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1	*UKCAA*	2 Background	4	Section 2 states: "*In accordance with CS-E 15, an Engine Critical Part means a part that relies upon meeting prescribed integrity specifications of CS-E 515 to avoid its Primary Failure, which is likely to result in a Hazardous Engine Effect*" We suggest the proposed additional text shown within the next column is added to this statement to provide clarity	Added text in red colour In accordance with CS-E 15, an Engine Critical Part means a part that relies upon meeting prescribed integrity specifications of CS-E 515 to avoid its Primary Failure before reaching its agreed life, which is likely to result in a Hazardous Engine Effect	YES		Not accepted	The proposed text differs from the definition in CS-E 15. The commenter is reminded that the principle of the 'Approved Life' is elaborated in the subsequent paragraph.

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2	*UKCAA*	2 Background	4	We recommend that 'Failure' needs to be defined within section 1.4 Failure can be understood in a different way and to avoid ambiguity within applicants it is useful to define what does the Agency mean by 'failure' i.e. the feature has failed only when it is cracked? Or it has failed when it has stopped carrying out its intended function? Please use "Failure or cracked" throughout as a consistent terminology because at various sections within the CM only the terminology "failure" is used. For example, "No guidance is provided for the evaluation of features of an Engine Critical Part whose failure will not result in a Hazardous Engine Effect. For this reason, EASA is issuing this CM to aid applicants in the appropriate treatment of such features when demonstrating compliance with CS-E 515".	Define "failure" within section 1.4 Please use "Failure or cracked" consistently throughout the document	YES		Partially accepted	Additional text is added to the definition of a non-hazardous feature, however the commenter is reminded of the complexity associated with differing loading mechanisms present in Engine Critical Parts. The commenter is also reminded that for Static Critical Parts, a period of crack growth is already permitted when determining the Approved Life of the part, see AMC E 515. Definitions Amended: Definitions, Non-Hazardous Feature: An area, a region, or a zone in-separable from an Engine Critical Part whose localised failure (e.g., loss of material, loss of function, or cracking) will not result in a Hazardous Engine Effect.

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3	*UKCAA*	3.1	5	The section states "***The Engineering, Manufacturing and Service Management Plans as required by CS-E 515, should continue to ensure the closed-loop system which links the assumptions made in the Engineering Plan to how the part is manufactured and maintained in service***" With non-hazardous features included within the engineering plan i.e. by the design approval holder (Part J), it is possible for the production approval holder (manufacturing part G) to produce a component with failed or cracked non-hazardous features because as per engineering plan the failed or cracked non-hazardous features are acceptable. With this the continued airworthiness regime i.e. the service management plan could also allow components to carry on operating with failed non-hazardous features. This also means that the continuing airworthiness requirements i.e. Part M and Part 145 needs to be adjusted to accommodate such a relaxation given within the engineering plan to accept engine critical components with failed or cracked non-hazardous features. Otherwise those non-hazardous features allowed by part 21J would be rejected by Part 145. This could generate a potential inconsistency within the initial airworthiness regulatory framework i.e. Part 21J and Part 21G, as well as continuing airworthiness regulatory requirements.	Update to include text to cover Part G, Part M and Part 145 requirements. Components shall not be released with known defects or cracks or failed non-hazardous features as a new component as certified on an airworthiness release form 1.		YES	Not Accepted	Taking credit for a non-hazardous feature within the Engineering Plan of CS-E 515 (a) (for the Approved Life definition see CS-E 15) is not an authorisation to release cracked parts into service. Similarly, giving credit for a non-hazardous feature within the Engineering Plan is not an acceptance of cracking or localised failure within an Engine Critical Part. The following clarifications are made are made to the CM: Section 3.1, paragraph 3. " ……and in some instances, credit may be taken for such features within the Engineering Plan when determining the Approved Life of the part." Section 3.5, title change and additional paragraph "In-service findings and repairs Additional clarifications added to CM in Section 3.5: New paragraph 1: It is not the intention of this CM to allow failed or cracked hardware to return to service. The identification of a non-hazardous feature enables credit to be taken in the Engineering Plan when assessing the Approved Life. It is not an approval to consider a cracked or failed part as airworthy. Final paragraph added as follows: When credit is taken for a non-hazardous feature within the Engineering Plan in determining the Approved Life of a critical part, this does not constitute an approval of repair designs (production concession, non-conformances, or unrepaired damage), for individual parts found with failed (including cracked) non-hazardous features.
4	*UKCAA*	3.1 paragraph 6	5	"Closed Loop System", in this regard a continued airworthiness policy or protocol, should be instigated to ensure the Closed Loop system feeds back appropriate validating information for the NHF, a programme of Certification feedback or Maintenance assessment policy. This would reinforce the requirements of Section 3.5.	Continued airworthiness policy or protocol, should be instigated to ensure the Closed Loop system feeds back appropriate validating information for the NHF, a programme of Certification feedback or Maintenance assessment policy. This would reinforce the requirements of Section 3.5.		YES	Partially accepted	This is already achieved by the Service Damage Monitoring process established in EASA CM EASA CM-PIFS-007. Cross reference added in last sentence: ", see EASA CM EASA CM-PIFS-007 for details regarding Service Damage Monitoring."

