Dedicated to innovation in aerospace

Unmanned Aircraft System Airworthiness Certification

SCI-328, Paper Nr. 21, Jan Willekens

Dedicated to innovation in aerospace

This NLR document is company confidential to its recipients and should not be copied, distributed or reproduced in whole or in part, nor passed to any third party without prior written consent of NLR.
Use, intentionally or unintentionally of any of the content, information, or services in this document in a manner contrary to the objective of this document is not allowed.

Table of Contents

1 Introduction
2 Certification Standards and Requirements
3 Functional Requirements and Performance Based Requirements
4 Preparing the Certification Basis
5 Defining the Means of Compliance
6 Preparing the Certification Plan
7 Conducting the Compliance Demonstration
8 Flight Test Plan
9 Flight Test Report
10 Preparing the Certification Report
11 Military Type Certificate
12 Examples
13 Conclusions

1) Introduction

- Airworthiness Certification in Europe
  - The Netherlands as example
- Military Type Certificate (MTC): Final objective
  - Extensive, complex and challenging process
- Certification process from a Flight Tests perspective
- Various steps to complete, brief overview will be presented
- No detailed UAS design information available

2) Certification Standards and Requirements

- Available Sets of certifications standards
- Category of UAS to be certified; UAV System
- Weight category, fixed- vs rotary wing, kinetic energy, safety levels e.g.
  - NATO STANAG 4703, Light UAS Airworthiness Requirements
  - NATO STANAG 4671, UAV Systems Airworthiness Requirements (USAR)
  - NATO STANAG 4702, Rotary Wing UAS Airworthiness Requirements
- Harmonized standards; new design to be embedded
- UAS elements: e.g. (U)AV, Launching System, Recovery System, Ground Control System, data link system.
- Elements of UAS to be certified? Command line

3) Functional Requirements and Performance Based Requirements

- Military Functional requirements
  - High level vs detailed;
  - Military vs Airworthiness requirements
  - Climb time to 2000 m AGL vs Climb rate > 1.5 m/s, Sea Level, ISA
- Where will the UAS be deployed?
- Intended operational usage conditions
  - Environmental conditions (e.g. Climatic zones) – detailed functional requirements
  - Environmental domain for which certification is requested – high level airworthiness requirement
- Functional requirements embedded in airworthiness requirements

4) Preparing the Certification Basis

- UAS design to be certified for intended usage
- Select proper set of airworthiness requirements, e.g. STANAG 4703
- Review requirements, consider their applicability for the UAS design
- Applicability matrix (Y, N, partial), reasoning for non-applicability
- Tailoring for the specific UAS design
- Examples:
  - Stall speed, pre-requisites
  - Engine type: reciprocating engine, electric engine, jet engine
- Next step: define Means of Compliance code(s) to arrive at compliance

5) Defining the Means of Compliance

- Standard set of Means of Compliance (MOC) codes available
  - E.g. design statement, analysis, safety assessment, laboratory test, ground test, flight test, simulation, similarity, qualification, manual, operational experience
- Select for each (sub) requirement the proper MOC code, *but how?*
  - The requirement may already give guidance
  - Guidance Material (GM), Acceptable Means of Compliance (AMC)
  - Experience of the applicant who runs the certification process
  - Expectations of the airworthiness authority in general
  - Not too limited, not too exhaustive for showing compliance, balance
  - Logical set-up and sequence, sufficient for compliance demonstration
  - Flight testing normally requires a lot of effort

6) Preparing the Certification Plan

- Intentions of the certification process described
- Parties involved (Applicant, OEM, Airworthiness Authority)
- Certification Basis (applicable requirements)
- Proposed MOC code(s) for each requirement
- Anticipated non-compliances – if any
- Foreseen tests to arrive at compliance, especially the bigger ones
  - E.g. Flight Test campaign, range, period, etc.
- Documentation as expected (e.g. System Flight Manual)
- Planning
- Approval by Airworthiness Authority

7) Conducting the Compliance Demonstration

- UAS design configuration frozen (hardware, software)
- Organizing and grouping the MOC codes in order to prepare test plans
- Hand-on experience of the tester
- Book keeping to complete all the proposed MOC codes
- Compliance demonstration may differ from CP, substantiate
- Organize the required tests
  - Reservations of flight tests ranges (restrictions, accessibility, special permits, etc.), lab test facilities, wind tunnel test facilities, etc.
- Focus on the Flight Test Plan here

8) Flight Test Plan (1/3)

- Pre-requisites (e.g. frozen design)
- Preparation by OEM, input from applicant
- Select all requirements with MOC code = Flight test
- Organize flight tests into a logical sequence
- Integrate functional requirements requiring a flight test as well
  - E.g. time to climb to 2000 m MSL, turn radius
- Include pre-flight, start-up, taxi, take-off, climb, cruise, descent, landing, taxi, shut down, post flight related airworthiness requirements
- Use available GM/AMC on the topic (*e.g. stall test example, see 3/3*)
- Flight test cards for selected data points, indicate repeats

8) Flight Test Plan (2/3)

