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Navigating Standards for Lightning Certification

Dan Morgan

Agenda

- Introduction
- What is Lightning
- How does it interact with Aircraft
- Standards (EU,US, Military, Changes)
- Certification (Fuels, Structures, Avionics)

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Introduction

Set up in 1972, previously known as Culham Lightning

Office and Facilities in Abingdon, UK
Near Oxford, 90 minutes from London Heathrow

10 staff based in Abingdon:
- Mainly Scientists, Test Engineers

Agenda

Introduction

What is Lightning

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What is lightning?

Lightning is an atmospheric discharge of electricity accompanied by thunder, which typically occurs during thunderstorms, and sometimes during volcanic eruptions or dust storms

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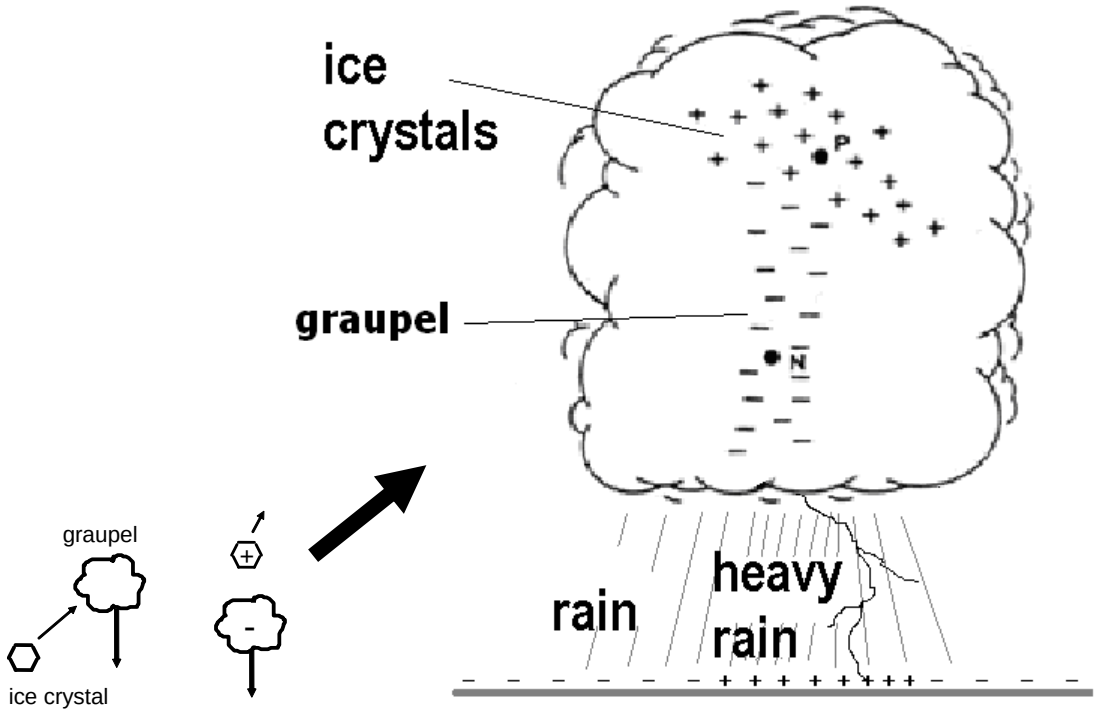
How is lightning generated?(Cloud to Ground)



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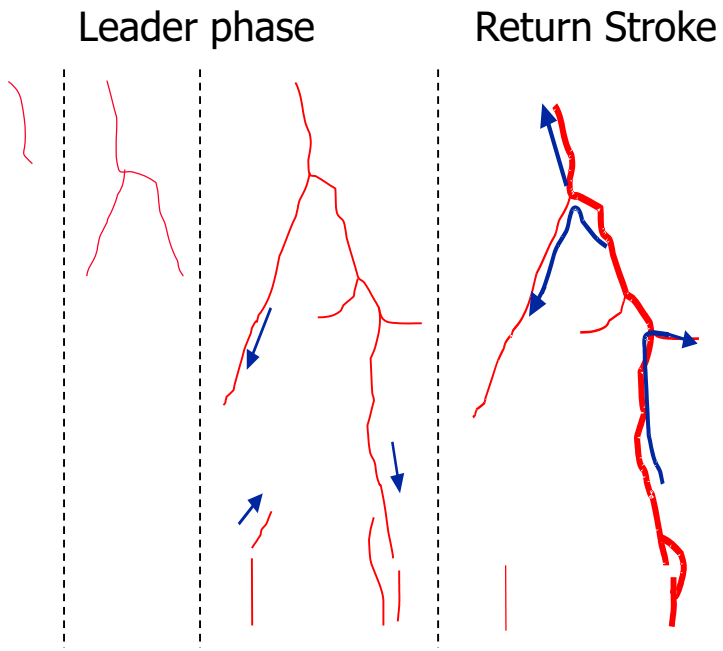
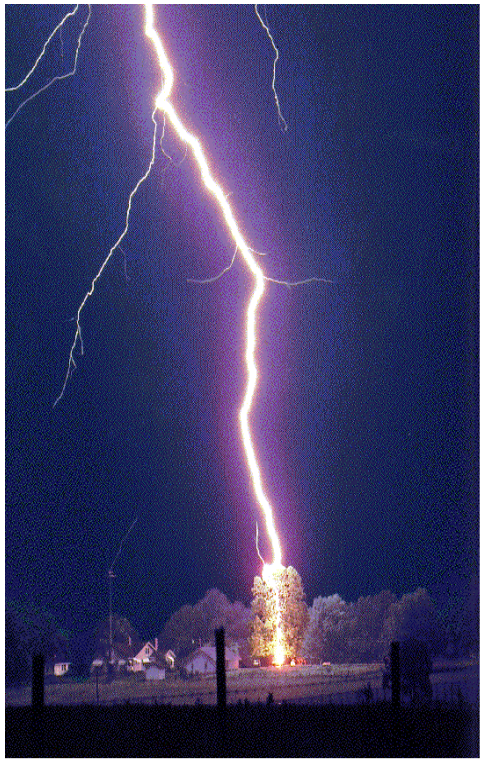
Elements of a lightning strike (Cloud to Ground)