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5	*UKCAA*	3.2	5	The first bullet point in Section 3.2 states: "***Integrally bladed rotor (IBR) aerofoils (figure 1a) and centrifugal rotor / impellor aerofoils (figure 1b) above the dashed line shown in figure 1 Note the dashed line is positioned at a radial position above the fillet, outboard of which defines the aerofoil. Failure of an aerofoil is contained (see CS-E 810) and does not lead to rotor burst"*** This paragraph states that failure of aerofoil is contained and does not lead to rotor burst. The requirement is that the failure or cracking of non-hazardous features shall not result in hazardous engine effect. Contained aerofoil does not lead to rotor burst, however there are other scenarios that could develop because of failed and contained aerofoil resulting in hazardous engine effect such as engine fire, downstream damage ,engine thrust reduction/imbalance for example.	Rather than adding a conclusive text that failed aerofoil is contained and does not lead to a rotor burst, suggest add a clear statement that "when aerofoils are classified as non-hazardous, such a classification must justify that failure of aerofoils does not result in a hazardous engine effect"		YES	Not accepted	The section in question identifies (with illustrations) the features where the Agency considers that a non-hazardous evaluation may be acceptable during type certification. The comment raised is a 'NOTE' to aid understanding the dotted line in the referenced illustration. Failure of an aerofoil is required to be contained (see CS-E 810) and shall not lead to rotor burst (a known hazardous outcome). Additional information is included in the CM regarding the Aerofoil-Rotor Interaction Zone (ARIZ), see section 3.4.2.1. Secondary effects, as noted by the author are considered in 3.4.3.
6	*UKCAA*	3.2	6	The examples given at the top of page 6 are simple and not necessarily representative of real life defects or failures. This should be further expanded to aid understanding. We suggest other critical parts such as Shaft should be included	Please include examples from a variety of critical parts.	YES		Not accepted	The choice of examples provided is explained in section 3.2, immediately following Figure 1. The objective of the CM is to provide the principles for consideration of non-hazardous features. Other feature types would require specific agreement and acceptance between the Type Certificate holder and the Agency as described in the CM.

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7	*UKCAA*	3.3	7	***Section 3.3 states: "(a) Either results in a safe shutdown requiring immediate maintenance rectification, or (b) may be tolerated until the next scheduled inspection (of the concerned part, and also any secondary components or systems), or (c) is detectable (e.g. loss of EGT margin) during operation such that required near-term engine maintenance and rectification (e.g. engine removal) is assured"*** With regards to the above paragraph, point (a) covers single engine safe shut down, however with a common design feature within every engine of a multi engine aircraft a common mod failure could be a possibility. We recommend paragraph (b) should end with word 'and' rather than 'or' It is not clear what the consequences on ETOPS operation are.	***a) Either results in a safe shutdown not involving more than one engine in a multi engine aircraft requiring immediate maintenance rectification, OR (b) may be tolerated until the next scheduled inspection (of the concerned part, and also any secondary components or systems), AND (c) is detectable (e.g. loss of EGT margin) during operation such that required near-term engine maintenance and rectification (e.g. engine removal) is assured*** A statement about ETOPS operation needs be added i.e. when one engine is already out for whatever reason and an aircraft is operating with one engine, safe shut down would not be a possibility in this case for the remaining engine with failed non-hazardous feature. So in this case, a recommendation from the Agency is needed.		YES	Partially accepted	Section 3.1 identifies that when credit is taken within the Engineering Plan, the Safety Analysis of CS-E 510 should also evaluate the failure modes and effects of those features, including the impact of engine installation assumptions. Those engine installation assumptions should include common mode effects and ETOPS. Section 3.1 is amended to highlight this aspect (red text): Where credit is taken for a non-hazardous feature, or features within the Engineering Plan (required by CS-E 515), the Safety Analysis of S-E510 should also evaluate the failure modes and effects of those features of Engine Critical Parts identified as non-hazardous, including the impact of engine installation assumptions, common mode effects, and ETOPS (CS-E 1040). Section 3.3 is not amended.

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8	*UKCAA*	3.3 paragraph 3	7	Even if IBR etc. are discounted these part types/features should still be monitored through the Closed Loop System, as per UK CAA Section 3.1 comment. While failure probability may be acceptable this would lead to a level of complacency with regard to currency of the Engineering Plan.	All non-hazardous features including IBR should be monitored.		YES	Not Accepted	IBR's are NOT discounted, it is proposed, as has been common practice since CF impellors / IBR's were first introduced (circa 1970), that they receive feature credit within the Engineering Plan when determining the Approved Life of the critical part in accordance with CS-E 515. Paragraph 3 highlighted by the commenter states: "The failed aerofoils of bladed rotor configurations have demonstrated positive field experience with respect to safety and meeting the relevant certification specifications (CS-E 510, CS-E 810). Therefore, the IBR or impeller aerofoil (as shown in figure 1) identified as a non-hazardous feature, need not be assessed, within the engine critical part life assessment methodology" The critical part life assessment methodology represents a set of TC holder tools that enable the establishment of an Approved Life before Hazardous Engine Effects can occur. Traditionally bladed rotor aerofoils are not subject to the lifing scrutiny of engine critical parts, because their failure do not result in a Hazardous Engine Effect. Once the aerofoil of an IBR has been demonstrated equivalent in safety to that of a traditional blade aerofoil, it may be treated in a consistent manner to a traditionally bladed aerofoil. As stated, this has been standard practice by certification authorities since the early introduction of IBRs and centrifugal rotor / impellor aerofoils. Additional information is included in the CM regarding the Aerofoil-Rotor Interaction Zone (ARIZ), see section 3.4.2.1. With respect to monitoring, the commenter is referred to Section 3.5 and UKCAA comment 4. Monitoring is already achieved by the Service Damage Monitoring process established in EASA CM EASA CM-PIFS-007, including IBR aerofoils.

