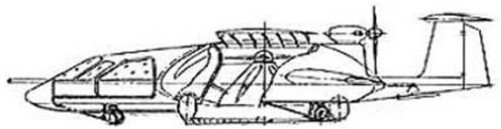


# Certification Requirements for hybrid aircraft

Wijnko Oomkens
Oliver Zysk
Bernd Kasiske

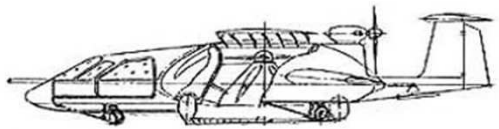
11.10.2013

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



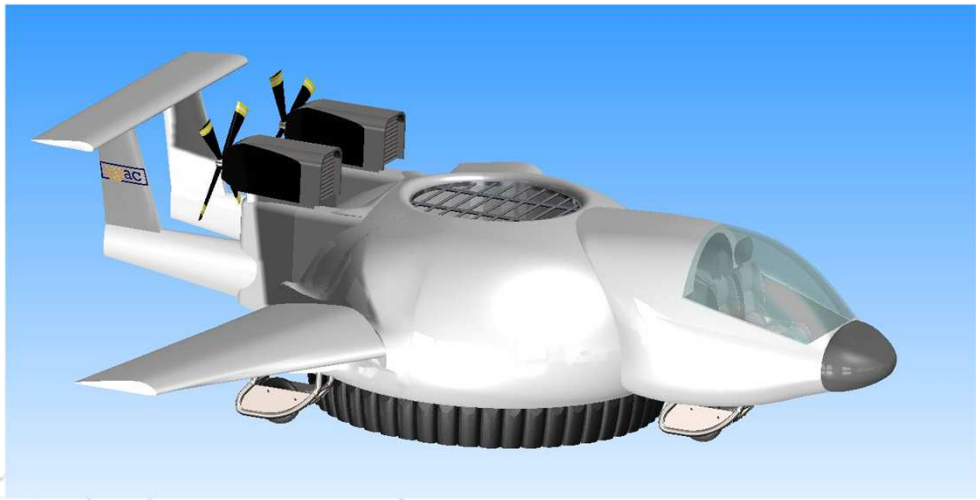
SEVENTH FRAMEWORK PROGRAMME

# Hybrid aircraft: ESTOLAS



## ESTOLAS

- ESTOLAS: Extremely Short Take Off and Landing All Surface
- Ability to take-off and land on any natural surface such as desert, snow, ice, marsh, ice, water
- Hybrid vehicle: Combination of features of aircraft and helicopter
- Multiple variants for different applications



ESTOLAS aircraft

| ESTOLAS aircraft variants | | | |
|---|---|---|---|
| Small | Medium | Heavy | Super heavy |
| Hybrid aircraft used as an alternative for light helicopters but with the property of longer range. | Hybrid aircraft used as an alternative for heavy helicopters with the capability to transport heavy goods | Hybrid aircraft for transportation of freight, for places with small airports, open space or water in the vicinity | Hybrid transport for transportation of very heavy goods for places with small airports, open space or water in the vicinity |

