Lion Air JT610 Boeing 737 Max 8 accident – human factors analysis

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SUMMARY

Lion Air JT610 departed Soekarno-Hatta International Airport, Jakarta Indonesia for Depati Amir Airport, Pangkal Pinang on the 29th of October 2018 at 06:20 AM local time. As the aircraft passed through 2,000 ft during the initial climb-out, it pitched down and the crew attempted recovery but were unable to do so. At 06:32 AM the aircraft crashed into the sea with an airspeed in excess of 400 knots. All 189 persons on board lost their lives. This fatal accident was a loss of control in flight (LOC-I) or "unintended deviation from flightpath", the number one category of fatal accident type over the last 60 years. Aircraft technology has seen significant development over this period with a corresponding reduction in fatal accident rate, yet LOC-I still persists. With technological advancements how could an accident like this have happened? This paper will explore contributory and causal human factors and what is proposed to prevent future occurrences.

KEYWORDS

Accident investigation, loss of control in flight, Boeing 737 Max 8

The accident

The aircraft generated several alerts shortly after take-off and as it passed through 2,000 ft during initial climb-out, there was an uncommanded pitch down. The crew maintained control (with decreasing success) for around 10 minutes as they attempted to deal with their situation. At 06:32 AM the aircraft crashed into the sea with an airspeed in excess of 400 knots and all persons on board lost their lives. The day before the accident, a different pilot in command had discussed maintenance log actions with an engineer. These maintenance actions included the replacement of the left angle of attack sensor. On that day, the aircraft departed I Gusti Ngurah Rai International Airport, Denpasar for Jakarta as flight LNI043. After departure at 10:20 PM local time, the stick shaker – a warning of impending stall – activated during rotation and remained active throughout the flight. The pilot in command on that flight noticed that the aircraft was automatically trimming the aircraft nose down, disabled the automation and continued manually flying without further incident.

Analysis

The 737 Max 8 was Boeing's response to fierce competition from the new Airbus A320 Neo - Airbus sales were projected to overtake Boeing. The 737 Max 8 had been in service for only a short period and the design ethos was commonality with the other 737 models to minimise conversion training. The aircraft design included new 'background' systems and conversion from 737-800 NG to Max required 'differences training' only (Level 'B') - Computer Based Training (CBT) and other visual media. No Flight Simulator time was required and conversion took 2 days or less for flight crew. The Boeing 737 has been in service since 1967, the new Max 8 incorporated higher thrust engines with 14% less fuel burn compared with the 737-800 NG. This required larger engine nacelles which were moved forwards and upwards reducing longitudinal static stability and 'control feel' at high angles of attack. The Manoeuvring Characteristics Augmentation System (MCAS) flight control law, triggered by a single Angle of Attack (AOA) sensor was designed and certified for the 737 Max 8 to compensate for these differences in flying qualities, providing enhanced pitch stability so that it "felt and flew" like other 737s. Although fitted with two AOA sensors, only one senor was used per flight and this was alternated between left and right sensor for successive flights. The crew were unaware of the existence of MCAS, it was not in the aircraft manual and they were not trained in MCAS operation or how to troubleshoot if/when required. They believed that the Airspeed Indicator (ASI) and Altimeter (ALT) were dependent on air pressure alone, and not AOA. This was not mentioned in the flight crew manual, although the emergency checklist had a subtle hint. They did not know that AOA affects both indicated airspeed (IAS) and altitude (ALT) displayed on each pilot's display independently. They were unaware that the AOA DISAGREE alert, a safety feature to identify differences between left/right AOA sensors was disabled. During the event they received multi-channel, conflicting feedback. Visual feedback via instrument displays for the Captain and First Officer showed different airspeed and altitude readings. The airspeed tape showed alerts (accompanied by aural warnings) and values that were not normal, although power and attitude were normal . The AOA DISAGREE alert was missing (but expected). Auditory feedback was conflicting – the stick shaker indicating high AOA (usually associated with 'low speed') and overspeed clacker indicating high speed. Differences in tactile and proprioceptive feedback were also evident - the aircraft did not 'feel right' as control forces needed to counter the uncommanded aircraft nose down pitch (caused by MCAS) were high. The Captain's and First Officer's situation awareness was different due to these conflicting cues. The combination of power AND aircraft attitude usually determine aircraft performance - however performance was not as expected.

Speed trim (a feature of the 737 since the introduction of the NG) is expected during take-off and the trim moves automatically, at the lower of two programmed trim motor speeds but MCAS trim is not expected. Multi-channel, conflicting cues are likely to have led to distraction - there were loud aural alerts, accompanied by haptic alerts form the stick-shaker. They matched the Captain's instrument display but not the First Officer's. The pilot flying found the aircraft difficult to control as it was in and out of trim for reasons which were unclear. Additionally, the power and attitude continued to diverge from normal, exacerbating the effect.

This case study strongly challenges the 'old view' (Dekker, 2014) - that – 'human error is a cause of accidents and you must find people's inaccurate assessments, wrong decisions, bad judgments'. It strongly supports the 'new view' – that 'human error is a symptom of trouble deeper inside a system and we should understand how people's assessments and actions made sense at the time given the circumstances that surrounded them'. The lack of crew knowledge, skills and training with respect to MCAS in addition to the other problems experienced are likely to have fostered degraded situation awareness and led to a range of human responses from distraction - disrupting normal operations and eroding safety margins - to inappropriate actions or expedited decision making, due to startle and/or surprise (EASA, 2020). Highly automated systems which provide limited feedback, no feedback or conflicting feedback and which then transfer control to the pilot or limit control of the pilot unexpectedly, are likely to cause surprise or even startle.

Impact & implications

The Indonesian National Transportation Safety Committee (KNKT) made 27 safety recommendations to address safety issues identified in the investigation covering design, certification, manufacturing, operations, training and maintenance. The report concluded that the flight crew started the Airspeed Unreliable Non-Normal Checklist (NNC) but did not identify the root cause of the pitch mis-trim (caused by repetitive MCAS activations) and the other multiple alerts. Distractions related to numerous ATC comms also contributed to the flight crew's reduced situation awareness and difficulties with aircraft control. The report concluded that the design and certification of MCAS was inadequate. LOC-I accidents have more possible permutations and combinations of contributory factors than any other accident category as they involve the pilot, aircraft, systems and environment together. The continued development of systems and technology and the reliance on automation means that threats are ever-present and ever-changing. Consideration of failure modes and their interaction with a better model of the human operator as the last line of defence will be vital if LOC-I accidents are to reduce.

References

Bromfield, M. A., and Landry. S. J., (2019) "Loss of Control in Flight (LOC-I) – Time to Re-define?", (AIAA 2019-3612), 2019 Aviation Technology, Integration, and Operations Conference, Dallas, Texas, USA, 17-21 June 2019, https://doi.org/10.2514/6.2019-3612

Dekker, S., (2014), Two Views of Human Error, Chapter 1, The Field Guide to Understanding Human Error, 3rd Ed., CRC Press, Boca Ratan, Florida, USA.

EASA (2015), Startle Effect Management, Final Report EASA_REP_RESEA_2015_3, European Aviation Safety Agency, Cologne, Germany. https://www.easa.europa.eu/sites/default/files/dfu/EASA_Research_Startle_Effect_Managements_Final_Report.pdf [Retrieved 11/01/22]

KNKT (2019), Aircraft Accident Investigation Report, KNKT.18.10.35.04, PT. Lion Mentari Airlines, Boeing 737-8 (MAX), PK-LQP, Komite Nasional Keselamatan Transportasi, Jakarta, Indonesia.