

STCs: Internal and External Installations

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Internal and External Installations

- Typical Installations
- Classification of Change Criteria
- Level of Involvement
- Applicable Structural Requirements
 - All STC Applications
 - Internal Installations
 - External Installations
- Additional Considerations
- Conclusions

Typical External Installations



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Typical Internal Installations



Change Classification

SIGNIFICANT

Latest
Amdt.

Emergency Medical Service (only if primary structural changes sufficient to invalidate the cert assumptions)

Human External Cargo Must comply with the latest HEC certification specifications (*for the affected areas*)

MINOR

As
TCDS

No appreciable effect on:

- Mass, balance, structural strength
- Reliability, operational characteristics, noise, fuel venting, exhaust emission
- Other characteristics affecting the airworthiness of the product

MAJOR

As
TCDS

Everything else!

External Installations: typically will affect flight conditions → **MAJOR**
Internal Installations: typically effect cabin safety such as evacuation or dynamic seats → **MAJOR**

Level of Involvement

Level of Involvement Criteria:



Novelty

- **May be novel**, depending on the Applicant experience and project specifics, and if a key or sensitive requirement or AMC is invoked, e.g. seat adapter plates.



Complexity

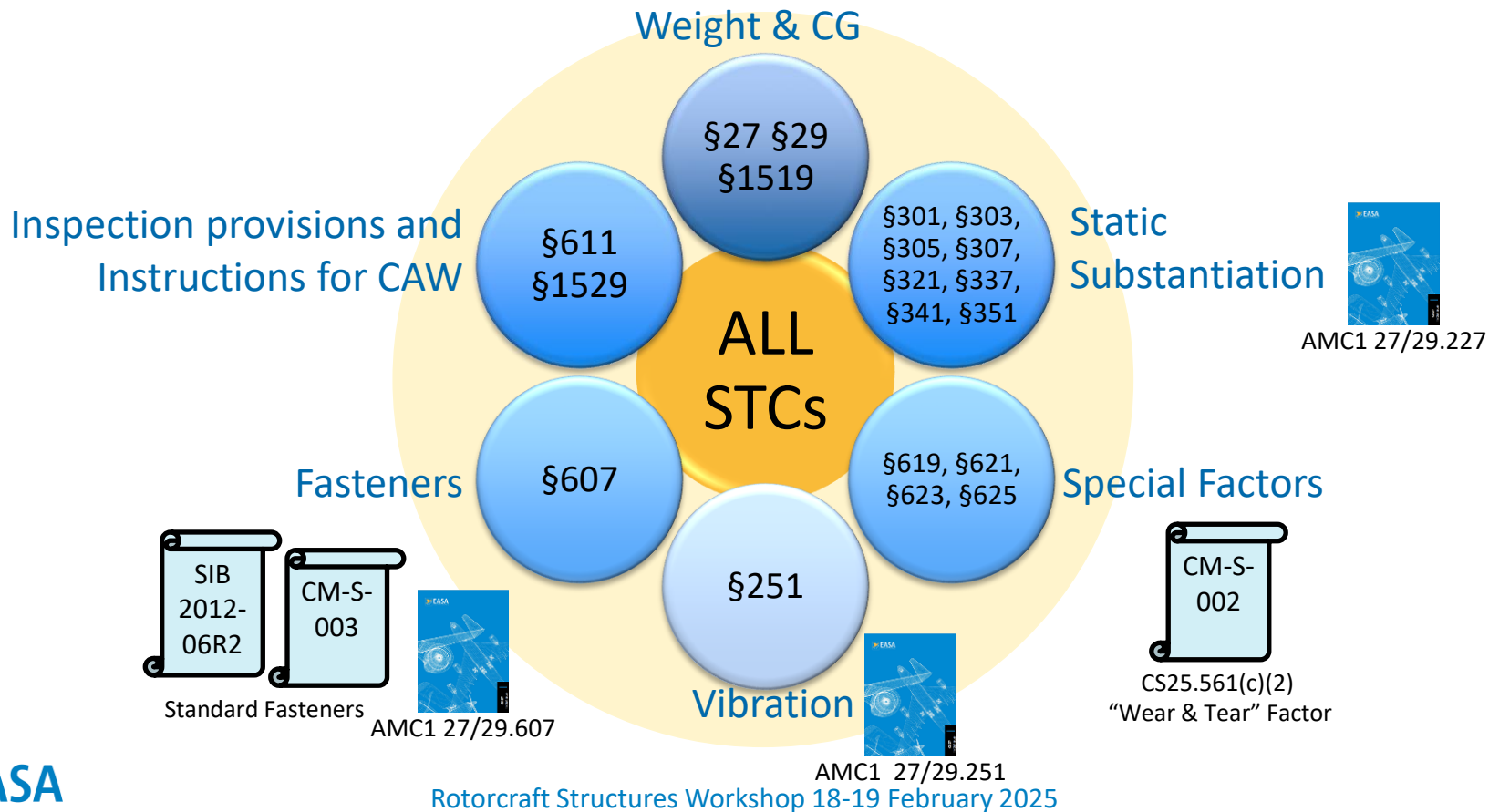
- **Complex**
 - If **dynamic analysis** is used
 - Could be Complex, if there is a strong interaction with other kits / installations.



