COMMENT RESPONSE DOCUMENT (CRD) TO NOTICE OF PROPOSED AMENDMENT (NPA) 2010-04

for amending the Executive Director Decision No 2003/15/RM of 14 November 2003 on certification specifications, including airworthiness codes and acceptable means of compliance, for small rotorcraft ('CS-27')

and

for amending the Executive Director Decision No 2003/16/RM of 14 November 2003 on certification specifications, including airworthiness codes and acceptable means of compliance, for large rotorcraft ('CS-29')

'Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structures'

Executive Summary

The Notice of Proposed Amendment (NPA) 2010-04, dated 29 April 2010, proposed new Certification Specifications and associated AMC for both small rotorcraft (CS-27) and large rotorcraft (CS-29). It required evaluation of fatigue and residual static strength of composite rotorcraft structures using a damage tolerance evaluation, or a fatigue evaluation if the applicant establishes that a damage tolerance evaluation is impractical. The aims are to address advances in composite structures technology and to provide internationally harmonised requirements.

Based on the review of stakeholders' comments, concerns raised primarily relate to the scope of structure applicable to these new rules, which has been further clarified in the amended text, and with duplication of Guidance Material that already exists elsewhere. The latter concern has arisen due to the considerable delays in publishing this material since it was first drafted and subsequent developments have taken place in the intervening years, including publication of generic Guidance Material on composite aircraft structure (AMC 20-29). While it is acknowledged that some duplication now exists, its removal at this time would only lead to further delays. Future work is, therefore, envisaged to rationalise Guidance Material and remove any unnecessary duplication.

Both FAA and EASA commented on each other's detailed rule text. Some of these comments were not adopted due to differences in the regulatory frameworks, rulemaking procedures and timescales. This has resulted in some differences in the wording of these proposals compared to FAA Amdt 27-47 and 29-54, although technical harmonisation is retained.

Explanatory Note

I. General

1. The purpose of the Notice of Proposed Amendment (NPA) 2010-04, dated 29 April 2010, was to propose an amendment to Decision 2003/15/RM of the Executive Director of the European Aviation Safety Agency of 14 November 2003[1] on certification specifications, including airworthiness codes and acceptable means of compliance, for small rotorcraft ('CS-27') and to propose an amendment to Decision 2003/16/RM of the Executive Director of the European Aviation Safety Agency of 14 November 2003 on certification specifications, including airworthiness codes and acceptable means of compliance, for large rotorcraft ('CS-29')[2]

II. Consultation

2. The draft Executive Director Decision amending Decision No 2003/15/RM and Decision No 2003/16/RM was published on the website (http://www.easa.europa.eu) on 29 April 2010.

   By the closing date of 29 July 2010, the European Aviation Safety Agency (hereafter referred to as the 'Agency') had received 18 comments from 9 National Aviation Authorities, professional organisations and private companies.

III. Publication of the CRD

3. All comments received have been acknowledged and incorporated into this Comment Response Document (CRD) with the responses of the Agency.

4. In responding to comments, a standard terminology has been applied to attest the Agency's acceptance of the comment. This terminology is as follows:

   - **Accepted** – The comment is agreed by the Agency and any proposed amendment is wholly transferred to the revised text.
   - **Partially Accepted** – Either the comment is only agreed in part by the Agency, or the comment is agreed by the Agency but any proposed amendment is partially transferred to the revised text.
   - **Noted** – The comment is acknowledged by the Agency but no change to the existing text is considered necessary.
   - **Not Accepted** - The comment or proposed amendment is not shared by the Agency

   The resulting text highlights the changes as compared to the NPA proposal.

5. In addition to responding to comments received, the Agency has also made the following changes resulting from its own internal review process:

   - Definitions are deleted and CS 27&29.573(c) is now shown as "Reserved". This follows existing practice of defining terms in associated AMC material.
   - CS 27&29.573(d)(5) is rewritten to avoid the term "allowable damage size", which could be confusing as the term is sometimes used in relation to Barely Visible Impact Damage (BVID) and acceptable manufacturing defects.

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1 Decision as last amended by ED Decision 2008/009/R of 10 November 2008 (CS-27 Amdt 2).
2 Decision as last amended by ED Decision 2008/010/R of 10 November 2008 (CS-29 Amdt 2).

