

# Flight Safety, Airworthiness, Type Certificates, Design Requirements & Specifications

Serkan Özgen, Prof. Dr.

Middle East Technical University

Dept. Aerospace Eng., Ankara, Turkey

# Outline

- Introduction
- Flight Safety
- Airworthiness
- ICAO and Civil Aviation Authorities
- Airworthiness Requirements
- Type Certification
- Design Requirements and Specifications

# Outline

- **Introduction**
- Flight Safety
- Airworthiness
- ICAO and Civil Aviation Authorities
- Airworthiness Requirements
- Type Certification
- Design Requirements and Specifications

# Introduction

- **Safety and Airworthiness Requirements** are becoming more and more stringent and complex.
- Quest for a **safer, greener, cheaper and more efficient** air transportation and aviation in general, worldwide.
- Designer shall keep Safety and Airworthiness Requirements in mind starting from the earliest stages of design ⇒ **technically sound, feasible, safe and reliable airplane.**

# Outline

- Introduction
- **Flight Safety**
- Airworthiness
- ICAO and Civil Aviation Authorities
- Airworthiness Requirements
- Type Certification
- Design Requirements and Specifications

# Flight Safety

- Safety: Control of **recognized hazards** to achieve an acceptable level of **risk**.
- Related to all **human activities**.
- Controlled by national states through **regulations**.
- Main conventional **safety factors** related to aeronautical activities:
  - **Man,**
  - **Environment,**
  - **Machine.**

# Flight Safety

- **Man:** active part of flight operations; pilots, maintenance crew, traffic controllers, etc. Placed in legislative and organized context to guarantee an adequate level of professional training, psychological and physical fitness.
- **Environment:** meteorological conditions, traffic, communications, etc.
- **Machine:** good design, sound construction, efficiency.
- Safety factors act in **series** not in parallel.

# Flight Safety





# Outline

- Introduction
- Flight Safety
- **Airworthiness**
- ICAO and Civil Aviation Authorities
- Airworthiness Requirements
- Type Certification
- Design Requirements and Specifications

# Airworthiness

- **Airworthiness:** Ability of an aircraft or any other equipment or system to operate **without significant hazard** to aircrew, ground crew, passengers or to the general public over which such airborne systems are flown.
- The aircraft must comply with **necessary requirements** for flying in **safe conditions, within allowable limits.**

# Airworthiness

- **Safe conditions:** Normal beginning, continuation and satisfactory termination of flight.
- **Compliance with necessary requirements:** Aircraft, or any of its parts, is designed and built according to the studies and tested criteria to fly in safe conditions.
- Aircraft are designed for operation within an **operating envelope**, which depends on speed and structural load factors. Overweight take-off, etc. may impose a risk on flight safety.

# Outline

- Introduction
- Flight Safety
- Airworthiness
- **ICAO and Civil Aviation Authorities**
- Airworthiness Requirements
- Type Certification
- Design Requirements and Specifications

# ICAO and Civil Aviation Authorities

- ICAO-International Civil Aviation Organization
- Main task: **Standardization** in the operation of a **safe, regular, and efficient air service worldwide.**
- Standardization has been achieved through 18 Annexes identified as **International Standards** and **Recommended Practices.**
- **International Standards** are directives that ICAO members agree to follow. They are considered as **necessary** for the safety and regularity of aviation.
- **Recommended practices** are desirable but not essential.

# ICAO and Civil Aviation Authorities

- **FAA or EASA airworthiness standards** for the certification of aircraft are issued in accordance with ICAO annexes.
- The **certification process** is based on these airworthiness standards rather than directly on the ICAO International Standards.

# ICAO and Civil Aviation Authorities

- **Annex 8** is the most relevant to the scope of the design phase.
- The technical standards dealing with the certification of airplanes include requirements related to:
  - Performance,
  - Flying qualities,
  - Structural design and construction,
  - Engine and propeller design and installation,
  - Systems and equipment design and installation,
  - Operating limitations,
  - General information to be provided in the airplane flight manual,
  - Crashworthiness of aircraft and cabin safety,
  - Operating environment,
  - Human factors and security in aircraft design.

# ICAO and Civil Aviation Authorities

- Special consideration is given to requirements and design features affecting the **ability of the flight crew** to maintain controlled flight.
- The layout of the **cockpit** must be such as to minimize the possibility of incorrect operation of controls due to confusion, fatigue or interference.
- The cockpit must present a **clear, extensive and undistorted field of vision**.



# ICAO and Civil Aviation Authorities



# ICAO and Civil Aviation Authorities

- Airplane design features also provide for the **safety, health and well-being of occupants** by granting an adequate cabin environment during operating conditions.
- The means for **rapid and safe evacuation in emergency landings** and the equipment necessary for the survival of the occupants are also described.
- Requirements for the certification of **engines and accessories** are defined such that they function reliably in foreseen operating conditions.

# ICAO and Civil Aviation Authorities

- A civil aviation authority or a regulatory authority is a **government statutory authority** in each country that oversees the approval and regulation of civil aviation. This is usually a National Aviation Authority (NAA).
- A regulatory authority typically regulates the following aspects of airworthiness and operation:
  - Design of aircraft and related products, parts and appliances.
  - Maintenance of aircraft and equipment.
  - Operation of aircraft and equipment.
  - Licensing of pilots and maintenance engineers.
  - Licensing of airports and navigational aids.
  - Standards for air traffic control.

# ICAO and Civil Aviation Authorities

Some of the major aviation regulatory authorities are:

- Federal Aviation Administration (FAA, USA);
- European Aviation Safety Agency (EASA, EU). EASA is not actually a NAA but plays part of the role within its member states of the EU;
- Civil Aviation Authority (CAA, UK);
- Direction Générale de l'Aviation Civile (DGAC, France);
- Luftfahrt-Bundesamt (LBA, Germany);
- Transport Canada (TC, Canada);
- Directorate General of Civil Aviation (SHGM-DGCA, Turkey).

