Podcast – Lion Air Crash

Hello again and welcome back to another Boeing 737 Talk. Having had a look at the return to service side of the Max we thought we'd take a look at one of the contributing factors to its grounding, namely the first crash involving the Lion Air Max PK-LQP on the 29th October 2018.

We will summarise the findings for you looking at the contributing factors according to the Final report written by the KNKT in 2019 which is well worth a full read when you have time.

On 29th October 2018 Lion Air flight LN1610 was operating from Jakarta to Pangkal Pinang with a scheduled departure time of 0545 Local. Total on board the Max 737-8 was 189 people including 2 pilots and six flight attendants.

Previous to this flight, 3 days earlier the SPD and ALT flags on the CPT PFD displayed and following a reoccurrence of the problem the left AoA sensor was replaced on the 28th October.

This AoA sensor had a 21-degree bias which was undetected during the installation test in Denpasar. This resulted in indications on the flight from Denpasar to Jakarta including IAS DISAGREE, ALT DISAGREE, FEEL DIFF PRESS light, activations of MCAS and left column stick shaker. The crew were able to stop the repetitive MCAS by switching the stabiliser trim to cut out. This crew had carried out the Airspeed unreliable checklist, Alt Disagree checklist and the Runaway stabiliser checklist on the flight.

After landing in Jakarta the crew reported some malfunctions but did not include the activation of Stick Shaker and use of STAB TRIM to CUT OUT. The CUT OUT switches had been returned to normal after landing. The stick shaker was not mentioned at all even though it had been active for the whole 96-minute flight, the CP believed the stick shaker was an outcome of the issues he had mentioned so didn't need a specific entry. An ASR was filed.

On this particular Max there was no AoA DISAGREE alert which would have helped identify the source of the problems. This was due to the software delivered to Boeing mistakenly linking the AoA Disagree alert to the AoA position indicator which itself was an optional feature on the Max series only taken up by approximately 20% of purchasers.

Prior to departure of the accident flight the CVR recorded the crew briefing but there was no mention of the previous problems entered into the tech log. The Captain was PF. At 0620 Local the take off roll was commenced. The first clue was there on the roll, although one any of us could perhaps miss in that the FD on the PFD's were showing 13 degrees up on the FO side while the CPTS showed 1 degree down.

The next anomaly on the PFD was the speed tape where at V1 the captains PFD had the low-speed barber pole visible with the overspeed barber pole on the Vr mark. As the nosewheel lifted the DFDR recorded left column stick shaker activation which continued for most of the flight.

7 seconds later and after a momentary take off config warning the IAS DISAGREE first appeared with the CPT airspeed at 164kts and the FO at 173kts. This warning remained until

the end of the flight. The FO questioned the problem and asked the CP if he intended to return but the CP did not respond.

After another 28seconds the FO advised the CPT "Altitude Disagree" and the CP acknowledged. The CP's Altimeter indicated 340ft with the FO's at 570ft. At this point the Terminal East controller cleared the aircraft to climb FL270. Just after the clearance the FO asked ATC to confirm the aircraft altitude. The TE controller passed altitude 900ft with the DFDR recording the CPT altimeter at 790ft with the FO's at 1040ft.

9 seconds after this which is 1 minute and 4 seconds after airborne, the CPT instructed the FO to perform memory items for airspeed unreliable. The FO did not respond to the request.

After a suggestion from the FO to turn downwind the CP instead commanded him to get a clearance to any holding point. The FO requested in his words "to some holding point for our condition now" perhaps indicating his current mental state. When asked for the nature of the problem the FO responded with "flight control problem". The controller did not respond to the flight crew request to go to a holding point.

The FO then suggested to configure to Flaps 1 which the CP agreed with the DFDR showing movement from flaps 5 to flaps 1. About 10 seconds later the CP directed the FO to take control. The FO responded with "standby".

1min and 42 seconds into the flight the controller noticed the flights altitude decrease from 1700ft to 1600ft and requested the intended altitude. At this point the CP Altimeter read 1600ft with the FO's at 1950ft. Altitude information for ATC was almost certainly Mode C/Mode S data coming from the aircraft. This was likely not realised at this point by controller or pilot and could have led to misdiagnosis on looking for a reliable altimeter. An important point for us all to remember.

Flaps were then further reconfigured to up with the CP airspeed at 238kts and the FO's at 251kts. And after an FO suggestion of 6000ft altitude the CP asked for 5000ft. The TE controller cleared the flight to 5000ft and to turn onto heading 050 degrees. There was then a momentary "BANK ANGLE" alert as the bank reached 35 degrees.

As the flaps reached up 2 minutes into the flight the automatic Aircraft Nose Down Trim, or AND Trim as we'll call it from now, was active for about 10 seconds and pitch trim reduced from 6.1 units to 3.8 units. The CP then called for flap 1 and the main electric trim was used for aircraft nose up trim or ANU trim as we'll call it from now bringing the trim back to 4.7 units.

