Transport Airplane Metallic and Composite Structures Working Group – Recommendation Report to FAA

RELEASE/REVISION	RELEASE DATE
Final	**June 27, 2018**

CONTENT OWNER:

Transport Airplane Metallic and Composite Structures Working Group

All revisions to this document must be approved by the content owner before release.

Document Information

Authorization for Release

AUTHOR/CONCURRENCE:	Chantal Fualdes	Airbus	6/26/18
	Chantal Fualdes - *Digital Signature*	Organization	Date
AUTHOR/CONCURRENCE:	Mike Gruber	Boeing Commercial	6/18/18
	Michael Gruber - *Digital Signature*	Organization	Date
AUTHOR/CONCURRENCE:	Salamon Haravan	Bombardier	6/19/18
	Salamon Haravan - *Digital Signature*	Organization	Date
CONCURRENCE:	Phil Ashwell	British Airways	6/18/18
	Phil Ashwell - *Digital Signature*	Organization	Date
CONCURRENCE:	Benoit Morlet	Dassault Aviation	6/20/18
	Benoit Morlet -*Digital Signature*	Organization	Date
AUTHOR/CONCURRENCE:	Douglas Jury	Delta Air Lines	6/19/18
	Doug Jury - Digital Signature	Organization	Date
CONCURRENCE:	Antonio Fernando Barbosa	Embraer	6/26/18
	Antonio Fernando Barbosa -*Digital Signature*	Organization	Date
CONCURRENCE:	Mark R. Boudreau	FedEx	6/19/18
	Mark Boudreau - *Digital Signature*	Organization	Date
AUTHOR/CONCURRENCE:	Kevin M. Jones	Gulfstream	6/19/18
	Kevin Jones - *Digital Signature*	Organization	Date
AUTHOR/CONCURRENCE:	T. Fukuoka 福岡 俊康	Mitsubishi	6/20/18
	Toshiyasu Fukuoka - *Digital Signature*	Organization	Date
AUTHOR/CONCURRENCE:	David K. Nelson	Textron Aviation	6/25/18
	David Nelson - *Digital Signature*	Organization	Date
AUTHOR/CONCURRENCE:	Eric Chesmar	United Airlines	6/18/18
	Eric Chesmar - *Digital Signature*	Organization	Date
CONCURRENCE:	Walt Sippel	FAA	6/26/18
	Walt Sippel - *Digital Signature*	Organization	Date

**Please note: The electronic signatures above confirm both concurrence with the information contained within the document and authorization of its release. Thank you.

Table of Contents

Executive Summary

On January 26, 2015, the Federal Aviation Administration (FAA) published a notice of a new task assignment for the Aviation Rulemaking Advisory Committee (ARAC). In short, the FAA assigned and ARAC accepted the task to provide recommendations regarding revision of the damage tolerance and fatigue requirements of Title 14, Code of Federal Regulations (14 CFR), part 25, including subparts C and E of 14 CFR part 26, and development of associated advisory material for metallic, composite, and hybrid structures (structure that includes a combination of composite and metallic parts and assemblies). Under the Transport Airplane and Engine (TAE) Subcommittee, the Transport Airplane Metallic and Composite Structures Working Group (TAMCSWG) was assigned to provide advice and recommendations on the tasking.
This report contains the working group's recommendations relative to the following main elements of the tasking:

- Evaluate current § 25.571, subparts C and E of part 26, and guidance material
- Recommend Rule or Guidance changes
- Estimate the Costs and Benefits associated with any changes

In September 2015, the TAMCSWG agreed to divide the working group members up into sub-teams responsible for developing recommendations in the following identified focus areas. These areas (other than 8, 11 and 12) are contained in the original tasking. Under the tasking, the FAA identified Policy Statement PS-ANM100-1993-00041, which is related to rotorburst, for the working group to address. The FAA provided clarification on this element by providing questions for the working group to address. Based on this, the working group added this as an additional focus area. The 8th and 12th items were also added by the working group following the review of current rule/guidance/policy and discussions under the tasking.

1. Threat Assessment
2. Structural Damage Capability (SDC)
3. Testing of Hybrid Structure
4. Aging Mechanisms
5. Inspection Thresholds
6. Bonded or Bolted Repairs
7. Large Modifications
8. Inspections and the Airworthiness Limitations Section (ALS)
9. Harmonize European Aviation Safety Agency (EASA) Aging Aircraft Rulemaking
10. Emerging Material Technology
11. Rotorburst Policy
12. Cracking During Full-Scale Fatigue Test

Because of the scope and complexity of the tasking, the TAMCSWG determined it needed additional technical experts in order to address Structural Damage Capability and Rotorburst. These topics are equally applicable to metallic and composite materials. The TAMCSWG requested that the Airworthiness Assurance Working Group (AAWG) assist them in developing recommendations on these two areas. The final recommendations in this report reflect the AAWGs input on both SDC and Rotorburst.

The list of 12 items studied by sub-groups do not represent a prioritized list. They were simply damage tolerance considerations that the TAMCSWG wanted to review in some detail, often discussed in combination because, as individual considerations, there was no need for each item to appear in the rule language. In fact, the fundamental goal to consider metal, composite and combined hybrid assemblies naturally led to a need for rule simplification. Recommended changes came with some caution, remembering that the essence of damage tolerance evaluations was to generate engineering data and evaluate other considerations to define practical maintenance practices, which avoid catastrophic failure.

The working group agrees with the FAA-driven initiative (for performance based rules) to revise section 25.571, Amendment 25-132 in order to make the rule more performance based. This performance based revision will allow the rule to be applicable to not only current aerospace materials and material systems, but those yet to be developed. In general, the TAMCSWG rule recommendations are consistent with industry practice. The associated guidance and policy material also needs updates to ensure a common understanding consistent with industry practice. With that in mind, the working group recommends that the FAA revise the rule to—

1. Generalize the environmental damage threat to address when evaluating the structure (e.g., replace corrosion with environmental deterioration).
2. Require applicants to address all modes of damage in the damage-tolerance evaluation (DTE) [e.g., add manufacturing defects to paragraph (b)].
3. Generalize the DTE to require applicants to establish inspections or other procedures for structure that exhibits growth or no growth behavior.
    a. For metals, generalize the assumptions to be used in threshold determination.
    b. For materials that exhibit growth, continue to allow the repeat interval to be different from the threshold.
    c. For materials that exhibit no growth, continue to allow the repeat interval to be equal to the threshold.
4. Require applicants to establish a limit of validity (LOV) based on the aging space (expected environmental exposure and repeated loading environment) for all structure, regardless of the materials used in construction of that structure.
5. Include analysis for certain loads in order for an applicant to supplement the full-scale fatigue test evidence to show freedom from aging (Widespread Fatigue Damage (WFD) for metals).

Each recommended rule change came by considering many factors, including the aforementioned list of 12 items, and involved months of discussion and debate. One area that received considerable discussion by the TAMCSWG, in combination with inputs from the AAWG, was differences in damage threats between metals, composites and hybrid assemblies including parts consisting of both classes of materials. All damage threats were important, regardless of the specific materials and combined hybrid assemblies. However, the TAMCSWG realized that industry uses ***other considerations*** such as design (e.g., material selection, structural design details, maximum stress or strain levels, structural damage capability), existing common maintenance practices (e.g., routine inspections and corrosion protection program) and factory quality controls to minimize the associated economic burdens in avoiding catastrophic failure. The rule updates retained the overall goal of damage tolerance, which is dependent on application of a baseline maintenance program supplemented by other considerations and directed inspections for the most difficult damage threats. Many factors contribute to the other considerations, which the TAMCSWG believes represent degrees of freedom that will differ based on a given application and the associated customer base, although experience and education can provide the necessary foundation for efficient industry practice.

The Working Group (WG) recognizes that during the timeframe this report was being prepared, the FAA published the re-write Part 23 at amendment 23-64, effective on August 30, 2017. Any reference in this report or recommendation that reference to CFR 23, refers to 14 CFR amendment level prior to 23-63 or prior.

Below is a summary of the 12 sub-teams' recommendations relative to the three main elements of the tasking:

Threat Assessment - The opening statement in 14 CFR 25.571(a) General, states, "An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, corrosion, manufacturing defects, or accidental damage, will be avoided throughout the operational life of the airplane." Overall, the TAMCSWG reached consensus that requirement adequately defines the damage threats, in broad categories, that need to be addressed as part of the Damage-tolerance and fatigue evaluation, with only simple rule changes to improve the rules language to encompass metallic, composite, and hybrid structures. In addition, there are several recommended changes to the guidance as found in Advisory Circular (AC) 25.571-1D and AC 20-107B that broaden the types of manufacturing defects beyond what are traditionally considered for mechanically fastened metallic structure during the Damage Tolerance Evaluation (DTE).

To ensure that all threats that could contribute to catastrophic failure are addressed as part of the DTE required in § 25.571(b), the WG recommends the FAA revise § 25.571(b) to include manufacturing defects in addition to fatigue, corrosion, and accidental damage as prescribed in the existing rule. Also, as aircraft move toward different materials requiring different manufacturing process, the range of size and type of manufacturing defects will vary greatly, such as disbond and weak bonds in both composite and metallic structure. All defects of concern need consideration as part of the Damage-tolerance evaluation required by 25.571(b). This change will also more consistently align with the 4 broad categories of damage threats (fatigue, corrosion, manufacturing, and accidental) that are listed in 25.571(a).

An additional rule change recommended for 14 CFR 25.571 is the current use of the word "corrosion", which is too narrow in context to address environmental deterioration associated with non-metallic structures including composite and hybrid structure.

While the addition of "manufacturing defects" to § 25.571(b) appears to change the requirements of 25.571 and place an additional burden on the applicant, the Original Equipment Manufacturer (OEM) WG members agreed they currently account for manufacturing process variation in their DTE's. Therefore, this change is reflective of current industry practices, and provides both clarification and consistency without expanding the scope of the DTE required by §25.571.

A detail discussion of these changes appears in Section 3.1 of this report with an example of proposed wording in Appendix B.

Structural Damage Capability (SDC) – The AAWG/SDC WG Sub-team initially tried to build off the 2003 General Structures Harmonization Working Group (GSHWG) recommendation for reintroducing fail-safety/SDC back into Part 25. The AAWG made three attempts to reach consensus on a rule and guidance change through different approaches described in Section 3.2.1. All industry and regulatory members of the WG believe SDC is important to safety and that some form of SDC is necessary to address damage to the structure. However, both the AAWG and the TAMCSWG could not agree on a uniform enforceable standard that would encompass the varied OEM practices. The working group identified six roadblocks (please see Section 3.2.2) which highlight the challenge of global re-introduction of fail-safety given the varied OEM fail-safe design practices developed over the past 40 years.

While the FAA provided a proposal to address the roadblocks, ultimately the majority of TAMCSWG members agreed there was still no viable path forward. Industry has traditionally incorporated SDC as a design practice, dependent on many factors including internal service databases, other design attributes, product inspection goals, and specific PSE locations. As a result, there is great variability amongst the OEMs with respect to economic and application-specific implications. In lieu of recommending discontinuation of all efforts in this area, the

TAMCSWG supports the following recommendation – focus future efforts beyond the ARAC working group only on limiting and developing requirements for single load path (SLP) structure, which by definition has no SDC.

Ten OEMs and operators voted in favor of this proposal and two operators have dissenting opinions, believing work should continue to also address multiple load path and integrally stiffened structure. However, in order to reach a general consensus within the working group both the dissenting operators agreed that they will support the proposal to focus on SLP structure as the majority working group recommendation. The specific recommendations, which provide a starting point for future efforts addressing SLP structure, are contained in Section 3.2.4 of this report.

Testing of Hybrid Structure- Current 14 CFR 25.571 rule text requires full-scale fatigue test evidence for demonstrating freedom from WFD; however, not all loads can be practically applied in the full-scale fatigue test (e.g. loads resulting from a thermal mismatch). Therefore, recommended rule change to 14 CFR 25.571 will allow the substantiation means of analysis supported by test evidence. In addition, the WG recommends changes to clarify the current rule text for LOV establishment as a general requirement in § 25.571(a) rather than in § 25.571(b), which focuses on the damage tolerance evaluation. Other changes are included in the recommendation leading to a more material independent performance based requirement.

Recommended changes to guidance materials would allow an analysis supported by test approach for a WFD demonstration method. Other recommendations address points of attention regarding differences between metallic and composite structures when testing for fatigue and damage tolerance evaluation, and other minor changes including definitions of related terms. Recommended guidance changes are for AC 25.571-1D, AC 20-107B and AC 120-104.

Aging Mechanisms – The WG agrees that current rules defined in 14 CFR 25.571 are metallic centric and that further assessment of the LOV and WFD aspects that are used for metals is needed along with a recommendation regarding composite and hybrid structures. Some changes are necessary in the rule and guidance material to be less or non-metallic centric. In particular, it is important to identify the key sensitive and influencing factors of the aging mechanisms of composite technologies that may affect the strength characteristic and design performance.

The WG agreed to recommend that the rule should include the general effect due to environmental deterioration.

Section 25.571(a)(3) already defines the LOV as the engineering data that supports the structural maintenance program. This definition provides a generic, high level, performance based requirement. It encompasses all materials and any kind of damage or threat, being consistent with the intent of the rule and with the general nature of § 25.571(a). Therefore, the WG conclude that no change is necessary and that the rule term defined in § 25.571(a) provides a definition that well addresses composite technologies. The FAA should revise policy statements to state that the LOV concept applies to both composite and metallic materials, although the aging mechanisms are different for each type of structure.

The link between LOV and WFD is just a particularity of metallic structures exposed to cyclic loading. Regulations address LOV in § 25.571(b). Guidance materials can distinguish different details for the establishment of LOV for metallic, composite and hybrid structure.

The WG also agreed that guidance materials need updates to address the several definitions:

- Aging – *AC20-107B should be updated to address aging and the LOV*
- LOV– *Applies to composite, metallic and hybrid materials*
- WFD– *As addressed for metallic materials in AC 25.571-1D*

- Repetitive impact damage– *AC 20-107B should be updated to reflect this aspect of aging*

The recommendations are primarily in AC 20-107B for composite structure but AC 25.571-1D for metallic structure also needs some change.

Inspection Thresholds – The TAMCSWG considered the 2003 General Structures Harmonization Working Group (GSHWG) recommendation when developing the recommendation contained in this report relative to the establishment of inspection thresholds and repeat intervals. The WG recommended both rule and guidance changes in order to move toward material-independent performance based requirements. The current rule is prescriptive in that only a material (metal) centric fracture mechanics approach “must be used” per the rule to establish inspection thresholds for SLP & hidden multi-load path (MLP) structure.

The WG also recommends that the FAA update the current guidance material to describe an acceptable means of compliance that aligns with the recommended material-independent and non-method specific rule recommendation. Reference to existing guidance information (AC 91-82A) on the necessary considerations for developing inspection intervals for metals is also included.

Bonded or Bolted Repairs – The WG recommends no rule change for bolted or bonded repairs. Repairs must meet the same certification standard as the original or modification structure. Additional guidance is recommended to be added to AC 25.571-1D to address bonded repairs. Although AC 20-107B and AC 43-214 address composite structure compliance matters, including fatigue and damage tolerance, bonding is a process not solely unique to composite structure, and presents a challenge for continued airworthiness. We recommend additional guidance be added to the FAA Policy Statement on Bonded Repair Size Limit, PS-AIR-20-130-01, and harmonized EASA Certification Memo CM-S-005. This guidance would clarify that repairs accomplished in a production facility, which are to a size substantiated by trials, tests and analyses, can be performed in-service if the same stringent quality controls are achieved. Since field repair substantiation is difficult, the guidance should also recommend support by the Type Certificate Holder (TCH) and regulator to develop affordable, approved data for repair design, meeting all the original certification requirements.

Additionally, the WG recommends the FAA clarify that the same stringent requirements provided in FAA policy letter PS-AIR-20-130-01 applies to in service repairs. The expectations prescribed in AC 20-107B for production repairs/rework/concessions accomplished by the OEM and its suppliers, are within the size limit established by TCH to meet limit load if repair fails but wording in both documents needs to be consistent to avoid any confusion.

Finally, we also recommend cross-referencing between the various guidance and policy to ensure consistent field and factory practice, assuming the same level of bond quality control.

Large Modifications – The WG recommends to incorporate the repair/alteration aspect of Part 26 Subpart E into Part 25 for large transport airplanes in parts 121 and 129 operations. This recommendation supports potential certification efficiency and reduction of redundant requirements for future aircraft. Current parts 121 and 129 operating rules along with Design Approval Holder (DAH) requirements to provide Fatigue Critical Structure) FCS lists are all that are required to meet the objectives of Aging Airplane Safety Final Rule (AASFR) for future airplanes. The WG is not making specific recommendations on how to update Part 25 or the corresponding Part 26 Subpart E requirements, but three separate options are described, along with advantages and disadvantages with each option.

Recommendation is also provided to update 14 CFR § 26.47 to ensure all Supplemental Type Certificates (STCs) issued from 2008 have an Fatigue Critical Alteration Structure (FCAS) list provided to Part 121 and 129 operators. This recommendation addresses a shortcoming in the current rule that older STCs were required to have an FCAS list where newer STCs (i.e., after 2008) did not have a similar requirement. This lapse has resulted in confusion amongst 121 and 129 operators with regard to accomplishment of DTE for repairs/alterations in areas that may be affected by STCs.

Additional guidance (FAA and other National Aviation Authorities (NAAs)) is recommended in the form of more details on what constitutes a proper review of STC impacts to existing Instructions for Continued Airworthiness (ICA) programs for a particular product as required by AC 21-40A (1-8). The statement in the AC is very brief but covers a lot of materials to be reviewed. This recommendation includes several specific elements that are to be addressed by the STC applicants current ICA review from a 14 CFR §25.571 based perspective. The basis for this recommendation are observations by operators that DAHs may not always accomplish a thorough review of the effect that STCs have on the existing ICA programs.

Additional recommended guidance promotes a common standard for development of new damage tolerant-based ALS ICA developed by Design Approval Holders and shared with operators. This recommendation includes a minimum set of data to be included in a damage tolerance-based inspection required by § 25.571 and § 25.1529. This recommendation is based on observations of wide variety of details provided by DAHs to operators to fulfill the maintenance actions that result from § 25.571 evaluations using crack-growth based analysis. This is an important element of the entire damage tolerance program and incorporation of detailed guidance of the minimum elements an operator requires to accomplish the maintenance tasks helps to eliminate gaps between the engineering data and analysis and the execution of tasks to maintain the continued airworthiness of the product. The WG recommends that this new guidance appear in a new AC referenced in ACs 25-1529, 120-93 and 25.571-1D.

This working group also proposed that the prior recommendations from AAWG to FAA Transport Airplane and Engine Issues Group (TAEIG) in 2003 contained in the report entitled “Recommendations for Regulatory Action to Enhance Continued Airworthiness of Supplemental Type Certificates” be re-recommended here. This report principally addressed the need for STC of applicants of structurally “complex” to consider the effect of existing STC’s or other compatibility matters into their engineering analysis, particularly for the fatigue and damage tolerance evaluation.

Structural Inspections and the ALS - Under the current rule, the damage tolerance assessment requires an evaluation of fatigue damage (FD), accidental damage (AD) and corrosion (environmental deterioration or ED) to show the appropriate mitigation of each threat. Per current regulation, damage tolerance evaluation (DTE) or other considerations address all threats that could contribute to catastrophic failure. Some threats are mitigated by the baseline maintenance program, while others require focused inspections at defined intervals derived by engineering analysis performed as part of the DTE required by § 25.571.

That baseline maintenance program, and specifically the Maintenance Steering Group’s MSG-3 derived Maintenance Review Board Report (MRBR), has been proven to be effective at detecting and repairing accidental and environmental damage, as well as cases of unexpected fatigue damage. The baseline maintenance program complements the more rigorous DTE used to identify those mandatory items that are to be listed in the Airworthiness Limitations Section (ALS) of the Instructions for Continued Airworthiness (ICA). Both programs are necessary to protect the structure from catastrophic failure, but the rule specifies that the ALS specifically contain those tasks identified through the DTE.

The WG recommends changes to guidance and policy to provide for a means of identifying scheduled maintenance tasks in the ALS without removing the flexibility inherent in the MSG-3/MRBR program.

For composite materials in particular, the scheduled inspection program derived by AC 20-107B should be revised to consider the MSG-3/MRBR intervals when evaluating AD/ED. Escalation of a MSG-3/MRBR task needs consideration in that evaluation. These inspections should be listed in the ALS unless the ALS references the maintenance document that contains those tasks. Any allowance for, or limitation of, escalation should be clearly stated in the ALS.

<u>Conditional Inspections Including HEWABI</u>

In 2016 the FAA published policy (PS-ANM-25-20) concerning the inspections of composite airframes following high-energy wide-area blunt impacts (HEWABI). In that policy, the FAA linked the development of inspection instructions for these events to the accidental damage evaluations required by § 25.571(a)(3) and specified that those instructions be included in the ALS of the ICA. The majority of the industry response to this policy documented in the public comments was negative, arguing that these inspections should instead link to the ICA required by § 25.1529. The FAA did not agree and published the policy linking HEWABI to the DTE and mandating the inspections in the ALS.

The WG was requested to evaluate this policy memo and the associated public comments. The WG agrees that the evaluations for HEWABI, or any other conditional inspection, should link to the requirements for ICA given in § 25.1529. Many inspections protect against the potential for catastrophic failure, but the requirements for the ALS are specific to those scheduled tasks derived by the formal DTE. Conditional inspections typically require some anomalous event outside of the aircraft design and operating limitations. They are necessary to establish the extent of damage prior to an operator returning the aircraft to service.

The DAH should prepare conditional inspection requirements as part of the ICA delivered in accordance with § 25.1529 and Appendix H25.3. The operator should incorporate those requirements into the maintenance program developed in accordance with their appropriate operating rule (Part 91, 121 or 135).

The WG recommends that the FAA revise PS-ANM-25-20 to reflect this position and clarify the current rules that address conditional inspections. The WG also recommends changes to the guidance that operators use to develop their maintenance programs to reflect conditional inspections in general, and HEWABI events in particular. The WG understands that a rule change to H25.3 to include conditional inspections may be necessary for the FAA to address the points raised in the development of this policy.

Harmonize EASA Aging Aircraft Rulemaking – A comparison of the 14 CFR 25.571 vs. Certificate Specification (CS) 25.571, and AC 25.571-1D vs. Acceptable Means of Compliance (AMC) 25.571 shows that overall each agency establishes similar certification requirements, as well as similar guidance related to DTE. Those differences considered for change are removing metallic centric wording such as “corrosion” as well related clarification between types of damage and the inspection program requirements.

In considering the Aging Aircraft Rule making, it would appear from the information provided, that EASA is moving toward a similar rule (Part-26) as the existing FAA Part 26 rule. Since the EASA rule is not currently available, the information presented could possibly change.

Emerging Material Technology – The WG does not recommend any specific rule change to address future material technology evolution. Emerging material technologies must continue to meet existing regulatory requirements in that they have approved material and process specifications with statistically based design values derived from test. A performance based rule does not need to specifically address a "material technology"; however, a new material technology may require additional guidance.

Rotorburst Policy - Investigation into existing methods of compliance concluded that all OEMs essentially apply identical approaches in showing compliance to Part 25 requirements pertaining to uncontained engine failure, with structural risk evaluated as a part of the aircraft level risk assessment. Service experience suggests that the existing method of compliance provides an adequate level of safety, and will continue to provide the same level of safety in the future. Although the well-established method of compliance has been historically consistent with available guidance material, it was determined that it does not agree with the current FAA interpretation.

Acknowledging similarity in interpretation between OEMs, the recommendation is for no specific rule change, although a lack of harmonization between different NAAs was noted. Guidance material change is recommended in order to clarify the contribution of structural considerations within the overall aircraft level risk assessment while recognizing averaging of all rotors and allowing for consideration of phase of flight.

Cracking During Full-Scale Fatigue Test - AC 25.571-1D contains detailed instructions on the development and evaluation of a full-scale fatigue test. However, it lacks guidance on the process to follow when cracking is found during this testing and that cracking is not related to Widespread Fatigue Damage (WFD).

The WG recommends changes to guidance to define a fatigue management plan for the affected fleet of aircraft.

Additional Recommendations – Each recommendation summarized above has a corresponding general recommendation for the creation of educational materials, which help facilitate updates in rules and guidance materials and promotes awareness by those that need to know. Such recommendations go beyond information typically documented in regulations and regulatory guidance to include international guidelines and standards that document accepted industry best practices at a level of detail that promotes efficient industry, manufacturing and maintenance field practices. This recommendation includes the encouragement for industry to work with regulatory bodies in both the development and delivery of such educational materials throughout the aviation industry. The TAMCSWG recommends such an effort for composites and hybrid assemblies’ of composite and metal structures, characteristic of current airplanes.

1 Introduction

This report documents the recommendations of the Transport Airplane Metallic and Composite Structures Working Group (TAMCSWG). The formal tasking was published in January 2015 requesting the working group evaluate § 25.571, subparts C and E of part 26, and associated regulatory guidance material (e.g., advisory circulars and policy statements) to determine whether any changes to the airworthiness standards and/or guidance material are required due to the increased use of composite and hybrid structures.

This report contains the working group's recommendations relative to the following main elements of the tasking:

- Evaluate current § 25.571, subparts C and E of part 26, and guidance material
- Recommend Rule or Guidance changes
- Estimate the associated Costs and Benefits

Addressing the first element, the working group reviewed current regulation, guidance and policy as an initial assignment to ensure all members were familiar with the material. The working group evaluated whether any changes to part 25 and the associated regulatory guidance material were required to provide consistency with the damage tolerance and fatigue airworthiness standards and associated guidance material for parts 23, 27, and 29. This review action followed our initial kick off meeting and no direct rule or guidance material changes resulted. The working group however agreed that beyond the original nine items identified in the tasking there were two additional items (8 & 12) that had sufficient importance and relevance to include and provide associated recommendations.

In addition, the FAA requested that the interpretation of the existing rotorburst policy also be assigned to this working group given the relevance to the subjects in the original tasking. With the addition of this request the list of 12 focus areas discussed in this report are:

1. Threat Assessment
2. Structural Damage Capability (SDC)
3. Testing of Hybrid Structure
4. Aging Mechanisms
5. Inspection Thresholds
6. Bonded or Bolted Repairs
7. Large Modifications
8. Inspections and the ALS
9. Harmonize EASA Aging Aircraft Rulemaking
10. Emerging Material Technology
11. Rotorburst Policy
12. Cracking During Full-Scale Fatigue Test

The Structural Damage Capability and Rotorburst topics are mostly material independent subjects, and given that most of the TAMCSWG members have skills specifically based on their experience working with composites, those two topics remained initially assigned to the Airworthiness Assurance Working Group (AAWG) to develop a recommendation with experts in those areas. The TAMCSWG considered the AAWGs suggested recommendations in the development of the final recommendations provided on those topics.

Although the above technical areas where addressed by sub-groups, it was essential to consider all topics in combination with other areas when considering rule and guidance changes. For the damage-tolerance evaluation under § 25.571(b), the tasks that interact include threat assessment, inspection considerations, structural damage capability, aging of composite and hybrid structures, testing of hybrid structure, and documentation of inspections and other procedures (ALS and MSG-3). The TAMCSWG held several face-to-face working group meetings, in addition to numerous virtual meetings over the 3-year effort culminating in the recommendations made in this report. It was realized early on that other rules, such as those for design and manufacturing quality control, have dramatic effects on how much is done in addressing § 25.571(b). For example, it is possible to achieve weight savings, maintenance relief, and overall customer satisfaction through composite design and quality control efforts that avoid aging phenomenon similar to metal WFD.

In addition to the goals for future rule and guidance recommendations, the TAMCSWG realized that many of the challenges faced by this ARAC related to different composite and metal industry practices for damage tolerance. Many of the composite differences led to complex discussions, further stymied by non-standard, proprietary methods, typically not documented in public references. Since these issues related to knowledge transfer and other general educational issues, they often appear as a challenge throughout this document with a final general recommendation given in Section 5.2.

A special workshop, sponsored by the FAA and Bombardier at Dorval, Quebec, that occurred near the start of TAMCSWG meetings (September 2015) proved a good general basis in understanding. Many workshop presentations shared some necessary knowledge on composite and hybrid structure engineering practices that was not available in public references. Many of the manufacturers with such experience shared their internal design criteria, structural methods and related procedures used to develop damage tolerant structures and repairs. This information has archives at the following website, which documents FAA/Industry workshops:

https://www.niar.wichita.edu/niarfaa/WorkshopRegistration/Dorval2015.aspx

Appendix A is the January 26, 2015 Federal Register, which was included as it provides additional background explaining the reason for the requested evaluation described in the tasking.

2 TAMCSWG Tasking

TAMCSWG specific tasking as defined in the Federal Register is shown below. The Working Group's recommendations relative to future rule and guidance are contained in Section 3 with the cost and benefit assessment in Section 4. Section 5 contains additional recommendations and interactions. Dissenting positions are captured in the section relative to the issue. Unless otherwise noted all cited language in CFRs, ACs or policy statements contained in this report are at the amendment, revision level as of the date of this report.

Below is an excerpt of the specific tasking taken from the January 26, 2015 Federal Register identifying the 3 main elements:

Element #1 - Evaluate current § 25.571, subparts C and E of part 26, and guidance material

1. Evaluate § 25.571, subparts C and E of part 26, and associated regulatory guidance material (*e.g.*, advisory circulars and policy statements) to determine whether any changes to the airworthiness standards and/or guidance material are required to address transport airplanes being constructed of metallic, composite, and hybrid structures. The working group is also tasked to evaluate whether any changes to part 25 and the associated regulatory guidance material are required to provide consistency with the damage-tolerance and fatigue airworthiness standards and associated guidance material for parts 23, 27, and 29. The working group is requested to include in its evaluation a review of the following advisory circulars (AC) and policy statements (PS):

    a. Advisory Circulars: AC 25.571–1, Damage Tolerance and Fatigue Evaluation of Structure; AC 20–107, Composite Airframe Structure; AC 120– 93, Damage Tolerance Inspections for Repairs and Alterations; AC 120–104, Establishing and Implementing Limit of Validity to Prevent Widespread Fatigue Damage; AC 27–1, Certification of Normal Category Rotorcraft (specifically, Subpart C—Strength Requirements); and AC 29–2, Certification of Transport Category Rotorcraft (specifically, Subpart C— Strength Requirements).
    b. Policy Statements: PS–ANM100–1989–00048, Policy Regarding Impact of Modifications and Repairs on the Damage Tolerance Characteristics of Transport Category Airplanes; PS–ACE100–2001–006, Static Strength Substantiation of Composite Airplane Structure; PS–AIR–100–120–07, Guidance for Component Contractor Generated Composite Design Values for Composite Structure; PS–ACE100– 2002–006, Material Qualification and Equivalency for Polymer Matrix Composite Material Systems; PS–ANM– 100–1991–00049, Policy Regarding Material Strength Properties and Design Values, § 25.613; PS–ANM100–1993, Compliance with § 25.571(e) Discrete Source Damage (Uncontained Engine Failure).

Element #2 - Recommend Rule or Guidance changes

2. Advise and make written recommendations on whether to change 14 CFR part 25, subparts C and E of 14 CFR part 26, and related regulatory guidance material, such as ACs 25.571– 1, 20–107, 120–93, and 120–104, to address the use of metallic, composite, and hybrid structures in transport airplanes. In developing the recommendations, the working group is requested to consider:

    a. The threats associated with fatigue, environmental exposure, and accidental damage that must be addressed per § 25.571.
    b. Applicability to emerging technology materials.
    c. The recommendations contained in the 2003 General Structures Harmonization Working Group (GSHWG) report entitled, ''Damage Tolerance and Fatigue Evaluation of Structures, FAR/JAR § 25.571.'' You can find the GSHWG report at *http://* *www.faa.gov/regulations_policies/ index.cfm/document/information/ documentID/384.* The working group recommendations should include whether it is appropriate to:
        i. Require applicants to assume the structure contains an initial flaw of the maximum probable size that could exist as a result of manufacturing or service- induced damage.
        ii. Add a requirement for showing structural capability in the presence of damage, so that even if the structure fails partially, there will still be enough structure remaining

to be safe.

d. The continued operational safety of composite and hybrid structures as they age, including any airworthiness limitations in the structural maintenance program.
e. The testing of hybrid structure, including, but not limited to, addressing thermal effects, test duration, load enhancement factors, and crack-growth retardation.
f. The bonding or bolting of repairs to metallic, composite, and hybrid structures.
g. The certification of large structural modifications on transport airplanes constructed of composite or hybrid structures.
h. The EASA rulemaking activity on aging aircraft for harmonization purposes.

3. Provide recommendations on appropriate performance-based requirements to address the results of the evaluations above, with consideration of applicability not only to metals and known composites, but also other emerging technology materials.
4. Provide recommendations on any new guidance or changes to existing guidance, including AC 25.571–1D, and AC 20–107B to address the results of the evaluations above.

Element #3 - Estimate the Cost and Benefit associated

5. Provide initial qualitative and quantitative costs and benefits. Based on the recommendations, perform the following:

   a. Estimate the costs to implement the recommendations;
   b. Estimate the benefits of the recommendations in terms of potential fatalities averted;
   c. Estimate any other benefits (*e.g.*, reduced administrative burden) that would result from implementation of the recommendations.

2.1 Working Group Members

The Working Group membership consisted of voting members, subject matter experts and regulatory advisors and participants. The population reflected OEMs, operators and both foreign and domestic regulatory agencies.

Voting members:

1.	Michael Gruber	(Boeing) – Chairperson
2.	Chantal Fualdes	(Airbus)
3.	Salamon Haravan	(Bombardier)
4.	Benoit Morlet	(Dassault Aviation)
5.	Antonio Fernando Barbosa	(Embraer)
6.	Kevin Jones	(Gulfstream)
7.	Toshiyasu Fukuoka	(Mitsubishi Aircraft)
8.	David Nelson	(Textron Aviation)
9.	Phil Ashwell	(British Airways)
10.	Doug Jury	(Delta Air Lines)
11.	Mark Boudreau	(FedEx)
12.	Eric Chesmar	(United Airlines)
13.	Walt Sippel	(FAA - advisor)

Subject matter experts:

1.	Steve Chisholm	(Boeing)
2.	David Polland	(Boeing)
3.	Kevin Davis	(Boeing)
4.	Al Fawcett	(Boeing)
5.	Rick Kawaguchi	(Boeing)
6.	John van Doeselaar	(Airbus)

Regulators:

1. Larry Ilcewicz (FAA)
2. Michael Gorelik (FAA)
3. Patrick Safarian (FAA)
4. Rusty Jones (FAA)
5. Richard Minter (EASA) European Aviation Safety Agency
6. Simon Waite (EASA)
7. Pedro Caldeira (ANAC) National Civil Aviation Agency – Brazil
8. Guilherme Momm (ANAC)
9. Maurizio Molinari (TCCA) Transport Canada Civil Aviation
10. Jackie Yu (TCCA)
11. Kohei Hase (JCAB) Japan Civil Aviation Bureau
12. Tomoaki Higashikawauchi (JCAB)

2.2 Determination of Consensus

This document uses the terms full consensus and general consensus and are defined per the ARAC Manual which states *"full consensus"* as a situation where all voting members are in agreement with a position and *"general consensus"* as a situation where although there may be disagreement, the group has heard, recognized, acknowledged, and reconciled the concerns or objections to the general acceptance of the group. Although not every member fully agrees in context and principle, all members support the overall position and agree not to object to the proposed recommendation report.

Dissenting positions, where the entire group could not reach agreement on a recommendation are explained and captured in the report.

3 Rule and Guidance Recommendations

Addressing the second element of the tasking, whether rule and guidance changes will be recommended, this section focuses on Tasks 2, 3, and 4 of the ARAC Tasking and summarizes the recommendations and supporting rationale from each of the 12 sub-teams.

Task 2 requires the working group to advise and make written recommendations on whether to change the damage-tolerance and fatigue evaluation requirements of parts 25 and 26 along with the associated guidance materials. Tasks 3 and 4 of the ARAC Tasking require the working group to provide rule and guidance recommendations. Section 3 summaries the recommendations for Tasks 2, 3, and 4.

In all cases, rule and guidance change recommendations, include a general desire to develop the corresponding public educational materials, particularly as related to composite Principal Structural Element (PSE) and hybrid PSE assemblies of composite and metal parts. All airline and maintenance organizations involved in the ARAC felt that transport airplane industry involved with such designs should be more willing to share damage tolerance methods and data with the organizations responsible for maintaining the aircraft structures. Without such knowledge, it becomes difficult for the airlines to ensure composite and hybrid repair and structural modifications or alterations are damage tolerant, particularly when they include structural bonding with unique design criteria, in-process controls, and structural methods.

Any points of dissention where the working group did not successfully reach full consensus appear in the individual sections.

3.1 Threat Assessment

All work in damage tolerance starts with an assessment to determine whether any of the four general classes of threats may potentially fail principle structural elements with catastrophic consequences to flight safety. Based on this assessment, a damage tolerance evaluation (DTE) and/or other considerations applied to a given damage threat for a specified structural design detail form the basis for maintenance and any other procedures used for practical management of all possible threats. The process of linking structural DTE with maintenance practices to avoid catastrophic failure includes an essential educational component of knowledge transfer for new designs such as a hybrid combination of traditional metal construction with advanced composite or other new materials (see Section 5.2).

3.1.1 Rule Change

The TAMCSWG recommends a simple change to the existing wording in 14 CFR 25.571, Amendment 25-132 to less metallic specific language that captures the threats associated with metals, composite, and hybrid structure. In addition, the TAMCSWG recommends that the broad categories of threats; fatigue, corrosion, manufacturing defects, and accidental damage, be consistently used throughout the rule and to assure that the applicant consider a wide range of possible manufacturing defects dependent on the manufacturing process capability as part of the Damage-tolerance evaluation (DTE). These can include defects such as disbonds or weak bonds for bonded structures. Additionally this provides clarity that the DTE required in 25.571(b) include "an evaluation of the strength, detail design, and fabrication" as stated in 25.571(a) as the overall Damage-tolerance and fatigue evaluation of the structure.

For example, in 25.571(a) and 25.571(b), the word "corrosion" would be change to "environmental deterioration" and 25.571(b) would have "manufacturing defects" added to the modes of damage that must be considered.

The WG reached general consensus that the requirement to perform a threat assessment as implied in the existing rule is sufficient even though the existing rule does not explicitly state the applicant must perform a "threat assessment". With the inclusion of all four damage threats at the start of 25.571(a), the rule is requiring control of such damages to avoid catastrophic failure. The DTE required by 25.571(b) also needs to consider the same damage threats in developing supporting engineering data to define related maintenance practices (e.g., inspection, and as necessary, damage removal and/or repair). In addition to the DTE, the rule allows *other considerations* applied when needed.

3.1.1.1 Rationale

The existing rule captures damage threats considered during the DTE in the broad categories of fatigue, corrosion, manufacturing defects, and accidental damage. Specifically, corrosion represents a threat to metallic structure. The WG recommends that the FAA change "corrosion" to "environmental deterioration". This is because it is more representative of environmental exposure that results in a decrease in strength or stiffness for composite or hybrid structure as well.

In addition, 25.571(a) lists the damage threats as "fatigue, corrosion, manufacturing defects or accidental damage," while paragraph 25.571(b) states that "the evaluation must include the probable locations and modes of damage due to fatigue, corrosion, or accidental damage." The WG recommends the FAA change 25.571(b) to include "manufacturing defects" as a damage threat considered in the DTE for consistency. These "manufacturing defects" range from the small flaws, such as the 0.05" rogue flaw assumption traditionally used for mechanically fastened metallic structure, to larger flaws, such as those associated with local disbond or weak bonds that can occur in both composite and metallic bonded structure.

3.1.1.2 Discussion

The overarching requirement for metallic, composite or hybrid structure remains the same. "An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, corrosion, manufacturing defect, or accidental damage, will be avoided throughout the operational life of the airplane."

The threats the applicant must evaluate are fatigue, corrosion, manufacturing defects, and accidental damage.

1. Fatigue - While composites and metals may not exhibit the same failure modes due to cyclic load, the word fatigue is broad enough to represent deterioration in strength due to cyclic loading.
2. Corrosion – Composite structures are not generally concerned with corrosion but deterioration due to the operation environment such as humidity, Ultra Violet (UV), etc. may still occur. Since corrosion is metal specific, the WG recommends that the FAA change the wording to a more encompassing term such as environmental deterioration.
3. Manufacturing Defects – The manufacturing defects term could apply to any type of structure. This defect is dependent on not only the type of structure but also the process capability and control used in the manufacturing of the structure. As stated in 14 CFR 25.571(a)(3) and as recommended in Section 3.5 Inspection Thresholds of this report, manufacturing and service variation must be accounted for when establishing inspection thresholds. The WG recommends that "manufacturing defects" be added to 25.571(b), as 25.571(a)(3) recognizes that manufacturing variation must be considered when

establishing inspection thresholds, and those thresholds are developed based on the DTE as required in 25.571(b).

4. Accidental Damage – This category is by far the largest and has the potential to encompass a wide variety of damage that may occur for aircraft structures. While the threats associated with accidental damage remain consistent between metallic, composite, and hybrid structure, the resulting damage may vary greatly. NOTE: Bird-strike and Uncontained engine failure are categorized as Discrete Source and covered under 25.571(e).

In general, corrosion is the gradual destruction of material, usually metals, by chemical and/or electrochemical reaction with the environment, the WG focused in on the reaction of the structure to its operating environment. The WG considered wording such as environmental effects, environment degradation, and environmental deterioration. The WG selected "environmental deterioration" based on two reasons:

1. Environmental deterioration indicates that exposure to environmental stimuli results in a permanent loss of strength and/or stiffness as opposed to a temporary change in those properties which can recover after removing the environmental effect. This is consistent with corrosion damage for metallic structure.
2. EASA CS 25.571, Amendment 19 already uses "Environmental deterioration" and this change moves toward harmonization of the rule.

The addition of "manufacturing defects" to 25.571(b) assures that as part of the Damage Tolerance Evaluation (DTE), the applicant will consider both a broad spectrum of damage threats as well as other considerations to address those threats. The opening sentence in paragraph of 25.571(a) states that, "An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, environmental deterioration, manufacturing defects, or accidental damage will be avoided throughout the operational life of the airplane." In addition to providing a framework to determine the broad categories of damage threats, it also provides a basis for other considerations in the review of these damage threats, specifically, the rule mentions an evaluation of strength, detail design, and fabrication. It follows that as part of the DTE in 25.571(b), the applicant would also consider the damage threats associated with manufacturing and the defects that could occur using the approved manufacturing process but not considered inspectable or detectable by the quality control process.

A specific area of concern often discussed by the WG was a disbond or weak bond in both composite and metallic structure. A weak bond is consistent with the threat category of manufacturing defect, and this type of damage needs consideration as part of the damage tolerance evaluation required by 25.571(b). This change also supports a more performance based requirement that covers composite structures as well as metallic structures.

This change is reflective of current industry practices, and provides both clarification and consistency without expanding the scope of the DTE required by §25.571.

The recommended change to 25.571 would be as follows:

(a) *General*. An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, ***environmental deterioration,*** manufacturing defects, or accidental damage will be avoided throughout the operational life of the airplane.

(b) *Damage-tolerance evaluation*. The evaluation must include a determination of the probable locations and modes of damage due to fatigue, ***environmental deterioration, manufacturing defects***, or accidental damage.

3.1.2 Guidance Change

The TAMCSWG recommend minor changes to guidance material as contained in AC 25.571-1D to more consistently use the four broad categories of threats listed as fatigue, corrosion, manufacturing defects, and accidental damage throughout that guidance.

AC 25.571-1D specifically states in Section 5.a.(1), “the focus of this AC is metallic structure,” the WG group does recommend use of the word “environmental deterioration” in lieu of “corrosion” to align with the wording contained in the rule. The WG also recommends the addition of wording be added to this section that specifically directs the applicant to the guidance contained in AC 20-107B when evaluating manufacturing defects in bonded metallic structure as well as some additional guidance specific to metal-to metal bonding.

As stated above, the WG recommends adding “manufacturing defects” to the list of threats identified in 14 CFR 25.571(b). The WG also recommends that AC 25.571-1D be changed to include some discussion of manufacturing defects under 5.c (“Structure to be evaluated”). The discussion should address the effects that manufacturing defects may have on the DTE and LOV. Furthermore, the changes should include a discussion on manufacturing defects associated with metallic bonded structure, the importance of stringent quality control associated with bonded structures, and considerations of the unique behavior of metallic bonded structure as compared to mechanically fastened metallic structure in regards to crack growth and crack arrest.

The WG also recommends that the FAA add a definition of “manufacturing defect” to AC 25.571-1D and modify the current definition in AC 20-107B to be consistent in both ACs. The revised definition should reflect that manufacturing defects are anomalies or flaws that occur as part of the fabrication operations, which includes manufacturing processes and assembly. The WG’s recommended definition provided below used the current definition in AC 20-107B as a starting point. The definition can also be found in Appendix B.2.1 and B.2.2.

Manufacturing Defect: An anomaly or flaw occurring during the manufacturing process that can cause degradation in structural strength, durability, stiffness or dimensional stability.

The WG recommends that the latter parts of the existing definition in AC 20-107B be deleted because they are already well-covered in other parts of the AC and are not needed in the definition. This includes the parts that note: “the manufacturing defects allowed by the quality control, manufacturing acceptance criteria are expected to meet appropriate structural requirements for the life of the aircraft,” and “the manufacturing defects that escape detections in the manufacturing quality control should be included in a damage threat assessment and must meet damage tolerance requirements until detected and repaired.” A thorough discussion of this recommendation appears in Section 3.1.2.1. (See Appendix B.2.2 for an example.)

As is discussed in Section 3.4 of this report, aging of bonded structure needs consideration as part of the DTE. Some evidence shows that the strength of a metal-to-metal bond can weaken over time and the applicant must consider suitable bond capability in both the residual strength and LOV assessments. To assure the applicant addresses these concerns, the WG recommends the FAA revise Section 6.h.(1)(a) Damage-tolerance analysis and test of AC 25.571-1D be expand the residual strength evaluation to include any reduction in capability for metal bond related to aging. The WG also recommends an addition to Section 7.a. be included that ties the LOV requirement in AC 25.571-1D, with the recommendation found in Section 3.4 of this report related to aging and LOV for composite structure. The additional wording should point to AC 20-107B and clarify that as with WFD, aging is not reliably detected through a structural inspection program for metal-to-metal bonding.

The WG recommends changes to AC 20-107B to address design robustness and damage tolerance evaluation for bonded structure, a new section is proposed in composite Section 8.a., Damage Tolerance Evaluation to address manufacturing defects. This new section would be Section 8.a.(9) as shown in Appendix B.2.2.

3.1.2.1 Rationale

AC 25.571-1D states in the introductions, 5.(1) “The requirements of § 25.571 apply equally to metallic and composite structure. The focus of this AC is metallic structure. Refer to AC 20-107B for guidance on composite structures.” While the term corrosion is acceptable when accessing the most likely damage threat associated with the environmental deterioration for metals, there is an advantage to harmonizing the language presented in 25.571 with that presented in the guidance.

NOTE: The WG recognizes the use of 14 CFR 23.573(a) in AC 20-107B is problematic as that paragraph no longer exist in the latest 14 CFR 23, Amendment 23-64 effective 30 August 2017.

The current definition found in AC 20-107B was developed with a primary focus on composite materials. The WG considered developing a new definition for “Damage Threats” that would be specific to metallic structure and adding it to AC 25.571-1D and maintain the existing definition for composites in AC 20-107B but the WG agreed that having a unique definition for the same term in separate ACs was not a desirable or sustainable solution.