Criticality

- **Criticality:**
 - **Internal Installations:** Structural elements whose failure could result in injury to occupants, the blocking of evacuation paths, or damage to critical systems.
 - **External Installations:** Typically not critical.
 - **External Cargo:** HEC is critical

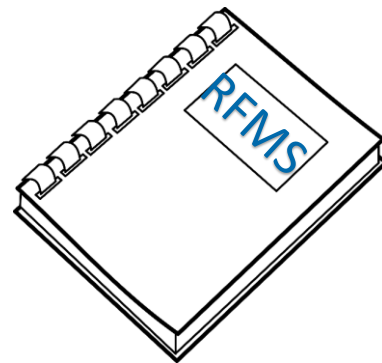
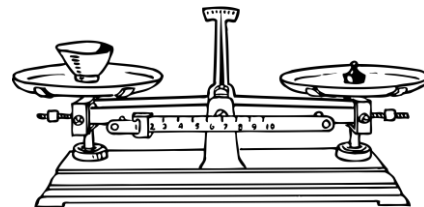
Circle of Requirements: all STCs



Weight and CG

§27 §29
§1519

- Weight and CG should be assessed
- If appropriate, separate into removable parts and fixed parts
- Ensure rotorcraft inside certified weight/CG envelope
- Publish in the Flight Manual Supplement to allow operators to manage the rotorcraft mass/cg.



Static Substantiation

§301, §303,
§305, §307,
§321, §337,
§341, §351

EXTERNAL INSTALLATIONS

INTERNAL INSTALLATIONS

§301 LOADS
§303 FACTOR OF SAFETY
§321 FLIGHT LOADS (General)

§337: -1.0g to +3.5g

TC Holder: Local Accelerations



AMC1 27/29.337

Aerodynamic Loads (Drag)

§341: Gust Loading

§351: Yaw Manoeuvre

§561: Occupied, Above
and/or Behind, Below
(ULTIMATE)