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9	*UKCAA*	3.3	7	***The final paragraph in Section 3.3. states: "Field experience records and non-hazardous definitions are not yet available for other rotor non-hazardous features. Consequently, the life of rotor non-hazardous features, other than IBR aerofoils and centrifugal rotor / impellor aerofoils, should be included within the Approved Life of the engine critical part. The life assessment principle applied to such rotor non-hazardous features may however be less restrictive (have reduced life margin) than features of the engine critical part whose failure would lead to a Hazardous Engine Effect".*** The above paragraph allows a less restrictive life assessment approach for the non-hazardous features. However, if a feature is to be declared non-hazardous on an engine critical part, then the life assessment of that feature should be carried out with the same rigor, because by using a less restrictive approach, a potential failure scenario could be missed i.e. repair by metal deposition or Additive Layer Manufacturing or 3D printing could introduce material anomalies that remain unassessed.	"***Field experience records and non-hazardous definitions are not yet available for other non-hazardous features. Consequently, the life of rotor non-hazardous features, other than IBR aerofoils and centrifugal rotor / impellor aerofoils, should be included within the Approved Life of the engine critical part.*** ~~***The life assessment principle applied to such rotor non-hazardous features may however be less restrictive (have reduced life margin) than features of the engine critical part whose failure would lead to a Hazardous Engine Effect***~~***"***.		YES	Not Accepted	The CM does not suggest, or indicate that less rigor may be taken, the CM recognises that such features may be life assessed to a reduced statistical (the word statistical is added to the CM) life margin than normally considered for a critical part. As stated in response to comment 8, this has been normal practice in IBR and centrifugal rotor / impellor certification since first introduction. The commenter is incorrect in their assumption that a less rigorous approach is accepted. The word 'statistical' is inserted in section 3.3 The life assessment principle applied to such rotor non-hazardous features may however be less restrictive (i.e. have reduced statistical life margin) than features of the engine critical part whose failure would lead to a Hazardous Engine Effect".
10	*UKCAA*	3.4.2.1	7	Section 3.4.2.1 appears to contradict with Section 3.3 Section 3.3 states "***The failed aerofoils of bladed rotor configurations have demonstrated positive field experience with respect to safety and meeting the relevant certification specifications (CS-E 510, CS-E 810). Therefore, the IBR or impeller aerofoil (as shown in figure 1) identified as a non-hazardous feature, need not be assessed, within the engine critical part life assessment methodology***." However, Section 3.4.2.1 requires that an assessment of IBR and Centrifugal compressor aerofoils is to be carried out to ensure that crack does not propagate into the disc body.	Section 3.4.2.1 to be deleted OR section 3.3 to be updated to remove "***Therefore, the IBR or impeller aerofoil (as shown in figure 1) identified as a non-hazardous feature, need not be assessed"***		YES	Not Accepted	The commenter is referred to the response to UKCAA comment 8 and comment 9. Section 3.3 highlighted by the commenter is achieving consistency with traditionally bladed aerofoils, part of that is done through ensuring that failure (including cracking and damage) in the interface area does not lead to disc burst. It is highlighted that the commenter has not quoted the full sentence identified in in 3.3. The full sentence included in the CM is: "Therefore, the IBR or impeller aerofoil (as shown in figure 1) identified as a non-hazardous feature, need not be assessed, within the engine critical part life assessment methodology." When reviewing the complete sentence, it should clear that IBR or impellor aerofoils DO need to be assessed vis-à-vis their consequences of failure. However, the aerofoil above the dashed line in figure 1, having been identified as not leading to a Hazardous Engine Effect, need not be assessed, within the engine critical part life assessment methodology. The commenter is advised that additional information is included in the CM regarding the Aerofoil- Rotor Interaction Zone (ARIZ) (see 3.4.2.1).

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11	*UKCAA*	3.4.2.2	8	The last paragraph within Section 3.4.2.2 conflicts with Section 3.4.1, 'Primary Containment ' which states:. **"Failure does not lead to the non-containment of high-energy debris" T**his implies that the failure is allowed to release debris as long as they are not high energy debris. However, paragraph 3.4.2.2 does not allow any kind of release i.e. full containment. This also contradicts with the intent of CS-E 810 We suggest the paragraph "If the static Critical Part … contained a failed blade" is deleted	Delete the following ~~If the static Critical Part is a containment case (refer to the guidance of AMC 520 (d)), cracking or localised failure could lead to the release of uncontained high energy debris. Therefore, the following shall be demonstrated for all features:~~ ~~• cracks are not predicted to initiate in, or propagate into, any containment area within the Approve Life of the part~~ ~~or~~ ~~• the case, with the crack length predicted at the Approved Life of the part, will still contain a failed blade~~		YES	Not Accepted	The Hazardous condition identified in CS-E 510 is "non-containment of high-energy debris". The commenter is reminded that static critical parts are already permitted to have a period of crack growth within their Approved Life (see AMC E 515). The section identified by the commenter in 3.4.2.2 is regarding the functioning of the containment case and the continued ability of the engine to meet the certification specifications of CS-E 810 in the event of blade release with an existing crack already present in the case. This text is essential to maintain consistency of CS-E integrity requirements. Other revisions to the identified paragraph have been made

