering Order (EO) to perform thorough check of the A/T mechanical wiring on all Boeing 737 aircraft which will be conducted within 250 hours after issuance of the EO and will be repeated during the C Check.
19. Evaluated maintenance personnel workload based on the number of flights at each station and relocated maintenance personnel to ensure proper workload, duty limitation, and rest requirement.

After the interim statement published on 13 January 2022, the KNKT had been informed safety actions taken by Sriwijaya Air as follows:

1. Established three monthly safety meeting with Boeing to discuss Sriwijaya Air operational safety issues, started on 9 March 2022.
2. Revised FDAP to enable capturing upset condition and to anticipate QAR system malfunction by adding the procedure to request engineering action to rectify FDA recording system in aircraft in the case of QAR data unable to be retrieved or error in the FDA Manual.
3. Reported the progress of the implementation Upset Prevention and Recovery Training (UPRT) Program.
4. Implemented Competency-Based Training and Assessment (CBTA) program to improve pilot technical and non technical skill including pilots active monitoring.
5. Performed thorough A/T and spoiler inspection on Boeing 737-500 registered PK-CLE to ensure the correct function of the system. The inspection also planned for Boeing 737-800 fleet.
6. Revised Company Maintenance Manual and Aircraft Maintenance Procedure Manual regarding the procedure defect management.
7. Revised Quality Procedure Manual regarding to procedure of closing Service Difficulty Report.
8. Initiated to conduct EZAP & EWIS training to improve engineer skill in identifying structural and electrical degradation.
9. Improved Line Operation Safety Audit (LOSA) program to include key competencies for pilot.
10. Modified Crew Resources Management (CRM) training syllabus to include complacency (human factors), cockpit distraction, tail strike event, unstabilized approach and loss of control in-flight.

4.3 Garuda Maintenance Facility

In November 2021, Garuda Maintenance Facility amended the checklist on Cockpit Voice Recorder readout. The checklist includes the requirement to check the waveform quality and audio duration for each channel.

4.4 Boeing

On 15 February 2021, issued a Flight Operation Technical Bulletin (FOTB) 737-12-2 Rev.1 regarding to Airplane Upset Prevention and Recovery.

On 30 March 2021, issued a Boeing Multi Operator Message (MOM) number MOM-MOM-21-0145-01B9(R2) regarding the Potential for Latent Flap Indication System Wiring Failure and Impacts to the Autothrottle System advising operators to perform the inspection within 250 flight hours of the issuance of the MOM. Following issuance of this MOM, the Federal Aviation Administration (FAA) issued Airworthiness Directive AD-2021-08-14. Boeing is developing a service bulletin to issue additional fleet guidance on the flap synchro inspection.

On 25 March 2022, Boeing published a revision to the Maintenance Planning Document (MPD) for the 737-300/-400/-500 requiring repetitive inspections on the spoiler and aileron deployment and associated position sensors. Boeing is developing a service bulletin to address a pending Airworthiness Directive mandate of an initial inspection to be performed within 250 flight hours of the issuance of the service bulletin and repetitive tests of the spoiler deployment and aileron position sensing not exceeding a 2,000 flight hours interval.

5 SAFETY RECOMMENDATIONS

The *Komite Nasional Keselamatan Transportasi* (KNKT) acknowledged the safety actions taken by the related parties. The KNKT considered that the safety actions were relevant to improve safety, however there are still safety issues remain to be considered. Therefore, the KNKT issued safety recommendations to address safety issues identified in this report.

5.1 Sriwijaya Air

- **04.O-2021-01.03**

  The procedure on the Sriwijaya Air version of the Boeing 737 QRH required the PM to call out attitude, airspeed and altitude throughout the recovery. The Sriwijaya Air modified the procedure described in the Sriwijaya Air Training Aid that required the PM to callout "upset brown", for an upset in nose down position, followed by the requirement to inform the ATC "May Day 3x, SJY___ Upset".

  The Sriwijaya Air did not ask for a NTO (No Technical Objection) from the aircraft manufacturer nor was the DGCA consulted for this modification.

  During an observation of the Sriwijaya Air upset recovery training after the accident, this added task impeded the PM from communicating the aircraft state, including attitude, airspeed, altitude, or other deviations during the recovery, or assisting the PF in the recovery process, such as verifying that all required actions had been performed. The modification of the Sriwijaya Air procedure of upset recovery training practices produced the potential of un-noticed or un-addressed negative pilot competencies building.

  Therefore, KNKT recommends Sriwijaya Air to consult the DGCA prior to modifying any flight operation procedure, and also to obtain a NTO from the aircraft manufacturer prior to modifying any existing aircraft manufacturer's flight operation procedure.

- **04.O-2021-01.04**

  Sriwijaya Air has established the Flight Data Analysis Program (FDAP) to identify operational exceedances and confirming normal operating procedures. The FDAP between 2018 and 2020 retrieved the average data of 28.1%. The low rate of FDAP data analysis reduced the program ability to monitor flight operation safety performance.

  Therefore, KNKT recommends Sriwijaya Air to increase the number of data retrieval of the FDAP so as to improve the ability of monitoring flight operation safety performance.

- **04.O-2021-01.05**

  The samples of the Sriwijaya Air hazard report in the period of 2020 showed that majority of the hazard were reported by ground personnel. Few hazards were reported by pilots and maintenance personnel and there was no hazard report by dispatchers. This unbalance composition of the hazard reporters indicated that hazard reporting program has not been emphasized to all employees which might result in hazards not being identified and mitigated.

  Therefore, KNKT recommends Sriwijaya Air to emphasize the hazard reporting program to all employees to encourage hazard reporting.

6 APPENDICES

6.1 Maintenance Record of the Pilot Reports and Rectifications Since 20 December 2020 Until the Accident Flight

No	DATE	Page Number	ATA	PILOT REPORT	RECTIFICATION
1	20-Dec-2020	15	33	*During transit check found R/H position light not illuminate*	*After replaced bulb HLX, trouble still exists. Insert to DMI number 07953 ref. MEL 33-11 Cat C 10 day*
2	20-Dec-2020	15	22	*During transit check found A/T can't engage*	*Insert to DMI Cat C 10 day no 07954 ref MEL 22-0*
3	20-Dec-2020	17	22	*DMI light and autothrotle*	*Still DMI progress trouble shoot*
4	20-Dec-2020	17	34	*FO side RA both side PWS fail*	*Replace RA altimeter module ground test result good*
5	20-Dec-2020	17	34	*Terrain data base not update*	*Clean up receiver transceiver ground test result good ref. AMM 34-41-02*
6	20-Dec-2020	18	21	*During di check found equip cooling exhaust normal CB pop out*	*Replace equipment cooling exhaust normal fan ground test result good ref. AMM 21-58-31*
7	20-Dec-2020	18	33	*DMI no. 07953 during TC found RH pos lt not ill*	*Rectified cable pos. light ground check light ill. Ref. AMM 33-43-03 DMI closed*
8	20-Dec-2020	18	21	*During DI check found equip cooling supply lt. ill.*	*Replace fan motor equip cooling supply normal ground check good*
9	21-Dec-2020	20	21	*Pressurization using auto mode cabin ROC climb 2000ft/min un-control*	*CPC conn. cleaned & retightened ref. 21-31-21*
10	21-Dec-2020	22	21	*Pressurization problem page 20 this AML still exist*	*Out flow valve aft connector cleaned & retightened ref. 21-31-11*
11	21-Dec-2020	22	36	*For system no.2 engine bleed trip appears on every descent.*	*Pre-cooler control valve sensor retightened ref. 36-12-43*
12	22-Dec-2020	28	21	*Pressurization mode auto U/S*	*Clean up CPC elect plug check auto mode problem still exist. defect to DMI 07955 ref. MEL 21-14-01 Cat C.*
13	22-Dec-2020	28	34	*Inflight RA sometime appears on L/H EADI*	*LH radio module altimeter elect plug cleaned up test ok. ref. AMM 34-28-41*
14	22-Dec-2020	30	21	*Ref DMI page 07955 pressurization auto mode U/S*	*Replace cabin pressure controller operational test result ok. Ref. AMM 21-31-00 DMI closed*
15	22-Dec-2020	32	34	*RA flag capt side appears at altitude above 2000 feet.*	*Radio altimeter receiver transmitter #2 cleaned up & retightened ground check result good ref. AMM 34-48-21*

No	DATE	Page Number	ATA	PILOT REPORT	RECTIFICATION
16	22-Dec-2020	32	34	*GPS invalid appears*	*MMR #2 conn plug cleaned up & reposition GPS test result good. Ref. AMM 34-31-02.*
17	22-Dec-2020	32	33	*During service found conn of light bulb not ill*	*Replace & installation turn of light bulb after check result good RH side ref. AMM 34-42-41*
18	22-Dec-2020	33	22	*Ref DMI no. 07954 A/T can't engage*	*Replace RH side servo motor actuator A/T after check result good still under monitor ref. AMM 22-04-00*
19	23-Dec-2020	39	32	*RH MLG no indication down & lock*	*Ref. AMM 32-32-00-715-001 performed replacement bulb on landing gear annunciator light (green light) & performed functional; test L/G retraction & extension result normal (3times).*
20	25-Dec-2020	44	34	*On pre-flight check MASI FO side counting*	*Insert to DMI no 07956 Cat C d/t nil spare ref. MEL 34-01-01*
21	26-Dec-2020	02	22	*Ref. DMI no. 07954 auto throttle can't engage*	*> autothrottle computer clean-up & re-secured.* *> after BITE found alpha vane DADC LH, auto throttle servo 2 failure so clean up all suspect components failure* *> Swab DADC left and right but trouble still exists, DMI Still valid.*
22	28-Dec-2020	17	25	*RH seat harness stuck in several positions when in use.*	*Rectified F/O harness seat several time test ok.* *Ref. AMM 25-10-00*
23	29-Dec-2020	21	21	*Cabin ALT selector unable to set*	*Replace press control panel ref AMM 21-31-25*
24	29-Dec-2020	21	25	*F/O RH shoulder harness sometimes stuck*	*Rectified shoulder harness f/o seat several times test OK. Ref. AMM 25-10-00*
25	29-Dec-2020	21	56	*Please check RH no.2 window*	*RH sliding window still within limit ref. AMM 56-12-11/P606*
26	29-Dec-2020	22	21	*Maintenance*	*After replaced Press Control Panel auto fail/outflow valve will not open on ground, insert to DMI no. 07957 ref MEL 21-14-01 Cat C (10 day)*
27	29-Dec-2020	26	21	*STBY CAB ALT hundred switch lost (not function)*	*Replace Cab Press Control Panel check Cab ALT working was normal.*
28	29-Dec-2020	26	21	*Ref DMI no. 07957 auto system cabin press fail*	*Cabin Press Control Panel replaced. Check cabin pressurization system working was normal*