The agreed upon approach was to define the class of damage covered by “manufacturing defect” as any damage that occurs during the manufacturing process. The removed parts of the definition are those related to the quality control and detectability addressed as part of the DTE. Recommended changes to AC 25.571-1D in this Section related to weak bonds as well as Section 3.5. Thresholds, to address expected variation as well as larger but rare missed defects, clarify the methodology for addressing “manufacturing defects” as part of the DTE for metals. For composites, the existing guidance in AC 20-107B, Section 8.a. Damage Tolerance Evaluation, contains a thorough discussion of the defect considered as part of the DTE.

The part of the definition for “manufacturing defect” that states, “’…meet structural requirements for the life of the aircraft part,” was also removed since the overarching requirement for 14 CFR 25.571(a) states “that catastrophic failure due to fatigue, corrosion, manufacturing defects, or accidental damage, will be avoided throughout the operational life of the airplane.”

The WG looked at the addition of examples to the definition for “manufacturing defects” similar to that found in AC 27-1B for rotorcraft for “intrinsic or discrete manufacturing defects” but the WG felt that definitions typically do not include examples, and the list generated was a mixture of metallic specific defects and composite specific defects without significant overlap. Therefore the WG recommendation does not include a list of examples, but the inclusion of appropriate examples in AC 25.571-1D and AC 20-107B could be a future consideration for the FAA. The list compiled by the working group as part of this discussion is for information only.

Examples of Manufacturing Defects (Metals) - drilling defects, machining marks, gaps, chemical milling undercuts, inclusions. (for Metal Bond) - kissing bonds, weak bonds, bond voids, and porosity

Examples of Manufacturing Defects (Composites) - weak bonds, bond voids, delamination, gaps, porosity, inclusions, and fiber dislocation.

3.1.2.2 Discussion

The WG recommend the FAA make the following changes to AC 25.571-1D to align with the proposed rule changes presented in Section 3.1.1:

5. **Introduction** –

a.(1), The AC states, "The requirements of § 25.571 apply equally to metallic and composite structure. The focus of the AC is metallic structure, Refer to AC 20-107B for guidance on composite structures." Since AC 25.571-1D is metallic centric, the use of the term "corrosion" is acceptable, but for consistency, the WG recommends the FAA change any occurrence of the term "corrosion" to "environmental deterioration (corrosion)" to align with the proposed rule change.

a.(2), states "Section 25.571 requires the applicants to evaluate all structure that could contribute to catastrophic failure of the airplane with respect to susceptibility to fatigue, corrosion, and accidental damage". It also notes, "Although the LOV is established based on WFD considerations, it is intended that all maintenance actions required to address fatigue, corrosion, and accidental damage up to the LOV are identified in the structural-maintenance program." The WG recommends the FAA add manufacturing defect to the damage threat lists.

6. **Damage-Tolerance Evaluation** –

g.(1), states that the applicant select locations based on a "determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage." The WG recommends that the FAA add "manufacturing defect" to the list of damage threat categories.

g.(1)(b), The WG recommends the FAA revise to add manufacturing defect so it states, "In addition, the areas of probable damage from other sources, such as severe corrosion, accidental damage, or manufacturing defect should be determined from a review of the design and past service experience".

As is mentioned in Section 3.2 of this report, the concern of weak bonds was often raised as an issue that needed to be addressed especially as the use of both metal bonding and composites become more common. The WG readily agreed that in general the experienced OEMs had established in-house methods to assure that a combination of stringent process controls and robust design details are consistent with the fleet history of reliable bonded structure. However, current guidance did not provide assurance that a new entry with limited knowledge would both adequately understand the risk and methods to evaluate this type of structure. As a step toward addressing this issue, the Threat Assessment, SDC, and Hybrid sub-teams worked both together and separately toward possible solutions. The final resolution was reached to primarily use the guidance in AC 20-107B to address specifically weak bonds in both metallic and composite structures as related to the DTE requirements for manufacturing defects as found in recommended revision of 25.571(b). An example of these changes appear in Appendix B.

The following changes to AC 25.571-1D are not part of the WG recommendation but capture the WG discussions on the topic of Threat Assessment and an option that was considered.

AC 25.571-1D does not explicitly state the requirement of a threat assessment, but AC 20-107B contains the following language in section 8.a(1): "Damage tolerance evaluation starts with identification of structure whose failure would reduce the structural integrity of the aircraft. A **damage threat assessment** must be performed for the structure to determine possible locations, types, and sizes of damage considering **fatigue, environmental effects, intrinsic flaws, and foreign object impact or other accidental damage (including discrete source)** that may occur during manufacture, operation or maintenance." If this wording were adopted and included in AC 25.571-1D in 6.g(1), this would align both AC's and change the threat assessment requirement in AC 25.571-1D from implicit to explicit. The majority of the WG agreed that since the rule remains with the implicit requirement for a threat assessment, it is acceptable for AC 25.571-1D to retain the current implicit language. It should be noted that the FAA and EASA disagrees with this rationale given that threat assessment is specifically used in AC 20-107B.

The Table presented here as Table 3.1 served as a tool in WG discussions related to Damage Threat Assessment. The tool was primarily presented to assure that different types of damage were sufficiently covered by the four broad categories of fatigue, environmental deterioration, accidental damage, and manufacturing defects. During these discussions, several operators and NAAs advocated for the inclusion of the Table in AC 25.571-1D, while the OEMs expressed a strong preference not to include the Table in guidance of AC 25.571-1D. Based on the final vote of 8 (OEMs) in favor of omitting the table and 5 (Operators and FAA) in favor of including the Table, **the WG reached general consensus, therefore recommends not to include the Table.**

Majority Position: The OEMs reluctance to include the Table related to a concern that applicants as well as regulators would interpret the Table as a checklist without accounting for other considerations. The OEMs agreed that differences in operational environment, manufacturing techniques, materials, and maintenance could greatly affect the damage threats each OEM considers and thus is best handled by the individual applicant. The OEMs also agreed that each company represented had developed a methodology that often encompassed several damage threats listed in the Table, such as the ability of the structure to tolerate large damage from accidental damage, without necessitating the detail of addressing each damage threat listed in the Table individually under accidental damage. This could lead to NAAs interpretation that each item listed in the Table needs individual consideration and thus result in an increased burden on the applicant. This concern is similar to the thoughts shared by industry during the discussion of SDC. It should also be noted that the WG believes the implied requirement to perform a damage threat assessment is sufficient and the inclusion of the Table in AC 25.571-1D could be problematic. As one example, the existing guidance to address the four broad classes of damage are scattered throughout the AC and including the Table would likely require an extensive rewrite of AC 25.571-1D.

Dissenting Position: The dissenting position expressed by operators and the FAA focused primarily on the concern that STC applicants or a new applicant without the depth of knowledge and understanding of the Damage Threats that needed to be considered, would benefit greatly from a Table with examples of the 4 broad classes of damage. This group also felt the use of examples and Tables by the FAA in guidance was well established and therefore the concern of using it as a checklist was unwarranted.

Table 3.1 – Damage Threats

FATIGUE	**ENVIRONMENTAL**	**MANUFACTURING**	**ACCIDENTAL**
Crack Initiation	Corrosion	Rogue Flaw	Maintenance
Crack Growth	Finish Erosion	Machining Marks	Ground Handling
Damage Growth	UV Degradation	Weak Bond	Cargo Handling
WFD/MSD	Moisture Intrusion	Bond Voids	Runway Debris
Aging	Hail Impact	Chem Mil Undercut	Foreign Object

	Lightning	Delamination	Bird Strike*
	Chemical Exposure		Uncontained Rotor*
	Water Entrapment		
	Environmental Assisted cracking		

* These Items are covered by requirements of 25.571(e)
The Above list is not meant to be an exhaustive list of threats.

The above table is not an exhaustive list of damage threats, but was utilized by the WG to identify examples of threats that are currently covered by design, manufacturing quality control and other considerations that minimize the need for more exhaustive substantiation efforts relating to specific DTE per §25.571. In other words, industry may use several development and certification tasks to minimize the need or scope of damage tolerance tests and analyses with related maintenance inspection tasks. Customer relationships may also play a role in design decisions to reduce stress levels or enhance manufacturing quality control to relieve field inspection burdens and such practice was acceptable to regulatory agencies. One example of such practice is material screening tests and design constraints used by industry to avoid past composite aging problems (see Section 3.4).

3.2 Structural Damage Capability (SDC)

All industry and regulatory members of the WG believe SDC is important to safety. However, industry has traditionally incorporated SDC as a design practice, dependent on many factors including internal service databases, other design attributes, product inspection goals, and specific PSE locations. As a result, there is great variability amongst the OEMs with respect to economic and application-specific implications. Therefore, codifying a meaningful regulatory standard is unviable. This is in part due to the disparate OEM fail-safe design approaches developed over 40 years. The FAA proposed an approach with the intent of providing flexibility to allow the freedom of disparate OEM approaches, but the working group became most concerned about inconsistent interpretation of the proposal, especially amongst different regulatory bodies. These issues again highlight the importance of knowledge transfer within industry and regulatory bodies to minimize the economic impact of allowing multiple, equally effective and safe industry approaches. In many cases, several regulations for design, structural substantiation, manufacturing quality control, maintenance tasks and other procedures supplement damage tolerance to avoid catastrophic failure. Such credit should be given without restating the effects of those rules in §25.571. Instead, industry guidelines to promote such practice within industry standards provide the necessary knowledge (also see Section 5.2).

The OEMs noted that significant OEM and regulatory resources have been used for more than 20 years to globally re-introduce fail safety/SDC and there has been little to no progress made with respect to a practical approach to incorporating these topics into CFR 14 Part 25 and guidance material. Furthermore, during these past 20+ years, OEMs have continued to incorporate non-mandated considerations, including fail-safety, into their products as internal design practices.

The TAMCSWG concludes that the structural robustness of future designs can be best addressed by limiting usage and developing specific requirements for SLP structure which unlike multiple load path structure has no inherent SDC.

3.2.1 History of Attempts to Standardize and Codify SDC

The history with respect to reintroducing fail safety/SDC into a rule and guidance material spans over 22 years as summarized in Section 2 of the “AAWG Structural Damage Capability

Recommendation Document – Supplement" dated September 15, 2017 (provided as a separate report). Most notably, there were large efforts by the General Structures Harmonization Working Group (GSHWG) leading to a recommendation in 2003 that the FAA ultimately did not adopt due to various concerns. More recently, the Airworthiness Assurance Working Group (AAWG)/SDC WG Sub-team tried to build off the 2003 GSHWG recommendation. There were three attempts made by the AAWG to reach consensus on a path forward for creating regulatory provisions and guidance to incorporate fail-safety back into CFR 14 Part 25:

1. Providing specific bare minimum requirements for residual strength evaluations, some AAWG members did not believe this would enhance safety in any significant manner, while adding to OEM compliance burden (summarized in AAWG SDC Recommendation Document dated November 30, 2016, provided as a separate report).

2. Linking the requirement to include SDC based on level of threat assessments, AAWG members raised concern on what constitutes a thorough threat assessment (summarized in AAWG SDC Recommendation Document dated June 23, 2017, provided as a separate report).

3. Changing the focus from level of threat assessment to assumptions used in damage tolerance assessment, led to the concerns summarized in the roadblocks below.

3.2.2 Primary Roadblocks to Incorporation of SDC

The September 15, 2017 AAWG supplement report (provided as a separate report) documents the following primary roadblocks to incorporating SDC into Part 25:

1. Compliance burden of a requirement without an appreciable gain in safety.
2. Conflict between having explicitly defined guidance and allowing for flexibility with resulting interpretation issues.
3. No working group agreement on linking level of SDC with certain variables.
4. Problems with developing industry guidance to address "other considerations".
5. Period of unrepaired use.
6. Effectiveness of crack retardation features in monolithic metallic MLP structure.

The TAMCSWG agreed that the six roadblocks are correctly identified.

3.2.3 TAMCSWG Voting

As noted in the September 15, 2017 supplement, the TAMCSWG originally put the following four options to address (or not address) SDC to vote:

1. NAAs draft up elements of rule change and guidance including SDC as an "other consideration" as part of the applicant's damage tolerance evaluation (DTE)
2. Conclude there is no practical approach, due to major points of dissention:
    a. Conclude the major points of dissention are insurmountable and discontinue efforts to incorporate fail-safety back into CFR 14 Part 25; or
    b. Halt efforts to incorporate fail-safety back into CFR 14 Part 25 until the FAA can propose an approach that addresses the major points of dissention. At that time, the FAA would re-task another team to resume this effort, possibly as an ARAC or Advisory and Rulemaking Committee (ARC); or
    c. Continue efforts to incorporate fail-safety back into CFR 14 Part 25 as an extension to the TAMCSWG assignment; the FAA would still commit to proposing an approach that addresses the major points of dissention.
3. Seek a different approach, perhaps re-visit 25.6xx proposal

4. Assume inherent SDC for MLP structure, focus only on how to address Single Load Path structure

Of the voting members, three voted for Option 2a, five voted for Option 2b and four voted for Option 2c. The OEM sub-team recommended that if the TAMCSWG opts to continue with the effort to reintroduce fail-safety back into CFR 14 Part 25, then the NAAs should propose a practical path that fully addresses the challenges/roadblocks identified in Section 3.2.2 above.

In an effort to gain support for Option 2b or 2c, the FAA attempted to address the six roadblocks. However, in October 2017 TAMCSWG voting, the majority of the voting members did not believe the FAA proposal fully addressed the roadblocks. The FAA and two operators (Delta Air Lines and British Airways) believed there was sufficient viability in the proposal and that efforts should continue outside or beyond the ARAC working group to fully incorporate “other considerations” and SDC into a rule and guidance material respectively. The dissenting opinion of the two operators is documented in Section 3.2.5 below.

Recognizing lack of consensus, and in lieu of recommending discontinuation of all efforts (Option 2a), the majority of the ARAC working group (Boeing, Airbus, Embraer, Mitsubishi, Bombardier, Dassault, Gulfstream, Textron, FedEx and United Airlines) voted to continue efforts beyond the ARAC working group but focus only on the primary area of concern with respect to SDC which is addressing single load path (SLP) structure. This was Option 4 in the original round of voting (noted above). The working group felt that focusing on usage of SLP structure would have a greater impact on enhancing safety, especially with respect to ensuring equally robust designs from future or less experienced Type Certificate Holder applicants. Addressing weak bonds was also an area of concern by the working group but that is addressed separately by the ”Threat Assessment” sub-team in Section 3.1 of this report.

3.2.4 Recommendations Pertaining to SLP Structure

There is broad agreement among the voting members to address concerns over future use of SLP architecture by new applicants. It is recommended that future efforts begin with an approach similar to that outlined in Appendix L and N of the June 23, 2017 AAWG SDC Recommendation Document (provided as a separate report). **In this approach, use of SLP structure that is non-safe life and subject to in-flight loading is only allowed where multiple load path structure is established to be impractical.** In addition, it is proposed that the applicant should consider the following items for SLP structure:

- Minimization of environmental and accidental damage (i.e. consider protection, different materials, etc.)
- Perform a fatigue test or complete fatigue analysis based on test to demonstrate an acceptable level of fatigue reliability
- Perform testing, or analysis based on testing, to demonstrate that the materials and stress levels chosen do indeed provide a controlled slow rate of crack propagation combined with high residual strength
- Develop a manufacturing process control and tracking plan document

It is important to make a clear delineation between SLP and integral multiple load path structure (MLP) and it could be a challenge to demonstrate that integral MLP structure does not behave as SLP. In order to do so, the applicant would likely have to consider effectiveness of crack stopping features and period of unrepaired use. Secondly, challenges would exist with respect to clearly defining what constitutes demonstration of impracticality for usage of MLP structure in order to justify usage of SLP structure. Lastly, it is recognized that there is a challenge of defining the regulatory basis for focusing on SLP structure.

3.2.5 Dissenting Opinions

The following is a coordinated dissenting opinion from Delta Air Lines and British Airways with the majority decision to recommend continued work beyond the ARAC working group focusing only on limiting and providing requirements for SLP structure:

"The effort to address incorporation of SDC in either rule or guidance material was a delegated task to the AAWG, though this effort was largely, if not exclusively, accomplished by OEM representatives within the AAWG. It is recognized that extensive effort was put forward by these organizations to work towards resolving open items from the effort in 2003 GSHWG ARAC. As largely an observer to this activity, it appears that to an extent the NAA were not closely participating in these discussions, rather had been passive recipients of the results of the OEM caucus.

There is recognized value by the OEM AAWG subgroup in the identification of the six key roadblocks in incorporating SDC guidance or rules. This is a tangible, real product of the effort by the groups, and should be acknowledged as real progress rather than just a dead end. It is therefore reasonable to believe that NAA and industry groups can work through differences related to the six roadblocks and establish a shared understanding and approach. The next steps would build upon the work from this current group through addressing the specific items. It is not a given that all items can be successfully resolved between NAA and industry representatives, but a good faith effort should be made and therefore, this recommendation is that further work be invested in continuing progress in this subject, as possible. Based on observations from discussions of proposed results from the current OEM subgroup and feedback from NAA, it appears that there is a great deal of common ground, and that should be considered and investigated with respect to the six roadblocks. The most likely approach that will lead to a successful outcome would be a focus on solely the technical aspects of the cited roadblocks, including sufficient time to develop the solutions. The knowledge of the existing sub-team members makes them best placed to address these issues in the least time. It is recognized by all parties that there is inherent value of SDC in design to overall safety, and therefore, for such a foundational design philosophy in maintaining the continued operation of a truly damage tolerant structure this should be promoted in every possible way, including guidance and potentially rule-making."

However, in order to reach a general consensus with the working group both the dissenting operators agreed at a minimum that they would support the proposal described above (focus on SLP) as the final working group recommendation.

3.3 Testing of Hybrid Structure

This section provides recommendations on rule and regulatory guidance changes to address the testing of hybrid structure (e.g., assemblies of composite and metal parts). This starts by considering all the damage threats important for the DTE of composite and metal parts, as well as the dominating aging mechanism when considering the structure as a whole. The impracticality of applying certain loads in hybrid structure tests is important to both metals and composites. Specifically, the working group recommends the use of analysis supported by test evidence to supplement testing, particularly at full-scale levels. This section also addresses operating limitations based on the status of the FSFT and other items to consider, such as Load Enhancement Factor (LEF) and artificial damage, when performing full-scale fatigue testing. This section links with Section 3.4, which primarily addresses aging mechanisms for composites. In combination, the two sections address the potential that composites may become more of a factor in setting the LOV. As discussed in the Introduction to this report (Section 1), an industry/regulatory workshop held near the start of TAMCSWG efforts reviewed damage tolerance practices for composite structures and hybrid assemblies of metal and composite parts. The workshop was successful in bridging the gap in ARAC team knowledge. It also led to identification of a need for more educational developments on this subject as a benefit for future applications (see further discussions in Section 5.2).

3.3.1 Rule Changes

Some of the recommended rule changes noted in the sections entitled Threat Assessment, Inspection Thresholds, and Aging Mechanisms are valid for this section, sometimes for different rationale. This section focuses on the working group recommended rule changes to address hybrid test issues for both metals and composites. Specifically, the change would allow substantiation by means of "analysis supported by test evidence" for appropriate types of loading.

3.3.1.1 Full-scale Fatigue Test Evidence

Current § 25.571(b) requires full-scale fatigue test evidence for demonstrating freedom from WFD up to the LOV. For new certification projects, the primary source of full-scale fatigue-test evidence is full-scale fatigue testing. However, this assumes the damage threat driving the LOV is metallic fatigue. There is a need for more general rule language since an applicant can also define the LOV by a composite aging mechanism. Section 3.4 addresses this issue.

Other testing issues make full-scale fatigue test evidence incomplete in validating LOV. It is impractical to apply all loads or other aging mechanisms in the full-scale tests. A typical example is cyclic thermal induced loads, which occurs in hybrid structure due to difference of coefficient of thermal expansion. The thermal loads in a hybrid structure are self-balancing. As a result, thermal loads cannot be replicated or simulated by increasing mechanical loads on the structure and the resulting total loads will not adequately represent internal load distributions. In addition, thermal inertia of the full-scale test article is so large that testing (static and fatigue) in a fluctuating environment cannot possibly be completed in timely manner. And most compelling is that thermally induced mechanical loads typically do not contribute to widespread fatigue damage, and in fact may reduce the susceptibility due to increased local variation in internal loads (e.g., end fastener load peaking in mechanically fastened structure of dissimilar materials). Similarly, there are other loads, which can become critical for composite applications with bonded elements, such as cyclic fuel pressure loads and external out-of-plane air pressures because they cannot be simulated in a full-scale fatigue test. As discussed in Section 3.4, aging mechanism noted for composite applications to date include complex interactions between environment, real-time, and manufacturing defects. These combined effects are also practically difficult if not impossible to cover in full-scale tests. Based on this, the WG recommends that the FAA revise the rule text to allow substantiation by means of "analysis supported by test evidence" other than direct testing.

As discussed in Section 3.4.1, the working group recommends that the rule have a general requirement [i.e., move requirement for establishing LOV from 25.571(b) to 25.571(a)] for establishing the airplane's LOV. Furthermore, section 25.571(a)(3) already defines limit of validity as the engineering data that supports the structural maintenance program. This change along with the existing definition should provide a generic, high level; performance based requirement that should address metallic, composite, and hybrid structures as well as any new emerging material technologies.

See Appendix C for example rule text, based on both sections 3.3 and 3.4.

3.3.1.2 Operating Limits and Fatigue Test Progress

The FAA requested the sub-team consider whether the factor of two used to define the operational limits associated with the number of cycles accumulated on the fatigue test article in § 25.571(b) needs to be changed. The working group recommends not changing the factor since the factor of two has traditionally been applied as an airplane number and there have been no safety issues identified based on fleet evidence (experience) indicating a change is necessary. In addition, the following justifications support the recommendation for no change.

- At the time of TC, analysis justifies the candidate LOV. This analysis is supported by test evidence including full-scale fatigue test, where accumulated fatigue cycles covers at least one year of in-service operation.

- Manufacturers are typically finished with the full-scale fatigue test and evaluation to establish the LOV well in advance of airplanes approaching the LOV.

In the WG discussion, a question was raised by ANAC regarding a perceived inconsistency between a factor of two (2) for operational limit and a factor of three (3) for the maintenance action for WFD susceptible structure. The factors however have a different intent as described below and thus the WG agreed are consistent and support the recommendation to not change the rule.

(a) The factor of two (2) restricts the operation at the aircraft level, while the factor of three (3) is used to establish the Inspection Starting Point (ISP) (or, in some cases, the Structural Modification Point (SMP)) which is determined at the WFD susceptible structure level.
(b) The factor of two (2) is applied during the full-scale fatigue test, before the final LOV is established, while the factor of three (3) is applied after the test completion or a WFD finding.

After reviewing the WG's rationale above ANAC had a dissenting position to be recorded and provided the following rationale:

> Both factors share the same intent: to preclude WFD. Both work at WFD susceptible structure level (at the end, working at the airplane level).
>
> The factor of two was included in the rule in the amdt. 25-96 in 1998. According to the preamble to the final rule, the factor of two "is necessary to ensure that, following type certification, the testing proceeds so that the affected airplanes receive the safety benefits that this rule is intended to provide."
>
> In 2011, the AC 25.571-1D was revised in the amendment 25-132 referring to the factor of three, considering an updated understanding of the matter. Presently, the inconsistency in the rule remains. The intention of the rule is to protect the fleet based on maintenance actions (ISP and SMP) and the factor of three is the key element in setting those actions based on WFD average behavior. By similarity, the factor of three "is necessary to ensure that, following type certification, the testing proceeds so that the affected airplanes receive the safety benefits that this rule is intended to provide."
>
> Finally, once the FSFT is noted as complete and the LOV is established typically well before the fleet approaches the LOV, the removal of this inconsistency by updating to the factor of three in the rule would pose no cost to the OEMs.

3.3.2 Guidance Changes

Some of the recommended guidance changes noted in the sections entitled Threat Assessment, Inspection Thresholds, and Aging Mechanisms are valid for this section, sometimes for different rationale. This section focuses on the working group recommended guidance changes to address hybrid test issues for both metals and composites. Please note that the guidance changes address more than the rule changes described above.

The working group recommended the following six changes for AC 25.571-1D, AC 120-104 and AC 20-107B. The recommended example text appears in Appendix C.

The first four (4) changes are to address the hybrid structure in terms of DTE including LOV establishment and consideration in full-scale fatigue testing.

(1) Thermal induced load between metallic and composite structural elements due to the difference in the coefficient of thermal expansion must be considered in the damage tolerance evaluation as well as the static strength assessment. Typical location of the issue may be end fasteners of a hybrid joint. Current guidance material includes this means of compliance; however, updates should more explicitly describe the means of compliance.
(2) Thermal loads, fuel pressure loads, external out-of-plane air pressures and some other particular loading conditions cannot be practically applied in the full scale static and fatigue test articles. Attempts to simulate the self-balancing thermal loads by an increase in mechanical loads is not acceptable since the resulting total loads will not adequately represent internal load distributions. In addition, thermal inertia of any large test articles is such that testing (static and fatigue) with a fluctuating environment cannot be completed in a timely manner. The WG recommends that the applicable guidance material be changed to address the following consideration in terms of necessary testing as an acceptable means of compliance:
    (a) Simulation of certain loading conditions in the full-scale testing is not necessary, if it can be shown impractical and accurately addressed by analysis supported by test evidence.
    (b) For damage tolerance evaluation of metallic structure, certain loads, such as thermal fatigue loads, will use analysis supported by test evidence, typically with lower level test articles (e.g., component, sub-component, and coupons).
    (c) For damage tolerance evaluation of composite structures, it may be sufficient to incorporate certain loads, such as thermal static loads, into lower level testing.
    (d) Thermal induced stress can be estimated by analysis. At a minimum, lower level tests (up to component) must be performed under controlled, non-cyclic temperature conditions to provide information that validates the analysis (e.g., constrained thermal expansion of the assembly). The cyclic temperature field used for the analysis may be validated by flight test measurement.
(3) For demonstration of freedom from WFD, the particular loads, which cannot be applied in the full-scale fatigue test (e.g., thermal effect), can be incorporated in the existing acceptable means of compliance-- that is, a combination of crack growth analysis and a tear down inspection. The working group recommends updates in the guidance material to clarify this.
(4) There is a difference in the fatigue and damage tolerance characteristics between metallic and composite structures. Guidance material should have information regarding necessity of careful assessment for specific issues, for example load enhancement factor, clipping and omission. Based on certification experience, industry standards have evolved in these areas. Based on this, the working group recommends that the FAA add information to enhance existing guidance.

The following two (2) changes are to address the general testing, not directly linked to hybrid structure. The FAA requested the sub-team consider the two topics as a part of discussions for testing.

(5) Artificial damage applied in full-scale fatigue test article may adversely affect WFD evaluation. FAA has issued FAQ (Frequently Asked Question) for this concern as attached below. Guidance material is changed to clarify this special consideration.

    FAA's FAQ on artificial damage:

    Should artificial damage be introduced into the full-scale fatigue test article as part of demonstrating that widespread fatigue damage will not occur within the design

service goal of § 25.571 at amendment 25-96 or LOV of § 25.571 at amendment 25-132? (3/6/2012)

The full scale fatigue test (FSFT) is the basis for establishing the model's LOV and any necessary maintenance actions to address WFD. An accurate representation of the airplane structure is necessary to properly establish and address the widespread fatigue damage (WFD) characteristics of the structure for the fleet. When demonstrating that WFD will not occur within the DSG or LOV, the FAA recommends that artificial damage not be induced into the FSFT article because it will cause the structure to be non-representative of the airplane's type design.

For any artificial damage proposed in the FSFT article, the applicant must define how they will address the induced damage to show that WFD will not occur in the affected structure up to the LOV. Such a demonstration may be difficult and labor intensive. If you induce artificial damage into the FSFT article, you will be required to demonstrate that the damage will not adversely affect the certification FSFT results. This would include accounting for load redistribution from the artificially damaged area to the adjacent undamaged areas.

Any artificial damage induced into the FSFT article may reduce the reliability of the test data because fewer structural areas that are representative of a production airplane are tested in a manner that simulates service. You must determine how this impacts the determination of the inspection start point (ISP) and structural modification point (SMP) for each affected WFD susceptible structural area. For example, assume the airplane's type design has a total of 100 feet of WFD-susceptible structure (e.g., each side of the fuselage has 50 feet of lap joints). If you induce artificial damage into 20 feet of the structure on one side of the fuselage, the FSFT article includes only 80 feet of structure that is representative of the fleet. In order to address this, you may be required to increase the scatter factors for establishing ISP and SMP or conduct separate, additional full-scale fatigue tests of the affected area. Final determination of the applicable scatter factors must also include residual strength testing and/or teardown inspection results of the WFD-susceptible structure tested.

(6) The past AAWG proposed changes on the examples of types of alterations that may require full-scale fatigue testing (Appendix 4 in AC25.571-1D). This Working Group recommends the FAA incorporate the guidance change proposed by the AAWG.

3.4 Aging Mechanisms

This section provides recommendations on rule and regulatory guidance changes to address the aging mechanisms in metallic, composite, and hybrid structure (e.g., assemblies of composite and metal parts). Current 14 CFR § 25.571 rules and guidance have a significant emphasis on WFD and the need to define a LOV for practical maintenance programs currently used to ensure continued operational safety for airframes dominated by metallic structure. As composite airframe applications have become more common for nearly all structures critical to safety of flight, it has become necessary to address their aging mechanisms and possible synergistic effects for hybrid assemblies consisting of both composite and metal parts. Section 3.3 of this report covers many of the technical issues associated with testing hybrid assemblies, which are common in nearly all new applications to transport airplanes. The current section will review composite aging mechanisms, including the past efforts performed in design, manufacturing quality control and other considerations to minimize the potential that composite parts become the critical structures that define a generalized airplane-level LOV. As discussed in Section 3.1, safety risks of many damage threats are reduced through efforts performed in meeting other rules, minimizing the DTE and maintenance needs specifically defined in meeting 14 CFR § 25.571.

The TAMCSWG noted that many composite aging mechanisms experienced in some early applications (e.g., minimum-gage sandwich construction often used for secondary structures) were unacceptable and would not be competitive design selections if applied to structures that are more critical to flight safety. This experience led to current industry practices for material and design detail screening, which effectively controlled the aging to acceptable levels for practical maintenance considerations. Such practice was not obvious to all TAMCSWG members, highlighting a need to update guidance in order to make regulatory expectations more evident. There was also a general recommendation to develop additional industry guidelines and standards for educational purposes (see Section 5.2).

As technology advances and more composite or other advanced design concepts that use emerging technologies become common in future applications, the typical LOV may change to depend on composite or new aging mechanisms. The TAMCSWG recognizes a need to generalize rules and guidance to give industry the freedom to retain a focus on safety, while taking advantage of technical advances. A goal to pursue performance-based rules is consistent with this need.

The WG agrees that current rules set in 14 CFR § 25.571 are metallic centric and that further assessment of the LOV and WFD aspects that are used for metals is needed along with recommendations regarding composite and hybrid structures. Some changes are necessary to the rule and guidance material to be less or non-metallic centric. Any changes need to identify the key sensitive and influencing factors of the aging mechanisms of composite technologies that may affect the strength characteristic and design performance.

The working group reviewed two aspects:

(a) Consider ‘sensitive’ and influencing factors of composites aging mechanisms in the rule and or guidance material.

(b) Address the LOV as part of DTE of composite structure to provide assurance that certification assumptions continue to remain valid.

(a) Aging mechanism influencing factors:

The TAMCSWG performed a review of any indications of aging mechanisms affecting composite technologies. A bibliography survey supported this effort (See Appendix D).

In the existing rules under §§ 25.6xx it is required to evaluate the influencing factors of composite technologies potentially affecting the strength characteristic and design performance. We can summarize the main aspects under:

1. “Environmental conditions” such as humidity (moisture), temperature, UV radiation, abrasion, erosion and chemical environments such as glycol, hydraulic fluid, fuel, cleaning agents are considered. The bibliography survey highlights that the more sensitive parameters affecting composite materials are humidity and temperature (Mathilde Vellas Ph. D bibliography analysis on composite aging phenomenon ref A).

Current §25.603 (Materials), §25.609 (Protection of structure), §25.613 (Materials strength properties and design values) address material suitability and durability regarding environmental considerations and its sensitivity to critical environmental exposures should be evaluated and characterized:

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

- 25.609: Each part of the structure must…

  (a) Be suitably protected against deterioration or loss of strength in service due to any cause, including…

- 25.613(c): The effects of temperature on allowable stresses used for design in an essential component or structure must be considered where thermal effects are significant under normal operating conditions.

2. Manufacturing Processes: Composite material differs from the relatively homogeneous metallic materials used in airframes, and is sensitive to manufacturing processes. Each process establishes procedures and controls to minimize manufacturing defects and a unique relation can result for a given design, selected fiber & resin and established curing parameters, including assembly processes (bonding). As part of §25.605 (fabrication methods), a process specification should be established to ensure reproducible and reliable structure defined as 'sound structure'. Per current industry practice, manufacturing defects are part of the design performance evaluation.

   (a) The methods of fabrication used must produce a consistently sound structure. If a fabrication process (such as gluing, spot welding, or heat treating) requires close control to reach this objective, the process must be performed under an approved process specification

3. Accidental damage: Such as mechanical impact (in production and/or in-service), weathering, lightning strike, fire, etc. are part of the threat evaluation required under DTE of §25.571.

4. Fatigue: As in the case for accidental damage, this is addressed under the DTE at §25.571 evaluation. [1]

The working group concluded that the level of requirement is explicit and covers adequately the influencing factors to characterize the aging mechanism. No modification of existing rules under §25.6XX is required.

[1] Any relationships between accidental damage or other damage threats and repeated load is fundamental to composite structural integrity and damage tolerance because of fatigue resistance and the ability to design within a no-growth space. When metals have studied such relationships in the past, growth was eventually noted but variables affecting the time it takes for dents, scratches, penetrations or other forms of accidental damage to yield live cracks has been generally unpredictable. As a result, the MSG-3 inspections are critical to controlling accidental damage in metal structures.

Details on ‘Material and Fabrication’ development is further presented in the guidance materials under AC20-107B §6 for material sensitive factors and §7 and §8 for structural consideration of accidental damage and other threats.

(b): LOV definition

For LOV a generic definition exists in the current rule in §25.571 (a)(3) that can address the specificity of composite long term durability. Nevertheless, some words (corrosion, cracks) should be adapted to address both material technologies.

The requirement to establish an LOV is identified in §25.571 (b) but can be perceived as restricted as it is identified as a particularity of metallic structure degradation linking the LOV with the WFD.

3.4.1 Rule Changes

The WG recommends the following modifications to §25.571 to be less metallic centric:

- Change the word “corrosion” to “environmental deterioration” to cover composite structure equally well and use “environmental conditions” for loading spectra paragraph.
- Move the requirement for establishing LOV from 25.571(b) to 25.571(a). Retain the WFD evaluation in § 25.571(b), since § 25.571(a) is a general requirement and § 25.571(b) is for evaluation means (i.e., it is acceptable to emphasize the aging phenomena that currently dominates the LOV determination for most existing aircraft designs).

Section 25.571(a)(3) already defines limit of validity as the engineering data that supports the structural maintenance program. This definition provides a generic, high level, performance based requirement. It includes all materials and all types of damage or threat, being consistent with the intent of the rule and with the general nature of § 25.571(a). The link between LOV and WFD is just a particularity of metallic structures under cyclic loading and can continue to appear in § 25.571(b). The WG conclude that no change is necessary and that the rule term defined in § 25.571(a) provides a definition that well addresses composite technologies.

- Change the word for metallic *cracks* to a more generic term, such as *“damage”* for damage growth or damage arrest in § 25.571 (3).

See Appendix C for rule text proposal.

Details for LOV establishment for metallic, composite and hybrid structure should remain described in guidance materials.

3.4.2 Guidance changes

The Working Group focused mainly on AC 20-107B as AC 25.571-1D identifies that composite technologies are addressed in AC 20-107B.

There was considerable discussion regarding the best approach for making recommended changes to AC 20-107B for addressing the ‘aging’ mechanism of composites. The group agreed with the understanding that it is an overall degradation phenomenon addressing all types of damage threats and the potential combined effect of multiple damage threats.

The WG recognized it was important to broaden the understanding of the operating limits of composite structural parts similar to practices applied on metallic technologies. Such as implementing analysis and design concepts controlling environmentally assisted cracking of metallic airframes. See briefing for CMH-17 DTE WG in Oct 2015 ("The Aging Composite Airframe", J.C. Halpin, see proceedings for the 64th CMH-17 Meeting, Wichita, KS, October, 2015).

The WG suggested that 'aging' and its associated definition be included in the guidance material.

Proposed Aging definition:

> ***Response of an aircraft structures material system in service to long-term exposure environments. A fundamental understanding of the physical or chemical phenomena causing changes in the molecular structure of resins and epoxy-based materials to occur (e.g. exposure to extended periods of sub-Tg temperatures).***
>
> ***This can result in mechanical, thermodynamic, and physical properties affected in ways that can compromise the reliability of resin-based engineering components and structures.***

The WG recommends the following changes:

AC 20-107B draft update revised to address this point in §6-d 'environmental considerations' in (3)

> ***The effect of aging on static strength, fatigue, stiffness properties and design values should also be characterized for the material system through testing or analysis supported by test or in-service evidence. Aging may include effects such as UV radiation, erosion and viscoelastic behavior***.

A similar recommendation will emphasize the importance of addressing any 'design configurations' that may be sensitive to aging degradation.

> ***Some further characterization may be required at the design level to address aging mechanisms accounting for any specific structural detail design not established as reliable given previous design experience.***

AC 20-107B addresses in §**7 "Proof of Structure – Static"** the requirement that both aging degradation and non-detectable defects be accounted for in the static strength demonstration. Repeated loading is typically part of the demonstration, supported by adequate test evidence. The overall goal of such efforts is to establish acceptable levels of damage and defects that may remain in the structure for the life of the aircraft. This added effort is fundamental to the "no-growth" approach for structural designs, whose static strength capability accounts for specified levels of such damage threats and environmental exposures that do not degrade the as-designed structural integrity for a defined period of service.

Structure made of Carbon Fiber Reinforcement Polymer (CFRP) material may have undetectable damage (either manufacturing flaws or from in service realistic impacts) per the specified inspection procedures, provided that the design ultimate loads can be sustained. This is the methodology applied by Aerospace Industries supported by a large amount of test data to establish the strength of the structure with 'un-detectable' damage. Thirty to forty years of experience supports the adequacy of these practices, (see references in various Work Shops supported by both FAA and EASA, Chicago 2012 with summary in the Composite Materials

Handbook (CMH) 17 chapter 12), where no strength degradation was demonstrated after fatigue cycling:

- For coupons and details up to 10^6 cycles
- Complemented by sub-components and demonstrator component level tests with Ultimate loads conditions demonstrated after One Service Life factored to cover fatigue scatter

Collected service data established over time on large conventional metallic airframes consolidated the accidental damages threat characterization. The principle used is in four main steps:

1. Damage collection, overall history of a fleet over a period of time, including damage metrics of details (locations, sizes…)

2. Mapping of damage occurrences identifying damage prone areas (repetitive damage occurrences). An example can be found in FAST 48 Airbus Technical Magazine August 2011 by E Morteau, V Faivre, "Damage Tolerant Composite Fuselage Sizing Characterization of Accidental Damage Threat"

3. Design assumption definition, such as impact energy law, impactor size and shape, (examples can be found in CMH 17 rev 3G at §12.9 'realistic impact energy threats to aircraft') and associated design criteria development

4. Assessment of inspection programs according to residual strength accounting for relevant damage threats versus load occurrence avoiding catastrophic failure

The WG recognized that for areas identified with significant impact occurrences, the potential deterioration due to repetitive impacts is well addressed i.e. the higher damage frequency measured the higher damage resistance you need to take into account for sizing.

To address this concern the WG recommends AC 20-107B §7-f 'proof of structure-Static' in (3) be updated based on the following:

When a threat assessment demonstrates the likelihood of repetitive impact damage, the accumulated impacts for those structural areas should be addressed and satisfy Category 1 guidance as stated in paragraph 8.a. This includes consideration of impactor type and geometry, which are to be representative of the defined threat and consider energy levels that satisfy the Category 1 visual (or other selected field inspection procedures) guidance. For example, repetitive impacts can occur in the same location where ground handling operations contact the airplane on a repeatable flight cycle basis and there is a documented known history of impact damage.

<u>In §8 (b) Proof of Structure-Fatigue and Damage Tolerance</u>

Service data collected over time can better define impact surveys and design criteria for subsequent products, as well as establish more rational inspection intervals, maintenance practice and identify locations that may be affected by repetitive impact damage occurrence. In review of such information, it should be realized that the most severe and critical impact damage, which are still possible, may not be part of the service database if it was derived from visible surface damage detection criteria.

<u>In Appendix 2. Definitions, add the following new definition for repetitive impact damage:</u>

> ***Repetitive Impact Damage: Multiple concentrated impact damage in the areas of the structure supported by a documented threat assessment. When using a visual inspection procedure, the impact damage is at the threshold of reliable detection and treated as Barely Visible Impact Damage (BVID) category 1 damage but depending on the impact test protocol used to determine this level in a given structure, some damages may be missed. For example, this can occur due to blunt impact occurring during in-service ground handling incidents, occurring where operations are repeatable on a flight cycle basis.***

The WG recommends that consideration of limit of validity as stated in the Part 25.571 needs coverage in the guidance material. The recommendation is to include "LOV" in the paragraph in AC 20-107B where §8c mentions 'Extension in service life'.

§8c title should be changed to: ***Damage Tolerance, Fatigue Evaluation and Limit of Validity****.*

The recommended change to this paragraph to include LOV is as follows:

> *Generally, it is appropriate for a given structure to establish both an inspection program and demonstrate a service life to cover all detectable and non-detectable damage, respectively, which is anticipated for the intended aircraft usage. Extensions in service life should include evidence from component repeated load testing, fleet leader programs (including NDI and destructive tear-down inspections), and appropriate statistical assessments of accidental damage and environmental service data considerations****. If applicable, the Limit of Validity (LoV) is established for the airframe and initially is based on the susceptibility of the design to wide spread fatigue damage. If present, metallic structure will typically determine the practical Limit of Validity due to sensitivity to operational fatigue loads*****.** **Composite structure is typically fatigue resistant to operational loads even when considering allowable damage states that are detectable through visual means. However, composite structure remains part of the LoV assessment based on the initial engineering data. For certain airframe designs, composites may become the controlling element. Any proposed extension in LoV needs evaluation per** 14 CFR §**25.571 and AC25.571-1E or** 14 CFR §**26.23. Additional maintenance actions may be necessary if the initial structural maintenance program does not preclude in service widespread environmental deterioration.**

The WG discussed the current definition for Limit of Validity found in Appendix 2 Definitions and there were some concerns raised about having different definitions for LOV between metallic and composite technologies as stated today in the related AC. The WG agrees with the reasoning behind the delineation established in the Amendment 25-132 preamble and recognized that care should be taken with future efforts to develop a common definition given the risk of diluting the important aspects highlighted in the past preamble discussion.

Currently a common definition is stated in the general paragraph of the § 25.571 at §a(3) defining the need to establish an LOV. In the DTE of section (b) of the § 25.571, it is requested to consider all potential threats including specific ones, for example WFD for metallic technologies. For composites, all threats and the potential combinations also need consideration. Each AC is dedicated to a given technology:

- AC 25.571-1D is specific to metal and it make sense that the definition pointed out some specificity of metallic technologies, and it should also ensure the link with the wording developed in the FAR 26 (definition of LOV is also included in the § 26.21).

- AC 20.107B is specific to composite; the definition in 25.571 §a(3) is generic and acceptable with an additional point to consider any aging degradation.

To reflect the different damage mechanisms between metallic and composite technologies the WG recommended the following changes to the definition:

24. Limit of Validity of the engineering data that supports the structural maintenance program (LoV): The period of time (in flight cycles, flight hours, or both), up to which test evidence, analysis and, if available, service experience and teardown inspection results of high-time airplanes, support the structural maintenance program.

- **For metallic structures, the demonstration must show that WFD will not occur before the LOV.**

- **For composite structures, the demonstration must show that any known aging mechanism that degrades the structure below residual strength will not occur before the LOV.**

The WG proposes this definition in the guidance materials, AC 25.571-1D, AC 20-107B and AC 120-104.

It was discussed among manufacturers whether a fleet leader program is a current practice and it was concluded that no systematic fleet leader approach is applied. In the earlier introduction of composite technologies on highly loaded parts a few tear downs of fleet leaders, or aircraft retrieved from operations have been performed (refer to survey from Boeing and Airbus). None have identified unexpected degradation, most probably due to the conservative assumptions typically used in design of early composite airframe structures (materials aging degradation, humidity up to saturation, and demonstration of ultimate load with impact damages after 1DSG).

NDI for potential damage occurrence (damage threat analysis with a focus on damage prone areas) can be performed in selected structural areas, consistent with MSG-3 defined inspections. Although not covering all potential composite aging mechanisms, MSG-3 inspections may yield indications of structural changes (e.g., surface deterioration, blistering, evidence of condensation, system deterioration or failure, etc.) and motivate investigations that are more thorough and inspections to understand the root causes of the change.

A concern was raised regarding the applicability of the Limit of validity and §26.21 to include airplanes 75000 pounds and below. The WG agreed with no change recommendations. The following rationale supports the recommendation, in particular the justification for not applying WFD to ATR programs or other aircraft of the same category:

The rationale is:

- *Most in-service events related to Widespread Fatigue Damage are in the pressurized fuselage of jet A/C with relatively large diameter (>12 ft).*

- *This is explained by the large hoop stresses (P x R / t) associated with high differential pressure (high altitude operation in cruise), a relatively high diameter (2R) and small skin thickness (t) in generic fuselage areas going down to 1 or 1.2 mm.*

- *Regional jets and turboprops have thin skin, but they are not much thinner than larger jets. This is mainly because of the minimum gauge required to install countersunk rivets in panel joints. Because the regional jets typically have much smaller fuselage radius than larger transport A/C, with typically similar skin thickness, the expected hoop fatigue stresses are less critical for these category airplanes than the larger transport A/C, and therefore risk of WFD is expected to be less for the regional jets. Turboprop A/C such as the ATR are operated at a lower cruise altitude than jets, keeping the hoop stress at much lower level than jets.*

- *The 2 x DSG full scale fatigue test combined with the tear down inspection provide freedom from non-expected WFD up to DSG.*

- *The safety record doesn't show any in-service occurrence of Multiple Site Damage (MSD) or Multiple Element Damage (MED) over the fleet (<75,000 lb airplanes).*

- *Applying 14 CFR §26.21 to these aircraft categories would not bring any safety benefit for the compliance demonstration effort required.*

ANAC provided the following dissenting position based on the working groups rationale above.

"ANAC has disagreed with the WG regarding the decision not to discuss any change to the Part 26 weight cutoff of 75,000lb. In the preamble to the 14 CFR Part 26 amendment 5, the FAA acknowledged that the existing cutoff excludes thousands of Part 121/129 regional airplanes, which are also at risk of developing WFD as they age, and therefore mentioned that a future reassessment of this cutoff would be necessary. At that time, (National Transportation Safety Bureau (NTSB), EASA, TCCA and Air Line Pilots Association (ALPA) agreed with the FAA. Since then, that fleet has aged, in already some cases above DSG. In-service / Full Scale Fatigue Tests (FSFT) shows fatigue cracking, including MSD. As not required by the rule at the time of certification of these models (pre amdt 25-96), their FSFT evidence may vary significantly in regards to the amount, characteristics and representativeness. As a result, ANAC has understood that none of the WG rationale can be consider as the reassessment of the fleet referred in the preamble to the 14 CFR Part 26 amendment 5 nor the 'One Level of Safety' initiative was addressed".