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12	*UKCAA*	3.4.3-	9	Section 3.4.3 states: "Cracking or failure of a non-hazardous feature may lead to a change in conditions and operating environment of neighbouring features or components. The consequences of these changes and their effect on the life of other features or parts should be included in the safety assessment of CS-E 510 and where relevant, the Engineering Plan of CS-E 515. It should also be identified whether single or multiple feature cracking / failure leads to more severe conditions elsewhere on the component. Secondary downstream effects or damage may occur as a result of the primary failure, an example of this is blade aerofoil separation or the balling of released material causing damage to surrounding or downstream hardware. The resultant consequences of any material loss should be considered in addition to the primary effect within CS-E 510." We suggest amending the above statements to include the additional text shown in red in the next column, for clarity	Cracking or failure of a non-hazardous feature may lead to a change in conditions and operating environment of neighbouring features or components. The consequences of these changes and their effect on the life of other features or parts should be included in the safety assessment of CS-E 510 and where relevant, the Engineering Plan of CS-E 515. It should also be identified whether single or multiple feature cracking / failure leads to more severe conditions elsewhere on the component. If hazardous engine effect is identified because of such assessment the feature should not be included within the list of non-hazardous features. Secondary downstream effects or damage may occur as a result of the primary failure, an example of this is blade aerofoil separation or the balling of released material causing damage to surrounding or downstream hardware. The resultant consequences of any material loss should be considered in addition to the primary effect within CS-E 510. If hazardous engine effect is identified because of such assessment the feature should not be included within the list of non-hazardous features.	YES		Accepted	The intent of the commenter is addressed in section 3.1: "When features of an Engine Critical Part credited for being non-hazardous (i.e. their failure has no Hazardous Engine Effect), the following additional information should be included in the Engineering Plan: • The features deemed non-hazardous • Assumed crack location and crack path that is deemed non-hazardous • Justification of how the feature or features were deemed non-hazardous • Demonstration by test or validated analysis that the Primary Failure (as defined in CS-E 15) of the feature or features does not result in a Hazardous Engine Effect • Justification by test or validated analysis that the consequence of failure of the non-hazardous feature, or features is appropriately addressed within the determination of the Approved Life of the part (see sections 3.3 and 3.4)" If the applicant cannot achieve these objectives, then any proposed feature should NOT be considered as a non-hazardous feature. Section 3.4, including 3.4.3 is titled "Additional considerations when identifying when identifying a feature as non-hazardous. The request made by the commenter is implicit in 3.1, however the Agency has no objection to the proposal made by the commenter. Section 3.4.3 amended: Cracking or failure of a non-hazardous feature may lead to a change in conditions and operating environment of neighbouring features or components. The consequences of these changes and their effect on the life of other features or parts should be included in the safety assessment of CS-E 510 and where relevant, the Engineering Plan of CS-E 515. It should also be identified whether single or multiple feature cracking / failure leads to more severe conditions elsewhere on the component. If a Hazardous Engine Effect is identified because of such assessment, then the feature should not be included within the list of non-hazardous features. Secondary ~~downstream~~ effects or damage may occur as a result of the primary failure, an example of this is blade aerofoil separation or the balling of released material causing damage to surrounding or downstream hardware. The resultant consequences of any material loss should be considered in addition to the primary effect within CS-E 510. If a Hazardous Engine Effect is identified because of such assessment, then the feature should not be included within the list of non-hazardous features. Section 3.4.2.2 has also been amended following review of this comment: The Approved Life should be the minimum life of the feature whose failure could lead to a Hazardous Engine Effect. It should therefore be demonstrated that crack growth does not propagate in such a manner that may cause Hazardous Engine Effects within the Approved Life of the part. For example, a crack length which compromises engine mount redundancy, high pressure structural integrity, or blade containment would not meet this objective

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13	*UKCAA*	3.4.4	9	Section 3.4.4 states: "The loss of portions of a rotating part causes unbalanced loading in both a transient and steady state manner. The effects of such abnormal loading should be considered for both rotating parts and static load paths." We suggest amending the above statements to include the additional text shown in red in the next column, for clarity	The loss of portions of a rotating part causes unbalanced loading in both a transient and steady state manner. The effects of such abnormal loading should be considered for both rotating parts and static load paths. If hazardous engine effect is identified because of such assessment then feature should not be included within the list of non-hazardous features.	YES		Accepted	The intent of the commenter is addressed in section 3.1. refer to UKCAA comment 12 response. The request made by the commenter is implicit in 3.1, however the Agency has no objection to the proposal made by the commenter 3.4.4 amended: The loss of portions of a rotating part causes unbalanced loading in both a transient and steady state manner. The effects of such abnormal loading should be considered for both rotating parts and static load paths. If a Hazardous Engine Effect is identified because of such assessment, then the feature should not be included within the list of non-hazardous features.
14	*UKCAA*	3.5	9	Section 3.5 last sentence states: "***The part in question should be considered unserviceable unless an appropriately approved repair can be established***." This statement conflicts with the intent of this CM which allows design of non-hazardous features on an Engine Critical part. When design has already concluded that failed/cracked non-hazardous features does not result in a hazardous outcome at engine level, then the reason is unclear in declaring an engine critical component unserviceable if found cracked or failed within non-hazardous feature location. We propose this Section is amended to include the additional text shown in red in the next column	3.5. In-service findings When the engine type enters service, in accordance with point 21.A.3A of Part 21, the Type Certificate holder must collect, investigate and analyse reports related to cracking or failure of a critical part **outside the boundary of identified non-hazardous feature location**. The TC holder should investigate the root cause and determine if the certification assumptions remain valid. The part in question should be considered unserviceable when failed/cracked **outside the boundary of identified non-hazardous feature location** unless an appropriately approved repair can be established	YES		Not Accepted	It is not the intention of this CM to allow failed or cracked hardware to return to service. The identification of a non-hazardous feature enables credit to be taken in the Engineering Plan when assessing the Approved Life. It is not an approval to consider a cracked or failed part as airworthy. Refer to response for UKCAA Comment 3 Section 3.5, title change and additional paragraph "In-service findings and repairs …………………….. Additional clarifications added to CM: New paragraph 1: It is not the intention of this CM to allow failed or cracked hardware to return to service. The identification of a non-hazardous feature enables credit to be taken in the Engineering Plan when assessing the Approved Life. It is not an approval to consider a cracked or failed part as airworthy. Final paragraph added as follows: When credit is taken for a non-hazardous feature within the Engineering Plan in determining the Approved Life of a critical part, this does not constitute an approval of repair designs (production concession, non-conformances, or unrepaired damage), for individual parts found with failed (including cracked) non-hazardous features.
15	*UKCAA*	General	All	This CM doesn't appear to address multiple site damage on non hazardous features, that is when a component contains multiple cracks and thus could release a number of sizeable pieces of debris into the engine	Please include examples of multiple site damage when a component contains multiple cracks and could release a number of sizeable pieces of debris downstream.		YES	Not Accepted	This CM does not represent a blanket approval and cannot detail all feature types be that singularly or multiple. The CM provides additional guidance to applicants. Any specific situation will always be subject to agreement and concurrence from the Agency.

