Lion Air Flight 610

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Abstract- On 29 October 2018, an Airbus of Aircraft type Boeing 737 MAX 8, operated by Lion Air with IATA flight No. JT610 and ICAO flight No. LNI610 registered PK-LQP departed to Depati Amir Airport Pangkal Pinang, Indonesia from Soekarno-Hatt International Airport Jakarta, Indonesia with scheduled passenger of 181 and crew 8 crashed shortly after take-off on the site Java Sea, Indonesia 5°46'15"S 107°07'16"E.

Keywords: Angle of Attack(AoA), Second in Command(SIC), Aircraft Nose Down(AND), Aircraft Flight Maintenance Log (AFML), Aircraft Availability (AA), flight crew operations manual (FCOM), Digital Flight Data Recorder (DFDR), Maneuvering Characteristics Augmentation System (MCAS)

I.Introduction

Lion Air Flight 610 was a scheduled domestic flight operated by the Indonesian airline Lion Air from Soekarno–Hatta International Airport in Jakarta to Depati Amir Airport in Pangkal Pinang. The aircraft took off from Jakarta on 29 October 2018 at 6:20 a.m. local time (28 October 2018, 11:20 p.m. UTC) and was scheduled to arrive at Depati Amir Airport in Pangkal Pinang at 7:20 a.m.

The aircraft was leased from China Minsheng Investment Group (CMIG) Aviation Capital and delivered new to Lion Air on 13 August 2018. At the time of the accident, the aircraft had flown about 800 hours in service.This was the first accident involving a 737 MAX since the type's entry into service on 22 May 2017, and the deadliest accident involving a Boeing 737.

Then ATC informed to concerned authorities about the incident and Indonesian National Search and Rescue Agency deployed three ships and a helicopter for search purpose. Around after nearly hour later, agency received reports regarding Fight 610 that it was crashed and the site was located 34 kilometers off coast of Java sea, offshore northeast of Jakarta in water estimated to be up to 35 meters deep

According to the workers, the aircraft crashed with a steep nose-down angle.

There were 189 people on board the aircraft: 181 passengers (178 adults, 1 child and 2 infants), as well as six cabin crew and two pilots.Officials confirmed that all 189 passengers and crew on board had been killed.

II.BACKGROUND

Findings

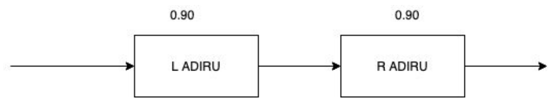
- On 28 October 2018, a Boeing 737-8 (MAX) aircraft registered PK-LQP was operated as a scheduled passenger flight from Denpasar to Jakarta. Prior to the flight, the Angle of Attack (AoA) sensor had been replaced and tested.
- The Digital Flight Data Recorder (DFDR) showed the stick shaker activated during the rotation and remained active throughout the flight. About 400 feet, the PIC noticed on the Primary Flight Display (PFD) that the IAS DISAGREE warning appeared.
- The Pilot in Command (PIC) cross checked both PFDs with the standby instrument and determined that the left PFD had the problem. The flight was handled by the Second in Command (SIC).
- The PIC noticed that as soon the SIC stopped trim input, the aircraft was automatically trimming aircraft nose down (AND). After three automatic AND trim occurrences, the SIC commented that the control column was too heavy to hold back.
- The pilot performed three Non-Normal Checklists (NNCs) consisting of Airspeed Unreliable, ALT DISAGREE, and Runaway Stabilizer. None of the NNCs performed contained the instruction “Plan to land at the nearest suitable airport”.

- After parking in Jakarta, the PIC informed the engineer about the aircraft problem and entered IAS (Indicated Air Speed) and ALT (altitude) Disagree and FEEL DIFF PRESS (Feel Differential Pressure) light problem on the Aircraft Flight Maintenance Log (AFML).
- The PIC also reported the flight condition through the electronic reporting system of the company A-SHOR.
- The engineer performed flushing the left Pitot Air Data Module (ADM) and static ADM to rectify the IAS and ALT disagree followed by operation test on ground and found satisfied. The Feel Differential Pressure was rectified by performed cleaned electrical connector plug of elevator feel computer. The test on ground found the problem had been solved.
- At 2320 UTC, (29 October 2018, 0620 LT) the aircraft departed from Jakarta using runway 25L and intended destination Pangkal Pinang. The DFDR recorded a difference between left and right Angle of Attack (AoA) of about 20° and continued until the end of recording. During rotation the left control column stick shaker activated and continued for most of the flight.
- During the flight the LNI610 SIC asked the TE controller to confirm the altitude of the aircraft and later also asked the speed as shown on the TE controller radar display. The LNI610 SIC reported experienced „flight control problem‟.
- After the flaps retracted, the FDR recorded automatic aircraft nose down (AND) trim active for 10 seconds followed by flight crew commanded aircraft nose up (ANU) trim. The flaps extended to 5 and the automatic AND trim stopped.
- At 23:25:18 UTC, the flaps retracted to 0 and several seconds later, the automatic AND trim and flight crew commanded ANU trim recorded began again and continued for the remainder of the flight.
- The flight crew and the flight attendants held valid licenses and medical certificates and certified to operate B737.
- B737 MAX had MCAS system installed varying from prior to B737. Maneuvering Characteristics Augmentation System (MCAS) The system activates when the sensed Angle of Attack (AOA) “exceeds a threshold based on airspeed and altitude.” That tilts the 737 Max’s horizontal stabilizer upward at a rate of .27 degrees per second for a total travel of 2.5 degrees in just under 10 seconds. How much the stabilizer moves depends on Mach number. At higher Mach the stabilizer moves less, at slower speeds it moves more. The trim system under MCAS is not stopped by simply moving the control yoke.
- In conversations with pilots and airline officials over the weekend, Boeing executives didn’t directly address why MCAS was designed with such flaws, one person with direct knowledge of the meetings said. The system isn’t mentioned in the flight crew operations manual (FCOM) that governs the master description of the aircraft for pilots and is the basis for Southwest’s airline documentation and training.