No	DATE	Page Number	ATA	PILOT REPORT	RECTIFICATION
29	30-Dec-2020	30	22	*Ref DMI no. 07954*	*Replaced auto throttle computer & monitor for 4 flights found satisfied. Ref AMM 22-31-10/401 DMI closed*
30	30-Dec-2020	34	27	*During DI check found tube flight spoiler #3 to actuator leak.*	*Replaced & installation tubing & ops & leak check result good ref AMM 27-61-00*
31	31-Dec-2020	42	25	*Please check F/O shoulder harness*	*F/O side shoulder harness roller reposition after test result good. Ref AMM 25-11-01*
32	31-Dec-2020	42	33	*#1 oil press integral lt. U/S.*	*Replaced bulb 387, test good ref AMM 33-11-81*
33	3-Jan-2021	7	22	*A/T U/S*	*Auto throttle computer cleaned up & reposition after check result good. Ref AMM 22-31-10*
34	4-Jan-2021	16	22	*A/T U/S*	*Check & cleaned A/T computer problem still exist. Insert to DMI no. 07958 ref MEL 22-04 Cat C*
35	4-Jan-2021	18	34	*Ref DMI no. 07956*	*Replaced MASI F/O side test result good. Ref AMM 34-12-21 DMI closed*
36	5-Jan-2021	24	22	*DMI No, 07958 A/T U/S*	*Cleaned A/T TOGA switch BITE test of A/T result good. Ref AMM 22-1-10/501. DMI closed*
37	6-Jan-2021	30	32	*During transit forward L/H nose wheel deep cut*	*Replaced nose wheel assy post L/H d/t deep cut. Ref. AMM 32-45-21*
38	6-Jan-2021	30	32	*During transit forward R/H nose wheel ply visible*	*Replaced nose wheel assy post R/H d/t ply visible. Ref. AMM 32-45-21*
39	7-Jan-2021	37	34	*RA flag & IAS flag captain side appeared in flight.*	*Radio Altimeter receiver transmitter electrical connector clean up. Ref. AMM 34-48-00. Radio Altimeter self-test satisfy.*
40	7-Jan-2021	40	34	*PWS fail*	*WX Radar transceiver reposition*
41	8-Jan-2021	43	34	*ILS. When ILS capture then LNAV disconnect and A/P also disconnect.*	*Reset DFCS CB's. Performed BITE and operational test result good. Ref. AMM 22-1-01*
42	8-Jan-2021	43	34	*PWS fail*	*Reposition WX Radar Control Panel. Operational test OK. Ref AMM 34-41-03.*
43	8-Jan-2021	44	33	*LH inboard light not illuminate*	*Replace LH inboard light due to burn out. Test result OK. Ref. AMM 33-42-21*

6.2 Maintenance Record as Derived from Aircraft Maintenance Log (AML)

The following maintenance record related to autoflight derived from the Aircraft Maintenance Log (AML) starting from 2012 until the end of the flight.

