AAWG Structural Damage Capability Recommendation Document - Supplement

Revision 2017.New

Release History

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Acronyms

AAWG	Airworthiness Assurance Working Group
AC	Advisory Circular
AIA	Aerospace Industries Association
ARAC	Aviation Rulemaking Advisory Committee
CFR	Code of Federal Regulations
CS	Certification Specifications
DSG	Design Service Goal
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
GSHWG	General Structures Harmonization Working Group
LDC	Large Damage Capability
LOV	Limit of Validity
MLP	Multiple Load Path
NAA	National Aviation Authorities
OEM	Original Equipment Manufacturer
PS	Policy Statement
SDC	Structural Damage Capability
SLP	Single Load Path
TAMCSWG	Transport Airplane Metallic and Composite Structures Working Group
TOGAA	Technical Oversight Group on Aging Aircraft

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	
AAWG Structural Damage Capability Recommendation Document, Revision 1, dated June 23, 2017	

1. Executive Summary

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 the possible reintroduction of some fail-safe concepts (in the form of Structural Damage Capability (SDC)) into Part 25 of the Code of Federal Regulations (CFR). This report documents the findings, conclusions, and recommendations of the Working Group for this Task.

Since this effort began in 1995, numerous challenges have been identified with respect to this effort. From the original GSHWG recommendation in 2003 thru present day, the most difficult challenges include the following:

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.

Most recently, the TAMCSWG has considered the following four options to address (or not address) SDC:

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 ARC; or
    c. In spite of major conclusion, 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 twelve voting members, three voted for Option 2a, five voted for Option 2b and four voted for Option 2c. We note that in the original vote in August of 2017, the results were three votes for Option 2a, three votes for Option 2b and six votes for Option 2c, but these results changed during a subsequent OEM caucus. The OEM sub-team recommends that if the TAMCSWG opts to continue with the effort to reintroduce fail-safety back into CFR 14 Part 25, that the NAAs propose a practical path that fully addresses the challenges/roadblocks identified in Section 3 of this report.

2. Introduction and Background

In July of 1995, ARAC originally tasked the General Structures Harmonization Working Group (GSHWG) to develop harmonized requirements and advisory material for Damage Tolerance and Fatigue Evaluation of Structure, §25.571. In August of 1999 the GSHWG agreed to accept a re-tasking to reach harmonization between the JAR and FAR requirements with respect to Amendment 96 while re-introducing fail safe requirements back into the rule and advisory material. This included the establishment of criterion for the amount of damaged structure with the remaining structure still able to carry residual strength loads. In July of 2003, The GSHWG submitted their Working Group Report as the culmination of eight years of continuing and often controversial effort by the group to reach consensus on a very significant requirement in regard to overall and continuing aircraft safety (please reference Appendix A).

However, the FAA decided to delay addressing the 2003 recommendations from the GSHWG related to SDC and inspection thresholds. This was in part due to the controversy related to Technical Oversight Group on Aging Aircraft (TOGAA) concerns. Such concerns included purging of the term “fail-safety” from the proposed rule and Advisory Circular (AC), not addressing period of unrepaired usage and elimination of the rogue flaw concept to establish inspection thresholds by crack growth for SLP structure.

In June of 2014, the FAA asked industry (comprised of Operators and OEMs) the following three questions (please reference Appendix C):

> 1. Do you agree on the recommendation to add a requirement to show a certain level SDC to ensure that the airplane maintenance program will not be defeated by unforeseen damage sources?
>
> 2. Do you agree that the proposed standard (2003 GSHWG recommendation) increases the level of safety relative to industry practice in regard to compliance with Amendment 25-96 or 25-132?
>
> 3. Does the proposed standard generally capture what has been industry practice?