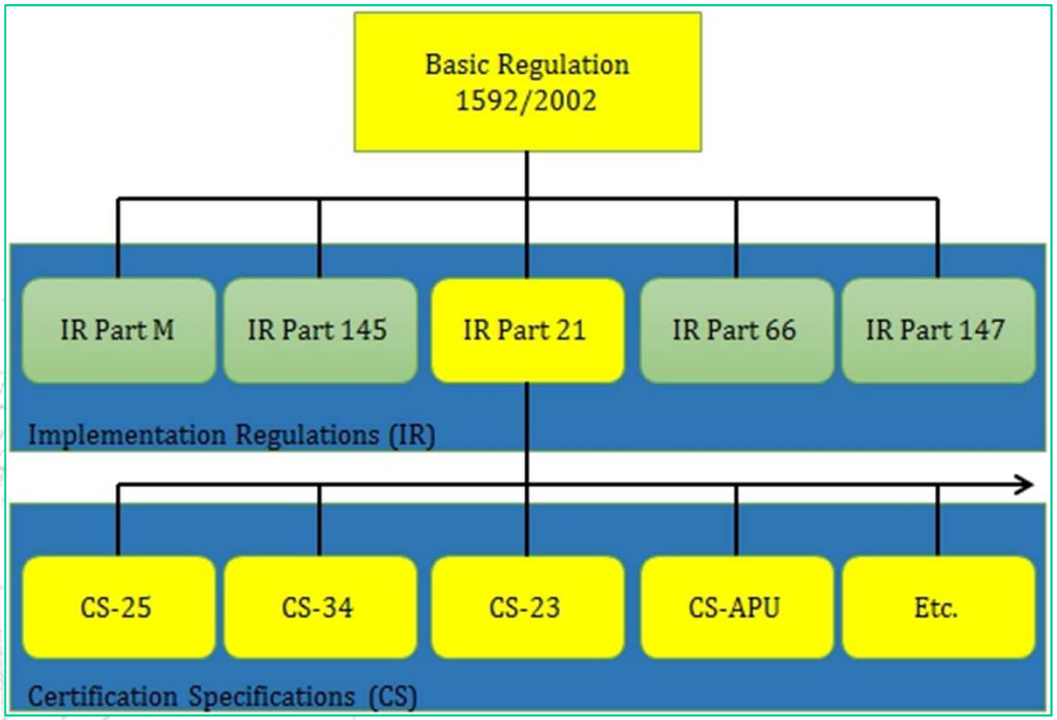
Different variants of the ESTOLAS aircraft

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2

# Certification Agencies and Processes



- European Aviation Safety Agency (EASA): Europe
- Federal Aviation Administration (FAA): United States
- Joint-Aviation Requirements (JAR) and Federal Aviation Regulations (FARs): provisions designed, monitored and implemented by aviation authorities
- EASA Implementation Rules (IRs): Define basic regulation
- Certification Specification (CS): Certification of aircraft and related products, parts and appliances



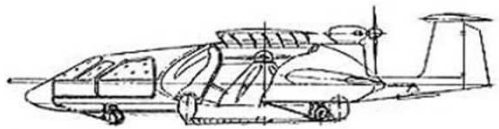

Hierarchy of the EASA rules and regulations

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



SEVENTH FRAMEWORK PROGRAMME

# EASA Certification Specification (CS)



## ESTOLAS

- Each CS applies to a particular aircraft type or product
- These codes include the requirements for systems and engines of the aircraft

| Section | Title/Contents |
|---|---|
| CS-22 | Gliders and motorized gliders |
| CS-23 | Normal, utility, commuter & aerobatic planes |
| CS-25 | Large aero planes |
| CS-27 | Small rotorcraft |
| CS-29 | Large rotorcraft |
| CS-34 | Aircraft engine emission and fuel venting |
| CS-36 | Aircraft noise |
| CS-APU | Auxiliary power units |
| CS-AWO | All weather operations |
| CS-E | Engines |
| CS-ETSO | European technical standard orders |
| CS-Definition | Definitions & abbreviations |
| CS-P | Propellers |
| CS-VLA | Very light aero planes |
| CS-VLR | Very light rotorcraft |
| AMC-20 | General AMC for air worthiness of products, parts and appliances |