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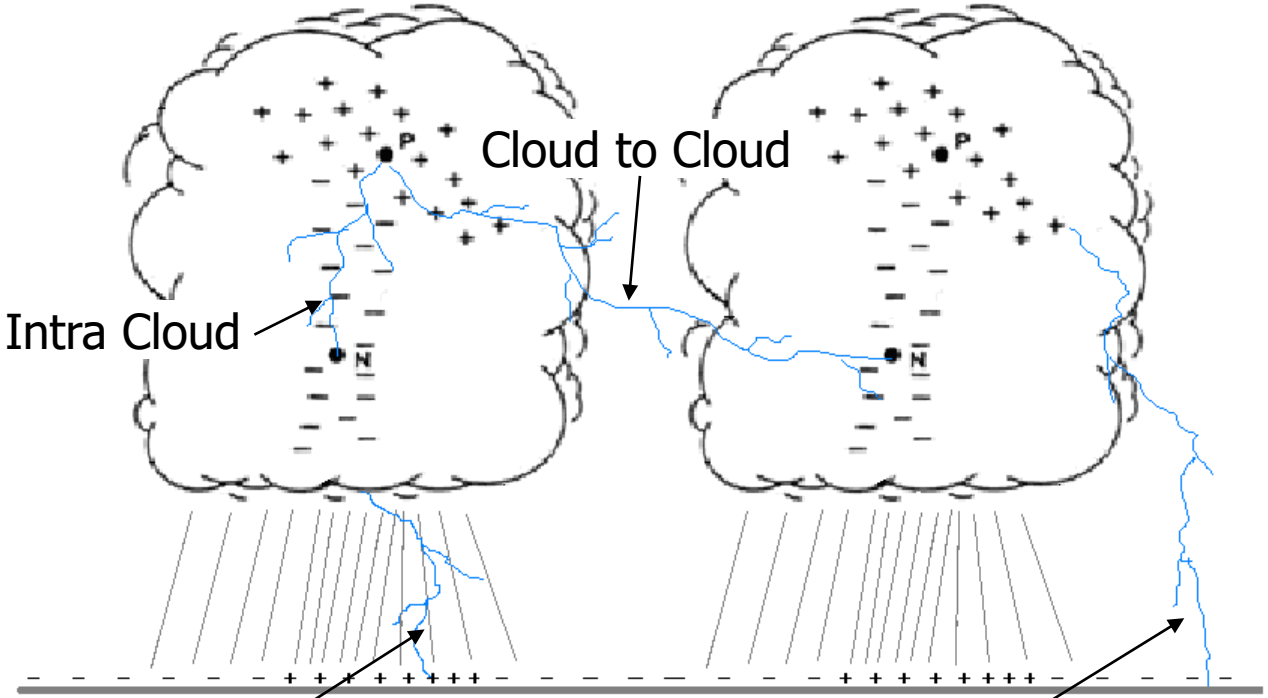
Types of Lightning



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Lightning in Heathrow, UK

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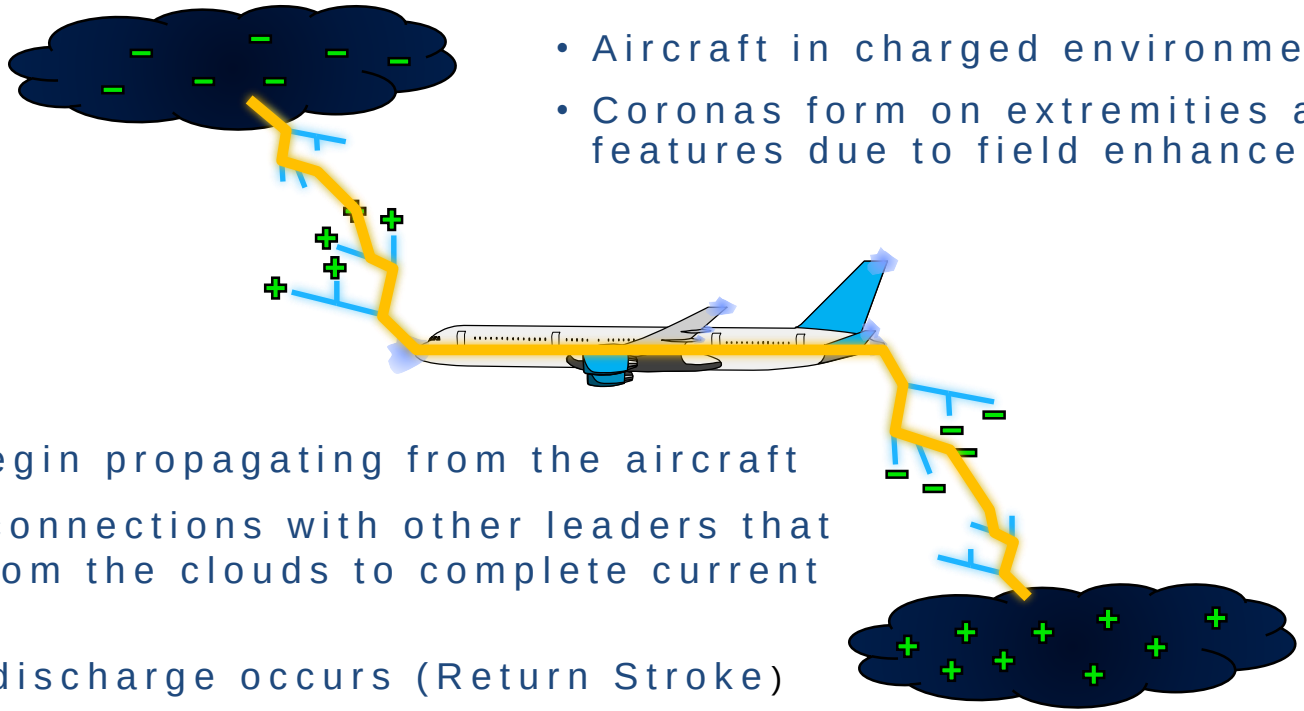
Triggered Lightning



- Aircraft in charged environment
- Coronas form on extremities and sharp features due to field enhancement

- Leaders begin propagating from the aircraft
- Potential connections with other leaders that begin to from the clouds to complete current path
- Lightning discharge occurs (Return Stroke)

(Cloud or ground)

