EASA Proposed CM-PIFS-003 Issue 01 – Turbine Over-speed Resulting from Shaft Failure (previously referred to as Non-Hazardous Shaft Failures) - Comment Response Document

Comment				Comment summary	Suggested resolution	Comment is an observation or is a suggestion	Comment is substantive or is an objection	EASA comment disposition	EASA response
NR	Author	Section, table, figure	Page						
1	*Francis Fagegaltier*			The referenced document is apparently focused on turbine rotor overspeed after shaft failure (see in "background" paragraph: "a shaft failure may not match the results of the predictive analysis, therefore creating the risk of rotor overspeed"). With regard to this safety issue, the document does not draw comments. However, when interpreting CS-E 850 (b) (1), the release of the complete fan rotor on a turbofan engine should not be forgotten. Example of such potential hazardous effect can be found in the NTSB report found at http://www.airdisaster.com/reports/ntsb/AAR82-05.pdf. This safety concern was expressed in the sentence "Where it is claimed that Hazardous Engine Effects are avoided by ensuring that rotating components are retained substantially in their normal plane of rotation". When discussing the current text of what is now CS-E 850, this failure case had been a difficult subject and is a significantly different scenario than turbine rotor overspeed.				Partially Accepted	We acknowledge that the policy addresses in essence turbine rotor behaviour as a consequence of shaft failure. The commenter mentions the case of a forward fan shaft failure that resulted in the release of a fan rotor. The probable causes of this fan shaft failure have been determined by the accident investigation. We believe that the consequences of this fan shaft failure - release of the fan rotor – are currently more predictable than the consequences of a shaft failure leading to turbine rotor overspeed. Also the evolution of engine technology and features in fan and surrounding designs are not deemed to have recently substantially evolved, up to significantly increased the risk of underestimating these consequences. However to address the comment, some amendments to the policy are implemented to clarify its scope according to the explanations above. Firstly, the title of the Certification Memorandum is changed to **"Turbine Over-speed Resulting from Shaft Failure"** in order to clarify its scope. Secondly, the text is amended as shown below: *In **2. BACKGROUND*** *Recent service experience has shown that engine behaviour following a shaft failure may not match the results of the predictive analysis, therefore creating the risk of turbine rotor overspeed in excess of the predicted value, and uncontained failure. This may be due to one or more of the following: unforeseen effects of improved aerodynamics and/or control logic, inaccurate compressor surge predictions, improper assumptions of rotor to stator friction and/or clashing effects, etc…* *In **3.1 EASA POLICY*** *Per CS-E 850 (b)(1), when it is claimed that Failures of the shaft systems will not result in Hazardous Engine Effects ("Non-Hazardous Shaft Failures") caused by turbine overspeed, a test will normally be required.* *For shaft failure resulting in turbine rotor overspeed, EASA considers the following:* *· The test should be performed …*
2	*CAA UK*			Re: 1. Proposed Equivalent Safety Finding on CS E-740 and CS E-750 – Endurance Test and Engine Starting Tests; 2. Proposed Certification Memorandum on Non-Hazardous Shaft Failures Please note that there are no comments from the UK CAA on the above referenced documents.				Noted	
3	*Turbomeca*	3.1	5	"If compliance is not shown with a full engine test but with a system or component rig test, it should be shown that the rig test is highly representative in term of the key characteristics of the shaft failure and its consequences on all relevant engine parts and sub-systems behaviour, as it would occur on a full engine." Comment: "highly representative" should be replaced by "sufficiently representative". The proposed wording is deemed more appropriate as "highly representative" could be interpreted as "identical".	"highly representative" should be replaced by "sufficiently representative".	No	Yes	Accepted	The comment is accepted. See EASA response to comment NR 8 for modified text.