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16	*UKCAA*	General	All	Generally, we believe the purpose of this CM should be to add clarification about existing/ambiguous certification requirements or when certain certification requirements are missing altogether. The purpose of this CM should be to enhance overall safety of component however this particular CM seems to allow failure of certain features of critical parts by defining them as non-hazardous features and thus dilutes the intent of CS-E 515.	Rather than providing a blanket approval via CM we believe such non-hazardous features should be assessed on a case by case basis as part of the CS-E 515 compliance demonstration.		YES	Not Accepted	Non-hazardous features such as IBR aerofoils and centrifugal rotor / impellor aerofoils have been accepted by all major certification authorities and routinely received credit within the lifing system and Engineering Plan since their first introduction into product designs. This CM does NOT allow failure of certain features of critical parts as a consequence of defining them as non-hazardous. The CM provides a structured approach for evaluating non-hazardous features of engine critical parts and taking credit for this within the Engineering Plan of CS-E 515 when determining the Approved Life of the part. The commenter is reminded that CS-E 515 (a) requires: "An Engineering Plan, the execution of which establishes and maintains that the combinations of loads, material properties, environmental influences and operating conditions, including the effects of parts influencing these parameters, are sufficiently well known or predictable, by validated analysis, test or service experience, to allow each Engine Critical Part to be withdrawn from service at an Approved Life before Hazardous Engine Effects can occur." The guidance of this CM is consistent with the Certification Specifications of CS-E 515. The Engineering Plan, complete with non-hazardous features identified will continue to achieve the objectives of CS-E 515 (a). Section 3.1 states: "When features of an Engine Critical Part credited for being non-hazardous (i.e. their failure has no Hazardous Engine Effect), the following additional information should be included in the Engineering Plan: • The features deemed non-hazardous • Assumed crack location and crack path that is deemed non-hazardous • Justification of how the feature or features were deemed non-hazardous • Demonstration by test or validated analysis that the Primary Failure (as defined in CS-E 15) of the feature or features does not result in a Hazardous Engine Effect • Justification by test or validated analysis that the consequence of failure of the non-hazardous feature, or features is appropriately addressed within the determination of the Approved Life of the part (see sections 3.3 and 3.4)" The commenter suggests that the CM provides a blanket approval. However, this EASA CM does not provide a blanket approval. On the contrary, it ensures a controlled approach to non-hazardouss features in critical parts; the Engineering Plan will continue to require acceptance in accordance with EASA procedures.

* Please complete this column using the word "yes" or "no"
** Please complete this column using the word "yes" or "no"

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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
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1	*Safran Helicopter Engines*	§1.1	3	It is understood by SafranHE that the CM would only be applicable if the applicant intends to identify non Haz features on a critical part (ie it would be a non systematic application of the CM when the part is considred as critical as a whole). Is it the right understanding ?	Proposed wording: *"The purpose of this Certification Memorandum is to provide specific guidance for applicants when demonstrating compliance with CS-E 515 (a) for Engine Critical Parts, in the specific case where applicants intend to identify non hazardous features on a critical part. This CM provides guidance concerning the recognition of non-hazardous features (an area, a region, or a zone whose localised failure will not result in a Hazardous Engine Effect) within an Engine Critical Part and how such features may be credited within the Engineering Plan of CS-E 515 (a)."*	YES	No	Not Accepted	Sections 1.1 and 2 identify the purpose, scope and background to the CM, and are considered clear in their intent. Section 1.1 and 2 have been updated for other reasons.
2	*Safran Helicopter Engines*	§3.3	7	SafranHE understanding of the Certification Memo intention is that a failed feature in a non Hazardous area of the critical part must not generate Hazardous engine effect (by propagation to a Hazardous area). The paragraph "*the consequences of this failure should be considered in all other relevant certification specifications and should not compromise compliance to integrity requirements e.g CS-E 100, 520, 540(a), 640, 810(a) and (c), 840(a),(b) and (c), 850."* might be understood as a request of full compliance to the refered CS-E § while considering a failed feature. In that case, we believe this requirement to be more stringent than requirements for a Hazardous area where no further compliance to other CS-E paragraphs than CS-E 515 is requested while considering a failed feature. This is then perceived as being new requirements (new rule) compared to current requirements of CS-E (beyond the scope of a certification memo).	*"In cases (b) and (c) above the engine may operate for several flights after the failure of the non-hazardous feature. Unless a crack initiation life is calculated for the feature and accounted for in the Approved Life, the consequences of this failure should be considered in all other relevant certification specifications and should not compromise compliance to integrity requirements e.g CS-E 100, 520, 540(a), 640, 810(a) and (c), 840(a),(b) and (c), 850."* Proposed to be replaced by: *"In cases (b) and (c) above the engine may operate for several flights after the failure of the non-hazardous feature. Unless a crack initiation life is calculated for the feature and accounted for in the Approved Life, the consequences of this failure should not cause any Hazardous Engine Effect under the conditions defined by integrity requirements."*	YES	YES	Partially Accepted	Section 3.3 is amended: In cases (b) and (c) above the engine may operate for several flights after the failure of the non-hazardous feature. Unless a crack initiation life is calculated for the feature and accounted for in the Approved Life, the consequences of this failure should be considered in all other relevant certification specifications. Continued compliance with the integrity requirements of CS-E (e.g. CS-E 100, 130, 520, 540(a), 640, 810(a) and (c), 840(a),(b) and (c), 850), should be ensured in meeting the objective that no Hazardous Engine Effect can occur.