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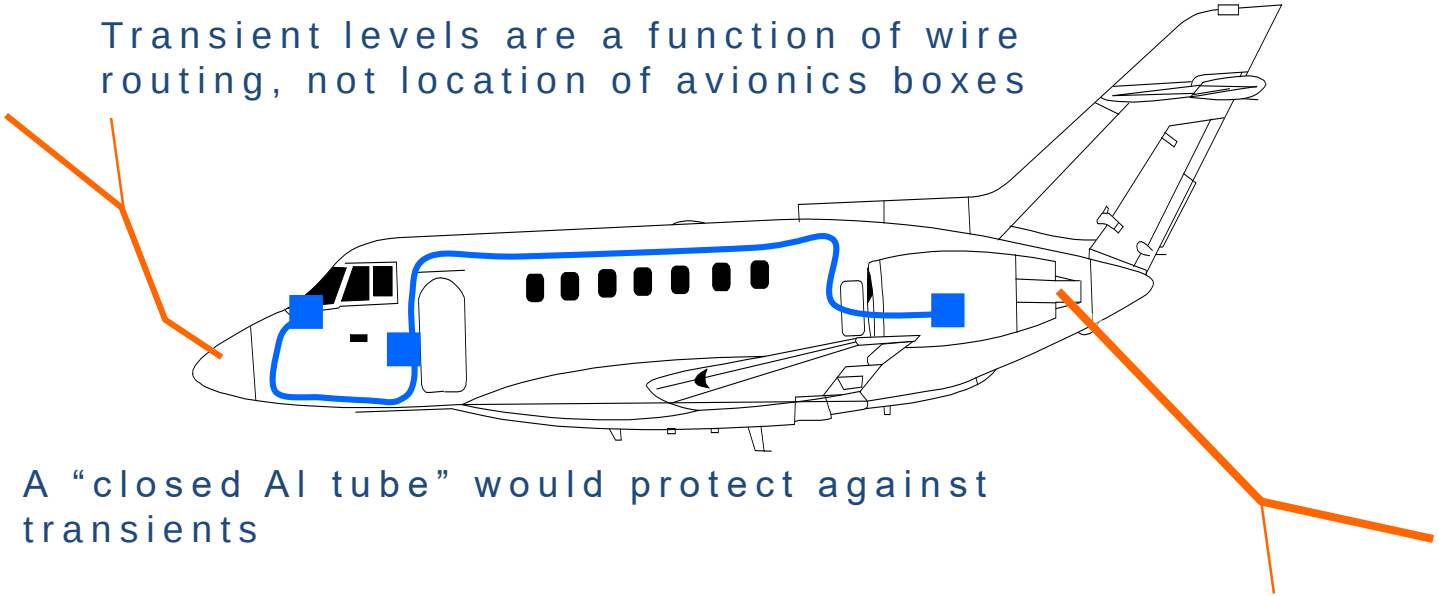
Coupling to aircraft wiring

Transients are induced into aircraft wiring by magnetic fields

Transient levels are a function of wire routing, not location of avionics boxes



A “closed Al tube” would protect against transients

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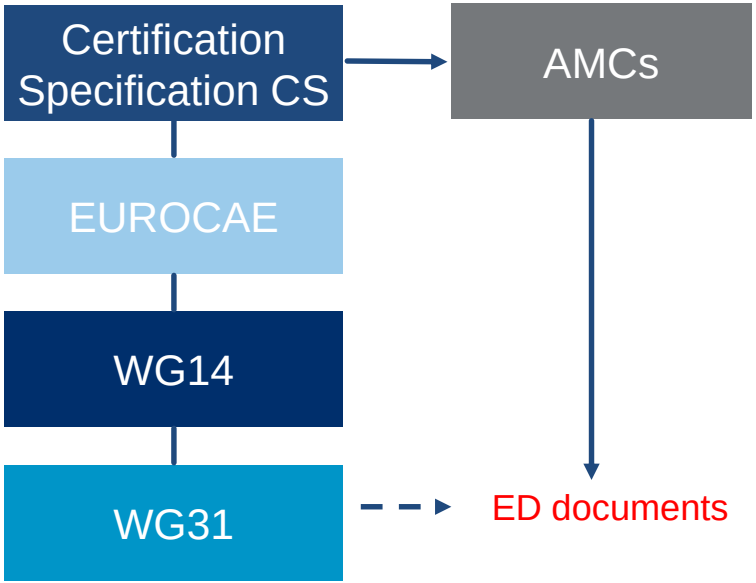
Relationship between Standards Committees and Authorities

European Nations, EASA



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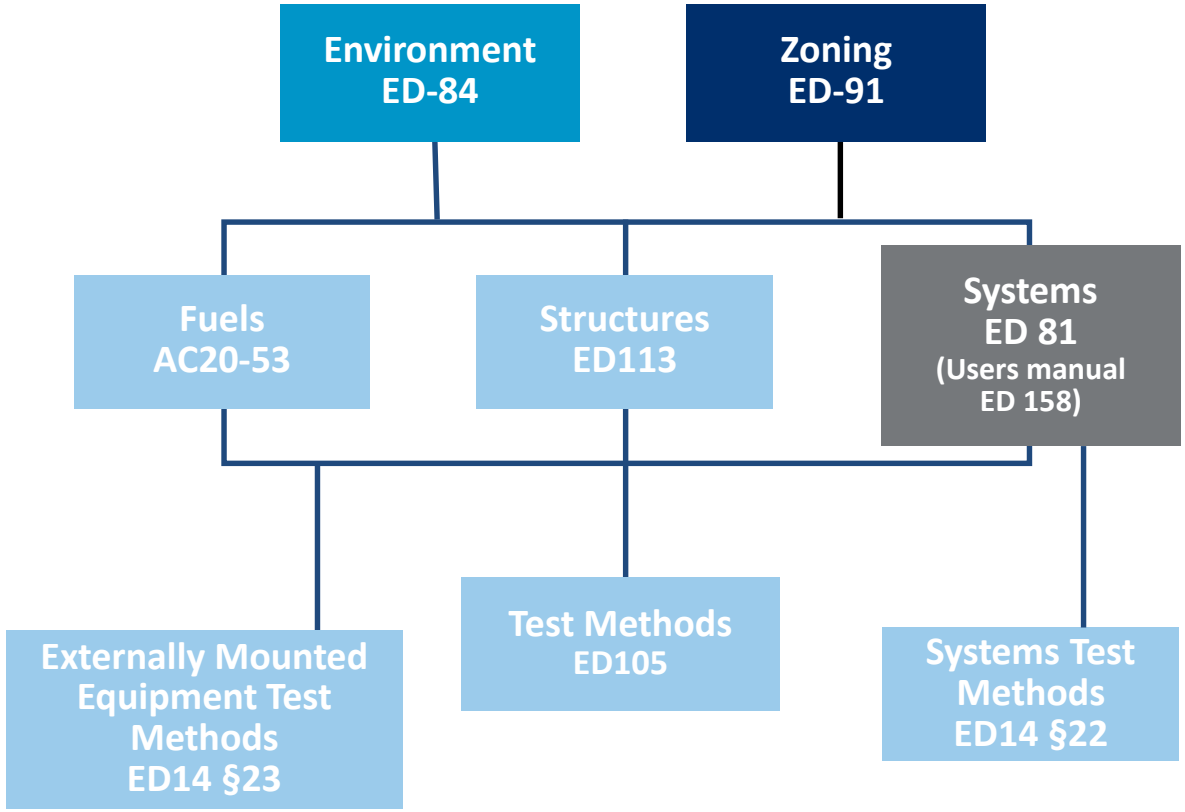
Structure of EUROCAE documentation