Overview of EASA CS specifications

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2

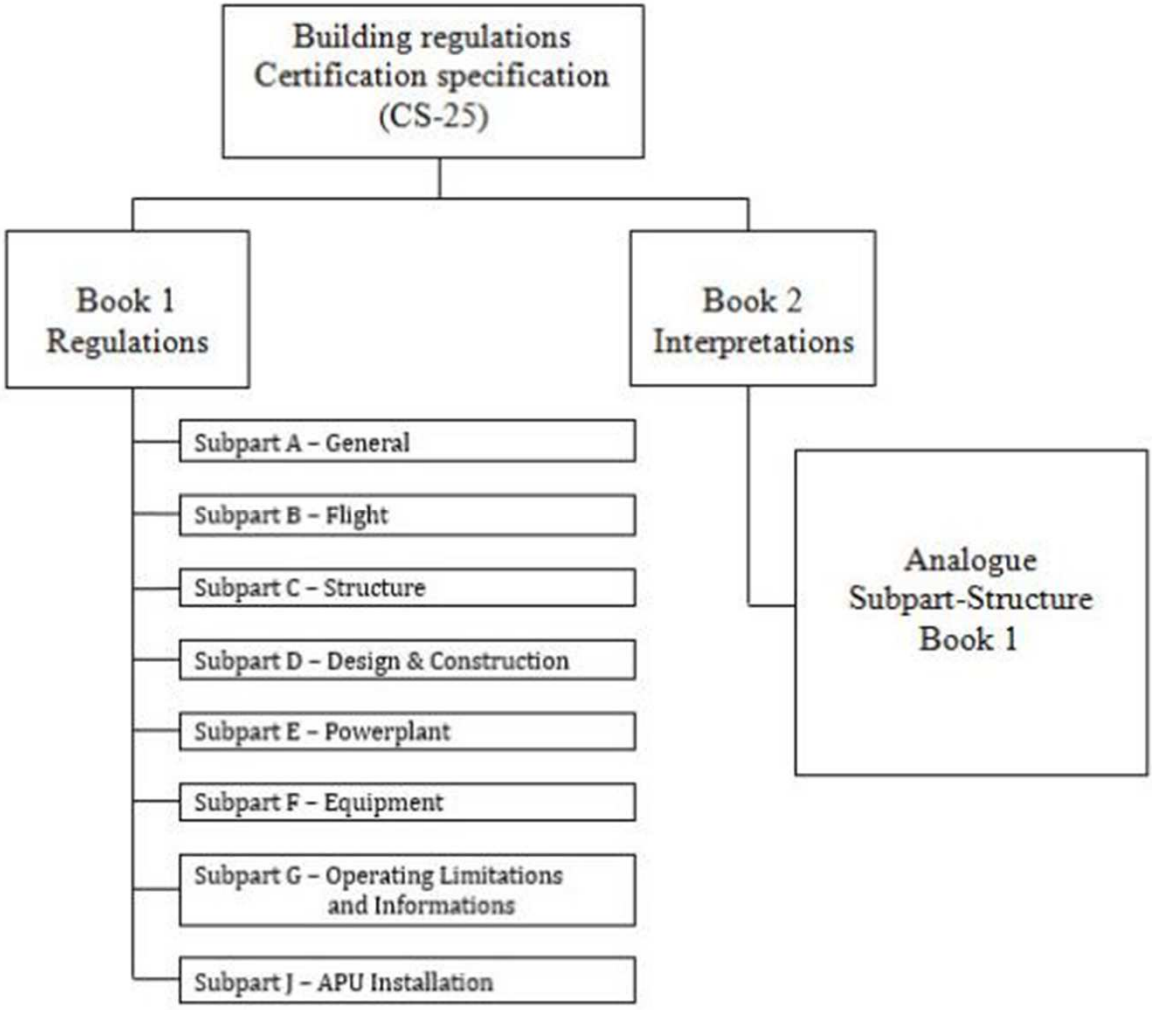


SEVENTH FRAMEWORK PROGRAMME

# EASA Certification Specification (CS)



- Each of the products listed below is divided into two books.
  - Book 1 contains the main requirements.
  - Book 2 offers the Acceptable Means of Compliance (AMC).
- Applicability of a CS is defined in Subpart A – GENERAL. For e.g.:
  - CS-25: *"(a) These Certification Specifications are applicable to turbine powered Large Aero planes."*