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
1	28-May-2012	117916	22	*localizer unreliable during VOR /LOC wing A/P*	*MCP elect plug clean up, ground check ok, reff. AMM: 22-11-34*
2	05-Feb-2013	136037	22	*B' channel auto pilot do not catch, localizer run w 25R*	*FCC 'B' channel OPS test ok, reff. 22-22-00*
3	05-Feb-2013	136037	22	*Auto pilot 'B' channel do not catch, localizer (legging), please check it*	*Rectified FCC 'B' and VHF, BITE test pass, reff 34-31-42*
4	06-Feb-2013	136040	22	*Problem on page 136037 still exist*	*Rectified FCC 'B' and VHF Nav, BITE test phase, reff AMM 34-31-42*
5	22-Feb-2013	135581	22	*Mach trim fail " light illuminate during re call"*	*WO 437/ENG/II/2013/B737-500, routine insp 250 FH on PK-CLC d/t schedule*
6	23-Feb-2013	135582	22	*Mach trim fail "light illuminated during re call*	*DFCS BITE pass, Mach trim fail light not illuminate during, recall, reff. AMM 22-03-10*
7	23-Feb-2013	135583	22	*Mach trim fail light on recall*	*Reposition and clean up FCC CTRL module, reff. AMM 22-21-31*
8	16-Mar-2013	109	22	*Auto pilot A disengage by itself*	*FCC "A" cleaned up & reposition GND test, result OK, reff. AMM 22-11-37*
9	28-Apr-2013	350	22	*Speed trim fail caution light illuminate*	*DFCS BITE found N1 ENG #2 IND was bad, N1 ENG #2 IND elect conn clean up, DFCS speed trim BITE result pass reff. AMM 22-03-00*
10	17-May-2013	527	22	*A/P A U/S*	*Cleaned FCC A GND test A/P A working normal*
11	01-Jun-2013	629		*A/p disengage 2 times when cruising*	*FCC #1 Clean up GRND DFCS BITE result normal Ref AMM 22-11-53*
12	30-Aug-2013	1169	22	*STAB out ok trim light illuminated during flight*	*Electrical motor stab trim cleaned up & erase fault memory route test ok ref 22-31-11*
13	30-Aug-2013	1170	22	*Stab out of trim illuminate*	*Clean up of stab motor trouble still exist, A/P both test fail*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
14	30-Aug-2013	1170	22	*ALT hold can't maintain altitude*	*Both FCC's clean up, BITE A/P test not fully success see. Mel: 01-22-11*
15	30-Aug-2013	1171	22	*Previous problem still exists*	*Auto pilot stab trim actuator replaced DFCS BITE result passed ref AMM: 22-11-81/P401*
16	07-Nov-2013	1309	22	*Auto throttle switch is unable to hold on ARM Position*	*A/T comp. resecure BITE result satisfy reff AMM: 22-04-10*
17	12-Nov-2013	1346	22	*During des After idle power eng.1 & eng. 2. ENG no.1 N:33.0 N2:71.0 F/F: 0.5 ENG no.2 N: 52.7 N2: 82.0 F/F: 0.5 for sure*	*Clean up DAA and FMC please monitor further info. Reff. AMM: 34-20-31 ref AMM: 22-02-01*
18	26-Jan-2014	1758	72	*Engine no.2 is 50% N1 during descent & Idle power*	*Clean up and reposition idle reset solenoid conn plug reff. AMM: 73-21-03*
19	26-Jan-2014	1764	72	*R/H Engine during idle power remain above 51 N1 at above FL 120-*	*For T/S cleaned conn elect plug N1 speed sensor eng#2 ref AMM: 71-00-00*
20	13-Feb-2014	1885	72	*R/H Engine on Descend idle thrust 55% for about 5 minutes*	*El conn Bar clean up RH Engine p'se monitor next flight*
21	22-Feb-2014	1938			*Replaced DAA#1 d/t IRS#1 fault code 05. check ok. Reff AMM: 34-28-41.* *<u>Replacement Part</u>* *Description: DAA* *Off: P/N 10-62042-301* *Off: S/N* *On: P/N 10-62042-301-01* *On: S/N 94073344*
22	23-Feb-2014	1946	72	*During descend, idle power value Engine no.2 51%*	*CDP and CBP Engine 2 flushed c/o ref AMM: 73-21-10*
23	11-Mar-2014	20006	22	*Speed trim fail light ill. QRH Accomplish*	*Examine Both FCCS and DFCS BITE result speed trim no fault and speed trim fail light not illuminated reff AMM: 22-11-01*
24	04-Apr-2014	2211	22	*At "Des 1" "FMA" Annunciator at-retard- The Engine num 2 not fo*	*Repost and Cleaned up A/T Computer elect connector BITE test ok. Reff AMM: 22-31-10*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
25	09-Apr-2014	2243	27	*Speed Brake not Move up while landing*	*Rectified and cleaned electrical connector plug of Auto Speed Brake control unit and reset C/B. Ground check was Good. Reff AMM: 27-00-00*
26	25-Apr-2014	2326	22	*F/D Light on f/o side u/s (MCP)*	*Electrical plug Mode Control panel Reposition reff: 22-31-00*
27	27-Apr-2014	2340	27	*Auto Speed Brake is not Available (u/s)*	*Check and Clean Auto speed Brake cont. Module Reff AMM:*
28	30-Apr-2014	2360	27	*When Speed brake Lever in ARM Position, speed brake Armed light not illuminated, Automatic speed Brake Inoperative*	*Electrical Connector of Auto speed Brake control module cleaned up. Reff AMM: 27-62-00 Ground Test Several times, Found Good*
29	08-May-2014	2410	27	*When during descend. Idle power Value N1 no. 1 Eng. 32.0% N1 no*	*Reposition and Clean Up Elect Connector reset solenoid on MEC Reff AMM: 73-23-00*
30	08-May-2014	2411	22	*Problem FD still Exist*	*Remate Both of FCC*
31	09-May-2014	2414	22	*When Push Toga, There not N1 Toga and F/D Display appear P'se Check!!!*	*Reset Both CB of MCP and Cleaned elect plug of Both FCC. Test OK*
32	09-May-2014	2415	22	*Problem previous pages still exist!*	*Rec #A and FCC B Retightened*
33	09-May-2014	2416	22	*Problem previous pages still exist!*	*For Trouble Shoot Swap FCC "A" with FCC "B" DFCS BITE pass. Reff: 22-11-00*
34	11-May-2014	2424	22	*F/D: Toga mode Disappears*	*Replaced T.A.T Probe Ground check ok. Reff AMM: 34-12-31 Please info for Further flight* *Replacement Part* *Description: TAT* *Off: P/N 102AH2A6* *Off: S/N A77848* *On: P/N 102AH22A5* *On: S/N A66200*
35	25-May-2014	2511	22	** In flight idle Power L N1: 32% R N1 : 52%*	*Cleaned up connect plug Sensor T2 Temperatur Ok. Reff AMM: 73-21-09*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
36	25-May-2014	2512	22	*Problem still exist See page Before tks*	*For T/s Cleaned elect-conn plug PMC Eng#1 next flt p'se give info-AMM: 73-21-00*
37	06-Jun-2014	1828	22	*Descend With Thrust Lever idle#2 Engine N1 Indicate 51% Follow the Other Engine Instrument*	*Low Idle Sol Conn Cleaned*
38	06-Jun-2014	1830	22	*Speed Trim fail*	*Check FCC Modul Clean up and Rerack Reff AMM: 22-11-00*
39	06-Jun-2014	1831	22	*Speed Trim fail again*	*For T/S check and reset Both FCC. P'se Monitor*
40	13-Jun-2014	1880	72	*During descend on Idle power at FL 250* *No.1 N1: 34,5 no.2 N1 : 54,2* *EGT : 304 EGT : 423* *N2 : 71,3 N2 : 824* *FF : 490 FF : 1080*	*Both PMC Check and Cleaned elect conn plug Reff AMM: 73-11-12 please further info*
41	16-Jun-2014	1898	72	*During Descent no.2 Engine N1 Showing up to 50% until passing FL 200 when Throttle is idle*	*Engine 2 N1 electrical connector plug check and cleaned up. Reff AMM: 77-12-02*
42	17-Jun-2014	1908	72	*On descend engine#2 N1 on idle thrust is 52,5% until 6000 ft then started to decrease 31%*	*Clean elect plug of PMC and idle reset Solenoid for Trouble shooting, please further info*
43	01-Jul-2014	2042	72	*During Desc with Idle no.2 eng. N1=53% followed the Other*	*Idle reset solenoid Eng#2 electrical connector plug rectified. Reff AMM: 77-00-00/'101*
44	01-Jul-2014	2046	72	*Problem still exists on page 2042 when descend Eng. Parameter* *Eng#no.1 Eng#no.2.* *34.4 N1 49.0* *385 EGT 419* *71.3 N2 81.1* *490 FF 910*	*Reff AMM: 71-00-42/162 Eng#2 CDP ill CBF Flushed*
45	04-Jul-2014	2064	72	*During Descend Engine 2. 52% N1 (idle)*	*Eng#2 PMC elect plug Cleaned up check ok. Reff AMM: 73-21-04*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
46	04-Jul-2014	2065	72	*While Descend #2 stuck* *#1 #2* *N1 35 51,2%* *EGT 107 425oC* *N2 71 81,8% Get interval pass 10.000* *FF 52 1,02* *OP 28 37*	*CBP tube connection line Retightened BP Venturion bleed bras sensor cleaned check ok. Reff AMM: 71-00-42 P162*
47	05-Jul-2014	2066	72	*Sometimes still exist as page before*	*N1 Speed Sensor & fuel flow connector plug clean up. Reff AMM: 77-12-01*
48	05-Jul-2014	2070	72	*Eng 2 very slow reducing during descent.* *Takes ± 100 sec to be Equalized to Eng 1(31%N1)*	*RH Engine idle sol conn Cleaned*
49	06-Jul-2014	2473	72	*Flt idle Eng#2 51%N1 - Eng#1 32% N1*	*Clean up and Reposition PMC elect conn plug Eng#2 and Eng#1. Reff AMM: 73-21-04*
50	10-Jul-2014	2495	22		*Completed Auto flight status Annunciator due to Spare taken for service PK-CLE light test ok. Reff AMM:* *<u>Replacement Part</u>* *Description: Autoflight Annunciator* *Off: P/N D434-56-001* *Off: S/N 3003/05-97* *On: P/N D434-56-001* *On: S/N 1997107-92*
51	18-Jul-2014	2536	72	*While descend idle power#2 Stuck at fl 210* *N1 = 33 - 52%* *EGT = 399o - 417oC* *N2 = 71 - 81%* *PF = 48 - 91* *#1 #2*	*Rectified and Clean up Conn D3016 of idle reset Solenoid Reff AMM: 73-21-02/71-00-41 Pse Further info*
52	27-Jul-2014	2588	72	*CX Eng#1*	*All PMC Elect connector plug Retightened. Pls Give Further info*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
53	28-Jul-2014	2595	72	*During Descent no.2 Eng parameter Higher Than Engine no.1 sometimes 330 N1 55.2 419 EGT 447 714 N2 840 63 FF 1.42 During Idle Descent*	*Clean up and Reposition PMC Eng#2. Reff AMM: 73-21-03 Please Further info*
54	16-Aug-2014	2705	72	*RH Engine while Throttle lever to Flight idle R/H Engine stop on N1 52 About 4 Minutes and then go to Flight Idle (N1 32)*	*Engine no.2 Low Idle Solenoid Electrical Connector plug Cleaned AMM: 73-21-00*
55	03-Sep-2014	2817	72	*At Idle descent no.2 N1 49%*	*Power Management control connector Cleaned and Retightened. Reff : 73-21-04*
56	03-Sep-2014	2818	72	*At Descent idle no.2 N1 50% (High Idle)*	*Eng#2 N1 Tachometer sensor elect-plug cleaned & repost. Reff AMM: 77-12-01*
57	06-Sep-2014	2830	22	*Speed trim fail light ill*	*CB N1 Sensor reset*
58	06-Sep-2014	2831	22	*EADI no.1 Speed limited flap Appear*	*N1 Sensor no.1 Clean up. 72-33-05*
59	07-Sep-2014	2841	72	*During Descend N1#2 followed by the other steady 53% until ± 10*	*Check All Resistant parameter and clean up PMC Electrical connector plug p'se for further info flt. Thank reff AMM: 73-21-00*
60	10-Sep-2014	2858	72	*No.2 N1 Indicator Higher 20% than Eng no.1 when thrust lever in idle position. Specially in Hight Speed.*	*Idle reset Solenoid connector plug clean up. Reff AMM: 73-11-01 Operational check found Normal*
61	14-Sep-2014	2884	72	*During Descend, Engine power idle L. N1: 32,9% R N1 : 50.5%*	*N1 Speed sensor off Eng 2 elect conn plug Cleaned up. Reff AMM: 77-12-01*
62	15-Sep-2014	2889	72	*Power plant, descent - LH # 34% N1 - RH#52.9% N1 RH High idle*	*For Trouble shooting, Reset & clean elect plug of idle control Solenoid and T12 temperature sensor. Reff AMM: 71-00-42 please further info*
63	15-Sep-2014	2890	72	*On Descend Eng 2 wen 52% N1, Eng 1 33% N1 see previous page*	*For Trouble shooting, Flush Eng#2 sensing line of CBP and Compressor Bleed. Bias sensor. Reff AMM: 71-00-42*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
64	28-Sep-2014	2951	72	*When descent thrust idle retard R Eng N1 -52 L Eng N1 -52*	*Clean up and Reposition Eng#2 PMC elect conn plug. Reff AMM: 73-11-04*
65	29-Sep-2014	2967	72	*Problem on Pge 00002951 about flt idle still exist*	*Clean up T12 Sensor Temperature Connector plug Reff AMM: 73-21-09 for info The Next flight*
66	30-Sep-2014	2971	72	*Same problem as page 2950*	*PMC Electrical plug Resecured. Reff AMM: 73-21-04*
67	30-Sep-2014	2973	72	*During descend with Thrust lever idle position N1#2 Indicates 52,7% and Gradually Decrease with decrease in Altitude and Approx. at 10,000 ft The N1 Back normal*	*CBP Line flushing, Reff AM: 73-21-10*
68	30-Sep-2014	2975	72	*Problem still exist nothing change*	*Thrust lever Travel check and Lubricated lever cable Reff AMM: 76-11-07 check and flushing with Nitrogen CDP tube and Drain holes for leak, Damage Blockage result Good. Reff AMM: 71-00-59, pse further info*
69	03-Oct-2014	2995	72		*Replaced N1 Speed Sensor for T/S Engine#2 high N1 valve during Idle c/o. Reff AMM: 77-12-01.* *<u>Replacement Part</u>* *Description: N1 Sensor* *Off: P/N 320-094-001-0* *Off: S/N 94-06* *On: P/N 320-094-001-0* *On: S/N 94-07*
70	05-Oct-2014	3007	72	*Pse Master fd ind (Both) and Auto fail light, dont use sticky tape please*	*Rectified Master fwd Indication and Auto fail lt. Reff : 33-11-00*
71	11-Oct-2014	3043	72	*When Dees Eng RMA retart, Diff Eng Instrument: Eng no.1 # Eng no.2# 33,5 N1 52,4 435 EGT 443 71.3 N2 82,5 590 F/F 1210*	*Performed Trouble Shooting in accordance with AMM: 71-00-42. Web specific Gravity check, CBP tube & Venture check result Good. Please further info*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
72	18-Oct-2014	3084	72	*On Des, Eng 2 very slowly Reducing to flt idle Eng 1. 32% N1 Eng 2. 52% N1*	*For T/S Performed Cit sensor Leak check by Alternate. Method & retightened Cit Connection tube c/o. IAW AMM: 71-00-00 Further info*
73	22-Oct-2014	3107	72	*During descend N1 Eng no.2 Retard to Idle for Thrust lever found N1 eng no2 in High Idle stop in position N1 = 50%..??*	*in accordance with AMM: 71-00-42/P162 Performed Adjustment VSV/VBV Rigging, EGR Oat 26oC Baro 29 88 in Hg found high Idle N2 70,6% and Low Idle N2 61,8% Result Good. in accordance with AMM: 71-00-00*
74	12-Nov-2014	3221	27	*1) During walk around we founded Hyd leak some pant below man landing Gear on Right side. Check condition Apparently from one spoiler Actuator*	*Ground Spoiler Actuator no.5 (Inner). Replaced d/t leak Install Gnd ops test found Good. Reff AMM: 27-61-51. Replacement Part Description: Ground Spoiler Actuator Off: P/N 65-44851-13 Off: S/N 9825 On: P/N 65-44851-13 On: S/N 5916*
75	22-Nov-2014	3284	72	*During descend Eng#2 takes long time to reach high idle (maintain 49% in until 10.000 ft)*	*PMC Eng 2 Electrical connector plug clean up. Pse further info. Reff AMM: 73-21-04*
76	23-Nov-2014	3289	72	*Problem N2 for Eng no.2 still exist*	** Eng no.2 N1 sensor Electrical plug cleaned up. Reff AMM: 77-12-01*
77	02-Dec-2014	3340	22	*A/T sometime not function*	*Repost Auto throttle Computer & BITE test no fault. Reff AMM: 22-31-00*
78	02-Dec-2014	3345	22	*A/T Disconnect during t/o run*	*Clean up and Reposition Auto throttle computer performed BITE test result no fault. Reff AMM: 22-04-00*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
79	15-Jan-2015	3545	27		*MI. REPLACED OUTBOARD GND SPOILER #5 DUE TO LEAKAGE. LEAK CHECK C/O. REFF AMM: 27-62-12 (GND SPOILER ACTUATOR). <u>Replacement Part</u> Description: Ground Spoiler Actuator Off: P/N 65-44851-13 Off: S/N 9815 On: P/N 65-44851-13 On: S/N 6417*
80	30-Jan-2015	3616	72	*AT DESCEND R/H ENGINE HIGH IDLE L/H R/H N1 31.8 50.1 EGT 429 429 N2 71 81 FF 700 1260*	*#2 ENGINE PMC ALL ELCTRICAL PLUG CLEAN-UP. GROUND CHECK C/O. REFF AMM: 72-21-12*
81	31-Jan-2015	3621	72	*FLIGHT CONTROL ROL AXIS FEEL HEAVY AND LEGING FROM BOTH SIDE*	*CLEANED UP F.C.C UNIT YAW DAMPER COMPUTER ELECTRICAL PLUG GROUND BITE TEST OK. REFF AMM: 22-00-00*
82	04-Feb-2015	3633	72		*ENG #1 REPLACEMENT PEFORMED REF WO: 270/MPC/1/2015/B737-500 REFF AMM: 71-002-12/71-001-12*
83	03-Mar-2015	3777	27	*AUTO SPEED BRAKE CB POP'S OUT ON LDG ROLL. (NEED TO EXTEND) SPEED BRAKE MANUALLY)*	*CLEANED UP ELECT CONN. PLUG OF SPEED BRAKE ACT. REFF AMM: 27-62-00/104 GROUND TEST RESULT GOOD. REFF AMM: 27-62-00/501*
84	23-Mar-2015	3902	72	*ENGINE NO.2 INFLIGHT IDLE POWER NI 50.7 EGT 440 N2 819 FF 1.18*	*IDLE SENSOR ENG #2 ELECTRICAL CONN. RW6 CLEAN UP REFF AMM: 73-21-03*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
85	22-Apr-2015	4066	72	*POWER PLANT: -STILL PROBLEM EXIST: *DESCEND FROM CRUISE FLT LEVEL UNTIL 7000 FT, N1 HIGH IDLE ENG. NO.2 FOUND IS 54.6%, AND THAN FROM <7000 FT LOWER N1 HIGH IDLE ENG. NO.2 COMES TD 28.5% (BELOW LIMIT IF N1 HIGH IDLE IS 32 %, 35%)*	*CLEAN UP T12 SENSOR AND FMC ELCON, PLEASE MONITOR. REFF AMM: 73-21-64 AND 73-21-05*
86	02-May-2015	4120	72	*FYI: ON DESCEND IDLE THRUST, ENG. 1 N1 INDICATED: 35% AND ENG #2 N1 ±55%*	*IDLE CONTROL CB RESETED AND CLEANED UP ELECTRICAL CONN. OF AUTO THROTTLE COMPUTER. REF AMM: 71-00-42*
87	03-May-2015	4123	72	*CABIN CLIMB INDICATOR POINTED UP WHEN THRUST LEVER RETARD TO IDLE DURING DESCEND*	*ELECTRIC CONNECTOR CLEANED UP AND RETIGHTENED CABIN PRESS CONTROL MODULE. REFF AMM: 21-31-25*
88	03-May-2015	4124	72	*PREVIOUS PROBLEM STILL EXIST L/H PRESS 10 PSI R/H PRESS 30 PSI *WHILE THRUST LEVER RETARD TO IDLE*	*-RECTIFIED CARGO DOOR SEAL REFF AMM: 52-31-00 -CLEANED UP AND REPOSITION ELECTRIC CONN. PLUG BAR. REFF AMM: 36-11-16*
89	03-May-2015	4126	72	*PREVIOUS PROBLEM STILL EXIST*	*CLEANED ELEC CONN. L/H ENG. HIGH STAGE REGULATOR, PLEASE FOR FURTHER INFO. REFF AMM: 36-11-56*
90	03-May-2015	4128	72	*SEE PREVIOUS 2 PAGE 80 PCL*	*RETIGHTENED LINE SENSING 440^{o}F PRE-COOLER CONTROL VLV, GND RUN IDLE RESULT GOOD. REFF AMM: 36-12-35*
91	08-May-2015	4153	72	*ON DESCEND, IDLE THRUST #1 N1: 35%, #2 NI: 55%, MAINTAIN UNTIL ALTITUDE PASSING GOOD FT. #1 N1: 32%, #2 N1: 30%*	*RERACK AND REPOSITION AUTO THROTLE COMPUTER ACC, IDLE ENG. #2 SOLENOID ELECTRICAL CONN. PLUG CLEANED UP. REFF AMM: 71-00-00*
92	08-May-2015	4154	27		*MI. #3 SPOILER (FLT) 'O' RING SEAL REPLACED D/T. SEAL BROKEN. LEAK CHECK AND OPS CHECK OK. REFF AMM: 27-61-00*
93	09-May-2015	4156	27	*FLT CONTROL SYST. - FLAPS ASSYMETRIC DURING APP. (STUCK AT 5/10)*	*LUBRICATED SCREW JACK FLAP GND OP'S FLAP RESULT SATISFIED. REFF AMM: 27-51-73*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
94	12-May-2015	4169	27	*FLAPS ASSYMETRY ON LANDING L: <15^{o} R: >15^{o} NO SWING INDICATION*	*FLAP POSITIONED SWITCH REPOSITIONED AND CLEANED. OPS CHECK OK. REFF AMM: 27-88-41*
95	28-May-2015	4267	27	*LEFT SIDE TE FLAP STOP AT 10^{o} THAN DOWN TO 15^{o}*	*FLAP TRANSMITER POSITION ELECTRICAL CONECTOR PLUG CLEANED UP. PLEASE FURTHER INFO.*
96	02-Jun-2015	4300	22	*A/T U/S*	*CLEAN UP AND REPOSITION A/T COMPUTER A/T BITE NO FAULT. REFF AMM: 22-04-10*
97	02-Jun-2015	4305	27	*1X GO AROUND D/T T.E FLAPS ASSYMETRY LEFT 0.5, RIGHT 1. NNC PERFORM. AFTER STEP 1 NNC 9.30 FLAPS GOING TO NORMAL OPERATION --> LDG FLAPS 30*	*LUBRICATED SCREW JACK /BALL. SCREW GND OPS CHECK FOUND OK. REFF AMM: 12-22-51*
98	05-Jun-2015	4322	72	*A/C ON DESCEND FL 260 TO 8000 ENG. NO REDUCED TO IDLE POSITION*	*A/T COMPUTER RERACK AND CLEANED A/T BITE TEST RESULT NO FAULT. REFF AMM: 22-04-11*
99	08-Jun-2015	4347	27	*FLAP ASSY. STOP BETWEEN 5^{o} AND 10^{o} (INDICATE SPLIT*	*REPOST AND CLEAN UP FLAP POSITION INDICATOR CONN. PLUG. GND OPS CHECK 2 TIMES RESULT OK. REFF AMM: 27-88-00*
100	12-Jun-2015	4369	72	*HIGH IDLE ENG.2 --> N1 EGY DESCENT N2 & FUEL FLOW ONLY ON DESCENT (L) (R) 34.5 N1 : 52.3 41.8 EGI : 45.6 73.2 N2 : 83.5 0.74 EF : 1.50*	*ENG. #2 IDLE SOLENOID CONN. PLUG CLEANED. REFF AMM: 73-21-03*
101	13-Jun-2015	4373	72	*LOW IDLE LIGHT ILL. ENG. (2)*	*CONNECTOR PLUG D2794. LOW IDLE OPC, RESULT GOOD. REFF AMM: 73-21-00*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
102	14-Jun-2015	4377	22	*A/T PROBLEM STILL EXIST*	*IDLE SOLENOID ELECT. PLUG RETIGHTENED AND CHECK.* *REFF AND: 73-21-03*
103	14-Jun-2015	4379	72	*LOW IDLE LIGHT ENG. (2) STILL DECURED*	*REPLACED IDLE SOLENOID CONTROL.* *REFF AMM: 73-21-00. EGR PASS* *Replacement Part* *Description: Idle Solenoid Control* *Off: P/N 66503SOCN 1311-59* *Off: S/N 5842* *On: P/N 66503SOCN 1311-59* *On: S/N NO SHOW*
104	14-Jun-2015	4380	72	*LOW IDLE LIGHT ILL. DURING DESCENT.* *(#1 N1 32%, #2 N2 24%)*	*CLEANED UP LOW IDLE SOLENOID R/H ENG.2.* *PLEASE FURTHER INFO.* *REFF AMM: 73-21-03*
105	14-Jun-2015	4380	27	*FLAPS STUCK AT 10 ® AND 15 (L) ON APPROACH LANDING*	*LUBRICATE ALL SCREW JACK OF FLAP AND REFILL SPINDLE NUT.* *REFF AMM: 27-51-61* *PLEASE FURTHER INFO*
106	15-Jun-2015	4381	72	*LOW IDLE LIGHT ILLUM. (SEE PREVIOUS PAGE)*	*REPLACED T2 TEMPERATURE SENSOR GND CHECK BY E.G.R. RESULT GOOD.* *REFF AMM: 73-21-09/401.* *Replacement Part* *Description: T2 Temp. Sensor* *Off: P/N 8901-326* *Off: S/N WYG7587* *On: P/N 8901-326* *On: S/N WYG79487*
107	16-Jun-2015	4383	72	*LAST TWO LEGS, PROBLEM ENG.2 (LOW IDLE) STILL EXIST (ENG.1 33% ENG.2 22.7%) SEE SOME PAGES BEFORE THIS*	*FOR TROUBLE SHOOT CLEANED AND RETIGHTENED ENG. ACC UNIT CONNECTOR.* *REFF 78-34-05*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
108	16-Jun-2015	4385	72	*LOW IDLE LT STILL ILLUM.*	*REPLACED AIR SENSING RELAY R280.* *REFF WDM: 73-23-11* *EGR IDLE NORMAL*
109	17-Jun-2015	4389	72	*LOW IDLE LIGHT STILL ILLUM.*	*REPLACED ENG.#2MEC PERFORMED.* *REFF AMM: 73-21-01/P401* *CHECK WITH ENG. R/U UNTIL T/O POWER.* *RESULT: GOOD, NO LB ILL.*
110	17-Jun-2015	4390	72	*SEE PAGE 4389*	*ENG. #2 MEC REPLACED.* *REFF AMM: 73-21-01/P401* *CHECK WITH ENG. #2 R/U RESULT GOOD.* *Replacement Part* *Description: MEC* *Off: P/N 8063-208* *Off: S/N WYG 43719* *On: P/N 8063-214* *On: S/N 12392544*
111	28-Jul-2015	4670	22	*SPEED TRIM AND MACH TRIM FAIL BY RECALL*	*CROSS FCC ON RECALL CHECKSPEED TRIM AND MACH TRIM FAIL LIGHT NOT ILLUM.* *REFF AMM: 22-11-33*
112	31-Jul-2015	4690	22	*L/H SIDE F/D FLAG SPPEARS ON EADI*	*FCC A ELEC CONN CLEAN UP. CHECK OK.* *REFF AMM: 22-11-33*
113	03-Aug-2015	4710	22	*FD AND SPEED CURSOR FLAGS CAPTAIN SICE APPEARS*	*FOR T/SHOOT SWAP FCC 'A' WITH FCC 'B' GND TEST OK.* *REFF AMM: 22-03-00* *PLEASE INFO FOR FURTHER FLIGHTS*
114	20-Aug-2015	4807	22		*DURING PRE FLIGHT CHECK FOUND - F/D APPEAR AT EADI F/O SIDE TO DISPATCH AIRCRAFT, INSERT TO DMI.* *REFF NO: 02277 CAT 'C'. REFF MEL: 34-12*