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ED105 Direct Effects Example

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ED-14 Section 22&23 Examples

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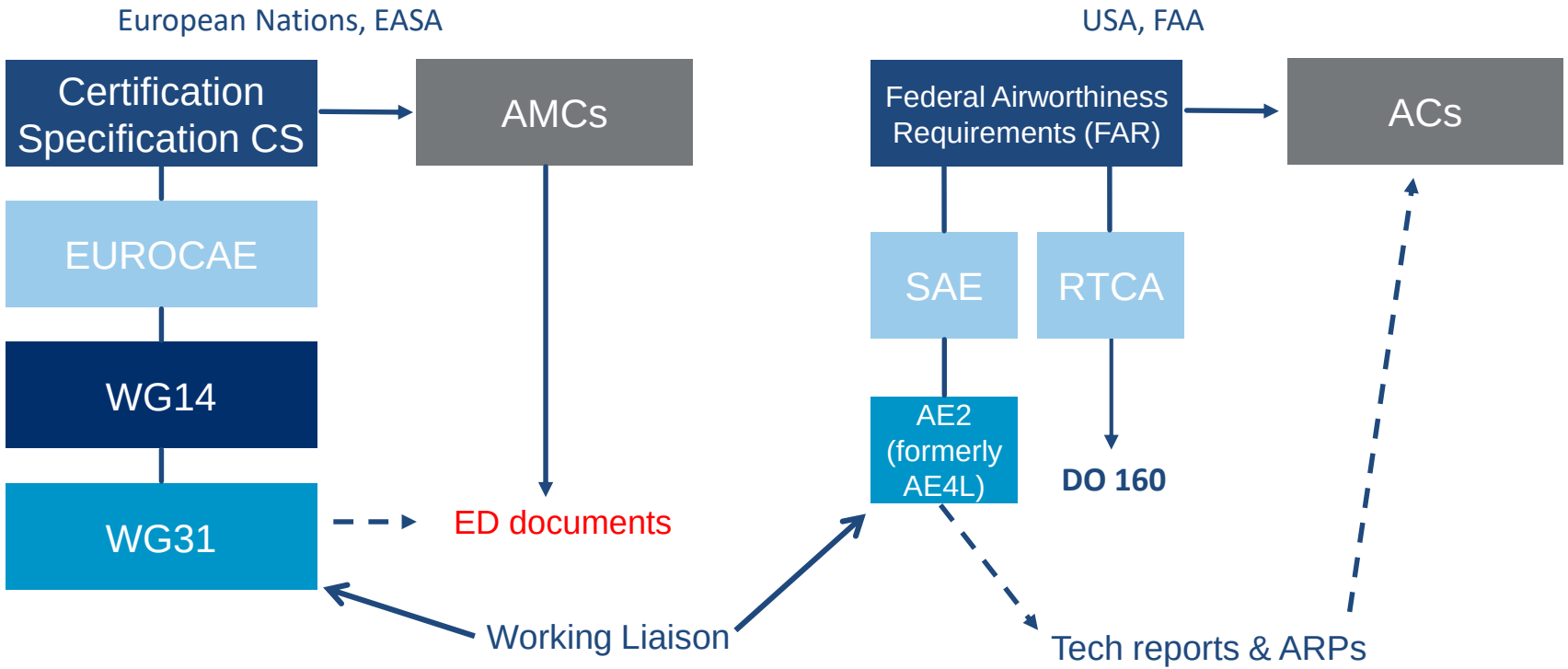
Relationship between Standards Committees and Authorities – Comparison between EU & US/FAA