# Authorizations in the EU

Certificate of Approval, Permit to Fly	Issued by			
	EASA	Competent authority	Design organisation	Production organisation
Type Certificate (TC), Restricted Type Certificate (RTC), Supplementary Type Certificate (STC)	X			
Changes	X		X	
Repairs	X		X	
Certificate of airworthiness		X		
Noise certification		X		
Permit to fly		X	X	X
Design organisation approval	X			
Production organisation approval		X <sup>1</sup>		

<sup>1</sup> By EASA when the applicant is a legal entity in a country, which is not a member of EASA.

# Outline

- Introduction
- Flight Safety
- Airworthiness
- ICAO and Civil Aviation Authorities
- **Airworthiness Requirements**
- Type Certification
- Design Requirements and Specifications

# Airworthiness Requirements

**Airworthiness codes** are established by regulatory authorities and contain a series of **design requirements** including:

- Strength of structures,
- Flight qualities,
- Performance,
- Criteria for good design practice,
- Systems,
- Necessary tests,
- Flight and Maintenance manual content.

# Airworthiness Requirements

## Airworthiness Codes

Code	Organization	Definition
CS-Definitions/FAR-1	EASA/FAA	Definitions used in other CS/FAR documents
Part-21/FAR-21	EASA/FAA	Certification procedures for aircraft and related products and parts
CS-VLA	EASA	CS for very light airplanes
CS-VLR	EASA	CS for very light rotorcraft
CS-22	EASA	CS for sailplanes and powered sailplanes
CS/FAR-23	EASA/FAA	CS/FR for normal, utility, acrobatic, commuter category airplanes
CS/FAR-25	EASA/FAA	CS/FR for large airplanes
CS/FAR-27	EASA/FAA	CS/FR for small rotorcraft
CS/FAR-29	EASA/FAA	CS/FR for large rotorcraft
FAR-31	FAA	FR for manned free balloons
CS/FAR-34	EASA/FAA	CS/FR for aircraft engine emissions and fuel venting
CS/FAR-36	EASA/FAA	CS/FR for aircraft noise
CS-AWO	EASA	CS for all weather operations
CS-E/FAR-33	EASA/FAA	CS/FR for engines
CS-ETSO	EASA	CS for European Technical Standard Orders
CS-P/FAR-35	EASA/FAA	CS/FR for propellers
CS-LSA	EASA	CS for light sport airplanes
CS-APU	EASA	CS for auxiliary power units



# Airworthiness Requirements

## Airplane Categories

Types and categories of airplanes relevant to the present context:

- CS-VLA: Very Light Aeroplanes.
- CS-LSA: Light Sport Aeroplanes.
- FAR/CS-23: Normal, Utility, Aerobatic and Commuter Aeroplanes.
- FAR/CS-25: Large Aeroplanes.

# Airworthiness Requirements

## Airplane Categories

### CS-VLA: Very Light Aeroplanes:

- Single engine with spark or compression ignition.
- Maximum two seats.
- Maximum certified take-off gross weight  $\leq 750$  kg.
- Stalling speed in landing configuration  $\leq 45$  knots (83 km/h).
- Non-aerobatic use only.
- Stalls (except whip stalls).
- Lazy eights, chandelles, steep turns where bank angle  $\leq 60^\circ$ .
- Day-VFR only.

# Airworthiness Requirements-VLA (Aero AT-3)



# Airworthiness Requirements

## Airplane Categories

### CS-LSA: Light Sport Aeroplanes:

- Single, non-turbine engine or electric propulsion unit fitted with a propeller.
- Maximum two seats.
- Maximum certified take-off gross weight  $\leq 600$  kg.
- Stalling speed in landing configuration  $\leq 45$  knots (83 km/h).
- Day-VFR only.

# Airworthiness Requirements-LSA (Cessna 162)



# Airworthiness Requirements

## Airplane Categories

FAR/CS-23: Normal, Utility, Aerobatic and Commuter Category

Aeroplanes:

- Aeroplanes in the normal, utility, and aerobatic categories that have a seating configuration, excluding the pilot seat(s), of nine or fewer and a maximum certified take-off weight of 5670 kg (12 500 lb) or less;
- Propeller-driven, twin engine aeroplanes in the commuter category that have a seating configuration, excluding the pilots seat(s), of 19 or fewer and a maximum certified take-off weight of 8618 kg (19 000 lb) or less.

# Airworthiness Requirements

## Airplane Categories

- **Normal.** The Normal Category is limited to non-aerobatic operations. Non-aerobatic operations include stalls (except whip stalls) and some simple manoeuvres in which the bank angle  $\leq 60^\circ$ .
- **Utility.** The Utility Category is limited to the operations in the Normal Category, spins, and some aerobatic manoeuvres, where the bank angle is between  $60^\circ$  and  $90^\circ$ .
- **Aerobatic.** The Aerobatic Category has no restrictions other than those shown to be necessary as a result of required flight tests.
- **Commuter.** The Commuter Category is limited to any manoeuvre incident to normal flying, stalls (except whip stalls) and steep turns in which the bank angle is  $60^\circ$  or less.
- For single-engined Normal, Utility and Aerobatic Category Airplanes, and twin-engined airplanes in the same Category that cannot satisfy a specified climb rate requirement with one engine inoperative, **stalling speed** in landing configuration must be less than or equal to 61 knots (113 km/h).

# Airworthiness Requirements-CS-23 (Cirrus SR.20)





# Airworthiness Requirements-Commuter (Cessna-421)



# Airworthiness Requirements-Structure

- Airworthiness codes like CS-22, CS-VLA, CS-VLR, CS/FAR-23, 25, 27 and 29 have a **common structure**.
- They are composed of **Subparts and Appendices**.
- Same topics are dealt with paragraphs with the same number, i.e. XX.25 is for «Weight Limits», XX.125 is for «Longitudinal Control», etc.