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115	24-Aug-2015	4833	22	*F/O SIDE U/S*	*REPLACED FCC 'B' GND CHECK OK. REFF AMM: 22-31-00 <u>Replacement Part</u> Description: FCC B Off: P/N 4051600-914 Off: S/N 94033530 On: P/N 4051600-914 On: S/N 99044580*
116	05-Sep-2015	4911	22	*SPEED TRIM FAIL ILL. ON FLIGHT.*	*FCC COMP. REPOSITIONED BITE TEST RESULT SATIS. REFF AMM: 22-11-01*
117	25-Oct-2015	5014	22	*YAW DAMPER U/S*	*BITE TEST YAW DAMPER COMPUTER RESULT GOOD. REFF AMM: 22-13-21*
118	06-Dec-2015	5199	27	*SPEED BRAKE SPEED BRAKE LT NOT ILLUMINATE GREEEN AND NOT DEPLOY AFTER LANDING*	*REPOSITIONED AND RESECURED AUTO SPEED BRAKE ACCESSORY MODULE. GND CHECK FOUND GOOD. REFF AMM: 27-62-35*
119	17-Dec-2015	5266	22	*MCP IAS/LCD NOT CLEAR/DIGITALMISSING*	*REPLACED M.C.P TEST OK. REFF AMM: 34-22-11 <u>Replacement Part</u> Description: MCP Off: P/N 4051601-938 Off: S/N 94102338 On: P/N 4051601-937 On: S/N 96022554*
120	18-Jan-2016	5432		*A/T SOMETIME DISENGAGE IN FLIGHT*	*CLEAN UP SERVO MODULE OF A/T GROUND BITE TEST FOUND SATISFIED, REFF AMM: 22-31-91*
121	19-Jan-2016	5438	22	*A/T DISENGAGE OPEN IDLE*	*A/T FAULT MEMORY ERASE AND A/T BITE FOUND NO FAULT ENGAEMENT CHECK OK, REFF : 22-04-00/501*
122	20-Jan-2016	5443	22	*AUTOMATIC FLIGHT: SOMETIMES AUTO THROTTLE DISENGANGED ITSELF*	*CHECK A/T COMPUTER AND A/T SERVO ACT CURRENT STATUS AND LRU BITE TEST RESULT NO FAULT, REFF AMM: 22-04-00*