A further survey was taken amongst the manufactures operating aircraft at 75000 pounds or below to review the dissenting point issued by ANAC on the above rationale. The summary of the OEM survey appears below:

- The rationale proposed was shared and accepted by all the manufacturers of the WG operating A/C in this category. All manufacturers confirmed that the inspections performed have not exhibited any evidence of WFD or MSD on their fleet i.e. Dassault (Falcon), Embraer (ERJ), Gulfstream (GXXX), Bombardier (CRJ) and Textron (Cessna business jet). It is also reported that Business jets have relatively low utilization rates (compared to airliners), on top of some design considerations such as smaller cross sections and minimum gauge skin thickness and as a result are less prone to in-service fatigue issues.

- Compliance to §25.571 is done in the state of the art and there has been no in-service experience or FSFT evidence identifying WFD concerns. Most of the models were fatigue tested in some form, and the results of those tests were incorporated into the damage tolerance based inspection programs for those models that are subject to a damage tolerance rule. Those that are not Damage Tolerance (DT) based have life limits on primary structure that effectively establish an upper limit.

- Business jets predominantly operate under Part 91, with a small number of Part 135 operations. For these fleets, uniform application of the guidance and procedures given in AC 91-82A would meet the safety objective without the compliance exercise of Part 26.

- The "one level of safety" cannot by itself be justification to change a rule as it still exist in the current rules such differences for example on landing gear (§25.721) with requirements tailored to the design of the aircraft ("airplanes that have a passenger seating configuration, excluding pilots seats of 10 seats or more"…

- All OEM operating such airplanes types conclude that:

  - No additional inputs, from fleet survey or from FSFT have exhibited any evidence of WFD that would support expanding the requirements of Part 26 on aircraft below 75000lbs.

  - Priority set at the time of publication of the 'PART26, Aging Airplane program: Widespread Fatigue Damage to tackle first the largest fleet and associated operating service life can be complemented with today's body of knowledge supporting the exclusion of aircraft below 75,000 lbs.

After reviewing the outcome of the addition OEM survey, ANAC maintained their dissenting position and submitted the additional rationale:

- Inspections are generally not reliable to detect MSD/MED and then preclude WFD. *"WFD is difficult, if not impossible, to detect (…) Airplane maintenance programs include inspections that are designed to detect obvious damage and irregularities. WFD, by its nature, is usually hidden, and not readily detectable."* [Preamble to the final rule of amdt. 25-132]

- In addition to the MSD detected on a full-scale fatigue test cited in our last position (proprietary data), there is publicly available data reporting WFD evidence in FSFT of (turboprop) airplane below 75,000lb. *"In addition, to improve the local design of the cargo door, where WFD was found during the test (…)"*.[CAJANI,M. et al. 'ATR Life Extension Project'. 26th ICAF Symposium. Montreal, 2011.].

- For pre amdt. 25-96 models, beside the FSFT evidence (when existing) significant variation in representativeness and duration, extensive teardown and/or residual strength test were uncommon, since there was no compliance need.

- Current 25.571 requires the demonstration of freedom of WFD up to LOV based on FSFT evidence for all transport airplanes, irrespective of airplane weight, size, propulsion system, operational characteristics and capacity ('One Level of Safety initiative'). Considering its intent and similarity, 26.21 should be consistent.

- With all the knowledge, awareness and experience gathered worldwide about WFD since the 80´s, the aviation community has acted proactively, not only reactively, to preclude it. The FMS referred in the AC 91-82A is reactive. *"(...) the FAA developed this guidance to assist an applicant on what actions to take following a catastrophic failure due to fatigue or an in-service finding of fatigue cracking that poses a demonstrated risk"* [AC 91-82A]. Besides, this AC does not address WFD specifically.

3.5 Inspection Thresholds

There is little safety benefit in performing an inspection to detect fatigue cracking earlier than it could reasonably be expected that a detectable defect has developed. There is, however, a cost to performing these inspections. Therefore, industry uses inspection thresholds to relieve this maintenance burden of directed inspections until the initially undetectable damage progresses to a detectable size and if left unattended is assumed to continue to grow to a critical size. Fundamental to this concept of relieving maintenance burden is determining the period of time for the undetectable damage to progress to a detectable size. For situations where propagation is shown to be unlikely, such as with composites, the focus is on the static performance following any accidental damage. Given that accidental damage can occur at any time in the life of an airplane, there is no latency period and the concept of an inspection threshold does not apply.

In developing the working groups recommendation relative to inspection thresholds, the 2003 General Structures Harmonization Working Group (GSHWG) report entitled, ‘‘Damage Tolerance and Fatigue Evaluation of Structures, FAR/Joint Aviation Requirements (JAR) § 25.571” was reviewed by the sub-team. The 2003 recommendation relative to the need for applicants to assume the structure contains an initial flaw of the maximum probable size that could exist as a result of manufacturing or service-induced damage was considered in developing the recommendation. This WG considered product variation, and agreed that the expected variation of production quality can leave undetected defects that may impact the durability of the structure and thus it needs to be considered in the establishment of inspection thresholds regardless of the analytical method used. The WG discussed the subject of “rare” quality escapements outside the typical expected manufacturing and maintenance variation. The WG agreed that managing such exceeding damage by setting “early” inspection thresholds is not practical because these types of damage are more likely discovered before entering or returning to service. An undetectable defect that falls outside of expected manufacturing variation is fortunately rare given today’s mature manufacturing controls. In the rare event such an escape were to occur robust designs such as those with redundant load paths or integral with effective crack retarding features tend to drive latent defects to become obvious damage and detected prior to catastrophic failure.

The WG recommendation described in section 3.5.1 & 3.5.2 allows the applicant to choose the analytical method that best reflects the performance of their structure and thus develop appropriate inspection thresholds. This added freedom does not reduce the level of safety from the current rule nor erode the primary focus that drove the amendment 25-96 change regarding the establishment of thresholds. The goal remains to establish inspection thresholds that ensure damage detection prior to catastrophic failure.

Another specific area of the 2003 report discussed by the WG was the suggested instructions for developing repeat inspection intervals. Recognizing that the intent of the 2003 suggestion was effectively captured in AC 91-82A a recommendation to duplicate the guidance in a future revision of AC 25.571-1D was not only considered redundant but also presents future revision control challenges. However the WG was not opposed to the addition of a reference or link to AC 91-82A to ensure important points such as the process for addressing the condition of the secondary load path in redundant structure are not overlooked. Appropriate content will need identification as the title of AC 91-82A appears to focus mainly on field issues but it is also applicable to type certification activities as well. While the WG agrees on the concepts identified in AC 91-82A, the WG did not discuss any specifics on how industry has applied the guidance for certification of transport category airplanes. The tasking had many complex topics to address. In addition, the WG believed the discussion on development of inspections related to AC 91-82A were beyond the original tasking. The FAA noted that there has been a variety of ways that applicants have complied with the requirements of the rule in establishing scheduled inspections and associated procedures. The WG acknowledges this is an important topic and believes there may be a need for the FAA to provide additional guidance.

In addition to these two specific areas from the 2003 GSHWG report the WG considered the following in developing the recommended changes.

- Damage Threats – fatigue, manufacturing, operational/maintenance, accidental/environmental
- Existing required layers of inspections
- Structure type – inherent robustness
- Detectability – hidden, visible
- Material behavior – metallic (aluminum, steel, Ti) & composite
- Methods: - importance of calibration to reflect performance of production hardware

  - growth of a representative initial flaw acknowledging traditional 0.05" (fracture)

  - damage accumulation (fatigue)
- Potential linkage to 2003 GSHWG efforts which suggested threshold severity linked to the "type" of structure such as single load path (SLP), hidden or detectable

3.5.1 Rule Change

Full agreement was reached at the second face-to-face meeting that a rule change was necessary in order to move toward a material independent performance based requirement building on what was suggested by the 2003 GSHWG effort. The current rule is prescriptive in that only a material (metal) centric fracture mechanics approach must be used to establish inspection thresholds for SLP & hidden multi-load path (MLP) structure. The specific text states, *"Inspection thresholds… must be established based on crack growth analyses",* which removes any flexibility for an applicant to use an alternate means.

It is understood that there is no evidence that either analytical method (fracture mechanics or damage accumulation) used to establish the point at which inspections need to start is inherently more accurate than the other. The following excerpt from the Technical Oversight Group on Aging Aircraft (TOGAA) discussion on the execution of the GSHWG tasking captures both past and current industry position and strengthens this WG recommendation.

> "*The GSHWG, the Transport Airplane Directorate (TAD) & the FAA National Resource Specialist (NRS) for fatigue and fracture agreed that constraining the applicant to one particular analytical method was not necessary."*

With this understanding, the WG agreed to recommend replacing the current rule text with the new example rule text shown below in italics:

Current Rule Text:

Inspection thresholds for the following types of structure must be established based on crack growth analyses and/or tests, assuming the structure contains an initial flaw of the maximum probable size that could exist as a result of manufacturing or service-induced damage:

(i) Single load path structure, and

(ii) Multiple load path “fail-safe” structure and crack arrest “fail-safe” structure, where it cannot be demonstrated that load path failure, partial failure, or crack arrest will be detected and repaired during normal maintenance, inspection, or operation of an airplane prior to failure of the remaining structure.

New Rule Text:

When inspections are required to prevent catastrophic failure, inspection thresholds must be established to ensure that damage in a PSE will be detected before it results in a catastrophic failure. The inspection thresholds must account for the expected range of damage threats to the structure and use methods substantiated by representative tests or in service data.

National Civil Aviation Agency – Brazil (ANAC) raised a concern that with the move toward more performance based / less prescriptive rule there is risk the NAAs may lose the ability to review and accept applicant’s compliance methodologies as is required in Part 27 and 29. The WG felt the recommended rule and guidance changes with specific mention that substantiated methods must be used was sufficient to allow the regulators opportunity to review the necessary substantiation methods.

3.5.2 Guidance Change

Full agreement was reached at the second face-to-face meeting that an update to the current guidance was necessary in order to describe an acceptable means of compliance that aligns with both the material-independent and non-method specific rule recommendations.
The WG identified five specific areas of concern that the sub-team needed to address in the proposed guidance recommendation. Those concerns appear below with the WG resolution following in sequence.

1. Replace the current initial flaw only verbiage in AC 25.571-1D with provisions for use of <u>either</u> a damage accumulation or fracture based method.

2. Improve on the 2003 recommendation of defining thresholds as an arbitrary percentage of Design Service Goal (DSG) with linkage to redundancy and inspectability.

3. Clarification relative to inspection thresholds for both metals and composites exposed to accidental and environmental damage is included in the recommendation, defining the threshold at the first repeat interval.

4. How to address quality escapements vs. the range of “normal production quality”?

5. Ensure continued use of historically accepted assumed initial flaws.

Concern #1 - Replace the current initial flaw only verbiage in AC 25.571-1D with provisions for use of <u>either</u> a damage accumulation or fracture based method.

Remaining consistent with the agreed rule change allowing use of a material neutral and non-method specific approach the guidance recommendation follows accordingly. The recommendation not only provides the flexibility relative to method but also explains the important considerations necessary to allow less experienced applicants to produce reliable and confident thresholds for detecting damage. The proposed guidance does not define specific details of either a crack growth or fatigue method used by an applicant but it specifically mentions the importance of validation and all of the aspects needed in the analysis. Such guidance is critical to ensure the methodology chosen produces results reflective of the many variables involved (such as the applicants manufacturing techniques), as well as providing visibility on all the important variables that must be considered.

The example guidance text appears in Appendix E with the relevant text annotated associated with the concern.

Concern #2 - Improve on the 2003 recommendation of defining thresholds as an arbitrary percentage of DSG with linkage to redundancy and inspectability.

The arbitrarily assigned “thresholds as a percentage of DSG” suggested by the 2003 effort with linkage to redundancy and inspectability was determined difficult to defend given the arbitrarily selected cut-offs. However, the intent behind the added scrutiny on less redundant or hidden structure is a sound approach that warranted consideration. As a result, the TAMCSWG developed an alternate approach of defining reliability & confidence targets that are reflective of structure type, inspectability and material to ensure the necessary added scrutiny. The premise is that less redundant structure needs a higher associated reliability target defining when the inspections are required to begin in comparison to the other extreme for a highly visible failure of a redundant part in a multi-load path system. The following figure 3-1 illustrates the concept.

- SLP (hidden & visible)
- MLP integral (hidden)
- MLP integral (visible)
- MLP built up (hidden)
- MLP built up (visible)

Higher reliability

Lower reliability

Hidden = non-normal visual access such as behind an Auxiliary Power Unit (APU) or requires NDI

Figure 3-1. Illustration Linking Reliability with Structure Type & Inspectability

The challenge with the target reliability approach is selecting targets that align with all the OEMs calibrated analytical methods and internal processes. Given the complexity of aligning each OEMs processes and methods the recommended guidance defines the relevant aspects necessary that an applicant must account for when defining their reliability targets used to establishing thresholds. The aspects to be accounted for include:

- Structure type, robustness (e.g. SLP vs MLP integral vs MLP built up)
- Exposure and susceptibility to damage
- Inspectability (variable and can range from visually apparent to requiring special tools and equipment)
- Material scatter (characteristic capturing the inherent variation in a materials performance)
- Manufacturing process variation

ANAC suggested the WG consider a guidance change that specified the reliability and confidence targets used for establishing thresholds similar to what is done for safe life structure or AC 23-13A. The intent being to assist smaller Type Certificate (TC) and STC applicants. The WG however decided not to prescribe specific target levels for the reasons stated above. The recommendation defines the relevant aspects necessary that all applicants regardless of experience level must account for when establishing their reliability targets.

The example guidance text appears in Appendix E with the relevant text annotated associated with the concern.

Concern #3 - Clarification relative to inspection thresholds for both metals and composites exposed to accidental and environmental damage is included in the recommendation, defining the threshold at the first repeat interval.

It was agreed that the recommendation include the simple clarification that when considering accidental damage the first inspection or the threshold should correspond to a period equal to the repeat inspection interval.

The example guidance text appears in Appendix E with the relevant text annotated associated with the concern.

Concern #4 - How to address quality escapements vs. the range of "normal production quality"?

The WG agreed that for clarification the recommendation must recognize the impact of expected production variation on the establishment of inspection thresholds. Manufacturing process variation was specifically included in the list of important aspects to consider.

As discussed previously, it is not practical to manage rare quality escapements outside the typical expected manufacturing and maintenance variation by setting "early" inspection thresholds. The thresholds established per the recommended reliability approach are linked to the normal expected production quality variation controlled by process and specifications. Egregious quality escapements outside of the process and related specifications that could result in unexpected damage earlier than the above defined thresholds are fortunately rare due to the required quality systems necessary in an approved manufacturing and maintenance facility.

The example guidance text appears in Appendix E with the relevant text annotated associated with the concern.

Concern #5 – Ensure continued use of historically accepted assumed initial flaws.

The recommendation does not eliminate the historic use of initial flaw sizes such as 0.05" that have traditionally been considered to produce conservative results.

There was a strong desire by the NAAs and two operators that the recommended guidance specify a specific default flaw size in the absence of any other data. There were two associated risks identified:

- unintentionally biasing the level of importance toward only one variable alone vs the other important decisions involved in computing realistic threshold estimates
- suggested value may be viewed as 'mandatory' resulting in added burden to applicants intending to justify a more reasonable initial flaw consistent with their build quality

In the end the NAAs felt these risks were low and thus the recommended guidance includes a "default" approach and flaw size in the absence of data. General consensus was eventually reached with the noted areas of risk above.

The WG agreed to remain consistent with the existing published suggestion of using 10 times the size of the manufacturing flaw size established at 90% reliability and 95% confidence assuming log-normal distribution as the recommendation for flaw size. AC 91-82A, Fatigue Management Programs for In-Service Issues references the FAAs Damage Tolerance Analysis (DTA) handbook which states the use of as flaw 10X the typical manufacturing size.

The recommended guidance text includes reference to the AC in order to offer additional background and guidance to applicants on establishment of an initial flaw size. It also includes mention of the 0.05 inch initial flaw in the absence of other data.

The example guidance text appears in Appendix E with the relevant text annotated associated with the concern.

3.6 Bonded or Bolted Repairs

This section addresses changes to guidance that the WG determined to be necessary to address repairs. Repairs to structure must result in the structure being able to continue to meet all applicable certification requirements after repair. When evaluating a repair, the person must consider the damage threats for the repair in a similar way as for the baseline structure of the airplane (such as Sections 3.1 and 3.3, 3.4, and 3.5, and 3.8 of this report). For damage tolerance, CFR §25.571 and 23.573(a)(5)* specifically address limitations to the size of bonded repairs. In addition, in Para 6.c.(3)(a) of AC20-107B shows as an acceptable means of compliance: "For any bonded joint, the failure of which would result in catastrophic loss of the airplane, the limit load capacity must be substantiated by the maximum disbonds of each bonded joint consistent with the capability to withstand the critical limit flight loads." In order to heighten awareness of these certification requirements to the in-service maintenance providers, the FAA and EASA wrote policy memos (PS-AIR-20-130-01 and Certification Memo CM-S-005 respectively).

Repairs often mean any restoration to defects whether found in-service or during manufacturing, which are sometimes referred to by other names such as rework or concession. The TCH have other means of dispositioning and approving repairs (via the Material Review Board (MRB) process), but the same certification requirements and substantiating data apply regardless of the words used to describe the work performed on the article. If the repair design or work performed is outside of the Type Certification basis (such as materials, process, new joints or bond-lines, etc.) then new regulatory approval is required.

Please note that many CFRs and guidance material apply to repairs and alterations (or modification), and the words "repairs and alterations" are often used together. For the sake of reducing duplication in this report, all the recommendations for alterations in Section 3.7 apply to repair, and we have not repeated those recommendations in this section.

As discussed at the start of Section 3, airline and maintenance organizations involved in the ARAC want to promote more sharing of damage tolerance knowledge derived by manufacturers at the time of type certification. Such information will facilitate efficient maintenance practices because users often find that they are handicapped in both the expected maintenance inspection to detect damage and subsequent repair actions without a better understanding of damage tolerance (see Section 5.2).

*NOTE: The part 23 CFRs are obsolete and have been replaced by new more performance-based rules. Meanwhile, the past rules often move to American Society for Testing and Materials (ASTMs) specifications in support of compliance. In this case, ASTM 3115 para 6.1.1 retained CFR 23.573(a)(5). In this report, the CFR references have been used as they more closely relate with existing guidance. AC20-107B, Appendix 1 has a cross-reference between CFR Parts 23, 25, 27 and 29, which needs revision, including new rules and the associated ASTM references.

3.6.1 Rule Change & Rationale

The working group does not recommend a rule change related to the subject of bonded or bolted repairs.

3.6.2 Guidance Change & Rationale

The working group recommends changes to guidance AC 20-107B and AC 25.571-1D. The recommendations for repairs are similar to and overlap with the recommendations made previously in Section 3.1, since the threat of a weak bond applies to repairs as well as original manufacturing. For clarity, we have included the recommendations for repairs in Appendix B.

AC 20-107B:

The working group recommends a brief description on the importance of bond considerations and adding cross references within AC 20-107B Sections 8 for PSE Structural Bonding (Reference Section 3.1.2 Guidance Change and Appendix B.2.2), and adding recommendations for ICA addressing bonded repairs in para 10.

AC 25.571-1D

The working group also recommends adding cross-references on bonding, including a brief description on the importance of bond considerations, within AC 25.571-1D para 5 (see Appendix B.2.1). Rationale for these structural bonding changes is:

i. Structural bonding has unique aspects with regard to damage tolerance in that conventional fatigue and damage tolerance approaches may not be effective in maintaining continued airworthiness. Such challenges include: lack of current reliable Non Destructive Testing (NDT) technology to detect loss in bond strength, and an inability to successfully model this loss in strength or predict growth of weak bonds, and the growth of cracks in metal approaching a bonded section of the structure.

ii. Guidance needs to ensure applicants address bonding concerns, including quality control and structural redundancy.

iii. Bonding issues are not unique to repairs. The challenges related to structural bonding are a concern for all industry (TC, STC efforts as well as repairs outside of the original TC; including when performed in production or in-service).

3.6.3 Related Policy Statement and FAA Order Changes & Rationale

Policy Statement PS-AIR-20-130-01 establishes guidance in setting size limits for bonded repair to critical composite (monolithic and sandwich structures) and metallic structure. Size limits are necessary because inspection techniques are typically not reliable in detecting weak bonds. As a result, applicants must use the smaller of two size limits for bonded repair. The first size limit directly relates to the limit of substantiating data. The second size limit is at a maximum size whereby limit load residual strength can be demonstrated with a complete or partial failure of the bond within the repair or base structure arresting design features. This policy statement restates the same constraints that are first applied to bonded structural design details for type design and manufacturing (see AC 20-107B), and emphasizes the existence of the constraints, and their equal importance and relevance to in-service repairs. The working group recommends the following changes to Policy Statement PS-AIR-20-130-01:

a. Make clear in FAA policy letter PS-AIR-20-130-01 Bonded Repair Size Limit (BRSL) is consistent with existing policy regarding the size of production repairs/reworks/concessions. These same limits apply during manufacturing of the structure, but the definition of repair and the approval methods are tied to certification basis (see AC 20-107B) not repair approval (which the Policy Statement is specifically addressing).

   RATIONALE:
   For consistency across the whole industry and to ensure new applicants adhere to existing standards of compliance with 23.573 and 25.571. Sub-group discussions with various OEM WG members confirmed applicable production repairs/reworks/concessions conform to AC 20-107B expectations for bonded structure redundancy and the FAA policy statement.

b. Expand the list of regulatory and guidance material references to include the following:

   i. ASTM 3115 para 6.1.1 (formerly CFR 23.573(a)(5)). This ASTM requires that “The maximum disbond of bonded joints consistent with the capability to withstand the residual strength loads … must be determined by analysis, tests, or both. Disbonds of each bonded joint greater than this must be prevented by design features.” In the event of bond failure, you may use design features to prevent disbond growth such that less than Ultimate Load, but greater than Limit Load capability is maintained.
   ii. Section 25.571(b). This section requires applicants to show that the extent of damage for residual strength evaluation at any time within the operational life of the airplane must be consistent with the initial detectability and subsequent growth under repeated loads.

   RATIONALE: The two requirements are the root of the limitation described in PS-AIR-20-130-01, which is based on current technology and knowledge of bonded joints. When future technology and knowledge exists to develop inspection techniques that reliably detect bond strength degradation, it may be possible to revise or remove the current limitations.

c. Currently there are many FCS that are not classified by the TCH as PSE. The repair classifications employed by Maintenance, Repair and Overhaul (MRO) organizations vary, with resulting possibility for inconsistency amongst maintenance providers regarding the scrutiny of engineering review and approval. It is the experience of working group members that maintenance providers may not meet the expected intent of major repair. Accordingly, these repairs may not receive proper review associated with major repairs, including Required Inspection Item (RII), Service Difficulty Report (SDR) submission, or review and approval of substantiating data by FAA designee. The working group recommends that TCHs classify all FCS as PSE.

   RATIONALE: Because there are FCS that are not classified by the TCH as PSE , operators have seen repairs/alterations in the past where compliance to 25.571 declared, but since it is not a PSE some MROs/operators may not classify the repair design as requiring approved data. Furthermore, this is consistent with AC 25-571-1D Appendix 5, Definition for FCS, para b, which says: “Fatigue critical structure is a subset of principal structural elements, specifically those elements that are susceptible to fatigue damage.”

d. Harmonize FAA PS-AIR-20-130-01 with EASA Certification Memo CM-S-005: The working group recommends to add to FAA AC20-107B para 6(c)(3)(a) this paragraph (or thoughts based on rationale below), which appears in CM-S-005:

CM para 2.1:

- From CM page 8: “Nonetheless, there have also been long established successes with bonded repairs and extensively bonded baseline structures, including many examples in the CS-22 gliding industry, small CS-23 aircraft industry, and the rotorcraft industry, the latter experience being recognized (in conjunction with some governing conditions) for safe utilization in critical joints, ref.AC29-2C MG8 para. 6.ii.C.3:“

  RATIONALE: In order to prove a satisfactory service history, these product fleets closely monitor bond failures and reliability, and if problems are found, all parts in the fleet are replaced to prevent systemic weak bonds, ensuring weak bonds remain rare.

  These repairs have been performed on CS-22 gliding industry, small CS-23 aircraft industry, and the rotorcraft industry only with the OEMs, who have knowledge of: original design (such as limit loads, residual strength, arrestment features, load paths, failure propagation, etc.), material and process controls (material and process specifications, NDI methods and their pass/fail criteria, manufacturing defects allowable, etc.). Repairs by OEMs also have qualified staff familiar and experienced with the original manufacturing processes and techniques. The design of the repair must not add new bonded joints without considering failure propagation and arrest features in order to meet limit load if failed. Since these repairs are outside the original TC and are a major repair, they would require approved data with regulator.

FAA Order 8100.8D is a comprehensive publication establishing policy and procedures for the selection, appointment, orientation, training, oversight, renewal tracking, and termination of certain representatives of the Administrator, under the cognizance of the Aircraft Certification Service and Flight Standards Service. The working group recommends the following changes to the order, due to the complexity acknowledged in AC 20-107B and relative immaturity (with regard to metallic structure analysis and data availability) and particular challenge with identifying all potential areas of concern for a non-OEM organization addressing changes to composite PSEs/FCS:

Add a requirement for specific experience in dealing with composites/hybrids in Order 8100.8D and for finding compliance to damage tolerance, similar to the requirements for experience/background in fatigue analysis and fracture mechanics.

RATIONALE: It is expected that such delegation specialty will help meet the intent of the objective in AC 20-107B, and may supplement any other recommended changes to this AC with regard to alterations and repairs.

3.7 Large Modifications

This section provides recommendations on rule and regulatory guidance changes to address considerations of fatigue and damage tolerance requirements for large structural alterations/modifications. In addition, there is discussion of Part 26 Subpart E requirements in this section, as this subpart was originally introduced to address concerns with repairs and alterations. Though the scope of recommendations contained in this section extend beyond large modifications, the history of Part 26 Subpart E has led these recommendations to make most sense to the WG to be included in this section.

A brief summary of the proposed changes included in this section:

- Section 3.7.1: Incorporation of 14 CFR § 26, Subpart E requirements into Part § 25, with certain caveats and considerations;
- Section 3.7.2: Change to 14 CFR § 26.47 to require FCAS lists for all STCs issued since 2008;
- Section 3.7.3: Update to definition of FCS in 14 § 26.41;
- Section 3.7.4: Update to existing guidance (AC & FAA Order) to elaborate on what STC applicants should consider when addressing how their STC affects existing ICA with context to larger requirements of 14 CFR § 25.571 beyond ALS;
- Section 3.7.5: New guidance to define essential elements of an ALS document provided to operators to ensure the inspections meet the intent of the DTA;
- Section 3.7.6: New guidance to instruct STC applicants of the need and how to address compatibility of structurally complex STCs.

Details of the proposed changes, alternate options considered and rationale for the proposals as presented are contained in the following sections.

Additional discussion related to harmonization with proposed and associated EASA requirements specific to the recommendations included in this section is included here where it has made sense. Section 3.9 of this report includes further and more general discussion related to harmonization between EASA rules and guidance.

3.7.1 Recommendation to Update Part 25 to include Part 26, Subpart E, Fatigue Critical Structure Lists for Part 121 and 129 Operators

The WG recommends that the FAA revise 14 CFR part 25 to include the requirements of 14 CFR § 26, Subpart E, *Aging Airplane Safety – Damage Tolerance Data for Repairs and Alterations,* to address repairs and alterations that persons install on certain airplanes after the effective date of rule. Sections 25.571 and 25.1529 along with Appendix H of part 25 already require applicants to perform a DTE and establish inspections or other procedures Damage Tolerance Inspections (DTI) of certain repairs and alterations. Persons who repair or alter/modify airplanes are already required to show those repairs or alterations meet the certification basis of the airplane and 121 and 129 operators are required to have a program in place to ensure that this is accomplished. This includes performing a DTE and establishing DTIs. Thus the recommendation, in effect, is for the FAA to revise part 25 to include a requirement for persons to develop a fatigue critical structure (FCS) list for certain airplanes. The requirement would be the same as found in § 26.43(b) and § 26.45(b), except it would apply to any person repairing or altering the airplane. Whereas, after the effective date of the subpart E of part 26, the requirement to publish an FCS list only applies to type certificate holders.

The WG considered both options of leaving the Part 26 requirements as currently written and of adding those requirements to Part 25 and the advantages and disadvantages associated with both approaches. The WG ultimately decided to recommend the option to add Part 26 Subpart E to Part 25. The WG is not recommending the specific changes to Part 25 to accomplish this general recommendation, but the WG considered three separate options and the benefits and challenges associated with each of those options appear in this Section. Though ultimately the WG recommends Part 26 Subpart E requirements be added to Part 25. In the event the FAA decides to leave Part 26 and Part 25 as is with respect to these requirements, then the WG recommends the FAA review and adjust delegation authorization for Part 26 to help certification efficiency.

3.7.1.1 FCS Lists: Recommended change

This WG reached general consensus on recommendation to FAA that the current requirements in 14 CFR § 26, Subpart E, *Aging Airplane Safety – Damage Tolerance Data for Repairs and Alterations* be transferred into 14 CFR § 25, *Airworthiness Standards* as follows. Note, all four business jet OEM WG members expressed a preference to leave the Part 26 Subpart E as is, but did share that they can support incorporation into Part 25 as presented as option 3.b described in following page. As described below and in the following rationale section, if the requirements of Part 26 Subpart E are added to Part 25, then the only principal requirement that would exist for design approval holders (DAH) and applicants would be the creation and publication of fatigue critical structure (FCS) list. Other related requirements of Part 26, Subpart E are not considered to be required in the rules, such as providing repair evaluation guidelines (REG), which is today not required for TC's issued after January, 2008.

1. The list of fatigue critical structure (FCS) should be included as part of the Part 25 requirement. This may be best accomplished by incorporating in either § 25.571 or § 25.1529, Appendix H.
   a. The present requirement for publication of a fatigue critical baseline structure (FCBS) or fatigue critical alteration structure (FCAS) list exists in 14 CFR26.41(b), 26.45(b) and 26.47(b)[2]. These lists are intended to be made available to persons required to comply with § 26.47 (for STC FCAS list), § 121.1109 and § 129.109.
   b. The present applicability for Part 26 Subpart E is defined in § 26.43(a), which is for transport category airplanes which have (i) maximum type certificated passenger seating capacity of 30 or more, or (ii) a maximum payload capacity of 7,500 pounds or more. This applicability limit should be retained in the proposed inclusion of Part 26, Subpart E requirements into Part 25.
   c. As long as 14 CFR § 121.1109 and § 129.109 are retained for operator requirements to have a program in place to address the adverse effects of repairs and alterations, and the DAH have a requirement to provide a FCS list, then there is no need to require DAH repair evaluation guidelines (REG) for future certification projects. This notion is currently met in § 26.43(e).
   d. Additional guidance should be provided that repairs are not considered applicable to the requirement to generate FCS list. That is, DTE for a repair would not result in a new FCS list specific for that repaired structure.
   e. Upon inclusion of Part 26, Subpart E requirements into Part 25, any product certified at that amendment level would be excluded from the compliance requirements of Part 26 Subpart E. In other words, the requirements currently in Part 26, Subpart E would be fulfilled by the Part 25 compliance, and there would be no need to comply with Part 26, Subpart E.

[2] Note, the current language of § 26.47 does not require FCAS list for future STC alterations, only for STCs issued prior to January 11, 2008. This WG recommends that all new STCs also require FCAS list to maintain consistency amongst all types of TC, see Section 3.7.2.

2. If the FAA pursues an approach to incorporate the requirements of Part 26 Subpart E into Part 25 as recommended, then the following rules related to performing DTE for repairs in § 26.43, or repairs/or alterations to § 26.45 or 26.47 can be exempted for A/C certified under the amendment level with this proposed change: § 26.43(c),(d),(e),(f)(4); § 26.45(d),(e)(5); 26.47(c)(d),(e)(5).
3. The WG considered three different options for how the Part 26 Subpart E requirements could merge into Part 25, each of which was found to have both benefits and challenges. The benefits and challenges appear in the following Section 3.7.1.2. The three options considered by this WG were:
    a. Inclusion of FCS list as a part of § 25.571. This would require the TC applicant to provide the FCS list to operators;
    b. Inclusion of FCS list requirement as part of § 25.1529, Appendix H25.3; and
    c. Inclusion of FCS list requirement as part of § 25.1529, Appendix H25.4.

    Of the three separate options considered, majority of OEMs (both large transport and business jet) indicated a preference for option 3.b.

4. If the FAA adopts the approach to incorporate the requirements of Part 26 Subpart E into Part 25 as recommended, the WG recommendations contained in section 3.7.2 and 3.7.3 of this report related to Part 26 amendments (require FCAS lists for future and STCs since 2008 and update the definition of FCS) should also be considered for inclusion into Part 25.

In the event the FAA decides not to pursue the recommendations 1-3 shown above, and instead decides to leave the basic structure of Part 26, Subpart E as is, then the WG recommends the following:

1. FAA pursue changes to Part 26, Subpart E delegation.
    a. Presently FAA limits Part 26 delegation authorization beyond the limits associated with §25.571 delegation.
    b. WG recommends FAA expand delegation authorization of Part 26 Subpart E compliance findings to qualified designees and/or Organization Designation Authorization (ODAs).
    c. However, as a means to ensure proper FAA control of FCS lists, the WG recommends that the FAA may consider developing new delegation policy that requires approval of initial FCS lists for a TC or STC as a retained government authority. Then, subsequent revisions to FCS lists may be delegated as appropriate.

3.7.1.2 FCS Lists: Change rationale and additional discussion

The WG considered the benefits and challenges of the general recommendation to move Part 26, Subpart E requirements for large transport airplanes to Part 25 for airplanes certified in future. The converse benefit and challenges of making no such change and leaving the current Part 26, Subpart E requirements in place as is (with some change proposed in Section 3.7.2).

1. Moving Part 26 Subpart E requirements to Part 25:
    a. Benefit

i. Improves certification efficiency for DAH. As presently required in Part 26, all FCS lists are to be approved by and Aircraft Certification Office (ACO), and this is not a delegated function. Whereas FCS are considered to be a subset of PSE there is no expected safety benefit in requiring this level of oversight beyond the normal FAA delegation process (i.e., Designated Engineering Representative (DER) and Organization Designation Authority (ODA) Unit Member (UM) properly delegated authorities).
ii. Streamlines certification activities through reduction of rules.
iii. Part 26 Subpart E addresses an industry-wide shortcoming for development of DTE for repairs and alterations to ensure the airplane meets the safety objectives set by the certification basis throughout its life, in the presence of repairs or alterations. This rule mandated new DAH actions to provide proper support to 121 and 129 operators for products to address this potential safety gap. Now, as there is awareness of the DAH needs and the operational rules for the operators are in place (in 121.1109 and 129.109), there is no observed safety benefit for this rule to be a standalone requirement. The requirements of Part 26 Subpart E can be embodied in Part 25 without any expectation that the industry would revert to prior practices of insufficient DTE of repairs or alterations.

b. Challenges
i. Moving the Part 26 Subpart E requirements to Part 25 requires additional rule making activities.
ii. FAA may encounter challenges with maintaining Part 26, Subpart E, applicability limits (i.e., payload capacity of 7,500 lb or 30+ passengers) in Part 25 requirements. Note, the WG did consider simply eliminating the current applicability limit contained in Part 26, Subpart E, and making this FCS list a requirement for all TC products. This increase in scope is not recommended by this WG for the following reasons:
1. As stated in Aging Aircraft Safety Final Rule (AASFR) preamble, the applicability of AASFR is limited to Part 121 and 129 operators. The affected airplanes, which operate under Parts 91, 125 or 135 were considered to have much lower risks associated with fatigue damage as Part 121 or 129 operated airplanes. It was therefore decided that the Part 91, 125 and 135 operated airplanes are excluded from the new AASFR requirements.
2. There has been no meaningful change in expected risk in the past 10 years since the preamble notes that Part 91, 125 or 135 operated airplanes now require additional DT focused operational rules.
3. Similarly, there has been no meaningful change in the industry since AASFR preamble notes that there is a decreased risk of fatigue cracking for 121 or 129 operators. Therefore, it is not recommended that there should be any exemption for 121 or 129 operators either.
4. Therefore, the current Part 26 Subpart E applicability requirements should be retained in Part 25 updates, such that current objectives

of Part 26 Subpart E applicability are met, and not expanded to Part 91, 125 or 135 operators.

5. However, if the FAA were to expand the applicability of this rule contrary to this WG recommendation, there would be additional cost to DAH of TC and STCs for airplanes currently exempted from this Part 26 Subpart E rule.

iii. The business jet OEM representatives on this WG have shared the following thoughts regarding challenges of moving Part 26 Subpart E requirements to Part 25: the current requirement is to support large aircraft as defined in 14CFR 26.43(a) and is intended to enable airline operators to comply with 121.1109. Extending that applicability to provide an 'approved' list for smaller jets operated under Parts 91 and 135 would add significant certification costs without a safety or regulatory directive. The tempo and schedule pressures for Part 91 and 135 operations are much less than those operated under Part 121. The business practices are differ from those used by Part 121 airline maintenance departments, and maintenance for many of these aircraft occurs at OEM service facilities. There are current procedures in place for Part 91 and 135 operators supporting major repairs and alterations (see Order 8300.16 for example), and the FCBS list does not necessarily add anything to that process.

2. Leaving Part 26 Subpart E as is for all future certification programs
   a. Benefits
      i. Consistent expectation of certification. This rule has been in effect for over a decade. There is general awareness of the requirements by applicants and ACOs and therefore will not necessarily require any additional training or other policy changes.
   b. Challenges
      i. Similar to previous statement, the current challenge is associated with delegation authority by FAA versus a retained compliance finding. There is no particular safety benefit expected for the FAA retention of delegation authority for the creation of an FCS list.
      ii. However, to address this challenge the WG has made recommendation to FAA to consider expansion of delegation authorization for this part of the rule.

The WG members weighed the above considerations and it was decided to recommend that the Part 26 Subpart E requirements should be moved to Part 25 for future large transport aircraft. The following provides additional rationale associated with the specific recommendations presented in Section 3.7.1:

1. Retention of requirement to provide an FCS list is essential to maintaining the safety objectives of the AASFR as described in preamble to the final rule presented in FR Vol 72, No. 238. It is stated in this preamble:

   With the AASFR, we now have in place the regulatory means to provide for comprehensive implementation of DT methods on all large transport airplanes used by air carriers. To carry out these requirements fully, however, it is necessary to place corresponding requirements on the holders of FAA design

> *approvals for these airplanes. Otherwise, the operators may not be able to obtain the data and documents the need to comply with the AASFR. As the owners of the data for these airplanes, the design approval holders are in the best position to identify the fatigue critical structure and the methods and frequency of necessary inspections.*

This need for DAH support has not changed since the issuance of this AASFR in 2007. Therefore, DAHs are mandated by rule to make FCS lists available. Note, the WG reiterates the position by FAA in AASFR preamble that "make available" does not mean provide at no cost.

This WG is not recommending extending the applicability of current Part 26 Subpart E beyond the present limit of aircraft with more than 30 passengers or with maximum payload capacity of 7,500 lbs or more. The WG agrees with the prior FAA rationale on general applicability to Part 121 and 129 operators stated in the AASFR preamble. The FAA stated that the expected lower utilization of Part 91, 125 or 135 airplanes results in a lower risk of fatigue damage. Therefore, the current applicability of Part 26, Subpart E should apply towards the recommendation to incorporate into Part 25.

Paragraph (c) of §§ 26.45 and 26.47 require accomplishment of DTE of FCAS (except as noted above for future STC). This is an inherent requirement of a DTE for any type design change that affects fatigue critical structure. Therefore, under this proposed change, the requirement of §§ 26.45(c) and 26.47(c) for TC and STC alterations, respectively, will be redundant and add no additional safety benefit, and therefore, these paragraphs should be exempted for TC issued at this proposed rule change.

2. The explicit requirement for DAHs to provide Part 121 and 129 operators with an FCS list that is current contained in Part 26 needs to be retained in any future change. There are both safety and economic reasons for the requirement of a FCS list. The safety reasons are as follows:

    a. There is no current requirement to provide the operators with a complete PSE list and therefore it is a safety concern that future aircraft may not have a complete list. This could lead to repairs and alterations that do not have DTE accomplished.
    b. There are inconsistencies between the completeness of PSE lists from different manufacturers.
    c. Although the FCS list is supposed to be a subset of the complete PSE list, for many aircraft there are items in the FCS list which are not in the PSE list. Those additional Items may be missed when evaluating alterations.
    d. With a smaller FCS list, it is less likely that an affected item would be missed.

    The economic reasons are as follows:

    a. If a DTE was required for every repair that affected a PSE, there would be a large burden on the OEMs to provide this service even though many of the items they reviewed were not fatigue critical.
    b. If a DTE was required for every repair that affected a PSE, there would be a large burden on the operator to track, obtain and incorporate the results of a DTE even though many of the items they reviewed were not fatigue critical.

   c. A smaller list of FCS also reduces the burden on the operator when determining when DTE is required.

3. Paragraphs (c) and (d) of § 26.43, paragraph (d) of § 26.45 and paragraph (d) of § 26.47 all similarly require the development of DTE for repairs accomplished to FCS, either FCBS for § 26.43 or FCAS for § 26.45 or 26.47. The requirement for a DTE of repairs to FCS (or previously identified as PSEs subjected to fatigue damage), has always been an implicit requirement of airplanes certified after amendment 25-45; this is a noted position by FAA in preamble to AASFR. AASFR also required new operational rules that ensure 121 and 129 certified operators update their maintenance programs to include means to address adverse effects of repairs and alterations to FCS. This has been in place for operators since 2010 (reference 14 CFR § 121.1109(c)(2) and § 129.109(b)(2)). As long as this operational requirement is retained, operators will be required to obtain DTE for repairs and alterations to FCS. FAA AC 120-93 provides guidance for operators in their program to accomplish DTE on repairs and alterations to FCS, which includes a timing requirement for completing DTE on future unpublished repairs (two or three stage approval process). The current operating rules for DTE programs also require that changes to operator maintenance programs for DTE of repairs/alterations require approval by the Principal Maintenance Inspector (PMI). Therefore, under current operating rules and existing guidance there is equal safety benefit with proposal of exemption of § 26.43(c),(d); 26.45(d); or 26.47(d) for future certified airplanes which retain a DAH requirement to provide FCS lists to operators.

4. The WG considered three possible locations for inclusion of Part 26, Subpart E requirements.

   a. Inclusion of FCS list into 14 CFR § 25.571
      i. Potential benefits:
         1. Ability of DAH to update FCS list with proper delegated authority from FAA (i.e., through a normal DER or UM properly designated authority) rather than only approvable directly by FAA;
         2. Clear connection between DAH DTE and consideration of effects of continuing airworthiness & operational needs under one regulation (i.e., DAH must consider if structure would be considered to be PSE if repaired or altered).
      ii. Potential challenges:
         1. May be inconsistent with present division of data within a compliance finding. Presently § 25.571 cites § 25.1529 Airworthiness Limitations for all maintenance information or operator provided data from § 25.571. This proposed change would point to § 25.1529 for required maintenance information to prevent catastrophic failure except for a separate list. In other words, the DTE in § 25.571 is currently understood to be the engineering data (for instance, DAH do not generally provide operators with the certification data), while FCS list is operational/maintenance data.
   b. Inclusion of FCS list requirement as part of § 25.1529, Appendix H25.3

i. Potential benefits:
   1. Ability of DAH to update FCS list with proper delegated authority from FAA (i.e., through a normal DER or UM properly designated authority) rather than only approvable directly by FAA;
   2. Helps reinforce the current standard practice where large transport TCH typically provide FCBS lists as part of the structural repair manual (SRM). Operator representatives in this WG prefer the retention of FCS lists in SRM, as the FCS list is, in part, in support of repair evaluations. Keeping the FCS list close to the principal document used for structural repairs is considered to be a prudent location for such information and is considered to be intuitive location;
   3. Harmonization with EASA rules. Proposed EASA Part 26.360 rule regarding future changes (alterations) requires new FCS introduced or created by the change to be identified and listed in the Instructions for Continued Airworthiness.

ii. Potential challenges:
   1. May need to explicitly link FCS list in the Appendix H25.3 to an evaluation per § 25.571 since that does not currently exist. This may depend on how FAA would retain § 26.41 definitions. If the FCS definition is retained then this challenge may be addressed through that definition, which provides the link between FCS list and evaluation per § 25.571.
   2. FAA would not retain approval authority for creation of or changes to FCS lists, which may undermine a separate FAA safety objective or rationale as to why this delegation authority has been limited. Note, current Part 26, Subpart E rules for FCS list require approval directly by FAA ACO.

c. Inclusion of FCS list requirement as part of §25.1529, Appendix H25.4

i. Potential benefits:
   1. Maintains consistency with current language in §25.571(a) such that the FCS list may be considered to be an "other procedure" to ensure that catastrophic failure is avoided; this is a view held by some, but not all WG members. These fatigue critical structure lists are mandated to support operational requirements for 121 or 129 certified carriers and the need for identifying what structure requires DTE when repaired or altered. Paragraph (a)(3) of 25.571 states that "based on evaluations required by this section, inspections <u>or other procedures</u> must be established, as necessary to prevent catastrophic failure, and must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by §25.1529". In addition, the FAA has noted in the preamble to the AASFR "if fatigue cracking occurs in a repaired or altered area, the results can be just as catastrophic as if it had occurred in the baseline structure." Therefore, there is clear direction from the FAA that the expectation is that the airplane

remains protected against catastrophic failure due to repairs and alterations, and the subsequent rules in AASFR require DTE to be accomplished for repairs/alterations to FCS. Therefore, it is essential for operators to know what structure requires DTE when repaired or altered for continued airworthiness. This need falls under the category of an "other procedure" to be provided to operators, and therefore that should appear in the airworthiness limitation section of ICA in 25.1529. Though some may consider the FCS list as just a list of structure, the implication and how the list is used is considered by operators to be integral to the objectives of 14 § 25.571 in protection from catastrophic failure. There is an inconsistency between this interpretation based on discussion in AASFR preamble and the discussion presented below in item 3 of the potential challenges.

2. The mandatory aspect of the ALS portion of the ICA would require the FCS list to be part of the initial certification package. This would result in the FCS list being approved and available to the operator at first embodiment of the STC. There is the possibility that if the FCS list were not part of the ALS, it could be deferred and incorporated in future revisions of the ICA which may not have regulatory oversight and not be available to the operator at first embodiment.
3. Harmonization with EASA rules. Proposed EASA Part 26.360 rule regarding future changes (alterations) requires new FCS introduced or created by the change to be identified and listed in the Instructions for Continued Airworthiness.

ii. Potential challenges:

1. The FAA does not presently delegate changes to Airworthiness Limitations.
2. An airworthiness limitation document is typically used in support of a maintenance program development, and is not normally made available by operators to the organizations supporting repairs. It is recognized by WG members that inclusion of FCS list in an ALS, as it has been conventionally used, is not intuitive.
3. Based on the specific language in §25.1529, Appendix H25.4 and the preamble discussions for §25.571, Amendment 25-54 (Reference Section 3.12.2.2), only those scheduled maintenance tasks related to the results of the DTE are required to be listed in the ALS. The FCS list is not a scheduled maintenance task and therefore would dilute the purpose of the tasks in the ALS which may be part of the reason why the FAA limited the scope of 25.571, Amendment 25-54 and §25.1529, Appendix H25.4.