# Airworthiness Requirements-Structure

- **Subpart A: General.** Information about the types and categories of aircraft to which the standard is applicable.
- **Subpart B: Flight.** Flight tests to be carried out to show compliance with performance, controllability, maneuverability and stability requirements.
- **Subpart C: Structure.** Contains the requirements for flight (maneuver and gust loads) and ground load assessment, and for structural design of airframes, control systems, landing gears, and others. Crashworthiness and fatigue requirements are also provided.
- **Subpart D: Design and Construction.** Deals with the design technique, materials, safety factors, control system and landing gear design, structural tests to be carried out, cockpit and passenger cabin design, fire protection and flutter requirements.

# Airworthiness Requirements-Structure

- **Subpart E: Powerplant.** Contains the requirements for power plant installations and related systems. Powerplant controls, accessories, and fire protection are also considered.
- **Subpart G: Operating Limitations and Information.** Provides requirements for all the information that must be available to the pilot and other personnel for correct aircraft operations like markings, placards, and the content of the flight manual.
- **Appendices.** Provide design load criteria, test procedures for material flammability, and instructions for continued airworthiness.

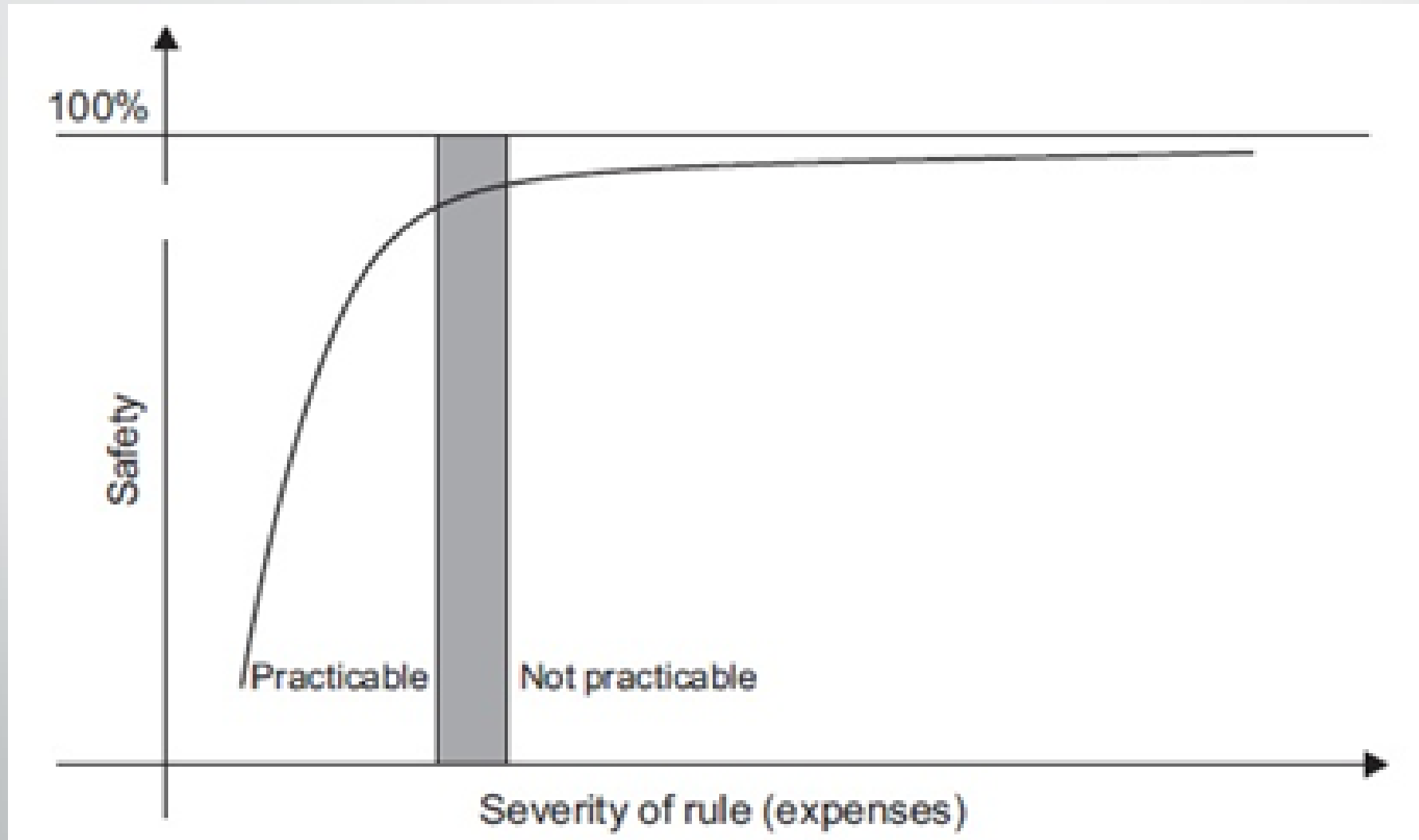
# Airworthiness

## Severity of Airworthiness Standards

- The application of an airworthiness rule involves **expense**.
- **Increase in safety** is **not** always **proportional** to the **severity** of the rule.
- At and beyond a certain level of safety, negligible safety increases incur at **great cost**. At this point, the rule is **not practicable**.
- A proposal should be:
  - Economically reasonable;
  - Technologically practicable;
  - Appropriate to the particular type of aircraft.

# Airworthiness

## Severity of Airworthiness Standards



# Airworthiness

## Severity of Airworthiness Standards

- Various airworthiness standards
  - for different types of aircraft (airplanes, rotorcraft, etc.)
  - for different categories of the same type of aircraft (according to weight, number of passengers, etc.).
- Aircraft are arranged in groups as homogeneous as possible. In CS-23:
  - Normal, Utility, Aerobatic,
  - Commuter airplanes.
- Does not mean airworthiness standards are higher for transport airplanes than others because they must be safer.
- Safety must be maximized for all aircraft within the **practicability concept**, i.e. simple aircraft should have simple airworthiness standards to comply with. CS-25 is 919 pages, CS-23 is 405, and CS-VLA is only 121!
- The designer should be capable of choosing the **right airworthiness standard** with respect to the design project.