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123	20-Jan-2016	5445	22	*AUTO THROTTLE SOMETIMES DISENGAGE STILL EXIST*	*AUTO THROTTLE COMPUTER REPOSITIONED, BITE RESULT NO FAULT REFF AMM: 22-31-10*
124	21-Jan-2016	5447	22	** PRESSURIZE OFF SCHED DESCEND ILLUMINATES ON DESCEND PASS FL140. * A/T FREQUENTLY DISCONNECTED*	*A/T COMPUTER REPOSITION REFF AMM; 22-31-10*
125	23-Jan-2016	5462	22	*AUTO THROTTLE DISARM SEVERAL TIMES DURING CLIMBING & APPROACH*	*A/T ELECTRICAL CONNECTOR PLUG CLEANED OPS TEST OK, REFF AMM: 22-31-00*
126	23-Jan-2016	5464	22	*AUTO THROTTLE STILL PROBLEM SOME TIME OFF BY SELF*	*BOTH A/T SERVO ACTUATOR ELECT PLUG RESECURE AND CHECK, REFF AMM: 22-31-91*
127	23-Jan-2016	5465	22	*AUTO THROTTLE STILL PROBLEM DFF BY SELF*	*AUTO THROTTLE SYSTEM BITE TEST NO FOUND FAILED, AND AUTO THROTTLE COMPUTER CONN PLUG CLEANED UP, CHECK FAULT SATISFIED, REFF AMM; 22-04-10*
128	23-Jan-2016	5466	22		*A/T COMPUTER REPLACED COMPANY POLICY, REFF AMM: 22-04-10* *<u>Replacement Part</u>* *Description: A/T Computer* *Off: P/N 735SUE10-12* *Off: S/N 5442* *On: P/N 735SUE10-12* *On: S/N 5501*
129	12-Feb-2016	4312	27	*SPEED BRAKE UNABLE ARM*	*CHECK & CLEANED UP AUTO SPEED BRAKE MODULE, REFF AMM: 27-62-35*
130	08-Mar-2016	5640	22	*SPEED TRIM FAIL ILL.*	*CHECK BOTH FCC AND RESETED CBs. GND CHECK RESULT SPEED TRIM FAIL LT NOT ILL. REFF AMM: 22-11-81*

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131	08-Mar-2016	5641	22	*SOMETIME LH N1 & SPEED TRIM INDICATOR FAIL LT. ILL*	*LH ENG. 1 (N1). CHECK CONNECTOR PLUG N1. CLEANED AND RETIGHTENED. CHECK OK. REFF AMM: 77-12-92 AND 27-00-00 FCC NO DATE. LH CLEANED CHECK OK.*
132	14-Mar-2016	5688	22	*AT'S PREQUENCY 'DISARM'*	*CHECK AND CLEAN UP VHF COM RECEIVER MODULES, OPS TEST FOUND OK. REFF AMM: 23-21-21*
133	28-Mar-2016	5785	27	*FL. CONTROL SPEED BRAKE UNDER SET TO AUTO DISPLAY*	*RESET CB AUTO SPEED BRAKE AND CHECK AND RE RACK AUTO SPEED BRAKE MODULE. REFF AMM: 27-62-00*
134	28-Mar-2016	5789	27		*NOTE: REPLACED SPEED BRAKE AUTO MODULE D/T CB AUTO SPEED BRAKE TOP OUT Replacement Part Description: Speed Brake Auto Module Off: P/N 65-84209-21 Off: S/N DOO726 On: P/N 65-84209-21 On: S/N DO1715*
135	02-Apr-2016	5816	22	*SPEED TRIM FAIL ILL. IN FLIGHT*	*CLEANED FCC A AND BY TEST PASS REFF AMM: 22-11-01*
136	24-May-2016	6065	22	*SPEED TRIM FAIL ILL. DURING FLIGHT*	*BOTH FCC REPOSITIONED & RESECURED REFF 22-11-25*
137	24-Jun-2016	6283	21	*DURING CLIMB & DESCEND PRESSURIZATION CABIN RATE OF ... UP TO 800 FT/MINS*	*CABIN PRESS CONTROLLER REPOSITIONED AND CLEANED UP. REFF AMM: 21-31-21 P*

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138	03-Jul-2016	6337	27		*ON TRANSIT CHECK FOUND HYD. LEAK FROM GND SPOILER (5). REPLACED GND SPOILER (5) INSTALLATION AND OPERATIONAL CHECK GOOD AND NO LEAK. REFF AMM: 27-61-51* *<u>Replacement Part</u> Description: Ground Spoiler Off: P/N 65-44851-13 Off: S/N 6417 On: P/N 65-44851-13 On: S/N 2235*
139	31-Jul-2016	6106	21	*ON DESCEND PRESSURIZE CABIN RATE OF DESCEND 800 FO 1000 FT/MINS*	*DURING PRESSURIZATION TEST FOUND AIR … FROM LH LOWER CORNER OF FWD ENTRY DOOR SEAL. REPOSITION FWD ENTRY DOOR SEAL (L1) PRESSURIZE TEST REFF AMM: 05-51-91*
140	28-Aug-2016	6481	22	*SPEED TRIM SOMETIME ILL*	*CLEAN UP AND REPOSITION BOTH FCC, GND OPS. TEST OK. REFF AMM: 22-11-33*
141	28-Aug-2016	6482	22	*SPEED TRIM FAIL LIGHT SOMETIMES ILL.*	*CLEANED UP FCC FILTER D/T DIRTY REFF AMM: 22-11-33*
142	23-Oct-2016	4809	22	*SPEED TRIM FAIL FROM F/O ADC => SPEED LIM NAV ADI F/O SIDE*	*FCC B ELECTRICAL CONN. PLUG CLEANED UP. REFF AMM: 21-11-33*
143	23-Oct-2016	4813	22	*ON THE GND & IN FLIGHT RH N1 SOMETIME STUCK/ US. THAN FOLLOW 1. SPEED TRIM ILL. 2. RH SPEED LIM APPEAR N1 RESET MANUAL ALL PROBLEM. NORMAL*	*CHECKED AND CLEANED ELEC CONN. PLUG PMC. REFF AMM: 73-21-00*

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144	27-Oct-2016	4838	22	*IN FLIGHT LH N1 SOMETIME STUCK FOLLOW - SPEED TRIM ILL. - SPD LIM (LH) APPEAR*	*REPLACE N1 INDICATOR AFTER MOTORING RESULT GOOD. REFF AMM: 77-12-02 <u>Replacement Part</u> Description: N1 Indicator Off: P/N WL101EED3 Off: S/N AM817/034 On: P/N WL101EED3 On: S/N AA523/084*
145	17-Jan-2017	6298	22	*MCP PANEL LIGHT VERY WEAK: HARD TO DISINGUISH SPEED AND ALTITUDE*	*DFCS MCP CLEANED REFF AMM: 22-11-34 DFCS MCP BITE TEST. REFF AMM: 22-11-34 RESULT OK.*
146	04-Feb-2017	5103	22	*A/T U/S*	*REPLACED AUTOTHROTTLE COMPUTER. BITE TEST RESULT GOOD. REFF AMM: 22-34-10/401. <u>Replacement Part</u> Description: A/T Computer Off: P/N 735 SUE 10-12 Off: S/N 5501 On: P/N 735 SUE 10-12 On: S/N 5151*
147	20-Feb-2017	31	22	*SOMETIME A/T UNABLE TO ENGAGE BUT ON CLIMB OK.*	*CLEANED UP AUTO THROTTLE SERVO MOTOR BITE TEST OK. REFF AMM: 22-31-91*

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148	09-Apr-2017	2	22	*- LOC FLAG INSTRUMENT FO SIDE* *- N1 ENG. #2 MANUAL SET*	*DURING TRANSIT CHECK DAA CROSS CHANGE IRS CODE* *FAULT 05. PROBLEM RH DAA. MINIMIZE DELAY. INSERT TO* *DMI CAT B/3 DAY* *REFF MEL: 34-35*
149	11-Apr-2017	13	22	*- LOC FLAG APPEAR AND EADI NO.2* *- LE FLAPS TRANSIT LT. ILL. WHEN FLAPS SELECTED TO 15˚ (LE DEVIOUS NO.2)* *- N1 REV. BUG NO.2 DISP. DASHES.* *- POST JET X JOIND LEFT ENG. FIRE BOTTLE ONLY 600 PSI*	*1. DAA REPLACED PER AMM: 34-28-41. OPS TEST PERFORMED, RESULT GOOD.* *DMI NO. 05848 CLOSED.* *2. ADJUSTED TARGET GAP LH LE FLAP SWITCH S171 OPS TEST PER TASK 27-88-00-715-013 OK.* *<u>Replacement Part</u>* *Description: DAA* *Off: P/N DG1035AB03* *Off: S/N 1906-3* *On: P/N DG1035AB03* *On: S/N 2540*
150	20-May-2017	35	27		*MI. REPLACED ACTUATOR GROUND SPOILER #4 O/B SIDE* *D/T HINGE BROKEN.* *REFF AMM: 27-62-12/401.* *<u>Replacement Part</u>* *Description: Ground Spoiler* *Off: P/N 65-44851-13* *Off: S/N 6496* *On: P/N 65-44851-13* *On: S/N 9874*
151	20-May-2017	35	27		*MI. REPLACED LH WING SPOILER TUBE HYD PRESSURE* *D/T LEAK.* *REFF AMM: 27-62-12/401*

