

Proposed Equivalent Safety Finding on 25.1305(a)(2) : 'Fuel Quantity Indicator'

Applicable to Bombardier DHC-8 400, modified with an External Auxiliary Fuel Tank System

Introductory note:

The following Equivalent Safety Finding (ESF) has been classified as important and as such shall be subject to public consultation, in accordance with EASA Management Board decision 12/2007 dated 11 September 2007004, 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:

On the DHC-8-400 Series (Q 400) an External Auxiliary Fuel Tank System (EAFS) integration outside the existing Outer Mould Line (OML) will be installed to increase the endurance capability. The EAFS includes Auxiliary Fuel Tanks (AFT) attached to the fuselage below the wing and inboard of the Engine Nacelle/ Main Landing Gear, with aerodynamic fairings and systems within the tank.

The aircraft is civil-certified, but flight with the EAFS is not intended for commercial operation but for special missions (e.g. maritime patrol aircraft).

The modification consists of three related STC's:

- Auxiliary Fuel Management System provisions (AFMS)
- Auxiliary Fuel Tank Structural Provisions (AFTSP)
- Auxiliary Fuel Tank and System Activation (AFTSA)

The AFMS STC comprises the auxiliary fuel control and indication system and associated electrical harnesses and interfaces, but will be installed as provisions (i.e. inactive, secured and unpowered). The AFMS will be activated only once an EAFS is installed, either by the applicant or another qualified design authorization. The concept of the EAFS is to provide additional fuel for special missions to increase the endurance only and not to alleviate any existing aircraft limitations. It should be noted that these modifications are to be installed on aircraft that are designated for Special Missions with dedicated Special Missions crew having undergone specific training in the operation of the EAFS prior to flying a Q400 with EAFS installed.

The modified aircraft shall not be used for Commercial Air Transport operations and therefore normal commercial Q400 pilots shall not fly the aircraft without first completing specific training on the EAFS, even if this system is not operated.

The applicant acknowledges that the EAFS modifications are classified as 'Significant Major'. Therefore compliance will be demonstrated with the applicable clauses of CS-25 at Amendment 15, but the EAFS modification does not include a full time display of the total fuel quantity as required per CS 25.1305(a)(2), including both EAFS fuel and the Wing Tank fuel of the pre-modified aircraft fuel system. The Certification Specifications at CS 25.1305 were updated at Amendment 12 specifically to address several accidents that were the result of aircraft running out of fuel. However, provided that the STC is not permitted for installation in aircraft for Commercial Air Transport operations, EASA will accept that compliance with CS 1305(a)(2), may be compensated by factors that provide an equivalent level of safety (in accordance with Part-21.A.115).

ESF E-101 :25.1305(a)(2) : Fuel Quantity Indicator – DHC 8 400 equipped with External Auxiliary Fuel Tank System –

Applicant Proposal:

To assure that the DHC-8 400 Series (Q 400) operated with EAFS are not to run out of fuel due to non-provision of a single indication of total usable fuel on board, the following limitations provide an equivalent Level of Safety as that required by CS 25.1305(a)(2) and shall be included in the EAFS AFM Supplement:

Limitation 1:

The Auxiliary Fuel Management System provisions (AFMS) must not be installed in aircraft used for CAT operations.

Limitation 2:

The aircraft must not operate at a range greater than 1 hour's flying time at the one-engine inoperative cruise speed, in standard atmospheric conditions and still air, from an adequate aerodrome.

Note:

The concept of the EAFS is to provide additional fuel for special missions to increase endurance only and not to alleviate any existing aircraft limitations. Although this limitation is already in the AFM to cover non-ETOPS, it must also appear in the AFM Supplement that covers the EAFS. This is because flight crews are likely to associate the existing limitation with ETOPS rather than to the installed EAFS. With the provision of the EAFS and its associated fuel, EASA considers it prudent to remind flight crews when they suddenly have an aircraft with up to 10.000 lbs extra fuel, that they still have to stay within 1h of an adequate airfield.