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4	*Turbomeca*	3.1	6	"The analysis should be validated against an actual engine test and/or service events, showing a high degree of similarity with the engine model for which compliance is sought. This similarity should encompass all relevant aspects of the failure mechanism and its consequences such as, but not limited to, aerodynamics, surge characteristics, engine control logic, rotor speeds and associated acceleration characteristics, relevant rotor and stator design features, materials, clearances, etc… and should be submitted to the Agency for acceptance." Comment: "a high degree of similarity" should be replaced by "sufficient similarity". The proposed wording is deemed more appropriate as "a high degree of similarity" could be interpreted as "identical".	"a high degree of similarity" should be replaced by "sufficient similarity".	No	Yes		The comment is accepted. See EASA response to comment NR 9 for modified text.
5	*Boeing Commercial Airplanes*	Sec. 3.1	5/6	Boeing has concerns about systems that automatically shut down engines in flight. Active overspeed systems risk false activation at a rate that may be higher than the underlying shaft failure rate. As such, there may be the potential for multiple in-flight shutdowns or thrust asymmetry during a critical flight phase.	We recommend Inserting the following text in this section: ***"Where active overspeed protection devices are installed, they must be shown to resist false activation at rates that do not compromise aircraft safety."***		Yes	Not Accepted	Notwithstanding the importance of the issue addressed by the comment, the proposal is not accepted. The comment is relevant for the Safety Analysis at aircraft level, using input from the Safety Analysis at engine level. The purpose of this policy is to provide additional guidance when an Applicant is showing compliance with CS-E 850 (b)(1). It is also to be noted that current CS-E 50 (c) addresses Engine Control System Failures. The policy is not modified.
6	*Rolls-Royce Plc (ZM)*	2a) Last Sentence.	5	Although leaving the cert by analysis route open, this pushes towards having to test to better validate assumptions where the consequences are not readily predictable.	Suggested: 'The analysis should be validated against an actual engine test and/or service events'.	Yes	No	Not Accepted	Section 2.(a) is an extract of current AMC E 850, and therefore may not be altered. The suggested text is already part of Section 3.1.
7	*Rolls-Royce Plc (ZM)*	3.1 First Bullet Point.	5	Cannot accept the statement as it may not always be practical to perform/duplicate a test at the most critical condition. It may not even be possible to define one point as the most critical, so some level of correction to other conditions is needed. Also it would force the applicant to consider shaft failure conditions which may be highly unlikely (extremely remote or less), but which then would become the sizing factor for the whole shaft system.	Suggested: 'The test should be performed by initiating the shaft failure at the most critical conditions (where practical) which will maximise the rotor overspeed and subsequent effects. Where it is impractical to fully duplicate the most critical conditions, it is allowable to test at suitably representative conditions to analytically account for the most critical conditions. Failure conditions with a probability of Extremely Remote or less do not need to be taken into account. In addition to initial rotor speed other aspects should also be taken into consideration, such as shaft torque and relevant engine pressures and temperatures'.	No	Yes	Partially Accepted	The proposal is accepted in principle. The text is amended to replace "most critical conditions" by "worst case operating conditions within the flight envelope, in any dispatchable configuration", to discard "worst cases" that cannot occur in service. The need to submit the test conditions to the Agency for acceptance is added. The allowance to not consider the failures predicted to occur with a probability of Extremely Remote or less is also added, with the condition that they meet all requirements of CS-E 850 (b)(2). The policy is modified as follows: *In **3.1 EASA POLICY*** *·The test should be performed by initiating the shaft failure at the ~~most critical~~ worst case operating conditions within the flight envelope, in any dispatchable configuration, which will maximise the rotor overspeed and subsequent effects. Where it is impractical to fully duplicate the worst case conditions, the Applicant may propose a test at suitably representative conditions to account for the worst case conditions. Those test conditions would need to be submitted to the Agency for acceptance. In addition to initial rotor speed other aspects should also be taken into consideration, such as shaft torque and relevant engine pressures and temperatures. Failures predicted to occur with a probability of Extremely Remote or less do not need to be taken into account, if they meet all requirements of CS-E 850 (b)(2).*

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8	*Rolls-Royce Plc (ZM)*	3.1 Second Bullet Point.	5	Implies there will only be one system or rig test. It should be left open for doing more than one test, with the tests together making the case. This would be similar to the approach in the AMC for Hazardous Shaft failures (4(b))	Suggested: 'If compliance is not shown with a full engine test but with a system or component rig test(s), it should be shown that the test(s) are sufficiently representative in terms of the characteristics of the shaft failure and its consequences to all relevant engine parts and sub-systems'.	Yes	No	Partially Accepted	The comment is partially accepted. The possibility to perform more than one test is included. However the analogy to full engine behaviour is retained as in the current text. The policy is modified as follows: *In **3.1 EASA POLICY*** *· If compliance is not shown with a full engine test but with a system or component rig test(s), it should be shown that the ~~rig~~ test(s) ~~is~~ are ~~highly~~ sufficiently representative in term of the key characteristics of the shaft failure and its consequences on all relevant engine parts and sub-systems behaviour, as it would occur on a full engine.*
9	*Rolls-Royce Plc (ZM)*	3.1 Third Bullet Point + Sub Bullet	5/6	Should try to retain the use of analysis where justified. The requirement should be that the analysis method is validated, using test/service evidence, and that an acceptable case should be made as to why the resulting method can be extrapolated to the design case in question.	Suggested: 'If compliance is shown by analysis as allowed by AMC E 850 (2), the following aspects should be considered, whether or not the affected rotor components are designed to be retained substantially in their rotational plane: - The analysis should ideally be validated against an actual engine test and/or service events, showing a sufficient degree of similarity with the engine model for which compliance is sought. Alternative means of validating the analysis may be considered but will require review and approval on a case by case basis. This similarity should encompass all relevant aspects of the failure mechanism and its consequences such as, but not limited to, aerodynamics, surge characteristics, engine control logic, rotor speeds and associated acceleration characteristics, relevant rotor and stator design features, materials, clearances, etc… and should be submitted to the Agency for acceptance'.	Yes	Yes	Partially Accepted	The policy already establishes the necessary conditions for validating the analysis. However the possibility to use system or component rig test may be repeated in this paragraph as in the previous bullet. But allowing "alternative means" other than test(s) for validating the analysis would pose the risk of increased inaccuracy. The policy is modified as follows: *In **3.1 EASA POLICY*** *- The analysis should be validated against an actual engine or system or component rig test(s) and/or service events, showing a ~~high~~ sufficient degree of similarity with the engine model for which compliance is sought.*