§305 STRENGTH AND DEFORMATION
§307 PROOF OF STRUCTURE

Test

Hand Calculations

Finite Element Analysis



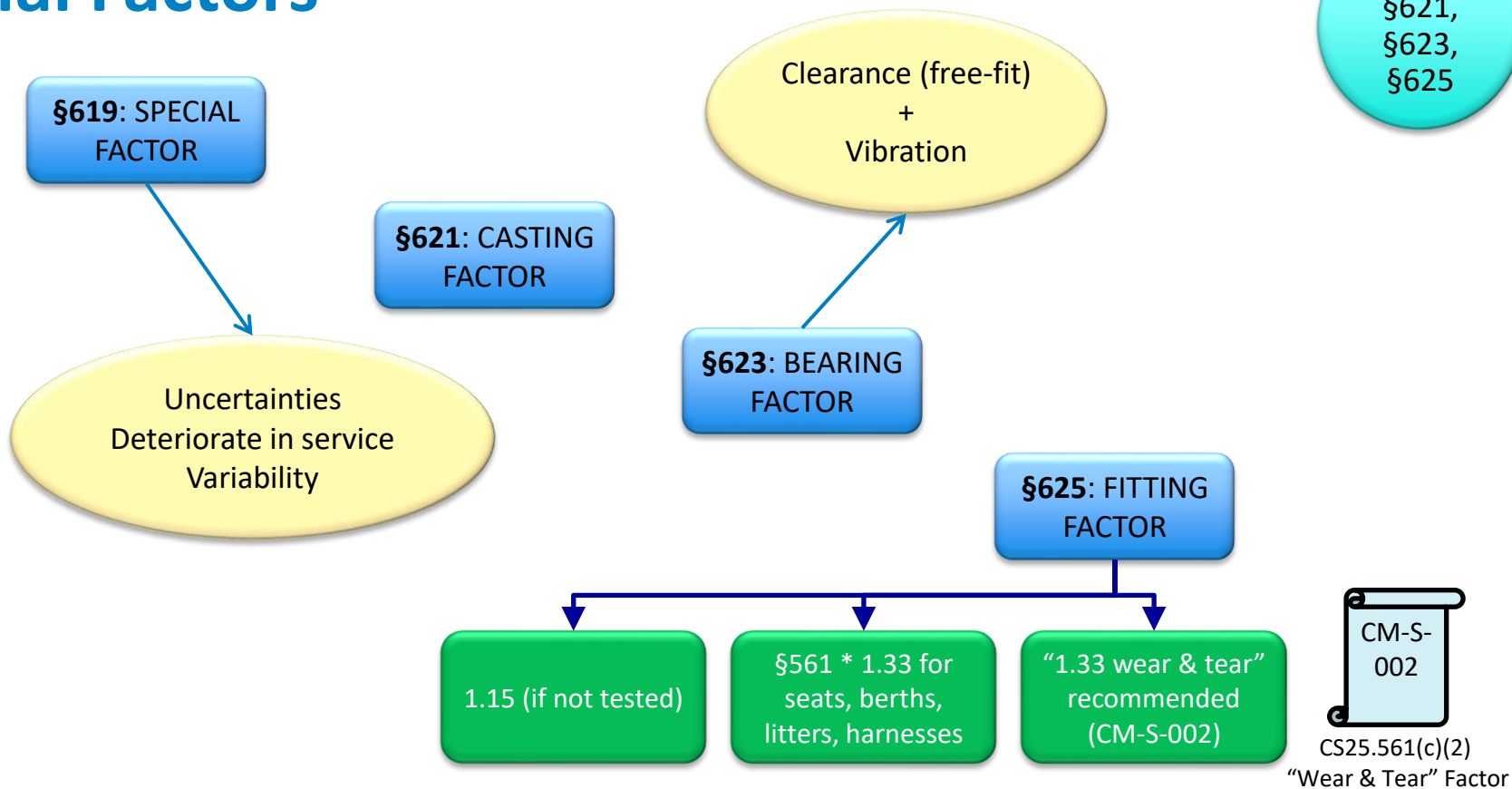
Validate

Static Substantiation

§301, §303,
§305, §307,
§321, §337,
§341, §351

- Rotorcraft Structure Analysis (attachment point and local structure):
 - Strength of attachment points from TC holder (or TC holder NTO)
 - Reverse engineering
 - Analysis with conservative assumptions
 - Multiple variants: careful to cover “weakest” variant
- Influence on Global Rotorcraft loading
 - Large masses far from the CG
 - Drag (total and lateral)