# Airworthiness

## Stall speed for single-engine airplanes

- When the **engine** of a single-engine airplane **fails**, it has to **glide** and make an **emergency landing**.
- Gliding and power-off landing of a single-engine airplane must not require outstanding pilot skill and effort.
- A limitation on the stall speed is required because power-off landing is related to **approach speed**, which itself is dependent on stall speed in the landing configuration.
- The stalling speed of single-engine airplanes in landing configuration are limited to **61 knots (113 km/h)** for CS/FAR-23 Class airplanes.
- For CS-VLA and CS-LSA Class airplanes, the stalling speed limitation is **45 knots (85 km/h)**.



# Airworthiness - Crashworthiness

- Stalling speed limitation cannot guarantee a safe, power-off landing, since all the conditions during landing cannot be considered, i.e. rough terrain.
- Then, the possibility of a **crash landing** shall be considered ⇒ **crashworthiness**.
- Crashworthiness concerns **all** types of airplanes.

# Airworthiness - Crashworthiness

- CS/FAR-23 contains appropriate safety standards for **emergency landing conditions**.
- Deals with structural rules for the protection of occupants, requiring extensive **static and dynamic tests** for:
  - Seat and seat restraint system;
  - Fuselage structure supporting these.
- CS-VLA contains a section dealing with emergency landing conditions, providing rapid escape in normal and crash attitude.
- Dynamic crash tests are not required for CS-VLA airplanes.

# Airworthiness – Fire Protection

- An aircraft has engines, fuel, electrical installations, making fire hazard a real threat.
- For fire protection, **fire zones** in the airplane need to be identified; engine compartment, fuel tanks, etc.
- Three methods for protecting the occupants of an airplane from fire:
  - Abandoning the aircraft;
  - **Passive protection** to contain the fire for a time necessary for emergency landing;
  - **Active protection** by means of fixed or portable extinguishers.

# Airworthiness – Fire Protection

- In civil aircraft, passive protection is prescribed to allow a safe emergency landing, whenever possible.
- Achieved by isolating fire zones so that essential structures and systems can be protected until landing. Fire extinguishers are not ruled out but **not** considered as primary protection.
- For **transport and commuter** aircraft, **active protection** is prescribed in order to put out fires in the cockpit, cabin, engines, baggage and cargo compartments.
- Airworthiness standards provide rules for **materials** used for cabin interiors from **flammability and toxic fumes** points of view.
- Certification requirements provide procedures for tests.

# Airworthiness – Safety Assessment

- Ideally, the **reliability** of a vital aircraft system should be **100%**, however this is **practically impossible**.
- **Reliability** of a system can be improved with **redundancy**  
⇒ heavy, expensive, complex.
- Instead, systems are designed with minimum redundancy by improving the **reliability of single components**. This ensures an **acceptable safety level**.
- **Failure conditions:** Effects on the aircraft and its occupants, both direct and consequential, caused or contributed by one or more failures, considering operational or environmental conditions.