6. The Executive Director Decision will be issued at least two months after the publication of this CRD to allow for any possible reactions of stakeholders regarding possible misunderstandings of the comments received and answers provided.
7. Such reactions should be received by the Agency not later than 5 September 2012 and should be submitted using the Comment-Response Tool at http://hub.easa.europa.eu/crt .

IV. CRD table of comments, responses and resulting text

(General Comments)	-

comment	*4* comment by: *Luftfahrt-Bundesamt* The LBA has no comments on NPA 2010-04.
response	*Noted*

comment	*7* comment by: *UK CAA* **Paragraph No:** General **Comment:** Large quantities of text appear to have been duplicated from AMC 20-29, which is referenced directly from CS 29.603 & CS 27.603, as amended by NPA 2009-06. **Justification:** This is unnecessary and could lead to mismatches between the two sets of texts when they are subsequently amended **Proposed Text:** Delete duplicated text and make references to AMC 20-29 where required. Any advisory material should limit itself to rotorcraft specific issues, as generic aircraft issues should be covered under AMC 20 guidance.
response	*Noted* The NPA was initially drafted many years ago as a harmonised document with FAA and industry, prior to the development of AMC 20-29, which subsequently utilised many of the concepts of the rotorcraft advisory material. While it is recognised that there is some overlap, there is no contradiction in the text, and any attempt to remove this overlap at this stage would only delay publication.

A. Explanatory Note - VII. Regulatory Impact Assessment	p. 5-9

comment	*3* comment by: *Swedish Transport Agency, Civil Aviation Department (Transportstyrelsen, Luftfartsavdelningen)* The Swedish Transport Agency, Civil Aviation Department is supporting the content of option 2 of NPA 2010-04.
response	*Noted*

B. DRAFT DECISIONS - I. Draft Decision CS-27 - Proposal 1: Introduce new CS 27.573 - (b) Reserved p. 10

comment *9* comment by: *FAA*

EASA approval statement needed to obtain harmonization with NPRM for FAA Part 27.573(b) and 29.573(b) and consistency with CS 27.571(a)(1). Recommend to add "The compliance methodology of each applicant, and the results of that methodology, requires EASA approval".

response *Partially accepted*

The Agency does not approve compliance methodologies directly as it is the responsibility of the applicant to establish and to demonstrate compliance. However, the intent of this paragraph is covered under Part-21, specifically during the establishment and acceptance of the certification programme under 21A.20.

It is recognised that CS-27 does not fully reflect the Agency's process and it will therefore be changed to align with CS-29.

comment *11* comment by: *FAA*

The FAA NPRM requires the compliance methodology be approved (CFR 27/29.573(b). The EASA NPA does not require approval of the compliance methodology. (CS 27/29.573(b) is shown as "Reserved").

We recommend the NPA 2010-4, CS 27.573 and CS 29.573 incorporate the requirement for Authority approval of the compliance methodology, similar as currently required in FAA NPRM for composites, 27.573 and 29.573 and FAA NPRM for metallics, 29.571. This addition will be consistent with the current EASA certification specifications, CS 27.571, and FAA federal regulations, CFR 27.571, that currently require the procedures for evaluation must be approved.

response *Partially accepted*

See Comment #9.

resulting text

CS 27.571 Fatigue evaluation of flight structure

(a) …

(1) <u>*Reserved*</u> ~~The procedure for the evaluation must be approved.~~

(2) …

…

B. DRAFT DECISIONS - I. Draft Decision CS-27 - Proposal 1: Introduce new CS 27.573 - (d) Damage Tolerance Evaluation p. 10-11

comment *5* comment by: *CAA-NL*

CS27/29.573(d)(1) Please delete the following wordt from this paragraph:

"Damage tolerance evaluations of the strength of composite PSEs ~~and other~~

	~~parts, detail design points,~~ and fabrication techniques must show that Catastrophic Failure due to static and fatigue loads is avoided throughout the operational life or prescribed inspection intervals of the rotorcraft." Justification: The definition of a PSE: ""Principal Structural Elements" (PSEs) are structural elements that contribute significantly to the carrying of flight or ground loads, the failure of which could result in Catastrophic Failure of the rotorcraft." includes these items and to repeat these here is more confusing than clarifiing, espessialy when in CS27/29.573(d)(2) all psosible PSE's within the helicopter are mentioned including these: "The damage tolerance evaluation must include PSEs of the airframe, main and tail rotor drive systems, main and tail rotor blades and hubs, rotor controls, fixed and movable control surfaces, engine and transmission mountings, landing gear and any other parts, detail design points, and fabrication techniques deemed critical."
response	*Partially accepted* The proposal to delete reference to "and other parts, detailed design points," is not accepted. Such items could potentially lead to catastrophic consequences if not adequately controlled and may not be identified as PSE due to historic differences in interpretation of the terms "that contribute significantly to the carrying of flight or ground loads" and "could result in Catastrophic Failure". The text is changed to add clarity and to avoid the use of "PSE" where inappropriate.