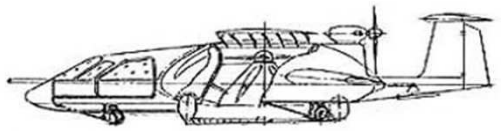

Structure of CS-25

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



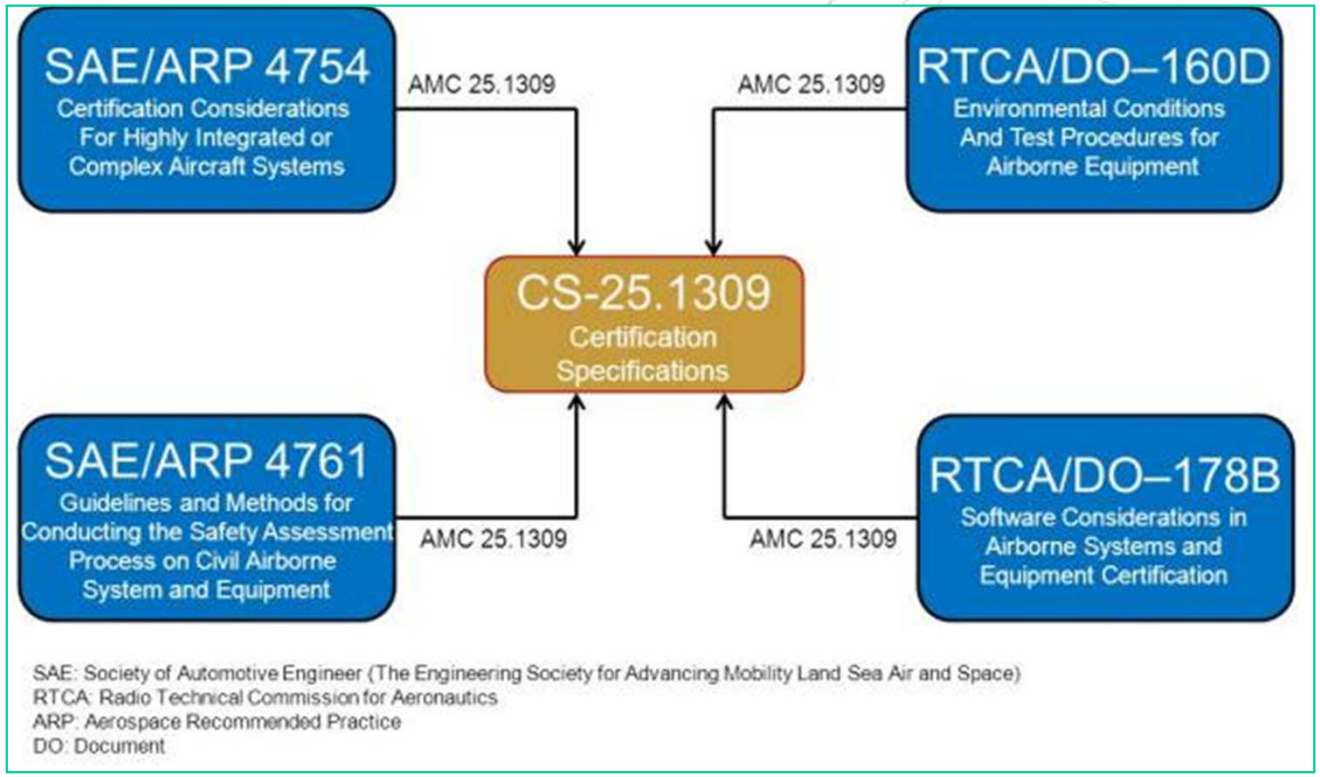
SEVENTH FRAMEWORK PROGRAMME

# Means of Compliance



## ESTOLAS

- Important requirement for aircraft certification:
  - Airworthiness demonstration
  - Identification of failures, hazards and the effects
  - Qualitative and quantitative evaluation of systems
- Different standards and specifications are used as acceptable means of compliance