Subsequently, the FAA decided to re-task the TAMCSWG to re-evaluate the 2003 GSHWG proposal and add composites to the evaluation. As part of this effort, the TAMCSWG assigned the Airworthiness Assurance Working Group (AAWG) to evaluate the possible reintroduction of some fail-safe concepts (in the form of Structural Damage Capability (SDC)) into Part 25 of the Code of Federal Regulations (CFR). The AAWG provided an initial recommendation to the TAMCSWG in Melbourne, Florida in December of 2016. However, the report included major points of dissention, especially with respect to the minimum residual strength requirements. The TAMCSWG recognized this point of dissention and suggested the AAWG propose SDC as an “other consideration” used to mitigate extent of threat assessments.

An OEM sub-team took on this task but voiced concerns that showing compliance on threat assessments led to too many unknowns. Again, they were not able to reach consensus with respect to a recommendation and shared this at the face-to-face meeting in Everett in June of 2017. Again, the NAAs recognized this shortcoming and offered to come up with a proposal

tying SDC more to damage tolerance assumptions (in lieu of threat assessments). Also at this meeting, the TAMCSWG identified four options as detailed in Section 4 of this report.

This report supplements the AAWG recommendation dated June 23, 2017 (please reference Appendix D) on the effort to re-introduce fail-safe concepts in the form of SDC to Part 25 of the CFR.

3. Roadblocks to Incorporating SDC into Part 25

3.1 Roadblock #1 (Compliance burden of a requirement without an appreciable gain in safety)

Description of Roadblock #1 - Thus far, all proposed SDC guidance has added little or no robustness to the structural design beyond what is already provided by existing requirements and design practices for some OEMs. If adopted, this proposal may impose additional burden on the applicant to formally show compliance for vague SDC requirements without an appreciable gain in safety.

2003 TOGAA Comments – "These (fail safe damage) sizes are smaller than most current large transport aircraft can tolerate."

2003 GSHWG Response to TOGAA Comments – "TOGAA would like to impose the best-case fail safe characteristics on all structure (e.g.: "completely severed stringer and adjacent skin bays"). The GSHWG does encourage robust SDC capability, however, the largest SDC sizes are not always feasible, even for those manufacturers who strive to achieve the kinds of damage sizes TOGAA promotes. The sizes cited in the AC represent the minimum that would be accepted under the proposed rule, and these reflect the minimum that manufacturers are currently achieving in applying in-house failsafe principles to their designs. The statement of the requirement proposed is consistent with the pre-amendment 45 minimum requirements, which do not specify damages of this size. The damage sizes TOGAA promotes were never required, even under the pre-amendment 45 requirement. As with any regulation, regulatory minimums are exceeded by some applicants."

2014 General Comment Noted in FAA Excerpt Presentation (see Appendix C):

- Benefits may be hard to quantify

2017 AAWG/OEM Sub-Team Comments - The Boeing Company notes that the original intent of SDC is to add robustness to the structural design to account for unknown threats. In addition to Boeing, Airbus, Embraer and Bombardier concur that, in many cases, the requirements being proposed do not add any robustness to the structural design beyond what is already provided by existing requirements, such as damage tolerance. This proposal, if adopted, may institute significant effort to formally show compliance for SDC evaluations without an appreciable gain in safety. Textron Aviation concurs that the intent of both the 2003 recommendation and this proposal do not add robustness to the structural design beyond the current requirements.

3.2 Roadblock #2 (Conflict between having explicitly defined guidance and allowing for flexibility with resulting interpretation issues)

Description of Roadblock #2 - There is a conflict between allowing for flexibility versus having clear cut guidance, and allowing for flexibility can lead to different interpretation by NAAs and even by individuals within a given NAA.

2014 Comments Noted in FAA Excerpt Presentation (see Appendix C):

- Compliance demonstration is unclear and it may be difficult to show compliance because the proposed guidance material is not adequate
- Consistent interpretation & compliance policy will be difficult to implement
- Compliance demonstration may be difficult to show for repairs and supplemental type certificates
- Insufficient guidance may result in additional compliance costs
- All commenters expressed concern that the FAA's and EASA's rules may not be harmonized

2017 AAWG/OEM Sub-Team Comments - Textron Aviation notes that the proposal may result in confusion among applicants and inconsistencies in interpretation among regulators. Boeing, Airbus, Embraer and Bombardier agree that differing interpretation among applicants, regulators, and even individuals within a given regulatory agency is a major concern and the interpretation may not stay consistent over time.