Limitation 3:

The conditions for the activation of the AFMS and the operational procedures for an Auxiliary Fuel Tank System (EAFS) must be approved by the competent authority.

Note:

As for the time being only AFSM provisions are installed and approved, it is assured that the activation of any EAFS to be installed, will be compliant with CS 25 as effective at the time of application to the competent authority in accordance with Part 21.A.17.

As these modifications are to be installed on aircraft that are designated for Special Missions with dedicated Special Missions crew only, it is also assured that normal commercial Q400 pilots shall not fly the aircraft without first completing specific training on the EAFS. The approval of the specific training is the responsibility of the competent authority for the modified aircraft.

Applicant Safety Equivalency Demonstration:

1. Functional Description

During normal operations the EAFS is armed after take-off. When wing tank fuel levels reduce from 5980lbs (maximum) to 5500lbs, and the Main Boost Pumps are not functioning, the EAFS fuel will transfer from the left and right hand Auxiliary Fuel Tanks (AFT) to their respective wing tank. With the EAFS switched on, the aircraft wing tanks will be maintained above 5500lbs provided that EAFS fuel is available for transfer and the system operates correctly. Transfer will cease once the wing tank fuel level reaches 5700lbs.

2. EAFS Specific Crew Training

The EAFS related training program development will be carried out in conjunction with the development of the modification to activate the EAFS but shall include normal / abnormal fuel system operation (both wing fuel and EAFS) and FMS operation (including accounting for EAFS fuel). Training shall also include familiarity with the amended AFM, AOM and checklists which will also be produced as part of the EAFS activation modification and used for EAFS equipped aircraft operations.

3. Normal operations including crew error

3.1 Fuel system

Fuel system operations affected by the introduction of the AFMS are fuel monitoring and the initiation of auxiliary fuel transfer. To monitor total fuel on board the crew are required to observe two separate gauges; the existing aircraft wing tank [FQIS] gauge and the MA1995 introduced EAFS [AFQGS] gauge.

There is one crew limitation in the AFM and the AOM for the green aircraft relating to the fuel system: *Maximum fuel imbalance between contents of main fuel tanks is 272 kg (600 lb).*

The EAFS will introduce the following additional AFM and AOM limitation: *Maximum fuel imbalance between contents of auxiliary fuel tanks is 454 kg (1000 lb).*

The frequency for monitoring EAFS contents will be no more than that for the green aircraft fuel contents. This monitoring task is regarded as within the scope of basic airmanship.

Auxiliary fuel transfer is initiated after take-off by selecting the two Push Button Switch Indicator (PBSI) on the Aux Fuel Control Panel.

An assessment of potential crew error when operating the aircraft fuel system has determined that no unsafe condition will be introduced as a result of the installation of the EAFS. Potential crew operating errors are:

- a) Crew mistake the EAFS gauge for the FQIS wing tank gauge – The mission would be curtailed due to presumed insufficient wing tank fuel. However, the wing tanks would actually be full.
- b) Crew switch on EAFS but do not monitor EAFS contents during flight – The crew will observe that the FQIS fuel quantities remain static until EAFS fuel is exhausted, after which time the FQIS fuel quantities will deplete in line with the rate of engine fuel burn. A considerable safety margin exists on wing fuel should the crew fail to monitor EAFS contents.
- c) Crew confuse the baseline aircraft fuel system and EAFS balance limitations - For wing tanks the green aircraft BALANCE advisory will alert crew to 600lb imbalance before the incorrect 1,000lb limit is reached. For the EAFS, maintaining a 600lb imbalance in lieu of a 1,000lb limit is considered a safe condition. If the crew confuse the EAFS BALANCE advisory for the wing tank BALANCE advisory or vice-versa; monitoring the gauges while transferring fuel in an effort to re-balance will allow the crew to recognise their error.
- d) EAFS transfer is not switched on – The aircraft will be operated in line with the baseline aircraft. The FQIS gauges will show the correct fuel quantity available.
- e) Only one side of the EAFS is switched on – If this is not identified through periodic fuel checks then the wing imbalance advisory will eventually annunciate. At this point the minimum wing fuel would be 5500lb (side with EAFS transfer on) + 4900lb (side with EAFS transfer off) = 10,400lb. This fuel quantity is significantly greater than the 2,773lb* fuel load required for the 1 hour diversion and would allow for identification through subsequent periodic checks before it became a safety concern.