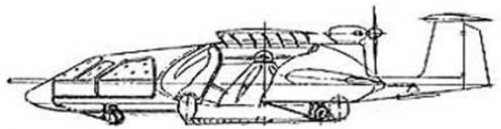

CS-25.1309 Acceptable Means of Compliance

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



SEVENTH FRAMEWORK PROGRAMME

# CS Applicability to ESTOLAS



- Evaluating the applicability of each CS to ESTOLAS
- For e.g.: CS-23 applicability:

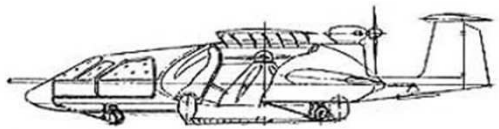
  *"(a) This airworthiness code is applicable to - (1) Aero planes in the normal, utility and aerobatic categories that have a seating configuration, excluding the pilot Seat, of nine or fewer and a maximum certificated takeoff weight of 5670 kg (12500 lb.) or less; and (2) Propeller driven twin-engine aero planes in the commuter category that have a seating configuration, excluding the pilot seat(s), of nineteen or fewer and a maximum certificated takeoff weight of 8618 kg (19 000 lb.) or less."*
- Maximum take-off weight and seat configuration applies to the small ESTOLAS
- Not applicable to larger variants of ESTOLAS

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2

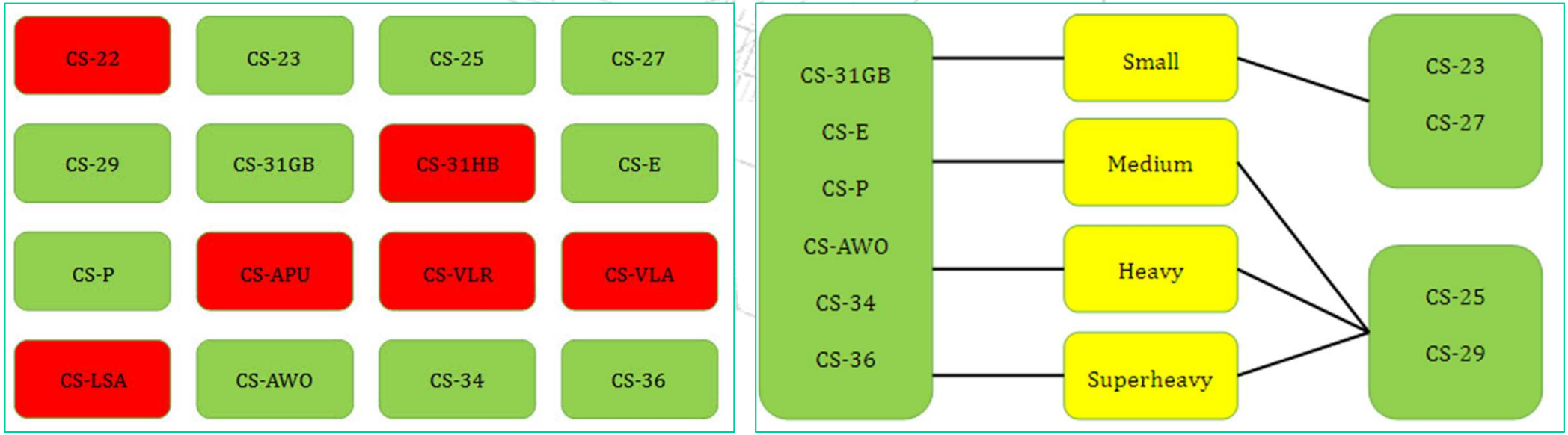


SEVENTH FRAMEWORK PROGRAMME

# CS Applicability to ESTOLAS



- Each ESTOLAS variant will have its own set of applicable CS
- Successful licensing of aircraft requires compliance with these regulations



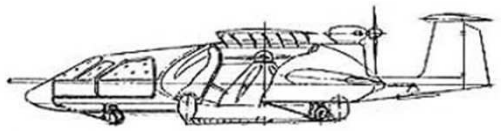

Applicable CS regulations to the ESTOLAS variants.

