EASA European Union Aviation Safety Agency	**Consultation paper** **Deviation**	Doc. No.: CPTS-0000432 Issue : 1 Date : 15/12/2023 Proposed ☒ Final ☐ Deadline for comments: 31 Jan 2024

SUBJECT	:	Inhibition of electronic engine shaft shear overspeed protection system
REQUIREMENTS incl. Amdt.	:	CS-E 840(a)(c), CS-E 850(a)(1) initial issue or higher
ASSOCIATED IM/MoC	:	Yes☐ / No ☒
ADVISORY MATERIAL	:	AMC E 840, AMC E 850 initial issue or higher

Table of Content for Public Consultation

INTRODUCTORY NOTE:

The following Deviation (DEV) shall be subject to public consultation in accordance with EASA Management Board decision 12/2007 dated 11 September 2007, Article 3 (2.) 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.*"

ABBREVIATIONS:

N/A

IDENTIFICATION OF ISSUE:

CS-E requires for each fan, compressor, and turbine rotor, to comply with CS-E 840 Rotor Integrity. In particular per CS-E 840(a):

> *(a) For each fan, compressor, and turbine rotor, it must be established by test, analysis, or combination thereof, that a rotor which has the most adverse combination of material properties and dimensional tolerances allowed by its type design will not burst when it is operated in the Engine for five minutes (…)*

Additionally, CS-E 840(c) provides clarification for loss of load scenarios that need to be evaluated by the Applicant.

> *(c) The highest over-speed which will result from a complete loss of load on a turbine rotor, (…), must be included in the over-speeds considered under each of CS-E 840(b)(3)(i), (ii) and (b)(4), (…)*

CS-E 840 is accompanied by further requirements captured in CS-E 850 concerning shafts safety:

> *(a) Objectives*
>
> > *(1) It must be demonstrated that Failures of the shaft systems will not result in Hazardous Engine Effects, except as provided in CS-E 850(a)(3). (…)*

The objective of the rule is to prevent a Hazardous Engine Effect due to rotor burst. As a response to the certification specifications listed above, the industry has developed different means to detect and mitigate the effect of shaft failure occurrences which may otherwise lead to rotor burst representing a Hazardous Engine Effect. Often an electronic shaft shear overspeed protection system is introduced to comply with CS-E 840 and 850. Such protection systems monitor various engine parameters to detect any anomalies in engine behaviour that are attributed to a shaft shear event. If a shaft shear event is detected, the system reacts and shuts the engine down safely. Without a protection system, or other mechanical means to limit rotor overspeed and prevent rotor burst, an engine does not comply with CS-E 840 and 850.

It is important that the risk of spurious electronic engine shaft shear overspeed protection system activation is minimised by thorough protection system design and verification. Nonetheless, it is not possible to entirely eliminate the risk of spurious activation of such system. In case of failure and loss of thrust on one engine (operation with One Engine Inoperative (OEI)) for a twin engine aeroplane, a spurious activation on the remaining engine leads to a catastrophic failure condition on aircraft level, i.e., the remaining engine could

be shut down in an automated manner due to a reaction of an electronic engine shaft shear overspeed protection system.

To protect the aeroplane safety, the availability of thrust must be preserved 'as much as possible' and the ultimate decision to shut down all engines in flight must be taken solely by the flight crew. The risk of a system-based shutdown of the remaining engine in flight must be carefully analysed and minimised. The introduction of an engine function that would automatically inhibit the electronic engine shaft shear overspeed protection system in the remaining engine during operation with One Engine Inoperative (OEI), provides further protection against the risk of total loss of thrust at aeroplane level.

However, the inhibition of the electronic engine shaft shear overspeed protection system in an operation with One Engine Inoperative (OEI) would lead to a non-compliance of the engine with CS-E 840 and CS-E 850.

Considering all the above, the following Deviation is proposed.