* Assuming: AUM=20 Tons, OEI, non-icing, ISA.

3.2 Flight Management System (FMS) operation:

The FMS includes two Flight Management Computers located on the Pilot and Co-Pilot centre console, unchanged by the introduction of the AFMS modification. Total fuel and payload weight can be programmed into the FMS pre-flight and can be amended as required during flight. Engine fuel flow data is provided to each FMS from the Flight Data Processing System; the quantity of burnt fuel is subtracted from the total fuel quantity with the result (i.e. fuel and aircraft weight) used to calculate and display data on the fuel page; this will provide access to all fuel management data including fuel and weight entry, range and endurance estimates, fuel requirement summary, projected landing weight, fuel flow and fuel consumption.

The introduction of the AFMS affects the operation of the FMS as fuel from two gauges (wing tank (FQIS) and EAFS (AFQGS) has to be considered.

Prior to mission start, the crew will enter the verified total fuel quantity (the combined aircraft wing tank (FQIS) gauge total and EAFS (AFQGS) gauge total) into the FMS fuel page as total fuel quantity to be used for validating reference speeds and mission planning purposes noting that diversion calculations will remain unchanged from that of the baseline aircraft.

Considering the pre-existing risk of inaccurate data input into the FMS; starting at programming the FMS before departure and working backwards:

- a) FMS performance data is always verified by both pilots. One will enter the data and the other will check it.

b) The performance data will be verified from the load-sheet. Both crew members will check the load-sheet for basic operating weight, cargo and fuel load (wing and EAFS) etc. This will provide a take-off AUM which is the figure used to gross error check the FMS. This is where V speeds are checked as well.

c) The fuel load (wing and EAFS) entered on the load-sheet will be the figure checked and obtained from the aircraft techlog by the aircraft captain which is verified on the flight deck fuel gauges (wing and EAFS).

d) The fuel quantity loaded on the aircraft will be the minimum quantity to complete the flight safely as accepted by the aircraft captain.

There are at least 3 occasions where the captain verifies the fuel load and 2 where both pilots verify the FMS data.

The aircraft checklists will be amended for EAFS to remind the pilots to include EAFS fuel in the review of take-off data.

Similarly, both pilots will independently calculate the expected landing weight. One will program the FMS and the other will verify it.

4. Abnormal operations

4.1 FMS

In the event of an EAFS malfunction, the total quantity of fuel on board within the FMS would need to be updated to reflect the wing tank fuel quantity only with the result that the mission may be compromised. Any remaining auxiliary fuel would be regarded as payload and the FMS would be updated accordingly to ensure aircraft weight data is available and crew awareness is maintained. The update of the FMS performance data will be verified by both pilots as per normal FMS operation to safeguard against the risk of inaccurate data input.

5. AFM Processes

Operating procedures (input to AFM and QRH).

On activation of the EAFS, technical publications will be produced to provide supplemental procedures for the following actions in order to meet CS 25.1585:

- Procedure for refuelling.
- Procedure for entering the auxiliary fuel in the Flight Management System (FMS) as fuel load.
- Procedure for in flight monitoring of the planned fuel burn, indicated Wing Fuel, indicated Aux Fuel and indicated FMS fuel.
- Procedure for EAFS Transfer initiation (Post Take-off).
- Procedure for EAFS Transfer deactivation, once aux tanks are empty.
- Procedure for defueling.