Special Factors



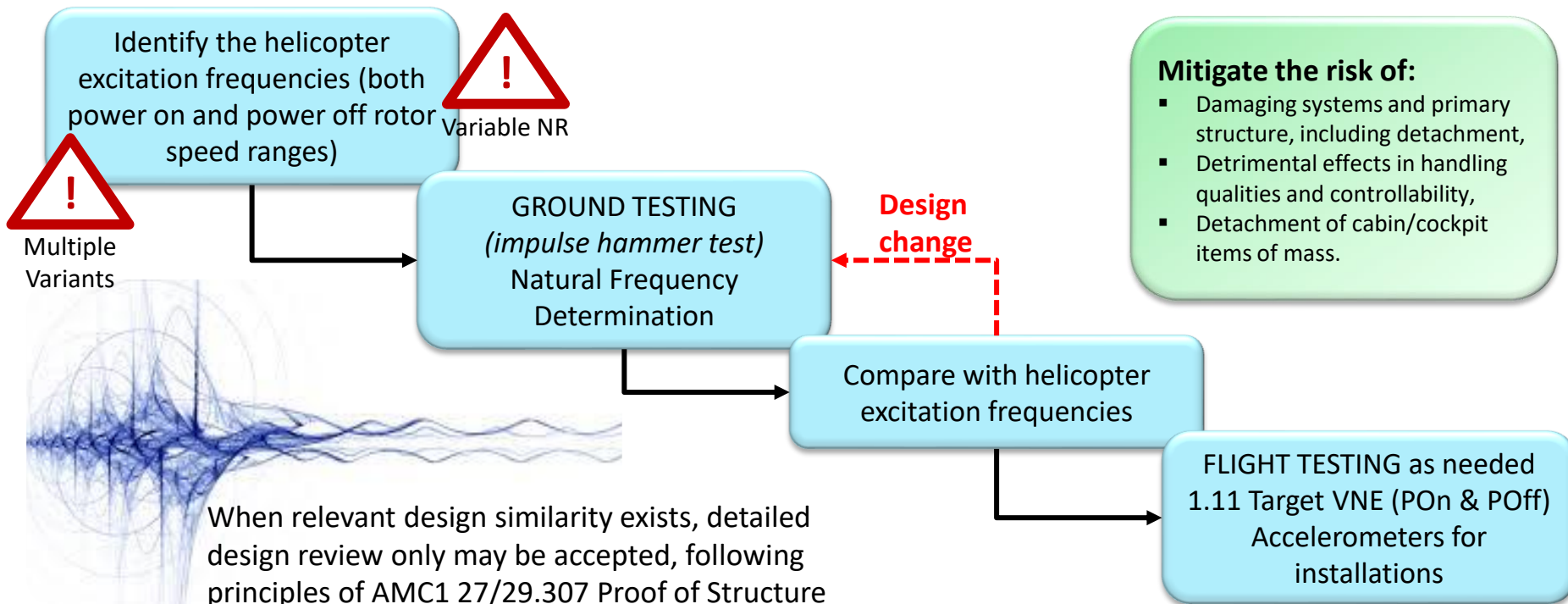
Vibration

Objective: Prevent the risk of excessive vibration



AMC1 27/29.251

§251



Fasteners

\$607

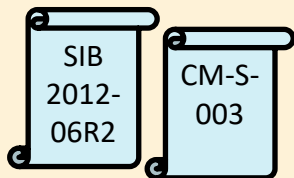
Loss can jeopardise the safe operation of the rotorcraft



Independent double locking

[Adhesive is not considered to be a locking device]

STANDARD FASTENERS



Standard Fasteners



AMC1 27/29.607



Is the **expected reliability sufficient** for intended use:

- criticality (HAZ or CAT),
- location,
- level of redundancy,
- margins of safety,
- environment,
- (adverse) service experience?

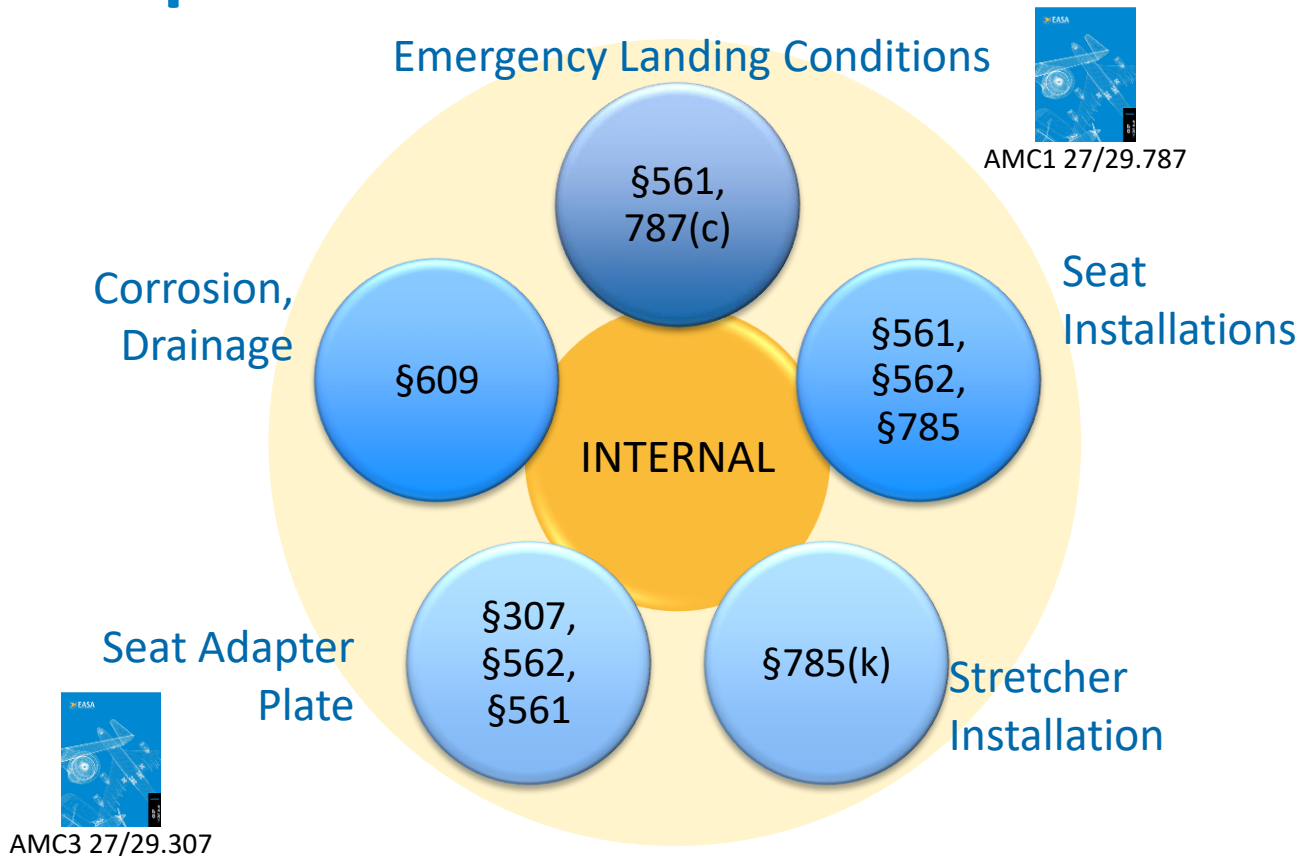
Instructions for Continued Airworthiness and Inspection Provisions