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1	*GE Aviation*	3.4.2.2	8	Clarity can be provided on the applicability of the requirements described in Paragraph 3 of this section. Because the intent of the document is to address the effect of non-Hazardous features, a clarifying clause is proposed.	Suggest amending first sentence from "For all features in a static Critical Part…" to "Following the failure of a non-Hazardous feature, all remaining features in a static Critical Part…"	Yes	No	Not Accepted	The section identified in the CM clarifies how a portion of the residual crack growth life as described in AMC E 515 may be considered. The commenter is referred Safran Helicopter Engines comment 1 Section 3.4.2.2 has been amended in response to UKCAA comment 12
2	*GE Aviation*	3.4.2.2	8	Sub-bullets of paragraph 3 appear redundant with the introductory sentence. The introductory sentence "For all features in a static Critical Part that have a predicted minimum material crack initiation life less than the Approved Life of the part, the part, with the crack length predicted at the Approved Life, should be shown, as relevant, to support without Hazardous Effect" indicates that a hazardous effect may not be induced. The sub bullets should identify the loading conditions to be considered but the failure mode need not be specified because it already specified that a hazardous effect may not be created.	Suggest changing sub bullet #1 **FROM** "the pressure loads defined by CS-E 640 without casing fracture or burst" **TO** "the pressure loads defined by CS-E 640"	Yes	No	Accepted	3.4.2.2 is modified as suggested by the commenter
3	*GE Aviation*	3.4.2.2	8	Sub-bullets of paragraph 3 appear redundant with the introductory sentence. The introductory sentence "For all features in a static Critical Part that have a predicted minimum material crack initiation life less than the Approved Life of the part, the part, with the crack length predicted at the Approved Life, should be shown, as relevant, to support without Hazardous Effect" indicates that a hazardous effect may not be induced. The sub bullets should identify the loading conditions to be considered but the failure mode need not be specified because it already specified that a hazardous effect may not be created.	Suggest changing sub bullet #3 **FROM** "the vibratory loads/stresses induced by normal or fault conditions (CS-E 650 (f) and (g)) without the crack exceeding the high cycle fatigue crack growth threshold" **TO** "the vibratory loads/stresses induced by normal or fault conditions (CS-E 650 (f) and (g))"	Yes	No	Accepted	3.4.2.2 is modified as suggested by the commenter

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1	*AIRBUS* *P.E. ARNAUD*	3.1	Page 5	Be more specific on the consequences of the policy in terms of engine critical parts management.	At the end of third paragraph, add an explanation on the type of credit that can be taken for non-hazardous features (greater life limitation derived from the parts/areas that are hazardous and not from those that are not hazardous)	x		Accepted	Section 3.1 is amended: However it is recognised that an Engine Critical Part may include one or more features, the failure of which will not lead to a Hazardous Engine Effect, and in some instances credit may be taken for such features within the Engineering Plan when determining the Approved Life of the part. The commenter is also referred to Section 3.3 for further guidance: The failed aerofoils of bladed rotor configurations have demonstrated positive field experience with respect to safety and meeting the relevant certification specifications (CS-E 510, CS-E 810). Therefore, the IBR or impeller aerofoil (as shown in figure 1) identified as a non-hazardous feature, need not be assessed, within the engine critical part life assessment methodology.
2	*AIRBUS* *P.E. ARNAUD*	3.4.2. Crack growth behaviour	Page 7	Typo	Please correct the sentence: ‘ this assessment should consider all relevant effects which may include, but may not **be** limited to …’	x		Accepted	Section 3.4.2 is modified as proposed by the commenter.
3	*AIRBUS* *P.E. ARNAUD*	3.4.2.2 Static Critical Parts	Page 8	Please ensure completeness of the non-hazardous demonstration for a cracked static part.	Should this part include the requirement to withstand a fire with the crack length predicted at the Approved Life and w/o Hazardous Effect such as a possible uncontained/uncontrolled fire if an engine casing is also a firewall?	x		Accepted	A new paragraphs is introduced in 3.4.2.2: If the static Critical Part is designed, constructed and installed to act as a firewall (refer to CS-E 130), cracking or localised failure could lead to an uncontrolled fire. Therefore, the following should be demonstrated for all features: …… The part, with the crack length predicted at the Approved Life continues to act as an engine firewall For consistency with the above introduced text, minor revision to the preceding paragraph concerning containment cases are made, as follows: If the static Critical Part is a containment case (refer to the guidance of AMC 520 (d)), cracking or localised failure could lead to the release of uncontained high energy debris following compressor or turbine blade failure (refer to CS-E 810). Therefore, the following should be demonstrated for all features: ……

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1	*AIA RISC* *(AIA Rotor Integrity Steering Committee: GE, PW, PWC, Honeywell, Rolls-Royce (DE, USA), MTU, Safran Aircraft Engines, Safran Helicopter Engines*	3.2	5	Need to define the region of the airfoil in Section 3.2 that is identified as non-hazardous	Added reference (in red below) to new section that defines the region on the aerofoil considered hazardous (ARIZ) • Integrally bladed rotor (IBR) aerofoils (figure 1a) and centrifugal rotor / impellor aerofoils (figure 1b) above the black dashed line shown in figure 1 (see section 3.2.1 for definition of the location of the black dashed line)	No	Yes	Partially Accepted	Since cracking in the AIA RISC proposed ARIZ may lead to a Hazardous Engine Effect, the ARIZ is considered a portion of the rotor body subject to the damage tolerance requirements of CS-E-515. 3.2 ammended: Integrally bladed rotor (IBR) aerofoils (figure 1a) and centrifugal rotor / impellor aerofoils (figure 1b) above the black dashed line (Schematic representation of the start of ARIZ zone) shown in figure 1 (see Section 3.4.2.1) Annotation is also added to the figure depicting the black dashed line as the start of the ARIZ zone
2	*RISC*	3.2	5	There are multiple dashed lines in figure 1. Need to define which dashed line is being used to define border between hazardous and non-hazaardous regions of the aerofoil	Add black in before the referenced to the dashed line in the 1st bullet in section 3.2 • Integrally bladed rotor (IBR) aerofoils (figure 1a) and centrifugal rotor / impellor aerofoils (figure 1b) above the black dashed line shown in figure 1 (see section 3.2.1 for definition of the location of the black dashed line) Note the black dashed line is positioned at a radial position above the fillet, outboard of which defines the aerofoil. Failure of an aerofoil is contained (see CS-E 810) and does not lead to rotor burst.	Yes	No	Accepted	Section 3.2 ammended as proposed by the commenter. Annotation is also added to the figure depicting the black dashed line as the start of the ARIZ zone