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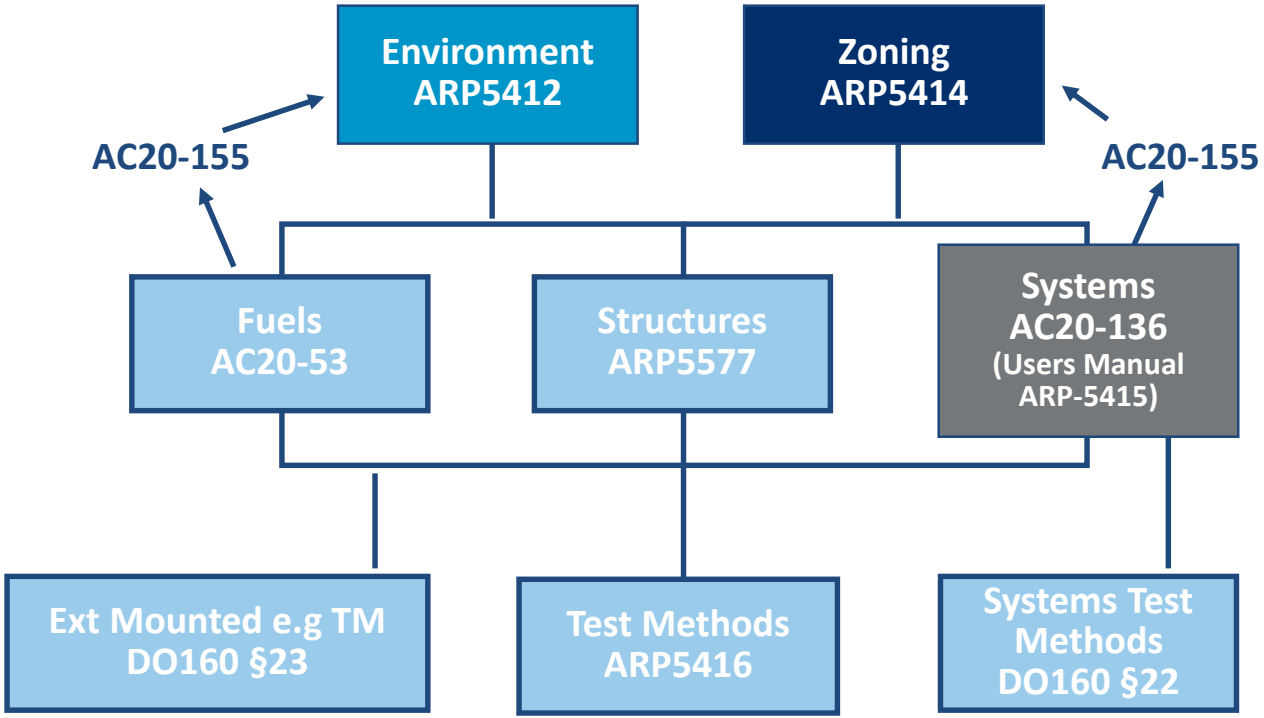
Structure of SAE documentation



- AC20-155 – 1 Page FAA AC that recommends use of ARP documents for Environment and zoning

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Military

- UK Aircraft
  - Def Stan 59-113
    - Incorporates a higher Action Integral (3.5MJ/Ω c.f. 2MJ/Ω)
    - Larger charge transfer (330C c.f. 200C)
  - Def Stan 59-411 – just concerns Equipment Tests

- NATO Ordinance
  - STANAGS
    - Also incorporate the higher Action Integral

- US - Mil Standards
    - US military now generally follow same requirements and procedures as Civil

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Evolution of standards – Environment

Showing G-TIGK drifting in heavy seas after ditching and evacuation of occupants, with tail rotor/gearbox missing and damaged main rotor blade.

- TSS (Transport supersonique standards) ~1975 200kA, 0.6MJ/ΩΩ
- Super Puma TRB by similarity to Ecureuil TRB, tested to TSS but change from GRP to CFC
- ED84 1998 200kA, 2.0MJ/Ω

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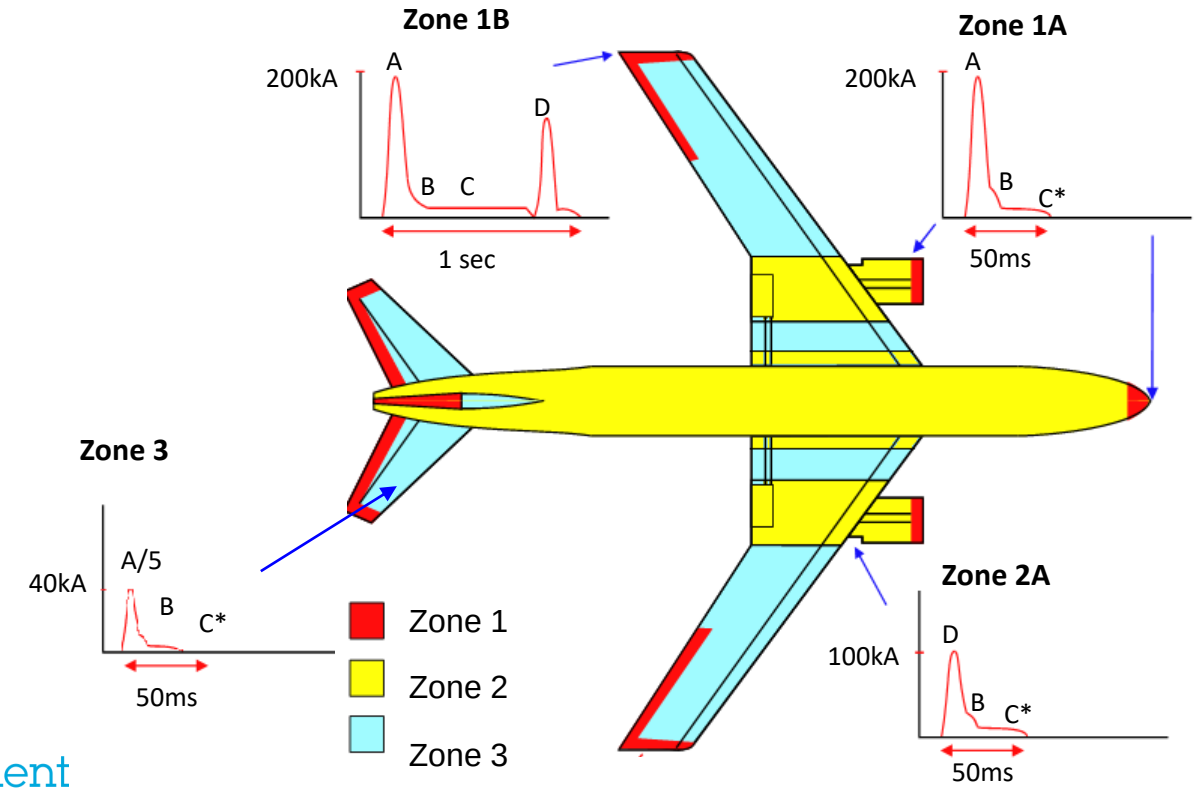
Different Zones, Different Threats