3.7.2 Recommendation to require FCAS lists for future STCs and STCs issued since 2008 (14 CFR § 26.47)

Applicants for STCs after the effective date of the subject rule do not have to provide a FCAS list under § 26.47(b). The WG believes not requiring future STC applicants to make a list available to operators creates a risk of non-compliance with the AASR (§§ 121.1109 and 129.109) for operators, which could lead to a safety concern. The recommendation contained herein proposes to correct this.

3.7.2.1 14 CFR § 26.47: Recommended change

With regard to 14 CFR § 26.47, the working group recommends the following:

1. Change 14 CFR § 26.47(b) to add a requirement for future STCs to have a FCAS list made available to 121 and 129 operators.
2. Require STC holders to review their STCs issued between January 11, 2008 and the time at which FAA may incorporate this recommendation to provide a clear list of FCAS to 121 and 129 operators for the same purpose as described in AASFR preamble.
    a. Note, to address the FCAS list review for STCs issued between January 11, 2008 and the time at which FAA incorporates proposed change, the FAA should also address § 26.47(e), compliance times. New dates would be required to accommodate STC holders to review existing DT data for their STCs and provide to FAA revised or new documents which contain a clear, distinguishable FCAS list for Part 121 and 129 operators.
3. Additionally, this WG recommends FAA issue a policy statement to communicate this change to reduce additional delay with this codification of change into CFR. This change likely will have minimal impact to STC applicants and there is no compelling reason for STC applicants to avoid providing this to operators in interim period.
4. This recommendation acts along with the recommendations for both ALS ICA in Section 3.7.3 and compatibility for complex STC (CSTC) in Section 3.7.4. It is imperative that the FAA provides clear and consistent guidance to STC holders for defining FCAS and affected FCBS to ensure the industry meets the safety objectives of AASFR.

Cost impact: The Supplemental Type Certificate Holders (STCHs) would already have the engineering analyses needed to develop the FCAS lists completed as part of their prior Part 26.47 and 25.571 compliance findings. Therefore, the additional effort (and cost) for transferring the existing certification engineering data into publication as an FCAS list (i.e., identification of fatigue critical structures affected or added by STC) should be limited and thus associated costs are expected to be negligible.

However, the operator representatives in this WG have experiences with various industry STCHs that reveal that the level of engineering review to determine the extent of “affect” of their STC to the baseline structure may not consistently meet the regulators expectations. It is unknown by WG members if most or all STCHs have determined the extent of “affected” FCS in terms of 14 CFR 26.41 FCS definition context of “if repaired or altered”. While STCHs do consistently provide the required ALS tasks for detail design points of affected FCS (such as: new fastener holes in skin, penetration holes, etc.), it is not well-known by the WG members if all STCHs have complete data currently available to identify the extent of where their STC “affects” any other existing FCS. This has noteworthy effects in cases where that FCS would need to be considered differently for DTEs of repair or alteration (such is the case if that FCS is newly affected by higher local loads or decreased inspectability due to the specific STC). These experiences have, in large part, motivated this WG to propose some of the other guidance recommendations shared in this section (reference sections 3.7.4 – 3.7.6). In that case, there may be additional, yet unknown, costs to the STCH in developing additional engineering data to provide to operators in their identification of what is considered to be “affected” fatigue critical structure, which in turn is new FCAS.

EASA future Ageing Aeroplane Rule CRD Issue 2 to NPA 2013-07 Part 26.360 (a) will require applicants of future changes to identify and provide a list of FCS introduced or created by the change *(alteration)* and list them in the instructions for continued airworthiness. Therefore, DAHs who plan to make their STCs available in both Europe and the US are likely to be required to be required to develop and provide the list. In these situations, there would be no additional cost apportioned to the STC applicant if the FAA adopted the WG recommendation.

3.7.2.2 14 CFR § 26.47: Change rationale and additional discussion

The omission of “and future” creates an inconsistency of data required by STC holder to be developed and provided to operators between alterations issued prior to 2008 and those after 2008. Furthermore, the proposed language change to § 26.47 matches the current language for § 26.45, which should be similar. Requirements for alterations should not be different between TC and STC holders.

The current omission of “and future” in this paragraph allows STC holders to avoid creating a list of FCAS / affected FCBS to be approved by FAA as an explicit requirement, though it is expected that development of such a list is an essential component of developing DT data required by paragraph (c). There is loss of standardization of the DT data by allowing STC holders not to address paragraph (b) for future alterations.

The proposed change to 14 CFR 26.47 should also be accompanied with a change to FAA AC 120-93 to clearly state that STC holders are to provide FCAS list to operators to support their 121.1109 and 129.109 DT programs.

The WG considered the need for STCs issued from January 11, 2008 until the time in which this recommended change be implemented to be reviewed for creation of FCAS list. These STCs should be reviewed and FCAS lists provided to operators to meet the overall safety objective of AASFR. Similar to the basic motivation for AASFR there may presently be a gap in the DTE performed for repairs or other alterations accomplished on unidentified FCAS. One example of such a case is accomplishment of repairs in proximity to a large STC, such as a large external radome. Such a case may change both global loads in the fuselage (through new aerodynamic or inertial loads), or local stresses due to stiffening effects related to strain/displacement compatibility, or diminish the expected detectability in the routine maintenance program by large areas obscured by normal visual inspections. Any of these may result in adverse effect to the DTE performed for repairs or alterations in this vicinity of this large STC. The STC holder has not been explicitly required to determine this and make such information available to the operator. If the STC applicant is not being compelled by rule to make this information available to operators, the safety objective of the AASFR may not be met for these areas affected by the STC (also considered FCAS).

The operator representatives of this WG believe that the FAA should not expect that the AASFR safety objectives will wholly be met by relying on operators alone applying commercial pressure to STC applicants to obtain data that ensures proper DTE is performed. An example of such data is the definition of boundary of where STC is considered to affect the baseline structure. If an operator is unaware to request this information and simply assume the STCH has addressed the adverse effects of all aspects to baseline structure then they may incorrectly believe that there is no adverse effect. Then, the safety objective may not be achieved over the life of the airplane yet the operator/installer may believe they have all necessary operational information they need since they have an FAA approved STC.

EASA has notified industry of a future Ageing Aeroplane Rule. The rule is further discussed in section 3.9 of this report. At time of writing, the rule is in the final stages of the rulemaking process and industry has had the opportunity to comment twice (Comment Response Document (CRD) to Notice of Proposed Amendment (NPA) 2013-07 refers). EASA will require applicants of future changes (alterations) to identify and provide a FCS list. Part 26.360 relates to the fatigue and damage tolerance evaluation of future changes. Paragraph (a) of the rule requires the applicant for a change approval to identify any new FCS introduced or created by the change, and list them in the instructions for continued airworthiness. The recommendation for the FAA to require the FCS list would harmonize with the proposed EASA requirement.

In addition, the EASA rule will require DAHs to review existing changes approved prior to the effective date of the rule. As previously stated, Part 26.360 will address future changes; therefore the DAH for all applicable changes will be required to identify and provide a list of introduced and created FCS. The WG proposes that the FAA also consider STCs issued post January 11, 2008, helping to ensure all STCs are addressed in harmonization with the EASA proposed rules.

3.7.3 Recommendation to update definition of Fatigue Critical Structure

3.7.3.1 FCS Definition: recommended change

Part §26.41 currently defines fatigue critical structure (FCS) as:

> *Fatigue critical structure means airplane structure that is susceptible to fatigue cracking that could contribute to a catastrophic failure, as determined in accordance with §25.571 of this chapter. Fatigue critical structure includes structure, which, if repaired or altered, could be susceptible to fatigue cracking and contribute to a catastrophic failure. Such structure may be part of the baseline structure or part of an alteration.*

This WG proposes the FAA change the above 14 CFR §26.41 definition of fatigue critical structure to reflect the four following aspects:

1. Replace “fatigue cracking” with less metallic centric “damage growth in fatigue environment”;
2. Ensure proper emphasis in the definition is given to meet the objective of current definition in AC 120-93, which states: “FCS refers to the same class of structure that would need to be assessed for compliance with § 25.571(a) at amendment 25-45, or later.”
3. Ensure proper emphasis in the definition, and amongst the various supporting guidance materials, that the FCS is for structure which <u>if repaired or altered</u> can lead to catastrophic failure for the damage threats listed in § 25.571(a);
4. Maintain consistency in FCS definitions between §25.571, AC 25.571-1D Appendix 5, and AC 120-93

The WG also recommend the FAA and EASA harmonize their respective FCS definitions. In addition, both need to ensure the definitions are consistently applied in both the rules and associated guidance material.

3.7.3.2 FCS Definition: Change rationale

The current definition of fatigue critical structure in § 26.41 is metallic focused by only identifying fatigue cracking as a damage threat. This definition may omit composite structure since composites may not be considered susceptible to fatigue cracking, but may have a greater sensitivity to other damage threats, such as accidental damage or manufacturing flaws. Though the FCS definition in AC 120-93 does still identify fatigue cracking as a threat, it also states that the structure is the same class of structure that would need to be assessed for 25.571(a), in which all four damage threats are identified. This more generic term would cover composite PSE subjected to fatigue loading environment, which would be a preferable definition for FCS.

EASA proposed Ageing Aeroplane rule as detailed in CRD to NPA 2013-07 also provides guidance material in AMC20-20. Appendix 3, paragraph 2 'Definitions' defines FCS as,

*'**Fatigue-critical structure (FCS**) is defined as aircraft structure that is susceptible to fatigue cracking, which could contribute to a catastrophic failure. Fatigue critical structure also includes structure which, if repaired or modified, could be susceptible to fatigue cracking and contribute to a catastrophic failure.'*

The recommendation made in section 3.7.3.1 to ensure the definition provided in AC 120-93 aligns with § 26.41 would technically harmonize the guidance material with EASA guidance.

Note that EASA representatives have shared concern with the WG members of the proposed change item 1 above (replacement of term "fatigue cracking" with "damage growth in fatigue environment"). The stated concern is that there is no safety threat to warrant proposed change and the majority of the fleet are already compliant to the existing terminology.

3.7.4 Guidance for STC Impact on Existing Continued Airworthiness

3.7.4.1 Guidance for STC Impact on Existing Continued Airworthiness

The following changes or new guidance are proposed.

AC 21-40A and FAA Order 8100.54A need revision or a new AC created to provide additional detail on what constitutes a proper review of STC impacts to the existing ICA program for a particular product. Several specific elements should be addressed by the STC applicants current[3] ICA review from a 14 CFR §25.571 based perspective. Those elements should include, but not be limited to:

1) Airworthiness Limitations Section (ALS)/Airworthiness Limitations Item (ALI) for fatigue and damage tolerance-based inspections.
2) Maintenance Review Board Report (MRBR) for MSG-3 based inspections for accidental and environmental deterioration.
3) Airplane Maintenance Manual (AMM), Section 05-50 for conditional/unscheduled inspections as the result of accidental damage or operation outside the aircraft load envelope.
4) Corrosion Prevention and Control Program (CPCP) for environmental deterioration.

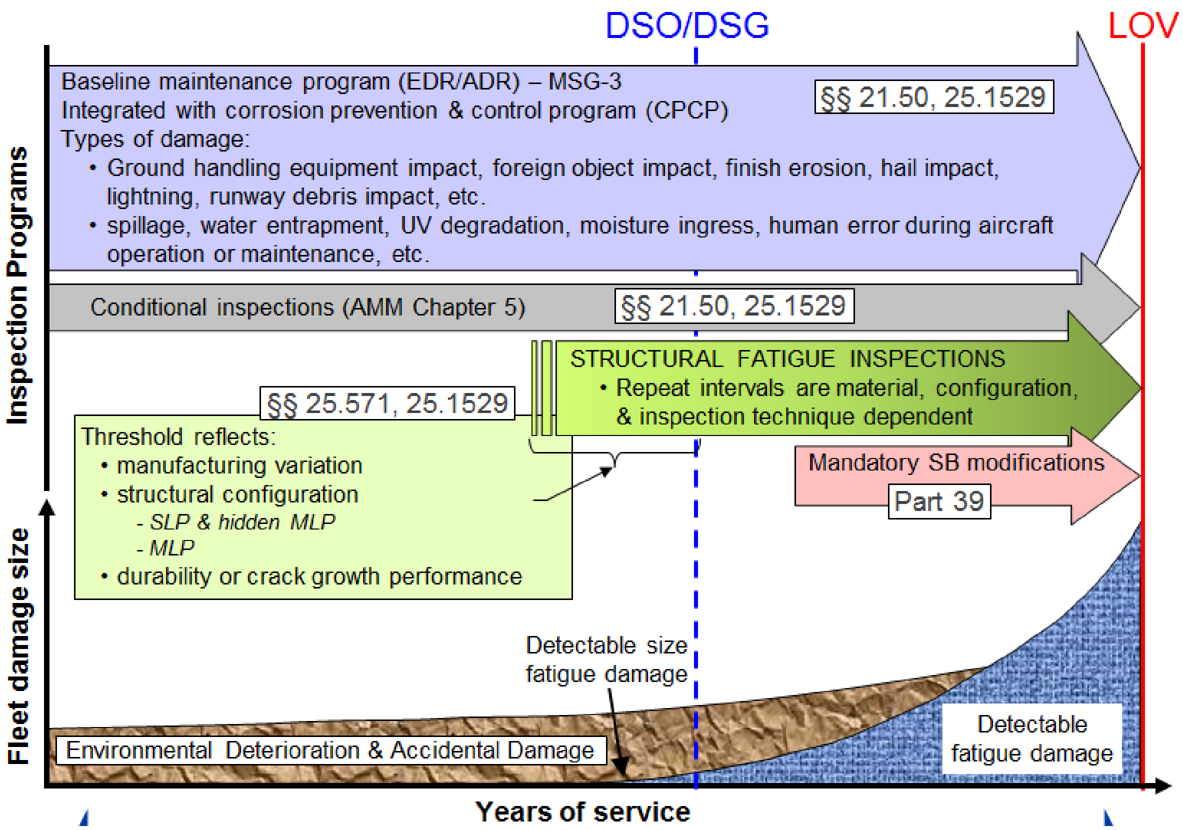
[3] Note, use of the term "current" in this case is to mean the serial number specific ICA program as defined by the installer/operator. Products modified by STC may have existing ICA changes due to prior modifications or repairs (reference AC 20-188 for discussion on compatibility), and so use of term "baseline" rather than "current" may suggest that the STC applicant may not need to consider compatibility with regard to other existing alterations/etc. Or, STC holder must make clear to owner/installer what the "current" configuration and associated ICA must be for the product to be modified by the STC for the STC data to be considered valid.

5) Structural Repair Manual (SRM) for allowable damage (manufacturing flaws, accidental damage and environmental deterioration) and typical repairs.
6) Non-Destructive Testing Manual (NDTM) for applicability of inspection procedures identified in STC ALS requirements.
7) Airworthiness Directives (AD) for known specific damage threats.

The WG considered putting this guidance into AC 25.1529-1A by segmenting it into 3 sections dealing with STC/modification/repair requirements, ALS and ICA. We discounted this as it required a significant change of scope to the existing AC. The WG also reviewed AC 21-40A but partially discounted it due to its applicability to aircraft other than large transport (Title 14, Part 25). We also reviewed FAA order 8100.54A, and recognize that these orders are generally considered internal FAA policy and our focus is primarily on providing guidance that is widely available for applicant access. We recognize that expectations established in guidance available to applicants should also be clear and consistent with internal FAA policy for ACO engineers who may be approving STCs.

3.7.4.2 Rationale for guidance update on STC impact on existing ICA

Per the requirement of 25.571, failure due to fatigue, corrosion, manufacturing defects or accidental damage will be avoided throughout the operational life of the airplane, and inspections or other procedures must be established as necessary to prevent catastrophic failures. All of the TCH representatives participating in this working group have advised the baseline maintenance programs of their airplanes take a multiple layered approach to addressing potential damage threats. The following figure shows a generic graphical representation of this strategy. For example, fatigue-based maintenance requirements generally will begin after some threshold, supported by analysis and testing, that may begin long into the airplane life, where the likelihood of fatigue initiation tends to increase as a function of age. However, the likelihood of accidental damage may be more uniform over the airplane life (though threat of potential interacting accidental damages may increase as function of age), and so regular and frequent visual inspections are expected to mitigate that damage threat. Similarly, conditional inspections for unscheduled events, such as overweight/hard landings, tail strikes, lightning strikes or hail damage, etc are used to ensure specific and unique maintenance programs following certain accidental damage threats ensure continued airworthiness when airplane is returned to service. All of these examples, and other programs like corrosion maintenance programs, specific damage threat ADs, etc, are used to meet the objective of protection of the airplane from catastrophic failure over its operational life.



Accordingly, a STC holder is expected to evaluate the complete current product ICA to ensure the new STC does not undermine or adversely affect any existing maintenance program that serves to satisfy the objective of 25.571. This evaluation is expected to extend beyond the airworthiness limitation section (ALS) to ensure all DT threats and supporting inspection programs receive engineering consideration.

The basis for this recommendation comes from operator experience that there is inconsistency between STC Design Approval Holders (DAH) in the thoroughness of their review of the effect that STCs have on the existing ICA programs. As a result of these experiences, the operators have concern regarding STC holders and their tendency to overlook many of the noted ICA elements, such as conditional/unscheduled inspections, when considering the effect of their STC on the “bigger picture” damage tolerance capability of the product which they are modifying. Additional safety benefits should be ensured when using ICAs on a modified product by providing more information regarding the ICA items (this is not meant to be an all-inclusive list but a minimum list) that must be considered, which include those details, such as conditional/unscheduled inspections, that are often overlooked as part of the ICA program as a whole. This is in alignment with the larger WG and FAA discussed position that the objective of § 25.571 is met through a number of maintenance program elements and not just one crack growth based element in the ALS.

3.7.4.3 Considered rule change for conditional inspections in 14 CFR § 25.1529

The WG reviewed the current Part 25 regulations covering the ICA including § 25.1529 and H25.3(b). The majority of the WG members agreed that conditional inspections are adequately addressed in the wording of H25.3(b)(2) and current industry practice. However, one airline operator WG member did not fully agree, and felt the wording should be revised to specifically mention conditional inspections. This is primarily due to the concern that many STC applicants may not be aware of the requirements to address these unscheduled events (this is discussed further in Appendix GI, section G.8.2.1).

3.7.5 Guidance for Airworthiness Limitation Section Contents

3.7.5.1 Airworthiness Limitations Section: Recommended guidance

The following guidance is proposed for inclusion in a new AC to be created for ALS content guidance. It is recommended AC 25-1529-1 or a new AC be created or revised to include this new content detailed below together with all other ALS content guidance. This new AC is being proposed because the working group considers it important (see rationale) to provide guidance for ALS content and to have it all located in the same AC.

The following proposed content should be included in this revised AC.

Damage Tolerance Inspections (DTIs) should be comprised of but not be limited to the following items that may result from a DTE: (See Appendix F for detailed definition of each included item)

- For repairs and alterations, a statement indicating if the required ALS for inspections based on these present evaluation supersede or supplement any existing ALI, Supplemental Structural Inspection Document (SSID) or AD driven inspections. This statement should list the specific affected inspections. As required, Alternative Means of Compliance (AMOC) statements are allowed. If the DTE concludes that the repair or alteration does not affect any existing inspections, the DTI documentation should include a statement that the repair or alteration does not affect any existing inspections.
- When a Widespread Fatigue Damage (WFD) evaluation of an STC is required due to the aircraft type certification basis *(Advisory Circular 25.571-1D, Appendix 4 refers)* or under §21.101, it should be stated that the STC will be free from the presence of WFD up to the aircraft published Limit of Validity (LOV).
- Access requirements.
- An Inspection threshold and interval in cycles, flight hours or calendar time. This period should indicate if it is applicable to an aircraft or for a specific removable structural component. If more than one type of threshold and/or interval is indicated, then there should be statements as to whether it occurs earlier or later. It should also specify when the threshold occurs.
- A time limit when the repair or modification needs to be replaced (if necessary).
- An inspection description and illustration that provides the specific Non Destructive Inspection (NDI) method, identifies the parts requiring inspection, indicates the direction and/or surface to be inspected as well as the location of the critical details to be inspected.
- A set of NDI procedures, which were the basis of the probability of detection utilized in the DTI. These statements should specify a revision level and/or if applicable later revisions.
- The required NDI tooling and/or standards, which were the basis of the detectable flaw sizes and probability of detection utilized in the DTI.

- If the DTE concludes that DT-based supplemental structural inspections are not necessary, the DTI documentation and ALS should include a statement that the normal zonal inspection program is sufficient.

3.7.5.2 Airworthiness Limitations Section: Rationale

The preceding proposed guidance change is based on industry feedback related to the quality and content of Fatigue Critical Structure (FCS) identification and the Instructions for Continued Airworthiness (ICA) of Supplemental Type Certificated major modifications. Detailed guidance is required for the preparation of affected FCS documentation and ICAs.

A. Industry has been subject to numerous modifications with no or poor quality illustrations that define the extent of affected FCS. This is a safety and economic issue since it is possible to make errors when determining when structure maybe affected:
   1. By a new Airworthiness Directive (AD)
   2. By accidental damage, corrosion or lightning strike.
   3. By repairs in the affected area
   4. By additional modifications in the affected area.

B. Industry has been subject to numerous modifications with incomplete ICA Airworthiness Limitation Item (ALI) inspections. This is a safety, regulatory and economic issue since it is possible to have errors in the inspection procedures utilized by the operator, which could result in missed critical cracks (possible catastrophic failure) and/or un-necessary inspections. Examples include:

   1. No specific Non Destructive Testing (NDT) inspection type specified resulting in an inspection that is not looking for the correct detectable flaw size.
   2. No specific NDT procedure specified resulting in an inspection that has no probability of detection basis associated with it.
   3. No specific NDT tooling or standards specified (when needed) resulting in an inspection that is not looking for the correct detectable flaw size and has no probability of detection basis associated with it.
   4. No or inaccurate illustrations and/or descriptions of where to inspect resulting in inspection fatigue and inspection from the wrong side of the part.
   5. No specific inspection details with a requirement to inspect the entire surface of a part or every detail resulting in inspection fatigue.
   6. ICA developed without regard to a SSID program, AD or ALI requirement that existed at the time of development and is affected by the modification.

3.7.6 Guidance for STC Structural Compatibility

3.7.6.1 STC Compatibility: Recommended Changes

The Working Group agrees with the conclusions and recommendations presented by AAWG to FAA TAEIG in 2003 report titled “Recommendations for Regulatory Action to Enhance Continued Airworthiness of Supplemental Type Certificates” which were not previously enacted (https: // www.faa.gov / regulations_policies / rulemaking / committees / documents / media / TAEaaT1-03222001.pdf). The objective of this report was to address effects of multiple complex structural supplemental type certification (STC) modifications installed on transport category airplanes. The recommendations from the AAWG report are repeated here, with an update to item 1 referencing a recent AC issued since the prior AAWG recommendations in 2003:

1. The existing STC Limitations and Conditions template should be revised. The current wording implies that is the installer's responsibility to ensure that the incorporated STC does not introduce any adverse effects on the airplane. It is the recommendation of the AAWG that this responsibility belongs with the Operator/STC holder/Installer. This includes configuration control, STC compatibility with actual airplane, and continued airworthiness in regard to the STC design and application. This will require a new 14 CFR 21 rule with a revision to AC 21-40, new operating rules with an advisory circular (AC), and a change to Order 8110.4b*. Update to prior AAWG recommendation 1: AC 20-188, issued 12/9/2016 since AAWG recommendation, will need update as well.*
2. Require a special identification of complex STCs, where the installation may result in interaction effects with other STCs. The recommendation would require the determination of a complex STC by applicants for new STCs. This will require a new 14 CFR 21 rule, revision to Order 8110.4b and AC 21-40.
3. Establish a set of criteria to consider in evaluating interaction effects amongst complex STCs. This recommendation would require the development of an FAA Order and possibly some advisory material.
4. Require all STC applicants to provide information within the Instructions for Continued Airworthiness of the regions and areas affected by the proposed STC. This will require a new part 21 rule, possible revision to § 25.1529, Appendix H, revision to AC 21-40 and Order 8110.4b.
5. The AAWG further recommends that the FAA conduct a Special Certification Review of those items (listed below) categorically classified as CSTCs to determine any additional maintenance actions required based on interactions not considered when the CSTS was installed:
   a. Hush kits;
   b. Winglets;
   c. Auxiliary Fuel Tanks;
   d. Re-engine;
   e. Weight increases;
   f. PAX cargo conversions;
   g. Reinforced Flight Deck Doors
6. The AAWG recommends that the FAA and Joint Aviation Authorities (JAA) regulations specific to the certification and continued airworthiness of STCs and CSTCs be harmonized to the extent possible.

The Working Group recommends a pragmatic approach to addressing the limitations on the installer/owner/operator with access to certification data for any installed STCs/SB alterations. Although the responsibility of configuration control is considered to be retained by the owner/operator, the DAH of the CSTC/Service Bulletin (SB) alteration must provide to the owner/operator the geometric boundary (See Appendix F) of the affected area of the aircraft by the CSTC as part of the mandated ICA.

The term "affected areas" should be further and clearly defined for DAH and operators/installers with notional definition to include the following elements:

1. A review of the baseline OEM SRM to ascertain whether it still is applicable to the affected area. If it is not, the STC ICA should identify where the SRM can and cannot be applied (e.g, is there a proximity effect?). If it can be applied, the DAH should define whether there are any supplemental requirements introduced with the STC installation (e.g. DTI reduction factors).

2. Increased or redistributed loads due to the presence of the alteration which would appreciably adversely affect the baseline airframe/PSE DTA where NAAs may need to provide definition of the term appreciably;

3. Decreased inspectability relative to the baseline maintenance program

3.7.6.2 STC Compatibility: Rationale for proposed change

From experience of operators participating in this WG, there have been challenges in resolving the overall objective of ensuring compatibility of complex STCs between the DAH, who has responsibility for developing and getting approval of certification data for their STC, and the operator/installer, who has responsibility in identifying complex STCs and/or any other general structural compatibility issues. It is therefore expected that without a particular recommendation in guidance material of how to do this effectively, the objective will not reliably be met. The STC DAH should have knowledge of a STC affected structure boundary (generally expected to be affect to baseline structure, through load increases, reduction of inspectability as common examples). If this information is not shared with operators then upon installation of a future STC the operator/installer may not have full knowledge of whether or not the compatibility of the new STC is impacted by an existing complex STC.

Currently, the regulation places the sole responsibility for airplane configuration and any interaction considerations with the operator/installer (reference AC 20-188 & Limitations & Conditions section of FAA form 8110-2 for the STC). The operator/installer rarely has access to the STC design data required to meet their responsibility. DAHs should be actively encouraged by the regulatory Agencies to provide the STC design data to the operator (if necessary proprietary data arrangements can help facilitate this). The responsibility in this way becomes a partnership/shared responsibility and thus much better suited to address the airworthiness aspirations intended by the current regulation.

3.8 Structural Inspections and the ALS

This section provides recommendations on rule and regulatory guidance changes to address the tasks (inspections or other procedures) that should be included in the Airworthiness Limitations section (ALS) of the Instructions for Continued Airworthiness (ICA). This includes how to address tasks related to accidental and environmental damage. Applicants for TCs typically base these tasks on programs defined by the Airlines for America (formally the Air Transport Association of America, Inc.) Maintenance Steering Group's MSG-3 or other accepted version of the "Operator/Manufacturer Scheduled Maintenance Development." Lastly, this section addresses conditional inspections, such as those related to High Energy Wide-Area Blunt Impact (HEWABI) for composites. This section links with many of the sections within this document, starting with the discussion on damage threat assessment found in Section 3.1. Specifically, this section provides rationale as to why certain inspections or other procedures, such as part replacements, are necessary to be included in the ALS and why it is acceptable not to include others.

3.8.1 Issue

Currently, section 25.571(a) requires applicants to perform an evaluation to show that catastrophic failure due to fatigue, corrosion, manufacturing defects and accidental damage will be avoided throughout the operational life of the airplane. It also requires applicants to establish inspections or other procedures, as necessary, to prevent catastrophic failure, and that these tasks be included in the Airworthiness Limitations section (ALS) of the Instructions for Continued Airworthiness (ICA).

Under the current rule, the damage tolerance assessment requires an evaluation of fatigue damage (FD), accidental damage (AD) and corrosion (environmental damage, ED) to show that each threat is mitigated appropriately. All threats that could contribute to catastrophic failure need consideration. The baseline maintenance program mitigates some threats, while others require focused inspections at defined intervals. That baseline scheduled maintenance program, and specifically the MSG-3 derived Maintenance Review Board Report (MRBR), has been proven to be effective at detecting and repairing accidental and environmental damage as well as cases of unexpected fatigue damage.

Section 25.571 requires that all of these inspections be included in the ALS in some form. Advisory Circular 25.571-1D provides applicants with the option to use the Maintenance Steering Group's MSG-3 or other accepted version of the "Operator/Manufacturer Scheduled Maintenance Development" procedures as a means of compliance for establishing inspections or other procedures for addressing accidental and environmental damage. The AC also states that applicants may reference in the ALS the maintenance documents that contain tasks that address accidental or environmental damage. Historically, those tasks have typically resided in documents other than in the ALS, without specific reference to them within the ALS. In addition, it has been industry practice to revise those documents related to MSG-3 procedures without FAA engineering approval. This is because applicants typically establish those tasks based on the MSG-3 process rather than by performing a DTE.

There are times that engineering data, such as test data, defines a period of time that the maintenance task is valid. This is often the case for addressing accidental damage to composite materials. In those cases, the ALS typically includes any limitation related to the task. In short, industry practice has been to reserve the ALS to inspections or other procedures that relate to fatigue damage or tasks that are supported by engineering data, such as testing. However, there is no guidance addressing this practice for composites in AC 20-107B.

It is the TACMSWG position that mandating routine maintenance tasks, such as MSG-3 derived items, in the ALS is problematic as it removes flexibility, creates a compliance burden, and diminishes the focus of the ALS. This conflict can result in there being two equivalent maintenance actions specified at different intervals: one in the ALS (fixed flight cycle intervals) and one in the MRBR (calendar based). This scenario may result in additional compliance costs and lead to confusion for operators incorporating the maintenance tasks. It may also pose a problem for operators seeking approval of any revision to the tasks. It is not an efficient way to track maintenance tasks.

The WG discussed this issue with FAA legal for assistance in developing an enforceable standard. That review showed that within the current regulations, flexibility could be included in the ALS if the ALS clearly defined the expectations. FAA legal stated that the guidance should clarify what must go into the ALS and provide guidance on the process for changing inspection and other procedures, including the approval of such changes. The current guidance is for all tasks related to the damage tolerance evaluation, even those based on the MSG-3 process, need to be included or referenced in the ALS. The TAMCSWG has determined that this level of control is not necessary and can diminish the safety objective of the ALS by having tasks that are not needed to be in the ALS. Thus, the TAMCSWG recommends that the FAA develop regulatory guidance (i.e., policy and eventual AC changes) to clarify what is required to be in the ALS, what can be controlled outside of the ALS, and when FAA approval is necessary for any adjustments to tasks.

Finally, as part of the tasking to consider current FAA policy, the FAA requested that the WG consider conditional inspections including HEWABI and provide recommendations on policy that requires these inspections to be included in the ALS. Conditional inspections are intended to address certain rare high-load events that are outside of the operating limitations of the aircraft.

The TAMCSWG felt that it was important to realize that the baseline maintenance program was as important to safety as the scheduled inspection tasks mandated by the ALS. In fact, without the baseline maintenance program, many of the assumptions used in deriving scheduled inspection tasks would not be valid (e.g., crack growth from starter flaws much larger than small manufacturing defects). The diagram presented in Section 3.7 helps illustrate this fact. As a result, the current section also proposes general recommendations for such knowledge documented into industry guidelines and international standards for more global awareness of all measures applied for safety from damage tolerance and associated maintenance (see Section 5.2).

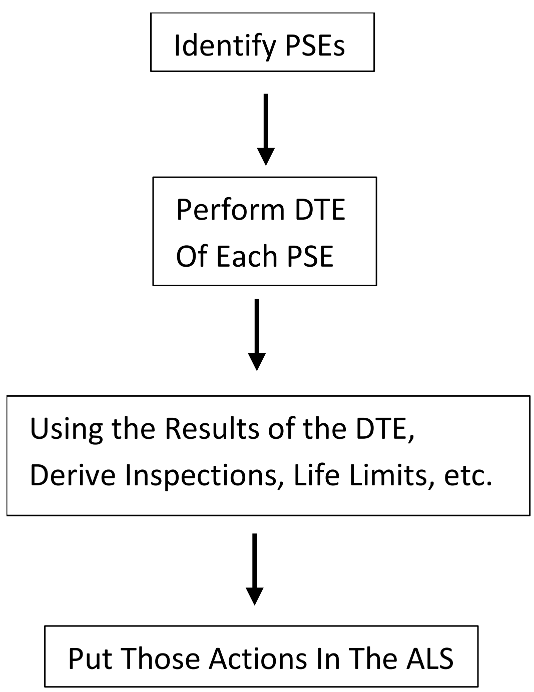
3.8.2 Review of Current Regulations

A review of the regulations and guidance governing type design as well as operator's responsibilities and maintenance programs was conducted to provide the WG with an understanding of the current requirements. The review included the historical regulations and preamble discussions and disposition of public comments. The text of these various rules and discussions is included in Appendix G.

The following outlines the WG understanding of the current regulations related to evaluations and maintenance programs developed to address accidental damage and conditional inspections.

3.8.2.1 Damage Tolerance Evaluations

The fatigue and damage tolerance evaluations are defined in § 25.571(b) and (c). The process flow is shown below. The evaluations are intended to provide a scheduled maintenance program of inspections and limits to detect damage that otherwise could not be found during operation.



The evaluations consider the probable damage scenarios when operated within the design envelope. Typical (normal operating) fatigue loads are used to calculate damage accumulation or progression. The design limit load envelope establishes the upper limit of damage capability for residual strength. There must be an acceptable period of unrepaired use in order to establish a feasible inspection; otherwise, the part must be life-limited. These intervals and limits are established through a rigorous quantitative evaluation (DTE) process and are then listed in the ALS as required by 25.571(a) and H25.4.

Section 25.571(b) requires a determination of the probable damage sizes, modes due to accidental damage and the appropriate evaluation. These accidental damage scenarios are currently defined in guidance documents such ATA MSG-3 document for general structures, and AC 20-107B (Category 2 damage) specifically for composite structures. Each of these guidance documents further defines the means to develop schedule maintenance inspections for the detection of these damage scenarios using the concepts of damage growth and residual strength.

3.8.2.2 Basis for ALS Contents

The Airworthiness Limitations form part of the operating limits as part of the Type Design Data as discussed in 21.31(c). It is a list of those scheduled maintenance tasks and procedures specifically derived by the damage tolerance evaluation. This is specifically stated in Appendix H25.4:

> *(a) The Instructions for Continued Airworthiness must contain a section titled Airworthiness Limitations that is segregated and clearly distinguishable from the rest of the document. This section must set forth—*
>
> *(1) Each mandatory modification time, replacement time, structural inspection interval, and related structural inspection procedure approved under § 25.571.*

The objective of the ALS was outlined in the preamble discussions to Amendment 25-54, the rule change that introduced the ALS concept. The FAA outlined the intention of the ALS in their response to public comments, some of which are highlighted below.

> *For example, the proposed Airworthiness Limitations section on a transport category airplane must contain mandatory inspection intervals and related procedures because the damage-tolerance concept described in Sec. 25.571 is predicated upon the use of such inspections to detect initial cracks in principal structural elements before crack growth under repeated loads could progress to a degree which would cause catastrophic failure of the airplane.*
>
> *The language proposed for the Airworthiness Limitations sections of the appendices to Parts 23, 25, 27, and 29 is being retained, except that the mandatory replacement times, mandatory inspection intervals, and related procedures are specified as those associated with structural integrity-- including those approved under current Sec. XX.571. It also is made clear that FAA approved alternative programs may be used. To avoid unnecessary restriction being placed on operation, only these items are listed in the pertinent Airworthiness Limitations section. Other items can of course be listed in other sections of the Instructions for Continued Airworthiness.*

Many maintenance tasks are critical to safety, but only those scheduled maintenance tasks related to the results of the damage tolerance evaluations are required to be listed in the ALS. It is not feasible or desired to list all safety related maintenance tasks in the ALS, which is why the FAA limited the scope in Amdt. 25-54 and H25.4.

3.8.2.3 Operator Maintenance Programs

There are four typical inspection programs available to operators of large turbine powered aircraft as outlined in 14 CFR 91.409(e) and (f):

1. A Continuous Airworthiness Maintenance Program (CAMP) – Part 121 Airlines and 135 Commuters/Charter
    a. Also Can Include Part 91 Fractional Operations
    b. See AC 121-16G for Details
2. An Approved Aircraft Inspection Program under Part 135.419 – Small Part 135 Commuter/Charter
    a. See AC 135-10B for Details
3. The 'Current' Manufacturer's Recommended Program – Business/Private Jets
4. An Inspection Program Approved By the Administrator – Usually Aircraft Without MSG-3 MRBR
    a. See AC 91-90 for Details

Maintenance of US registered aircraft operated by foreign airlines is covered under 14CFR Part 129.14. The maintenance programs for these aircraft are detailed in AC 129-4A. Programs 1-3 above may be approved; however, a reliability based program is required to use MSG-3 and would apply to foreign air carriers. The maintenance program used must be approved by the FAA.

3.8.2.4 Airworthiness Responsibility

The current regulatory framework places the responsibility of ensuring airworthiness on the operator. This is codified in each of the operational rules (Parts 91, 121 and 135), an example of which is shown below:

§ 135.413 Responsibility for airworthiness

(a) Each certificate holder is primarily responsible for the airworthiness of its aircraft, including airframes, aircraft engines, propellers, rotors, appliances, and parts, and shall have its aircraft maintained under this chapter, and shall have defects repaired between required maintenance under part 43 of this chapter.

When defects or events occur between scheduled inspections, conditional inspections are provided by the OEM to support the operator. This is 'Unscheduled Maintenance' and is discussed in the next section.

3.8.2.5 Unscheduled Maintenance

'Unscheduled Maintenance' is the term used in the operational rules and guidance to describe conditional inspections. Several definitions are provided below:

Reference ATA iSpec 2200

Those maintenance checks and inspections on the aircraft, its systems and units which are dictated by special or unusual conditions which are not related to the time limits … Includes inspections and checks such as hard landing, overweight landing, bird strike, turbulent air, lightning strike, slush ingestion, radioactive contamination, maintenance checks prior to engine-out ferry, etc.

AC 121-16G

You should have a comprehensive process in the unscheduled maintenance portion of your manual that addresses those rare, extremely high-load events that occur to aircraft.

Specifically, you should have inspection processes that you use following certain high-load events.

As detailed earlier, it is the operator's responsibility to address the unexpected event and repair any discrepancies prior to returning the aircraft to service as required by Part 43. The conditional inspection program enables to operator to meet these requirements:

§ 43.15 Additional performance rules for inspections

(a) General. Each person performing an inspection required by part 91, 125, or 135 of this chapter, shall—

(1) Perform the inspection so as to determine whether the aircraft, or portion(s) thereof under inspection, meets all applicable airworthiness requirements; and

(2) If the inspection is one provided for in part 125, 135, or § 91.409(e) of this chapter, perform the inspection in accordance with the instructions and procedures set forth in the inspection program for the aircraft being inspected.

3.8.3 Recommendations to Address Baseline Maintenance Tasks

The WG considered these two options to achieve flexibility of task scheduling within the ALS:

- A rule change that specifies only inspections related to fatigue damage be included in the ALS.
- Leave the rule text as is and revise the guidance for ALS development to include those baseline maintenance tasks without removing the flexibility of those programs.

The first option would remove inspections for AD and ED from the ALS and meet the overall goal of minimizing mandatory baseline inspections. However, there are many instances of fatigue damage that are not readily addressed by the standard DT based threshold and instead rely on baseline maintenance. In addition, the overall intention of the damage tolerance rule is the avoidance of catastrophic failure by developing inspections. Removal of all AD and ED inspections from the ALS may lead to a reduction in safety.

The WG therefore selected the second option in developing this final recommendation with full consensus. This requires guidance changes to distinguish those maintenance actions that are mandatory ALS inspections from those that support the baseline (MSG-3) program. The guidance should provide instructions on the requirements to list or reference certain baseline tasks in the ALS without removing the flexibility of the baseline program. A consistent philosophy should be applied for both metallic and composite structures in ACs 25.571-1D and 20-107B. Reinforce these instructions with policy to ensure the flexibility concept is understood and universally applied.

3.8.3.1 Guidance/Policy Changes for Metallic Structure

AC 25.571-1D already recognizes the effectiveness of the MRBR/MSG-3 program at detecting AD, ED, and details that these inspections be included in the ALS or referenced by the ALS. The guidance should further clarify how to achieve escalation of any of these inspections tasks is to be addressed (see 3.8.3.2.1) and include instructions where baseline tasks are used to address fatigue damage.

The following tables summarize the evaluation and associated maintenance action. Note that single load-path structures often require additional DTE to address locations susceptible to AD and ED where that damage and associated cracking may not be visually detected.

Table 3.8-1. Maintenance Tasks for Multi-Element Metallic Structure

Threat	Evaluation	Maintenance Task
FD	DTE	Special Inspection in the ALS unless DTE indicates baseline task provides acceptable coverage. (1) List baseline task in ALS and appropriate control of escalation.
AD/ED	MSG-3 Qualitative Assessment	Baseline maintenance tasks referenced in the ALS

(1) See inspection threshold discussion, Sect. 3.5, for more information.

Table 3.8-2. Maintenance Tasks for Single Load-Path Metallic Structure

Threat	Evaluation	Maintenance Task
FD	DTE	Special Inspections in the ALS.
AD/ED	DTE and MSG-3 Qualitative Assessment	Special Inspection in the ALS; Baseline maintenance tasks referenced in the ALS.

A baseline task listed or referenced in the ALS is mandatory within any limitations given in the ALS.

For example: ‘Baseline task XXX must be performed and cannot be performed any less frequently than YYY.’

Or: ‘The baseline tasks given in Document XXX must be performed as described in that document.’

Note: Any threshold calculated for AD inspections should correspond to the repeat interval.

3.8.3.2 Guidance/Policy Changes for Composite Structure

For large transport aircraft, AC 20-107B needs revision to specify consideration of the MRBR/MSG-3 derived scheduled inspection programs, including service experience indicating a history of Airworthiness Directives. The damage sizes and inspection intervals used in the engineering evaluations for AD/ED should be consistent with that baseline scheduled inspection program.

The engineering evaluations should use conservative assumptions regarding damage sizes, utilization rates, and inspection intervals and missed inspections. Once the aircraft are in-service, rely on MSG-3 process to evaluate fleet findings/non-findings to optimize inspection intervals. Place limitations on flexibility and escalation of the baseline inspections (see 3.8.3.2.1) when evidence exists, requiring fixed control is required.

AC 20-107B should use the term ‘Scheduled Inspections’ throughout for consistency instead of terms such as ‘directed field’ or ‘normal inspection’. This will align the description with the MSG-3 process.

Category 3 Damage should be ‘obviously detectable’ but is extremely rare and an evaluation of a MSG-3 task is not applicable.

For composite structure maintenance tasks, when the baseline task is listed or referenced in the ALS, it is mandatory within any limitations given in the ALS.

For example: ‘Baseline task XXX must be performed and cannot be performed any less frequently than YYY.’

Or: ‘The baseline tasks given in Document XXX must be performed as described in that document.’

Scheduled baseline AD/ED inspections required to find damage that is “visually detectable and beyond the Accidental Damage Limit (ADL)” are referenced in the ALS. When using “slow” or “arrested” growth as defined in AC20-107B, “special” inspections are usually required in the ALS.

Note: Any threshold calculated for AD inspections should correspond to the repeat interval.

3.8.3.2.1 Escalation (Optimization) of Baseline Scheduled Tasks

There is a formalized process for operators to change or modify inspections and intervals based on their individual experience. Please see the details listed in Section G.5 of Appendix G. Experience has indicated this process results in an efficient maintenance program, and the ALS should limit any restrictions unless that control is necessary.

This is particularly applicable for scenarios involving accidental or environmental damage. The engineering evaluations generally assume some ‘worst case’ damage state exists at the onset of a fixed inspection interval. However, operator experience established through repeated inspections may show that damage state never occurs in their operation. The WG agrees that the operator should not be restricted from escalating their inspection interval following their approved process if supported by such evidence. Therefore, the ALS should list or reference this maintenance task, but a limitation on escalation of the interval is not necessarily required. If allowing escalation, a de-escalation clause can return the inspection interval to that supported by the original engineering assessment. Accidental impact damage is random and not a predicted phenomenon. It can change with the operating environment so allowance must be in place to de-escalate if necessary.

When deciding if control of escalation is necessary, the following elements of the engineering evaluation are considered:

> Conservative assumptions for initial damage: For accidental damage, the expectation is such that the threshold will be equal to the repeat interval. Review service experience and determine if this rare damage state has occurred.

Conservative assumptions for aircraft usage between inspection intervals: Assume high-end utilization when converting calendar based MSG-3 intervals to aircraft flight cycles, or extend test durations to cover expected escalation.

Accounting for missed inspections: The evaluations should characterize damage growth, or 'No Growth', over a period of two inspection intervals (typically considered conservative) or other acceptable probabilistic considerations, supported by engineering or in-service data.

Conservative structural residual strength data showing little to no degradation due to the presence of large damage (i.e., sometimes exhibited by stiffness or stability-driven designs).

If a combination of these conservative aspects appear in the evaluation, then fixed control of a task interval is generally not necessary. The instructions provided or referenced in the ALS should state that the task is required, and guidelines on escalation appear within the procedures given in the MSG-3 document.

However, if the engineering evaluation shows the scope or frequency of the scheduled inspections in the MRBR are not sufficient to ensure timely detection of damage, specific inspection intervals and inspection procedures should then be included in the ALS. In addition, the ALS needs to describe any limits on escalation of an MRBR task and changes beyond those limits must be approved by FAA engineering.

3.8.4 Conditional Inspections

This task is intended to specifically address the handling of inspections following high-energy wide-area impacts (HEWABI) to composite structures, but the conclusions apply to any of the rare high-load events for which conditional inspections are developed (see Section 3.12.2.5). The discussions that follow therefore consider the more general case, and rationale is provided to justify HEWABI being a subset of that case.

In 2016 the FAA published policy (PS-ANM-25-20) concerning the inspections of composite airframes following high-energy wide-area impacts (HEWABI). In that policy, the FAA linked the development of inspection instructions for these events to the accidental damage evaluations required by § 25.571(a)(3) and specified that those instructions be included in the ALS of the ICA. The majority of the industry response to this policy documented in the public comments was negative, arguing that these inspections should instead be linked to the ICA required by § 25.1529. The FAA did not agree and published the policy linking HEWABI to the damage tolerance evaluation and mandating the inspections in the ALS.

The main aspect of the FAA position as summarized in their response to the public comments to the proposed policy is shown below. Key points have been highlighted for this report.