§611
§1529

- Appropriate inspection instructions should be included in the maintenance manual.
- This should cover the STC and the region of the rotorcraft where the external device is attached
- There must be a means to allow inspection of any part that requires recurring inspection or adjustment.



Circle of Requirements: Internal Installations



Emergency Landing Conditions



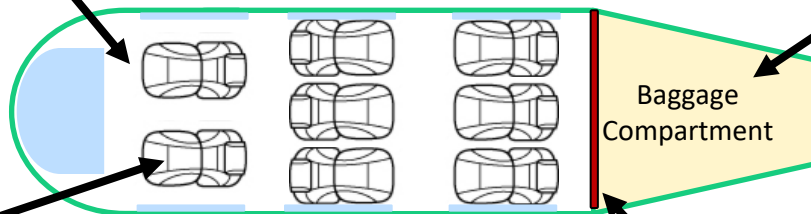
AMC1 27/29.787

§561,
§787(c)

Objective: Protection of occupants in the cabin from detached items of mass or blocking of the evacuation path

Occupied Space:

- CS27/29.787
- CS27/29.561(b)
[16g forward]



Baggage Compartment

No Structural Partition:

- CS27/29.787
- CS27/29.561(b)

[16g forward]

With Structural Partition:

- CS27/29.787
- CS27/29.561(c)

[12g forward]

Seats:

- CS27/29.561(b)
- CS27/29.562(b)
[18.4g forward]
[30.0g vertical]

Structural Partition:

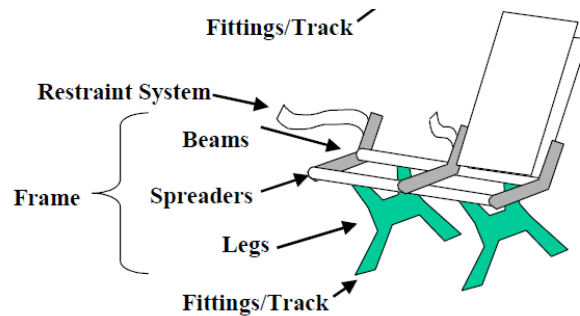
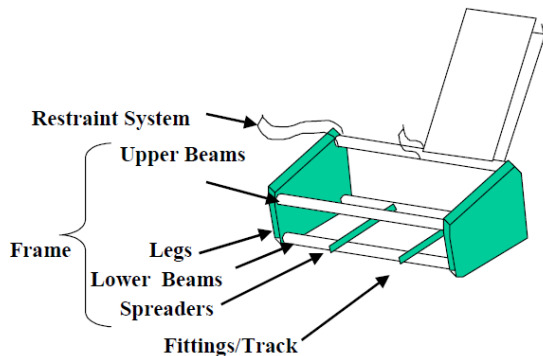
- CS27/29.561(c)
[12g forward]

NOTE: For simplicity only forward g factors are quoted. All directions must be considered.