M-TS-0000432

Deviation

Inhibition of electronic engine shaft shear overspeed protection system

1. APPLICABILITY

This Deviation is planned to be applicable to CS-E Turbine engines installed on a twin engine aeroplane, equipped with an electronic engine shaft shear overspeed protection system that incorporates an inhibition functionality to prevent dual engine shut down.

1.1 AFFECTED CS

Compliance with the following paragraphs is not ensured when the electronic engine shaft shear overspeed protection system is inhibited in case of One Engine Inoperative (OEI) on a twin-engine aeroplane:
CS-E 840(a) at Initial Issue or higher
CS-E 840(c) at Initial Issue or higher
CS-E 850(a)(1) at Initial Issue or higher

1.2 PRE-CONDITIONS FOR APPLICATION OF THE DEVIATION

Not applicable

2. APPLICABLE ESSENTIAL REQUIREMENTS OF REGULATION (EU) 2018/1139

The following paragraphs of the "*Essential Requirements" for Airworthiness* as defined in Annex II to Regulation (EU) 2018/1139 are related to the CS identified in 1.1 for which a non-compliance exists:

1.2. Propulsion

1.2.1. The integrity of the propulsion system (i.e. engine and, where appropriate, propeller) must be demonstrated throughout and sufficiently beyond the operational envelope of the propulsion system and must be maintained for the operational life of the propulsion system, taking into account the role of the propulsion system in the overall safety concept of the aircraft.
(…)
1.2.5. All necessary instructions, information and requirements for the safe and correct interface between the propulsion system and the aircraft must be promulgated.

1.3. Systems and equipment (other than non-installed equipment):

1.3.1. The aircraft must not have design features or details that experience has shown to be hazardous.
1.3.2. The aircraft, including those systems, and equipment required for the assessment of the type design, or by operating rules, must function as intended under any foreseeable operating conditions, throughout and sufficiently beyond, the operational envelope of the aircraft, taking due account of the system or equipment operating environment. Other systems or equipment not required for type-certification, or by operating rules, whether functioning properly or improperly, must not reduce safety and must not adversely affect the proper functioning of any

other system or equipment. Systems and equipment must be operable without needing exceptional skill or strength.

1.3.3. The aircraft systems and equipment, considered separately and in relation to each other, must be designed such that any catastrophic failure condition does not result from a single failure not shown to be extremely improbable and an inverse relationship must exist between the probability of a failure condition and the severity of its effect on the aircraft and its occupants. With respect to the single failure criterion above, it is accepted that due allowance must be made for the size and broad configuration of the aircraft and that this may prevent this single failure criterion from being met for some parts and some systems on helicopters and small aeroplanes.

1.3.4. Information needed for the safe conduct of the flight and information concerning unsafe conditions must be provided to the crew or maintenance personnel, as appropriate, in a clear, consistent and unambiguous manner. Systems, equipment and controls, including signs and announcements must be designed and located to minimise errors which could contribute to the creation of hazards.

1.3.5. Design precautions must be taken to minimise the hazards to the aircraft and occupants from reasonably probable threats, including information security threats, both inside and external to the aircraft, including protecting against the possibility of a significant failure in, or disruption of, any non-installed equipment.

3. STATEMENT OF DEVIATION

To address the non-compliance with the affected CS, the mitigating factors in chapter 4 shall be met. Compliance with the mitigating factors ensures compliance with the applicable essential requirements.

4. MITIGATING FACTORS

The following mitigating factors have been identified as alternative means to ensure compliance with the above identified airworthiness essential requirements:

a) Aeroplane-level Safety Assessment.