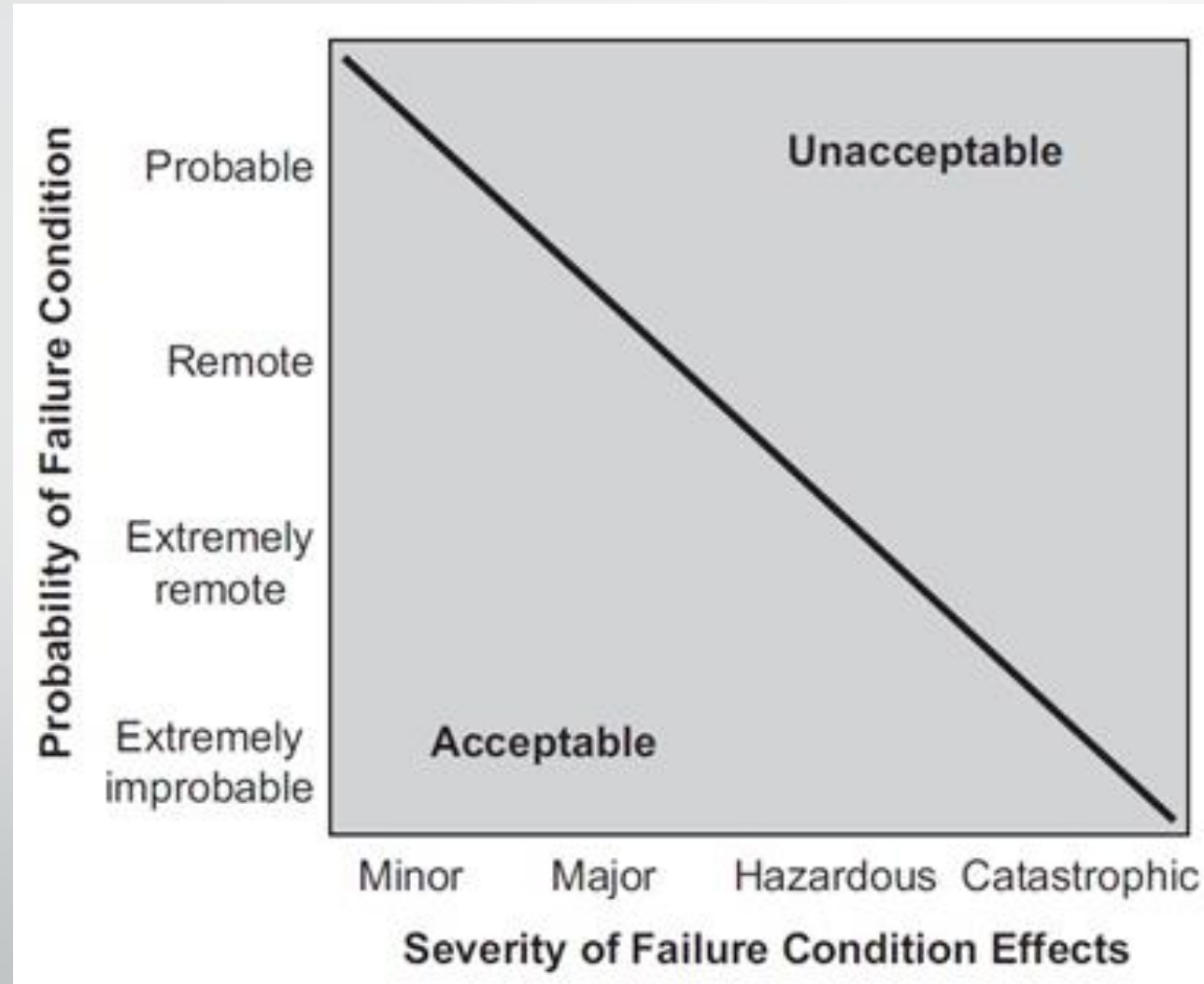
# Airworthiness – Safety Assessment

- Failure conditions are classified according to their severity as:
  - **Minor.** Failure conditions that do not reduce airplane safety significantly. These involve crew actions well within their capability. Example: Malfunction in the rate of turn indication system.
  - **Major.** Failure conditions that would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions. Significant reductions in safety margins or functional capabilities or a significant increase in crew workload may result. Discomfort to occupants, possibly injuries. Example: Malfunction in the autopilot disengagement switch.
  - **Hazardous.** Failure conditions that would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions such that large reductions in safety margins or functional capabilities occur. Physical distress or workload of the flight crew is so high that the flight crew cannot perform their tasks accurately or completely. Serious or fatal injury to a small number of occupants may result. Example: Malfunction in the display of altitude information.
  - **Catastrophic.** Failure conditions that would prevent continued safe flight and landing. Example: Loss of all means of attitude information.

# Airworthiness – Safety Assessment

- An **inverse relationship** exists between the severity of **failure conditions** and **probability of occurrence**:
  - Minor failures are probable and could arise several times in the aircraft's life.
  - Major failures are remote ( $\sim 10^{-5}$ ), might arise once in an aircraft's life and would arise several times in the whole fleet's life.
  - Hazardous conditions are extremely remote ( $\sim 10^{-7}$ ), might arise once in the whole fleet's life.
  - Catastrophic conditions are extremely improbable ( $\sim 10^{-9}$ ), are unlikely to arise in the whole fleet's life.
- The safety assessment of equipment, systems, and installation is a very important part of aircraft design. The techniques of safety assessment are a specialist matter and it is very important to start the assessment from the very early phases of design. Late assessments will obviously result in expensive design changes and delays (which are also expensive).

# Airworthiness – Safety Assessment





# Airworthiness – Fatigue Strength

The airworthiness standards consider two kinds of aircraft structure:

- Single load path structures.
- Multiple load path structures.

# Airworthiness – Fatigue Strength

- **Single load path structures.** Applied loads distributed through a **single member**. Failure results in the loss of the structural capability to support the applied loads. Example, a wing-fuselage attachment made by a single structural element like in most light aircraft.
- The structure must result in **safe-life** and must be able to sustain a number of cycles during which there is a low probability of the structure to degrade below its ultimate design load value due to fatigue ⇒ may result in an oversafe (heavy) airplane, which is the case for CS-VLS and CS-LSA category airplanes.

# Airworthiness – Fatigue Strength

- **Multiple load path structures.** Redundant structures in which the applied loads would be safely distributed to other load-carrying members in case of the failure of an individual element.
- The structure is **damage-tolerant**, it is able to retain its residual strength for a period without being repaired after a failure or partial failure occurs due to fatigue, corrosion, etc. This kind of structure is called **fail-safe**.

# Airworthiness – Fatigue Strength

- For **large airplanes**, the airworthiness standards (CS/FAR-25), require **fail-safe** structures, except when it is not possible to implement such a design due to geometrical restrictions. An example to such a case is the landing gear and its attachments.
- For CS/FAR-23 airplanes, it is possible to choose among safe-life and fail-safe approaches. An exception to this is **composite airframes**, where the design must be accomplished according to **fail-safe** criteria.

# Airworthiness – Fatigue Strength

In the case of loads and loading spectra, the assumptions made for fatigue assessment are:

- For CS/FAR-25 and CS/FAR-23 airplanes, the principal loads that should be considered in establishing a **loading spectrum are flight loads (gust and manoeuvre), ground and pressurization loads**. In assessing the possibility of serious fatigue failures, the design is examined to determine possible points of failure in service. In this examination, results for stress analysis, static and fatigue tests, strain gauge surveys, tests of similar configurations and service experience are considered.
- For CS-VLA airplanes, it is recommended that **stress concentration areas** are avoided as much as possible and fatigue tests are performed only when they are necessary. Instead, reference is made to data resulting from fatigue tests on similar structures and service experience. A way to avoid fatigue tests is to design critical structures with **stress levels below the fatigue limit** of the material used. This must be demonstrated by static tests and strain gauge surveys.

# Outline

- Introduction
- Flight Safety
- Airworthiness
- ICAO and Civil Aviation Authorities
- Airworthiness Requirements
- **Type Certification**
- Design Requirements and Specifications

# Type Certification

- A type certificate is an **approval** made by a **regulatory authority** that an aircraft is manufactured according to an **approved design**, and that the design ensures **compliance with airworthiness requirements**.
- The type certificate (TC) implies that the aircraft manufactured according to the **approved design** can be issued an **Airworthiness Certificate**. To meet airworthiness requirements, the aircraft, related products (engine and propeller), parts and appliances must be approved.
- Therefore, a Type Certificate is **not** an Airworthiness Certificate.