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152	09-Jun-2017	43	22	*A/T U/S*	*A/T COMPUTER RERACK & ELECT PLUG CLEANED BITE RESULT GOOD*
153	09-Jun-2017	44	22	*DIFFICULT TO ARMING A/T*	*AUTO THROTTLE COMPUTER REPOS AND CLEANED A/T GROUND TEST GOOD, REFF AMM: 22-31-10*
154	27-Jun-2017	40	22	*MAINTENANCE*	*YAW DAMPER COUPLER BACK TO ORIGINAL TEST OK. REFF AMM: 22-11-37.* *Replacement Part* *Description: Yaw Damper Coupler* *Off: P/N 4084042-911* *Off: S/N 98100180* *On: P/N 4084042-911* *On: S/N 53169*
155	28-Jun-2017	45	22	*THERE IS 'SPEED LIMIT' SHOW ON PIC EADI.*	*ADC #1 ELCON PLUG CLEANED UP. GND TEST OK. REFF AMM: 34-12-00*
156	30-Jul-2017	1	22	*THE PROBLEM ABOUT AUTO THROTLE STILL EXIST*	*CLEAN UP A/T COMPUTER AND A/T SERVO MOTOR BITE RESULT NO FAULT, REF AMM : 22-01-00*
157	20-Aug-2017	23	22	*SPD LIM APPEAR ON EADI CAPT SIDE WHEN FLAPS UP WHILE GORUND IN FLIGHT*	*REPOSITION STALL MANAGEMENT COMPUTER #1, BITE RESULT SYSTEM OK, AND GROUND CHECK OK. REFF* *AMM; 27-32-42*
158	05-Oct-2017	26	22	*A/T SOMETIMES DISCONNECT*	*A/T COMPUTER ELECTRICAL CONNECTION CLEANED & REPOSITION, REFF AMM; 22-31-10*
159	13-Oct-2017	16	22	*A/T IN FLT ALWAYS DISCONNECT*	*CHECKED AND INSPECT AUTO THROTTLE SERVO MECHANISM ELECTRICAL CONN PLUG, REFF AMM: 22-31-91/BITE TEST RESULT NO FAULT*
160	29-Oct-2017	41	22	*MACH TRIM FAIL ILL*	*CHECK & REPOSITION BOTH FCC. GROUND BITE TEST OK.* *REFF AMM: 22-11-33*

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161	17-Nov-2017	46	22	*A/T MANY TIMES DISENGAGED*	*AFTER B.I.T.E FOUND "R" SYNC ACT DISCONNECT CLEANED UP ELECT CONN OF R ACT SYSN A/T CLEARED MERMORY FAULT AND TEST RESULT PASSED. REFF AMM: 22-04-00/101*
162	18-Dec-2017	18	22	*AT SOME TIME OFF IT SELF*	*A/T COMPUTER CHECK AND CLEANED UP BITE RESULT NO FAULT. REF AMM: 22-04-00*
163	10-Jan-2018	10	22	*IAS OF MCP -> DARKNES*	*MCP ELECTRICAL PLUG CLEANED UP & REPOSITION CHECK OK. REFF AMM 22-03-00/101*
164	10-Jan-2018	10	22	*A/T ON DESENDING TO APPROACH DIS CONNECT*	*REPOSITION & BITE A/T COMPUTER RESULT OK. REFF AMM 22-04-10/101*
165	03-Feb-2018	39	22	*AT. * ON CLIMB A/T DISCONNECT ALL THE TIME, BUT ON CRUISING IS OK.*	*A/T COMP REPOST AND BITE TEST NO FAULT. REF AMM 22-04-00*
166	11-Feb-2018	42	22	*FD - V NAV R/H SIDE EADI NOT APPEAR*	*DUE TO LACK OF TIME INSERT TO DMI 09797. REF MEL 22-15-08 CAT C.*
167	16-Feb-2018	16	22	*USING A/T, SOME TIMES THROTTLE ENG NO. 2 LATE. (A/C SWING)*	*CLEANED A/T COMPUTER. BITE TEST OK. REFF AMM 22-31-00*
168	07-Apr-2018	23	22	*AT. AT - SOME TIME GOING TO OFF*	*COOLING DOWN A/T COMPUTER BITE PASS REF AMM 22-11-81*
169	05-May-2018	47	22	*PROBLEM AUTO THROTTLE OSMETIME DISCONNECTED DURING FLY*	*AUTO THROTTLE COMPUTER ELECTRICAL CONN PLUG CLEANED UP REFF AMM 22-31-00*
170	06-May-2018	7	22	*A/T SOMETIMES DISCONNECTED*	*A/T SYNCRO MOTOR CONNECTOR PLUG CLEANED AND BITE TEST FOUND GOOD. REF AMM 22-04-00*
171	25-May-2018	1	22	*AUTOTHROTLE SOMETIMES DISANGAGE*	*AUTOTHROTLE COMPUTER CLEANED REF 22-31-10*
172	30-Jun-2018	38	22	*L/H AT SOMETIMES DISCONNECT*	*RERACK AND CLEAN UP A/T COMPUTER BITE TEST OK. REFF AMM 22-31-10*
173	09-Jul-2018	8	22	*A/T SOMETIMES DISCONNECTED*	*REPOST A/T COMPUTER BITE RESULT NO FAULT REFF AMM 22-04-01*

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174	10-Jul-2018	12	72	*UN NORMAL THRUST LEVER TENSION. -> HARA TO MOVED*	*THRUST LEVER MECHANISM LUBRICATION REFF AMM 76-11-01*
175	10-Jul-2018	14	72	*ON NORMAL THRUST LEVER MOVEMENT HARD TO MOVEMENT*	*CHECK CABLE AND PULLEY #1 AND #2 ENGINE ARE OKAY REFF AMM 76-11-07*
176	25-Jul-2018	16	22	*AUTOMATION. WHILE CLIMB, AUTO THROTTLE IS DISENGAGE BY IT SELF (ABLE ENGAGE AT CRUISE)*	*BITE AUTO THROTTLE FOUND MESSAGE A/T SYNCRO #2 SO ELECTRICAL CONNECTOR PLUG OF SYNCRO #2 CLEANED. BITE AUTO THROTTLE RESULT NO FAULT. REF AMM 22-31-00*
177	28-Jul-2018	39	22	*A/T CUT OFF IT SELF MANY TIME DURING CLIMB*	*AUTOTHROTTLE COMPUTER ELCON CLEANED GROUND CHECK FOUND NORMAL REFF AMM 22-31-10*
178	17-Aug-2018	43	22	*A/T DURING CLB DISCONECT*	*ELECT PLUG OF ENG #2 SYNCROMOTOR CLEANED. BITE RESULT GOOD.*
179	17-Aug-2018	44	22	*A/T DISCONNECTED DURING CLB*	*RERACK ADN CLEANED UP A/T COMPUTER, GND TEST RESULT PGOOD. REFF AMM 22-04-10*
180	23-Sep-2018	30	22	*A/T U/S*	*BITE TEST ON CDU, NO FAULT. REFF AMM 22-04-00. TEST ON GROUND NORMAL*
181	08-Oct-2018	38	22	*A/T DISENGAGED LIGHT DISENGAGED OK.*	*CHECK AND REPOSITION A/T COMP REFF AMM 22-31-00. BITE A/T RESULT NO FAULT*
182	09-Oct-2018	45	22	*A/P A DISENGAGED ON ILS APP UNABLE TO RE ENGAGE EITHER A NOR B*	*BITE DFCS FOUND VHF/NAV CONTROL PANEL ERR, AND FCC GND FAULT. SO SECURED VHF/NAV CONTROL PANEL AND FCC A & B RE GITE PASS. A/P OPS CHECK SATISFIED. AMM 22-11-00*
183	24-Oct-2018	6	22	*A/T SOMETIMES DISENGAGE*	*CLEANED A/T COMP BITE PASS. REFF AMM 22-04010*
184	29-Oct-2018	40	22	*A/T SOMETIMES DISCONNECT IN FLIGHT*	*RERACKED A/T COMPUTER AND CLEARED FAULT MEMORY BITE RESULT PASSED, REFF AMM 22-04-00/101*