comment	*12* comment by: *FAA* NPA 2010-4, CS 27.573 and CS 29.573, paragraph (d)(4)(ii) requires that inspection intervals for PSEs be established. It also requires consideration of certain items when establishing these inspection intervals: growth rate of the damage under repeated loads and the required residual strength. However, it does not include as a consideration whether the inspection will detect the damage growth before the minimum residual strength is reached and restored to ultimate load capability or if the component will require replacement. We recommend this item be included in the list of items for consideration when establishing the inspection intervals for PSEs to assure damage growth is detected and repaired prior to reaching the ultimate load capability or replaced when appropriate.
response	*Not accepted* The repair or replacement of a part prior to reaching minimum residual strength is already addressed in the lead in paragraphs (d)(4) and (d)(4)(ii). The sub-bullets of (d)(4)(ii) provide all necessary considerations for establishing inspection intervals, including damage growth and detectability.

B. DRAFT DECISIONS - I. Draft Decision CS-27 - Proposal 2: Amend Appendix A p. 12

comment

1 comment by: *Eurocopter*

With the proposed change to Appendix A, possible mandatory replacement times not associated with structural integrity should also be included in the Airworthiness Limitations Section. This would go beyond the scope of the NPA which addresses structural integrity of composite structures. We would therefore suggest to amend the wording as follows:

"... This section must set forth each mandatory replacement time, ~~structural~~ inspection interval, and related ~~structural~~ inspection procedure required for type-certification <u>of structure</u>. ..."

Such a wording would also cover possible Certification Maintenance Requirements for systems that affect structural performance.

response

Partially accepted

Under the Agency's published proposals, replacement times for non-structural items would be within the scope of the ALS, but inspection intervals and associated procedures of non-structural items are explicitly excluded by reference to "structural". While the Agency believes that the ALS is the correct place for all forms of mandatory ICA, and many TCHs already include non-structural items, this change would be outside the scope of this NPA. The Agency's intent had been to broaden the applicability of the ALS to include all forms of mandatory ICA required by structural requirements only. The changes included in the new CS 27.573 make reference to "other procedures" and "supplemental procedures" which may include procedures which some TCH's may consider as CMRs. Therefore, it is agreed that it is not sufficient to limit the scope as previously proposed and Eurocopter's proposed change will also not address other procedures not related to inspection. See revised text.

resulting text

"... This section must set forth each mandatory replacement time, ~~structural~~ inspection interval, ~~and~~ related ~~structural~~ inspection procedure <u>and any other supplemental procedure</u> required for type-certification <u>of structure</u>. ..."

B. DRAFT DECISIONS - II. Draft Decision CS-29 - Proposal 4: Introduce new CS 29.573 - (b) Reserved p. 12

comment

10 comment by: *FAA*

EASA approval statement needed to obtain harmonization with NPRM for FAA Part 27.573(b) and 29.573(b) and consistency with CS 27.571(a)(1). Recommend to add "The compliance methodology of each applicant, and the results of that methodology, requires EASA approval".

response

Partially accepted

The Agency does not approve compliance methodologies directly as it is the responsibility of the applicant to establish and to demonstrate compliance. However, the intent of this paragraph is covered under Part-21, specifically during the establishment and acceptance of the certification programme under 21A.20.

It is recognised that CS-27 does not fully reflect the Agency process and will therefore be changed to align with CS-29.

comment 13 comment by: *FAA*

The FAA NPRM requires the compliance methodology be approved (CFR 27/29.573(b). The EASA NPA does not require approval of the compliance methodology. (CS 27/29.573(b) is shown as "Reserved").

We recommend the NPA 2010-4, CS 27.573 and CS 29.573 incorporate the requirement for Authority approval of the compliance methodology, similar as currently required in FAA NPRM for composites, 27.573 and 29.573 and FAA NPRM for metallics, 29.571. This addition will be consistent with the current EASA certification specifications, CS 27.571, and FAA federal regulations, CFR 27.571, that currently require the procedures for evaluation must be approved.

response *Partially accepted*

See response to Comment #10.