III.METHODOLOGY

A. *Reliability*

Reliability analysis of selected aircraft system is performed at different levels of detail. In each case appropriate reliability analysis technique is applied (failure mode and effect analysis, reliability block diagrams or fault trees, dependence modelling). Model quantification is based on accident and incident report databases, service difficulty reports, generic component reliability databases and expert judgement. Finally, the results are compared and discussed in the context of the needs of the risk analysis, maintenance requirements determination and in-service occurrences safety classification and analysis.



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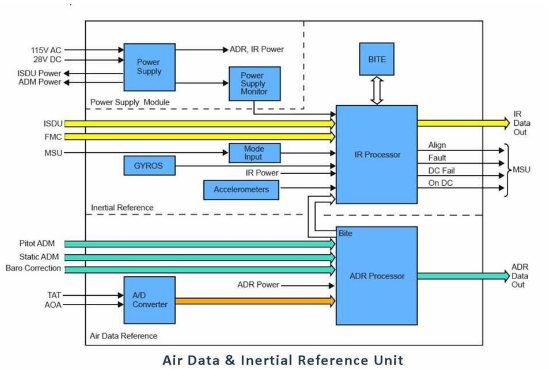

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Let us assume the individual left and right ADIRU unit has independent reliability of 0.90 and 0.90 as given in. We have to compute the reliability of the system.

Probability of ADIRU L & R breaking = 1- 0.90 = 0.10
Reliability of ADIRU L, R and not breaking = 1-(.10 = 0.9
We can see that initially the reliability of the system was 0.9 or near 90.00%

B. Availability

In the broadest sense, Aircraft Availability (AA) is defined as the portion of time the weapon system can fulfil the dedicated function. Availability is also dependent of reliability and maintainability of the system.
To calculate the availability, two factors needs to be known, Mean time to failure (MTTF) and Mean Time to Repair (MTTR). With the both value obtained, availability can be calculated as :
Availability = (MTBF)/ (MTBF + MTTR)

Mean Time Between Failure:
It is the average time of normal operation before the system fails.
To calculate MTBF, operating time of the system is needed and the number of failures is needed which gives,

MTBF = (Operating Time/ Number of Failures)
In the case of Lion Air Boeing 737 max system, there were 2 ADIRU units and their individual operation time and failures is given below.

TABLE 1
Operating Time and number of failures of ADIRU's

ADIRU	L ADIRU	R ADIRU
Operating Time	895.30	895.30
No. of Failures	3	1

Considering the above table, MTBF of individual ADIRU can be known as:
MTBF of ADIRU L = 298.44 hours
MTBF of ADIRU R =895.3 hours

Mean Time to Repair:
It is the average time it takes to repair the system and restore it to working condition after it fails. It can be computed as:
MTTR = (Downtime / No of failures)
Let's us assume the downtime for ADIRU be 24 hours
MTTR of L ADIRU = 8 hours.
MTTR of R ADIRU = 24 hours.

Now we can compute the Availability of the system, which can be computed from individual ADIRU components:
L ADIRU = 298 / (298+8) = 0.973856
R ADIRU = 895.3/ (895.3+24) = 0.97389
Considering a same system configuration as in Fig, which includes L ADIRU and R ADIRU.

Availability of ADIRU L, R in series = A1*A2 = 0.948428
Availability of the ADIRS system = .948428

C. Maintainability

For the maintainability of the flight control system the following aspects need to be implemented: ·

- System modularity and accessibility for maintenance ·
- Preventative maintenance by the implementation of a good maintenance scheme and organization plan.
- Maintenance frequency should be less than the Mean time between failure (MTBF).

Reliability centered maintenance (RCM) should be implemented to achieve safety.