Section 25.571(a) states: "An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, corrosion, manufacturing defects, or accidental damage, will be avoided throughout the operational life of the airplane" (emphasis added). While this policy does not require that Category 5 damage be considered as part of the damage-tolerance evaluation used to establish scheduled inspections or other procedures as required by § 25.571(b), ***applicants are required to consider the potential impact of Category 5 damage per § 25.571(a).***

Section 25.1529 only requires the applicant to issue instructions for continued airworthiness and does not directly address the need to conduct an evaluation of accidental damage.

> *Appendix H25.4, Airworthiness Limitations section (ALS), does require each mandatory structural inspection approved under § 25.571 to be included in the ALS.* ***This policy clarifies that mandatory conditional inspections also need to be included in the ALS.***

This WG was tasked with reviewing that policy and the associated public comments, and providing a recommendation as part of the review of the damage tolerance rule.

Conditional inspections to address rare high-loads events are not covered in the damage tolerance evaluation process. The event loads are outside of the design envelope and result in residual strength below limit load requirements. There is no period of unrepaired use, and the event itself calls into question the airworthiness of the airplane. The inspection is intended to support the return-to-service of the damaged aircraft. The inspection details are derived from a qualitative assessment of typical events.

Furthermore, the ALS is part of type design data to address the fact that normal operation can lead to hidden degradation that would affect the ability of the airframe to resist the required loads. Conditional inspections address events that are outside of those considered for type design.

Finally, listing an unscheduled maintenance task such as HEWABI in the ALS is unexpected by line operations personnel. The ALS is a listing of scheduled maintenance tasks, and the contents are known primarily to the OEM, the ACO and maintenance schedulers. This is not the target audience and ignores line maintenance and Aviation Safety Inspectors. If an unscheduled maintenance task were listed only in the ALS, it is unlikely that operations personnel would ever know about it. Furthermore, in the event the ALS is revised and then mandated via Airworthiness Directive (AD), the notion of managing the common type of conditional inspections as being AD and requiring Part 39-related compliance requirements creates a number of potential regulatory challenges for both operators and Flight Standards Certificate Management personnel responsible for AD enforcement and oversight; see Appendix G.7 for additional discussion. Listing the task in the 'Unscheduled Maintenance' portion of the ICA is the key to addressing the safety issue. This is currently Chapter 05-50-00 using the ATA guidance.

3.8.4.1 Safety Objective of Category 5 Damage Criteria

The safety objectives are specified in AC 20-107B and the WG agrees that these statements appropriately define the issue:

> *… ensure the engineers responsible for composite aircraft structure design and the FAA work with maintenance organizations in* ***making operations personnel aware of possible damage from Category 5 events*** *and the essential need for immediate reporting to responsible maintenance personnel. It is also the responsibility of* ***structural engineers to design-in sufficient damage resistance*** *such that Category 5 events are self-evident to the operations personnel involved.* ***An interface is needed with engineering to properly define a suitable conditional inspection*** *based on available information from the anomalous event.*

The WG also believes these objectives can be met within the current regulatory framework outlined previously:

- Design A Robust Structure: § 25.601
- Define A Suitable Condition Inspection: § 25.1529 and H25.3(b)(2)
- Educate Operations Personnel: Guidance Changes & Policy

As practical, a structural design should provide sufficient external indication of damage following a Category 5 event especially if the structure is in an area that is prone to damage to these types of events. Mitigation should be in the form of design features, crew annunciation, or scheduled inspections to address the problem. Mitigation by placing some conditional inspection in the ALS may be convenient from an engineering perspective, but the preceding arguments show that does not meet the safety objective. Listing an unscheduled maintenance task in the ALS is not expected and therefore may not be known to operations.

The WG reviewed the current Part 25 regulations covering the ICA including § 25.1529 and H25.3(b). The majority of the WG members agreed that conditional inspections are adequately addressed in the wording of H25.3(b)(1) and (2) and current industry practice. Therefore, the majority of the WG members does not recommend changing the rule due to practical issues related to any rule change, and since the industry currently include these inspections in their ICA material.

However, several airline operator WG members, as well as the FAA and other NAA members, did not fully agree, and felt the wording should be revised to specifically mention conditional inspections. This is primarily due to the concern that many STC applicants may not be aware of the requirements to address these unscheduled events. They proposed amending H25.3(b)(1) to specifically include unscheduled maintenance inspections in the rule text. The FAA also believes that such a rule change may be necessary to address the regulatory points raised in their response to public comments to the policy memo PS-SNM-25-20.

In general, the WG is not opposed to this rule change, but most do not believe it to be necessary.

Guidance changes are necessary and are discussed further. Background and recommendations for development of guidance to address unscheduled maintenance inspections for STC applicants are discussed in Appendix G.8.2.1.

The WG conducted a review of the guidance listed for each maintenance program listed in Section 3.8.2.3. That review showed that only Part 121 and 135 adequately addressed 'Unscheduled Maintenance'. Part 129 guidance does not defined unscheduled maintenance, and has only a cursory discussion. Part 91 guidance has no discussion on unscheduled maintenance. Furthermore, none of the guidance materials addressed HEWABI specifically, or composite materials in general. The WG recommends this be corrected and the safety points addressed in policy memo PS-ANM-25-20 be added to each of these documents (which are included in the summary below).

Oversight of the operator's unscheduled maintenance programs is a responsibility of FAA Flight Standards. These personnel are tasked with ensuring operators incorporate the OEM conditional inspections into their individual maintenance programs. For example, Order 8900.1, Vol. 3, Chapter 43 provides instructions for the Aviation Safety Inspector (ASI) to review the operator's unscheduled maintenance program as part of the oversight of an airline's continuous airworthiness maintenance program. The key safety points addressed in policy memo PS-ANM-25-20 should also be added to the appropriate sections of 8900.1 to ensure Flight Standards staff provides the proper oversight.

The primary means to educate operations personnel is through guidance and policy. As discussed above, the WG reviewed these items and recommends the FAA revise them to include the safety points raised in policy memo PS-ANM-25-20:

• AC 121-16G – Air carrier maintenance programs

• AC 135-10B – Charter maintenance programs

• AC 91-90 – Part 91 operators who develop their own maintenance program

• AC 20-77B – Part 91 operators who use the OEM maintenance program

• AC 129-4A – Part 129 (foreign) operators of US registered aircraft

• ATA iSpec 2200 – Basic instructions for OEM maintenance documents

• Order 8900.1 – Flight Standards oversight procedures

In addition, the policy memo should be revised to clarify how ICA developed under § 25.1529 is to be incorporated into the operators' maintenance programs. The policy should clearly state that the unscheduled maintenance programs developed by the OEM are to be included in each operator's inspection program. The 'Inspection Program' as formally defined in the operating rules should include both scheduled and unscheduled maintenance tasks.

3.8.4.2 Summary and Recommendation to Address Conditional Inspections

The WG recommends revision to the HEWABI policy memo PS-ANM-25-20. This policy memo currently requires an evaluation of HEWABI to be in compliance with § 25.571(a). However, requiring compliance to § 25.571 in the context of Category 5 damage is not supported by the instructions given in AC 20-107B. Furthermore, listing a conditional inspection task in the ALS is unexpected and should not be required.

The evaluation and disposition of Category 5 events, and the post-event inspections for Category 4 events, in AC 25-107B should be linked to the requirements for the ICA in § 25.1529 and H25.3. The majority of the WG believes these current regulations already establish the need to develop conditional inspections, but are not opposed to amending H25.3 to specifically include 'unscheduled maintenance inspections' in the ICA. The policy should also provide a clear tie to these OEM derived tasks, typically provided in Chapter 05-50-00 of the maintenance manual, to the operating rules governing inspection programs.

In addition to a revision of the policy memo, the guidance materials covering the various inspection programs used by operators should be revised. Each document should provide a consistent approach directing operators to develop an unscheduled maintenance program to address rare events, and highlight the additional safety aspects related to composite structures in general, and HEWABI in particular.

AC 20-107B should also be revised to define 'conditional inspections' and that term be used to describe the inspections necessary following Category 4 and 5 events.

Finally, the FAA and other Regulatory Agencies should consider providing guidance material to STC holders regarding an evaluation of impact to the baseline unscheduled maintenance program; this is consistent with the recommendation shared in Section 3.8.4. As discussed in Appendix G, Section 8.2.1, a suitable, specific, existing guidance document was not identified. This is a general recommendation, applicable to all conditional inspections as required and valid for all airplanes regardless of the construction (e.g., metallic, composite or hybrid).

3.9 Harmonize EASA Aging Aircraft Rulemaking

The EASA Aging Aircraft Rulemaking (related to Part 26) was not finalized and implemented at the time this report was compiled. It is the recommendation that harmonization of the FAA and EASA rulemaking be pursued in the interest of certification efficiency, and in instances where significant differences exist, that preference be given to the implemented FAA rule. Industry has several years of experience complying with the FAA requirements, which have become the industry standard, and to address significant differences in the two rules will represent a significant burden with no apparent safety benefit.

3.9.1 14 CFR 25.571 Amd. 25-132 and CS-25 Amd. 19

This section presents the differences between the existing FAA and EASA rule. There are some minor differences not presented, such as use of the word aeroplane and airplane, that are considered insignificant.

25.571(a)	FAA regulation states an evaluation must show that catastrophic failure due to fatigue, corrosion, manufacturing defects, or accidental damage will be avoided through the operation life of the airplane, where EASA uses the terms fatigue, manufacturing defects, environmental deterioration or accidental damage. This difference is eliminated through the recommendation of Section 3.1, Threat Assessment.
25.571(a)(3)	FAA requires that threshold inspections must be established based on crack growth analyses and/or tests, assuming the structure contain an initial flaw of the maximum probably size that could exist as a result of manufacturing or service-induced damage. The EASA language in CS 25.571(a)(4) is less metallic/crack growth specific and states, the threshold must be established based on analyses and/or tests, assuming the structure contains an initial flaw representative of a defect or damage of the maximum probable size that could exist as a result of manufacturing processes or manufacturing or service-induced damage. This difference is similar to the concern addressed in the recommendation of Section 3.5, Threshold.
25.571(b)	Similar to 25.571(a), the FAA rule current uses corrosion and EASA used “environmental deterioration”. This difference is eliminated through the recommendation of Section 3.1, Threat Assessment.
25.571(e)	14 CFR 25.571(e) requires consideration of uncontained rotor and fan damage to structure not limited to pressurized compartments. This remains a significant difference based on the AAWG recommendation as found in Section 3.11.
H25.1(c)	CS-25 specifically states that the applicant must consider the effect of ageing structures in the Instruction for Continued Airworthiness Section (See AMC 20-20).

3.9.2 AC 25.571-1D and AMC 25.571

This section presents the differences between FAA guidance as found in AC 25.571-1D and AMC 25.571. The differences listed are those deemed beyond minor and are items considered by the TAMCSWG.

1. Purpose	AMC 25.571 states in the purpose that it is applicable to metallic and non-metallic structure. There is no such statement made in the purpose section, but it does state in 5(1) the focus of this AC is metallic structure.
5. Introduction	In Section 6(a)(1) of AMC 25.571, the guidance specifically addresses the link between AD (accidental damage) and ED (environmental damage) with use of the MSG-3 process. This is

	stated as, “Any special inspection required for AD and ED, i.e. ones in addition to those that would be generated through the use of MSG-3 process for AD and ED, or the baseline CPCP development, and which as necessary to prevent catastrophic failure of the airplane, must be included in the ALS of the ICA required by 25.1529.” This provides clarity on the link between a baseline MSG-3 inspection program and any additional inspection required by the DTE for AD and ED.
6. Damage Tolerance Evaluation	EASA has included a section in AMC 25.571 which mentions probabilistic evaluations though it states, “No guidance is provided in this AMC on probabilistic evaluation.” This is not considered a significant difference. Detailed Design Point (DDP) – AMC 25.571 provides criteria on selection of DDP’s as part of the Damage tolerance guidance. This term is not used in AC 25.571-1D but in general the same guidance is found in 5.g. Identification of location to be evaluated.
7. Establishing an LOV	In general, there is consensus between the FAA and EASA guidance for LOV as contain in AC 25.571-1D and AMC 25.571. One area that needs review is found in 7.f. Repairs. EASA directly addresses significant major changes, STC’s and the relation to LOV in Section 11(e) with the addition of the following statement: (3) for significant major changes and STCs only, establish a new LOV. There is no similar language in AC 25.571-1D.
Appendix 1	Definition presented in Section 4 of the AMC 25.571 generally fall in line with those in Appendix 1 – Some notable difference and exception are as follows: Damage Tolerance – AC 25.571-1D uses the word “corrosion” as a damage threat, where AMC 25.571 uses the less metallic specific word “environmental”. Fatigue Critical Structure – The definition is listed in Appendix 5 of the AC 25.571-1D and references 14 CFR 26.41. The following definitions are included in AMC 25.571 but are not part of AC 25.571-1D: Detail design point (DDP) Normal Maintenance Level 1 corrosion The following definitions are found in AC 25.571-1D but not AMC 25.571: Airworthiness Limitation item (ALI) Airworthiness Limitation Section (ALS) Instructions for Continued Airworthiness (ICA)

None of these differences are considered significant.

3.9.3 14 CFR 26 and EASA Part 26

At the time of this report, the EASA Part 26 Rule was not released. Therefore, the below description is limited to what we believe to be the comparison based on Opinion No 12/2016. Based on the changes highlighted in this opinion, the major difference is that all 14 CFR 25 certified aircraft will need to develop a CPCP including those excluded from 14 CFR Part 26 (i.e., airplanes with payload below 7,500 lbs. or less than 30 passengers). Please note that the FAA rule actually states Maximum Takeoff Weight (MTOW) greater than 75,000 lbs. for CFR 26 applicability.

a) Acceptance of approved data, which satisfied the FAA requirement on ageing aircraft, to comply with Part 26 requirements for ageing aircraft. EASA intends to accept largely the existing data
b) Requirements for damage tolerance inspection (DTIs) and corrosion prevention and control programs (CPCP) for large airplanes below 7,500 lbs. of payload or 30 passengers which is not required by FAA requirements for ageing aircraft. – The rule has been redrafted as to not require the DTI's for airplanes below 7,500 lbs. payload or 30 passengers. However, the development of a CPCP will be retained.
c) No clear provision to exclude certain aircraft from the Part 26 applicability similar to the exemption process used by the FAA for the aging aircraft rule. The rule has been redrafted to allow DAHs to identify if any additional application limit applies to their airplanes, modification or repair based on specific condition defined by EASA (taking into account risk and proportionality).
d) Implementation of a process to ensure the continuing structural integrity program remains valid throughout the life of the aircraft. The details of the rule and guidance material requiring such a process have been extensively modified in response to the comments received. In particular, the elements related to the monitoring of fleet usage at rule level have been deleted.
e) Difference with the FAA regarding the definition of the limit of validity (LOV) of the structural maintenance program In order to avoid potential additional costs for European operators compared to their US competitors, it was decided to fully harmonize the definition of the Limit of Validity with the LOV definition used by the FAA. In addition, the required actions to extend an LOV are harmonized with the FAA as well.
f) Lack of flexibility for operators regarding means to address the adverse effects repairs and modifications may have on fatigue critical aircraft structure. The first rule proposal did not allow the operators to have flexibility regarding the means they could use to address the adverse effects that repairs and modifications existing in their fleet would have on fatigue critical structure. The redrafted proposal allows operators to use other means (i.e. inspections and other procedures) than those promulgated by the DAHs under the ageing aircraft rule.
g) Burden on STC holders to develop DTI for certain STCs. Following the redrafting of the rule, and because of historical reasons related to record keeping before the entry into force of Part 21, some STCs holders will not be required to develop DTI unless operators request the DTI.

3.10 Emerging Material Technology

The working group agreed that no changes were necessary to accommodate emerging material technologies and that any recommended changes by the other focus areas in work would need to be generic enough to accommodate emerging/future technologies. This agreement by the working group remained consistent as captured herein. When addressing an emerging technology, you must consider all damage threats to determine which threats require formal DTE and maintenance procedures. Any remaining threats should have proof that they are not active or best dealt with through practical design and quality control procedures.

No specific rule changes are recommended to address future material technology evolution. Emerging material technologies must continue to meet existing regulatory requirements in that they have approved material and process specifications with statistically based allowables derived from test. A performance based rule does not need to specifically address a "material technology"; however, a new material technology may require additional guidance, e.g. with regards to material-specific acceptable means of compliance. Furthermore, emerging technologies require knowledge transfer at practical levels best documented in industry guidelines or other international standards that promote common practices and an educational basis to minimize traditionally long timelines for engineering acceptance and advanced applications (see Section 5.2).

Additive manufacturing (AM) is a new material technology that is being evaluated and adopted by a broad range of aviation companies and OEMs. An Aerospace Industries Association (AIA) AM working group was established per FAA's request to explore the potential for accommodating changes to rules, guidance and policy, and to support development of guidance and best practices for AM. The initial perspective from the AIA WG is consistent with this ARAC working group's recommendation that no AM-specific rule changes are anticipated. However, AM-specific guidance materials will need to be developed. The FAA AM National Team (AMNT) has developed a draft of the multi-year strategic AM roadmap that includes identification of guidance materials (ACs, policies, orders) that will be developed by the FAA, as well as supporting activities such as training and research and development. This roadmap is currently being reviewed by aircraft certification services (AIR) management, and will be revisited / updated on an annual basis, given the rapidly evolving nature of AM technology.

3.11 Rotorburst Policy

The FAA formally tasked the Aviation Rulemaking Advisory Committee (ARAC); Transport Airplane Metallic and Composite Structures Working Group (TAMCSWG) to provide recommendations on § 25.571 and associated regulatory guidance material. As part of this effort, the TAMCSWG assigned the Airworthiness Assurance Working Group (AAWG) to evaluate § 25.571(e) and associated guidance material (AC 25.571-1D, AC 20-128A and FAA Policy Statement PS-ANM100-1993-0041) as they pertain to uncontained engine failures.

At the meeting held in Melbourne, FL in December of 2016, the ARAC group accepted the AAWG conclusions and recommendations. The AAWG full report is titled, "AAWG Rotorburst Recommendation Document", dated November 1, 2016, and is provided as a separate report.

The AAWG conclusions and recommendations are extracted from the report and shown below for convenience.

Conclusions:

1. The Original Equipment Manufacturers (OEM) essentially use an identical approach in showing compliance to the Part 25 requirements for uncontained engine failure. For compliance to § 25.571(e), OEMs have included structural risk within the airplane level risk assessment.

2. The existing method of compliance for showing compliance to Part 25 uncontained engine failure requirement provides an adequate level of safety and will continue to provide the same level of safety in the future. This conclusion is supported by service experience.

3. The existing engine failure model per AC 20-128A is adequate for structural evaluation and there is no basis for having different requirements for structure. The established method, which includes the existing engine failure model combined with assumptions in the structural evaluation, provides a conservative approach that result in an adequate level of safety for airplane structure.

4. The guidance materials, including the FAA Policy Statement, require clarification with respect to risk assessment requirements. Although the method of compliance used by the AAWG member OEMs has been well established and understood to be consistent with available guidance, it does not agree with the current FAA interpretation of the guidance materials.

Recommendations:

1. Revise AC 25.571-1D to clarify that structural risk is included within the airplane level risk calculations as performed per AC 20-128A. In addition, clarify that the applicant may consider phase of flight aspects and allow for averaging all rotors on all engines of a given airplane when calculating the structural risk component within the airplane-level risk calculation.

2. Revise AC 20-128A to strengthen the definition of structural design considerations and further emphasize that risk from structural damage should be included in the calculation of the airplane level hazard ratios.

3. Keep regulations § 25.571(e) and § 25.903(d) unchanged, recognizing that there will continue to be a lack of harmonization between the various NAA regulations.

While the regulations are not harmonized, the AAWG recommends harmonization with respect to guidance material. The Working Group therefore recommends that the other National Airworthiness Authorities (NAA) revise their guidance material in accordance with the proposed changes to FAA AC 25.571-1D and AC 20-128A.

3.12 Cracking during Full-Scale Fatigue Test

This item relates to whether any actions are necessary to address the continued operational safety of the flying fleet. The information is to enhance the guidance material described in AC 25.571-1D. The guidance material should cover more than MSD or MED because the management of fatigue cracks at single details (normal damage tolerance) relies heavily on inspections, but at some point part replacements may be needed. AC25.571-1D needs revision to more clearly define the management process for these scenarios and be coordinated with other FAA guidance and policy.

Additionally, there are cases where fatigue test and in-service findings are to be reported In Accordance With (IAW) 14CFR21.3. The guidance should include details of that notification.

Recommendations for Guidance (AC 25.571-1D) to address cracking found during a fatigue test that could contribute to catastrophic failure in the fleet:

- Reporting of the fatigue test finding IAW 14 CFR 21.3 is required if there are aircraft in-service and once it is determined that the cracking would not be detected or operation limited by the current ALS or baseline maintenance tasks. Otherwise, the procedure to report fatigue test findings should be coordinated with the FAA during the test planning stage.

- For cracking involving multiple details or over large areas for relatively small cracks (WFD), determine the ISP and SMP as described in AC 25.571-1D, Appendix 3, for WFD susceptible details.
- For cracking scenarios that are not related to WFD, damage tolerance based inspections should be introduced into the ALS to address known cracking based on fatigue test or in-service findings if shown to be reliable. Otherwise, part replacements should be considered and included in the ALS. Information on the determination of intervals and replacement times is summarized in AC 25.571-1D, Appendix 3.
- In addition, for cracks found in single load-path parts, design changes should be implemented to address the unreliability and incorporated in future production airplanes. The design change should be substantiated by fatigue tests or analysis based on the original testing.
- If the inspection program detects cracking in the fleet, a modification or part replacement should be investigated and the guidance in AC91-82A may be used to implement a terminating action.
    - Notification IAW 14 CFR 21.3 is required for all significant in-service inspection findings
    - Most OEMs have a COS process. Notification requirements should be consistent with that process.

4 Cost & Benefit Analysis

Addressing the third element of the tasking, this section provides an estimated cost and benefit associated with the working group recommendations outlined in section 3 and associated appendices.

The Working Group agreed that all of the recommendations made are aligned with current industry practice and thus do not have any appreciable cost associated. However, three of the recommendations associated with the Damage Tolerance Evaluation of bonded structure, establishing inspection thresholds, and the clarifications associated with testing of hybrid structures would result in cost avoidance or a benefit.

The WG agreed the recommendations were all considered clarifications consistent with current industry practice and thus neither added nor removed any expectations. In the case of SDC the recommendation found in Section 3.2 is for follow on work focusing on single load path structure and as a result that new industry activity will have to develop costs and benefits associated when their recommendation for single load path structure is available.

The details of the 3 recommendations that resulted in cost avoidance and benefits are provided below.

4.1 Threat Assessment (Cost Saving)

In Section 3.1 and Appendix B, the WG recommended changes to 25.571 and associated guidance material to clarify the threats that must be considered, including manufacturing defects as part of the DTE for bonded structure, both metallic and composite. These recommendation are consistent with current industry practices and do not require any additional compliance activities. As these changes do not affect airframe design, efficiency, manufacturing, certification complexity or maintenance actions there is no cost impact expected.

Given that the recommended changes are based on current industry practice there are no direct benefits to airplane safety. The benefit of the changes comes in expected savings by eliminating the associated technical discussions between the regulatory authority and the applicant. Currently, OEM's must show compliance to a generic issue paper titled, "Damage Tolerance Requirements for Bonded Joints". The changes recommended would eliminate these issue papers and eliminating the associated technical discussions between the regulatory authority and the applicant.

The following estimated savings are based on the OEMs past volume and level of effort required to close the issue papers which would be eliminated by Section 3.2 recommendations.

- 6,000 labor hours eliminated per OEM (assumes 5 TC at 800hrs each + 5 amended TC projects at 400 hrs each over 10 years), amended TC projects constitute a major design change to structure

4.2 Inspection Threshold (Cost Saving)

With the rule and guidance changes recommended in section 3.5 and Appendix E relative to removing the prescriptive requirement forcing applicants to use one particular analytical method, the WG agreed the added flexibility would not add any cost to certification but for those choosing to use the alternate fatigue approach would see cost savings and potential benefits to safety.

The cost savings or avoidance would come from allowing applicants to leverage the durability of their product as demonstrated by the full-scale fatigue test in deriving inspection thresholds. The current crack growth of an 'initial flaw' requirement in 25.571 requires extensive analysis beyond the evaluation of the full-scale fatigue test. Millions of dollars are spent on the full-scale fatigue tests required by 25.571 Amdt. 25-132, but the ability to use these results to support the determination of inspection thresholds is limited. Detailed crack growth analysis must also be performed and documented in order to support initial type certification at a significant cost. Allowing other methods in addition to the 'initial flaw' requirement would allow applicants to better apply the full-scale fatigue test results and eliminate the labor costs associated with the duplication of work to derive inspection thresholds.

The benefit to safety comes as a result of allowing applicants to use analytical methods that best represent or match the demonstrated performance of their structure. This will best ensure that damage in a PSE will be detected before it results in a catastrophic failure.

The WG was surveyed and results showed the potential cost avoidance for the recommended change outlined in section 3.5 would range from just over $1 million to as much as $2.5 million for an initial type certification for several of the OEMs. For the WG members that choose to continue use of the initial flaw approach there would not be any additional expected certification cost.

4.3 Testing of Hybrid Structure (Cost Saving)

In section 3.3 and Appendix C, the working group recommended changes to § 25.571 and associated guidance material that reflect industry standard practices related to establishing full-scale fatigue test (FSFT) evidence. All of the recommendations found in Section 3.3 are intended to describe current industry standard practices, and these changes will not require additional compliance activities, such as certification testing or analysis reports. As these changes do not affect airframe design, efficiency, manufacturing, certification complexity or maintenance actions there is no cost impact expected.

The current industry standard practices for Hybrid/WFD/Testing consideration are to conduct full-scale fatigue testing to demonstrate freedom from WFD which is done without applying thermal loads in the test. The thermal effects are evaluated by analysis. This Method of Compliance (MOC) is established in Intellectual Property (IP)/Equivalent Level of Safety (ELOS) between regulatory authority and TC applicant. Given the recommended changes are based on this current industry practice there are no direct benefits to airplane safety. The benefit of the changes comes in expected savings by reducing the associated technical discussions between the regulatory authority and the applicant.

The following estimated savings are based on the OEMs past volume and level of effort required to close the issue papers which would be eliminated by Section 3.3 recommendations.

- 6,000 labor hours eliminated per OEM (assumes 5 TC at 800 hrs. each + 5 amended TC projects at 400 hrs. each over 10 years), amended TC projects constitute a major design change to structure

5 Additional Recommendations

5.1 New PSE Definition & Applicability to Large External Modifications

The FAA requested the TAMCSWG working group review a proposed change to the PSE definition that adds mention of systems and aeroelastic stability as well as a proposed policy addressing large external modifications. The proposed new PSE definition appears here with the modified sentence in italics:

> Definition being considered: An element that contributes significantly to the carrying of flight, ground, or pressurization loads, and whose integrity is essential in maintaining the overall structural integrity of the airplane. *PSEs include elements necessary to maintain the stiffness of airplane structure and systems necessary to prevent aeroelastic instability and all structure susceptible to fatigue cracking that could contribute to a catastrophic failure.* Refer to appendix 5 of this AC for clarification on how this relates to the terms, fatigue critical structure (FCS) and WFD-susceptible structure.

The working group reviewed the proposed material and agreed that no change was warranted to the current PSE definition and that collateral impact resulting from parts departing the aircraft is not considered in selecting PSEs.

The OEMs unanimously agreed that no change to the current PSE definition is required since “aeroelastic instability” falls under the category of “catastrophic failure” and systems influence is assessed under § 25.629(d). In addition, paragraph (b) and (e) of § 25.571 specifically require acknowledgement of stiffness change due to damage (either complete or partial failure) as part of the assessment. It was also noted by several OEMs that the current definition is well established and has been extensively applied over decades of certification programs.

The proposed policy statement relative to large external modifications (Policy No: PS-ANM-25-17 “Structural Certification Criteria for Antennas, Radomes, and Other External Modifications”) is included in Appendix H. Feedback from the working group members was collected on whether external modifications such as large radomes should be classified as principal structural elements. It was a common understanding that collateral damage or secondary events have never been considered a criteria for PSE selection, therefore external modifications such as large radomes are not to be classified PSE’s. To codify this common understanding the WG recommends a statement be added in the AC that makes it clear that collateral impact resulting from parts departing the aircraft is not considered in selecting PSEs. The OEMs were also in full agreement that the separation of any large item from the aircraft requires consideration in design and analysis (§ 25.601) to prevent or minimize the occurrence.

5.2 Related Educational Needs

Many discussions derived in addressing the FAA tasking for this ARAC resulted in some frustration by experienced teammates supporting the TAMCSWG. This included, but was not limited to, an understanding of many damage threats, structural bonding design/process protocol, accidental damage simulations, composite/hybrid structural test and analysis methods and the composite design screening practices used to avoid non-durable design details, including specific materials, processes, and sandwich structural joint/close-out features. When reviewing the various inspection procedures applied to ensure damage is detected before reaching critical limits and, hence, avoiding catastrophic failure, it was often realized that numerous current practices were essential and key personnel responsible for airworthiness should not promote the ALS as the most critical means of ensuring awareness. In fact, in some cases even operations personnel that are not familiar with maintenance or damage tolerance must report anomalous ground or flight events to ensure continued airworthiness.

Per safety management principles, the most effective means of ensuring that all parts of the safety system are active in addressing continued airworthiness starts with the sharing of knowledge. This includes a clear understanding of damage tolerance principles for design and structural substantiation of all critical structural details. Equally important is an awareness of the critical damage threats and design, manufacturing or other assumptions used to perform DTE and establish practical maintenance procedures. With the combination of metal and composite parts to create hybrid assemblies for many modern aircraft, it is essential to understand the associated technical issues including interface considerations (e.g., thermal loads) and other unique structural behaviors evident when combining metal and composite parts in the same assembly.

Currently, metallic design components control the LOV for the maintenance program of such structures but new design and engineering or maintenance practices could change that in the future. In all cases, knowledge sharing ensures continued airworthiness for each new application. At the same time, the TAMCSWG was sympathetic to the fact that new designs and the associated supporting technology has certain proprietary rights to protect based on the large investment expended. Nevertheless, the WG recommends special efforts to separate the essential safety knowledge openly shared with organizations maintaining the aircraft in the field from the databases and efficient processes applied for design development and substantiation.

The metal and composite differences discussed by the TAMCSWG started with clear technical differences between damage threats, aging mechanisms and the corresponding engineering assumptions and methods used to address damage tolerance. Those members that understood both metal and composite damage tolerance helped highlight any differences and aided these discussions. It was clear that there was far more public information available for metal damage tolerance assessments than existed for composites, partly due to the evolving and generally proprietary nature of much of the composite and hybrid composite/metal assemblies in applications to date. Again, it appears that some parts of this knowledge most closely associated with safety and related maintenance actions needs educational awareness within the field to ensure continued airworthiness.

As a result, the TAMCSWG felt that a general recommendation for regulatory bodies to work with industry in developing future educational materials that not only addressed composite challenges but also placed some focus on the unique technical issues of hybrid assemblies consisting of both composite and metal parts. It is clear that hybrid assemblies of both composite and metal parts will dominate the future design of transport airplane PSE. There is an obvious need for more practical educational references with the engineering depth needed to support applications and promote academic awareness. ***Note that this provides a basis or starting point for those embarking on their own unique designs without providing the databases and design manuals needed for a specific design (i.e., protecting proprietary rights).*** To date, the regulatory bodies have worked with industry practitioners in standards organizations such as Composite Material Handbook 17 (CMH-17), Society of Automotive Engineers (SAE) and ASTM for that purpose. The continuation of such efforts is encouraged into the future. Once available, future regulatory guidance can reference such information as relevant.

References

FAA Advisory Circular AC 25.571-1D, "Damage Tolerance and Fatigue Evaluation of Structure", dated January 13, 2011
FAA Advisory Circular AC 20-107B, "Composite Aircraft Structure", dated September 8, 2009
General Structures Harmonization Working Group (GSHWG) Report on Damage Tolerance and Fatigue Evaluation of Structures FAR/JAR §25.571, dated July 2, 2003

Appendix A Published Tasking & Current 25.571

Federal Register / Vol. 80, No. 16 / Monday, January 26, 2015 / Notices 4029

top and bottom of the cover page and each succeeding page; and

(3) Must provide a non-confidential summary of the information or advice.

Any comment containing confidential information must be submitted by fax. A non-confidential summary of the confidential information must be submitted to *www.regulations.gov.* The non-confidential summary will be placed in the docket and will be open to public inspection.

Pursuant to section 127(e) of the Uruguay Round Agreements Act (19 U.S.C. 3537(e)), USTR will maintain a docket on this dispute settlement proceeding, docket number USTR–2015–0001, accessible to the public at *www.regulations.gov.*

The public file will include non-confidential comments received by USTR from the public regarding the dispute. If a dispute settlement panel is convened, or in the event of an appeal from such a panel, the following documents will be made available to the public at *www.ustr.gov*: The United States' submissions, any non-confidential submissions received from other participants in the dispute, and any non-confidential summaries of submissions received from other participants in the dispute. In the event that a dispute settlement panel is convened, or in the event of an appeal from such a panel, the report of the panel, and, if applicable, the report of the Appellate Body, will also be available on the Web site of the World Trade Organization, at *www.wto.org.* Comments open to public inspection may be viewed at *www.regulations.gov.*

Juan Millan,

Assistant United States Trade Representative for Monitoring and Enforcement.

[FR Doc. 2015–01332 Filed 1–23–15; 8:45 am]

BILLING CODE 3290–F5–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

[Docket No: FAA–2011–0786]

Deadline for Notification of Intent To Use the Airport Improvement Program (AIP) Primary, Cargo, and Nonprimary Entitlement Funds for Fiscal Year 2015

AGENCY: Federal Aviation Administration, DOT.

ACTION: Notice.

SUMMARY: The Federal Aviation Administration (FAA) announces May 1, 2015, as the deadline for each airport sponsor to notify the FAA whether or not it will use its fiscal year 2015 entitlement funds available under Section 47114 of Title 49, United States Code, to accomplish Airport Improvement Program (AIP)-eligible projects that the sponsor previously identified through the Airports Capital Improvement Plan (ACIP) process during the preceding year.

The sponsor's notification must address all entitlement funds apportioned for fiscal year 2015, as well as any entitlement funds not obligated from prior years. After Thursday, July 2, 2015, the FAA will carry over all remaining entitlement funds, and the funds will not be available again until at least the beginning of fiscal year 2016. This notification requirement does not apply to non-primary airports covered by the block-grant program.

FOR FURTHER INFORMATION CONTACT: Mr. Frank J. San Martin, Manager, Airports Financial Assistance Division, APP–500, on (202) 267–3831.

SUPPLEMENTARY INFORMATION: Title 49 of the United States Code, section 47105(f), provides that the sponsor of each airport to which funds are apportioned shall notify the Secretary by such time and in a form as prescribed by the Secretary, of the sponsor's intent to apply for its apportioned funds, also called entitlement funds. Therefore, the FAA is hereby notifying sponsors about steps required to ensure that the FAA has sufficient time to carryover and convert remaining entitlement funds, due to processes required under federal laws. This notice applies only to those airports that have had entitlement funds apportioned to them, except those nonprimary airports located in designated Block Grant States. Sponsors intending to apply for any of their available entitlement funds, including those unused from prior years, shall submit by 12 p.m. prevailing local time on Friday, May 1, 2015, a written indication to the designated Airports District Office (or Regional Office in regions without Airports District Offices) their intent to submit a grant application no later than close of business Thursday, July 2, 2015, to use their fiscal year 2015 entitlement funds available under Title 49 of the United States Code, section 47114. This notice must address all entitlement funds apportioned for fiscal year 2015 including those entitlement funds not obligated from prior years. By Friday, June 5, 2015, airport sponsors that have not yet submitted a final application to the FAA, should notify the FAA of any issues with meeting the final application deadline of Thursday July 2, 2015. Absent notification from the sponsor by the May 1 deadline and/or subsequent notification by the June 5 deadline of any issues with meeting the application deadline, the FAA will proceed after Thursday, July 2, 2015 to take action to carry over all remaining entitlement funds without further notice. The funds will not be available again until at least the beginning of fiscal year 2016.

This notice is promulgated to expedite and facilitate the grant-making process.

The AIP grant program is operating under the requirements of Public Law 112–91, the "FAA Modernization and Reform Act of 2012," enacted on February 14, 2012, which authorizes the FAA through September 30, 2015 and the "Consolidated and Further Continuing Appropriations Act, 2015" which appropriates FY 2015 funds for the AIP.

Issued in Washington, DC, on January 20, 2015.

Elliott Black,

Director, Office of Airport Planning and Programming.

[FR Doc. 2015–01318 Filed 1–23–15; 8:45 am]

BILLING CODE 4910–13–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee—New Task

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of new task assignment for the Aviation Rulemaking Advisory Committee (ARAC).

SUMMARY: The FAA assigned the Aviation Rulemaking Advisory Committee (ARAC) a new task to provide recommendations regarding revision of the damage-tolerance and fatigue requirements of Title 14, Code of Federal Regulations (14 CFR), part 25, including subparts C and E of 14 CFR part 26, and development of associated advisory material for metallic, composite, and hybrid structures. Past changes to the damage-tolerance and fatigue airworthiness standards and advisory material have been more specific to transport airplanes constructed predominantly of metal, using skin-stringer-frame architecture. Today, the trend in industry is to use more composite and hybrid structures (*i.e.*, structure that includes a combination of composite and metallic parts and assemblies) to improve the performance of transport airplanes. As a result, the damage-tolerance and fatigue airworthiness standards and advisory material may not be adequate to address this trend. This notice informs the public of the new ARAC activity and solicits membership for the new Transport Airplane Metallic and Composite Structures Working Group.

FOR FURTHER INFORMATION CONTACT: Walt Sippel, Federal Aviation Administration, 1601 Lind Avenue SW., Renton, WA 98057–3356, *walter.sippel@faa.gov*, phone number 425–227–2774, facsimile number 425–227–1232.

SUPPLEMENTARY INFORMATION:

ARAC Acceptance of Task

As a result of the December 18, 2014, ARAC meeting, the FAA has assigned and ARAC has accepted this task establishing the Transport Airplane Metallic and Composite Structures Working Group, under the Transport Airplane and Engine (TAE) Subcommittee. The working group will serve as staff to the ARAC and provide advice and recommendations on the assigned task. The ARAC will review and approve the recommendation report and will submit it to the FAA.

Background

The FAA established the ARAC to provide information, advice, and recommendations on aviation related issues that could result in rulemaking to the FAA Administrator, through the Associate Administrator of Aviation Safety.

The Transport Airplane Metallic and Composite Structures Working Group will provide advice and recommendations to the ARAC on the damage-tolerance and fatigue requirements of part 25 and any associated advisory material for metallic, composite, and hybrid structures. This includes the requirements of and regulatory guidance material for subparts C and E of part 26 and any associated advisory material.

The requirements of § 25.571 apply equally to structure constructed from either metallic or nonmetallic materials. Guidance material is contained in the Federal Aviation Administration (FAA) Advisory Circulars (AC) 25.571–1D and 20–107B for metallic and composite structures, respectively. The changes to § 25.571 that the FAA has adopted over the years have been more specific to the technical issues primarily associated with metallic structure. In Amendment 25–132 to § 25.571, the FAA added requirements for applicants to establish a limit of validity of the engineering data that supports the structural maintenance program (hereafter referred to as LOV) and to demonstrate that widespread fatigue damage (WFD) will not occur in the airplane prior to reaching the LOV. The objective of this change, along with the development of the related guidance material, was focused on addressing the normal fatigue wear-out of metallic structure. Among other things, § 25.571 requires applicants to establish an LOV based on WFD considerations, and identify in the structural-maintenance program all maintenance actions required to address fatigue, environmental damage, and accidental damage throughout the operational life of the airplane. In a similar way, subpart C requires certain actions to prevent catastrophic failure due to WFD throughout the operational life of certain existing transport category airplanes. The FAA also adopted subpart E of part 26 to require holders of design approvals to make available to operators damage tolerance data for repairs and alterations to fatigue critical airplane structure. In addition to AC 25.571–1D, guidance material for subparts C and E of part 26 are contained in ACs 120–104 and 120–93, respectively. Because the adoption of those requirements and § 25.571 were primarily focused on metallic structure, the FAA needs to evaluate those rules and advisory material to determine whether further changes are required to address composite structures.

Remaining Rulemaking Recommendations

In 1995, the FAA tasked the ARAC to recommend appropriate revisions for harmonization of § 25.571, supporting policy and guidance material, and corresponding paragraph 25.571 of the Joint Aviation Requirements (JAR), which is now Certification Specification (CS) 25.571 under the European Aviation Safety Agency (EASA). The ARAC formed the General Structures Harmonization Working Group (GSHWG) to carry out that task. In 2003, the GSHWG submitted the Working Group Report on § 25.571 and JAR 25.571 [CS 25.571] to ARAC. That report described proposed changes to harmonize the rules and related guidance material. The GSHWG recommended revising or adding requirements for inspection thresholds, LOV, and structural damage capability.

Subpart C of part 26 and § 25.571, Amendment 25–132, incorporated the recommendation to add requirements for establishing an LOV. The FAA has not yet addressed the GSHWG recommendations related to inspection thresholds and structural damage capability, and would request these be considered in the context of this rulemaking, which include:

- Replacing the prescriptive requirement of § 25.571(a)(3) for setting damage-tolerance inspection thresholds with a performance-based requirement.
- Adding a requirement for showing structural capability in the presence of damage, so that even if the structure fails partially, there will still be enough structure remaining to be safe.

Increased Use of Composites

Today, the trend in industry is to use more composite structures than in the past. The Small Airplane and Rotorcraft Directorates addressed this trend by creating separate rules for parts 23, 27 and 29 for composite structures (§ 2X.573). This tasking will consider the changes to those rules as part of the evaluation of the damage-tolerance and fatigue airworthiness standards and associated advisory material.

In June of 2009, the FAA Transport Airplane Directorate sought comments through the **Federal Register** (74 FR 26919) on a need for future rulemaking to address extensive use of composite materials in transport category airplane construction. Several candidate technical areas were noted in the request, including fire safety, crashworthiness, lightning protection, fuel tank safety and damage-tolerance. The response by industry indicated that each area needs improved guidance and possible rulemaking. We believe the damage-tolerance requirements would require relatively small changes versus some of the updates desired in other areas.

Composite considerations the working group will need to address include:

- Composite analyses and test protocols as related to evolving industry practices and the development of regulatory standards.
- Composite damage threats (*e.g.*, environmental and accidental damage) and associated maintenance practices.
- Large-scale test demonstration of repeated-load reliability and a need to use load enhancement factors for composite structure.
- Thermal stresses generated between metal-composite interfaces, which are difficult to replicate in structural repeated-load testing but are required by § 25.571 to be considered.

Future Applicability

Any future change to § 25.571 should be performance-based to the extent possible, allowing application to not only current aerospace materials and material systems, but those yet to be developed (*i.e.*, emerging technology). Guidance material, including changes to AC 25.571–1D, or AC 20–107B, should provide complete guidance for

Federal Register / Vol. 80, No. 16 / Monday, January 26, 2015 / Notices 4031

traditional metal structure, composite structure, and hybrid structure (*i.e.*, structures that include a combination of composite and metallic parts and assemblies).

There are other FAA initiatives in the area of transport crashworthiness, fuel tank lightning protection, and composite flammability testing, which will lead to further standardization of requirements related to composite airframes. These initiatives would not affect § 25.571.

The Task

The Transport Airplane Metallic and Composite Structures Working Group is tasked to:

1. Evaluate § 25.571, subparts C and E of part 26, and associated regulatory guidance material (*e.g.*, advisory circulars and policy statements) to determine whether any changes to the airworthiness standards and/or guidance material are required to address transport airplanes being constructed of metallic, composite, and hybrid structures. The working group is also tasked to evaluate whether any changes to part 25 and the associated regulatory guidance material are required to provide consistency with the damage-tolerance and fatigue airworthiness standards and associated guidance material for parts 23, 27, and 29. The working group is requested to include in its evaluation a review of the following advisory circulars (AC) and policy statements (PS):

a. Advisory Circulars: AC 25.571–1, Damage Tolerance and Fatigue Evaluation of Structure; AC 20–107, Composite Airframe Structure; AC 120–93, Damage Tolerance Inspections for Repairs and Alterations; AC 120–104, Establishing and Implementing Limit of Validity to Prevent Widespread Fatigue Damage; AC 27–1, Certification of Normal Category Rotorcraft (specifically, Subpart C—Strength Requirements); and AC 29–2, Certification of Transport Category Rotorcraft (specifically, Subpart C—Strength Requirements).

b. Policy Statements: PS–ANM100–1989–00048, Policy Regarding Impact of Modifications and Repairs on the Damage Tolerance Characteristics of Transport Category Airplanes; PS–ACE100–2001–006, Static Strength Substantiation of Composite Airplane Structure; PS–AIR–100–120–07, Guidance for Component Contractor Generated Composite Design Values for Composite Structure; PS–ACE100–2002–006, Material Qualification and Equivalency for Polymer Matrix Composite Material Systems; PS–ANM–100–1991–00049, Policy Regarding Material Strength Properties and Design Values, § 25.613; PS–ANM100–1993, Compliance with § 25.571(e) Discrete Source Damage (Uncontained Engine Failure).

2. Advise and make written recommendations on whether to change 14 CFR part 25, subparts C and E of 14 CFR part 26, and related regulatory guidance material, such as ACs 25.571–1, 20–107, 120–93, and 120–104, to address the use of metallic, composite, and hybrid structures in transport airplanes. In developing the recommendations, the working group is requested to consider:

a. The threats associated with fatigue, environmental exposure, and accidental damage that must be addressed per § 25.571.

b. Applicability to emerging technology materials.

c. The recommendations contained in the 2003 General Structures Harmonization Working Group (GSHWG) report entitled, "Damage Tolerance and Fatigue Evaluation of Structures, FAR/JAR § 25.571." You can find the GSHWG report at *http://www.faa.gov/regulations_policies/rulemaking/committees/documents/index.cfm/document/information/documentID/384.* The working group recommendations should include whether it is appropriate to:

i. Require applicants to assume the structure contains an initial flaw of the maximum probable size that could exist as a result of manufacturing or service-induced damage.

ii. Add a requirement for showing structural capability in the presence of damage, so that even if the structure fails partially, there will still be enough structure remaining to be safe.

d. The continued operational safety of composite and hybrid structures as they age, including any airworthiness limitations in the structural maintenance program.

e. The testing of hybrid structure, including, but not limited to, addressing thermal effects, test duration, load enhancement factors, and crack-growth retardation.

f. The bonding or bolting of repairs to metallic, composite, and hybrid structures.

g. The certification of large structural modifications on transport airplanes constructed of composite or hybrid structures.

h. The EASA rulemaking activity on aging aircraft for harmonization purposes.

3. Provide recommendations on appropriate performance-based requirements to address the results of the evaluations above, with consideration of applicability not only to metals and known composites, but also other emerging technology materials.

4. Provide recommendations on any new guidance or changes to existing guidance, including AC 25.571–1D, and AC 20–107B to address the results of the evaluations above.

5. Provide initial qualitative and quantitative costs and benefits. Based on the recommendations, perform the following:

a. Estimate the costs to implement the recommendations;

b. Estimate the benefits of the recommendations in terms of potential fatalities averted;

c. Estimate any other benefits (*e.g.*, reduced administrative burden) that would result from implementation of the recommendations.

6. Develop a report containing recommendations on the findings and results of the tasks explained above.

a. The recommendation report should document both majority and dissenting positions on the findings and the rationale for each position.

b. Any disagreements should be documented, including the rationale for each position and the reasons for the disagreement.