With the flaps still moving at this point the aircraft started to descend at a rate of up to 3,570fpm and lost about 600ft of altitude. Pitch trim at this point was 4.4 units.

As the flaps reached position 1 the left control column stick shaker briefly stopped. At this point the left AoA sensor recorded 18 degrees nose up with the right AoA sensor at -3 degrees nose down. The rate of decent increased up to 3200fpm and on the CP's PFD the low-speed barber pole appeared with the top at 285kts.

There was then further automatic AND trim for 8 seconds and the EGPWS warning of AIRSPEED LOW sounded. After a request for the Aircraft speed as shown on radar the controller responded with 322kts ground speed. At this point the CP airspeed showed 306kts and the FO 318kts.

Flaps 5 was then selected and the CP commanded ANU trim, during this the automatic AND trim ended. The left stick shaker started again and continued until the end of the flight. At this point the aircraft was climbing at about 1500fpm with a pitch of 3 degrees.

The CP PFD airspeed now showed a merger of the low speed and overspeed barber pole with the FO's showing only the high-speed Barber pole positioned at 340kts.

Here the CP commanded "memory item, memory item". 8 seconds later the FO responded, "Feel differential already done, auto brake, engine start switches off, what's the memory item here?" to which the CP responded "Check".

There were then multiple automatic AND trim inputs, and the aircraft heading was 100 degrees instead of the cleared 050 degrees.

At now 3 minutes into the flight the FO suggested "Flight control" and the CP responded "yeah". 9 seconds later the FO called "flight control low pressure". Here the Altitude indications showed 4,110ft on the CP side and 4,360 on the FO's. 17 seconds after the "flight control" call the FO then called "Feel Differential Pressure". The CP then commanded to perform the airspeed unreliable checklist which was acknowledged by the FO. After 4 seconds the FO stated he was unable to find the Airspeed Unreliable checklist.

The aircraft continued to climb through the cleared 5000ft as the CVR picked up the sound of paper pages being turned. Throughout this the controller was still under the impression the Lion air flight 1610 was having flight control trouble though no urgency call was made.

Flaps were then moved to 1 without the CVR recording any discussion and CP ANU trim was recorded. At 4mins and 38 seconds into the flight the FO repeated ATC instructions for heading 350 degrees then informed the CP there was no airspeed unreliable checklist. Flaps were then moved to UP again without the CVR picking up any discussion.

6 seconds after stating there was no checklist the FO then stated "10.1" and began reading the Airspeed Unreliable Checklist.

The automatic AND trim activated by MCAS then started again only to be interrupted by the CP using main ANU trim. For the next 5 minutes and 21 seconds there was a constant battle between the CP and the MCAS which took the CP's capacity away from flying correct assigned headings from ATC. Each time the MCAS commanded AND trim the CP responded with main ANU trim with his reaction varying from 1 seconds to 7 seconds after MCAS activation. In this period there were a total of 21 MCAS activations. All this time the FO was working his way through the UAS checklist and answering ATC communications as well as briefing Cabin Crew.

At this point the CP handed over control to the FO with the FO replying, “I have control”. The CP then obtained a clearance point to avoid weather.

A further MCAS activation of 8 seconds then occurred reducing pitch trim to 3.4 units with the FO stating “wah, it’s very”. The CP was then talking to ATC stating he couldn’t determine aircraft altitude due to all the aircraft instruments indicating different altitudes. The CP used the incorrect callsign during the transmissions likely due to his stress levels.

Further MCAS activation with only slight ANU correction by the FO led to a pitch trim of 2.9 units with the FO’s control column sensor Force recording 65lbs of back pressure. The FO did then alleviate this to a degree bringing the pitch trim to 3.4 units.

As the CP requested a block altitude MCAS again activated for 8 seconds leaving the trim at 1.3 units with a control column force of 82lbs. The FO now informed the CP the aircraft was flying down. THE DFDR recorded a pitch angle of -2 degrees with a ROD of 1920fpm. 3 seconds later the FO exclaimed the aircraft was flying down which the CP responded, “it’s ok”.

At 11 minutes and 10 seconds after lift off MCAS again activated for 4 seconds putting the trim at 0.3 units and the FO’s control column pressure read 93lbs. The FO commanded 2 seconds ANU trim but at this point the altitude indicated 3200ft on the CP side and 3600ft on the FO but more importantly the ROD was more than 10,000fpm.

TERRAIN TERRAIN followed by SINK RATE was heard on the CVR along with the overspeed clacker. MCAS then activated again until the DFDR stopped at 11 minutes and 18 seconds with the CVR stopping 1 second later.

Horrible. The aircraft was destroyed, and all 189 lives were tragically lost. As some crew background, the CP was 31 years old with just over 6000 flying hours with over 5,000 of those on type and was current with 80 hours and 5 minutes in the last 30 days. The Captain had passed all checks on his training record with a couple of comments of note. These were a remark in May 2017 that “CRM needed to be improved” and then a year later a remark “to use standard signal for effective communication and good teamwork during abnormal or emergency situation.” The CVR picked up that on the day the CP had complained of flu like symptoms and had coughed around 15 times within the hour of pre flight.