3.3 Roadblock #3 (No working group agreement on linking level of SDC with certain variables)

Description of Roadblock #3 - The working group has not reached agreement on how to link the level of SDC with load levels, damage risk identified by service history and DTE assumptions.

2017 AAWG/OEM Sub-Team Comments – Again, all proposals shown thus far have been vague and subjective and may lead to issues with interpretation among applicants and regulators.

The bullet points below are slightly modified from the June 2017 AAWG report and explain some of the problems associated with obtaining and using service history as a factor in an evaluation:

- Operator service data may be obtained from individual operators or from a forum, such as the Structures Task Group (STG). However, many OEMs do not typically have access to operator service data and operators may not retain such data. Thus, it may not be available to support a thorough assessment.

- OEMs typically have access to in-service data for damage and repairs that are reported by the operators but this may not fully capture the true risk of damage.
- There is a concern that OEMs may be driven to design to worst-case in-service data. OEMs do not typically design in robustness for all potential cases of extreme damage due to rare events.
- Collected fleet historical service data may not necessarily be applicable to new designs.

No definition has been provided for what constitutes load levels as being high or low and it is therefore open to interpretation. The DTE assumptions column of the table is also subjective.

3.4 Roadblock #4 (Problems with developing industry guidance to address other considerations)

Description of Roadblock #4 – The recent FAA proposal states that OEMs will be engaged to develop guidance material regarding "other considerations." OEMs are concerned with the practicality of assembling industry guidance.

2017 AAWG/OEM Sub-Team Comments – Some of the problems with industry developing such guidance include the following:

- Who is responsible for assembling, maintaining and updating such guidance?
- Would this focus on DTE methodology or SDC practices or something else?
- Conflict between "too high level" vs. proprietary
- No acceptance criteria – how does the NAA determine an applicant is working within the bounds set by assembled industry guidance? With no clear target, NAAs may keep asking for more compliance data.
- Furthermore, Airbus notes that the industry guidance will represent a wide range of possibilities that could even be different for a given OEM depending on the location of the structure of interest. This could lead to significant variance in interpretation or subjective evaluation by the NAAs.

3.5 Roadblock #5 (Period of unrepaired use)

Description of Roadblock #5 – In 2003 TOGAA stated SDC should address the fact that the remaining structure must be able to retain its required residual strength for a period of unrepaired usage. Such a requirement would link SDC with damage tolerance evaluation which would be counter to the tenet that SDC should be primarily a design consideration.

2003 GSHWG Response to TOGAA Comments – "This interpretation of the fail safe requirement goes far beyond the way that fail safe was practiced prior to the introduction of the damage tolerance requirement. This would not be accepted by the industry. The damage tolerance requirement introduced at amendment 45 provides the methodology for setting up

inspections to detect cracks before they become critical. The GSHWG does not consider it part of their task to completely re-evaluate the adequacy of the Amendment 45 damage tolerance requirement. The GSHWG task is only to **add** to that requirement some essential features of the fail-safe concept which were omitted at Amendment 45."

2014 Gulfstream Comments Noted in FAA Excerpt Presentation (See Appendix C) – The concept of 'fail-safe' does not necessarily provide increased safety if there is no evaluation showing an acceptable period of unrepaired use to allow detection. There are several significant accidents where 'fail-safe' features did not provide adequate protection. In general, the structure should be able to withstand some initially detectable damage for a number of normal (as defined in the MRBR) inspection intervals.
Gulfstream believes that the major portions of the airframe should be able to withstand initially detectable damage for a period of use equivalent to the normal maintenance interval as defined in the MRBR for that structure. It is also possible to safely design detail design points that do not possess such large damage capability and protect them through inspections/replacements.
It is difficult to see how this delineation can be codified into a regulation applicable across the industry. Gulfstream would prefer to see guidance that a threat assessment be performed and design features be added to enable that threat to be mitigated through the normal maintenance inspections of the MRBR. Detail design points that do not possess this capability are to be evaluated for special damage tolerance based inspections/replacements.

