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BRIEFING LEAFLET

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Loss of Control Related to Angle of Attack

NOTE

This Briefing Leaflet supersedes the Position Paper 14POS24.

BACKGROUND

Several incidents have occurred where aircraft ended up in upsets, in some cases leading to loss-of-control accidents. These events often involved aircraft still being technically capable of safe flight. To prevent these incidents and accidents, upsets and loss of control awareness have to be addressed.

This paper deals with upsets and loss of control related to angle of attack, possibly leading to a stall. From here on, this is referred to as Loss of Control - Angle of Attack (LoC-AoA).

PREVENTION OF LOSS OF CONTROL RELATED TO ANGLE OF ATTACK

The leading cause of LoC-AoA is flight control inputs that are not appropriate for the situation the aircraft is in, or the lack of flight control input. These control inputs can be manual or auto-flight inputs. In the case of auto-flight, flight control law degradation on a fly-by-wire airplane can change flight control sensitivity, increasing the chance of inappropriate inputs.

Two scenarios can lead to the above-mentioned inappropriate manual or auto-flight flight control inputs. Either the pilots do not identify the situation they're in, or they do identify the situation but are unaware of the correct flight control inputs required to regain control of the aircraft.

Consequently, the prevention of a LoC-AoA incident is two-fold; the first step is to recognize and identify the condition correctly, the second step is to fly the aircraft out of that condition correctly. Both steps require a clear and intuitive presentation of flight information and guidance. This enables a timely response by the flight crew and prevents incorrect control inputs. In addition, adequate training of pilots is required to obtain and maintain the required level of skill to deal with LoC-AoA.

In summary, preventing LoC-AoA is accomplished by adequate training and providing a clear and intuitive display of flight information and guidance.

LOC-AOA TRAINING

LoC-AoA events are rare. Consequently, LoC-AoA training is important during both initial and recurrent training. The following elements should be included in the training:

- Manual flying skills, i.e., pitch-power flying
- Awareness of flight envelope limits, i.e., high-altitude aerodynamics and low speed regime
- Specific high altitude flying skills and knowledge of flight control deflection effects, i.e., spoiler pitch up effect
- Interpretation of flight information presented, i.e., stall warnings and AoA-based indications, such as pitch limit indications and flight path vectors in combination with pitch angle
- Stall margin awareness at low and high altitudes
- Upset and stall recovery procedures at low and high altitudes
- Knowledge of flight control characteristics, i.e., elevator authority and pitch trim behaviour
- Knowledge of flight control law degradation and flight control sensitivity change
- Startle factor

FLIGHT INFORMATION AND GUIDANCE

Flight information regarding aircraft energy state can aid pilots in recognizing and recovering from LoC-AoA. Identifying an excessive increase in AoA will aid the pilot in choosing the proper flight control inputs required. Recovery from an excessive AoA requires unloading the airplane by decreasing the AoA. So, a primary flight parameter during an upset is AoA. As a result, prevention of LoC-AoA demands a clear and intuitive display of AoA-based information.

AoA can be presented on the flight deck in two ways, directly and indirectly. The direct way is by means of an AoA indicator that displays the actual AoA. In most large aircraft, AoA is not presented directly on the flight deck. It is presented indirectly, and different manufacturers have different ways to do this.

Indications such as a pitch limit indicator and colored speed tapes provide limits of the flight envelope, based on AoA. Therefore, they present information based on angle of attack

without presenting the actual AoA itself. In addition, aural warnings related to the stall should warn the pilots based on AoA. Stall warnings should not be suppressed during flight.

AOA INDICATOR

The advantage of an AoA indicator is that it directly displays the main flight parameter involved in recognizing and recovering from the LoC-AoA condition. Therefore, it might seem contra-intuitive not to provide an AoA-indicator on the flight deck. However, several drawbacks of an AoA-indicator can be identified:

- The majority of the pilots are not trained in using an AoA indicator.
- In the normal flight regime, an AoA indicator is not used. As a consequence, the use of an AoA indicator will not become second nature to the current generation of pilots, even after training. It is therefore unlikely to be used in high-workload situations, such as when loss of control is likely. A stall margin indicator would be more useful and could be used continuously.

- A significant amount of flight information is already available on the flight deck. Adding an extra parameter, such as AoA, should not lead to confusion.

- The interpretation of an AoA indicator is not intuitive. A mind step has to be made before the use of AoA information can be translated into action.

- In most modern flight decks, AoA information is already available in the form of a flight path vector in combination with the aircraft symbol. The pitch limit indicator also provides AoA information, as well as stall warning systems.

- To display the true AoA, the AoA indicator requires Mach compensation which relies on an air data system input.

As a result of this list of drawbacks, a better solution than an AoA indicator can be found to deal with LoC-AoA. If no direct AoA indicator is available on the flight deck, another way of displaying AoA information is required. The solution is found in the display of AoA-based information and guidance.

DISPLAY OF AoA-BASED INFORMATION AND GUIDANCE

The indirect display of AoA, referred to as AoA-based information, can be designed in various ways. The advantage is that this design can be tailored to provide clear and intuitive guidance to deal with LoC-AoA. In addition, it can complement the way modern day pilots use the information presented on the PFD, instead of adding a new flight parameter to their scan. Examples of a guidance cue on the PFD, possibly using color-coding, are:

- A pitch limit indicator
- A flight path vector showing flight envelope limitations
- Presentation of a “fly-to” or “fly-away” zone

These AoA information and guidance cues can be used to present information useful to prevent LoC-AoA, as well as guidance to recover from LoC-AoA. A disadvantage is that there is no common standard yet for such a display. Pilots flying different types of aircraft during their career may have to adapt to different displays as long as there is no standardization. The quality of the design will minimize this drawback.

Consequently, human factors, different backgrounds and experience levels of pilots, and standardization among manufacturers are issues that have to be addressed while deciding on the way to go. The design of these AoA-based cues will determine their usability, and consequently their success.

SUMMARY

Preventing LoC-AoA is essential to reducing a major contributing factor to incidents and accidents. The following aspects should be addressed:

1. Pilots should be trained on AoA behaviour and not simply on its definition
2. Presentation of AoA information and guidance should be designed so that it is clear and intuitive
3. Presentation of AoA information should be independent of the airplane’s air data system

The direct display of AoA using an AoA indicator has several drawbacks and is not desired. A clearer and more intuitive display of AoA-based information and guidance will help in the recognition and recovery of upsets due to excessive AoA.