7. The working group may be reinstated to assist the ARAC by responding to the FAA's questions or concerns after the recommendation report has been submitted.

Schedule

The recommendation report must be submitted to the FAA for review and acceptance no later than 24 months after publication of this notice.

Working Group Activity

The Transport Airplane Metallic and Composite Structures Working Group must comply with the procedures adopted by the ARAC. As part of the procedures, the working group must:

1. Conduct a review and analysis of the assigned tasks and any other related materials or documents.

2. Draft and submit a work plan for completion of the task, including the rationale supporting such a plan, for consideration by the Transport Airplane and Engine Subcommittee.

3. Provide a status report at each Transport Airplane and Engine Subcommittee meeting.

4. Draft and submit the recommendation report based on the review and analysis of the assigned tasks.

5. Present the recommendation report at the Transport Airplane and Engine Subcommittee meeting.

4032 **Federal Register** / Vol. 80, No. 16 / Monday, January 26, 2015 / Notices

6. Present the findings from the additional tasks at the Transport Airplane and Engine Subcommittee meeting.

7. Present the findings in response to the FAA's questions or concerns about the recommendation report at the Transport Airplane and Engine Subcommittee meeting.

Participation in the Working Group

The Transport Airplane Metallic and Composite Structures Working Group will be comprised of technical experts having an interest in the assigned task. A working group member need not be a member representative of the ARAC. The FAA would like a wide range of members to ensure all aspects of the tasks are considered in development of the recommendations. The provisions of the August 13, 2014, Office of Management and Budget guidance, "Revised Guidance on Appointment of Lobbyists to Federal Advisory Committees, Boards, and Commissions" (79 FR 47482), continues the ban on registered lobbyists participating on Agency Boards and Commissions if participating in their "individual capacity." The revised guidance now allows registered lobbyists to participate on Agency Boards and Commissions in a "representative capacity" for the "express purpose of providing a committee with the views of a nongovernmental entity, a recognizable group of persons or nongovernmental entities (an industry, sector, labor unions, or environmental groups, etc.) or state or local government." (For further information see Lobbying Disclosure Act of 1995 (LDA) as amended, 2 U.S.C 1603, 1604, and 1605.)

If you wish to become a member of the Transport Airplane Metallic and Composite Structures Working Group, write the person listed under the caption **FOR FURTHER INFORMATION CONTACT** expressing that desire. Describe your interest in the task and state the expertise you would bring to the working group. The FAA must receive all requests by February 25, 2015. The ARAC and the FAA will review the requests and advise you whether or not your request is approved.

If you are chosen for membership on the working group, you must actively participate in the working group by attending all meetings, and providing written comments when requested to do so. You must devote the resources necessary to support the working group in meeting any assigned deadlines. You must keep your management chain and those you may represent advised of working group activities and decisions to ensure the proposed technical solutions do not conflict with the position of those you represent. Once the working group has begun deliberations, members will not be added or substituted without the approval of the Transport Airplane and Engine Subcommittee Chair, the FAA, including the Designated Federal Officer, and the Working Group Chair.

The Secretary of Transportation determined the formation and use of the ARAC is necessary and in the public interest in connection with the performance of duties imposed on the FAA by law.

ARAC meetings are open to the public. However, meetings of the Transport Airplane Metallic and Composite Structures Working Group are not open to the public, except to the extent individuals with an interest and expertise are selected to participate. The FAA will make no public announcement of working group meetings.

Issued in Washington, DC, on January 16, 2015.

Lirio Liu,

Designated Federal Officer, Aviation Rulemaking Advisory Committee.

[FR Doc. 2015–01044 Filed 1–23–15; 8:45 am]

BILLING CODE 4910–13–P

DEPARTMENT OF TRANSPORTATION

Federal Railroad Administration

[Docket No. FRA–2015–0001]

Establishment of an Emergency Relief Docket for Calendar Year 2015

AGENCY: Federal Railroad Administration (FRA), U.S. Department of Transportation (DOT).

ACTION: Notice of establishment of public docket.

SUMMARY: This Notice announces the establishment of FRA's Emergency Relief Docket (ERD) for calendar year 2015. The designated ERD for calendar year 2015 is Docket Number FRA–2015–0001.

ADDRESSES: See **SUPPLEMENTARY INFORMATION** section for further information regarding submitting petitions and/or comments to Docket Number FRA–2015–0001.

SUPPLEMENTARY INFORMATION: On May 19, 2009, FRA published a direct final rule addressing the establishment of ERDs and the procedures for handling petitions for emergency waivers of safety rules, regulations, or standards during an emergency situation or event. 74 FR 23329. That direct final rule became effective on July 20, 2009, and made minor modifications to Title 49 Code of Federal Regulations (CFR) 211.45 in FRA's Rules of Practice published at 49 CFR part 211. Paragraph (b) of 49 CFR 211.45 provides that each calendar year, FRA will establish an ERD in the publicly accessible DOT docket system (available on the internet at *http://www.regulations.gov*). Paragraph (b) of 49 CFR 211.45 further provides that FRA will publish a notice in the **Federal Register** identifying by docket number the ERD for that year. As noted in the rule, FRA's purpose for establishing the ERD and emergency waiver procedures is to provide an expedited process for FRA to address the needs of the public and the railroad industry during emergency situations or events. This Notice announces that the designated ERD for calendar year 2015 is Docket Number FRA–2015–0001.

As detailed in 49 CFR 211.45, if the FRA Administrator determines that an emergency event as defined in 49 CFR 211.45(a) has occurred, or that an imminent threat of such an emergency occurring exists, and public safety would benefit from providing the railroad industry with operational relief, the emergency waiver procedures of 49 CFR 211.45 will go into effect. In such an event, the FRA Administrator will issue a statement in the ERD indicating that the emergency waiver procedures are in effect and FRA will make every effort to post the statement on its Web site at *http://www.fra.dot.gov/*. Any party desiring relief from FRA regulatory requirements as a result of the emergency situation should submit a petition for emergency waiver in accordance with 49 CFR 211.45(e) and (f). Specific instructions for filing petitions for emergency waivers in accordance with 49 CFR 211.45 are found at 49 CFR 211.45(f). Specific instructions for filing comments in response to petitions for emergency waivers are found at 49 CFR 211.45(h).

Anyone is able to search the electronic form of any written communications and comments received into any of our dockets by the name of the individual submitting the comment (or signing the document, if submitted on behalf of an association, business, labor union, etc.). In accordance with 5 U.S.C. 553(c), DOT solicits comments from the public to better inform its processes. DOT posts these comments, without edit, including any personal information the commenter provides, to *www.regulations.gov*, as described in the system of records notice (DOT/ALL–14 FDMS), which can be reviewed at *www.dot.gov/privacy*. See also *http://*

Current 25.571 Amendment 25-132

§25.571 Damage-tolerance and fatigue evaluation of structure.

(a) *General.* An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, corrosion, manufacturing defects, or accidental damage, will be avoided throughout the operational life of the airplane. This evaluation must be conducted in accordance with the provisions of paragraphs (b) and (e) of this section, except as specified in paragraph (c) of this section, for each part of the structure that could contribute to a catastrophic failure (such as wing, empennage, control surfaces and their systems, the fuselage, engine mounting, landing gear, and their related primary attachments). For turbojet powered airplanes, those parts that could contribute to a catastrophic failure must also be evaluated under paragraph (d) of this section. In addition, the following apply:

(1) Each evaluation required by this section must include—

(i) The typical loading spectra, temperatures, and humidities expected in service;

(ii) The identification of principal structural elements and detail design points, the failure of which could cause catastrophic failure of the airplane; and

(iii) An analysis, supported by test evidence, of the principal structural elements and detail design points identified in paragraph (a)(1)(ii) of this section.

(2) The service history of airplanes of similar structural design, taking due account of differences in operating conditions and procedures, may be used in the evaluations required by this section.

(3) Based on the evaluations required by this section, inspections or other procedures must be established, as necessary, to prevent catastrophic failure, and must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by §25.1529. The limit of validity of the engineering data that supports the structural maintenance program (hereafter referred to as LOV), stated as a number of total accumulated flight cycles or flight hours or both, established by this section must also be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by §25.1529. Inspection thresholds for the following types of structure must be established based on crack growth analyses and/or tests, assuming the structure contains an initial flaw of the maximum probable size that could exist as a result of manufacturing or service-induced damage:

(i) Single load path structure, and

(ii) Multiple load path “fail-safe” structure and crack arrest “fail-safe” structure, where it cannot be demonstrated that load path failure, partial failure, or crack arrest will be detected and repaired during normal maintenance, inspection, or operation of an airplane prior to failure of the remaining structure.

(b) *Damage-tolerance evaluation.* The evaluation must include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage. Repeated load and static analyses supported by test evidence and (if available) service experience must also be incorporated in the evaluation. Special consideration for widespread fatigue damage must be included where the design is such that this type of damage could occur. An LOV must be established that corresponds to the period of time, stated as a number of total accumulated flight cycles or flight hours or both, during which it is demonstrated that widespread fatigue damage will not occur in the airplane structure. This demonstration must be by full-scale fatigue test evidence. The type certificate may be issued prior to completion of full-scale fatigue testing, provided the Administrator has approved a plan for completing the required tests. In that case, the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by §25.1529 must specify that no airplane may be operated beyond a number of cycles equal to ½ the number of cycles accumulated on the fatigue test article, until such testing is completed. The extent of damage for residual strength evaluation at any time within the operational life of the airplane must be consistent with the initial detectability and subsequent growth under repeated loads. The residual strength evaluation must show that the remaining structure is able to withstand loads (considered as static ultimate loads) corresponding to the following conditions:

(1) The limit symmetrical maneuvering conditions specified in §25.337 at all speeds up to V_c and in §25.345.

(2) The limit gust conditions specified in §25.341 at the specified speeds up to V_c and in §25.345.

(3) The limit rolling conditions specified in §25.349 and the limit unsymmetrical conditions specified in §§25.367 and 25.427 (a) through (c), at speeds up to V_c.

(4) The limit yaw maneuvering conditions specified in §25.351(a) at the specified speeds up to V_c.

(5) For pressurized cabins, the following conditions:

(i) The normal operating differential pressure combined with the expected external aerodynamic pressures applied simultaneously with the flight loading conditions specified in paragraphs (b)(1) through (4) of this section, if they have a significant effect.

(ii) The maximum value of normal operating differential pressure (including the expected external aerodynamic pressures during 1 g level flight) multiplied by a factor of 1.15, omitting other loads.

(6) For landing gear and directly-affected airframe structure, the limit ground loading conditions specified in §§25.473, 25.491, and 25.493.

If significant changes in structural stiffness or geometry, or both, follow from a structural failure, or partial failure, the effect on damage tolerance must be further investigated.

(c) *Fatigue (safe-life) evaluation.* Compliance with the damage-tolerance requirements of paragraph (b) of this section is not required if the applicant establishes that their application for particular structure is impractical. This structure must be shown by analysis, supported by test evidence, to be able to withstand the repeated loads of variable magnitude expected during its service life without detectable cracks. Appropriate safe-life scatter factors must be applied.

(d) *Sonic fatigue strength.* It must be shown by analysis, supported by test evidence, or by the service history of airplanes of similar structural design and sonic excitation environment, that—

(1) Sonic fatigue cracks are not probable in any part of the flight structure subject to sonic excitation; or

(2) Catastrophic failure caused by sonic cracks is not probable assuming that the loads prescribed in paragraph (b) of this section are applied to all areas affected by those cracks.

(e) *Damage-tolerance (discrete source) evaluation.* The airplane must be capable of successfully completing a flight during which likely structural damage occurs as a result of—

(1) Impact with a 4-pound bird when the velocity of the airplane relative to the bird along the airplane's flight path is equal to V_c at sea level or $0.85V_c$ at 8,000 feet, whichever is more critical;

(2) Uncontained fan blade impact;

(3) Uncontained engine failure; or

(4) Uncontained high energy rotating machinery failure.

Appendix B Threat Assessment

The following examples show the existing rule and guidance with highlighted changes that align with the recommendation from Section 3.1. These changes do not reflect discussion in other parts of this report.

B.1 Rule Changes – 25.571

The following changes use 14 CFR 25.571 Amendment 25-132 effective 1/14/2011 as the baseline rule. Only the section of the rule that contain areas of recommended changes are presented.

25.571 – Damage-tolerance and fatigue evaluation of structure

(a) *General*. An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, environmental deterioration, ~~corrosion~~, manufacturing defects, or accidental damage, will be avoided throughout the operational life of the airplane. This evaluation must be conducted in accordance with the provisions of paragraphs (b) and (e) of this section, except as specified in paragraph (c) of this section, for each part of the structure that could contribute to a catastrophic failure (such as wing, empennage, control surfaces and their systems, the fuselage, engine mounting, landing gear, and their related primary attachments). For turbojet powered airplanes, those parts that could contribute to a catastrophic failure must also be evaluated under paragraph (d) of this section. In addition, the following apply:

(b) Damage-tolerance evaluation. The evaluation must include a determination of the probable locations and modes of damage due to fatigue, ~~corrosion~~, environmental deterioration, manufacturing defects, or accidental damage. Repeated load and static analyses supported by test evidence and (if available) service experience must also be incorporated in the evaluation. Special consideration for widespread fatigue damage must be included where the design is such that this type of damage could occur. An LOV must be established that corresponds to the period of time, stated as a number of total accumulated flight cycles or flight hours or both, during which it is demonstrated that widespread fatigue damage will not occur in the airplane structure. This demonstration must be by full-scale fatigue test evidence. The type certificate may be issued prior to completion of full-scale fatigue testing, provided the Administrator has approved a plan for completing the required tests. In that case, the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 25.1529 must specify that no airplane may be operated beyond a number of cycles equal to 1/2 the number of cycles accumulated on the fatigue test article, until such testing is completed. The extent of damage for residual strength evaluation at any time within the operational life of the airplane must be consistent with the initial detectability and subsequent growth under repeated loads. The residual strength evaluation must show that the remaining structure is able to withstand loads (considered as static ultimate loads) corresponding to the following conditions:

B.2 Guidance Change

B.2.1 AC 25.571-1D

The following changes use AC No. 25.571-1D, dated 1/13/2011. The entire AC is not presented and only the sections affected by the recommendation on threat assessment are presented for brevity.

5. Introduction.

a. General. The FAA considers the contents of this AC in determining compliance with the damage-tolerance, fatigue, and discrete source damage requirements of § 25.571.

(1) The requirements of § 25.571 apply equally to metallic and composite structure. The focus of this AC is metallic structure. Refer to AC 20-107B for guidance on composite structures, including aspects of metal bonded structure.

(2) Section 25.571 requires applicants to evaluate all structure that could contribute to catastrophic failure of the airplane with respect to its susceptibility to fatigue, environmental deterioration (corrosion), manufacturing defects and accidental damage. The applicant must establish inspections or other procedures (herein also referred to as maintenance actions) as necessary to avoid catastrophic failure during the operational life of the airplane based on the results of these evaluations. Section 25.571 also requires the applicant to establish an LOV. The LOV, in effect, is the operational life of the airplane consistent with evaluations accomplished and maintenance actions established to prevent WFD. Although the LOV is established based on WFD considerations, it is intended that all maintenance actions required to address fatigue, corrosion, and accidental damage up to the LOV are identified in the structural-maintenance program. All inspections and other procedures (e.g., modification times, replacement times) that are necessary to prevent a catastrophic failure due to fatigue, up to the LOV, must be included in the Airworthiness Limitations section (ALS) of the Instructions for Continued Airworthiness (ICA), as required by § 25.1529, along with the LOV.

c. Structure to be evaluated. When assessing the possibility of fatigue failures, the applicant should examine the design to determine probable points of failure in service. In this examination, consideration should be given, as necessary, to (1) the results of stress analyses, static tests, fatigue tests, strain-gauge surveys, and tests of similar structural configurations and (2) service experience. Service experience has shown that special attention should be focused on the design details of important discontinuities, attachment fittings, tension joints, splices, and cutouts such as windows, doors, and other openings. If the reliance on bond line is established, the applicant should also consider the type and size of manufacturing defects that are likely to occur depending on the method of manufacturing, the quality control process, and quality acceptance inspection program as discussed in AC 20-107B, Material and Fabrication Development. The applicant should also evaluate the crack growth behavior and effect in metallic bonded structure. This evaluation should address the use of bonded tear-straps or crack arrest features. Locations prone to accidental damage (such as that due to impact with ground servicing equipment near airplane doors) or to corrosion should also be considered.

6. Damage-Tolerance Evaluation.

a. General. The damage-tolerance evaluation of structure is intended to ensure that—should fatigue, environmental deterioration (corrosion), or accidental damage occur within the LOV of the airplane—the remaining structure can withstand reasonable loads without failure or excessive structural deformation until the damage is detected. The damage-tolerance evaluation should include the following:

b. Damage-Tolerance Assessment Methodologies. Normally, the damage-tolerance assessment consists of a deterministic evaluation of the design features described in this section. Sections 6c through 6j below provide guidelines for this approach. In certain specific instances, however, damage-tolerant design might be more realistically assessed by a probabilistic evaluation, employing methods such as risk analysis. Risk analyses are routinely employed in fail-safe evaluations of airplane systems and have occasionally been used where structure and systems are interrelated. These methods can be of particular value for structure consisting of discrete elements, where damage tolerance depends on the ability of the structure to sustain redistributed loads after failures resulting from fatigue, environmental deterioration (corrosion), manufacturing defect, or accidental damage. Where considered appropriate on multiple load path structure, a probabilistic analysis may be used if it can be shown that (1) loss of the airplane is extremely improbable, and (2) the statistical data employed in the analysis of similar structure is based on tests or operational experience, or both.

g. Identification of locations to be evaluated. The locations of damage to structure for damage-tolerance evaluation should be identified as follows:

(1) Determination of general damage locations. The evaluation would include a determination of the probable locations and modes of damage due to fatigue, environmental deterioration (corrosion), manufacturing defects, or accidental damage. Repeated load and static analyses, supported by test evidence and (if available) service experience, would also be incorporated in the evaluation. Special consideration for widespread fatigue damage must be included where the design is such that this type of damage could occur. The location and modes of damage can be determined by analysis or service experience, or by fatigue tests on complete structures or subcomponents. However, tests may be necessary when the basis for analytical prediction is not reliable, such as for complex components. If less than the complete structure is tested, ensure that the internal loads and boundary conditions are valid.

h. Damage-tolerance analysis and tests.

(1) Analysis, supported by test evidence, should determine that:

(a) The structure with the extent of damage established for residual-strength evaluation, and in the case of bonded structure, any reduction in strength as a result of aging, can withstand the specified design-limit loads (considered as ultimate loads)

7. Establishing an LOV.

a. Structural-maintenance program.

(a) If an airplane is properly maintained, theoretically it could be operated indefinitely. However, it should be noted that structural-maintenance task for an airplane are not constant with time. Tasks typically are added to the maintenance program as the airplane ages. It is reasonable to expect, then, that confidence in the effectiveness of current structural maintenance tasks may not, at some future point, be sufficient for continued operation. Maintenance tasks for a particular airplane can only be determined based on what is known about that airplane model at any given time; from analyses, tests, service experience, and teardown inspections. Widespread fatigue damage is of particular concern because inspection methods cannot be relied on solely to ensure the continued airworthiness of airplanes indefinitely. To prevent WFD from occurring, the structure occasionally must be modified or replaced. Establishing all the replacements and modifications required to operate the airplane indefinitely is an unbounded problem. This problem is solved by establishing limit of validity of the engineering data that supports the structural-maintenance program. All necessary modifications and replacements are required to be established to ensure continued airworthiness relative to WFD up to the LOV. To operate beyond the LOV, the full-scale fatigue-test evidence and the structural maintenance program must be re-evaluated to determine if additional modifications or replacements are required. See paragraph 7.g for the steps to extend the LOV.

The degradation of bonds due to aging cannot be reliably detected through a structural inspection program. As a result, the applicant must not only consider WFD but also the aging mechanism of the bond when establishing the LOV. For a more thorough discussion on aging and LOV, the applicant should review AC 20-107BX.

Appendix 1 – References and Definitions

1. Definitions of Terms Used in this AC.

d. Damage tolerance — The attribute of the structure that permits it to retain its required residual strength for a period of use after the structure has sustained a given level of fatigue, environmental deterioration (corrosion), manufacturing defect, or accidental or discrete source damage.

q. Manufacturing Defect — An anomaly or flaw occurring during manufacturing that can cause degradation in structural strength, durability, stiffness or dimensional stability.

B.2.2 AC 20-107B

The following changes use AC 20-107B, dated August 24, 2010. The entire AC is not presented and only the sections affected by the recommendation are presented for brevity. Section 6 of AC 20-107B addresses bonded structure, including manufacturing quality controls, design details and other considerations intended to ensure the bond strength needed for structural integrity. One of the design attributes pursued by industry to ensure sufficient structural capability in the rare event of a “weak bond” manufacturing defect is structural redundancy through fail-safe design features. This is clearly not the primary means of ensuring structural integrity because it is effective only when quality control minimizes “weak bonds” to be a) extremely rare and b) of a size no larger than a localized area between arresting design features. As a result, the primary risk mitigation to loosing structural integrity remains the stringent quality control procedures as explained in Section 6.c of AC 20-107B. Specific recommendations for changes to AC 20-107B, Section 8 are given below as additions to reinforce information already existing in Section 6.c.

8. Proof of Structure – Fatigue and Damage Tolerance. The evaluation of composite structure should be based on the applicable requirements of 14 CFR §§ 23.573(a), 23.2240, 25.571, 27.571, and 29.571. Such evaluation must show that catastrophic failure due to fatigue, environmental effects, manufacturing defects, or accidental damage…

a. Damage Tolerance Evaluation.

(9) Manufacturing defects are also a concern for composite and metal bonded structures requiring attention in the damage threat assessment. Allowable defects during manufacturing are covered in Category 1 which is addressed in Section 8.a.(1)(c). However, there are other considerations that should be addressed for bonded structure. Structural bonding requires a quality control process that addresses the sensitivity of the structural performance based upon expected variation permitted per the process. This requires a more stringent process control than other fabrication processes and further proof of sufficient bond strength as described in detail within Section 6.c of this AC. Multi-load path bonded structure will often use the following option described in Section 6.c as the means of compliance for ensuring sufficient bond strength in the event of a rare weak bond manufacturing defect.

For any bonded joint structural detail or bonded repairs or modifications, the failure of which would result in catastrophic loss of the airplane, the limit load capacity must be substantiated by the maximum disbonds of each bonded joint consistent with the capability to withstand the critical limit loads must be determined by analysis, tests, or both. Disbonds of each bonded joint greater than this must be prevented by design features.

10. Continued Airworthiness

b. Maintenance Practices. Maintenance manuals should be developed by the appropriate organizations to include the necessary inspection, maintenance, and repair procedures for composite structures, including jacking, disassembly, handling, part drying methods, and repainting instructions (including restrictions for paint colors that increase structural temperatures). Special equipment, repair materials, ancillary materials, tooling, processing procedures, and other information needed for inspection or repair of a given part should be identified since standard field practices, which have been substantiated for different aircraft types and models, are not common. Manuals should contain enough detail about original design and manufacturing processes to support repair to original standards, including materials specifications, processing details such as tolerances, storage, handling, permissible manufacturing variability, and inspection methods with pass/fail criteria.

Appendix 2. Definitions

22. Manufacturing Defect: An anomaly or flaw occurring during manufacturing that can cause degradation in structural strength, durability, stiffness or dimensional stability.

Appendix C - Testing of Hybrid Structure: Example of Rule and Guidance Changes

This appendix identifies proposed rule and guidance changes and rationale for those changes related to the discussions in Sections 3.3 (Testing of Hybrid Structures) and 3.4 (Aging Mechanisms). The proposed changes also reflect current certification and industry practices.

C.1 Example of Rule Change, § 25.571(a) and (b)

14CFR 25.571(a)

(a) General

An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, ~~corrosion~~ environmental deterioration, manufacturing defects, or accidental damage, will be avoided throughout the operational life of the airplane. This evaluation must be conducted in accordance with the provisions of paragraphs (b) and (e) of this section, except as specified in paragraph (c) of this section, for each part of the structure that could contribute to a catastrophic failure (such as wing, empennage, control surfaces and their systems, the fuselage, engine mounting, landing gear, and their related primary attachments). For turbojet powered airplanes, those parts that could contribute to a catastrophic failure must also be evaluated under paragraph (d) of this section. In addition, the following apply:

> *<< Change Rationale >>*
>
> *The term "corrosion" is metal-centric. Replacing "corrosion" with environmental deterioration makes the requirement material general and would encompass composite and hybrid structures or any new material used that might be used in building aircraft structure.*

(1) Each evaluation required by this section must include—

(i) The typical loading spectra~~, temperatures, and humidities~~ and environmental conditions expected in service;

(ii) The identification of principal structural elements and detail design points, the failure of which could cause catastrophic failure of the airplane; and

(iii) An analysis, supported by test evidence, of the principal structural elements and detail design points identified in paragraph (a)(1)(ii) of this section.

> *<< Change Rationale >>*
>
> *Existing requirement is too narrowly focused. The change makes the requirement more performance-based. Guidance should be revised to include these examples.*

(2) The service history of airplanes of similar structural design, taking due account of differences in operating conditions and procedures, may be used in the evaluations required by this section.

(3) Based on the evaluations required by this section, inspections or other procedures must be established, as necessary, to prevent catastrophic failure, and must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by §25.1529. ~~The~~ A limit of validity of the engineering data that supports the structural maintenance program (hereafter referred to as LOV) that corresponds to the period of time, stated as a number of total accumulated flight cycles or flight hours or both, must be established. The LOV established by this section must also be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by §25.1529.

<< Change Rationale >>

Establishing LOV is a general requirement and it should be included in 25.571(a) rather than in paragraph (b). The phrase of "--- must be established" which originally appears in 25.571(b) is moved to 25.571(a). Ultimately, 25.571(a)(3) is clearly to require establishing maintenance action, establishing LOV and inclusion in ALS.

14CFR 25.571(b)

(b) Damage-tolerance evaluation

The evaluation must include a determination of the probable locations and modes of damage due to fatigue, ~~corrosion~~ environmental deterioration, manufacturing defects, or accidental damage. Repeated load and static analyses supported by test evidence and (if available) service experience must also be incorporated in the evaluation. Special consideration for widespread fatigue damage must be included where the design is such that this type of damage could occur. ~~An LOV must be established that corresponds to the period of time, stated as a number of total accumulated flight cycles or flight hours or both, during which it is demonstrated that widespread fatigue damage will not occur in the airplane structure. This~~ The demonstration that widespread fatigue damage will not occur within the LOV must be supported by full-scale fatigue test evidence; this may include analysis supported by other test evidence or service experience.

<< Change Rationale >>

- To replace the existing metallic specific word "corrosion" by the word applicable to composite and hybrid structure as well, "environmental deterioration".

- To address manufacturing defects they should be considered in the damage tolerance evaluation, for example a local weak bond of composite bonded structure. In current rule text, "manufacturing defect" is only seen in 25.571(a) since it has been intended only for establishing inspection threshold especially for metallic structure. However manufacturing defect should be also considered in DTE especially when considering composite structure, and this change could result in a performance based requirement to cover composite structure as well as metallic one. This is covered by the "Threat Assessment" discussion.

- Establishing LOV is a general requirement and it should be a part of 25.571(a), therefore the sentence to require LOV establishment is removed from 25.571(b), and clarified in 25.571(a)(3).

- And, when moving the LOV establishment to 25.571(a)(3), the sentence of "—during which it is demonstrated that WFD will not occur ---" is deleted, since the sentence seems to imply that LOV is only linking to WFD, although the rule text should cover any material and any kind of damage or threat. The current sentence in 25.571(a)(3) of "LOV of the engineering data that supports the structural maintenance program" already provides a generic, high level, performance based requirement without changes.

- For the loads which are not practically applied in full-scale fatigue test, for example thermal cyclic load or cyclic fuel pressure load, analysis should be allowed for WFD demonstration other than direct testing.

The type certificate may be issued prior to completion of full-scale fatigue testing, provided the Administrator has approved a plan for completing the required tests. In that case, the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by §25.1529 must specify that no airplane may be operated beyond a number of cycles equal to 1⁄2 the number of cycles accumulated on the fatigue test article, until such testing is completed. The extent of damage for residual strength evaluation at any time within the operational life of the airplane must be consistent with the initial detectability and subsequent growth under repeated loads. The residual strength evaluation must show that the remaining structure is able to withstand loads (considered as static ultimate loads) corresponding to the following conditions:

< No change proposed for the later section >

C.2 Example of Guidance Change, AC25.571-1D

AC25.571-1D Damage Tolerance and Fatigue Evaluation of Structure

5. Introduction

e. Hybrid Structure (New paragraph proposed)

For hybrid structure (e.g., structure that includes a combination of composite and metallic parts and assemblies), the following should be taken into account.

(1) Thermal effects should be considered in fatigue and damage tolerance evaluation. Typical thermal effects result in local and global loads developed due to thermal expansion of dissimilar materials of attached parts. Local induced loads appear at the interfaces between composite and metallic structural elements and global thermal loads may result from overall deformation of the airframe.

(2) Applying thermal cyclic loads in full-scale fatigue or component test may be impractical. Thermal effects in a damage tolerance evaluation, therefore, can be assessed by analysis supported by test. Lower level tests (up to component) under controlled non cyclic temperature conditions can provide information on thermal induced loads. Temperature field may be validated by flight test measurement.

(3) When a single test article is used to address both metallic and composite fatigue, care must be taken to avoid adverse or unconservative effects on either metallic or composite parts.

   (a) If load enhancement factors are used to address composite variability, analysis must show whether fatigue performance of metallic parts is affected. If conservative, test results for metallic parts can be adjusted by analysis to represent the non-factored loading.

   (b) Maximum load levels can be reduced (clipping) if they are shown to be acceptable for the composite parts.

(c) Low amplitude load levels can be omitted (truncation) if they are shown not to contribute to damage growth in either metallic or composite parts.

<< Change Rationale >>

- To describe that thermal induced load between metallic and composite elements due to difference of coefficient of thermal expansion has to be taken into account in DTE. (Rationale (1) for guidance change in Section 3.3)

- To allow analysis supported by test evidence approach for the particular loads which cannot be practically applied in the full-scale fatigue test. (Rationale (2) for guidance change in Section 3.3)

- To clarify a combination of crack growth analysis and a tear down inspection, which is an existing acceptable means of compliance, can be an acceptable means of compliance for demonstration of freedom from WFD. (Rationale (3) for guidance change in Section 3.3)

- To describe necessity of careful assessment regarding difference of fatigue and damage tolerance characteristics between metallic and composite. (Rationale (4) for guidance change in Section 3.3)

6. Damage-Tolerance Evaluation

f. Testing of principal structural elements.

The nature and extent of residual strength tests on complete structures or on portions of the primary structure depends upon applicable previous design, construction, tests, and service experience with similar structures. Simulated cracks should be as representative as possible of actual fatigue damage. Where it is not practical to produce actual fatigue cracks, damage can be simulated by cuts made with a fine saw, sharp blade, guillotine, or other suitable means. If saw cuts in primary structure are used to simulate sharp fatigue cracks, sufficient evidence should be available from element tests to indicate equivalent residual strength. In those cases where bolt failure or its equivalent is to be simulated as part of a possible damage configuration in joints or fittings, bolts can be removed to provide that part of the simulation. Additional guidance for full-scale fatigue test to demonstrate that WFD will not occur within LOV is included in appendix 2 of this AC.

<< Change Rationale >>

- To address that artificial damage in full-scale fatigue test article may adversely affect WFD evaluation. (Rationale (5) for guidance change in Section 3.3)

6. Damage-Tolerance Evaluation

g. Identification of locations to be evaluated.

The locations of damage to structure for damage-tolerance evaluation should be identified as follows:

(1) Determination of general damage locations. The evaluation would include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage. Repeated load and static analyses (including environmental conditions if applicable), supported by

test evidence and (if available) service experience, would also be incorporated in the evaluation. Special consideration for widespread fatigue damage must be included where the design is such that this type of damage could occur. (continued)

<< Change Rationale >>

- To describe that thermal induced load between metallic and composite elements due to difference of coefficient of thermal expansion has to be taken into account in DTE. (Rationale (1) for guidance change in Section 3.3)

6. Damage-Tolerance Evaluation

h. Damage-tolerance analysis and tests.

(2) The repeated loads should be as defined in the loading, temperature, and humidity spectra. The loading conditions should take into account the effects of structural flexibility and rate of loading where they are significant. Applying particular loads, for example thermal cyclic loads or cyclic fuel pressure loads, in full-scale fatigue or component test may be impractical. The particular loads, e.g. thermal effects, in a damage tolerance evaluation can be assessed by analysis supported by test if it can be shown impractical.

<< Change Rationale >>

- To allow analysis supported by test evidence approach for the particular loads which cannot be practically applied in the full-scale fatigue test. (Rationale (2) for guidance change in Section 3.3)

7. Establishing an LOV.

a. Structural-maintenance program.

(1) If an airplane is properly maintained, theoretically it could be operated indefinitely. However, it should be noted that structural-maintenance tasks for an airplane are not constant with time. Tasks typically are added to the maintenance program as the airplane ages. It is reasonable to expect, then, that confidence in the effectiveness of current structural maintenance tasks may not, at some future point, be sufficient for continued operation. Maintenance tasks for a particular airplane can only be determined based on what is known about that airplane model at any given time; from analyses, tests, service experience, and teardown inspections. Widespread fatigue damage is of particular concern because inspection methods cannot be relied on solely to ensure the continued airworthiness of airplanes indefinitely. To prevent WFD from occurring, the structure occasionally must be modified or replaced. Establishing all the replacements and modifications required to operate the airplane indefinitely is an unbounded problem. This problem is solved by establishing limit of validity of the engineering data that supports the structural-maintenance program. All necessary modifications and replacements are required to be established to ensure continued airworthiness relative to WFD up to the LOV. To operate beyond the LOV, the full-scale fatigue-test evidence, supporting analysis and the structural maintenance program must be re-evaluated to determine if additional modifications or replacements are required. See paragraph 7.g for the steps to extend the LOV.

<< Change Rationale >>

- To allow analysis supported by test evidence approach for the particular loads which cannot be practically applied in the full-scale fatigue test. (Rationale (2) for guidance change in Section 3.3)

- To clarify a combination of crack growth analysis and a tear down inspection, which is an existing acceptable means of compliance, can be an acceptable means of compliance for demonstration of freedom from WFD. (Rationale (3) for guidance change in Section 3.3)

7. Establishing an LOV.

c. Steps for Establishing an LOV.

(2)(c) Step 3 - Evaluation of WFD-Susceptible Structure. Applicants must evaluate all susceptible structure identified in Step 2. Applicants must demonstrate, by full-scale fatigue test evidence and supporting analysis that WFD will not occur in the airplane structure prior to the LOV. This demonstration typically entails full-scale fatigue testing, followed by teardown inspections and a quantitative evaluation of any finding or residual-strength testing, or both. Additional guidance about full-scale fatigue-test evidence is included in appendix 2 of this AC.

<< Change Rationale >>

- To allow analysis supported by test evidence approach for the particular loads which cannot be practically applied in the full-scale fatigue test. (Rationale (2) for guidance change in Section 3.3)

- To clarify a combination of crack growth analysis and a tear down inspection, which is an existing acceptable means of compliance, can be an acceptable means of compliance for demonstration of freedom from WFD. (Rationale (3) for guidance change in Section 3.3)

7. Establishing an LOV.

g. Extended LOV.

If an applicant proposes to extend an LOV, they must comply with the requirements of 14 CFR 26.23. Refer to AC 120-104 for guidance on extending an LOV. Typically, the data necessary to extend an LOV includes additional full-scale fatigue-test evidence and supporting analysis. The primary source of this test evidence should be full-scale fatigue testing. This testing should follow the guidance contained in appendix 2 of this AC.

<< Change Rationale >>

- To allow analysis supported by test evidence approach for the particular loads which cannot be practically applied in the full-scale fatigue test. (Rationale (2) for guidance change in Section 3.3)

- To clarify a combination of crack growth analysis and a tear down inspection, which is an existing acceptable means of compliance, can be an acceptable means of compliance for demonstration of freedom from WFD. (Rationale (3) for guidance change in Section 3.3)

8. Fatigue Evaluation.

b. Scatter Factor for Safe-life Determination.

(7) Due to the modifications to the flight-by-flight loading sequence caused by these changes, the applicant should propose either analytical or empirical approaches to quantify an adjustment to the number of test cycles which represents the difference between the test spectrum and the assumed flight-by-flight spectrum. In addition, an adjustment to the number of test cycles may be justified by raising or lowering the test-load levels, as long as data support such adjustment. Other effects to consider are different failure locations, different response to fretting conditions, and temperature effects. Applying particular loads, for example thermal cyclic loads, in full-scale fatigue or component test may be impractical. The particular loads, e.g. thermal effects, in a safe life determination can be assessed by analysis supported by test if it can be shown impractical. The analytical approach should either use well-established methods or be supported by test evidence.

<< Change Rationale >>

- To allow analysis supported by test evidence approach for the particular loads which cannot be practically applied in the full-scale fatigue test. (Rationale (2) for guidance change in Section 3.3)

8. Fatigue Evaluation.

e. Environmental effects such as temperature and humidity should be considered in the damage-tolerance and fatigue analysis, and should be demonstrated through suitable testing. Thermal induced load effect due to differential thermal expansion of attached parts should be included in this evaluation.

<< Change Rationale >>

- To describe that thermal induced load between metallic and composite elements due to difference of coefficient of thermal expansion has to be taken into account in DTE. (Rationale (1) for guidance change in Section 3.3)

Appendix 1 References and Definitions

2. Definitions of Terms Used in this AC.

i. Limit of validity (of the engineering data that supports the structural maintenance program) — The period of time (in flight cycles, flight hours, or both), up to which ~~it has been demonstrated by~~ test evidence, analysis and, if available, service experience and teardown inspection results of high-time airplanes, ~~that widespread fatigue damage will not occur in the airplane structure~~ support the structural maintenance program.

- For metallic structures, the demonstration must show that WFD will not occur before the LOV.

- For composite structures, the demonstration must show that any known aging mechanism that degrades the structure below residual strength will not occur before the LOV.

<< Change Rationale >>

- To update the definition so as that it can be adopted to both metallic and composite structure as deleting the sentence which implies LOV is only linking to WFD, since the engineering data other than those related to WFD should be also considered for LOV establishment especially for composite.

Appendix 1 References and Definitions

2. Definitions of Terms Used in this AC.

o. Widespread fatigue damage (WFD) — The simultaneous presence of ~~cracks~~ fatigue damage at multiple structural locations that are of sufficient size and density such that the structure will no longer meet the residual-strength requirements of § 25.571(b).

(1) Multiple site damage (MSD) — A source of widespread fatigue damage characterized by the simultaneous presence of fatigue cracks in the same structural element.

(2) Multiple element damage (MED) — A source of widespread fatigue damage characterized by the simultaneous presence of fatigue cracks in adjacent structural elements.

(3) Structural modification point (SMP) — The point in time when a structural area must be modified to preclude WFD.

(4) Inspection start point (ISP) — The point in time when special inspections of the fleet are initiated due to a specific probability of having a MSD/MED condition.

<< Change Rationale >>

- To update the definition so as that it can be adopted to both metallic and composite structure. And to correct a missing word.

Appendix 2 Full-Scale Fatigue Testing

1. Overview

a. Without intervention, simultaneous fatigue cracking would eventually occur at multiple locations that would be very difficult to detect before the structure strength degrades below required levels. A strategy must be in place to prevent such fatigue cracking from occurring, as mere inspection of these areas is not reliable to maintain continued airworthiness of the airplane. Section 25.571(b) requires the applicant to demonstrate with sufficient full-scale fatigue-test evidence and supporting analysis that WFD will not occur in any susceptible area within the LOV of the airplane.

<< Change Rationale >>

- To allow analysis supported by test evidence approach for the particular loads which cannot be practically applied in the full-scale fatigue test. (Rationale (2) for guidance change in Section 3.3)

- To clarify a combination of crack growth analysis and a tear down inspection, which is an existing acceptable means of compliance, can be an acceptable means of compliance for demonstration of freedom from WFD. (Rationale (3) for guidance change in Section 3.3)

Appendix 2 Full-Scale Fatigue Testing

1. Overview

b. As discussed in section 2 of this appendix, full-scale fatigue-test evidence may be obtained from in-service experience. Testing should involve subjecting a full-scale fatigue-test article to repeated loads followed by an evaluation to determine residual-strength capability. Thermal induced load effects due to differential thermal expansion of attached parts should be considered for damage tolerance and residual strength which can be assessed by analysis supported by test evidence. For new type certificates and derivative models, the applicant should use the results of the evaluation to help establish the LOV for the airplane as discussed in section 7 of this AC.

<< Change Rationale >>

- To describe that thermal induced load between metallic and composite elements due to difference of coefficient of thermal expansion has to be taken into account in DTE. (Rationale (1) for guidance change in Section 3.3)

Appendix 2 Full-Scale Fatigue Testing

2. Full-Scale Fatigue-Test Evidence.

Full-scale fatigue-test evidence, including supporting analysis, in the context of § 25.571 makes up the body of evidence (which may also include service experience) that supports the WFD evaluation for a certification project. It includes data used in determining or bounding the time to develop MSD/MED cracks of a certain size, MSD/MED crack-growth scenarios, and residual-strength capability with MSD/MED cracks present. Types of data include strain-survey results, non-destructive and destructive inspection results, and residual strength test results. The primary source of full-scale fatigue-test evidence is full-scale fatigue testing. The guidelines contained herein should ensure that sufficient test evidence is produced to provide a high degree of confidence that WFD will not occur within the LOV. This involves a laboratory test in which structure that is representative of the type design being considered is subjected to loading that simulates typical service operation. Applying particular loads, for example thermal cyclic loads, in full-scale fatigue or component test may be impractical. The particular loads, e.g. thermal effects can be evaluated by analysis supported by test evidence if it can be shown impractical. The test article may be the entire airframe or a portion of it. A source of data that may supplement full-scale fatigue-test evidence is data from operational airplanes. This “in-service” data includes maintenance findings and results of teardown inspections.

<< Change Rationale >>

- To allow analysis supported by test evidence approach for the particular loads which cannot be practically applied in the full-scale fatigue test. (Rationale (2) for guidance change in Section 3.3)

- To clarify a combination of crack growth analysis and a tear down inspection, which is an existing acceptable means of compliance, can be an acceptable means of compliance for demonstration of freedom from WFD. (Rationale (3) for guidance change in Section 3.3)

Appendix 2 Full-Scale Fatigue Testing

3. Elements of a Full-Scale Fatigue-Test Program.

a. Article.

The test article should be representative of the structure of the airplane to be certificated (i.e., a production article). The test article should be conformed in accordance with 14 CFR 21.23. Attributes of the type design that could affect MSD/MED initiation, growth, and subsequent residual-strength capability should be replicated as closely as possible on the test article. Artificial damage in the test article may cause the structure to be non-representative of the type design, therefore if any artificial damages are induced into the full-scale fatigue test article, the applicant must ensure that the damage will not adversely affect the MSD/MED evaluation. Critical attributes include, but are not limited to, the following:

<< Change Rationale >>

- To address that artificial damage in full-scale fatigue test article may adversely affect WFD evaluation. (Rationale (5) for guidance change in Section 3.3)

Appendix 2 Full-Scale Fatigue Testing

3. Elements of a Full-Scale Fatigue-Test Program.

b. Test setup and loading.

(3) For hybrid structure:

For hybrid structure (e.g., structure that includes a combination of composite and metallic parts and assemblies), guidance for the test loading can be referred to in section 5 of this AC.

<< Change Rationale >>

- To describe necessity of careful assessment regarding difference of fatigue and damage tolerance characteristics between metallic and composite. (Rationale (4) for guidance change in Section 3.3)

Appendix 2 Full-Scale Fatigue Testing

3. Elements of a Full-Scale Fatigue-Test Program.

e. Post-test evaluation.

(2) Teardown inspections. The residual-strength capability may be evaluated indirectly by performing teardown inspections to quantify the size of any MSD/MED cracks that might be present, or to establish a lower bound on crack size based on inspection-method capability. After this is done, the residual-strength capability can be estimated analytically. Depending on the results, crack-growth analyses may also be required to project backward or forward in time to estimate the WFD(average behavior) for an area. As a minimum, teardown-inspection methods should be capable of detecting the minimum size of MSD or MED cracking that would result in a WFD condition (i.e., residual strength degraded to below the level specified in § 25.571(b)).

Effective teardown inspections required to demonstrate freedom from WFD typically require significant resources. They usually require disassembly (e.g., fastener removal) and destruction of the test article. All areas that are susceptible to WFD should be identified and examined. Results obtained from the full scale test tear down may need to be analytically adjusted to reflect particular loading that could not be applied in full-scale fatigue test in a practical manner (e.g. thermal loads). The analysis methods to calculate the induced stress by the particular loading must be supported by test evidence.

<< Change Rationale >>

- To allow analysis supported by test evidence approach for the particular loads which cannot be practically applied in the full-scale fatigue test. (Rationale (2) for guidance change in Section 3.3)

- To clarify a combination of crack growth analysis and a tear down inspection, which is an existing acceptable means of compliance, can be an acceptable means of compliance for demonstration of freedom from WFD. (Rationale (3) for guidance change in Section 3.3)

Appendix 4 Examples of Alterations that May Require Full-Scale Fatigue Testing

1. The following are examples of types of alterations that may require full-scale fatigue testing, or analysis supported by full scale fatigue testing:

a. passenger-to-freighter conversions ~~(including~~ which includes addition of cargo doors~~)~~;

b. gross-weight increases (e.g., increased operating weights, increased zero-fuel weights, increased landing weights, and increased maximum-takeoff weights) to the extent that condition (i) occurs;

c. installation of large fuselage cutouts (e.g., passenger-entry doors, emergency-exit doors or crew-escape hatches, fuselage-access doors, and cabin-window relocations);

d. complete re-engine or pylon alteration to the extent that condition (i) occurs;

e. engine-hush kits to the extent that condition (i) occurs;

f. wing alterations ~~(e.g.,~~ such as installation of winglets~~;~~ or changes in flight-control settings ~~such as~~ (flap droop), ~~;~~ and alteration of wing trailing-edge structure~~)~~ to the extent that condition (i) occurs;

g. modified ~~or replaced~~ skin splice;

h. any alteration that affects three or more stiffening members (e.g., wing stringers and fuselage frames);

i. an alteration that results in or from operational-mission change~~, which~~ that significantly changes the original equipment manufacturer's ~~load/stress~~ load or stress spectrum (e.g., extending the flight duration from 2 hours to 10 hours); and

j. an alteration that changes areas of the ~~fuselage from being externally inspectable using visual means to being uninspectable~~ structure that prevents external visual inspection (e.g., installation of a large, external, fuselage doubler that results in hiding details beneath it).

<< Change Rationale >>

- To update the languages into more appropriate words for the examples of alterations which may require full-scale fatigue testing. (Rationale (6) for guidance change in Section 3.3)

C.3 Example of Guidance Change, AC120-104

AC120-104 ESTABLISHING AND IMPLEMENTING LIMIT OF VALIDITY TO PREVENT WIDESPREAD FATIGUE DAMAGE

APPENDIX 2

DEFINITIONS

Limit of validity (of the engineering data that supports the structural maintenance program)—The period of time (in flight cycles, flight hours, or both), up to which ~~it has been demonstrated by~~ test evidence, analysis and, if available, service experience and teardown inspection results of high-time airplanes, ~~that widespread fatigue damage will not occur in the airplane structure~~ support the structural maintenance program.

