General Aviation Joint Steering Committee

Safety Analysis Team – Angle of Attack Indicator Update

Historically, angle of attack (AoA) indication systems have been used primarily in turbine airplanes. Small airplanes have relied on other information for primary aircraft state awareness. As a result of its study on loss of control accidents, the General Aviation Joint Steering Committee (GA JSC), in coordination with the Part 23 ARC, placed emphasis on enhanced aircraft state awareness systems for small airplanes. This led to the development of two GA JSC safety enhancements: SE-1: AoA for New Airplanes and SE-2: AoA for Existing Fleet. SE-1 recommends AoA systems for in-production aircraft and new type designs. SE-2 recommends finding solutions for retrofitting AoA systems on the existing GA fleet. The culmination of this work led to the release of a policy memorandum from Federal Aviation Administration (FAA) AIR-100 in February 2014 outlining the approval of non-required AoA indicator systems for GA aircraft. This policy memorandum fueled considerable interest from the avionics community and led to four new AoA systems being introduced at the Experimental Aircraft Association's Airventure Oshkosh fly-in convention in July of that year. Since then, more systems have been released for retrofit as well as several models of GA aircraft now being offered with AoA as standard or optional equipment. With the recent focus on AoA systems in GA, two studies have been conducted to look at their effectiveness in mitigating the risks of inflight loss of control accidents.

Results from an initial study in 2016 conducted by the University of North Dakota (UND) indicated that "GA aircraft equipped with AoA systems experienced greater pitch reductions during the turn-to-final portion of their approaches, a crucial indicator of a stable approach." During the GA JSC's study of loss of control accidents on approach and landing, improper pitch on turn-to-final was identified as a significant risk factor. UND's 2016 study found that after AoA systems were installed, aircraft were flown differently. During the turn to final, "pilots of AoA-equipped aircraft dropped the nose about 0.7° more than pilots of aircraft not equipped with AoA systems." It was also found that AoA-equipped aircraft also experienced a wider G envelope than non AoA-equipped aircraft. Subsequent research using a much larger data set and longer-term data has continued to demonstrate this same AoA-pitch-reduction relationship. A full-scale research project is now underway at UND to further study this (and other) AoA effects.

The Partnership to Enhance General Aviation Safety, Accessibility and Sustainability (PEGASAS) Center of Excellence also conducted an AoA study. The PEGASAS study included pilots that had access to AoA displays and had either received training on the use of AoA displays or had received no training. The results from these groups were

compared against pilots that did not have access to AoA displays. Their study found differences in a pilot's flying in instances "where the AoA system could replace information that is normally present but was absent for a given approach." This can include a lack of a visual guidance system at the landing airport (e.g., PAPI or VASI) and unfamiliarity with the aircraft being flown. The researchers "discovered that there were differences amongst the groups involved in these tests and the more AoA information the pilot had received (in both education and AoA access), the more stable the approach." There were also instances in which improvement in the management of angle of attack was expected, but not found. For example, when a simulated engine-out approach was conducted, it was anticipated that the AoA system could be used as a tool to increase approach stability. However, study results from two universities did not indicate differences in the stability of the approaches in simulated engine failure situations with or without AoA systems. Participants at one university, who "were not trained on the use of the AoA system but were allowed to utilize the AoA display, performed less stable approaches than the other groups." This result was not anticipated, but with the highly-structured programs within the collegiate flight training environment and the level of proficiency present in practicing emergency and abnormal situations, "it might be a contributing factor in that participants were experienced in the scenarios that were presented and might have relied on their previous experiences to conduct as stable approaches as possible."

Both studies suggested ways that AoA systems helped mitigate certain risks associated with inflight loss of control accidents, such as increased cognizance of the aircraft pitch angle, particularly on complex approaches. The studies also indicated potential issues that may need to be addressed as more AoA units are developed and installed, such as the importance of training. The Safety Analysis Team (SAT) of the GA JSC will continue to monitor these and other AoA research projects as well as work with the GA community to gather additional data on AoA effectiveness. The SAT will also be working with the manufacturing community to report back to the GA JSC on the installation numbers of AoA units in the GA fleet. This work is continuing and the GA JSC will update this paper as more results are available.