To satisfy the *"Essential Requirements" for Airworthiness*, the aeroplane safety analysis must demonstrate that the aeroplane safety level is enhanced by inhibiting the electronic engine shaft shear overspeed protection system in the event of aeroplane One Engine Inoperative (OEI) operation or common mode failure. If any assumption is made concerning the intended engine installation, such assumption must be declared in the Engine instructions for installation in accordance with CS-E 20.

b) Compliance with CS-E 510 must be demonstrated for an engine operated with an electronic engine shaft shear overspeed protection system as well as an engine that has an operational electronic engine shaft shear overspeed protection system inhibition function.
Note: CS-E 510 excludes the consideration of operating with OEI, therefore it is not required to include an evaluation of OEI operation with inhibition function failure under CS-E. This aspect must be addressed by the analysis required in paragraph a).

c) The Applicant is required to provide a safety analysis demonstrating that the probability of a failed electronic engine shaft shear overspeed protection system inhibition function combined with a spurious activation of an electronic engine shaft shear overspeed protection system, for the operational engine in an OEI scenario, does not result in an aeroplane catastrophic failure condition

with a probability greater than 1×10^{-9} per flight hour. In order to fulfil this requirement, the aeroplane design organisation involvement is required and/or any assumption used for the analysis must be documented in the Engine instructions for installation.

d) Electronic Engine Shaft Shear Overspeed Protection System Reliability Detailed Demonstration

i. System Coverage Assurance

The proposed electronic shaft shear overspeed protection system must cover all operating conditions throughout certified engine operating envelope and must detect and prevent any rotor overspeed event leading to a hazardous outcome. Scenarios like ETOPS diversion and Take-off Go Around (TOGA) must be a part of this evaluation, if applicable.

ii. False Activation Analysis

The Applicant is required to present a failure scenario investigation completed as part of the safety analysis focusing on a false activation review. The investigation must include a discussion of all possible false activation modes including environmental occurrences (like ice or bird ingestion) and any other causes that can impact multiple engines simultaneously. Additionally, the Applicant must present a rate of spurious electronic engine shaft shear overspeed protection system activation with details about the source of activation.

iii. System Availability Guarantee

The electronic engine shaft shear overspeed protection system must be demonstrated to operate per design intent in all dispatchable configurations, without loss of function or degraded performance that would not satisfy the compliance with CS-E 840 and CS-E 850. The applicant needs to guarantee that dispatchability for all system sensors, electronic hardware, or software subsystems does not impact its availability. Additionally, a list of CS-E 1030 Time Limited Dispatch (TLD) and CS-MMEL Master Minimum Equipment List (MMEL) inputs is required to demonstrate that all system components of the electronic engine shaft shear overspeed protection system are evaluated and prohibited for dispatch in inoperative condition.

iv. Engine Restart Capability

The safety analysis must include an evaluation of engine restart following electronic engine shaft shear overspeed protection system activation causing engine shut down. The evaluation must include potential false activation modes and dispatchability. Additionally, a restart of a failed engine during flight must be considered. Procedures and consequences of such scenario must be presented to the Agency.

v. System Complexity Discussion

The engine safety analysis must include a review of electronic engine shaft shear overspeed protection system construction covering an overview of its sophistication in the aspect of failure scenario analysis complexity. The evaluation must cover failure mode review and their impact on system robustness as well as false activation detection difficulties. Additionally, the Applicant must provide a review of all shaft areas that are not addressed by the detection system or other means, which mechanically would be susceptible to a failure but are not covered by the electronic engine shaft shear overspeed protection system as required by CS-E 850(b)(2).

e) Inhibition Function False Activation and Activation Failure Reliability

The Applicant must comply with all the requirements from point d) in the aspect of electronic engine shaft shear overspeed protection system Inhibition function. Additionally, inhibition function failure to activate during One Engine Inoperative (OEI) scenario needs to be considered within the safety analysis and demonstrated not to degrade the safety of the aeroplane.

f) Protection and Inhibition System Documentation

The electronic engine shaft shear overspeed protection system and the inhibition function characteristics assumed in the engine design must be documented in the Engine Installation Manual. Additionally, the details of both aeroplane and engine system elements must be documented in an appropriate certification interface document signed by both the aeroplane and the engine manufacturer that can be accessible by the Agency.