The FO was 41 years old with just over 5000 hours total time with over 4,000 of those on type. He was current with 32 hours and 43 minutes in the last 30 days. There were multiple relevant remarks on the FO’s training record sited in the report including comments on SA and aircraft handling issues as well as automation knowledge. The flight was a standby call out for the FO was called at 4am with the revision.

The aircraft itself had gone through a run of technical issues and trouble shooting leading to the replacement of the left AoA sensor. The engineer replaced the AoA sensor in accordance with the AMM but didn’t have the equipment to perform the recommended installation test according to the AMM so performed the alternative method using the SMYD BITE module. This method involves deflecting the AoA vane to the fully up, centre and fully down positions

while verifying the indication on the SMYD computer. The engineer did not record the indication on the SMYD computer during the test.

The engineer performed the BITE test on the FMC which showed “No Current Faults”.

The engineer provided the investigation with several photos including of the CP’s PFD claimed to be taken after the AoA sensor was replaced. However, the investigation confirmed the SMYD photos were not of the accident aircraft.

The aircraft was released to service and flown to Jakarta with the recurrence of the problems on that flight as we mentioned earlier. Some further engineering work at Jakarta included an operational test which resulted in a satisfactory performance.

The history of the installed sensor is scrutinised in the report. It was previously installed on the right side of a 737-900ER and had been removed in August 2017 due to maintenance write ups indicating the SPD and ALT flags were shown on the FO PFD during a pre flight check. In October 2017 the faulty sensor was sent by Batam Teknik to Xtra Aerospace in the USA for repair.

An eroded vane was replaced, and the unit was calibrated and tested as satisfactory. Its return to service was approved on November 3rd, 2017. The AoA sensor was then stored until its use on PK-LQP the crash aircraft.

The conclusion lists 89 findings and 9 contributory factors to the accident. To go through all of those findings here would put us into next week so we’ll be putting a link to this report on our website for you to take a look at yourselves as they are an interesting read. They cover things such as what turned out to be incorrect assumptions made by Boeing during Flight Hazard Analysis in regard to the way flight crews would react to MCAS and areas where perhaps training should have been provided as well as some oversight issues by the regulator and procedural gaps by the crew. We’ll focus on the Contributing factors here. Out of interest Contributing factors defines 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. After that definition I need a rest so over to Mark!

These factors are listed purely in chronological order and not to show the degree of contribution.

Number 1 reads. During the design and certification of the Boeing 737-8 assumptions were made about flight crew response to malfunctions which, even though consistent with current industry guidelines, turned out to be incorrect.

2. Based on the incorrect assumptions about flight crew response and an incomplete review of associated multiple flight deck effects, MCAS’s reliance on a single sensor was deemed appropriate and met all certification requirements.

3. MCAS was designed to rely on a single AoA sensor, making it vulnerable to erroneous input from that sensor.

4. The absence of guidance on MCAS or more detailed use of trim in the flight manuals and in flight crew training, made it difficult for flight crews to properly respond to uncommanded MCAS.

5. The AoA DISAGREE alert was not correctly enabled during Boeing 737-8 development. As a result, it did not appear during flight with the mis-calibrated AoA sensor, could not be documented by the flight crew and was therefore not available to help maintenance identify the mis-calibrated AoA sensor.

6. The replacement AoA sensor that was installed on the accident aircraft had been mis-calibrated during an earlier repair. This mis-calibration was not detected during the repair.

7. The investigation could not determine that the installation test of the AoA sensor was performed properly. The mis-calibration was not detected.

8. Lack of documentation in the aircraft flight and maintenance log about the continuous stick shaker and use of the Runaway Stabiliser NNC meant that information was not available to the maintenance crew in Jakarta nor was it available to the accident crew, making it more difficult for each to take the appropriate actions.

And 9. The multiple alerts, repetitive MCAS activations, and distractions related to the numerous ATC communications were not able to be effectively managed. This was caused by the difficulty of the situation and performance in manual handling, NNC execution, and flight crew communication, leading to ineffective CRM application and workload management. These performances had previously been identified during training and reappeared during the accident flight.

As we now know, this crash along with the catastrophic loss of flight ET-302 in Ethiopia on the 10th March 2019 where another 157 people tragically lost their lives, led to the long grounding of the Max and the redesign of a number features including the much talked about MCAS system. We are only now in 2021 seeing it fully return to the skies, redesigned, recertified and with new pilot training requirements. In aviation we always look to learn from every mistake so that they are not in vain and enhance safety going forward. We believe the scrutiny the Max has been put under will deliver us as pilots a highly safe aircraft to operate as part of the 737 family.

Thanks again for listening to our podcast and we hope you found our first look at aircraft accidents informative and useful for your continued safe operation.