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185	02-Nov-2018	17	22	*AUTOTHROTTLE MANY TIME DISCONNECT*	*AUTO THROTTLE COMPUTER REPOSITIONED AND ELECTRIC CONNECTOR PLUG CLEANED UP. GND TEST OK. REFF AMM 22-31-10*
186	06-Nov-2018	25	22	*A/P A CMD UNSERVICABLE.*	*FLIGHT CONTROL COMPUTER #AACC UNIT ELECTRICAL CONNECTOR PLUG CLEANED UP. BITE TEST FOUND GOOD. REFF AMM 22-11-33*
187	06-Nov-2018	27	22	*AUTO PILOT A U/S* *AUTO THROTTLE U/S*	*FCC A RERACK AND CLEANED UP DFCS BITE TEST WAS GOOD. REFF AMM 22-11-00*
188	07-Nov-2018	28	22	*A/T DISENGAGE* *TCAS FAIL SOMETIMES*	*AUTO THROTTLE COMP CLEANED REF AMM 22-31-10* *TCAS PROCESSOR CLEANED REF AMM 34-45-11*
189	12-Nov-2018	7	22		*FCC "A" REPOST AND CLEAN UP REF AMM 22-11-00*
190	21-Nov-2018	17	22	*WHEN DESCEND SOMETIMES SPEED CLACKER SOUND WITH NO FLAGS*	*DADC BITE TEST NO FAULT RESET DADC CONTROL MODUL GND TEST NORMAL REFF AMM 22-00-00*
191	28-Nov-2018	18	22	*A/T DISCONNECT MANY TIMES DURING CLB & CRZ*	*CHECK AND CLEAN UP A/T COMPUTER GROUND TEST NO FAULT IAW AMM 22-04-10*
192	30-Nov-2018	33	22	*AP "A" U/S*	*F.C.C.A.C.C UNIT ELECTRICAL CONNECTOR PLUG CLEANED UP GROUND CHECK TROUBLE STILL EXIST INSERT TO DMI 12385 MEL REF 22-01A CAT C 10DAYS*
193	31-Jan-2019		72		*The right engine was removed*
194	21-Mar-2019	10	22	*A/P CONT BE ENGAGE DUE TO NO COMMAND BAR*	*REPOST FCC A M0DULE BITE TEST NO FAULT REFF AMM 22-01-01*
195	22-Mar-2019	19	22	*A/P A U/S*	*RESECURED FCC A ELEV SENSOR ELEC CONN PLUG CLEAN UP, NSS CONN PLUG CLEAN UP. DFCS BITE CURRENT STATUS PASS. ENGAGEMENT OK REF 22-03-00*
196	23-Mar-2019	32	22	*DMI NO 12387 A/P "A" CAN'T ENGAGED*	*DFCS BITE FOUND ELEVATOR ACT "A" FAULT REPLACED A/P ELEVATOR ACTUATOR "A" REFF AMM: 22-11-26 DFCS BITE RESULT SATISFY REFF AMM 22-11-00 DMI CLOSED*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
197	27-Mar-2019	11	22	*IN FLIGHT AUTO PILOT A DISCONNECT*	*DFCS BITE FOUND MSG STAB TRIM M255 FAULT. REPLACED STAB TRIM ACT ,255 RE BITE DFCS RESULT PASSED. OPERATIONAL CHECK RESULT GOOD REFF AMM 22-11-81 AND AMM 22-11-00*
198	28-Mar-2019	16	22	*AUTO PILOT A/P DISCONNECT WHEN DESCENDT*	*REPOSITION FCC B OPS TEST OK REFF AMM 22-11-33*
199	21-Aug-2019	36	22	*DURING DESCENT THROTTLE NO.1 RETARD 7 THROTTLE NO.2 RETARD VERY SLOW*	*A/T COMPUTER RERACK BITE TEST FOUND GOOD REF AMM 22-31-10*
200	19-Nov-2019	40	22	*A/P A & B FLUCTUATE, NOT STEADY*	*TRANSFER TO SUB*
201	19-Nov-2019	41	22	*SEE PAGE B4*	*ELECTRICAL CONNECTOR OF FCC A & B CLEANED. GROUND TEST RESULT GOOD*
202	09-Jan-2020	46	27	*AFTER TOUCHDOWN SPEED BRAKE NOT L/P*	*AUTO SPEED BRAKE CONTROL MODULE CLEANED UP REFF AMM: 27-62-00*
203	10-Jan-2020	2	27	*SPEED BRAKE AUTO U/S*	*REFF AMM: 27-62-00 P101. AUTO SPEED BRAKE CONTROL MODULE REPOSITION AND SPEED BRAKE ARMING SWITCH (S276) CLEANED*
204	11-Jan-2020	4	27	*SPEED BRAKE AUTO U/S*	*ELECTRICAL PLUG OF SPEED BRAKE ACTUATOR CLEANED AND TROUBLE STILL EXIST INSERT TO DMI CAT "C" REF MEL 27-07-01*
205	30-Jan-2020	14	27		*REPLACED AUTO SPEED BRAKE MODULE RETESTED OF THE SPEED BRAKE CONTROL SYSTEM RESULT GOOD. REFF AMM 27-62-00 PAGE 518. DMI CLOSED 11280.* *<u>Replacement Part</u>* *Description: Auto Speed Brake Module* *Off: P/N 65-84209-21* *Off: S/N D01715* *On: P/N 65-84209-21* *On: S/N D01342*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
206	03-Feb-2020	27	27		*> REPLACED SPEED BRAKE LEVER ACTUATOR ASSY. REF AMM 27-62-31 P401. > DO THE FUNCTIONAL TEST OF THE SPEED BRAKE LEVER ACTUATOR. RESULT GOOD. REF AMM 27-62-31 P501.* *Replacement Part* *Description: Speed Brake Lever Actuator* *Off: P/N R5303-51* *Off: S/N 861106* *On: P/N R5303-M1* *On: S/N 981112*
207	07-Mar-2020	16	22	*DURING T/O ROLLING WITH A/T THE THRUST LEVER NO.2 LATE RESPON*	*RESECURED AND CHECK A/T COMPUTER BITE TEST THE THRUST LEVER NO.2 GOOD RESPON. REFFF AMM 22-04-010*
208	08-Mar-2020	43	27	*FLT CONTROL > SPEED BRAKE SHOULD BE MANUAL OPS*	*AUTO SPEED BRAKE COMPUTER REPOSITION SIMULATE ON GROUND CHECK GOOD. REFF AMM 27-62-00*
209	16-Mar-2020	36	22	*RH SIDE BUG SPEED FLAG ASI & FD FLAG APPEARS. AUTO PILOT INOP*	*CADC CHECK AND RESECURED REFF AMM 34-12-00. -RECTIFIED A/P A, A/P B INSERT TO DMI*
210	16-Mar-2020	37	22	*SPEED TRIM FAIL & MACH TRIM FAIL ON RECALL*	*AUTO STAB TRIM MOTOR ELECT CONN CHECK AND CLEAN UP*
211	17-Mar-2020	6	22	*"FLIGHT INST" STILL XIST: -AUTO PILOT 2 U/S/ INSERT DMI. - NO FD 2". -SPEED BUG 2 USE NORMAL*	*DMI NO 1288 STILL VALID UNTIL 27 MAR 2020 NEED T/S*
212	18-Mar-2020	20	22	*SEE DMI AUTO PILOT "B"*	*REPLACED FCC REFF 22-11-33 /401 GROUND TEST FOUND OK.DMI CLOSED.* *Replacement Part* *Description: FCC B* *Off: P/N 4051600-914* *Off: S/N 96083964* *On: P/N 4051600-914* *On: S/N 90041943*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
213	18-Mar-2020	20	22	*ON TRANSIT CHECK FOUND A/P CAN'T ENGAGE*	*REPLACED FCC REFF 22-11-33 /401 GROUND TEST FOUND OK.* *Replacement Part* *Description: FCC A* *Off: P/N 4051600-914* *Off: S/N 94103655* *On: P/N 4051600-914* *On: S/N 90031936*
214	19-Mar-2020	21	22	*PSE SEE PAGE 20 ITEM 1*	*REPLACE AUTO PILOT STAB TRIM MOTOR REFF AMM 22-11-81.* *Replacement Part* *Description: Autopilot Stab Trim Motor* *Off: P/N AR6460M2* *Off: S/N AB0605* *On: P/N AR6460M2* *On: S/N AG0804*
215	19-Mar-2020	23	22	*SOME TIME STAB OUT OF TRIM AMBER LIGHT ILL AND ALTITUDE UNABLE TO MAINTAIN*	*AUTO PILOT SERVO STAB TRIM MOTOR ELECT CONNECTOR CLEAN UP AND RESECURED*
216	19-Mar-2020	10	72	*REFF WO NO. 1746/TSP/XII/20/B737-500*	*PERFORMED ENG REPLACEMENT POS 2 REFF 71-00-02/401 TEST WITH ENGINE GND RUN UP RESULT SATISFIED.* *Replacement Part* *Description: Right Engine* *Off: P/N CFM56-3* *Off: S/N 856435* *On: P/N CFM56-3* *On: S/N 858702*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
217	21-Mar-2020	36	22	*STAB OUT OF TRIM LT ILL DURING FLT*	*AUTO STAB OUT OF TRIM MOTOR ELECT PLUG CLEANED AND RESECURED GROUND TEST STILL EXIST. REF MEL 22-11 INSERT DMI NO 11290 CAT "B" EXPIRED 24-03-20*
218	21-Mar-2020	38	22	*>FLT CONTROL.>STAB TRIM PROBLEM BE COMING WORST. > IN THIS COMPITION CANNOT MAINTAIN RNAV 1 DUE TO NO ALT KEEPING DEVICE*	*REPLACE AUTO PILOT STAB TRIM MOTOR PERFORMED BITE AND OPERATIONAL TEST RESULT GOOD. REF AMM 22-11-81. DMI NO. 11290 CLOSED*
219	22-Mar-2020	40	22	*AUTOTHROTLE CANNOT ENGAGE*	*AUTOTHROTLE BITE TEST CARRY OUT FOUND GOOD. REF AMM 22-04-00*
220	21-Dec-2020	15	22	*DURING TC FOUND AUTO THROTLE CAN'T ENGANGED*	*INSERT TO DMI NO. CAT C 10 NO 07954 REFF MEL 22-0*
221	22-Dec-2020	33	22	*REF DMI NO. 07954 ALT CAN'T ENGAGE*	*REPLACE RH SIDE SERVOC MOTOR ACTUATOR ALT AFTER CHECK RESULT GOOD STILL UNDER MONITOR REFF AMM 23-04-00.* *<u>Replacement Part</u>* *Description: Right Servo Motor Actuator* *Off: P/N 763810-1* *Off: S/N GK3895* *On: P/N 111PAA3* *On: S/N 4448*
222	26-Dec-2020	2	22	*REFF DMI NO. 07954 AUTO THROTLE CAN'T ENGAGE*	*> AUTO THROTLE COMPUTER CLEAN UP & RESECURED.* *> AFTER BITE FOUND ALPHA PANEL DADC L, AUTO THROTTLE SERVO 2 FAILURE SO CLEAN UP ALL SUSPECT COMPONENTS FAILURE*

No	DATE	Page Number	ATA	PIREP	RECTIFICATION
223	30-Dec-2020	30	22	*REFF DMI NO. 07954*	*REPLACED AUTO THROTTLE COMPUTER & MONITOR FOR 4 FLIGHT FOUND SATISFIED. REFF AMM 22-31-10/401 DMI CLOSED.* *<u>Replacement Part</u>* *Description: A/T Computer* *Off: P/N 735SUE10-12* *Off: S/N 5151* *On: P/N 755SUE-4* *On: S/N 6952*
224	30-Dec-2020	34	27		*DURING D/I CHECK FOUND TUBE FLT SPOILER #3 TO ACTUATOR LEAK*
225	03-Jan-2021	5	22	*A/T U/S*	*AUTO THROTLE COMPUTER CLEANED UP & RESPOSITION AFTER CHECK RESULT GOOD. REFF AMM 22-31-10*
226	04-Jan-2021	14	22	*A/T U/S*	*CHECK & CLEANED A/T COMPUTER PROBLEM STILL EXIST. INSERT TO DMI NO. 07958 REF MEL 22-04 CAT C*
227	05-Jan-2021	24	22	*DMI NO, 07958 A/T U/S*	*CLEANED A/T TO GA SWITCH BITE TEST OF A/T RESULT GOOD. REFF AMM 22-1-10/501. DMI CLOSED*
228	08-Jan-2021	41	22	*WHEN ILS CAPTURE THAN NAV DISCONNECT AND A/P ALSO DISCONNECT*	*RESETED DFCS CB'S PERFORMED BITE AND OPEATIONAL TEST RESULT GOOD. REF. AMM 22-11-01*

6.3 Upset Recovery Training Observation

Location	NAM Training Center
Date	22 January 2021 (1400 to 1700 Local)
Overall Objectives	• Document simulator fidelity • Document Sriwijaya Air procedures and application for nose high "Upset Blue" • Document Sriwijaya Air procedures and application for nose low "Upset Brown" Document recovery procedures in conditions like the accident flight
Aircraft	Boeing 737 simulator (Level C Simulator)
Airport	Soekarno-Hatta International Airport
Invited Participants	KNKT, NTSB, Boeing

Initial Simulator Setup for UPRT training:

- All UPRT runs began in flight at FL250.
- All runs were conducted with motion on.
- All runs were flown to recovery from the UPRT.

