Subject: ESF – Alternate Endurance Test (CS-E 740)

Requirement Reference: Following CS-E[1] requirements: CS-E 40, CS-E 740

[1] *CS-E – Certification Specifications for Engines, Amendment 4, dated 12 March 2015*

Introductory Note:

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

CS-E 740 prescribes endurance test schedules and specifications for Turbine Engines, in order to demonstrate the intended type design engine's ability to safely operate within and up to its declared operating limits.

The Applicant considers that the engine design incorporates new features, materials and technologies such that it impacts the feasibility of conducting the endurance test schedules as prescribed by CS-E 740. The Applicant also considers that significant modifications of the test vehicle would be necessary to achieve the required conditions, such that it would not be representative enough of the type design, and that the test outcome could not be reconciled.

Applicant Proposal:

The Applicant proposes endurance test cycle and conditions, hereby called "alternate endurance test", that allow the engine to be run in type design configuration, with limited test enabling modifications.

The Applicant also proposes to demonstrate engine durability by addressing the limiting damage mechanism while the engine is operating in service.

EASA Position:

EASA recognises the technological advancements introduced in modern turbine engines, such as higher bypass ratio, higher airflow and pressure ratio, increased secondary air system and cooling complexities. Consequently, applicants have faced increased difficulties to run the endurance test schedules at the conditions prescribed by CS-E 740 (in particular the combined target speed and

temperature redline conditions for the time durations specified), resulting in the need to modify the tested vehicle in order to demonstrate the expected engine operating limitations.

However EASA has considered the architecture and design of the subject engine in view of Part 21.A.16B(a), and did not identify any novel or unusual design feature, nor any unconventional intended use that would justify a Special Condition. As the endurance test cycle and conditions proposed by the Applicant significantly differ from the prescriptions of CS-E 740 (up to Amendment 4), an equivalent level of safety to that provided by CS-E 740 shall be demonstrated.

In determining the requirements of this ESF, EASA has considered the work performed by the Aviation Rulemaking Advisory Committee (ARAC), Engine Harmonization Working Group (EHWG) on Engine Endurance Testing Requirements. The EHWG released a recommendation report 'Alternate Test to 14CFR33.87, EHWG task from Federal Register Vol.79, #14 January 22, 2014', dated January 31, 2017. It has been published on December 21, 2017 on FAA website under Regulations & Policies > Rulemaking > Committees > Documents.

The following requirements are to be considered if the applicant proposes to deviate from some of the specifications of CS-E 740, and in particular the test conditions and time durations at combined target speed and temperature redline conditions. Compliance with all other CS-E 740 specifications not compensated by the relevant provisions of this ESF shall be demonstrated.

In order to demonstrate the intended type design engine's ability to safely operate within and up to the declared engine operating limits, consistent with the level of demonstration intended by the current CS-E 740 requirement, it is expected that the Applicant addresses the following aspects:

1. The Applicant should identify from experience on previous testing and analysis the damage mechanisms exercised by the current test (CS-E 740, CS-E Amdt 4), and the associated affected engine systems and components.
2. Durability/severity criteria consistent with the "intent of the current CS-E 740 tests" associated with the damage mechanisms shall be established and justified. The proposed test shall be of sufficient severity and duration to exercise those damage mechanisms to a level at least equivalent to the established criteria.
    a. For these purposes the "intent of the current CS-E 740 test" should be understood as a theoretical set of conditions to which a particular component would be subjected to during a CS-E 740 test, if the practical limitations of engine testing did not apply. The assessment should therefore account for the current CS-E 740 schedules, maximum material temperatures or thermal severity, as applicable, of one, or more critically affected engine components associated with a type design engine running at the intended maximum Exhaust Gas Temperature (redline EGT) within its intended operational envelope, and combined with maximum physical rotor speeds (redlines).
    b. Damage levels for most severe predicted in-service conditions should also be analysed and provided for benchmark purposes.
3. The applicant must determine through a validated Critical Point Analysis (CPA) the highest rotor shaft rotational speeds (CPA speeds) expected to occur for each rotor shaft system within the declared operating envelope. The CPA must be conducted and validated for the

take-off and maximum continuous rated thrust and must consider the declared operating envelope, engine deterioration, engine-to-engine variability, and any other applicable variables that can cause the engine to operate at the extremes of its performance ratings.

4. In order to demonstrate maximum EGT limit for take-off (redline), the proposed test shall include testing at or above the rated take-off thrust/power and maximum take-off EGT for a minimum cumulated time of 18.75 hours. The associated average rotor speeds should not be lower than the maximum take-off CPA speeds.

5. In order to demonstrate maximum EGT limit for maximum continuous (redline), the proposed test shall include testing at or above the rated maximum continuous thrust/power and maximum continuous EGT for a minimum cumulated time of 45 hours. The associated average rotor speeds should not be lower than the maximum continuous CPA speeds. Testing shall include at least one continuous interval of a minimum of 30 minutes duration.

6. In order to demonstrate maximum rotor speed limits for take-off (redlines), the proposed test shall include testing for a minimum of 10 minutes duration at the maximum physical rotor speeds combined with the maximum take-off EGT, unless the CPA shows a longer period is required. If separate demonstration is proposed for each shaft, those shall be for a minimum of 10 minutes each.

7. In order to demonstrate maximum rotor speed limits for maximum continuous (redline), the proposed test shall include testing for a minimum of 10 minutes duration at the maximum continuous rotor speeds combined with maximum continuous EGT. This may be demonstrated by par. 6 above, unless the CPA shows a longer period is required, in which case testing would be extended at maximum continuous conditions. If separate demonstration is proposed for each shaft, those shall be for a minimum of 10 minutes each, plus extension if applicable.

8. Engine operating limitations shall be proposed and justified based on achieved test times and conditions. Note that EGT substantiation requires full demonstration of equivalent severity to the "intent of the current CS-E 740 test" as indicated in paragraph 2 above. Upon acceptance by the Agency, engine operating limitations will be declared in the EASA Type Certificate Data Sheet (TCDS) in accordance with CS-E 740 (f) and CS-E 40 (d) – see also AMC E 40 (d).

9. If test enabling modifications are used, their impact on the test results shall be detailed and reconciled with the type design, and found acceptable by the Agency.

The Applicant may propose additional compensating factors to contribute to the demonstration of the equivalent level of safety. Compensating factors may include additional test demonstrations (additional in form, extent and/or duration) or other evidence found acceptable by the Agency.

All provisions of CS-E 740 specification shall be addressed by the proposed alternate endurance test, directly or by equivalence found acceptable by the Agency.

CS-E 740 includes specific provisions whether the engine is to be installed on aeroplanes or rotorcraft, and depending on selected ratings. Although this ESF may be applied in principle to any turbine engine, the Applicant should confirm its applicability to his project with the Agency.