Civil Aircraft System Safety and Electromagnetic Compatibility

Federal Aviation Administration

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Presentation Topics

- **FAA regulatory structure**
  - Airworthiness regulations
  - Guidance and advisory circulars
- **Aircraft system safety approaches**
- **Aircraft electromagnetic compatibility**

FAA Regulatory Structure

- **FAA is directed to promote safe flight of civil aircraft under 49 USC 44701**
- **FAA adopts regulations for aviation safety under Code of Federal Regulations Title 14**
  - Aircraft certification and airworthiness standards are in 14 CFR parts 21 through 49
  - Airmen, airspace, general operating rules, and air carrier operating rules in 14 CFR parts 60 through 139

Aircraft and Engine Airworthiness Regulations

Prescribe *minimum* airworthiness standards for design, material, construction, quality of work, and performance of aircraft, aircraft engines, and propellers

- Part 23 Normal, utility, acrobatic, and commuter category airplanes
- Part 25 Transport category airplanes
- Part 27 Normal category rotorcraft
- Part 29 Transport category rotorcraft
- Part 33 Aircraft engines
- Part 35 Propellers

Airworthiness Regulatory Approach

Typically regulations define safety objectives, not prescriptive design requirements

System safety regulation example:

14 CFR 25.1309 Equipment, systems, and installations.

(a) The equipment, systems, and installations whose functioning is required by this subchapter, must be designed to ensure that they perform their intended functions under any foreseeable operating condition.

(b) The airplane systems and associated components, considered separately and in relation to other systems, must be designed so that--

(1) The occurrence of any failure condition which would prevent the continued safe flight and landing of the airplane is extremely improbable, and

(2) The occurrence of any other failure conditions which would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions is improbable.

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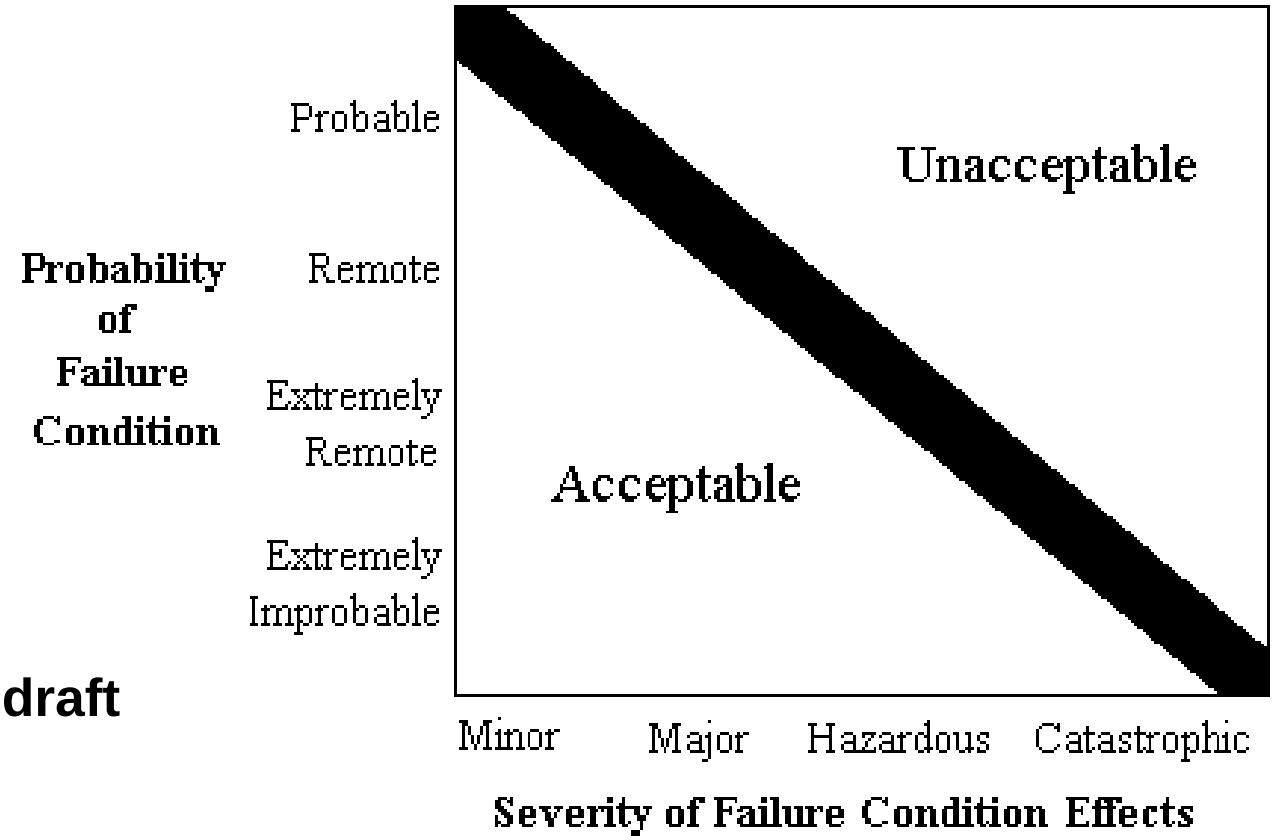
Compliance with Regulations