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



SEVENTH FRAMEWORK PROGRAMME

# Airworthiness requirements





The requirement 1309 in EASA certification specification CS-25 requires that a catastrophic failure condition is extremely improbable and not a result of a single failure.

**CS 25.1309 Equipment, systems and installations**
(See AMC 25.1309)

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

(1) Any catastrophic failure condition

(i) is extremely improbable; and

(ii) does not result from a single failure; and

(2) Any hazardous failure condition is extremely remote; and

(3) Any major failure condition is remote.

| | | Probability per Flight Hour |
|---|---|---|
| Catastrophic | Extremely improbable | $10^{-9}$ |
| Hazardous | Extremely remote | $10^{-7}$ |
| Major | Remote | $10^{-5}$ |
| Minor | Improbable | $10^{-3}$ |

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2

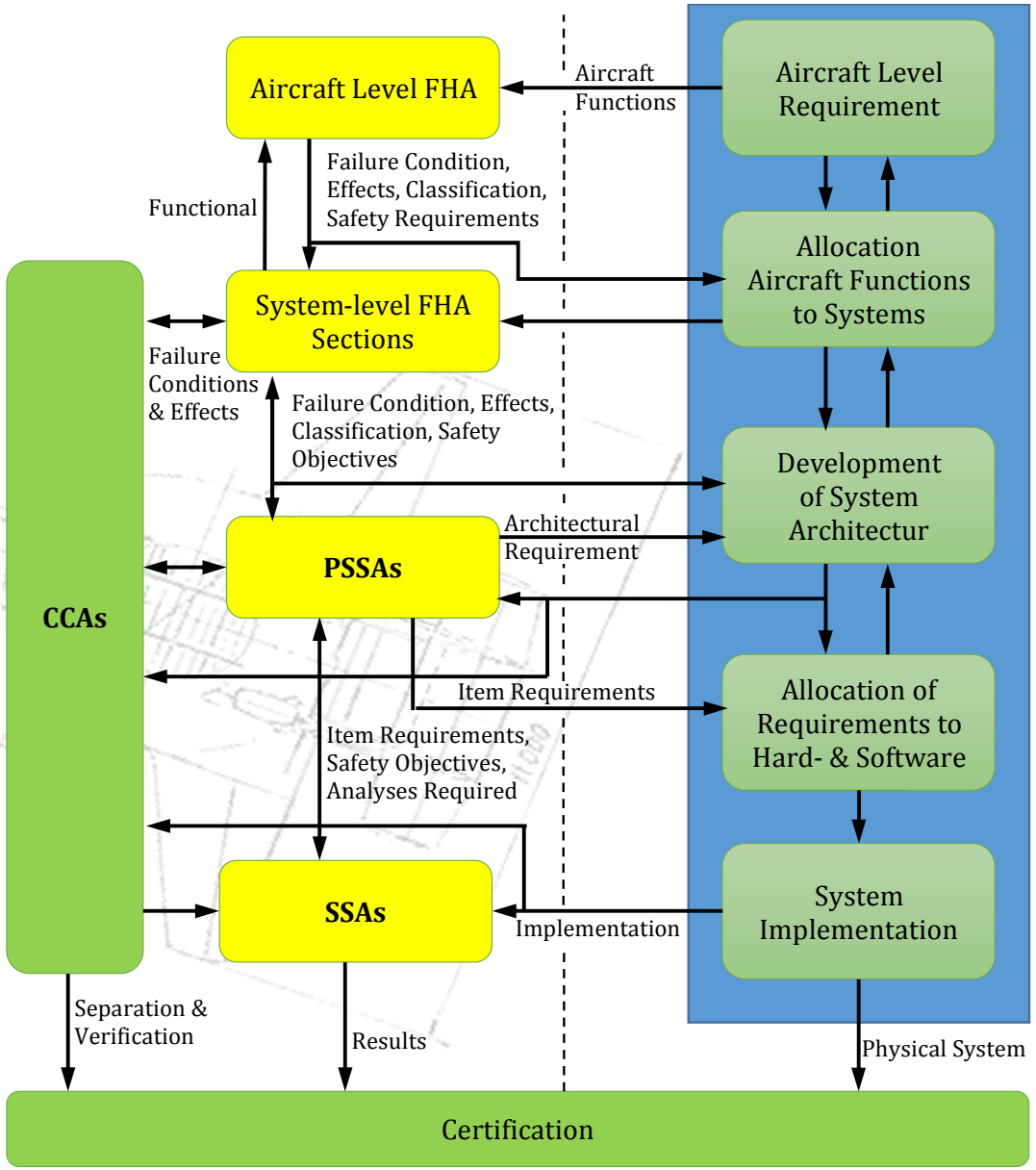


SEVENTH FRAMEWORK PROGRAMME

# System Safety



- Safety Assessment and System Development Process Model of ARP 4754: an iterative safety analysis process
  - FHA: Functional Hazard Assessment
  - PSSA: Preliminary System Safety Assessment
  - CCA: Common Cause Assessment
  - SSA: System Safety Assessment
- The analysis performed at aircraft as well as systems level
- The end result of this process is successful certification




Safety Assessment and System Development Process Model (ARP 4754)

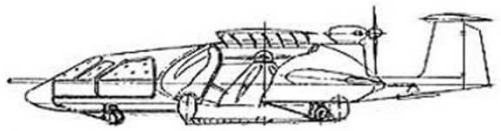
A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



SEVENTH FRAMEWORK PROGRAMME

# System Safety





- Functional Hazard Assessment (FHA): Qualitative method used to identify functional failures and classify them according to their severity. Purposes:
  - Identification of functions
  - Determination of failure modes and the impact
  - Classification of the failure modes
  - Determination of Design Assurance Levels (DAL)