Seat Installation or Modification

§561,
§562,
§785

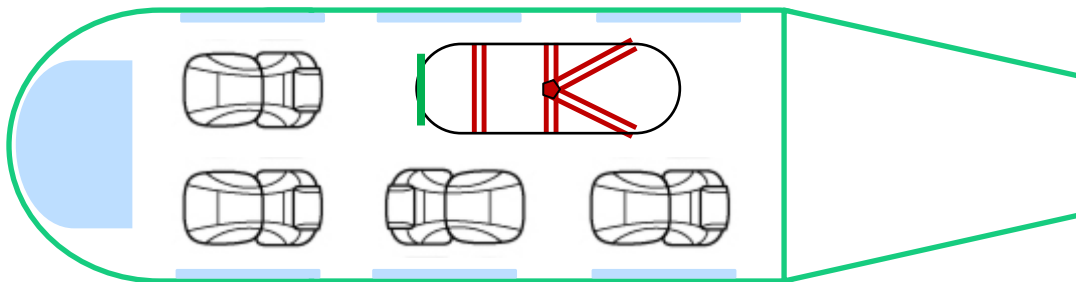
- Emergency landing loads §561 with 1.33 fitting factor
- New Dynamic Seat test may be necessary (*equivalent to CS-ETSO*):
 - Primary load path modification:
Restraint system, Seat frames, Fittings and tracks, Seat back, Bottom cushions, Seat pan
- Seat Family Definition, see (AC25.562-1B)
- Installations under the seat or changes to the lower part that are in the full stroke volume, affecting the energy absorption system.



Stretcher Installations

§785(k)

- §562 not applicable
- §561 stretcher attachments
- §785 harnesses
- 1.33 fitting factor
- Longitudinal orientation → padded end-board, cloth diaphragm or equivalent



Seat Adapter Plate



§307,
§562,
§561

AMC3 27/29.307

Objective: Level of safety equal to original seat to floor attachment

AC 25.562-1B

Option 1:
adapter = plinth

Adapter (plinth) used to mount a single seat assembly and the adapter plate is attached to the floor
→ Adapter plate is considered as part of the seat assembly

Plinth must be tested as part of the seat to §562b

Option 2:
adapter = pallet

Seats that are mounted on a pallet (e.g. multiple seat rows).
→ Pallet is considered part of the floor structure of the airplane based on its size, structural design, and redundancy of attachment.

Seat and its attachment to pallet tested to §562b
Pallet justified to §561 only

Option 3:
adapter ≠ plinth,
adapter ≠ pallet

Adapter proposed to be classified as part of floor based on (detailed) design review:

- Redundancy and strength of attachments
- Experience of the Applicant and Agency

If accepted → Seat and its attachment tested to §562b



Has a weak element between the seat and existing airframe been introduced?

Corrosion, Drainage

\$609

→ Protection of Structure:

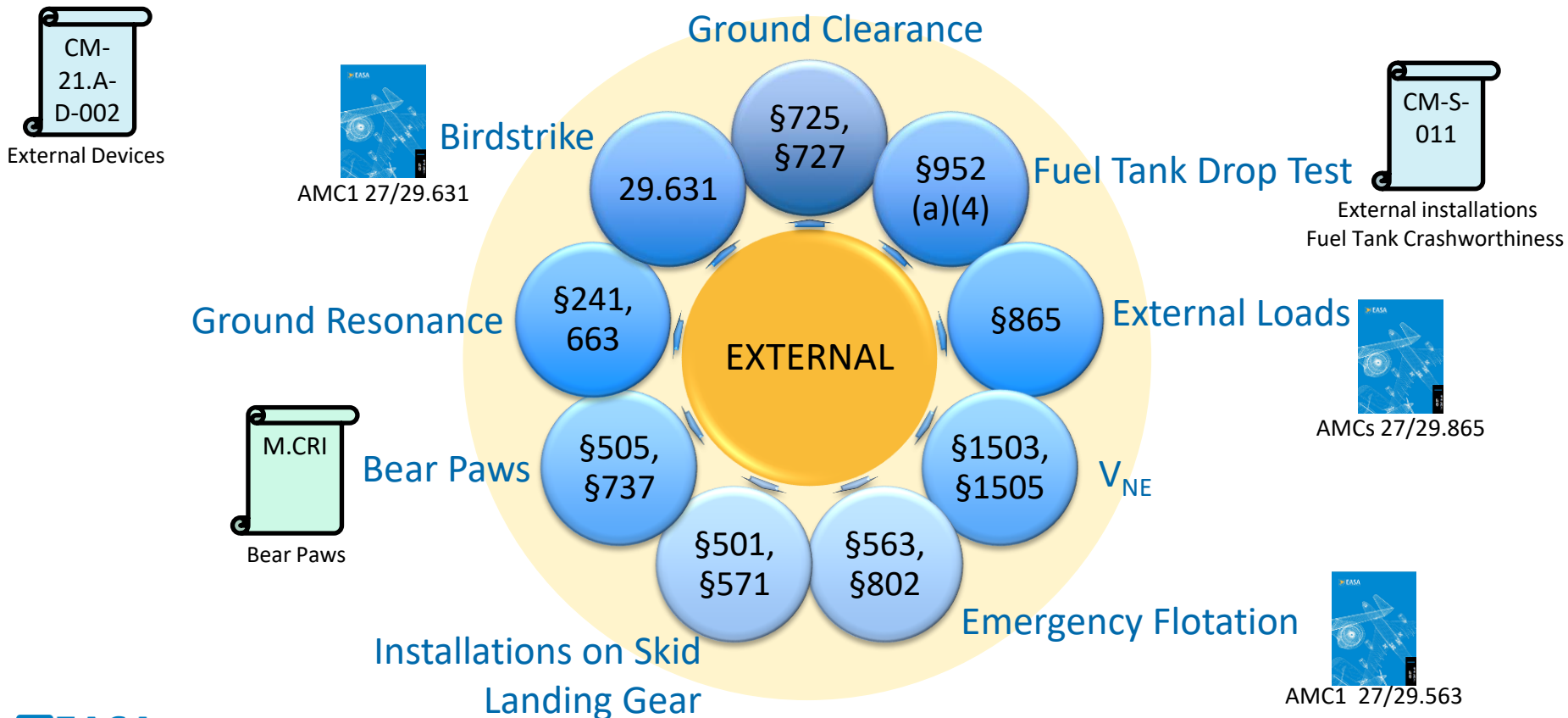
→ Floor protection for Medical Installations:

→ Corrosion

→ Drainage



Circle of Requirements: External installations



Ground Clearance

§725,
§727

Ground Clearance

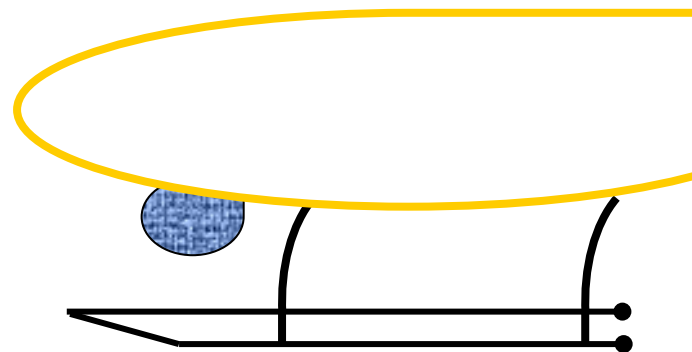
§725 Limit Drop Test

§727 Reserve energy absorption drop test

AC §.727(b)(2), AC§ MG6b.(8) External Devices

Limit landing load deflection:

The external fixture or device should not contact a level landing surface after a limit landing.



Clearance →



Ground Clearance

§725,
§727

Reserve energy absorption drop test deflection:

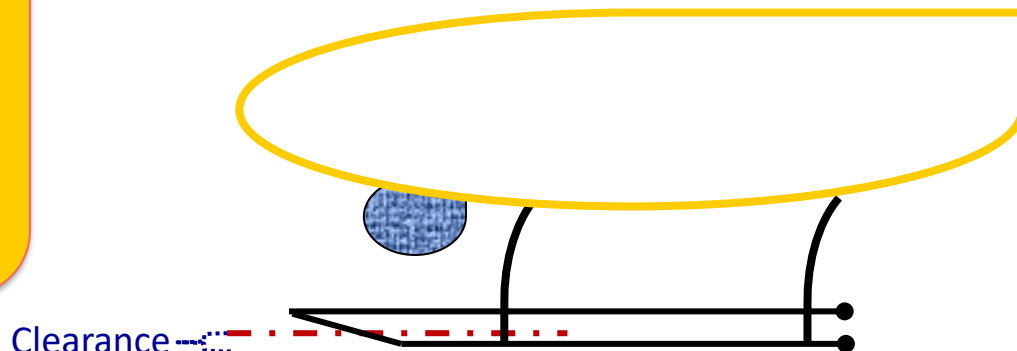
- Devices likely to cause post-landing fires → No Impact
- Electrical connections protection to prevent electrical fires
- Design and/or location to avoid penetration into a critical area

How to determine clearance:

- ✓ TC Holder Data
- ✓ Comparison with TC Holder external fixtures or devices
- ✓ Assessment of limit/reserve energy landing load deflection

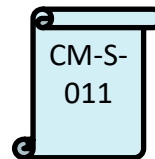
Flight Test:

Slope landing envelope: Check no problem exists within the TCH certified envelope

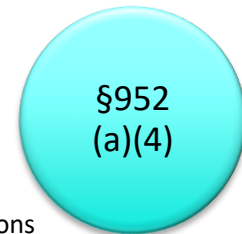


Fuel System Crash Resistance Drop Test

→ Installation of equipment in the vicinity of the fuel tanks may invalidate the §952(a)(4) fuel tank drop test compliance