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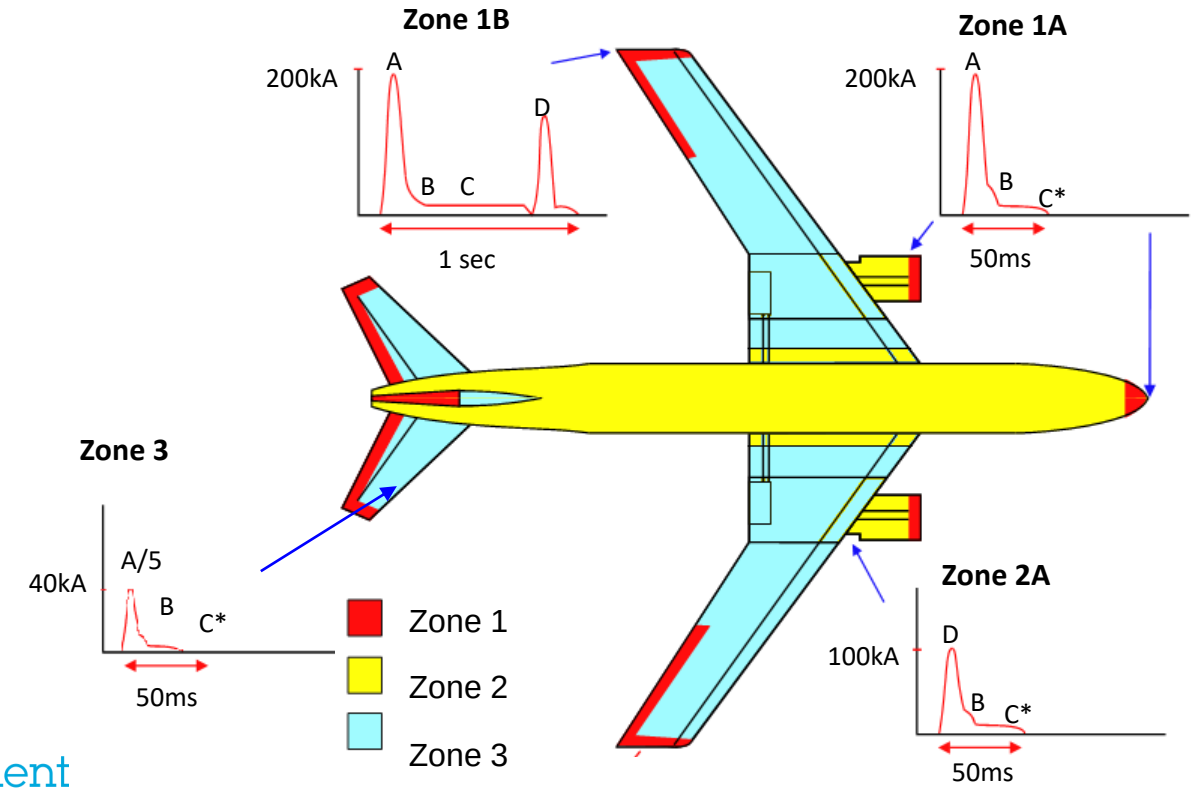
Change in zoning – ED-91B



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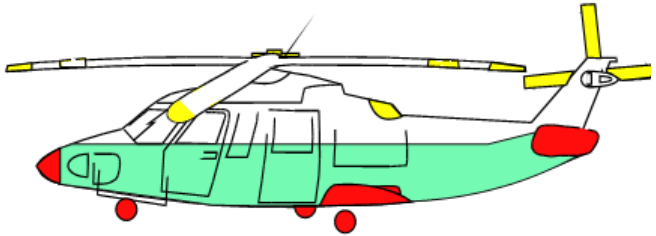
Helicopter Zones (ED91 B)

Old (Composite Hover/Forward)



New zoning

- Zone 1a
- Zone 1b
- Zone 2a
- Zone 3

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Main Concerns

- Structures
  - Flight Control surfaces, Fan Cowls…
- Fuel Tank Structure & Systems
  - Prevention of Fuel Ignition/Explosion
- Avionics & Electrical Systems
  - No Damage to Critical Avionics
  - No Disruption of data, or misleading data

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Structures

- General Approach given in Guidance Material (ARP5577 / ED113)
  - Determine Lightning Zones
  - Establish External Environment
  - Identify possible ignition sources or areas subject to detrimental damage
  - Design Protection (& pass/fail criteria)
    - Devise a certification plan
    - Review with Airworthiness Authorities
  - Verify Compliance

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Structures – Example Tests

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Structures – Example Tests

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Fuels

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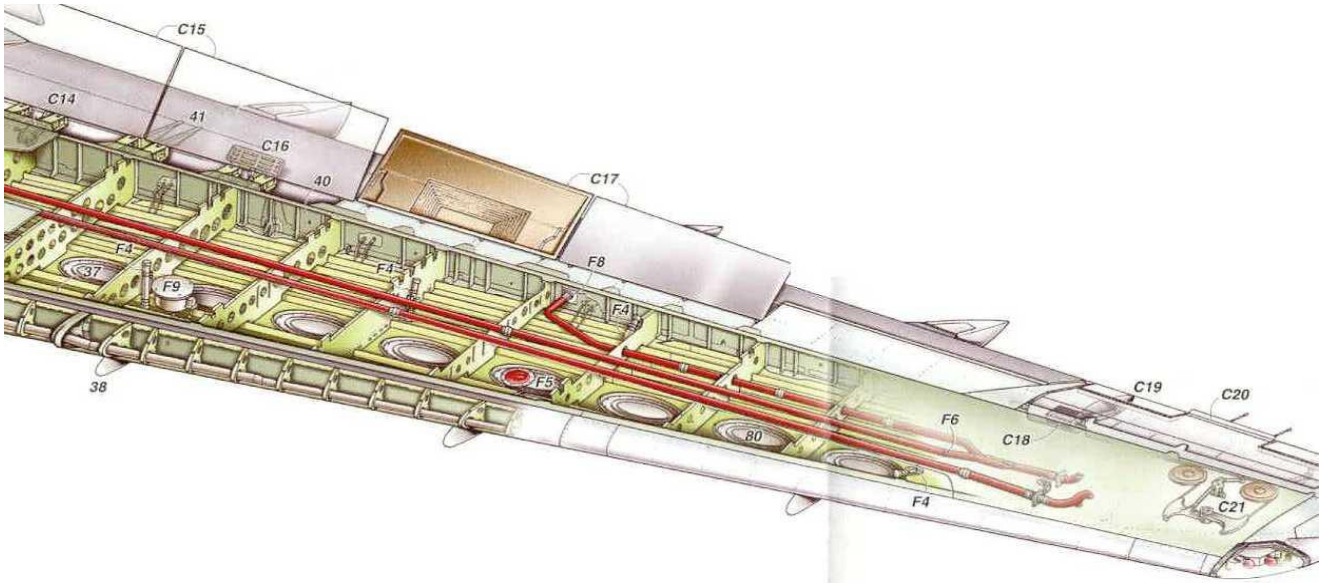
Identify possible ignition sources - Example