| Classification of failure | Probability of occurrence (per flight hour) | Development Assurance Level (DAL) |
|---|---|---|
| Catastrophic | $<10^{-9}$ | A |
| Hazardous | $<10^{-7}$ | B |
| Major | $<10^{-5}$ | C |
| Minor | $<10^{-3}$ | D |
| No special effect | - | E |

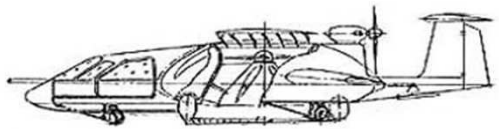
Failure modes, probability of occurrence and DAL values
(sources: in components following EASA CS-25, and ARP 4754)

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



SEVENTH FRAMEWORK PROGRAMME

# System Safety



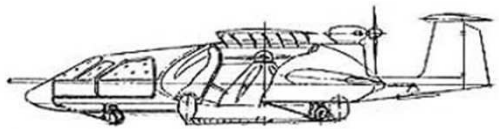
- Preliminary System Safety Assessment (PSSA):
  - Builds on the FHA
  - Combinations of FHA-identified failure modes determined
  - Usage of fault tree analysis or Markov analysis
- Common Cause Analysis (CCA):
  - Identification and grouping of critical components,
  - Test analogy within the classes,
  - Testing for failure modes within the analogy,
  - Identifying potential triggers for identified failure modes,
  - Summary of results and setting up of strategies for intervention.

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



SEVENTH FRAMEWORK PROGRAMME

# System Safety





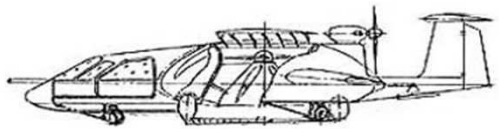
- Zonal Safety Analysis (ZSA):
  - Assesses the compliance of Safety requirements within individual zones
  - check whether the independent requirements by physical factors or facilities are being violated
  - Determine the common error sources and their effects on neighboring components
- Particular Risk Analysis (PRA):
  - Compendium of all the assessments accomplished during development
  - Threats to the airplane from external as well as internal environment
  - a single point reference for the new airplane with regard to its ability to survive all known threats
- Common Mode Analysis (CMA): To test the independence of the failure modes
- System Safety Assessment (SSA):
  - Final safety step to verify implementation of the system architecture by applying results of the FHA; PSSA and CCA