B. DRAFT DECISIONS - II. Draft Decision CS-29 - Proposal 4: Introduce new CS 29.573 - (d) Damage Tolerance Evaluation p. 13-14

comment 2 comment by: *Adhesion Associates Pty. Ltd.*

Attachment #1

Sir/Madam

I refer to NPA-2010-04 "Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structures". The intent of this amendment is to introduce a requirement for damage tolerance of primary structural elements on rotary aircraft, in a similar manner to the FAA NPRM Docket No. FAA-2009-0660; Notice No. 09-12 dated 06 January 2010. We made a submission to the FAA on this matter.

Adhesion Associates Pty. Ltd. is a small consultancy in Australia specialising in composites and adhesive bonding see www.adhesionassociates.com. Our director has over 38 years experience in these fields. He is the primary author of the FAA document DOT/FAA/AR – TN06/07, Apr 2007, *Best Practice in Adhesive Bonded Structures and Repairs.* He has also written an engineering standard DEF (AUST) 9005 *Composites and Adhesive Bonded Repairs,* for the Australian Defence Forces (ADF) and two handbooks on repair design and repair application technology. He has developed four ADF courses in composites and adhesive bonded repairs and facilitated the development of two other ADF courses for technicians.

Adhesion Associates strongly support the incorporation of damage tolerance for rotary aircraft as proposed by NPA-2010-04. However, we believe that this amendment alone will NOT provide assurance of continuing airworthiness for adhesive bonded structures, especially where the bonds involve metals.

Our contention is that adhesive bonds (especially to metals) may under some circumstances be susceptible to interfacial degradation, which results in a

reduction or even a loss of bond strength. Adhesive bonds rely on chemical bonds formed at the interface at the time of adhesive cure. Those chemical bonds provide the strength of the joint, and also control the longer term bond durability in the operational environment. The mechanism involved in interfacial degradation is that if the metal oxides are susceptible to hydration, the chemical bonds formed at the time of manufacture will dissociate to permit hydration of the oxide layer. For example in aluminium alloys, Al_2O_3 oxide has an affinity for the formation of bohemite $Al_2O_3.2H_2O$. This results in adhesion failure at the interface between the metal and the adhesive. Hence, bonds which are initially strong and may pass certification and quality assurance testing, may degrade in service leading to structural failure once the oxides on the surface have had time to hydrate.

There is a transition between the full strength cohesion failure to the weak adhesion failure. During this period the adhesive will fail in a mixed-mode where there is a combination of cohesion failure and adhesion failure. The strength of the bond will reduce as hydration progresses.

The deficiency in managing airworthiness by use of damage tolerance is that damage tolerance acceptance criteria are established by test or analysis on structures *where the interface has not degraded.* If these tests demonstrate adequate strength in the presence of artificial defects, the adhesive surrounding the defect is pristine and will not fail. If however the same size bond defect occurs in service, there is a very high probability that the failure is by *time dependent* adhesion at the interface, and there is no guarantee that the interface adjacent to the defect maintains adequate strength. There is therefore a high risk that the structure may fail with a defect considerably smaller than that determined by damage tolerance analysis or testing. We are publishing a paper in June 2010 which explains the sequence of progression from strong cohesion failures (the type for which damage tolerance is appropriate) to very weak, interfacial adhesion failures for which damage tolerance is inappropriate. The real concern is that in the intervening time between cohesion failure and adhesion failure, the bond displays mixed-mode failures, where the bond strength may be significantly below that demonstrated at certification. NDI can detect cohesion and adhesion failures, but can not detect the weak bonds which signify the onset of mixed-mode failure.

Similar concerns apply for applying damage tolerance to the effects of micro-voiding where moisture absorbed by adhesives or nomex core prior to hot-bonding results in significant weakening of the bond. This results in a loss of strength *form the time of manufacture,* and again unless the damage tolerance testing has been undertaken on bonds with similar reductions in strength, there is a risk of disbonding or failure. Our report Managing Micro-Voids is available at http://www.adhesionassociates.com/papers/Managing%20Micro-Voiding%20of%20Adhesive%20Bonds.pdf. It gives examples drawn from disbonds in the tail boom structure of AW139 helicopters, where there is evidence of significant micro-voiding. If the causes of micro-voiding are addressed at the time of manufacture, then damage tolerance analysis is appropriate.