Sriwijaya UPRT Training Observation

A KNKT investigator and NTBS technical advisor observed a demonstration of Sriwijaya UPRT. The briefing of the UPRT modules to the flight crew (a captain and FO) was performed in the simulator briefing room. The briefing that given by the instructor in 'instruction-form' to the flight crew. The instructor appeared to iterate the content in the Sriwijaya Upset Recovery Training Aid to both flight crews, then 'asked' the flight crew for the correct responses to "Upset Brown" and "Upset Blue" events. Both flight crew were responding to the instructor 'instruction' by reading the response of recognizing and recovery steps with aid of their tablet/smartphone, whereas the instructor was using an iPad. During the briefing, the instructor also used the white board to detail the steps of recognizing and recovering from the upset situation. The instructor only emphasized that the flow of the steps was necessary.

UPSET RECOVERY

An upset can generally be defined as unintentionally exceeding the following conditions:

- Pitch attitude greater than 25 degrees nose up, or
- Pitch attitude greater than 10 degrees nose down, or
- Bank angle greater than 45 degrees, or
- Within above parameters but flying at airspeeds inappropriate for the conditions.

UPSET RECOVERY		
PF	**PM**	**REMARKS**
Recognize and confirm the situation		
NOSE HIGH RECOVERY		
	▶ Call **"UPSET BLUE"** ▶ Inform ATC: **"MAY DAY 3X, SJY___UPSET"**	**Note:** The term Nose High is replaced by **"Upset Blue"**
▶ Disconnect autopilot and autothrottle ▶ Apply as much as full nose-down elevator ▶ * Apply appropriate nose down stabilizer trim ▶ Reduce thrust ▶ * Roll (adjust bank angle) to obtain a nose down pitch rate ▶ Complete the recovery: ✓ When approaching the horizon, roll to wings level ✓ Check airspeed and adjust thrust ✓ Establish pitch attitude.	▶ Call out attitude, airspeed and altitude throughout the recovery ✓ Verify all required actions have been completed and call out any omissions.	**WARNING:** * Excessive use of pitch trim or rudder may aggravate an upset situation or may result in loss of control and/or high structural loads.
NOSE LOW RECOVERY		
	▶ Call **"UPSET BROWN"** ▶ Inform ATC: **"MAY DAY 3X, SJY___UPSET"**	**Note:** The term Nose Low is replaced by **"Upset Brown"**
▶ Disconnect autopilot and autothrottle ▶ Recover from stall, if required ▶ * Roll in shortest direction to wings level (unload and roll if bank angle is more than 90 degrees) ▶ Recover to level flight: ✓ Apply nose up elevator ✓ *Apply nose up trim, if required ▶ Adjust thrust and drag as required (Thrust Lever and/or speedbrakes)	▶ Call out attitude, airspeed and altitude throughout the recovery ✓ Verify all required actions have been completed and call out any omissions.	If captured into High Speed Stall; keep stick shaker until reaching horizon and keep pitch at horizon **WARNING:** * Excessive use of pitch trim or rudder may aggravate an upset situation or may result in loss of control and/or high structural loads.

Complete the recovery		
▶ When approaching the horizon, roll to wings level ▶ Check airspeed and adjust thrust ▶ Establish pitch attitude.		
When Upset is recovered check MSA		
▶ Return to initial altitude or MSA as required	▶ Call " **MSA IS ___ FEET".** ▶ Inform ATC: **"SJ___REQUEST MAINTAIN/CLIMB/DESCEN D TO FL___/___FEET".**	
▶ Call **"SET MCP ALTITUDE"** ▶ Call **"CYCLE FLIGHT DIRECTOR "** ▶ Engaged A/P and A/T, reset speed.	▶ Cycle flight director	
Post recovery		
▶ **Assess:** ✓ Aircraft condition ✓ crew and passenger condition ▶ **Make a decision and inform:** ✓ ATC ✓ Cabin crew ✓ Passengers ✓ Company		

The team observed when the instructor detailed the steps of a Nose High situation, the instructor did not explain that the FD system could be providing incorrect guidance and that the flight crew must use the pitch attitude from EADI. Further, the instructor did not explain:

- Why the A/P & A/T must be disconnected.
- That applying much nose-down pitch control is necessary.
- Thrust adjustment with pitch effectiveness in relation with under wing mounted engines.
- If the bank angle is already greater than 60 degrees, it should be reduced to an amount less than 60 degrees.

Whereas with the steps of Nose Low situation, the instructor also did not explain that the FD system could be providing incorrect guidance and that the flight crew must use the pitch attitude from EADI. Further, the instructor did not explain:

- Why the A/P & A/T must be disconnected.
- Why even in a nose low situation, the airplane may be stalled, and it would be necessary to recover from a stall first. Why has it stalled?
- That in a nose low, high-angle-of-bank requires prompt action and the use of bank indicator on EADI.
- The important to reduce g-loading while attempting to roll to wings level.
- The use of thrust or speed brakes to control the airspeed.

The team noted that during the maneuver briefing, the instructor did not emphasize the flight crew common errors during recovery from the upset situation. According to the recurrent training syllabus, flight crew would also be shown an Upset Recovery video during the briefing which was not demonstrated. The briefing lasted about 15 minutes.

After the briefing, the training event relocated to the simulator. During the practical exercise, the instructor told to the team that the simulator only had the option for a Nose High and Nose Low exercise. In order to expose the flight crew of Nose High, High Bank Angle or Nose Low, High Bank Angle, the instructor would start the exercise while the aircraft was in a climbing turn or descending turn. There were two Nose High and two Nose Low exercises. All exercises were carried out at 25,000 ft. All exercises were flown by the left seat pilot.

Some important points noted during the upset recovery exercises**:**

- The right-seat pilot as PM after announcing “Upset Blue” or “Upset Brown” was making a MAYDAY call to ATC. The duration of call to ATC delayed the immediate monitoring of airspeed and attitude throughout the recovery and announcement of any continued divergence. The delay of monitoring could also affect the effectiveness of monitoring during recovery.
- The ‘less’ effectiveness of monitoring was seen during Nose Low, High Bank Angle exercise when during the first run the aircraft was stalled due to premature leveling off without rolling the bank first. The PF then carried out stall recovery after being told by the instructor.

- The other 'less' effectiveness of monitoring was also seen during the second run of Nose Low, High Bank Angle. The PM was engrossed with the ATC call and as such the aircraft speed became excessively high despite the PF already retarding the thrust to idle. The PF then extended the speed brakes to reduce speed after being advised by the instructor.

The practical exercise in the simulator lasted about 20 minutes. The observation ended after simulator session.

6.4 Hazard Identification and Risk Assessment

The following was the Hazard Identification and Risk Assessment (HIRA) made by the QSS Directorate, related to the hazard of change management when the Sriwijaya Air terminated the join cooperation with Garuda Indonesia. The HIRA title was Company Contingency Plan (08 Nov 2019) and the HIRA number was HIRA-20191108-036.

Sriwijaya Air

QUALITY, SAFETY AND SECURITY PROCEDURE

Doc. No.: SJ-F-DV-14-02

HAZARD IDENTIFICATION AND RISK ASSESSMENT

TITLE : COMPANY CONTINGENCY PLAN (08 Nov 2019) NO : HIRA-20191108 -036 AREA : COMPANY

NO	HAZARDS IDENTIFIED	RISK ASSESSMENT	RISK INDEX	RISK ANALYSIS AND MITIGATIONS	RISK INDEX ACCEPTABLE	RESPONSIBLE BY
1	Management personnel	- No key personnel in-charge	4B	• Provide definitive management personnel to perform decision making process • Update SIUAU/NB and ACL A6	3B	PS
2	Number of Engineer	- Limited availability of authorized Engineer. - Potential AOG due to no authorize personnel	4B	• Readiness review the strength of AMEL holder and SRIWIJAYA AIR Authorization holder. • Recruit additional appropriate AMEL holder	3B	DE
3	Tool and equipment	- Incapability of performing required maintenance action	4B	• Provide availability of tools and equipment • Optimize maintenance schedule on station with adequate tools and equipment	3B	DE
4	Maintenance housing and facility	- Incapability of performing heavy maintenance	4B	• Provide contract agreement with MRO • Set-up ministore or optimize flyaway kit • Optimize maintenance schedule on station with adequate housing and facility	3B	DE
5	Technical publication	- Lack of access to company and maintenance manual and procedures	4B	• Distribute all updated company and maintenance manual to all station	3B	DE

Authority: JKTDVSJ

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6	Material availability	- No parts for aircraft maintenance	4B	• Provide fast moving part • Close coordination with aircraft part procurement for any spare requisition • Maintain update of Sriwijaya Air approved vendor list (AVL)	3B	DE
7	Commercial Factor	- decrease of trust level from strategic partner - Decrease load factor for Pax and Cargo - Insufficient revenue/lost operation	4B	• Close coordination with strategic partner to maintain relationship • Prepare recovery communication plan to maintain Sriwijaya Air brand image • Launch promo offer to increase load factor	3B	DN
8	Services factor	- Unavailability of ground handling and catering service provider - Affected pax due to irregular flights	4B	• Provide ground handling agent service • Close monitor implementation of service recovery guidance and service recovery quick reference (SOP)	3B	DN/DO
9	Financial factor	- Increase of service recovery cost - Limited cash flow - Delay on payment	4B	• Preventive action for flight irregularities by preparing flight schedule refer to aircraft availability • Setting priority on cashflow management • Debt restructuring program • Company efficiency program	3B	DN/DF

Sriwijaya Air
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HAZARD IDENTIFICATION AND RISK ASSESSMENT

10	Operational Factor	- Reduce in safety awareness - Fatigue due to change in operational schedule, delay or cancelation	3B	• Noticed all crew to enhance safety awareness. • Closed monitor on crew rotation pattern and crew tracking	2B	DO

Prepared by:	Acknowledge by:	Approved by:
SM Quality & Safety Data Management	VP Quality & Safety	Director Quality, Safety and Security

RISK ASSESMENT
QUALITY, SAFETY & SECURITY DIRECTORATE

Ref. SMSM 8.2.3: Risk Index Matrix

RISK PROBABILITY	RISK SEVERITY				
	Catastrophe (A)	Major (B)	Moderate (C)	Minor (D)	Insignificant (E)
Most Likely (5)	5A	5B	5C	5D	5E
Likely (4)	4A	4B	4C	4D	4E
Possible (3)	3A	3B	3C	3D	3E
Unlikely (2)	2A	2B	2C	2D	2E
Rare (1)	1A	1B	1C	1D	1E

Ref. SMSM 8.2.4 : Risk Acceptable Table

Risk Index	Acceptability / Action Required
5A, 5B, 5C, 4A, 4B, 3A	Unacceptable under the existing circumstances.
5D, 5E, 4C, 4D, 4E 3B, 3C, 3D, 2A, 2B, 2C, 1A	Acceptable based on risk mitigation. It may require management decision.
3E, 2D, 2E, 1B, 1C, 1D, 1E	Acceptable

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