2017 AAWG/OEM Sub-Team C**omments** – The AAWG identified several issues with addressing "period of unrepaired use" within SDC:

1. No agreement could be reached on a specified maintenance/inspection interval during which non-detected damage should not lead to catastrophic failure;
2. Even if such an interval were identified, one could question the appropriateness of having a single standard interval. Conversely, a proposal that accounts for period of unrepaired use would be too complex if it included customized intervals, dependent on the nature and severity of the damage;
3. For accidental-type damage that is obvious or malfunction evident and should be detected by walk-around type inspections, period of unrepaired use becomes less relevant; and
4. For less obvious damage, similar to the conclusion reached by GSHWG in 2003, SDC complements damage tolerance requirements that establish inspections to detect cracks before they become critical.

For these reasons, the AAWG decided to the greatest extent possible to hold steadfast to basic tenets keeping SDC design requirements separate from damage tolerance/inspection requirements. However, high level requirements for demonstrating slow crack growth in metallic single load path structure, and establishing effectiveness of crack retardation features in monolithic metallic structure were included in the June 2017 AAWG recommendation. It was noted in the report that these requirements may blur the line between SDC as strictly a design characteristic and damage tolerance.

3.6 Roadblock #6 (Effectiveness of crack retardation features in monolithic metallic MLP structure)

Description of Roadblock #6 – In 2003 TOGAA had a concern that SDC does not address the fact that some multiple load path structure can act as single load path structure under some realistic damage scenarios.

2003 GSHWG Comments – "The mandatory damage tolerance evaluation of structure, which was introduced at amendment 45 (paragraph 25.571(b)), addresses this issue. No additional requirement is necessary for the SDC aspect. Because of the somewhat fictitious nature of some SDC failure scenarios (failures are assumed largely without regard to their source or likelihood of occurrence) the added realism of considering initial damage in redundant members is not considered appropriate for SDC evaluation. It would be addressed in the DT evaluation if the applicant relies on detecting damage after load path failure."

2017 AAWG/OEM Sub-Team Comments – One of the OEMs believes that under SDC requirements the applicant should not be required to address the effectiveness of crack retardation features. Conversely, one of the operators believes the applicant should always address the effectiveness of such features. The drawback with including it in the guidance is the subjectivity of a vague, high level requirement that potentially links SDC with damage tolerance and "period of unrepaired use".

The OEM Sub-Team considered the option of focusing solely on new requirements and guidance material for SLP structure since MLP structure has some level of inherent SDC. Airbus noted that with improvements to AC 25.571-1D for SLP plus consideration of MLP partial failures in existing guidance in Chapter 6d of this AC, this would provide an improved situation compared to today's guidance. But this option was also deemed difficult, especially when trying to demonstrate integral metallic structure functions as MLP.

4. Recommendations

NEXT STEP OPTIONS FOR SDC

At the face-to-face meeting in Everett in June of 2017, the TAMCSWG proposed four options for addressing (or not addressing) SDC. The following includes a summary of these options, including concerns raised.

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)**
    - Proposed new a.(3): "The evaluation may include other considerations that minimize risks based on any uncertainties and associated engineering assumptions used in DTE."
    - Guidance materials to document current industry practices that show degrees of freedom possible in trading more rigorous DTE for "other considerations"
    - FAA to consider criteria to address SDC damage size limits without using specific damage sizes (similar to categories of damage in AC 20-107B)

    Larry Ilcewicz shared a draft version providing details on this proposal, please reference Appendix E.