Adhesion Associates has recently been involved in a helicopter crash investigation. The report by the IIC has been submitted to the authorities but has yet to be released. We are confident that this case clearly demonstrates that damage tolerance alone will not prevent structural failures in metal bonded structures.

The way to manage these risks is to demonstrate at the time of certification that the adhesive bonds are resistant to in-service hydration. If there is certainty that the interface will not hydrate, then the current regulations, together with the proposed NPA WILL provide assurance of continuing airworthiness. Therefore, we strongly urge EASA to amend the regulations (equivalent to FAR 2x.603) to mandate demonstration of the resistance of the adhesive bond to the operating environment. If that amendment is incoprporated and hydration of the interface is prevented by appropriate production processes, then damage tolerance is an effective defence against in-service disbonding.

We would welcome the opportunity to forward copies of our submission to the FAA and an advance draft copy of our upcoming paper to relevant personnel in EASA.

We would be happy to discuss this issue further by email or telephone at +61 7 3381 8828 or +61 428 234 373.

Regards

Max Davis PSM
Director
Adhesion Associates Pty. Ltd., PO Box 265 Redbank 4301.

response

Not accepted

The Agency considers that the existing text of CS 29.603 addresses this point in principle. Nonetheless, the Agency is considering the development of further regulatory and Guidance Material related to bonded structure, not only in the field of rotorcraft.

CS 29.603 Materials

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must –

(a) Be established on the basis of experience or tests;

(b) Meet approved specifications that ensure their having the strength and other properties assumed in the design data; and

(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

comment

14 comment by: *FAA*

NPA 2010-4, CS 27.573 and CS 29.573, paragraph (d)(4)(ii) requires that inspection intervals for PSEs be established. It also requires consideration of certain items when establishing these inspection intervals: growth rate of the damage under repeated loads and the required residual strength. However, it does not include as a consideration whether the inspection will detect the damage growth before the minimum residual strength is reached and restored to ultimate load capability or if the component will require replacement.

We recommend this item be included in the list of items for consideration when establishing the inspection intervals for PSEs to assure damage growth is detected and repaired prior to reaching the ultimate load capability or replaced

when appropriate.

response

Not accepted

The repair or replacement of a part prior to reaching minimum residual strength is already addressed in the lead in paragraphs (d)(4) and (d)(4)(ii). The sub-bullets of (d)(4)(ii) provide all necessary considerations for establishing inspection intervals, including damage growth and detectability.

B. DRAFT DECISIONS - II. Draft Decision CS-29 - Proposal 5: Amend Appendix A p. 14

comment

1 ❖ comment by: *Eurocopter*

With the proposed change to Appendix A, possible mandatory replacement times not associated with structural integrity should also be included in the Airworthiness Limitations Section. This would go beyond the scope of the NPA which addresses structural integrity of composite structures. We would therefore suggest to amend the wording as follows:

"... This section must set forth each mandatory replacement time, ~~structural~~ inspection interval, and related ~~structural~~ inspection procedure required for type-certification <u>of structure</u>. ..."

Such a wording would also cover possible Certification Maintenance Requirements for systems that affect structural performance.

response

Partially accepted

Under the Agency's published proposals, replacement times for non-structural items would be within the scope of the ALS, but inspection intervals and associated procedures of non-structural items are explicitly excluded by reference to "structural". While the Agency believes that the ALS is the correct place for all forms of mandatory ICA, and many TCHs already include non-structural items, this change would be outside the scope of this NPA. The Agency's intent had been to broaden the applicability of the ALS to include all forms of mandatory ICA required by structural requirements only. The changes included in the new CS 27.573 make reference to "other procedures" and "supplemental procedures" which may include procedures which some TCH's may consider as CMRs. Therefore, it is agreed that it is not sufficient to limit the scope as previously proposed and Eurocopter's proposed change will also not address other procedures not related to inspection. See revised text.

B. DRAFT DECISIONS - II. Draft Decision CS-29 - Proposal 6: Introduce new AMC 29.573 p. 14-15

comment

6 comment by: *CAA-NL*

The CAA-NL wonders why this material is included here under AMC to Para 27/29.573 where in CS.25 very similar material is included under AMC to 25.603. For consistency and ease find ability the same paragraph would be preferable.

response | *Not accepted*

The text has been developed as a harmonised package by a working group. It is also considered that substantiation of structural elements is best placed in Subpart C.

