Structures Bulletin

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Subject: Guidance for the Classification of Aircraft Structural Critical Parts

References:
1. MIL-STD-1530D w/CHANGE 1, “Aircraft Structural Integrity Program (ASIP)”, 13 October 2016
2. JSSG-2006, “Department of Defense Joint Service Specification Guide, Aircraft Structures”, 30 October 1998
3. AFI 91-204, “Safety Investigation and Hazard Reporting”, 30 July 2019

Purpose:
MIL-STD-1530 (Reference 1) establishes the requirement for the classification of aircraft structural parts/processes and the controls for those critical parts/processes. The purpose of this Structures Bulletin (SB) is to establish guidance in the classification of these critical parts during the design phase of a program.

This SB does not apply to USAF landing gear structure since safe-life design concepts and damage tolerance evaluations are normally used in its design (see 5.1.3.5.2 in Reference 1).

Discussion:
MIL-STD-1530 (Reference 1) provides the definition of the structural critical parts and are repeated below for ease of reference:

- Normal-controls (NC) part is a non-safety-of-flight structural part where standard aerospace practices are sufficient in the design, manufacturing, and maintenance of the part to ensure structural integrity.
- Durability-critical (DC) part is a non-safety-of-flight structural part that is judged to require additional controls beyond those for normal-control parts.
- Fracture-critical (FC) part is a safety-of-flight structural part that is not single load path nor judged to require serialization and traceability.

- Fracture-critical traceable (FCT) part is a safety-of-flight structural part that is either single load path or judged to require serialization and traceability.

USAF specific design guidelines for the different criticalities are specified in Reference 2.

Reference 1 also establishes the requirement for the establishment of a Durability and Damage Tolerance Control Team (DADTCT). The DADTCT is established by the Program Manager (PM) or their delegate and shall be comprised of contractor and government representatives (as appropriate) from engineering, manufacturing, quality assurance, non-destructive inspection, maintenance, and others involved in the design, engineering development, production, structural certification, and force management of the aircraft structure. Among other responsibilities, the DADTCT shall execute the critical part classification process.

Reference 1 specifically states;

“For safety-of-flight parts that are not single load path, the DADTCT shall consider stability of materials and processes, producibility, design concepts, basis for part sizing, when determining if the part should be classified as fracture-critical-traceable and therefore require serialization and traceability as one of the controls. For non-safety-of-flight parts, the DADTCT shall consider production cost, impact of potential part failure on completing the mission, accessibility, ease of inspection, maintenance cost, when determining if the part should be classified as durability-critical and therefore require additional controls. The DADTCT shall ensure the critical part/process list is updated as the design matures. Procedures and associated TOs shall be established to ensure fracture-critical-traceable parts are properly controlled and tracked throughout their life cycle.”

Reference 1 also provides the following flowchart (Figure 1) to be used for the classification of critical parts.

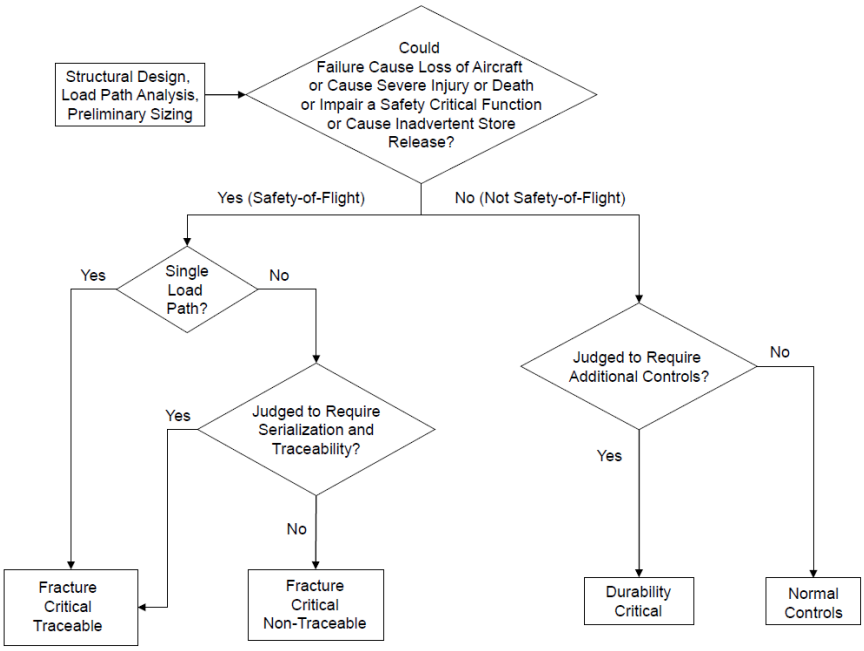

Figure 1: Critical Part Classification Flowchart

In order to find the right criticality using Figure 1, it is necessary to properly answer the questions in the decision diamonds. The primary challenge is determining at what point in the development phase the design is stable enough, and sufficient analysis exists, to answer the question in the 1st diamond. The lead-in box in Figure 1 indicates the structural design, load path analysis, and preliminary sizing should be completed to enable answering the 1st question. Structural arrangement and preliminary sizing should include consideration of damage tolerance requirements as appropriate. For example, the number of spars in the wing or the frame spacing in the fuselage should consider fail-safe damage tolerance requirements when decisions are being made on structural arrangement.

Guidance

The following guidance is provided to assist with the effort in the classification of the critical parts list and is based on a series of questions that should be answered for each of the decision diamonds in Figure 1 as follows:

1. Could failure cause loss of aircraft or cause severe injury or death or impair a safety critical function or cause inadvertent store release?