- Self and normal tests
- Log system of maintenance history

D. Fault Tree Analysis

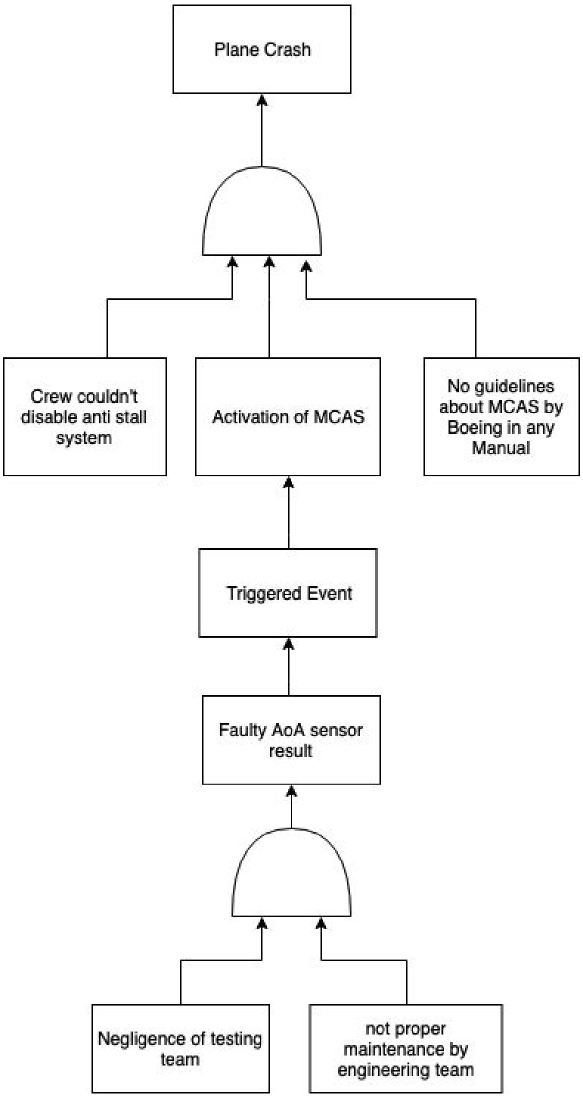

Fig: Fault tree for Lion Air 610

As we discussed about the crash, though it was minor problem but ultimately it caused death of passenger. It was caused due to minor reasons and negligence of management team, Boeing company and ignorance of crew members.

The Boeing company should have mentioned about new MCAS system in their maintenance.

The same problem was raised in previous flights so the maintenance team and engineers should have solved the sensor and AOA problems.

IV.Discussion

A. Angle of Attack (AoA)

The Angle of Attack is the angle at which relative wind meets an Aerofoil. It is the angle formed by the Chord of the aerofoil and the direction of the relative wind or the vector representing the relative motion between the aircraft and the atmosphere. The angle of attack can be simply described as the difference between where a wing is pointing and where it is going.

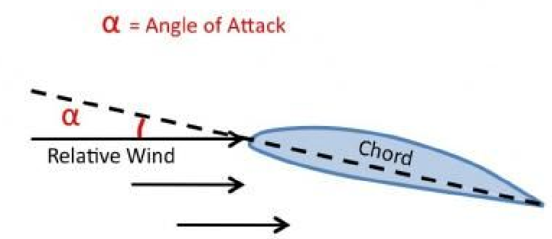

Fig. Angle of Attack (AoA)

An increase in angle of attack results in an increase in both lift and induced drag, up to a point. Too high an angle of attack (usually around 17 degrees) and the airflow across the upper surface of the aerofoil becomes detached, resulting in a loss of lift, otherwise known as Stall.

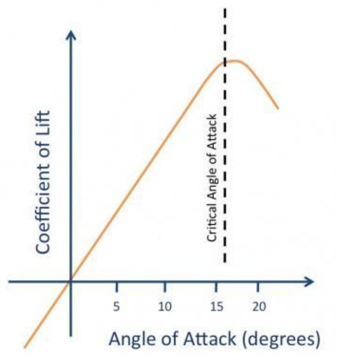

Fig. Lift Curve

B. MCAS (Maneuvering Characteristics Augmentation System)

When Boeing set out to develop the 737 Max, engineers had to find a way to fit a much larger and more-fuel efficient engine under the wing of the single-aisle jet's notoriously low-riding landing gear. By moving the engine slightly forward and higher up and extending the nose landing gear by eight inches, Boeing eked another 14% improvement in fuel consumption out of the continually tweaked airliner. That changed, ever so slightly, how the jet handled in certain situations. The relocated engines and their refined nacelle shape caused an upward pitching moment - in essence, the Max's nose was getting nudged skyward. Boeing quietly added a new system "to compensate for some unique aircraft handling characteristics during it's SIC Part 25 certification" and help pilots bring the nose down in the event the