The publication of AMC 20-29 has now superseded AMC 25.603. Although some guidance is duplicated between AMC 20-29 and AC 29-2C MG8 and the new 29.573, the future intent is to rationalise all AMC to minimise any unnecessary overlap.

B. DRAFT DECISIONS - II. Draft Decision CS-29 - Proposal 6: Introduce new AMC 29.573 - f. Procedures for Substantiation of Rotorcraft Composite Structure p. 20-40

comment | *8* comment by: *UK CAA*

Paragraph No: 2nd paragraph on page 21

Comment:
This paragraph makes numerous references to FAA staff and bodies e.g. DER, PMI, DMIRs and refers to 'FAA involvement' and 'FAA certification team'.

Justification:
Inappropriate references to the US system which should be referencing the EU system

Proposed Text:
Reference should be made to the appropriate EU bodies

response | *Not accepted*

It should be recognised that AC 27-1B/AC 29-2C are owned by the FAA and primarily reflect the FAA system.

A note was added to the NPA (Note 1, page 14), to clarify that this material will be published by the FAA in an update to AC 27-1B and AC 29-2C and adopted by the Agency, in accordance with existing Agency practice.

comment | *15* comment by: *Transport Canada Civil Aviation Standards Branch*

Document text -

(1) Consider isolated disbonds and weak bonds (represented by zero bond strength) in structural elements that use secondary bonding for primary load transfer. The associated disbond size should be up to the limitations provided by redundant design features (i.e., mechanical fasteners or a separate bonding detail). The structure containing such damage should be shown to carry limit load by tests, analyses, or some combination of both. For purposes of test or analysis demonstration, each disbond should be considered separately as a random occurrence (i.e., it is not necessary to demonstrate residual strength with all structural elements disbonded simultaneously).

Proposed Comment -

Paragraph f(6)(ii)(d)(1) The NPA suggests that a structure containing secondary bonding should be shown to carry limit load by tests, analysis or some combination of both, assuming presence of a disbond or weak bond. In general, the residual strength of a structure is determined by whether or not the damages/defects are readily detectable. If a disbond is not detectable by any inspection techniques, the residual strength is required to ultimate load.

response *Noted*

The threat assessment under f(6)(ii)(C) requires verification that the inspection method selected is capable of detecting the damage at the size and location determined. The reference to limit load reflects the damage tolerance requirement and is the minimum acceptable when the damage (disbond) is readily detectable.

It is agreed that higher load levels may be appropriate if detection is not assured, in a similar way as to how impact damage is addressed. The Agency is currently assessing the need for further Guidance Material on the subject of bonded structures.

comment *16* comment by: *Transport Canada Civil Aviation Standards Branch*

Document Text:

Variability in fatigue behavior should be covered by appropriate load or life scatter factors and these factors should take into account the number of specimens tested.

Proposed Comment:

Paragraph f(6)(ii)(g) Is this paragraph intended to address the load enhancement factor that is usually used for the purpose of reducing the fatigue test duration? If so, more elaboration of the intention is necessary.

response *Not accepted*

It is not addressing load factors used to reduce the duration of a test.

comment *17* comment by: *Transport Canada Civil Aviation Standards Branch*

Document Text:

This approach is appropriate for inspectable in-service damage which does not grow in service. See Figure NPA 29.573-3. (Damage growth should be substantiated using either method described in f.(6)(iii)(B)(2) or f.(6)(iii)(B)(3)). Structural details, elements, sub-components, and components of critical structural areas, or full-scale structures, should be tested under repeated loads for validating a no-growth approach to the damage tolerance requirements. The number of cycles applied to validate a no-growth concept should be statistically significant, and may be determined by load or life considerations or both. Residual strength testing or evaluations should be performed after repeated load cycling demonstrating that the residual strength of the structure is equal to or greater than limit load considered as ultimate.