# Type Certification

Within the European Union (EU), implementation rules for type certification are laid down by the Commission Regulation (EU) No 748/2012 of 3 August 2012 titled:

*Laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations.*

Annex I (Part 21) of this regulation specifically addresses “Certification of aircraft and related products, parts and appliances, and of design and production organisations”.



# Type Certification-Process

- Application to EASA.
- Issue of Airworthiness Codes and Acceptable Means of Compliance by EASA.
- Issue of Type Certification Basis by EASA.
- Presentation of a Certification Programme by the applicant.
- Presentation of Type Design by the applicant.
- Inspections and Tests.
- Flight Tests.
- Issue of the Type Certificate by EASA.

# Type Certification-Process

- **Application to EASA.**
- Issue of Airworthiness Codes and Acceptable Means of Compliance by EASA.
- Issue of Type Certification Basis by EASA.
- Presentation of a Certification Programme by the applicant.
- Presentation of Type Design by the applicant.
- Inspections and Tests.
- Flight Tests.
- Issue of the Type Certificate by EASA.

# Type Certification Eligibility and Demonstration of Capability

- An organization applying for a type certificate or a restricted type certificate shall demonstrate its capability by holding a **Design Organisation Approval**.
- The main duties of a design organization are as follows:
  - To design.
  - To demonstrate compliance with the applicable requirements.
  - To check the statements of compliance independently.
  - To provide items for continued airworthiness.
  - To check the work performed by partners/subcontractors.
  - To monitor the above functions independently.
  - To provide the authority with the compliance documentation.
  - To allow the authority to make any inspection and any flight and ground tests necessary to check the validity of compliance.

# Type Certification Eligibility and Demonstration of Capability

- A design organization should also have an established **design assurance system** for control and supervision of the design and design changes of the product covered by the application.
- This includes all the activities for the achievement of the type certificate, the approval of changes, and the maintenance of continued airworthiness.

# Type Certification Eligibility and Demonstration of Capability

As an alternative procedure to demonstrate capability, the applicant may seek the agreement of EASA to comply with Part 21, when the product is one of the following:

- an ELA2 aircraft;
- an engine or propeller installed on a ELA2 aircraft;
- a piston engine;
- a fixed or adjustable pitch propeller.

European Light Aircraft 2 (ELA 2) means the following in the current context:

- An airplane with a maximum take-off mass (MOTM)  $\leq 2000$  kg w/o a complex motor;
- A sailplane or powered sailplane with MOTM  $\leq 2000$  kg.

# Type Certification

## Eligibility and Demonstration of Capability

An applicant may choose to demonstrate its capability by providing EASA with the certification program if the product is one of the following:

- an ELA1 aircraft;
- an engine or propeller installed on an ELA1 aircraft;

European Light Aircraft 1 (ELA 1) means the following in the present context:

- An airplane with a maximum take-off mass (MOTM)  $\leq 1200$  kg w/o a complex motor;
- A sailplane or powered sailplane with MOTM  $\leq 1200$  kg.
- Balloons, hot air airships, very light rotorcraft may also be considered as ELA1 or ELA2 aircraft, but this is outside the present context.

# Type Certification-Process

- Application to EASA.
- **Issue of Airworthiness Codes and Acceptable Means of Compliance by EASA.**
- Issue of Type Certification Basis by EASA.
- Presentation of a Certification Programme by the applicant.
- Presentation of Type Design by the applicant.
- Inspections and Tests.
- Flight Tests.
- Issue of the Type Certificate by EASA.

# Type Certification Airworthiness Code

- The Agency shall issue **airworthiness codes** as **standard means to show compliance** of products, parts and appliances with the essential requirements of Annex I (Part 21).
- Such codes shall be sufficiently detailed and specific to indicate to applicants the conditions under which certificates will be issued.



# Type Certification

## Acceptable Means of Compliance

- The term Acceptable Means of Compliance (AMC): Technical interpretative material to be used in the certification process. In this respect, the AMC serve as means by which the certification requirements can be met by those subject to the Regulation.
- Some examples to means of compliance are as follows:
  - **Calculation/analysis.** Reports for the evaluation of loads, strength, performance, flying qualities, or other characteristics.
  - **Safety assessment.** Documents describing safety analysis philosophy and methods, safety evaluation plans, system safety assessment, zonal safety assessment and others.
  - **Flight tests.** Reports of flight tests written in the Flight Test Program and performed by a flight test crew.
  - **Inspections.** Conformity inspections to verify that materials, parts, processes, and fabrication procedures conform to the type design. Aircraft inspection to verify the compliance with the requirement, which cannot be determined adequately from the evaluation of technical data only.

# Type Certification-Process

- Application to EASA.
- Issue of Airworthiness Codes and Acceptable Means of Compliance by EASA.
- **Issue of Type Certification Basis by EASA.**
- Presentation of a Certification Programme by the applicant.
- Presentation of Type Design by the applicant.
- Inspections and Tests.
- Flight Tests.
- Issue of the Type Certificate by EASA.

# Type Certification-Certification Basis

The type certification basis for the issuance of a type certificate consists of:

- The applicable airworthiness code established by the Agency, effective on the date of application.
- Any special condition prescribed.
- An application for type certification of large airplanes and rotorcraft will remain effective for **five years**, and an application for any other type certification shall be effective for **three years**.

# Type Certification-Process

- Application to EASA.
- Issue of Airworthiness Codes and Acceptable Means of Compliance by EASA.
- Issue of Type Certification Basis by EASA.
- **Presentation of a Certification Programme by the applicant.**
- Presentation of Type Design by the applicant.
- Inspections and Tests.
- Flight Tests.
- Issue of the Type Certificate by EASA.