This first decision diamond after completion of load path analysis and preliminary sizing or preliminary DADT analysis (DADTA) is to identify if the part is Safety of Flight (SOF). Some questions that need to be answered to help in making this decision are:

Could the loss or failure of the single part:

- Cause loss of the aircraft or cause severe injury or death?

- Result in an inadvertent release of a store?
- Prevent the aircraft from landing safely?
- Prevent a safety critical item from functioning and leading to loss of aircraft?
- Result in an aeroelastic instability leading to loss of control of the aircraft?
- Result in fuel leakage onto an ignition source?
- Go undetected (between inspections intervals) and lead to the loss of the aircraft, severe injury or death, impair a safety critical function, or cause inadvertent release of a store?

Answering yes to any of the above questions shall classify the part as SOF, either FC or FCT. The use of multiple load paths to provide fail-safe capability based on damage tolerance considerations should not result in concluding the parts are not SOF. Some USAF legacy aircraft have classified only a portion of a part as SOF (FC or FCT). In the instance where only a portion of a part is classified as SOF, some of the fracture controls will apply to the entire part and some will apply only to the SOF portion. For example, an otherwise non-SOF rib which splices a SOF spar would be designed with damage tolerance requirements in the region of the splice and may require the entire part to be traceable. Recognizing the challenge described above, the following structure is typically SOF and therefore the part should be classified as either FC or FCT.

Potential SOF parts in Fighter/Bomber/Trainer Aircraft:

- Wing lower skins
- Wing upper skins (composites)
- Wing box periphery structure (front & rear spars, root rib, tip rib) and some or all additional spars
- Wing attach fittings & bolts/pins
- Wing ribs that react weapon pylon loads
- Wing pylons support structure
- Fuselage wing carry-through bulkheads
- Fuselage bulkheads, keel beams, frames, skins, and stringers
- Fuselage canopy sill longerons & other longerons
- Fuel boundaries where cracking/failure can leak fuel onto ignition sources
- Pressure boundaries where cracking/failure can result in rapid decompression
- Control surface hinges & pins
- Horizontal stabilizer main attach fittings, main torque box, & pins
- Vertical stabilizer main attach fittings, main torque box, & pins
- Engine mounts fittings & pins
- Structure forward of the inlet for single engine aircraft that could fail and will result in ingestion
- Landing gear main attach fittings & pins (airframe side)
- Leading edges where lateral instability could occur as a result of cracking/failure
- Bonded joints that join SOF critical structure (composites)

Note: Bolt/pins that are normally classified as SOF are generally limited in number and larger in diameter and act as single load path structure (either single bolt or group) in attaching critical aircraft components. For example, engine attach bolts, control surface attach bolts, etc.

Potential SOF parts in Cargo/Tanker and Similar Aircraft:

These types of aircraft should consider fail-safe multiple load path designs to alleviate a potentially onerous inspection program. In addition to the parts listed above, additional structure that is typically SOF for these type of aircraft include:

- Wing stringers
- Horizontal stabilizer stringers
- Vertical stabilizer stringers

2. Is the part considered to be “single load path”?

This second decision diamond or first decision diamond under the Safety-of-Flight branch should be straight forward. The part is considered “single load path” structure if there is no alternate and sufficient load path to retain the required residual strength upon part failure.

Answering yes to this question classifies the part as FCT, otherwise, the part is subjected to further screening to determine if it should be classified as FC or FCT.

3. Judged to require serialization and traceability?

This third decision diamond or second decision diamond under the Safety-of-Flight branch is to identify the part as FC or FCT. Some questions that need to be answered to help in making this decision are:

- Is the part fabricated from a new or relatively new material to the aerospace industry?
- Does the part use a new (or highly variable or operator dependent) process during its fabrication?
- Are fracture toughness values strongly dependent on the processing (too much variation)?
- Are fatigue crack growth rate (FCGR) or fatigue properties strongly dependent on the processing?
- Is the part sized by DT requirements (low margins of safety)?
- Can the part move from aircraft to aircraft requiring tracking to manage the life?
- Are there any other special considerations for traceability?

Answering yes to any of the above questions could classify the part as FCT, otherwise, it is classified as FC.

4. Judged to require additional controls?

The fourth decision diamond or first decision diamond under the not Safety-of-Flight branch is to identify the part as DC or NC. Some questions that need to be answered to help in making this decision are:

- Could the failure of the part cause monetary loss exceeding the thresholds of a Class B (see Reference 3 for definition) mishap?
- Is the part considered primary structure?
- Is the part subjected to complex loading?
- Is the part expensive to produce, repair, or replace?
- Does the part have to be repaired, removed, or replaced at a depot level or require the removal of systems or permanently installed parts?
- Would the loss or failure of the part result in functional impairment that would prevent a mission critical function from being performed?
- Is the part sized by durability requirements (low margins of safety)?
- Is the part similar to one in a legacy aircraft which has had a history of high maintenance problems that could be prevented by the application of additional controls?
- Were Life Enhancements methods used to meet durability requirements?
- Is the part in a difficult to access location that would make inspections difficult and/or costly to perform?

Answering yes to any of the above questions could classify the part as DC, otherwise, it is classified as NC.

To answer some of these questions, engineering judgment is required and it is one of the reasons why the DADTCT should execute the critical parts classification process with representatives from different disciplines such as engineering, materials and process, manufacturing, quality assurance, non-destructive inspection, maintenance, and others involved in the design, engineering development, production, structural certification, and force management of the aircraft structure. Revisions to assigned criticalities as the design matures are possible but they need to be agreed by the procuring agency.

Programs can decide to develop their own “tailored” critical part selection flowchart using Figure 1 as the baseline. However, the final product shall be approved by AFLCMC/EZ and the procuring agency.

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