Proposed Comment:

	Paragraph f(6)(iii)(B)(1): for No-Growth Evaluation, residual strength after fatigue test is required to meet the ***ultimate load****, not the limit load as as suggested in "… equal to or greater than limit load considered as ultimate.".* *Paragraph f(6)(iii)(B)(2) and (3): for Slow Growth Evaluation and Arrested Growth Evaluation, residual strength after fatigue test is required to meet the limit load . It is suggested that in the sentence "… equal to or greater than limit load considered as ultimate.", the wording "considered as ultimate" be removed because it does not serve any purpose while it may lead to unnecessary confusions.*
response	*Noted* 1) CS 27/29.573 requires residual strength to be demonstrated for at least the minimum required load level, which is limit load considered as ultimate. An applicant that sets the residual strength requirement close to this minimum will need to consider very frequent and reliable inspections to meet the intent of CS 27/29.573(d)(4)(ii). (See also AMC 20-29) 2) "Considered as ultimate" is used to negate the need for an additional factor of safety required by CS 27/29.301(a) and 303.

Revised text of CS 27.573

Book 1
SUBPART C – STRENGTH REQUIREMENTS

CS 27.573: Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structures

(a) Composite rotorcraft structure must be evaluated under the damage tolerance requirements of sub-paragraph (d) unless the applicant establishes that a damage tolerance evaluation is impractical within the limits of geometry, inspectability, and good design practice. In such a case, the composite rotorcraft structure must undergo a fatigue evaluation in accordance with sub-paragraph (e).

(b) Reserved

(c) Reserved

(d) Damage Tolerance Evaluation:

(1) Damage tolerance evaluations of composite structures must show that Catastrophic Failure due to static and fatigue loads is avoided throughout the operational life or prescribed inspection intervals of the rotorcraft.

(2) The damage tolerance evaluation must include PSEs of the airframe, main and tail rotor drive systems, main and tail rotor blades and hubs, rotor controls, fixed and movable control surfaces, engine and transmission mountings, landing gear, and any other detail design points or parts whose failure or detachment could prevent continued safe flight and landing.

(3) Each damage tolerance evaluation must include:

(i) The identification of the structure being evaluated;

(ii) A determination of the structural loads or stresses for all critical conditions throughout the range of limits in CS 27.309 (including altitude effects), supported by in-flight and ground measurements, except that manoeuvring load factors need not exceed the maximum values expected in service;

(iii) The loading spectra as severe as those expected in service based on loads or stresses determined under sub-paragraph (d)(3)(ii), including external load operations, if applicable, and other operations including high torque events;

(iv) A Threat Assessment for all structure being evaluated that specifies the locations, types, and sizes of damage, considering fatigue, environmental effects, intrinsic and discrete flaws, and impact or other accidental damage (including the discrete source of the accidental damage) that may occur during manufacture or operation;

(v) An assessment of the residual strength and fatigue characteristics of all structure being evaluated that supports the replacement times and inspection intervals established under sub-paragraph (d)(4); and

(vi) Allowances for the detrimental effects of material, fabrication techniques, and process variability.

(4) Replacement times, inspections, or other procedures must be established to require the repair or replacement of damaged parts to prevent Catastrophic Failure. These replacement times, inspections, or other procedures must be included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness required by CS 27.1529.

(i) Replacement times must be determined by tests, or by analysis supported by tests to show that throughout its life the structure is able to withstand the repeated loads of variable magnitude expected in-service. In establishing these replacement times, the following items must be considered:

(A) Damage identified in the Threat Assessment required by sub-paragraph (d)(3)(iv);

(B) Maximum acceptable manufacturing defects and in-service damage (i.e., those that do not lower the residual strength below ultimate design loads and those that can be repaired to restore ultimate strength); and

(C) Ultimate load strength capability after applying repeated loads.

(ii) Inspection intervals must be established to reveal any damage identified in the Threat Assessment required by sub-paragraph (d)(3)(iv) that may occur from fatigue or other in-service causes before such damage has grown to the extent that the component cannot sustain the required residual strength capability. In establishing these inspection intervals, the following items must be considered:

(A) The growth rate, including no-growth, of the damage under the repeated loads expected in-service determined by tests or analysis supported by tests; and

(B) The required residual strength for the assumed damage established after considering the damage type, inspection interval, detectability of damage, and the techniques adopted for damage detection. The minimum required residual strength is limit load.

(5) The effects of damage on stiffness, dynamic behaviour, loads and functional performance must be taken into account when substantiating the maximum assumed damage size and inspection interval.

(e) Fatigue Evaluation:

If an applicant establishes that the damage tolerance evaluation described in sub-paragraph (d) is impractical within the limits of geometry, inspectability, or good design practice, the applicant must do a fatigue evaluation of the particular composite rotorcraft structure and:

(1) identify structure considered in the fatigue evaluation;

(2) identify the types of damage considered in the fatigue evaluation;

(3) establish supplemental procedures to minimise the risk of Catastrophic Failure associated with damage identified in sub-paragraph (e)(2); and

(4) include these supplemental procedures in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by CS 27.1529.