# Type Certification-Certification Programme

- The applicant for a type certificate shall show compliance with the applicable **type certification basis** and environmental protection requirements and shall provide the Agency the means by which such **compliance** has been demonstrated.
- The applicant shall provide the Agency with a **certification programme** detailing the means of compliance demonstration. This document shall be updated during the certification process as necessary.
- The application shall record justification of compliance within compliance documents according to the certification programme established above.
- The applicant shall declare that it has demonstrated compliance with the applicable type certification basis and environmental protection requirements according to the certification programme established above.

# Type Certification-Process

- Application to EASA.
- Issue of Airworthiness Codes and Acceptable Means of Compliance by EASA.
- Issue of Type Certification Basis by EASA.
- Presentation of a Certification Programme by the applicant.
- **Presentation of Type Design by the applicant.**
- Inspections and Tests.
- Flight Tests.
- Issue of the Type Certificate by EASA.

# Type Certification-Type Design

The type design consists of:

- The **drawings and specifications** necessary to define the **configuration and the design features** of the product shown to comply with the applicable type certification basis and environmental protection requirements;
- Information on **materials and processes** and on **methods of manufacture and assembly** of the product necessary to ensure the conformity of the product;
- An approved **airworthiness limitations** section of the instructions for continued airworthiness as defined by the applicable airworthiness code;
- The type design not only deals with the product configuration but with the **production methods** as well. Every deviation from the type design is a **change**, which must also be approved. This is to ensure that series products are not inferior to the prototype identified by the type design.

# Type Certification-Process

- Application to EASA.
- Issue of Airworthiness Codes and Acceptable Means of Compliance by EASA.
- Issue of Type Certification Basis by EASA.
- Presentation of a Certification Programme by the applicant.
- Presentation of Type Design by the applicant.
- **Inspections and Tests.**
- Flight Tests.
- Issue of the Type Certificate by EASA.



# Type Certification-Inspections and Tests

- The applicant shall perform all inspections and tests necessary to demonstrate compliance with the applicable type certification basis and environmental protection requirements.
- The applicant shall allow the Agency to make any inspection necessary to check compliance.

# Type Certification-Process

- Application to EASA.
- Issue of Airworthiness Codes and Acceptable Means of Compliance by EASA.
- Issue of Type Certification Basis by EASA.
- Presentation of a Certification Programme by the applicant.
- Presentation of Type Design by the applicant.
- Inspections and Tests.
- **Flight Tests.**
- Issue of the Type Certificate by EASA.

# Type Certification-Flight Tests

- Flight testing for the purpose of obtaining a type certificate shall be conducted in accordance with conditions for such flight testing by the Agency.
- The applicant shall make all flight tests that the Agency finds necessary to determine compliance with the applicable type certification basis and environmental protection requirements.
- The flight tests shall include:
  - For aircraft incorporating turbine engines of a type not previously used in a type certificated aircraft, at least 300 hours of operation with a full complement of engines that conform to a type certificate, and
  - For all other aircraft, at least 150 hours of operation.

# Type Certification-Process

- Application to EASA.
- Issue of Airworthiness Codes and Acceptable Means of Compliance by EASA.
- Issue of Type Certification Basis by EASA.
- Presentation of a Certification Programme by the applicant.
- Presentation of Type Design by the applicant.
- Inspections and Tests.
- Flight Tests.
- **Issue of the Type Certificate by EASA.**

# Type Certification

## Issue of a Type Certificate

- The applicant shall be entitled to have a product type-certificate issued by the Agency after it is shown that:
  - The product to be certificated meets the applicable type certification basis and environmental protection requirements;
  - Any airworthiness provisions not complied with are compensated for by factors that provide an equivalent level of safety;
  - No feature or characteristic makes it unsafe for the uses for which certification is requested; and,
- In the case of an aircraft type certificate, the engine or propeller, or both, if installed on the aircraft, have a type certificate issued or determined.

# Outline

- Introduction
- Flight Safety
- Airworthiness
- ICAO and Civil Aviation Authorities
- Airworthiness Requirements
- Type Certification
- **Design Requirements and Specifications**

# Design Requirements and Specifications

Category	Normal, Utility, Aerobatic	Commuter	Very Light
<b>Characteristics</b>			
Maximum take-off weight (kg/lb)	≤ 5670/12500	≤ 8628/19000	≤ 750
Number of engines	1 or 2	2	1
Type of engine	All <sup>1</sup>	Propeller	Spark or compression ignition
Maximum number of occupants	≤ 9	≤ 19	0
Maximum operation altitude (ft)	25000	25000	8000
<b>Applicable Certification Specifications</b>			
Airplane	CS/FAR-23	CS/FAR-23	CS-VLA <sup>2</sup>
Engines	CS-E/FAR-33	CS-E/FAR-33	CS-E
Propellers	CS-P/FAR-35	CS-P/FAR-35	CS-P
Noise standards	CS/FAR-36	CS/FAR-36	-

<sup>1</sup> Although there is no explicitly specified restriction, single turbine engine airplanes are incompatible with the stall speed requirement.

<sup>2</sup> An equivalent FAA standard does not exist. FAA adopted CS-VLA for the certification of very light aeroplanes in the US.