External installations
Fuel Tank Crashworthiness



Option 1

Demonstrate added structure is not a contributing hazard to fuel tank

• Dynamic Drop Test

- Direct Compliance
- High Cost

Option 2

Demonstrate added structure is not a contributing hazard to fuel tank

• Dynamic Analysis

- Correlation of model with a fully instrumented drop test
- Only valid with close similarity to the reference drop test

Option 3

Remove interaction between installation and fuel tank

• By Design

- Locate installation away from the fuel tank

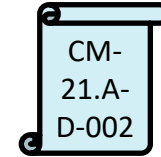
External Loads / PCDS

§865

§865 is not applicable to External Fixtures:

- NO true jettison capability
- NO true payload capability

Cameras
Searchlights
Equipment box with fixed mass/cg



External Devices

HUMAN EXTERNAL CARGO (HEC)

- 3.5g load factor, 30° angle to vertical
- Safety Factor ≥ 3 (if no static test)
- Fatigue evaluation §571 §573

NON HUMAN EXTERNAL CARGO (NHEC)

- 2.5g load factor, 30° angle to vertical
- Safety Factor ≥ 1.5
- Fatigue evaluation §571 §573 (hazard to rotorcraft)



AMCs 27/29.865

Simple PCDS

→ AMC §865 Simplified method

Complex PCDS

→ §571 §573 Fatigue evaluation



Reverse Engineering:
HEC STC on a NHEC rotorcraft
can be challenging

Never-Exceed Speed (V_{NE})

§1503,
§1505

- The operational never-exceed speed V_{NE} should be not more than:
 - 0.9 times the V_D speed analysed for structural strength
 - 0.9 times the speed flown for the vibration flight test
- Any restrictions should be clearly defined in the RFMS

Emergency Flotation



AMCs 27/29.563

§563,
§802

§802 Emergency Flotation and AMC§802

Introduced at CS27/29 Amendment 5, Replaces AC 29 MG 10

Compliance to **§563 Structural Ditching and emergency flotation provisions** is necessary for emergency flotation

CS27 and CS29 ≤ 9 passenger capacity:
Flotation units and attachments only

CS29 ≥ 10 passenger capacity:
Rotorcraft

Resist capsize in sea conditions selected by applicant:

- Scale Model Testing with irregular waves
- Sea conditions defined by significant wave height and mean wave period

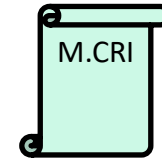
CS29: Rotorcraft will not sink following functional loss of any single complete flotation unit

Installations on a Landing Gear (Skid)

§501,
§571

- Attachment of the device to landing gear cross-tube:
 - Static and fatigue consideration of flight loads introduced on the skid landing gear
 - Behaviour of the landing gear may be modified in the landing phase
 - Ground resonance mode may be modified (§241, §663)
 - Protection of cross-tube against degradation at attachment point (§609)

Bear Paw Installations



Bear Paws

\$505,
\$707

- Rational flight and landing loads should be developed:
 - Interpretation of the loading conditions of CS 27/29.505 (Master CRI).
- **Vibration** should be investigated to ensure that the bear paw installations does not lead to excessive vibratory loads.
- Effect of the bear paw installation on the **fatigue substantiation** of the landing gear should be evaluated (if applicable)



Photo: LA(Phot) Bernie Henesy/MOD, OGL v1.0OGL v1.0, via Wikimedia Commons

Birdstrike

For CS-29 rotorcraft ONLY



AMC1 27/29.631

29.631

1. Identify exposed systems and equipment
2. Assess the criticality of the system / equipment:

Direct Effects:

- Integrity of the structure
- Functionality of the systems or equipment (also shock loads)

Not usually applicable to external installations

Induced Effects:

- Consequence of pieces that are ejected from the bird strike impacting other structures, systems and equipment

Could any part be ejected from the installation?

3. Compliance demonstration through tests of the installation, or analysis based on tests that are carried out on sufficiently representative installations.

Additional Considerations – All STCs

→ Influence on Global Rotorcraft:

- Evacuation (Internal Installations)
- Flammability (Internal Installations)
- Interference
- Compatibility with optional kits
- Global loading on aircraft:
 - Impact on global fatigue
 - Aerodynamic influence on horizontal stabiliser, TR, fin from external installations
- Check current ADs on variant

Conclusion

- Classification of change:
 - External Installations typically major
 - Internal Installations major if evacuation affected
- Requirement checklist → should be reviewed for each project
- External installation → location is important
(fuel tank drop test, loading, ground clearance, skid landing gear...)
- Impact on rotorcraft should not be forgotten



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