Proposed Equivalent Safety Finding on CS 25.1145(a)(b) – Ignition switches

Applicable to Boeing 747-8 / -8F

Introductory note:

The following Special Condition has been classified as an important Special Condition and as such shall be subject to public consultation, in accordance with EASA Management Board decision 02/04 dated 30 March 2004, Article 3 (2.) of which states:

"2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency."

Statement of Issue

The mandatory EASA airworthiness standards for the B747-8/-8F are determined as CS 25 Amendment 2 effective October 02, 2006 in accordance to Implementation Regulation Part 21 para 21.101 and their related AMC and GM to Part 21.
The Boeing models 747-8F and B747-8 flight deck does not include ignition control switches and therefore does not directly comply with CS 2.1145(a) and 25.1145(b). The GenX-2B design, as integrated in the Boeing models 747-8F and B747-8, includes an automatic starting and ignition control system which is fully controlled by the Engine Electronic Control.

Boeing 747-8 / -8F – Equivalent Safety Finding E-06

- Ignition switches -

Applicant Proposal:

Boeing requests an Equivalent Safety Finding (ESF) for the 747-8/-8F flight deck ignition switch configuration. Adequate control of the GEnx2B engine ignition system exist in the absence of dedicated control switches on the flight deck, providing an Equivalent Level of Safety in lieu of direct compliance with CS 25.1145(a) (b).

Applicant Safety Equivalency Demonstration:

All Boeing airplane models certified prior to the 777 incorporated flight deck ignition control switches as part of standard, manually-controlled ignition systems. Automatic control of an ignition system through the Electronic Engine Control (EEC) was incorporated only as optional airplane feature. Manual controls usually included a single or dual ignition selector, a continuous ignition selector, and a switch to control the power source for the igniters.

The 777 was the first Boeing aircraft to eliminate ignition control switches, as the EEC assumed control of igniter and igniter power supply selection. Rolls-Royce and some GE powered 777 aircraft also eliminated the continuous ignition switch making ignition control fully automatic on these 777 variants. Building on the automation of the 777 ignition control, the 787 / GEnx-1B is the first Boeing aircraft with a standard automatic ignition control configuration with no ignition control switches in the flight deck. Flight critical software in the EEC controls all ignition functions during starting, operation and shutdown.

The 747-8/-8F is a derivative of the 747-400. The baseline 747-400 flight deck has a rotary auto-ignition selector which is used to select single or dual ignition and a rotary standby ignition selector which controls standby power distribution to the igniters. Two push actuated switches are also integrated into the ignition panel to control manual selection of continuous ignition and engagement of Auto-start. The GEnx-2B engine implemented on the 747-8/-8F is a derivative of the 787 GEnx-1B engine with an ignition system which is entirely controlled by EEC Auto-start and auto-relight software. Therefore, all 747-400 based flight deck ignition control switches have been removed from the baseline flight deck.

The only switches that remain on the 747-8/-8F starting and ignition panel from the 747-400 panel are the pull actuated start switches. Manual control of the ignition system is not required for engine operation.

Flight safety concerns associated with the elimination of manual ignition control focus on the potential loss of ignition control during failures of EEC software and/or the malfunction of ignition system components. Automatic EEC control of ignition is accomplished through Auto-start and auto-relight software logic. All EEC software is Level A, flight critical per DO-178B and therefore is shown through extensive testing to exhibit high reliability. Failure of EEC ignition control is extremely remote and would only occur as part of a total EEC software failure, a condition which would require an in-flight engine shutdown (IFSD) per standard operating procedure. As a result, the loss of direct control of igniter power, selection, or excitation due to an EEC software failure will not impact safety of flight and is not impacted by the absence of manual ignition switches.

The second concern with loss of ignition control due to ignition system component failures is mitigated by the dual purpose of the fuel selector on the 747-8/-8F. On the 747-8/-8F, initiation/shutoff of engine ignition is directly tied to manual actuation of the Fuel Control switch in the flight deck. During starting and shutdown, ignition can only be initiated when the Fuel Control is actuated to RUN. Auto-start plays an intermediate role by deciding when ignition is physically initiated, based on fuel scheduling, but no ignition is allowed prior to actuation of the Fuel Control. For termination of ignition, command of the Fuel Control to CUTOFF will remove all igniter power by instructing the EEC to turn off both exciters powering both igniters. The direct link between the fuel selector and EEC ignition control in conjunction with the reliability of the EEC software provides suitable ignition control means between the flight deck and the ignition system.

Removal of ignition control switches enhances safety by simplifying flight deck design and crew procedures. Selection of ignition is no longer dependent on a pilot being cognizant of aircraft configuration or atmospheric conditions. In addition, pilots would not be required to manually select ignition configurations for ground and critical inflight engine starting situations. Auto-start logic monitors EGT, N1, N2, N2 rate-of-change,

and starter duct pressure during all start attempts, ground and inflight, until the engine stabilizes to ensure there is no abnormal engine behaviour. If abnormal behaviour such as a hung start, locked rotor, hot start, no light-off, or low duct pressure is observed, Auto-start implements corrective action. Types of Auto-start corrective action include flight crew notification, implementation of dual ignition, modified fuel scheduling, fuel supply cycling, or aborting a start if required (ground only) before reattempting another start. In addition, automatic relight logic is initiated if a flameout or rollback is detected once the engine is running. The auto-relight logic drives corrective action, such as fuel rescheduling and dual ignition, to preserve continued engine operation.