- **FAA guidance for compliance with airworthiness regulations published in Advisory Circulars (ACs)**
- **Define acceptable, but not the only, means to comply with the airworthiness regulations**
- **For example, AC 25.1309-1A describes acceptable means for showing compliance with requirements of 14 CFR 25.1309**

Relationship between Probability and Severity of Failure Condition Effects



From AC 25.1309-1 draft revision

Relationship Between Probability and Severity of Failure Condition (from AC 25.1309-1 draft)

Effect on Airplane	No effect on operational capabilities or safety	Slight reduction in functional capabilities or safety margins	Significant reduction in functional capabilities or safety margins	Large reduction in functional capabilities or safety margins	Normally with hull loss
Effect on Occupants excluding Flight Crew	Inconvenience	Physical discomfort	Physical distress, possibly including injuries	Serious or fatal injury to a small number of passengers or cabin crew	Multiple fatalities
Effect on Flight Crew	No effect on flight crew	Slight increase in workload	Physical discomfort or a significant increase in workload	Physical distress or excessive workload impairs ability to perform tasks	Fatalities or incapacitation
Allowable Qualitative Probability	No Probability Requirement	Probable	Remote	Extremely Remote	Extremely Improbable
Allowable Quantitative Probability (Average Probability per Flight Hour)	No Probability Requirement	$<10^{-3}$	$<10^{-5}$	$<10^{-7}$	$<10^{-9}$
Classification of Failure Conditions	No Safety Effect	Minor	Major	Hazardous	Catastrophic

Aircraft System Safety Analysis

- **Depth and scope of safety analysis depend on:**
  - Types of functions performed by the systems
  - Severity of the system failure conditions
  - Complexity of the systems
- **Structured safety analyses are advised, particularly for systems with catastrophic failure conditions**
- **Further guidance for safety analyses is in SAE ARP4754 and ARP4761**

Aircraft System Electromagnetic Effects Protection

- **Airworthiness regulations address system:**
  - Lightning protection
  - High intensity radiated RF fields protection
  - Electromagnetic compatibility
- **Regulations provide safety objectives**

  For example:

  14 CFR 25.1316 System lightning protection.

  (a) For functions whose failure would contribute to or cause a condition that would prevent the continued safe flight and landing of the airplane, each electrical and electronic system that performs these functions must be designed and installed to ensure that the operation and operational capabilities of the systems to perform these functions are not adversely affected when the airplane is exposed to lightning.

Compliance with Electromagnetic Effects Regulations

- **As with system safety, FAA advisory circulars define acceptable means of showing compliance with regulations**
  - System lightning protection – AC 20-136
  - HIRF protection – AC 20-158
- **Advisory circulars refer to industry standards from SAE and RTCA**
  - Standards define detailed test procedures, test levels, and lightning environment

System Electromagnetic Effects Protection

- **Objective is to prevent adverse effects to the aircraft due to the electromagnetic effects**
- **Compliance involves:**
  - Aircraft and system electromagnetic protection design
  - System and equipment electromagnetic qualification tests, such as those defined in RTCA/DO-160
  - Aircraft lightning, HIRF, and EMC tests

Airworthiness Directives (14 CFR 39)

- **FAA issues airworthiness directives when an unsafe condition exists in an aircraft, engine, propeller, or appliance, and**
- **The condition is likely to exist or develop in other products of the same type design**
- **Airworthiness directives are legally enforceable rules**
- **Airworthiness directives specify inspections, limitations, or actions that must be taken to resolve an unsafe condition**

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