Revised text of CS 29.573

Book 1
SUBPART C – STRENGTH REQUIREMENTS

CS 29.573: Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structures

(a) Composite rotorcraft structure must be evaluated under the damage tolerance requirements of sub-paragraph (d) unless the applicant establishes that a damage tolerance evaluation is impractical within the limits of geometry, inspectability, and good design practice. In such a case, the composite rotorcraft structure must undergo a fatigue evaluation in accordance with sub-paragraph (e).

(b) Reserved

(c) Reserved

(d) Damage Tolerance Evaluation:

(1) Damage tolerance evaluations of composite structure must show that Catastrophic Failure due to static and fatigue loads is avoided throughout the operational life or prescribed inspection intervals of the rotorcraft.

(2) The damage tolerance evaluation must include PSEs of the airframe, main and tail rotor drive systems, main and tail rotor blades and hubs, rotor controls, fixed and movable control surfaces, engine and transmission mountings, landing gear, and any other detail design points or parts whose failure or detachment could prevent continued safe flight and landing.

(3) Each damage tolerance evaluation must include:

(i) The identification of structure being evaluated;

(ii) A determination of the structural loads or stresses for all critical conditions throughout the range of limits in CS 29.309 (including altitude effects), supported by in-flight and ground measurements, except that manoeuvring load factors need not exceed the maximum values expected in service;

(iii) The loading spectra as severe as those expected in service based on loads or stresses determined under sub-paragraph (d)(3)(ii), including external load operations, if applicable, and other operations including high torque events;

(iv) A Threat Assessment for all structure being evaluated that specifies the locations, types, and sizes of damage, considering fatigue, environmental effects, intrinsic and discrete flaws, and impact or other accidental damage (including the discrete source of the accidental damage) that may occur during manufacture or operation.

(v) An assessment of the residual strength and fatigue characteristics of all structure being evaluated that supports the replacement times and inspection intervals established under sub-paragraph (d)(4); and

(vi) Allowances for the detrimental effects of material, fabrication techniques, and process variability.

(4) Replacement times, inspections, or other procedures must be established to require the repair or replacement of damaged parts to prevent Catastrophic Failure. These replacement times, inspections, or other procedures must be included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness required by CS 29.1529.

(i) Replacement times must be determined by tests, or by analysis supported by tests to show that throughout its life the structure is able to withstand the repeated loads of variable magnitude expected in-service. In establishing these replacement times, the following items must be considered:

(A) Damage identified in the Threat Assessment required by sub-paragraph (d)(3)(iv);

(B) Maximum acceptable manufacturing defects and in-service damage (i.e., those that do not lower the residual strength below ultimate design loads and those that can be repaired to restore ultimate strength); and

(C) Ultimate load strength capability after applying repeated loads.

(ii) Inspection intervals must be established to reveal any damage identified in the Threat Assessment required by sub-paragraph (d)(3)(iv) that may occur from fatigue or other in-service causes before such damage has grown to the extent that the component cannot sustain the required residual strength capability. In establishing these inspection intervals, the following items must be considered:

(A) The growth rate, including no-growth, of the damage under the repeated loads expected in-service determined by tests or analysis supported by tests; and

(B) The required residual strength for the assumed damage established after considering the damage type, inspection interval, detectability of damage, and the techniques adopted for damage detection. The minimum required residual strength is limit load.

(5) The effects of damage on stiffness, dynamic behaviour, loads and functional performance must be taken into account when substantiating the maximum assumed damage size and inspection interval.

(e) Fatigue Evaluation:

If an applicant establishes that the damage tolerance evaluation described in sub-paragraph (d) is impractical within the limits of geometry, inspectability, or good design practice, the applicant must do a fatigue evaluation of the particular composite rotorcraft structure and:

(1) identify structure considered in the fatigue evaluation;

(2) identify the types of damage considered in the fatigue evaluation;

(3) establish supplemental procedures to minimise the risk of Catastrophic Failure associated with damage identified in sub-paragraph (e)(2); and

(4) include these supplemental procedures in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by CS 29.1529.

Appendix A - Attachments

56 Assessing Adhesive Bond Failures - Mixed-Mode Bond Failures Explained.pdf
Attachment #1 to comment #2