# Design Requirements and Specifications

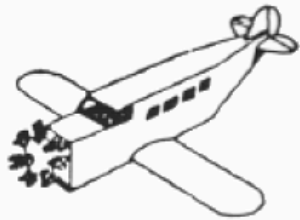
Classification	Normal, Utility, Aerobatic	Commuter	Very Light
<b>Velocity</b>			
Stall speed <sup>1</sup> , $V_{SO}$ <sup>2</sup> (km/h / knot)	$\leq 113/61$	-	$\leq 45/83$
Rotation speed, $V_R$ (single engine)	$\geq V_{S1}$ <sup>3</sup>	-	-
Rotation speed, $V_R$ (twin engine)	$\max(1.05V_{MC}^4, 1.10V_{S1})$	$\max(V_1^5, 1.05V_{MC}, 1.1V_{S1})$	-
Take-off speed, $V_{TO}$ (single engine)	$\geq 1.2V_{S1}$	-	-
Take-off speed, $V_{TO}$ (multi-engine)	$\max(1.10V_{MC}, 1.20V_{S1})$	$\max(1.10V_{MC}, 1.20V_{S1})$	-
Climb speed, $V_{CL}$ (single engine)	$\geq 1.2V_{S1}$	-	$\geq 1.3V_{S1}$
Climb speed, $V_{CL}$ (twin engine, AEO <sup>6</sup> )	$\max(1.10V_{MC}, 1.20V_{S1})$	-	-
Climb speed, $V_{CL}$ (twin engine, OEI <sup>7</sup> )	$\geq 1.2V_{S1}$	$\geq V_2$ <sup>8</sup>	-
Approach speed, $V_A$	$\geq 1.30V_{SO}$	$\max(1.05V_{MC}, 1.30V_{SO})$	$\geq 1.3V_{SO}$
<b>Climb</b>			
Climb gradient, $\gamma$ @ $V_{CL}$ ( $W_o \leq 2722$ kg, AEO)	$\geq 8.3\%$	-	$\geq 2$ m/s
Climb gradient, $\gamma$ @ $V_{CL}$ ( $W_o \geq 2722$ kg, AEO)	$\geq 4.0\%$	-	-
Climb gradient, $\gamma$ @ $V_{CL}$ ( $W_o \leq 2722$ kg, $V_{SO} \geq 113$ km/h, OEI)	$\geq 1.5\%$	-	-
Climb gradient, $\gamma$ @ $V_{CL}$ ( $W_o \leq 2722$ kg, $V_{SO} \leq 113$ km/h, OEI)	-	-	-
Climb gradient, $\gamma$ @ $V_{CL}$ ( $W_o \geq 2722$ kg, OEI)	$\geq 0.75\%$	$\geq 2.0\%$	-
<b>Landing</b>			
Descent gradient	$\leq 5.2\%$	-	-



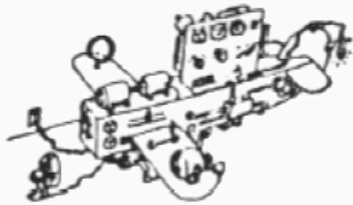
# Design Requirements and Specifications

- <sup>1</sup> There is no stall speed requirement for twin-engined airplanes provided that the one engine inoperative climb gradient requirement is satisfied.
- <sup>2</sup>  $V_{SO}$ : stall speed in the landing configuration.
- <sup>3</sup>  $V_{S1}$ : stall speed obtained in a specified configuration. In this case, take-off configuration.
- <sup>4</sup>  $V_{MC}$ : minimum control speed with the critical engine inoperative.
- <sup>5</sup>  $V_1$ : decision speed.
- <sup>6</sup> AEO: All engines operating.
- <sup>7</sup> OEI: One engine inoperative.
- <sup>8</sup>  $V_2$ : take-off safety speed.

# "Dream airplanes" – C. W. Miller



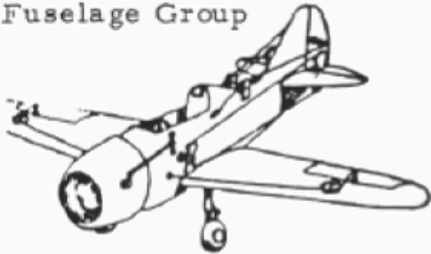
Fuselage Group



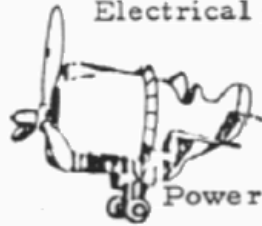
Electrical Group



Equipment Group



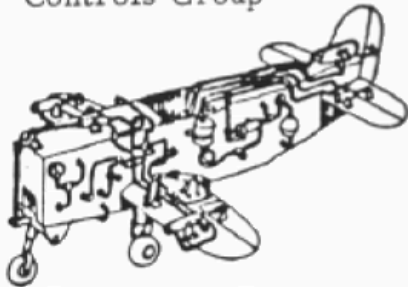
Controls Group



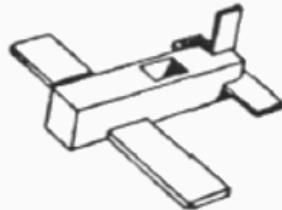
Power Plant Group



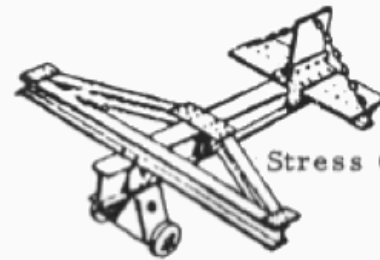
Aerodynamics Group



Hydraulics Group



Loft Group



Stress Group



Production Engineering Group

# References

- De Florio, F., *Airworthiness: An Introduction to Aircraft Certification*, Oxford: Elsevier, 2011.
- van Santen, C.W. Airworthiness Procedures Implementation Management (Joint Aviation Authorities), IR 21-Presentation, 2013.
- European Aviation Safety Agency, Certification Specifications for Very Light Aeroplanes, CS-VLA, Amendment 1, 2009.
- European Aviation Safety Agency, Certification Specifications and Acceptable Means of Compliance for Light Sport Aeroplanes, CS-LSA, Amendment 1, 2013.
- European Aviation Safety Agency, Certification Specifications for Normal, Utility, Aerobatic and Commuter category Aeroplanes, CS-23, Amendment 3, 2012.
- European Aviation Safety Agency, Certification Specifications for Large Aeroplanes, CS-25, Amendment 14, 2013.
- Airworthiness Procedures Implementation Management (Joint Aviation Authorities), IR 21-Annex Part 21, 2013.