    The OEMs raised concerns with practicality of assembling industry guidance to address other considerations:
    - Who is responsible for assembling, maintaining and updating such guidance?
    - Would this focus on DTE methodology or SDC practices or something else?
    - Conflict between "too high level" vs. proprietary
    - No acceptance criteria – how does the NAA determine an applicant is working within the bounds set by assembled industry guidance? With no clear target, NAAs may keep asking for more compliance data.
    - Furthermore, the OEMs note that the industry guidance will represent a wide range of possibilities that could even be different for a given OEM depending on the location of the structure of interest. This could lead to significant varience in interpretation or subjective evaluation by the NAAs

    They also noted there are no defined SDC limits:
    - Good in that it allows for flexibility
    - But does not offer any concrete enhancement to safety

2. **Conclude there is no practical approach, due to major points of dissention**

    During a teleconference in August of 2017, the TAMCSWG further refined this option into three sub-options as follows:

a) Conclude the major points of dissention are insurmountable and discontinue efforts to incorporate fail-safety back into CFR 14 Part 25
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 ARC.
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.

The TAMCSWG did reach consensus regarding the need to document major points of dissention and why some of the TAMCSWG members felt these points could be insurmountable.

3. Seek a different approach, perhaps re-visit 25.6xx proposal

Boeing initially proposed this approach – it was originally shared at the March 2016 AAWG face-to-face meeting and in general, was not supported by the other OEMs. The same concerns remain, many OEMs see no concrete enhancement to safety under this proposal and feel it is too subjective. Furthermore, if the guidance were to be in 25.6xx as opposed to 25.571, many did not know what the guidance would look like.

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

This option would capture some of the provisions for SLP structure included in the original AAWG report, including the following:

- Demonstrate impracticality of using MLP structure
- Stricter quality control measures
- Fatigue reliability and slow crack growth considerations
- Stricter requirements for Accidental Damage/Environmental Damage evaluations

Airbus noted that with improvements to AC 25.571-1D for SLP plus consideration of MLP partial failures in existing guidance in Chapter 6d of this AC, this would provide an improved situation compared to today's guidance.

Boeing stated that concerns with Option 1 could be similar when making the distinction between SLP and MLP structure, especially for integral metallic construction. There could be complex compliance issues when evaluating the effectiveness of crack arresting features. Secondly, current usage of SLP structure for flight load critical PSEs is limited, so the applicability/benefit of focusing on SLP structure could be limited.

RESULTS OF VOTING ON THE FOUR OPTIONS

In August of 2017, the TAMCSWG held a vote on the above four options. **We note that subsequent to the original vote in August of 2017, two OEMs changed their votes from**

Option 2C to Option 2B. As stated earlier, the TAMCSWG did reach consensus with respect to the need to document the important points of dissention (some form of Option 2); hence, these points have been captured in Section 3 of this report. The following is a breakdown of the final voting:

Option 2A (Airbus*, Dassault, Gulfstream*)

Option 2B (Boeing, Bombardier*, Mitsubishi, Textron, Embraer*)

Option 2C (British Airways, Delta Air Lines, FedEx, United Airlines)

*Although Option 2A,2B or 2C was the preferred option, there was also a desire for Option 4

Based on the above voting, no consensus was reached regarding the path forward. If the TAMCSWG recommends Option 2A, this document can function as a compilation of the roadblocks which were deemed to be insurmountable regarding the effort to reintroduce fail-safety back into CFR 14 Part 25. **If the TAMCSWG recommends Option 2B or 2C, this OEM sub team recommends that the NAAs need to propose a practical path to fully address the roadblocks/challenges identified in Section 3 of this report in order for the industry to further expend resources to continue this effort. Lastly, the OEMs note that significant OEM and regulatory resources have been put into this effort for more than 20 years and there has been little to no progress made with respect to a practical approach to incorporating fail-safety into CFR 14 Part 25.**

Appendix A – 2003 GSHWG Proposal

~~Appendix B – GSHWG Overview Document Including TOGAA Concerns~~

Appendix C – 2014 FAA Query to Industry

Appendix D – 2017 AAWG Report on SDC

Appendix E – FAA Draft Proposal on Option 1