- For metallic structures, the demonstration must show that WFD will not occur before the LOV.

- For composite structures, the demonstration must show that any known aging mechanism that degrades the structure below residual strength will not occur before the LOV.

Widespread fatigue damage (WFD)—The simultaneous presence of ~~cracks~~ fatigue damage at multiple structural locations that are of sufficient size and density that the structure will no longer meet the residual strength requirements of § 25.571(b).

<< Change Rationale >>

- To update the definition so as that it can be adopted to both metallic and composite structure. For the LOV, by deleting the sentence which implies LOV is only linking to WFD, since the engineering data other than those related to WFD should be also considered for LOV establishment especially for composite.

C.4 Example of Guidance Change, AC20-107B

AC20-107B Composite Aircraft Structure

6. Material and Fabrication Development.

d. Environmental Considerations.

(2) Depending on the design configuration, local structural details, and selected processes, the effects of residual stresses that depend on environment must be addressed (e.g., differential thermal expansion of attached parts).

(a) Local and global loads develop due to thermal expansion of dissimilar materials of attached parts. These loads should be accounted for in static, fatigue and damage tolerance analysis and more detail is covered in those sections. Temperatures used in thermal analysis should be supported by test evidence.

<< Change Rationale >>

- To describe that thermal induced load between metallic and composite elements due to difference of coefficient of thermal expansion has to be taken into account in DTE. (Rationale (1) for guidance change in Section 3.3)

8. Proof of Structure – Fatigue and Damage Tolerance.

a. Damage Tolerance Evaluation.

(2) Structure details, elements, and subcomponents of critical structural areas should be tested under repeated loads to define the sensitivity of the structure to damage growth. This testing can form the basis for validating a no-growth approach to the damage tolerance requirements. The testing should assess the effect of the environment on the flaw and damage growth characteristics and the no-growth validation. The environment used should be appropriate to the expected service usage. Local ~~Residual~~ residual stresses will develop at the interfaces between composite and metal structural elements in a design due to differences in thermal expansion, and this may also induce global thermal loading which should be accounted for in the internal loads. ~~This component~~ These components of stress will depend on the service temperature during repeated load cycling and ~~is~~ should be considered in the damage tolerance evaluation. Applying thermal cyclic loads in full-scale fatigue test may be impractical, therefore thermal effect on structural elements can be assessed by fatigue testing supported by thermal stress analysis. Lower level static tests (up to component) under controlled non cyclic temperature conditions can provide information on thermal induced loads. Temperature field may be validated by flight test measurement. Inspection intervals should be established, considering both the likelihood of a particular damage and the residual strength capability associated with this damage. The intent of this is to assure that structure is not exposed to an excessive period of time with residual strength less than ultimate, providing a lower safety level than in the typical slow growth situation, as illustrated in figure 4.

<< Change Rationale >>

- To describe that thermal induced load between metallic and composite elements due to difference of coefficient of thermal expansion has to be taken into account in DTE. (Rationale (1) for guidance change in Section 3.3)

- To allow analysis supported by test evidence approach for the particular loads which cannot be practically applied in the full-scale fatigue test. (Rationale (2) for guidance change in Section 3.3)

8. Proof of Structure – Fatigue and Damage Tolerance.

a. Damage Tolerance Evaluation.

(1)(c)(iii) Category 3: Damage that can be reliably detected within a few flights of occurrence by operations or ramp maintenance personnel without special skills in composite inspection. Such damage must be in a location such that it is obvious by clearly visible evidence or cause other indications of potential damage that becomes obvious in a short time interval because of loss of the part form, fit or function. Both indications of significant damage warrant an expanded inspection to identify the full extent of damage to the part and surrounding structural areas. In practice, structural design features may be needed to provide sufficient to ensure limit or near limit load is maintained with easily detectable, Category 3 damage. Structural substantiation for Category 3 damage includes demonstration of a reliable and quick detection, while retaining limit or near limit load capability. The primary difference between Category 2 and 3 damages are the demonstration of large damage capability at limit or near limit load for the latter after a regular interval of time which is much shorter than the former. The residual strength demonstration for Category 3 damage may be dependent on the reliable short time detection interval. Some examples of Category 3 damage include large VID or other obvious damage that will be caught during walk-around inspection or during the normal course of operations (e.g., fuel leaks, system malfunctions or cabin noise). As an example for substantiation methods (but are not limited to), Category 3 damages can be addressed by removal or cutting of singular structural elements to ensure coverage of unexpected damages or events outside of normal operations.

<< Change Rationale >>

- To incorporate an industry practice as a Category 3 damage simulation.

8. Proof of Structure – Fatigue and Damage Tolerance.

a. Damage Tolerance Evaluation.

(2) (a) The traditional slow growth approach may be appropriate for certain damage types found in composites if the growth rate can be shown to be slow, stable and predictable. The slow growth approach should not be considered as the comprehensive damage tolerance method for the airframe but as an approach for certain details where this may be beneficial or a way of addressing in-service issues for structure demonstrating slow growth behavior. Slow growth characterization should yield conservative and reliable results. As part of the slow growth approach, an inspection program should be developed consisting of the frequency, extent, and methods of inspection for inclusion in the maintenance plan. Inspection intervals should be established such that the damage will have a very high probability of detection between the time it becomes initially inspectable and the time at which the extent of the damage reduces the residual static strength to limit load (considered as ultimate), including the effects of environment. For any detected damage size that reduces the load capability below ultimate, the component is either repaired to restore ultimate load capability or replaced. Should functional impairment (such as unacceptable loss of stiffness) occur before the damage becomes otherwise critical, part repair or replacement will also be necessary.

(2) (b) Another approach involving growth may be appropriate for certain damage types and design features adopted for composites if the growth can reliably be shown to be predictable and arrested before it becomes critical. Figure 5 shows schematic diagrams for all three damage growth approaches applied to composite structure. The arrested growth method is applicable when the damage growth is mechanically arrested or terminated before becoming critical (residual static strength reduced to limit load), as illustrated in figure 5. Arrested growth may occur due to design features such as a geometry change, reinforcement, thickness change, or a structural joint. This approach is appropriate for damage growth that is inspectable and found to be reliably arrested, including all appropriate dynamic effects. The arrested growth approach should not be considered as the comprehensive damage tolerance method for the airframe but as an approach for certain details where this may be beneficial or a way of addressing in-service issues for structure demonstrating arrested growth behavior. Structural details, elements, and subcomponents of critical structural areas, components or full-scale structures, should be tested under repeated loads for validating an arrested growth approach. As was the case for a "no growth" approach to damage tolerance, inspection intervals should be established, considering the residual strength capability associated with the arrested growth damage size (refer to the dashed lines added to figure 5 to conceptually show inspection intervals consistent with the slow growth basis). Again, this is

intended to ensure that the structure does not remain in a damaged condition with residual strength capability close to limit load for long periods of time before repair. For any damage size that reduces load capability below ultimate, the component is either repaired to restore ultimate load capability or replaced.

<< Change Rationale >>

- To incorporate certification and industry practice for DTE of composite structures.

Appendix 2 Definitions

X. Limit of Validity of the engineering data that supports the structural maintenance program (LoV): The period of time (in flight cycles, flight hours, or both), up to which test evidence, analysis and, if available, service experience and teardown inspection results of high-time airplanes, support the structural maintenance program.

- For metallic structures, the demonstration must show that WFD will not occur before the LOV.

- For composite structures, the demonstration must show that any known aging mechanism that degrades the structure below residual strength will not occur before the LOV.

X. Widespread fatigue damage (WFD) — The simultaneous presence of fatigue damage at multiple structural locations that are of sufficient size and density such that the structure will no longer meet the residual-strength requirements of § 25.571(b).

<< Change Rationale >>

- To update the definition so as that it can be adopted to both metallic and composite structure. For the LOV, by deleting the sentence which implies LOV is only linking to WFD, since the engineering data other than those related to WFD should be also considered for LOV establishment especially for composite.

Appendix D Aging Bibliography

A bibliography survey has been compiled as a complement to OEM practices to illustrate the methodologies developed to address compliance to the requirements stated in the 14 CFR and CS 25.6XX series and further detailed in the AC 20-107B §-6(d), (e), (f), (g) and §7 (a) and §8.

It can be summarized that:

The more sensitive parameters affecting composite materials are Humidity and Temperature (Mathilde Vellas Ph D Bibliography analysis on composite aging phenomenon : Vellas, M., Fualdes, C., Morley, J.E. et al. Aeroaging – A new collaboration between life sciences experts and aerospace engineers. J Nutr Health Aging (2017) 21: 1024. *)*

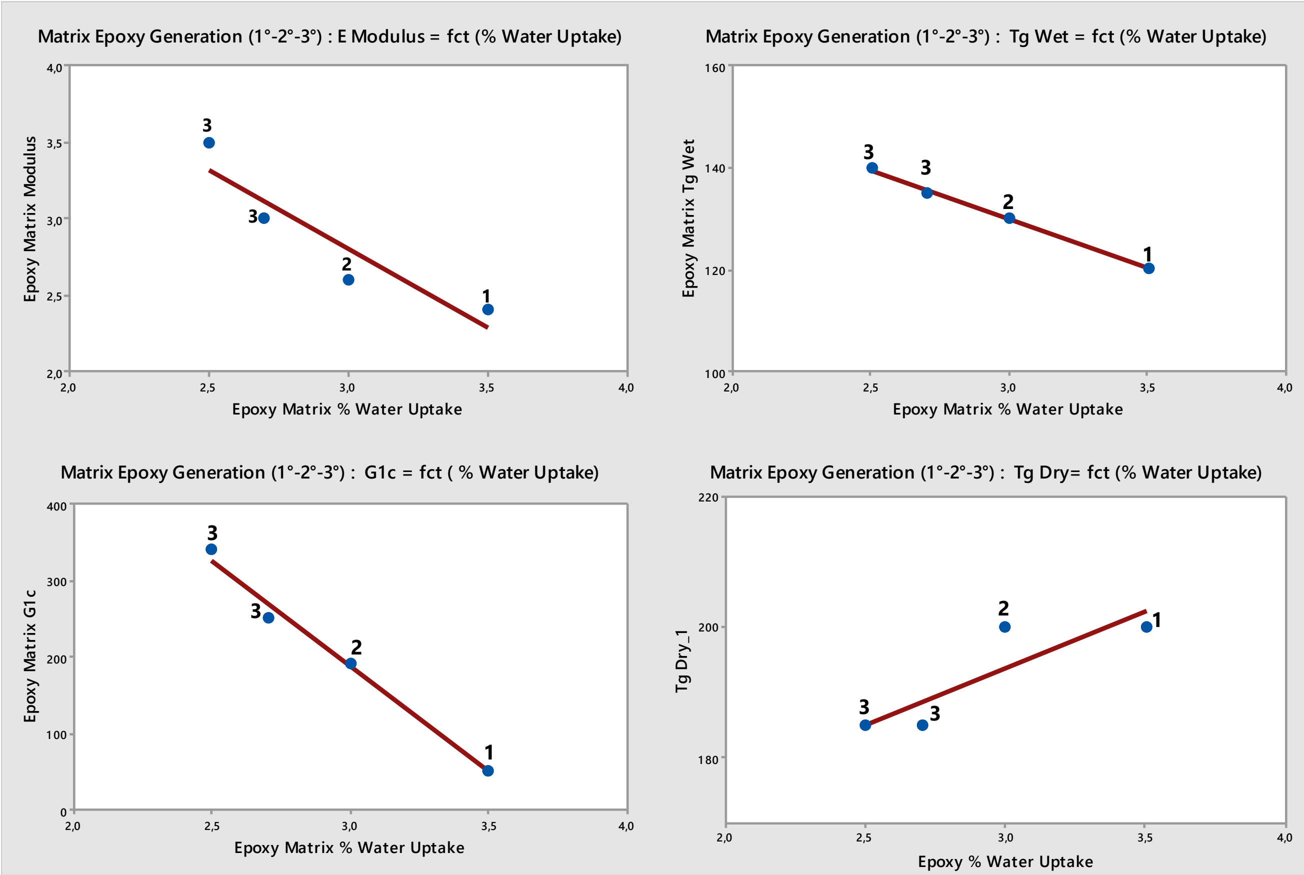
Aging is defined as a slow alteration of a material chemical or physical structure by the simple effect of time or by special environment to which it is exposed. These constraints have a detrimental effect on the material properties. It leads to gradual loss of the design function and ultimate failure or unacceptable loss of efficiency [David 2009]. Aging may be broadly categorized by three primary mechanisms: chemical, physical and mechanical. The interaction between these three areas is highly dependent on two variables: material characteristics and aging environment [Gates 2008]. The long-term properties of composite materials, when exposed to a combination of in-service loads and environments have to be characterized.

Three main characteristics from composite material suppliers have been deeply studied to improve the intrinsic epoxy matrix performances by progressively reducing detrimental effects:

- Improve the intrinsic E modulus of epoxy resin to reduce drop of performance in compression mode (one of the weakest points in composite design) in order to reduce buckling effect between matrix and fiber during compression loading.
- Improve intrinsic toughness of epoxy matrix resin itself and reduce its sensitivity to damage tolerance and crack propagation (moving from brittle → tough behaviour).
- Improve resistance towards water/humidity ingression in epoxy/carbon composite part to reduce the knock-down effect due to aging effect. Even if it has been demonstrated that this effect is reversible and are following typical Fick's Law and Langmuir's for water absorption behavior, the reduction of sensitivity of epoxy matrix against water absorption are improving material performance.

On the graphs below (extracted from '2017 Seminar Entretien de Toulouse Hexcel /AI) it is highlighted that the key evolutions of epoxy resin systems which have been moved progressively from:

- 1st generation (year 1970-80') where "simple" epoxy resin + hardener have been used and exhibited good temperature resistance but were a quite "brittle" material.
- 2nd generation (year 1980-2000') with epoxy + hardener + dissolved thermoplastic which improve intrinsic matrix toughness and reduce brittleness of overall composite material and improve the damage tolerance.
- 3rd Generation (2000's year + onward) where in the epoxy matrix, insoluble thermoplastic has been introduced to further increase the damage tolerance performance (by created a controlled interleave thermoplastic layer between ply layer in the final composite laminate part) and also reducing the sensitivity to potential water ingression in final composite properties.



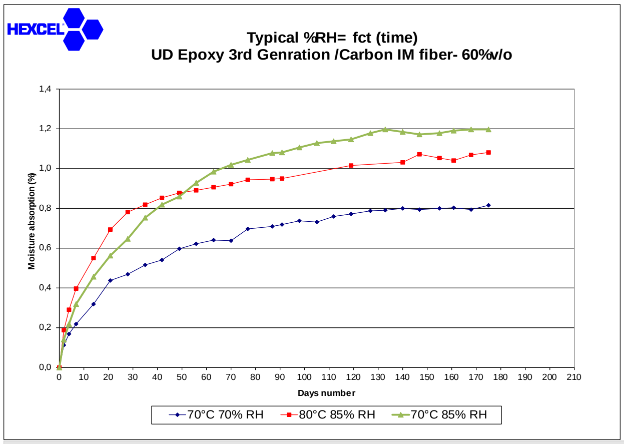
Main evolution of composite materials from Generation 1, Generation 2 and Generation 3

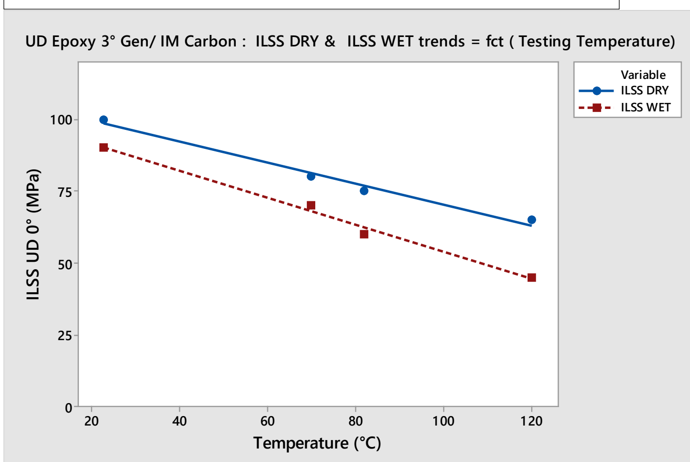
As highlighted in the above graphs, moving epoxy matrix from 1st generation to 3rd generation, have brought the following increasing performances on neat epoxy resin performances:

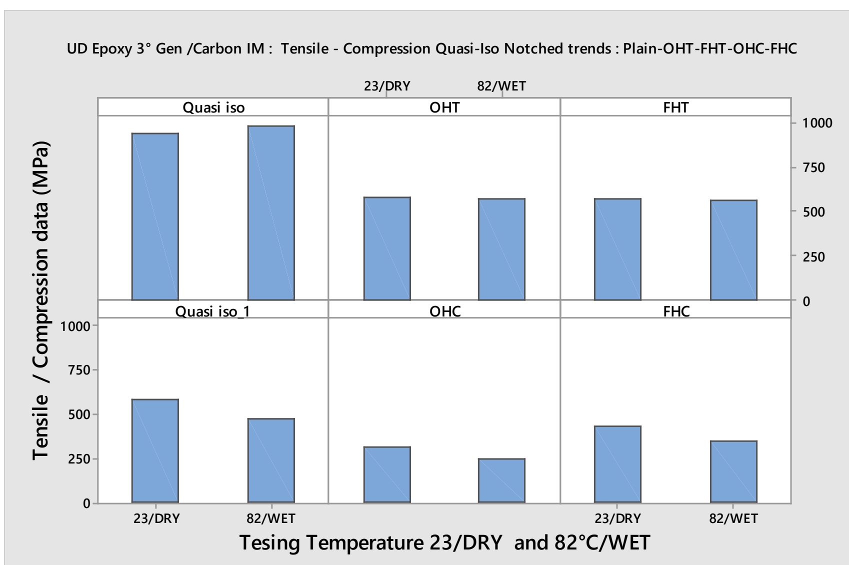
- E matrix modulus improvement of about **+30%**
- Toughness improvement by a factor of **7**
- Water sensitivity reduced close to **50%**

These achievements have directly translated into composite material performance improvements, specifically on aging after saturation level and hot/wet design performances, like static properties and un-notched and notched design values (OHT -Open Hole Tension; FHT- Filled Hole Tension; OHC Open Hole Compression; FHC – Filled Hole Compression as per graphs below).

Aging effect on hot/wet performances design for generation 3







Aging phenomenon is intrinsic to Composite material environmental effects, a definition is proposed to be added in AC 20-107 B

For long term exposure evaluation (moisture effects, temperature, UV, etc.) standardized manufacturer approaches have been developed and are commonly used as referenced by most of the CFRP materials suppliers.

Procedures for developing material design values and manufacturing process qualification up to worst environmental conditions have been calibrated by a sampling approach, retrieving parts from in service operations.

- Artificial accelerated ageing, used in material evaluation, up to humidity saturation level (set as critical humidity limit), is conservatively demonstrated compared to in service life exposure. An artificial climatic chamber (85% RH, 60-70 °C) was used as test procedure (CMH 17, Vol. 3 §4) for material reduction in static strength. Results are published in this paper.

- Maximum operating limits are compared to material Glass transition temperature (Tg °C). (Practices are described in CMH17 Vol3, §3), for typical guidelines.

- Exposure to different types of fluids (salt, oil, MEK, Kerosene, hydraulic fluids)

- Thermal cycling effect on strength characteristics (cold to hot).

In addition, good design practices (finishes), provide suitable protection against degradation in material properties.

A summary of publications either from Boeing or Airbus of investigations performed on aircraft retired from 15, 18 to 20 years of service operation: tear down and mechanical testing results have shown no degradation in performance compared to baseline capability established at time of certification.

From Boeing:

- 108 B737 spoilers, investigated after 15 years of service, no significant strength loss (see ref 1).

- Two B737 horizontal stabilizers that were in commercial service for 18 years. No noticeable or measurable degradation in material characteristics of interest. (see ref 2).

- B777 horizontal stabilizer, where long term exposure of panels attached to racks in several locations have been tested, and the result compared to baseline data (see CMH17-3G, §12.8.2.2).

From Airbus Industries:

- Five Airbrakes on A300B from Air France ref (4): They were tested up to rupture, showing no evolution compared to the strength level demonstrated initially after 5 to 17 years of real flight. Also no noticeable degradation in material characteristics. Max moisture content of 0.9% was below values using accelerated aging -85%RH, 70°c) considered during certification (from 60 to 71% [Relative Humidity]). No growth of damage was found during this campaign.

- One A320 horizontal stabilizer fabricated using F593-T300 ref [3]: 60000FC, 20 years. Moisture content is below certification baseline.

- One V10F wing for at least 18 years on ATR72 F098 manufactured with T300/914 (ref [5]). The airplane was flown beyond its design service goal with no detrimental effects from any damage accumulated on the aircraft. An investigation revealed that the maximum moisture content was below the amount used for accelerated aging in certifying the airplane (1.0% instead of 1.3%).

- One vertical fin on A300-600, in support of an accident investigation report of AA587. Ref [6] provide no strength deterioration in high loaded introduction area after ageing, repetitive loading and high peak loads.

The material systems have evolved since the mid 1980's, which is when these parts were built. However, the resin systems have not evolved too much since then. Thus we can still claim long term durability related to ageing degradation.

In conclusion for durability:

The material and fabrication qualification described in AC20-107B show explicitly what should be considered either in development or production control: §6 d (1) provides all guidance to be supported by experimental evidence and on the evaluation of effects of environmental cycling, including accelerated test methods that can be found in the CMH-17 handbook.

Manufacturers must account for all effects of environmental degradation that is expected in service when designing composite airplane structure.

Additional design and manufacturing considerations may be required to reduce the likelihood of water ingression.

Based on surveys of aircraft structure, aging related strength degradation has been found mainly on movable surfaces (e.g., rudder, elevator) and secondary structure, such as landing gear doors and aerodynamic fairings. These issues were corrected by design improvements.

A survey within the working group also revealed undesirable service experience associated with sandwich honeycomb construction. The working group determined that the root cause of the problems incurred were related to water ingress susceptibility due to thin-walled sandwich construction and insufficient robustness against low energy accidental impacts:

> Water ingress, in sandwich construction, occurs when at least one skin is insufficiently watertight, either from design selection or the manufacturing processes selected. The operational ground-air-ground cycling increases the fluid ingestion in the facesheet itself and or in the honeycomb core through the facesheet, accelerating the strength degradation.
>
> Water ingress will occur after a certain amount of time is spent on the ground or at cruise altitude. When there is no differential pressure between the inside and outside of the honeycomb, transient conditions will occur during climb and descent.
>
> During the descent phase, when the pressure is lower inside the honeycomb, water, condensation on the skin can be sucked into the structure with no irreversible effect during the following climb.

In July 2012, a significant event occurred on an Air Transat Airbus Model A310-300 airplane (flight 961) that caused the pilots to perform an inflight turn-back to the airport. After landing, investigations revealed most of the rudder structure to be missing.

Aviation Investigation Report A05F0047XYZ (reference [7]) provides conclusions on what was the most likely failure scenario. Those conclusions are provided below.

> "Some time before the occurrence flight, a disbond or in-plane core fracture occurred. The cause of this initial damage may have been a discrete event or a weak bond at the z-section. An indication of weak bonding was found at the z-section along the interior lower front of the left side panel. This damage then grew, possibly due to reduced pressure cycling loads associated with normal flight, without detection until it reached a critical size. During the occurrence flight, having reached the critical size, the damage rapidly propagated, resulting in a loud and sudden explosion of the skin. The resulting sudden reduction in torsional stiffness led to the onset of rudder flutter. About one second later, there was a large aft and downward force associated with failure of the upper hinge points, as the rudder separated. The rudder-separation event lasted about seven seconds, after which only 16 per cent of rudder effectiveness remained. During the remainder of the flight, more rudder pieces separated, and the aircraft landed with no aerodynamically effective rudder remaining."

Design experience applied on sandwich technologies used on landing gear door and movable surfaces (elevator, rudder) show an improved resistance to water ingression of the pre-cured skin by co-curing an adhesive film on the surface. In addition, fabrication must take care when using one shot processes (co-curing) if selected (low pressure curing), and often prefer a two-phase process with pre-cured outer skins. To improve resistance to water ingression, you should consider the following:

- Use, as far as necessary, a waterproof interlay thermoplastic film between the skin and the honeycomb and a waterproof film in the inner skin of the sandwich structure
- Improve design by avoiding inserts or blind fasteners in the honeycomb core
- Perform, to qualify the process/design, tightness tests by simple immersion in hot water (submersion leak testing).

- Ref [1]: 737 graphite composite flight spoiler flight service evaluation NASA –CR-178322
- Ref [2] Durability and Aging of Composite Aircraft Structures, John Tomblin, Lamia Salah and Dan Hoffman, 22 August 2011
- Ref [3] Analyse du vieillissement d'un HTP composite tissu A320 fin de vie, Alain Vinet, Sorez 6-8 Octobre 2014
- Ref [4] Vieillissement et propriétés résiduelles de matériaux issus du démantèlement d'avions en fin de vie, Fabien Billy, Poitiers, 2013.
- Ref [5] Expérimentation en service des aérofreins carbone sur A300 Air France, marche DGA 94/22 206 and CMH17-Vol4 §14)
- Ref [6] NTSB/AAR-04/04 adopted October 26, 2004

- Ref [7] AVIATION INVESTIGATION REPORT A05F0047, Loss of rudder in flight, Air Transat A310

Appendix E Inspection Threshold AC *Example Text*

j. Threshold for Inspections. ***25.571-1D Rev***

~~(1) Where it can be shown by observation, analysis, and/or test that a load path failure in multiple load path "fail-safe" structure or partial failure in crack-arrest "fail-safe" structure will be detected and repaired during normal maintenance, inspection, or operation of an airplane prior to failure of the remaining structure, the thresholds can be established using either:~~

~~(a) Fatigue analysis and tests with an appropriate scatter factor; or~~

~~(b) Slow-crack-growth analyses and tests, based on appropriate initial manufacturing damage.~~

~~(2) For single load path structure and for multiple load path and crack-arrest "fail-safe" structure where it cannot be demonstrated that load path failure, partial failure, or crack arrest will be detected and repaired during the normal maintenance, inspection, or operation of an airplane prior to failure of the remaining structure the thresholds should be established based on crack-growth analyses and/or tests, assuming the structure contains an initial flaw of the maximum probable size that could exist as a result of manufacturing or service-induced damage.~~

(1) The inspection threshold is the point in time at which the first planned structural inspection is performed following entry into service. The threshold may be as low as the repeat interval, or may allow for a significant period of operation before inspections are started. The concept of an inspection threshold exceeding the repeat interval is based on the premise that it will take a certain amount of time before damage would progress to a size that would be detectable during a structural inspection. Consequently, it may be acceptable to wait some period of time before starting to inspect for damage. Nevertheless, the inspections should begin early enough to ensure that there is a high reliability of confidently detecting the damage before catastrophic structural failure. This includes cases where the structure is of a lower bound manufacturing quality and is also reflective of expected service damage. #4 #1

Thresholds can be established based on either:

a) Fatigue methodology that has been substantiated directly by test or analysis substantiated by representative test or in service data
b) Damage-growth analyses that has been substantiated by representative test or in service data

For Damage-growth analyses the assumed initial flaw chosen must be recognized to produce conservative results. Historically starting flaw sizes such as 10 times the size of the manufacturing flaw size established at 90% reliability and 95% confidence assuming log-normal distribution have been used, or use 0.05" if no other data is available. Refer to AC 91-82A, Fatigue Management Programs for In-Service Issues for additional referenced background and guidance on establishment of initial flaw size. #5

The fatigue or damage growth based inspection thresholds to detect damage before catastrophic structural failure are to be established at target reliability and confidence levels that are reflective of:

- Structure type (e.g. SLP vs MLP integral vs MLP built up)
- Exposure and susceptibility to damage
- Inspectability (visually detectable or is special equipment required)
- Material scatter (characteristic capturing the inherent variation in a materials performance)
- Manufacturing process variation #4

#2

This may result in different reliability and confidence assigned to the various parts of the aircraft. As an example, the following single load path item would require a higher reliability target than the multi load path item:

- A single load path steel part with limited manufacturing controls, which could fail with non-obvious damage
- A portion of multi load path aluminum structure manufactured using controlled processes and is supported by inspections that would show obvious damage, such as by fuel leakage

(2) The process of normal maintenance is carried out from the entry of the aircraft into service. There is no associated threshold for normal maintenance inspections. In order to establish a condition where no special inspections are required, the results of the damage tolerance evaluations are needed to demonstrate that normal maintenance inspections (including those for ED and AD) are adequate in scope and interval to prevent a catastrophic failure. Those normal maintenance inspections should be listed or referenced in the ALS as being necessary to prevent fatigue damage and the intervals controlled as or when required. #3

An example of where no special inspection is required would be when:

(i) the critical damage size is greater than readily detectable damage size that can be found during a Zonal Inspection, and

(ii) the time from detectable to critical is greater than the GVI interval.

Appendix F Damage Tolerance Evaluation (DTE) Results

1. TITLE: A descriptive title of the PSE that is to be inspected.
2. Damage Threat: The damage threat should identify which of the damage threats cited in 14 CFR 25.571 are addressed by this task
    a. Fatigue
    b. Corrosion/Environmental deterioration
    c. Accidental Damage
    d. Manufacturing Flaw
3. ALI NUMBER: A set of numbers, letters or symbols that can be used to track the different required inspections. This tracking number should include an ATA code for ease of tracking. For alterations and repairs, the tracking number should be different from the OEM tracking numbers. Even if there is only one inspection associated with an alteration or repair, an identifying number should be used for the inspection.
4. AFFECTED INSPECTIONS: For alterations and repairs, this should include but not be limited to the following.
    a. A list of affected inspections (such as ALI, SSID or AD driven inspections) including specific document numbers and specific affected inspections.
    b. A statement indicating if the affected inspections are superseded or supplemented by the added inspections.
    c. If the DTE concludes that the repair or alteration does not affect any existing inspections, the DTI documentation should include a statement that the repair or alteration does not affect any existing inspections.
    d. An AMOC statement, as required.
5. REQUIRED MANUALS: A list of all the manuals required to accomplish the inspections. This should include but not be limited to all NDT manuals as well as any maintenance manuals for access or disassembly. This list should include the revision level and/or if applicable later revisions.
6. TIME LIMIT: This should include but not be limited to the following.
    a. A time limit for when repairs or components must be replaced or reworked in cycles, flight hours or elapsed time.
    b. Specify whether it is applicable to an aircraft or for a specific removable structural component.
    c. If more than one type of threshold and/or interval is indicated, specify as to whether it is whatever occurs earlier or later.
    d. Specify when the threshold is from.
    e. As required, there should be instructions to deal with components that are not currently tracked and have an unknown number of hours and cycles.
7. REQUIRED NDI TOOLING: This section should provide the specific part numbers for any tooling and/or standards required to accomplish the inspection. This list should include but not be limited to items such as LFEC standards and ultrasonic inspection standards.
8. INSPECTION THRESHOLD: This should include but not be limited to the following.
    a. An Inspection threshold in cycles, flight hours or elapsed time.
    b. Specify whether it is applicable to an aircraft or for a specific removable structural component.
    c. If more than one type of threshold and/or interval is indicated, specify as to whether it is whatever occurs earlier or later.
    d. Specify when the threshold is from.
    e. As required, there should be instructions to deal with components that are not currently tracked and have an unknown number of hours and cycles.
9. INSPECTION INTERVAL: This should include but not be limited to the following.

   a. This section should provide an Inspection interval in cycles, flight hours or elapsed time.
   b. This inspection period should indicate if it is applicable to an aircraft or for a specific removable structural component.
   c. If provided in the form of a graph with different inspection options, the graph (especially with LOG graphs) should be of sufficient size and resolution to prevent large errors in reading the graph and any limits to the use of this graph must be specifically provided for each inspection.
10. ACCESS REQUIREMENTS: This section should contain but not limited to the following.
   a. Zones and aircraft coordinates.
   b. A list of access panels that must be removed, including a reference to maintenance manuals for the removal of the panels.
   c. Any disassembly procedures and/or disassembly manual references.
11. DESCRIPTION: This section should provide but not be limited to the following information.
   a. Identification of all the parts to be inspected including part numbers and effectivities as necessary.
   b. An Indication of the direction and/or surface to be inspected as well as the location of the critical details to be inspected.
   c. A specific Non Destructive Inspection (NDI) method that includes a specific manual or document section. If no manual or document exists, then the specific inspection procedures should be provided in the DTE document. These NDI procedures should be the same procedures that were the basis of the probability of detection utilized in the DTI.
   d. A reference to the use of any required NDT tooling including specific part numbers.
12. INSPECTION ILLUSTRATION: These sketches should include but not limited to the following.
   a. A set of inspection illustrations that accurately portray the structure to be inspected.
   b. Identification of the Non Destructive Inspection (NDI) method to be utilized for each detail.
   c. Identification of the parts to be inspected.
   d. Identification of the direction/surface to be inspected
   e. A sketch that shows the location of critical details to be inspected.

1. Title:	
2. Damage Threat: ***EXAMPLE – Fatigue***	**3. ALI No.**
4. AFFECTED INSPECTIONS: ***EXAMPLE – The detailed visual inspection required by AD xxxx-xx-xx, Paragraph x is superseded by this LFEC inspection.***	**5. REQUIRED MANUALS:**

6. TIME LIMIT: ***EXAMPLE – Replace xx-xx-xx doubler prior to the accumulation of xx,xxx aircraft cycles after installation.***	**7. REQUIRED NDI TOOLING:**
8. THRESHOLD: ***EXAMPLE – xx,xxx total aircraft cycles after aircraft original manufacturing date.***	**9. INTERVAL*:* *EXAMPLE – xx,xxx aircraft cycles***
10. ACCESS REQUIREMENTS:	
11. DESCRIPTION:	
12. INSPECTION ILLUSTRATION: ***EXAMPLE – VIEW LOOKING FROM OUTSIDE AIRCRAFT***	

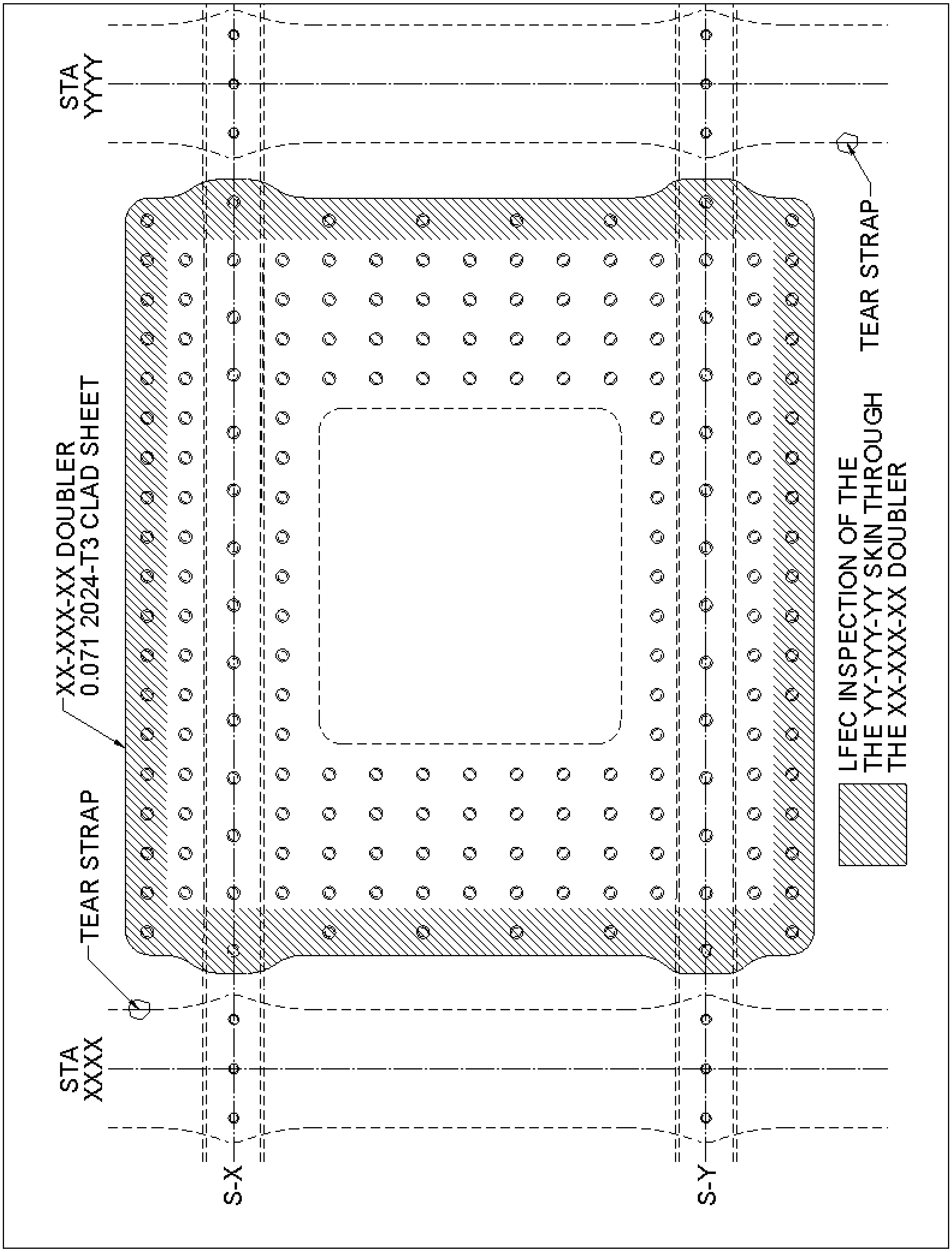


Figure Appendix F-1: ILLUSTRATION OF INSPECTION FIGURE

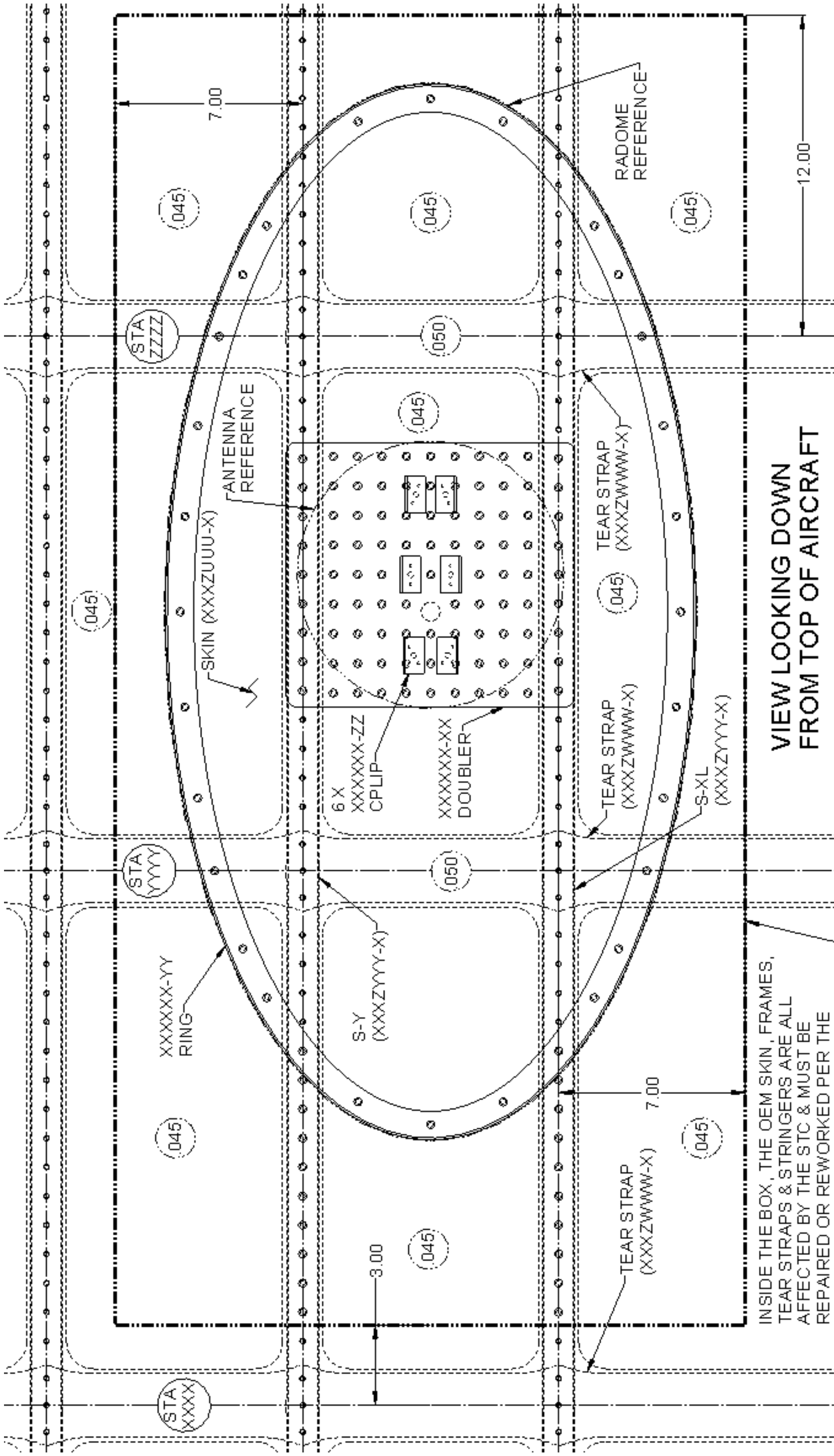


Figure Appendix F-2: ILLUSTRATION OF IDENTIFICATION OF STC AFFECTED AREA

Appendix G Structural Inspections and the ALS

The following background information is provided to support the recommendations given in the main report, paragraph 3.8.

G.1 Damage Tolerance Evaluations

The requirement to create an ALS that includes the inspections and procedures resulting from the Damage Tolerance Evaluation (DTE) was introduced by Amdt. 25-54 of Part 25 in 1980. The evaluations are required to consider fatigue, accidental and environmental damage. In the disposition of comments related to the HEWABI policy memo, the FAA pointed to the requirement to consider accidental damage as the basis for addressing HEWABI conditional inspections under the damage tolerance rule. The following compiles the current requirements and highlights aspects required to address accidental damage.

Pertinent sections of 25.571 at Amdt. 25-132

> ***(a)****General. An evaluation of the strength, detail design, and fabrication must show that catastrophic failure due to fatigue, corrosion, manufacturing defects, or accidental damage, will be avoided throughout the operational life of the airplane. This evaluation must be conducted in accordance with the provisions of paragraphs (b) and (e) of this section, except as specified in paragraph (c) of this section, for each part of the structure that could contribute to a catastrophic failure (such as wing, empennage, control surfaces and their systems, the fuselage, engine mounting, landing gear, and their related primary attachments)*
>
> ***(3)*** *Based on the evaluations required by this section, inspections or other procedures must be established, as necessary, to prevent catastrophic failure, and must be included in the Airworthiness Limitations section of the Instructions for Continued Airworthiness required by § 25.1529.*
>
> ***(b)****Damage-tolerance evaluation. The evaluation must include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage.*

For metallic airplane structures, the MSG-3 process is the primary means used to address accidental damage as described in AC 25.571-1D:

> *Comparison with past successful practice is the primary means of substantiating inspections or other procedures for accidental and environmental damage. For a new-model transport category airplane, the Maintenance Review Board generally conducts such comparison to substantiate inspections or other actions using the Air Transport Association of America, Inc. (ATA) Maintenance Steering Group's MSG-3 or other accepted version of the "Operator/Manufacturer Scheduled Maintenance Development" procedures.*

This process is detailed in Appendix G.4.

For composite airplane structures, the evaluation process for accidental damage is defined for Category 2 Damage in AC 20-107B:

> ***Category 2:*** *Damage that can be reliably detected by scheduled or directed field inspections performed at specified intervals. Structural substantiation for Category 2 damage includes demonstration of a reliable inspection method and interval while retaining loads above limit load capability. The residual strength for a given Category 2 damage may depend on the chosen inspection interval and method of inspection. Some examples of Category 2 damage include visible impact damage (VID), VID (ranging in size from small to large), deep gouges or scratches, manufacturing mistakes not evident in the factory, detectable delamination or debonding, and major local heat or environmental degradation that will sustain sufficient residual strength until found. This type of damage should not grow or, if slow or arrested growth occurs, the level of residual strength retained for the inspection interval is sufficiently above limit load capability.*

The outcome of these evaluation processes is a scheduled maintenance program of periodic inspections. The probable damage scenarios are defined in the guidance materials, as are the means to address damage growth and residual strength.

Additional requirements are necessary for composite materials after rare high-load events. These are defined for Category 4 and 5 Damage in AC20-107B:

> *Due to the nature of service events leading to Category 4 damage, suitable inspections will need to be defined to evaluate the full extent of damage, prior to subsequent aircraft repair and return to service. By definition, Category 5 damages do not have associated damage tolerance design criteria or related structural substantiation tasks. Category 5 damage will require suitable inspections based on engineering assessment of the anomalous service event, and appropriate structural repair and/or part replacement, prior to the aircraft re-entering service.*

These instructions highlight the need for the development of conditional inspections to establish the extent of damage following such events. Furthermore, the instructions clearly state that the evaluation of Category 5 damage is not part of the DTE.

G.2 ALS History And Objective

The requirement to create an ALS that includes the inspections and procedures resulting from the Damage Tolerance Evaluation (DTE) was introduced by Amdt. 25-54 of Part 25 in 1980. At that time, the focus of the DTE was on the evaluation of fatigue damage in metallic structures.

Guidance describing the objective of the ALS was limited to inspections finding crack-like defects. There were no criteria developed to review the underlying elements of the DTE and the associated maintenance tasks with respect to the ALS. Therefore, industry practice evolved to generally view fatigue damage as an ALS requirement, while inspections for accidental and environmental damage remained primarily in the baseline schedule maintenance in the ICA.

Part 25, Appendix H, H25.4:

(a) The Instructions for Continued Airworthiness must contain a section titled Airworthiness Limitations that is segregated and clearly distinguishable from the rest of the document. This section must set forth—

> *(1) Each mandatory modification time, replacement time, structural inspection interval, and related structural inspection procedure <u>approved under §25.571</u>.*

FAA Disposition of Public Comments to Amdt. 25-54:

For example, the proposed Airworthiness Limitations section on a transport category airplane must contain mandatory inspection intervals and related procedures because the damage-tolerance concept described in Sec. 25.571 is predicated upon the use of such inspections to detect <u>initial cracks in principal structural elements before crack growth under repeated loads could progress to a degree which would cause catastrophic failure of the airplane.</u>

The language proposed for the Airworthiness Limitations sections of the appendices to Parts 23, 25, 27, and 29 is being retained, <u>except that the mandatory replacement times, mandatory inspection intervals, and related procedures are specified as those associated with structural integrity</u>-- including those approved under current Sec. XX.571. It also is made clear that FAA approved alternative programs may be used. <u>To avoid unnecessary restriction being placed on operation, only these items are listed in the pertinent Airworthiness Limitations section. Other items can of course be listed in other sections of the Instructions for Continued Airworthiness.</u>

There are many maintenance tasks that are critical to safety, but only those scheduled maintenance tasks related to the results of the DTA are required to be listed in the ALS. It is not feasible or desired to list all safety related maintenance tasks in the ALS, which is why the FAA limited the scope in Amdt. 25-54 and H25.4.

G.3 Structural Maintenance Tasks

The following maintenance tasks are generally necessary to address the damage threats to the airframe structure are the primary focus of this appendix.