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



SEVENTH FRAMEWORK PROGRAMME

# Conclusion



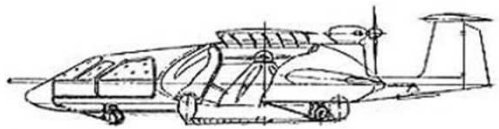
- Overview of licensing and certification requirements for aircrafts
- Applicability of regulations to ESTOLAS investigated
- System safety process defined as means of compliance for the approval of an aircraft
- Components of the safety analysis and certification process described in further detail
- A framework for the identification of applicable regulations and the process of safety analysis and certification offered

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



SEVENTH FRAMEWORK PROGRAMME

# References



ESTOLAS


- EASA, CS-22 (2009), "*Certification Specifications for Sailplanes and Powered Sailplanes CS-22, Amendment 2*", 09.03.2009 URL: http://www.easa.europa.eu/agency-measures/certification-specifications.php, (Jan 2013)
- EASA, CS-23 (2012), "*Certification Specifications for Normal, Utility, Aerobatic and Commuter Category Aero planes CS-23, Amendment 3*", 20.07.2012. URL: http://www.easa.europa.eu/agency-measures/certification-specifications.php, (Jan 2013)
- EASA, CS-25: Certification Specifications and Acceptable Means of Compliance for Large Aero planes CS-25, Amendment 12, 13.07.2012. URL: http://www.easa.europa.eu/agency-measures/certification-specifications.php. January 2013
- EASA, CS-27 (2008), "*Certification Specifications for Small Rotorcraft CS-27, Amendment 2*", 17.11.2008. URL: http://www.easa.europa.eu/agency-measures/certification-specifications.php, (Jan 2013)
- EASA, CS-29 (2008), "*Certification Specifications for Large Rotorcraft CS-29, Amendment 2*", 17.11.2008. URL: http://www.easa.europa.eu/agency-measures/certification-specifications.php, (Jan 2013).
- EASA, CS-31GB (2011), "*Certification Specifications and Acceptable Means of Compliance for Free Gas Balloons CS-31GB, Initial Issue*", 05.12.2011. URL: http://www.easa.europa.eu/agency-measures/certification-specifications.php, (Jan 2013).
- EASA, CS-31HB (2011), "*Certification Specifications and Acceptable Means of Compliance for Hot Air Balloons CS-31HB, Amendment 1*", 05.12.2011. URL:http://www.easa.europa.eu/agency-measures/certification-specifications.php, (Jan 2013).
- EASA, CS-LSA (2011), "*Certification Specifications for Light Sport Aeroplanes CS-LSA, Initial Issue*", 27.06.2011. URL: http://www.easa.europa.eu/agency-measures/certification-specifications.php, (Jan 2013).
- EASA, CS-VLA (2009), "*Certification Specifications for Very Light Aeroplanes CS-VLA, Amendment 1*", 05.03.2009. URL: http://www.easa.europa.eu, (Jan 2013).
- ESTOLAS project description (2012), URL: http://www.estolas.eu/ (Sep 2013)
- FAA (2000), "*FAA System Safety Handbook*", 30.12.2000. URL: http://www.faa.gov/library/manuals/aviation/risk_management/ss_handbook/, (Feb 2013).
- SAE ARP 4754 (2010): "*Certification considerations for Highly Integrated or complex Air-craft system*", 21.12.2010, URL: http://standards.sae.org/arp4754a/, (Sep 2013).

# Thank you!

A novel concept for an extremely short take off and landing all-surface (ESTOLAS) hybrid aircraft: from a light passenger aircraft to a very high payload cargo/passenger version. Work programme topics addressed: AAT.2012.6.3-1, AAT.2012.6.3-2



SEVENTH FRAMEWORK PROGRAMME