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3	*RISC*	3.2.1	6-7	Need to define the region of the airfoil in Section 3.2 that is identified as non-hazardous	Include section to provide applicants guidance in defining hazardous region of the airfoil – Substantiation provided along with comments Proposed new Section 3.2.1 to Define ARIZ **Definition of Aerofoil-Rotor Interaction Zone (ARIZ)** In IBR aerofoils and impellors, it is possible to grow a crack nucleated in the root section of the aerofoil into the rotor body through the combination of steady and vibratory stresses. Vibratory stresses can arise from disk body modes as well as aerofoil modes. This root section of the aerofoil is termed the aerofoil-rotor interaction zone (ARIZ). Crack nucleation within the ARIZ can occur from damage such as impact by foreign objects in the flowpath (i.e., foreign object damage – FOD). Because cracking in the ARIZ may lead to a hazardous engine condition, the ARIZ is considered a portion of the rotor body subject to the damage tolerance requirements of CS-E-515. AIA RISC has identified the radial position in the aerofoil (as illustrated as the black dashed line in figures 1a and 1b) above which a crack will liberate the aerofoil and below which a crack may grow into the rotor body. The portion of the aerofoil which may grow a crack into the rotor body is the ARIZ. The default ARIZ is defined as the radial distance from the inner annulus flowpath to a height determined as the maximum of criteria 1) or 2): 1) 200% of the maximum aerofoil fillet height found anywhere around the root perimeter of the aerofoil. For IBRs, the fillet height is measured as the radial distance from the fillet runout on the aerofoil to the fillet runout on the inner annulus flowpath. For Impellors, the fillet height is measured as the distance from the fillet runout on the aerofoil to the filler runout on the inner annulus flowpath such as measured normal from the platform. 2) 150% of the maximum root aerofoil thickness as measured at the aerofoil fillet runout. The aerofoil thickness is defined as the diameter of the largest sphere tangent to the aerofoil fillet runout and the opposite side of the aerofoil. The above criteria provide a default ARIZ height which can be used without further validation. An applicant can reduce the ARIZ height determined from these default criteria through the use of an appropriate damage tolerance methodology (such as a validated 3D crack growth assessment), tests, experience, or a combination thereof. A validated 3D crack growth assessment has the capability of assessing crack turning and should include the impact	No	Yes	Partially Accepted	Section 3.4.2.1 ammended in-line with commenter's proposal: 3.4.2.1 IBR / centrifugal compressor / impellor rotor aerofoils - Establishment of an Aerofoil-Rotor Interaction Zone (ARIZ) Damage to or cracking of a rotor aerofoil is shown not to grow into the body of the disc or any other area that may result in the release of high energy debris. In IBR aerofoils and impellors, it is possible for a crack nucleated in the root section (lower diameter region of the aerofoil for an IBR) of the aerofoil to grow into the rotor body through the combination of steady and vibratory stresses. Vibratory stresses can arise from disc body modes as well as aerofoil modes. This root section of the aerofoil is termed the aerofoil-rotor interaction zone (ARIZ). Crack nucleation within the ARIZ can occur from damage such as impact by foreign objects in the flowpath (i.e., foreign object damage – FOD). Since cracking in the ARIZ may lead to a Hazardous Engine Effect (growth of a crack into the rotor body leading to burst), the ARIZ is considered a portion of the rotor body subject to the damage tolerance requirements of CS-E-515. By definition, the start of the ARIZ represents the limits of the aerofoil which may be considered non-hazardous. Industry experience has identified the radial position in the aerofoil (as illustrated by the black dashed line in Figures 1(a) and 1(b), above which a crack will liberate the aerofoil, and below which a crack may grow into the rotor body. The portion of the aerofoil which may grow a crack into the rotor body is the ARIZ, where a Hazardous Engine Effect may result. A default ARIZ may be established as the radial distance from the inner annulus flowpath (gas washed surface representing the limit of the rotor body) to a height determined as the maximum of criteria (1) or (2): 1. 200% of the maximum aerofoil fillet height found anywhere around the root perimeter of the aerofoil. For IBRs, the fillet height is measured as the radial distance from the fillet runout on the aerofoil to the fillet runout on the inner annulus flowpath. For Impellors, the fillet height is measured as the distance from the fillet runout on the aerofoil to the fillet runout on the inner annulus flowpath such as measured normal from the platform. 2. 150% of the maximum root aerofoil thickness as measured at the aerofoil fillet runout. The aerofoil thickness is defined as the diameter of the largest sphere tangent to the aerofoil fillet runout and the opposite side of the aerofoil. The above criteria provide a default ARIZ height which may be used without further validation. An applicant may reduce the ARIZ height determined from these default criteria through the use of an appropriate damage tolerance methodology (such as a validated 3D crack growth assessment), tests, experience, or a combination thereof. A validated 3D crack growth assessment has the capability of assessing crack turning and should include the impact of steady and vibratory stresses. The assessment justifying the modification of the ARIZ height from the defaults above should consider the impact of vibratory modes of the disc body as well as the vibratory contribution from aerofoil high cycle fatigue modes and their interaction.

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					of steady and vibratory stresses. The assessment justifying the modification of the ARIZ height from the defaults above should consider the impact of vibratory modes of the disk body as well as the vibratory contribution from aerofoil HCF modes and their interaction.				
4	*RISC*	4	10-12	Added a new section describing how to measure criteria used for ARIZ	Section needed to ensure applicant appropriately measures geometric features used to define ARIZ region of airfoil. The default ARIZ is defined as the radial distance from the inner annulus flowpath to a height determined as the maximum of criteria 1) or 2): 1) 200% of the maximum aerofoil fillet height found anywhere around the root perimeter of the aerofoil. For IBRs, the fillet height is measured as the radial distance from the fillet runout on the aerofoil to the fillet runout on the inner annulus flowpath. For Impellors, the fillet height is measured as the distance from the fillet runout on the aerofoil to the filler runout on the inner annulus flowpath such as measured normal from the platform. 2) 150% of the maximum root aerofoil thickness as measured at the aerofoil fillet runout. The aerofoil thickness is defined as the diameter of the largest sphere tangent to the aerofoil fillet runout and the opposite side of the aerofoil.	No	Yes	Accepted	Refer to AIA RISC comment 3
5	*RISC*	3.3	7	Clarified language in the last paragraph of Section 3.3 to ensure that the approved life of engine critical parts takes into account the failure of non-hazardous rotor features. In the next column, we propose this paragraph be amended to include the additional text shown in blue and the red text that is struckthough to be removed.	Field experience records and non-hazardous definitions are not yet available for other rotor non-hazardous features. ~~Consequently~~ As a result, the life and the consequence of failure of rotor non-hazardous features, other than IBR aerofoils and centrifugal rotor / impellor aerofoils, ~~should~~ must be included within the Approved Life of the engine critical ~~part~~ parts. The life assessment principle applied to such rotor non-hazardous features may however be less restrictive (have reduced life margin) than features of the engine critical part whose failure would lead to a Hazardous Engine Effect.	No	Yes	Partially accepted	Text is amended as follows: Field experience records and non-hazardous definitions are not yet available for other rotor non-hazardous features. ~~Consequently~~ As a result, the life and the consequence of failure of rotor non-hazardous features, other than IBR aerofoils and centrifugal rotor / impellor aerofoils, should ~~must~~ be included within the Approved Life of the engine critical ~~part~~ parts. The life assessment principle applied to such rotor non-hazardous features may however be less restrictive (have reduced life margin) than features of the engine critical part whose failure would lead to a Hazardous Engine Effect.