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Fuel systems – Regulation History

- FAR 25.954 (Fuel System Lightning Protection)
  - The fuel system must be designed and arranged to prevent the ignition of fuel vapour within the system

- FAR 25.981 (Fuel tank ignition prevention)
  - Need to “Demonstrate that an ignition source could not result from each single failure, from each single failure in combination with each latent failure condition not shown to be extremely remote, and from all combinations of failures not shown to be extremely improbable. The effects of manufacturing variability, aging, wear, corrosion, and likely damage must be considered.”

  - Impossible to satisfy

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New Rule

- 25.981 was intended for other aspects such as aging of wires and short circuit fault currents rather than lightning, which why it is challenging to satisfy for lightning.

- An updated version of 25.954 has been released which is lightning specific and will mean that 25.981 no longer applies for lightning

- The standards committees (SAE and EUROCAE) are working on a guidance document (ARP-6205/DP-001 [Guidance for fuel tank compliance]) for the new rule

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Fuel systems – Example Tests

Conduction tests to simple coupons

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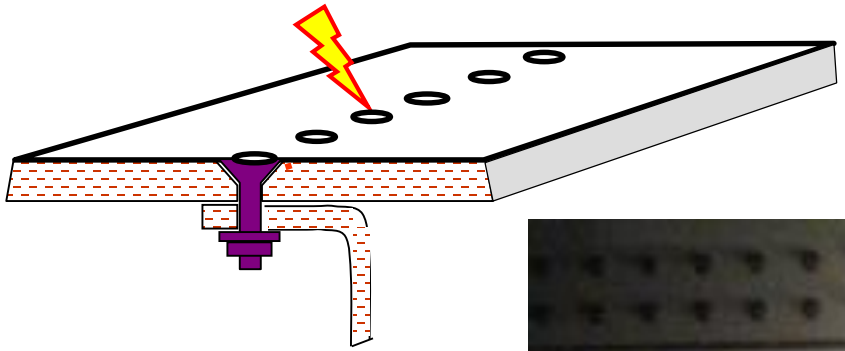
Fuel systems – Example Tests

Attachment or Conduction tests to more complex samples



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Avionic/Electrical Systems – Control and Design levels

- General Approach given in Guidance Material
  - Determine Lightning Zones
  - Establish Airframe Current Paths
  - Establish Internal Environment
    - Actual Transient Levels (ATL)/Transient Control Levels (TCL) for system on aircraft
  - Establish Equipment Hardness against transients
    - Equipment Transient Design Levels (ETDL)/Equipment Susceptibility Design Levels (ETSL)
  - Verify Compliance
    - by showing that ETDL >> TCL

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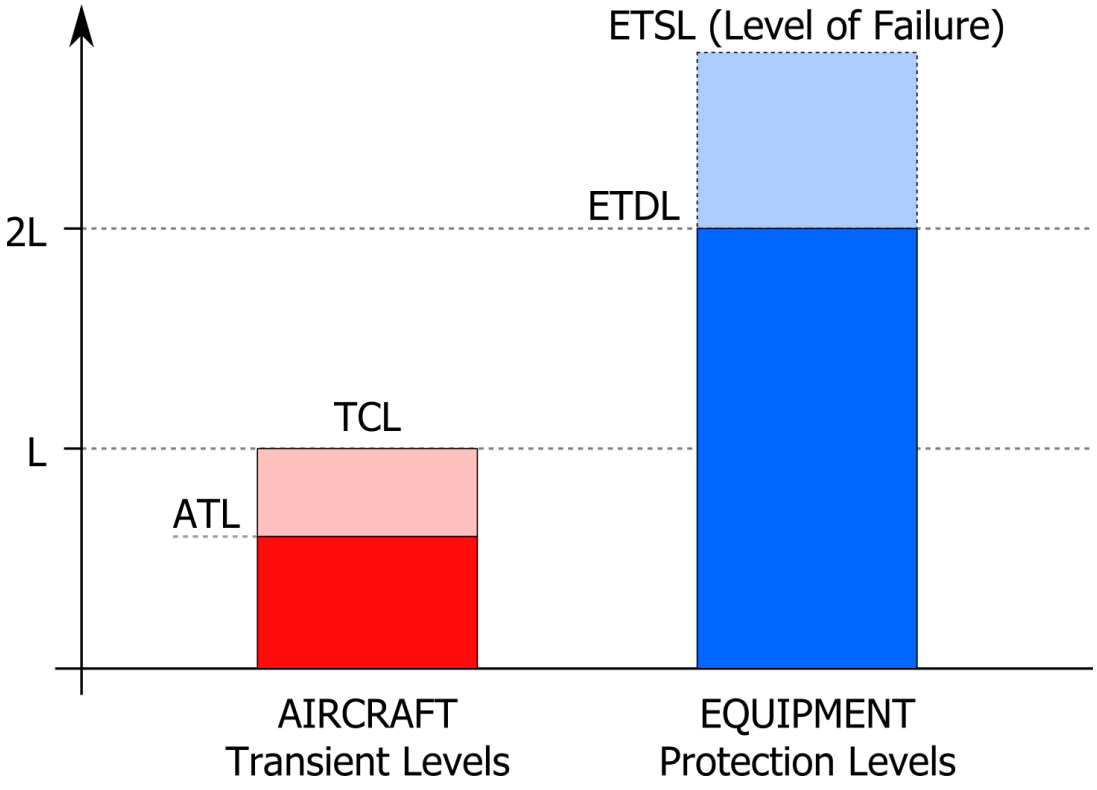
Avionic/Electrical Systems – Control and Design levels



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Avionic/Electrical Systems

- Criticality of a system influences the certification requirements. These follow from
  - Functional Hazard Assessment (FHA)
  - System Safety Assessment (SSA)

- Set of system assurance levels A to E
  - Level A systems whose failure would cause or contribute to a failure of function resulting in a catastrophic failure condition.
  - Level B … … resulting in a hazardous/severe-major failure condition
  - Level C … … major.
  - Level D … … minor.