<u>Special Damage Tolerance Based Inspections/Replacements</u>: Intervals and procedures of focused inspections or replacements for damage that could not be found by normal scheduled maintenance (baseline maintenance). These are derived from specific Damage Tolerance Evaluations (DTE) of the durability and damage growth of the structure and are the main focus of the ALS.

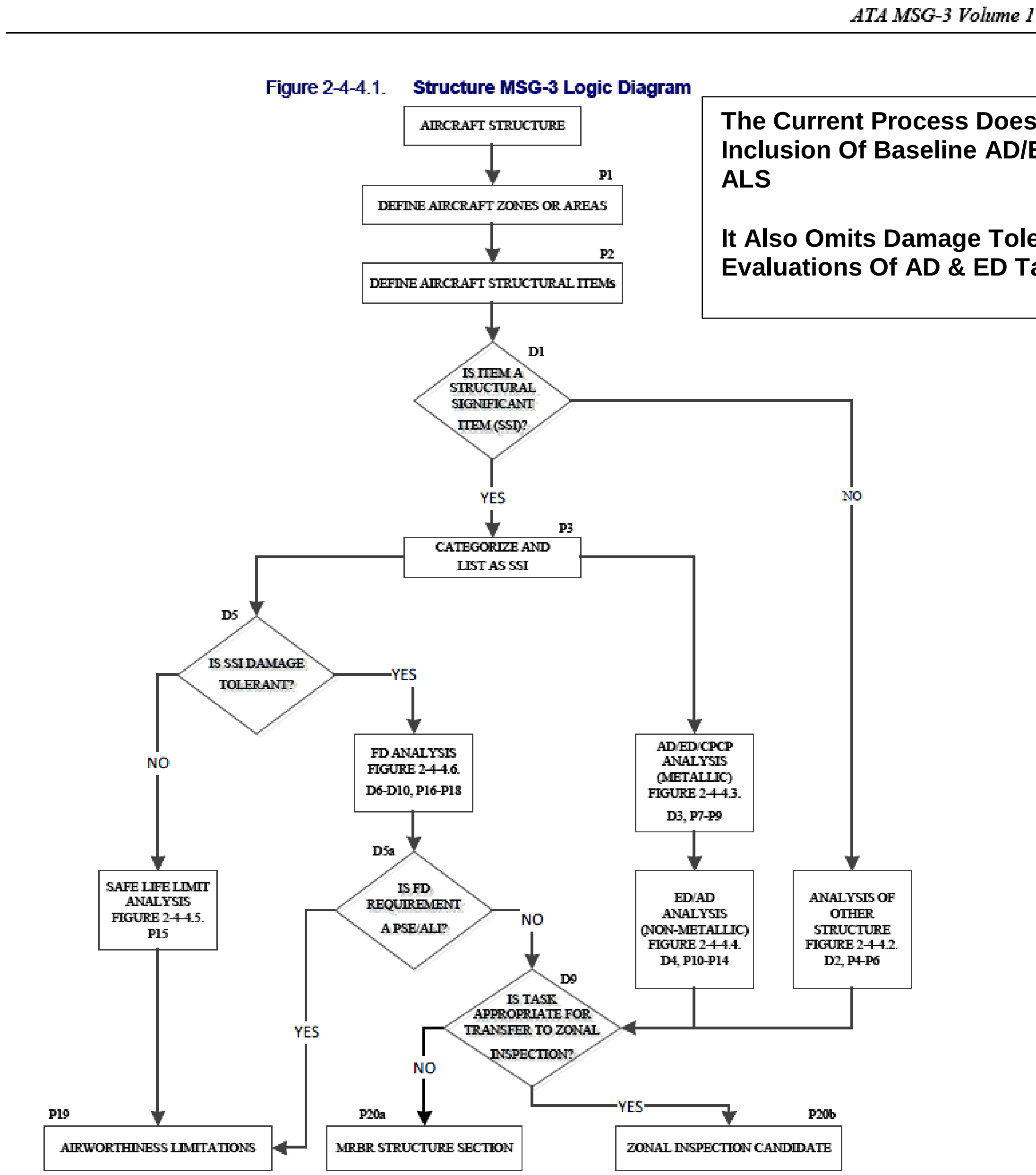
<u>Baseline Schedule Maintenance</u>: The schedule of normal maintenance inspections and procedures provided for the continued airworthiness of the airplane. MSG-3 is primary means to derive this program for large transport airplanes and is based on previous service experience. During initial certification, the Type Certificate Holder (TCH) derives the minimum recommended inspection program and publishes a Maintenance Review Board Report (MRBR). Once in service, the MRBR becomes the basis for an operator to develop their own individual maintenance program.

<u>Conditional Inspections (Unscheduled Maintenance):</u> Maintenance instructions prescribed following an anomalous event such as a hard landing or ground service vehicle impact. These are derived by the TCH based on an engineering evaluation of the strength and damage resistance of the affected structure.

G.4 MSG-3 Evaluations For Scheduled Maintenance

The MSG-3 Program ‘Assumes’ AD & ED Inspections are In The MRBR and that the ALS only addresses inspections for fatigue damage. Below is an excerpt from ATA MSG-3, rev. 2015.1:

Figure 5-1. ATA MSG-3 Structural Evaluation Logic



The Current Process Does Not Expect Inclusion Of Baseline AD/ED Tasks In The ALS

It Also Omits Damage Tolerance Evaluations Of AD & ED Tasks

The highlighted MSG-3 assessment activities below typically consist of qualitative assessments of the structure. However, particularly for the evaluation of Category 2 damage to composite structure, these can be derived from the quantitative engineering demonstrations.

1. Rating Accidental Damage

Accidental damage rating systems should include evaluations of the following

a. Susceptibility to minor (not obvious) accidental damage based on frequency of exposure to and the location of damage from one or more sources, including:

1. Ground handling equipment
2. Cargo handling equipment
3. Those resulting from human error during manufacture, maintenance, and/or operation of the aircraft, that are not included in other damage sources.
4. Rain, hail, etc.
5. Runway debris
6. Lightning strike
7. Water entrapment

b. Residual strength after accidental damage, normally based on the likely size of damage relative to the critical damage size for the SSI.

c. Timely detection of damage, based on the relative rate of growth after damage is sustained and visibility of the SSI for inspection. Assessments should take into account damage growth associated with non-chemical interaction with an environment, such as disbond or delamination growth associated with a freeze/thaw cycle.

Rating values should be assigned to groups of SSIs in the same inspection area on the basis of comparative assessments within the group.

Figure 5-2. ATA MSG-3 Accidental Damage Evaluation

Finally, the issue raised by the MRB policy committee highlights the need for consistent policy and guidance showing how to properly list a baseline task that satisfies a damage tolerance requirement in the ALS.

The recommended changes proposed by the WG discussed in paragraph 3.8.3 of this report are intended to address this issue. If they are adopted by the FAA, the ATA MSG-3 document should be revised to reflect the new process.

International Maintenance Review Board Policy Board (IMRBPB)
Issue Paper (IP)

Initial Date 20Jun 2008
CIP Number: CIP-IND-2008-3
Revision / Date: Feb. 21th[h] 2013

Title: Process for coordinating consolidated MSG-3 derived tasks (MRBR tasks) with Certification Process derived Fatigue and Damage Tolerant Airworthiness Limitation Requirements (DT-ALI)

Submitter: Airbus Wide Body Structures Task Group and Structures Working Group STG/SWG (FDX / LHT Operator Co-chairs)

Issue: Contrary to aircraft systems (CMR vs. MSI) there is no generally applied existing process that allows coordinating / covering the MSG-3 derived tasks contained within the consolidated structural maintenance tasks and intervals (e.g. MRB R) with DT-ALI requirements which are, for example, contained within the ALS.

Problem: The absence of a clearly described process for interaction between MRBR tasks and DT-ALI's is leading to non-harmonised decisions concerning:
- the criteria for deciding if a (Candidate) DT-ALI ((C) DT-ALI) will not become an ALI
- the criteria for the decision whether to cover (or not) a (C) DT-ALI with a MRBR task

Figure 5-3. ATA MSG-3 Structural Evaluation Logic

G.5 Escalation (Optimization) of Baseline Scheduled Tasks

There are currently several processes available to operators to optimize their maintenance schedules based on their fleet experience. TC applicants should consider these processes when evaluating the applicability of a baseline task to meet a damage tolerance based inspection requirement.

The following describes in general the types of maintenance programs available to operators and the processes available to make changes to those inspection schedules.

There are four typical inspection programs available to operators of large turbine powered aircraft as outlined in 14CFR91.409(e) and (f):

5. A Continuous Airworthiness Maintenance Program – Part 121 Airlines and 135 Commuters/Charter
    a. Also Can Include Part 91 Fractional Operations
    b. See AC 121-16G for Details
6. An Approved Aircraft Inspection Program under Part 135.419 – Small Part 135 Commuter/Charter
    a. See AC 135-10B for Details
7. The 'Current' Manufacturer's Recommended Program – Business/Private Jets
8. An Inspection Program Approved By the Administrator – Usually Aircraft Without MSG-3 MRBR
    a. See AC 91-90 for Details

Depending on the maintenance program used, inspection schedules can be changed based on operator experience according to these processes:

Programs Based on the TCH Inspection Program

1. TCH MRBR Developed During TC Used As Initial Basis
2. Changes Are Based On A Reliability Process That Evaluates Utilization and Inspection Results
3. Coordinated Between The TCH and ISC
    a. Access To TCH Engineering Data
    b. Results In A Revised MRBR (Maintenance Manual)
4. Part 91 Operators Are Expected To Follow The MRBR Provided To Them At Delivery of Their Aircraft
    a. MRBR Revisions should be mandated via AD if new safety-critical inspections are added
5. Details Are In AC 121-22C, Section 12

Part 121 and 135 Continuous Airworthiness Maintenance Programs (CAMP)

1. TCH MRBR Developed During TC Used As Initial Basis

2. Changes Are Based On An Approved Reliability Process That Evaluates Utilization and Inspection Results

3. Coordinated Between The Operator and FSDO (ASI)

    a. Limited TCH Involvement or Access To TCH Engineering Data

4. Details Are In Order 8900.1, Volume 3, Chapter 64, Section 1

G.6 Airworthiness Responsibility

The current regulatory framework places the responsibility of ensuring airworthiness on the operator:

91.403 General
(a) The owner or operator of an aircraft is primarily responsible for maintaining that aircraft in an airworthy condition, including compliance with part 39 of this chapter.

91.405 Maintenance Required
Each owner or operator of an aircraft—
(a) Shall have that aircraft inspected as prescribed in subpart E of this part and shall between required inspections, except as provided in paragraph (c) of this section, have discrepancies repaired as prescribed in part 43 of this chapter

121.363 Responsibility for airworthiness
(a) Each certificate holder is primarily responsible for—

(1) The airworthiness of its aircraft, including airframes, aircraft engines, propellers, appliances, and parts thereof; and

135.413 Responsibility for airworthiness
(a) Each certificate holder is primarily responsible for the airworthiness of its aircraft, including airframes, aircraft engines, propellers, rotors, appliances, and parts, and shall have its aircraft maintained under this chapter, and shall have defects repaired between required maintenance under part 43 of this chapter.

Conditional inspections are provided by the OEM/TCH to support the operator meeting this responsibility.

G.7 Unscheduled Maintenance

'Unscheduled Maintenance Checks' is the term used in the operational rules to described Conditional Inspections. The following outlines the elements of this maintenance program.

Reference ATA iSpec 2200

Those maintenance checks and inspections on the aircraft, its systems and units which are dictated by special or unusual conditions which are not related to the time limits … Includes inspections and checks such as hard landing, overweight landing, bird strike, turbulent air, lightning strike, slush ingestion, radioactive contamination, maintenance checks prior to engine-out ferry, etc.

AC 121-16G, "Air Carrier Maintenance Programs"

You should have a comprehensive process in the unscheduled maintenance portion of your manual that addresses those rare, extremely high-load events that occur to aircraft. Specifically, you should have inspection processes that you use following certain high-load events.

These inspections are intended to enable the operators to meet the Part 43 requirements when they return an aircraft to service following one of these rare events:

43.15 Additional performance rules for inspections
(a) General. Each person performing an inspection required by part 91, 125, or 135 of this chapter, shall—
(1) Perform the inspection so as to determine whether the aircraft, or portion(s) thereof under inspection, meets all applicable airworthiness requirements; and
(2) If the inspection is one provided for in part 125, 135, or §91.409(e) of this chapter, perform the inspection in accordance with the instructions and procedures set forth in the inspection program for the aircraft being inspected.

The four basic types of maintenance programs available to Part 25 airplanes are listed in Appendix G.5. Aspects of the guidance materials supporting each program related to unscheduled maintenance were reviewed by the WG. The following summarizes the findings:

- AC 121-16G, “Air Carrier Maintenance Programs”
  - Continuous Airworthiness Maintenance Program – Part 121 Airlines and 135 Commuters/Charter
  - Also Can Include Part 91 Fractional Operations
  - Defines ‘Unscheduled Maintenance’
  - Contains sufficient instructions to develop an unscheduled maintenance program to address these events
  - Does not address composite materials in general, nor HEWABI specifically

- AC 135-10B, “Approved Aircraft Inspection Program”
  - An Approved Aircraft Inspection Program under Part 135.419 – Small Part 135 Commuter/Charter
  - Defines ‘Unscheduled Maintenance’
  - Contains sufficient instructions to develop an unscheduled maintenance program to address these events
  - Does not address composite materials in general, nor HEWABI specifically

- AC 20-77B, “Use of Manufacturers’ Maintenance Manuals”
  - Those who use the ‘Current’ Manufacturer’s Recommended Program – Business/Private Jets
  - Does not define ‘Unscheduled Maintenance’ or provide any guidance on addressing these rare events

- AC 91-90, “Part 91 Approved Inspection Programs”
  - An Inspection Program Approved By the Administrator – Usually Aircraft Without a MSG-3 MRBR
  - Does not define ‘Unscheduled Maintenance’ or provide any guidance on addressing these rare events

A similar review was conducted of FAA Order 8900.1 which provides guidance to Flight Standards staff on the oversight of these maintenance programs. That review is summarized below.

- Volume 3, Chapter 43, Section 1 , “Evaluate A Continuous Airworthiness Maintenance Program”
  - Continuous Airworthiness Maintenance Program – Part 121 Airlines and 135 Commuters/Charter
  - Also Can Include Part 91 Fractional Operations
  - Defines ‘Unscheduled Maintenance’

  - Contains sufficient instructions to develop an unscheduled maintenance program to address these events
  - Does address composite materials in general, and HEWABI specifically

- Volume 3, Chapter 38, Section 1 , "Evaluate Part 135 (Nine Seats Or Less) Approved Aircraft Inspection Program"
  - An Approved Aircraft Inspection Program under Part 135.419 – Small Part 135 Commuter/Charter
  - Does not define 'Unscheduled Maintenance', but does require a program to address rare events
  - Contains some instructions to develop an unscheduled maintenance program to address these events
  - Does not address composite materials in general, nor HEWABI specifically

- Volume 6, Chapter 1, Section 2, "Inspect a Part 91 Inspection Program"
  - Those who use the 'Current' Manufacturer's Recommended Program or who develop their own – Business/Private Jets
  - Does not define 'Unscheduled Maintenance' or provide any guidance on addressing these rare events

The WG did review the ability to 'escalate' an unscheduled maintenance task. The process to optimize scheduled maintenance tasks is discussed in Appendix G.5. However, no such regulatory provision exists for unscheduled maintenance. The aircraft operating members of the WG also reported that escalation was not supported:

> *During the FAA ARAC WG call last Thursday there was discussion regarding the inclusion of conditional inspections in the ALS portion of the ICA as there may be some consideration of these inspections as an element of a DTA for 25.571 compliance finding. The following is a summary to address some suggested concern from some OEMs and NAAs during the last call that operators may arbitrarily adjust or outright omit structural conditional inspections and then potentially undermine any damage tolerance considerations from the OEM. I've cc'ed other operator representatives on ARAC WG in case they have different, or more enlightened perspective.*
>
> *For this discussion common conditional structural inspections are maintenance requirements which follow certain operational events such as hard landings, excessive turbulence, flap down overspeed, overweight taxi, high energy stop, tail strike, bird strike, lightning strike, hail damage, etc. and are included in ATA Chapter 5 of the AMM. These events are mostly rare or uncommon and unpredicted. This section of AMM does include other conditional inspections for those events which are not necessarily considered to have any effect to the aircraft structure, such as smoke in the cabin, pack system failure, etc.*
>
> *Part 121 operators (certificate holders) are required to meet 121.367:*
>
> ***§121.367 Maintenance, preventive maintenance, and alterations programs.***
>
> *Each certificate holder shall have an inspection program and a program covering other maintenance, preventive maintenance, and alterations that ensures that—*
>
> *(a) Maintenance, preventive maintenance, and alterations performed by it, or by other persons, are performed in accordance with the certificate holder's manual;*
>
> *(b) Competent personnel and adequate facilities and equipment are provided for the proper performance of maintenance, preventive maintenance, and alterations;*

and

(c) Each aircraft released to service is airworthy and has been properly maintained for operation under this part.

In DAL's case our Operating Specification document provides FAA acceptance of our Continuous Airworthiness Maintenance Program (CAMP). DAL's CAMP, presumably common for large 121 operators, incorporates numerous elements including Safety Management & Quality System, Maintenance Manual System, organizational structure, RII program, recordkeeping system, contract maintenance system, training system, airworthiness responsibilities, maintenance schedule and accomplishment and approval of maintenance and alterations. Part of the accomplishment and approval of maintenance and alterations element is our process to classify and substantiate engineering authorizations.

A particular challenge with adding conditional inspections to the ALS for operators and FAA Flight Standards, who have oversight of operating certificates, is management and enforcement of Airworthiness Directive compliance for such events. In cases where an airplane ALS is revised, FAA mandates operators accomplish the later revised ALS through Airworthiness Directives. There is a wide spectrum of airline operations that drive need to accomplish the conditional inspections included in ATA 05, such as any liquid spills, hard landings, etc, or other weather related events, such as lightning strikes, hail storms, etc. It is considered to be very difficult to demonstrate AD compliance for such unscheduled events. For the situation of AD compliance a few practical examples include the following scenarios where operators would have to demonstrate to regulators:

- an observed liquid spill in the cabin was cleaned up;
- a reported, or interpreted weather event that had some evidence of hail in vicinity of an airport where an operator had certain aircraft, let alone during flight operations, had a hail damage inspection;
- how a flight crew reported a "hard landing";
- how and when operators review FOQA data, or a requirement to do so in order to confirm that there were no flap overspeeds, overweight landings, etc., e.g., would an operator have to review FOQA data after every flight?
- Ground damage, which is a known concern between ground operations, such as ground support tugs, fueling, baggage & cargo handling (either airline or contracted service providers), and subject of specific topic of HEWABI.

The above examples are expected scenarios that would be a real challenge for operators to demonstrate compliance to ADs and for the flight standards offices responsible for certificate management and AD enforcement. The normal AD program would be a more binary or well defined process – such as a maintenance provider or operator schedules a task to find a condition, confirms that it exists or does not and reacts in a well-defined manner. The above scenarios are not necessarily well-defined, and so mandating by AD becomes difficult.

In the event there are existing repairs or alterations in the inspection areas for the ALS conditional inspection, or any repair or alteration which is otherwise considered to affect those conditional inspections (i.e., change of loads, etc), then AMoC approval would be required for each of these that affected each of the AD-mandated conditional inspection tasks. Furthermore, since conditional inspections are by definition unscheduled events, and can occur at any time, there would really be no deferral period for getting AMoC approval – the AMoC may be required prior to return to service. This is unlike changes to fatigue-crack growth driven inspection programs, for which the industry and regulators understand has time for crack initiation and/or growth and then AD programs can be devised in such a way that provides for service of airplanes with repairs that impact the ALS inspections while the DTE is being accomplished. Deferral of development of some alternate conditional inspection or analysis that shows no affect to be reviewed or approved by FAA ACO may not be deferrable since the conditional event is equally likely to occur the next flight as it is some time in the future.

The WG believes that placing an unscheduled maintenance task to address HEWABI in the ALS is no substitute for effective guidance to the operators. Instead, these four advisory circulars and Order 8900.1 should be revised to uniformly define unscheduled maintenance, to provide guidance on composite materials in general (Category 5 Damage), and to capture the key elements of the policy memo specific to HEWABI.

Finally, AC 20-107B should be revised to define 'conditional inspections' (see Appendix G.3) and use that term throughout where applicable. An example is shown below (para. 8.a.6.b):

> *Due to the nature of service events leading to Category 4 damage, suitable* ***conditional*** *inspections will need to be defined to evaluate the full extent of damage, prior to subsequent aircraft repair and return to service. By definition, Category 5 damages do not have associated damage tolerance design criteria or related structural substantiation tasks. Category 5 damage will require suitable* ***conditional*** *inspections based on engineering assessment of the anomalous service event, and appropriate structural repair and/or part replacement, prior to the aircraft re-entering service.*

G.8 Safety Objective

The safety objective of the evaluation of rare high-load events is defined in AC 20-107B for Category 5 Damage:

… ensure the engineers responsible for composite aircraft structure design and the FAA work with maintenance organizations in ***making operations personnel aware of possible damage from Category 5 events*** *and the essential need for immediate reporting to responsible maintenance personnel. It is also the responsibility of* ***structural engineers to design-in sufficient damage resistance*** *such that Category 5 events are self-evident to the operations personnel involved.* ***An interface is needed with engineering to properly define a suitable conditional inspection*** *based on available information from the anomalous event.*

- Design A Robust Structure: § 25.601
- Define A Suitable Condition Inspection: § 25.1529 and H25.3(b)(1) and (2)
- Educate Operations Personnel: Guidance Changes & Policy

The WG agrees with these objectives, but disagrees that the objectives are met by the instructions in policy memo PS-ANM-25-20. The safety objectives can be met within the current regulatory framework as reviewed below.

G.8.1 Robust Design

§ 25.601

The airplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

As practical, a design should provide sufficient damage resistance to Category 5 events. The rare events to be considered for Category 5 damage are outside of the operational envelope and are therefore not part of a DTE. However, these events do occur often enough to be considered as part of the design criteria. The failure modes and progression of damage experienced under these events should be evaluated. A qualitative evaluation based on tests and analysis is acceptable. The risk of continued operation with hidden damage should be mitigated by developing design features that contain the damage, or providing crew indications such as annunciation of hard landings.

G.8.2 Define A Suitable Conditional Inspection

§ 25.1529

The applicant must prepare Instructions for Continued Airworthiness in accordance with Appendix H to this part that are acceptable to the Administrator. The instructions may be incomplete at type certification if a program exists to ensure their completion prior to delivery of the first airplane or issuance of a standard certificate of airworthiness, whichever occurs later.

Part 25, Appendix H, H25.3:

(b) Maintenance instructions.

(1) Scheduling information for each part of the airplane and its engines, auxiliary power units, propellers, accessories, instruments, and equipment that provides the recommended periods at which they should be cleaned, inspected, adjusted, tested, and lubricated, and the degree of inspection, the applicable wear tolerances, and work recommended at these periods. However, the applicant may refer to an accessory, instrument, or equipment manufacturer as the source of this information if the applicant shows that the item has an exceptionally high degree of complexity requiring specialized maintenance techniques, test equipment, or expertise. The recommended overhaul periods and necessary cross references to the Airworthiness Limitations section of the manual must also be included. In addition, the applicant must include an inspection program that includes the frequency and extent of the inspections necessary to provide for the continued airworthiness of the airplane.

(2) Troubleshooting information describing probable malfunctions, how to recognize those malfunctions, and the remedial action for those malfunctions.

The majority of the WG members agreed that conditional inspections are adequately addressed in the wording of H25.3(b)(1) and (2). Changes to the rule to specifically mandate inclusion of ‘unscheduled maintenance’ inspections were not seen as necessary as all TCH on the WG already provide these instructions.

However, several airline operator WG members did not fully agree, and felt the wording of H25.3(b)(1) should be revised to specifically mention unscheduled maintenance inspections (conditional inspections)[4]. This is primarily due to the concern that many STC applicants may not be aware of the requirements to address these unscheduled events. The FAA and several NAA members also agreed with this view. Details are provided in the following subsection.

G.8.2.1 Conditional Inspections and STCs

[4] The term ‘Conditional Inspections’ not only addresses HEWABI events but also includes the other rare high-load events discussed in Appendix G.7 (hard landing, overweight landing, bird strike, turbulent air, etc.). The concern is valid for all aeroplanes regardless of the construction (e.g. metallic, composite or hybrid).

The following subsection expands upon the concern that STC applicants may not be aware of the requirements to address unscheduled events. It includes the background discussions as well as sub team recommendations for changes to rules and guidance.

A WG sub team conducted discussions regarding conditional inspections. The group was comprised of two OEM members and four operator members. All participants agreed that OEM conditional inspections should be amended to account for STC effects as applicable. All sub-WG members agreed in-service maintenance inspections and procedures should be considered to address unscheduled events. OEM members of the WG indicated they provide these inspections for the baseline airplane.

Generally, the operator does not have sufficient knowledge and data to know if the incorporation of the STC requires the baseline conditional inspections to be amended or supplemented. Whilst it is the operator's responsibility to incorporate the inspections into the maintenance program, the STC DAH is the appropriate entity to consider, develop and make available these inspections/procedures.

Initially, to address the lack of visibility to develop conditional inspections, the operator WG member proposed an amendment to H25.3 (b)(4) as indicated below.

(4) Other general procedural instructions including procedures for system testing during ground running, symmetry checks, <u>conditional inspections,</u> weighing and determining the center of gravity, lifting and shoring, and storage limitations.

The WG member believes procedural instructions related to conditional inspections are no less important than other procedures required by the current requirement (for example, storage procedures). The proposal does not affect the ALS requirements and as such satisfies the concerns raised by the majority of WG members.

Two OEM WG members commented H25.3 (b)(1) might be more appropriate due to the association with a requirement for maintaining continued airworthiness. In response, the operator WG member proposed the following addition in lieu of the initial suggestion above.

(1)…In addition, the applicant must include an inspection program that includes the frequency and extent of the inspections necessary to provide for the continued airworthiness of the airplane. <u>This would include conditional inspections.</u>

It was further suggested wording such as 'unscheduled maintenance checks' might be more appropriate because a definition of conditional inspections could not be found. The operator WG member agreed with the suggestion, provided associated guidance was also included.

The suggested rule text for H25.3(b)(1) would be something similar to that given below:

> *In addition, the applicant must include an inspection program that includes the frequency and extent of the inspections necessary, <u>**including inspections to address unscheduled events,**</u> to provide for the continued airworthiness of the airplane.*

Most members of the full WG are not opposed to such a rule change, but the majority believes it is not necessary and therefore it is not adopted as a recommendation. However, the WG does recommend that guidance to STC applicants be developed that directs them to consider the effect on baseline OEM conditional inspections if the STC affects them. There should be statements on what is expected from the STC applicant and what they need to address impact to the baseline maintenance program.

G.8.3 Educate Operations Personnel

The recommendations provided in Appendix G.7 are intended to meet this objective.

Appendix H Proposed Policy Statement – Large External Modifications (Policy No: PS-ANM-25-17)

U.S. Department of Transportation
Federal Aviation Administration

Policy Statement

Subject: Structural Certification Criteria for Antennas, Radomes, and Other External Modifications

Date: PROPOSED

Policy No: PS-ANM-25-17

Initiated By: ANM-115

Summary

This policy statement identifies applicable structural requirements and acceptable means of compliance for certification of external modifications, such as antennas, radomes, cameras, and external stores, on transport category airplanes.

Current Regulatory and Advisory Material

This policy statement provides guidance on application of the following structural requirements to external modifications: Title 14, Code of Federal Regulations (14 CFR) 25.23, 25.301, 25.305, 25.307, 25.365, 25.571, 25.581, 25.603, 25.605, 25.609, 25.613, 25.629, 25.841, 25.901, 25.903, 25.1419, 25.1529, 26.45, 26.47, and Appendix H of part 25.

Relevant advisory circular (AC) material includes the following:

- AC 20-107B, Change 1, *Composite Aircraft Structure*, dated August 24, 2010.
- AC 25-20, *Pressurization, Ventilation and Oxygen Systems Assessment for Subsonic Flight including High Altitude Operation*, dated September 10, 1996.
- AC 25-24, *Sustained Engine Imbalance*, dated August 2, 2000.
- AC 25-28, *Compliance of Transport Category Airplanes with Certification Requirements for Flight in Icing Conditions*, dated October 27, 2014.
- AC 25.571-1D, *Damage Tolerance and Fatigue Evaluation of Structure*, dated January 13, 2011.
- AC 25.613-1, *Material Strength Properties and Material Design Values*, dated August 6, 2003.

- AC 25.629-1B, *Aeroelastic Stability Substantiation of Transport Category Airplanes,* dated October 27, 2014.
- AC 120-27E, *Aircraft Weight and Balance Control*, dated June 10, 2005.
- AC 120-93, *Damage Tolerance Inspections for Repairs and Alterations*, dated November 20, 2007.

Relevant Past Practice

In recent years, there has been a significant increase in the number of structural certification projects involving external modifications, especially large antenna installations. To help standardize the certification of these projects, the FAA developed an issue paper, *Structural Certification Criteria for Large Antenna Installations*, which identifies applicable structural requirements and provides guidance on compliance. This issue paper has been applied to numerous projects involving external modifications since 2004. As compliance issues and questions arose on different projects, the issue paper was updated. This policy statement replaces that issue paper.

Policy

1 Certification Requirements.

1.1 This policy statement provides general guidance for certification of external modifications, such as antenna and radome installations, cameras, external stores, etc. These certification requirements apply to all external modifications. However, for smaller, less complex modifications, such as a blade antenna, the information needed to demonstrate compliance with the various requirements may be less rigorous. On the other hand, modifications such as the installation of an external tank for firefighting may require more extensive substantiation to comply with numerous regulations not addressed in this policy statement.

1.2 Certification requirements will vary depending on the certification basis established for the modification. An applicant for a type certificate change must show that the areas affected by the change comply with the requirements in effect on the date of the application, except as provided in 14 CFR 21.101. This policy statement provides information relevant to all amendment levels of 14 CFR part 25 except where noted.

2 Selected Structural Requirements.

The applicant should provide to the certifying office their proposed means of compliance for each of the following selected structural requirements, as well as any other applicable structural requirement not addressed in this policy statement. The selected structural requirements addressed in this policy are those considered most relevant and significant for external modifications. These requirements apply to the exterior of the modification, such as a radome, as well as any interior components identified as part of the modification.

2.1 Load Distribution Limits - Section 25.23.

2.1.1 The effect of the external modification on the weight, center of gravity (CG), and load distribution limits of the airplane must be considered. These changes must be documented in the weight and balance document as required by § 25.1519.

2.1.2 AC 120-27E states that the operational empty weight and center of gravity “should be reestablished through calculation whenever the cumulative change to the weight and balance log is more than plus or minus one-half of 1 percent (0.5 percent) of the maximum landing weight, or whenever the cumulative change in the CG position exceeds one-half of 1 percent (0.5 percent) of the mean aerodynamic chord (MAC).”

2.2 Flight Loads Validation - Section 25.301(b).

Methods used to determine load intensities and distribution must be validated by flight load measurement unless the methods used for determining those loading conditions are shown to be reliable. The FAA accepts the guidance provided in European Aviation Safety Agency (EASA), *Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes CS-25*, Acceptable Means of Compliance (AMC) No. 2 to CS 25.301(b) Flight Load Validation.

2.3 Vibration and Buffeting - Section 25.305(e).

The effects of vibration and buffet on the airplane must be considered, as well as on the external modification itself. In amendment 25-77, this vibration and buffeting requirement was moved from § 25.251 to § 25.305(e). Prior to amendment 25-77, this requirement was in § 25.251. Therefore, it is important to ensure that this requirement is not overlooked.

2.4 Proof of Structure - Section 25.307.

2.4.1 The applicant must demonstrate the structural strength of the external modification for the applicable aerodynamic, pressurization, and inertial design loads. Structural analysis is normally used to demonstrate adequate strength. However, analysis may only be used if it has been shown to be reliable on similar structures. Some proof testing may be necessary to demonstrate structural strength of the modification, or to validate the analysis, especially when structural margins are low. This may be the case for a modification whose inertial loads form a significant part of the design loads envelope.

2.4.2 AC 20-107B provides guidance on compliance with the proof of structure requirement for composite structures and on other subjects addressed by this policy statement, such as fatigue and damage tolerance, fabrication methods, and material strength properties.

2.5 Pressurized Compartment Loads - Section 25.365(e).

2.5.1 For external modifications that include a radome or similar structure, rapid pressurization of the radome must be considered as outlined in § 25.365(e) if loss of the radome, or the components underneath the radome, could interfere with continued safe flight and landing. Section 25.365(e)(3) requires the consideration of the maximum opening caused by airplane or equipment failures not shown to be extremely improbable.

2.5.2 The formula hole size requirement in § 25.365(e)(2) was introduced in amendment 25-54. Compliance with this requirement can be problematic

when
evaluating a radome, because the hole size may equal or exceed that of the radome. Specifically locating this formula hole directly under the radome, and then considering the subsequent effects of the loss of the radome and antenna, goes beyond the intent of the rule. Therefore, § 25.365(e)(2) need not be applied in this manner. Rather, the focus for compliance to the decompression requirement when analyzing external modifications should be § 25.365(e)(3), which requires consideration of any airplane or equipment failures not shown to be extremely improbable.

2.5.3 For external modifications to the fuselage, such failures may include fuselage skin cracking, or failure of any attachments, through fittings, or seals. Venting of the external modification may be used to mitigate the effects of any unintended pressurization.

2.6 Damage-Tolerance and Fatigue Evaluation of Structure - Sections 25.571, 26.45 and 26.47.

2.6.1 Compliance with § 25.571.

Section 25.571 requires an assessment of principal structural elements, which are defined in AC 25.571-1D as “structure that contributes significantly to the carrying of flight, ground, or pressurization loads and whose integrity is essential in maintaining the overall structural integrity of the airplane.” Therefore, an external modification such as a large radome attached to the fuselage crown would not typically be classified as a principal structural element. However, such a modification could affect the fatigue and damage tolerance capability of the fuselage structure to which it is attached. Any modifications to the fuselage must be assessed in accordance with § 25.571.

2.6.2 Compliance with §§ 26.45 and 26.47.

Sections 26.45 and 26.47 address “fatigue critical baseline structure” and “fatigue critical alteration structure.” A fuselage-mounted radome, for example, would not typically be considered a fatigue critical alteration structure. However, as noted above, such an alteration would affect the fatigue critical baseline structure (the fuselage).
Therefore, type certificate holders are required to comply with the applicable requirements in § 26.45, and supplemental type certificate holders and applicants must comply with the applicable requirements in § 26.47. The data required for compliance to § 25.571 at amendment 25-45 or later supports compliance with §§ 26.45 and 26.47.

2.6.3 Parts departing the airplane.

2.6.3.1 As noted above, §§ 25.571, 26.45 and 26.47 only address structural elements that contribute significantly to the carrying of flight, ground, or pressurization loads. These regulations do not specifically address the risk of parts departing the airplane. However, this risk is addressed indirectly by other requirements, such as §§ 21.21(b)(2), 25.601, 25.603, 25.605, 25.607, 25.609, 25.629, and 25.671. To meet these requirements, the applicant must show that no part of the external modification will depart the airplane if that part could potentially strike and damage the empennage, or other control surface, or an engine; or cause some other hazard, including a reduction in the controllability, structural strength, or aeroelastic stability of the airplane.

2.6.3.2 Unless it is shown that such a part will not depart the airplane due to any foreseeable circumstance, including fatigue, environmental or accidental damage or bird strike, the FAA assumes the part will come off the airplane and will follow the worst case trajectory, striking the airplane downstream. The FAA will not accept a probability analysis that the part will not strike the airplane downstream.

2.6.3.3 While § 25.571 only addresses structural elements that contribute significantly to the carrying of flight, ground, or pressurization loads, the process defined in § 25.571 may be used to show that all parts of an external modification will remain attached to the airplane. Directed, damage-tolerance-based inspections or other procedures should be used to prevent failure of the attachments of the external modification to the airplane.

2.7 Bird Strike - Section 25.571(e)(1).

2.7.1 Bird strike certification requirements applicable to the airframe were introduced at amendment 25-45 and vary depending on amendment level. The applicable bird strike requirements must be considered unless it can be shown that a bird cannot strike the modified structure at any airspeed up to the speeds required by § 25.571(e)(1).

2.7.2 Amendments 25-45 and 25-54 require assessment at “likely operational speeds at altitudes up to 8,000 feet.” This includes any speed up to V_{MO}. Amendments 25-72 and 25-86 require assessment at “V_C at sea level to 8,000 feet.” Amendments 25-96 and 25-132 require assessment at “V_C at sea level or 0.85 V_C at 8,000 feet, whichever is more critical.”

2.7.3 The applicant must consider all phases of climb-out, cruise, descent and approach, from sea level to 8,000 feet, at the full range of certified design weights, CG limits, and the airspeeds defined in § 25.571(e)(1).

2.7.4 Section 91.117, which restricts airspeed in the United States, is not applicable to the bird strike requirement of § 25.571(e)(1) and may not be used as a means of altering this requirement.

2.7.5 Probabilistic arguments (for example the likelihood of impact based on consideration of frontal area, flight phase, aircraft speed and altitude) are not acceptable by the FAA as a means of showing compliance to the bird strike requirement of § 25.571(e)(1), or as the basis for not complying with this requirement.

2.7.6 Compliance with the bird strike requirements must be shown by tests, or validated analysis. See paragraph 2.4. The failure modes of composites in a dynamic non-linear event such as bird strike are not easily predicted by analysis. Therefore, if analysis is used, it must be validated by sufficient testing.

2.8 Lightning - Section 25.581.

Section 25.581 requires that the external modification be designed such that the airplane is protected against catastrophic effects from lightning.

2.9 Materials - Section 25.603, Amendment 25-46 or later.

Materials used to fabricate must conform to approved specifications as described in this regulation. The suitability of the material to withstand the operational environment must be established based on experience or tests.

2.10 Fabrication Methods - Section 25.605, Amendment 25-46 or later.

The methods of fabrication used must produce a consistently sound structure. Each new fabrication method must be substantiated by a test program.

2.11 Protection of Structure - Section 25.609.

Each part of the structure must be suitably protected against deterioration or loss of strength in service and must have provisions for ventilation and drainage where necessary for protection.

2.12 Material Strength Properties and Design Values - Section 25.613.

Material strength properties must be based on enough tests of material meeting approved specifications to establish design values on a statistical basis. Testing must be conducted on materials that meet § 25.603 and that are fabricated in accordance with methods that meet § 25.605. The applicant must take into account the operational temperature when establishing design values. Amendment 25-112 added the requirement to account for the operational environmental condition (including temperature and moisture).

2.13 Aeroelastic Stability Requirements - Section 25.629.

2.13.1 The applicant must demonstrate by analysis and/or test that the airplane is free from aeroelastic instability with the external modification installed. This may be accomplished by a comparative analysis showing that the aeroelastic stability of the airplane will be unaffected by the change. If the external modification is not conformal to the airframe, such as an antenna mounted above the fuselage, the installation itself must also be evaluated per § 25.629.

2.13.2 The addition of external stores on the wing or other lifting surfaces requires special attention due to the potentially large and adverse effect they may have on the flutter characteristics of the airplane.

2.13.3 Section 25.629(e) requires that full scale flight flutter tests at speeds up to V_{DF}/M_{DF} must be conducted for modifications to a type design "unless the modifications have been shown to have an insignificant effect on the aeroelastic stability."

2.14 Cabin Pressurization - Section 25.841, Amendment 25-87 or later.

2.14.1 Section 25.841 requires applicants to show that occupants will not be exposed to dangerously low cabin pressure following any anticipated failure condition. The applicant should show that their modification does not introduce any potential failure condition that could lead to depressurization of the airplane. This could include fatigue cracking of the modified fuselage, or failure of seals or other attachments to the fuselage. AC 25-20 provides guidance on compliance with this requirement.

2.14.2 Certain airplanes approved for operation at high altitude (above 41,000 feet) have special conditions addressing pressurization. For these airplanes, the requirements defined in the special condition apply to any modification of the pressure vessel.

2.15 Sustained Engine Imbalance (windmilling) - Sections 25.901(c), Amendment 25-23 or later, and 25.903(c).

2.15.1 Sections 25.901(c) and 25.903(c) require that the safety of the airplane will not be jeopardized because of an engine failure and subsequent windmilling event. Therefore, it should be shown that during such an event, the resulting vibration would not cause a structural failure of the modification that would result in a foreseeable hazard, either at the point of failure or downstream. AC 25-24 provides guidance on this subject.

2.15.2 For external modifications mounted on the fuselage for which design load factors are not available, in lieu of a detailed analytical investigation, the applicant may show compliance by test, utilizing the appropriate vibration test standards outlined in RTCA DO-160G, *Environmental Conditions and Test Procedures for Airborne Equipment*, dated December 8, 2010, or later revision. The applicant should consider the appropriate test categories for short duration transient vibration levels consistent with blade loss, as well as the test categories for robust vibration tests for resistance to long duration exposure consistent with engine windmilling.

2.15.3 Certain modifications that are relatively lightweight and have a low center of gravity relative to their attachment may not be susceptible to windmilling-induced vibration sufficient to cause a structural failure. If the applicant determines this is the case for their particular modification, based on an evaluation of mass properties, configuration and method of attachment, they may propose this to the FAA. The certifying office will determine whether any further analysis or tests are required.

2.16 Icing - Section 25.1419.

AC 25-28 provides guidance on ice shedding from airplane components, including antennas and radomes.

2.17 Instructions for Continued Airworthiness - Sections 25.1529, and Appendix H of Part 25.

The applicant must demonstrate compliance by developing an appropriate maintenance and inspection program.

2.18 Airworthiness Directives.

The applicant must request an alternative means of compliance from the applicable aircraft certification office if the modification affects the operator’s ability to comply with the requirements of an airworthiness directive.

Effect of Policy

The general policy stated in this document does not constitute a new regulation. Agency employees, their designees, and delegations must not depart from this policy statement without appropriate justification and concurrence from the FAA management that issued this policy statement.

Whenever a proposed method of compliance is outside this established policy, the project aircraft certification office should coordinate it with the policy issuing office. Similarly, if the project aircraft certification office becomes aware of reasons that an applicant's proposal that meets this policy should not be approved, the office must coordinate its response with the policy issuing office. Applicants should expect that certificating officials would consider this information when making findings of compliance relevant to new certificate actions. In addition, as with all guidance material, this policy statement identifies one means, but not the only means, of compliance.

Implementation

This policy discusses compliance methods that should be applied to type certificate, amended type certificate, supplemental type certificate, and amended supplemental type certification programs. The compliance methods apply to those programs with an application date that is on or after the effective date of the final policy. If the date of application precedes the effective date of the final policy, and the methods of compliance have already been coordinated with and approved by the FAA or its designee, the applicant may choose to either follow the previously acceptable methods of compliance or follow the guidance contained in this policy.

Conclusion

This policy statement identifies applicable structural requirements and acceptable means of compliance for certification of external modifications, such as antennas and radomes, on transport category airplanes. This policy statement provides guidance on application of the following structural requirements to external modifications: §§ 25.23, 25.301, 25.305, 25.307, 25.365, 25.571, 25.581, 25.603, 25.605, 25.609, 25.613, 25.629, 25.841, 25.901, 25.903, 25.1419, 25.1529, 26.45, 26.47, and appendix H of part 25.

Acronyms

AMC	Acceptable Means of Compliance
AD	Accidental Damage
AM	Additive Manufacturing
ARC	Advisory and Rulemaking Committee
AC	Advisory Circular
AIA	Aerospace Industries Association
AASFR	Aging Airplane Safety Final Rule
ALPA	Air Line Pilots Association
ACO	Aircraft Certification Office
AIR	Aircraft Certification Service
AMM	Airplane Maintenance Manual
AAWG	Airworthiness Assurance Working Group
AD	Airworthiness Directives
ADL	Accidental Damage Limit
ALI	Airworthiness Limitations Item
ALS	Airworthiness Limitations Section
AMOC	Alternative Means of Compliance
ASTM	American Society for Testing and Materials
APU	Auxiliary Power unit
ARAC	Aviation Rulemaking Advisory Committee
ASI	Aviation Safety Inspector
BVID	Barely Visible Impact Damage
BRSL	Bonded Repair Size Limit
CFRP	Carbon Fiber Reinforced Polymer
CS	Certification Specification
CM	Certification Memo
CSTA	Chief Scientific and Technical Advisors
CFR	Code of Federal Regulations
CRD	Comment Response Document
CSTC	Complex Supplemental Type Certificate
CMH	Composite Materials Handbook
CAMP	Continuous Airworthiness Maintenance Program
CPCP	Corrosion Prevention and Control Program
DT	Damage Tolerance
DTA	Damage Tolerance Analysis
DTE	Damage Tolerance Evaluation
DTI	Damage Tolerance Inspections
DAH	Design Approval Holder
DSG	Design Service Goal
DSO	Design Service Objective

DER	Designated Engineering Representative
DDP	Detailed Design Point
ED	Environmental Deterioration
ELOS	Equivalent Level of Safety
EASA	European Aviation Safety Agency
AMNT	FAA AM National Team
FCAS	Fatigue Critical Alteration Structure
FCBS	Fatigue Critical Baseline Structure
FCS	Fatigue Critical Structure
FD	Fatigue Damage
FAA	Federal Aviation Administration
FAQ	Frequently Asked Question
FSFT	Full Scale Fatigue Test
GSHWG	General Structures Harmonization Working Group
HEWABI	High-Energy Wide-Area Blunt Impacts
IAW	In Accordance With
ISP	Inspection Start Points
ICA	Instructions for Continued Airworthiness
IP	Intellectual Property
JCAB	Japan Civil Aviation Bureau
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirements
LOV	Limit Of Validity
LEF	Load Enhancement Factors
MRBR	Maintenance Review Board Report
MSG	Maintenance Steering Group
MRO	Maintenance, Repair and Overhaul
MRB	Material Review Board
MTOW	Maximum Takeoff Weight
MOC	Method of Compliance
MED	Multiple Element Damage
MLP	Multiple Load Path
MSD	Multiple Site Damage
NAA	National Aviation Authority
ANAC	National Civil Aviation Agency - Brazil
NRS	National Resource Scientist
NTSB	National Transportation Safety Board
NDI	Nondestructive Inspections
NDT	Nondestructive Testing
NDTM	Nondestructive Testing Manual
NPA	Notice of Proposed Amendment
ODA	Organization Designation Authorization

OEM	Original Equipment Manufacturer
PS	Policy Statement
PMI	Principal Maintenance Inspection
PSE	Principal Structural Element
REG	Repair Evaluation Guidelines
RII	Required Inspection Item
SB	Service bulletin
SDR	Service Difficulty Report
SLP	Single Load Path
SAE	Society of Automotive Engineers
SDC	Structural Damage Capability
SMP	Structural Modification Points
SRM	Structural Repair Manual
SSID	Supplemental Structural Inspection Document
STC	Supplemental Type Certificate
STCH	Supplemental Type Certificate Holder
TOGAA	Technical Oversight Group on Aging Aircraft
TAE	Transport Airplane and Engine
TAEIG	Transport Airplane and Engine Issues Group
TAD	Transport Airplane Directorate
TAMCSWG	Transport Airplane Metallic and Composite Structures Working Group
TCCA	Transport Canada Civil Aviation
TC	Type Certificate
TCH	Type Certificate Holder
UV	Ultraviolet
UM	Unit Member
WFD	Widespread Fatigue Damage
WG	Working Group