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Substantiation for Defining Airfoil-Rotor Interaction Zone (ARIZ)

Prepared by AIA Rotor Integrity Steering committee (RISC)
September 15, 2021

Industry Data Collected to understand fleet experience

- More than 100 parts submitted by RISC members to summarize fleet experience
  - Experience from 34 engines manufactured from the 1960s to current installations
  - Multiple alloys submitted
    - Steel
    - Titanium
    - Nickel
    - An alloy that is neither Steel, Titanium, or Nickel
- Substantial part usage supplied in either Hours or Cycles
  - Impellor Usage
    - 900+ million Hours + ~2 million Cycles
  - IBR Usage
    - 750+ million Hours + 500+ million Cycles

Negative Experience Used to define ARIZ region

- Focus on damage in the Airfoil Fillet Region that cracked or Fractured Rotors
  - Thirteen (13) parts had eighteen (18) instances of a crack that started in the airfoil fillet region that cracked or fractured the disk body
    - Events consist of cracks that initiated naturally from Low Cycle Fatigue (LCF) and High Cycle Fatigue (HCF) as well as from damage
  - One (1) part had had an instance of a crack that started above the airfoil fillet tangency point on the airfoil that cracked or fractured the disk body
    - Highest initiation as a function of airfoil fillet height
      - 175% of the airfoil fillet height
    - Highest initiation as a function of airfoil root thickness
      - 132% of the airfoil root thickness

Summary of Negative Experience

The negative experience that guided the proposed ARIZ criteria is in **red** in the table

Eng.	PN	Axial or Radial	Matl.	In case of failure, how many occurrences ?	In case of crack find, how many occurrences ?	Distance to Rim Outer Surface (Fillet Height)	Distance to Rim Outer Surface (Fillet Thickness)	1st cause of initiation - use : FOD, LCF, HCF, D (damage other than FOD), U (unknown)	2nd cause of initiation - use : FOD, LCF, HCF, D (damage other than FOD), U (unknown)	Number of parts*	Number of cycles or hours (specifiy in box below)	Specify cycles or hours	Percentage of certified life for high cycle part (if unknown see below)	Decade of introduction to service
1	1	A	T		1	0.2	0.16	D*	HCF	1300	1,500,000	Cycles	25	10s
2	1	A	T	4		0.2	0.10	HCF		350	700,000	Cycles	20	10s
2	1	A	T		2	0.2	0.10	HCF		350	700,000	Cycles	20	10s
5	3	A	T	1		**1.75**	**1.32**	FOD	LCF / HCF	900	1.6E+07	Hours	100%	1990s
1	3	A	N	1		0.5		U		30000	250000000	Hours	95	70s
1	11	A	S	1		1		D		30000	250000000	Hours	95	80s
1	13	A	S	1		1		U		30000	250000000	Hours	95	70s
1	15	A	N	1		0.5		LCF		30000	250000000	Hours	95	80s
1	15	A	N	1		0.8		LCF		30000	250000000	Hours	95	80s
1	15	A	N	1		0.8		LCF		30000	250000000	Hours	95	80s
1	15	A	N	1		0.8		LCF	HCF	30000	250000000	Hours	95	70s
1	17	A	N	1		0.4		U		30000	250000000	Hours	95	80s
1	16	A	N	1		0.7				30000	250000000	Hours	95	80s
1	18	A	N	1		1		HCF		30000	250000000	Hours	95	80s

Proposed ARIZ Criteria

- Criteria protects against all known negative experience that cracked or fractured rotor bodies
  - RISC proposes to use an airfoil fillet height and an airfoil root thickness criteria to define the ARIZ region of the airfoil
    - The intent of including both criteria is to prevent designs that may be manipulated with the purpose of reducing the ARIZ region
  - **Proposed ARIZ Criteria** to be used without further validation
    - The default ARIZ is defined as the radial distance from the inner annulus flowpath to a height determined as the maximum of either criteria below
      - 200% of the maximum airfoil fillet height found anywhere around the root perimeter of the airfoil
      - 150% of the maximum root airfoil thickness
  - RISC also proposed that the default ARIZ definition can be modified by an applicant with appropriate substantiation
    - An applicant can reduce the ARIZ height determined from these default criteria through the use of an appropriate damage tolerance methodology (such as a validated 3D crack growth assessment), tests, experience, or a combination thereof

Justification for ARIZ Definition

- The proposed ARIZ definition meets the standards of an appropriate damage tolerance assessment consistent with other damage tolerance methods currently within the regulatory material (e.g. titanium hard alpha and circular holes)
  - All negative events (cracks initiated in airfoils propagating into the rotor body) captured in ~2 billion hours of industry experience
    - The proposed ARIZ definition provides margin above the highest recorded negative experience initiation location for each proposed ARIZ measurement criteria while still being considered achievable for OEMs on future products
  - The ARIZ definition also captures ~900 million hours of positive experience where cracks initiated in the proposed ARIZ region and the crack did not grow into the rotor body