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Avionic/Electrical Systems – Determining Control and Design levels

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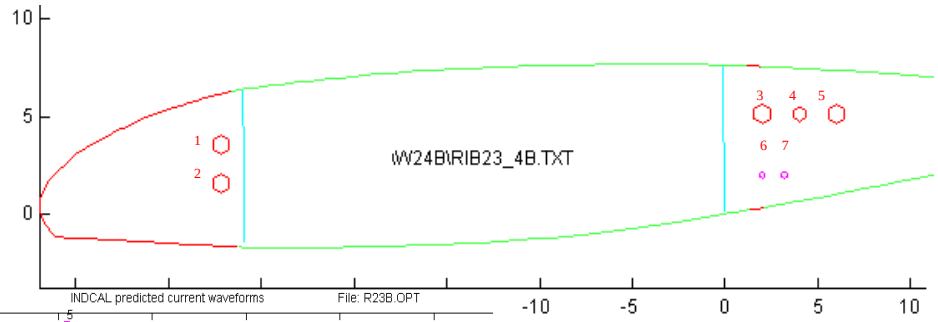
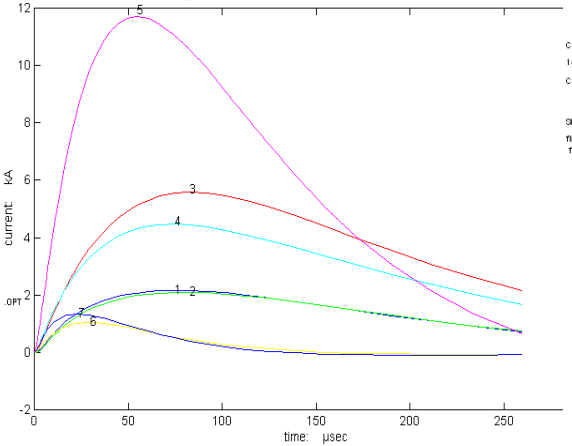
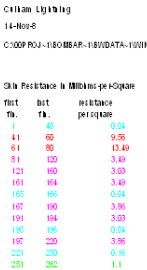
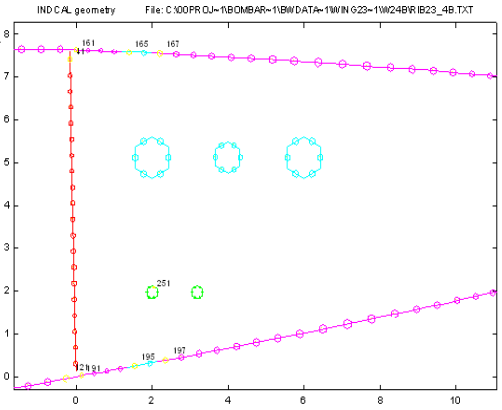
Avionic/Electrical Systems – Determining Control and Design levels









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Avionic/Electrical Systems – Verification of protection

- Pin tests demonstration equipment protection against damage

- Cable bundle tests demonstrating systems hardness against damage, interrupt, misleading information

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Avionic/Electrical Systems – Verification of protection Example

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Avionic/Electrical Systems – Verification of protection Example

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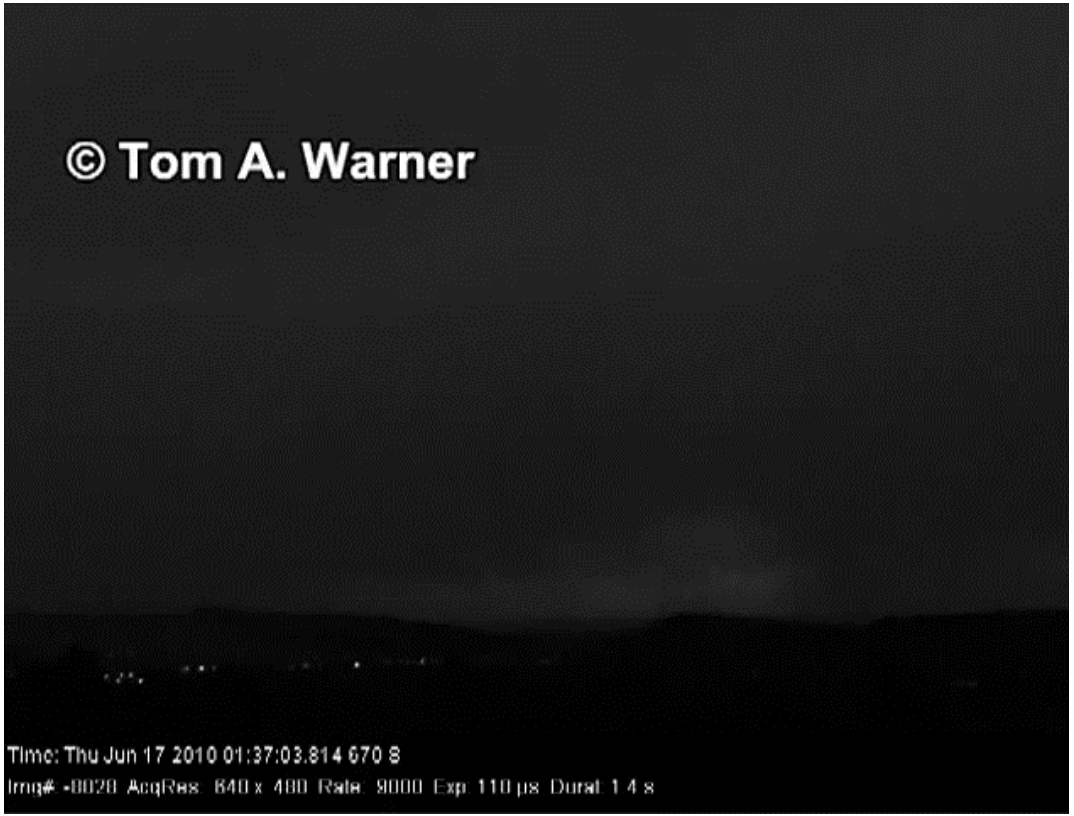
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Questions & Answers

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