- Indicate pass/fail criteria
- Tick box for test completion, room for comments by the tester
- UAS Flight modes, Autopilot design features
- Environmental conditions during the test
  - Demonstrated conditions vs desired conditions / requirements
  - Dedicated test campaign under particular conditions
- Flight test instrumentation for data recording and post flight analysis
- Number of flights, main objective of each flight test
- Agreement on FTP and approval by Airworthiness Authority

8) Flight Test Plan (3/3)

- ***EXAMPLE: NATO STANAG 4671: USAR.201 Wings Level Stall***
- *(a) Flight tests shall be conducted in straight flight for each relevant UAV flaps configuration, with the engine at idle position and for the most appropriate combination of weight and center of gravity while reducing the speed at a decelerating rate of approximately 1kt/s*
  - *(1) up to the time the UAV stalls, or*
  - *(2) until Vmin DEMO, if the stalling speed is not to be demonstrated in compliance with USAR.50, and,*
    - *(i) no stall tendency shall occur down to Vmin DEMO ,*
    - *(ii) Vmin DEMO shall be lower by the margin established under USAR.50 than the minimum steady flight speed (except take-off and landing) allowed by the flight envelope protection maintained by the flight control system.*
- *(b) These flight tests may be conducted, while possibly adjusting or inhibiting flight control protection features.*

9) Flight Test Report

- Execution of the flight test plan
- Follow the test points sequence thoroughly
- Tester will indicate pass/fail and any observations
- Record flight test data, repeats; more flight tests needed?
- Analyze flight test data and observations
- Prepare compliance statements for each single requirement that uses Flight test as compliance could be met
- Compliance statement by the OEM
- Not all supporting evidence may be released by the OEM (proprietary information)

10) Preparing the Certification Report

- For each requirement, a compliance assessment shall be made
- Tailoring, intended- vs actual MOC(s) codes
- Each MOC code shall be supported by reports
- Certification Data Package compilation
- OEM reports shall include compliance statements
- Flight Test report compliance statements shall be embedded to arrive at compliance for MOC code = Flight Test
- Non compliances: Delta tests, ‘Certification Review Item’ (CRI) process
- Final conclusions (e.g. limitations, restrictions, include in SFM)
  - All requirements can be met, declaration of compliance, apply for MTC

11) Military Type Certificate

- Certification Report completed, compliance statements included
- Military Type Certificate Data Sheet (MTCDS) preparation
  - Reference to Certification Report, operational documents
  - UAS configuration (hardware, software)
  - Restrictions, limitations from (flight) tests
- UAS elements (Command line)
- Besides organizational aspects, training, continued airworthiness a.o. in place: out of scope here
- MTC is the objective, granted by MAA
  - Confidence in the safe design, start operations, selling point etc.

12) Examples

- *No detailed UAS design information releasable/ available*

- Launching the UAV: environmental conditions
- Rocket booster assisted launch: preparations
- Pre-flight checklist: Human factors

13) Conclusions

- Airworthiness certification process is an extensive, complex and challenging process
- Selection of applicable requirements for the UAS to be certified
- Requirements that require MOC code Flight Test embedded in the Flight Test Plan
- Results and observations reported in the Flight Test Report (FTR) together with OEM compliance statements
- FTR used for the Certification Report to support the Military Type Certificate (MTC) request at Military Aviation Authority.
- MTC granted: Start operations; OEM to re-use it for other countries

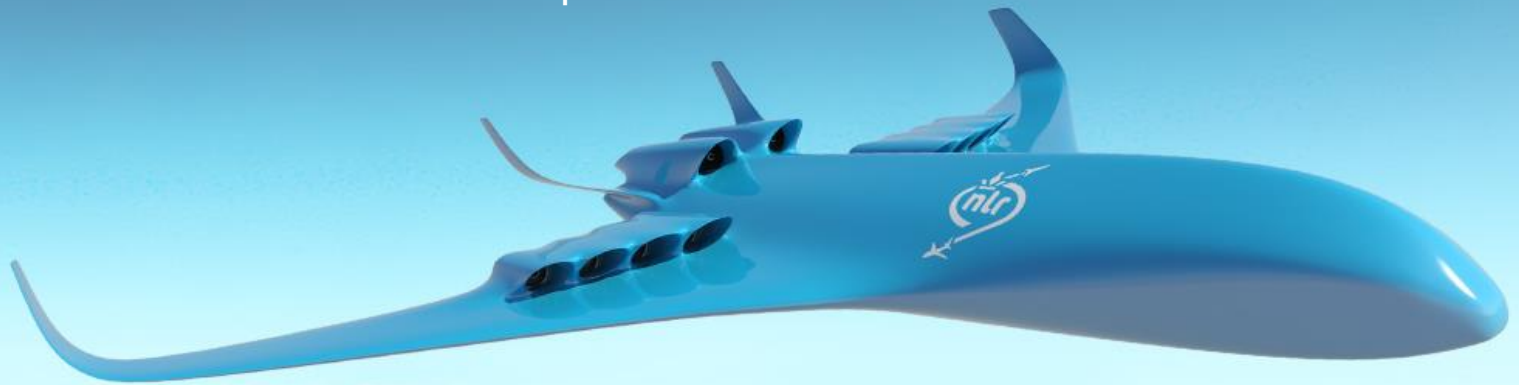
End of presentation – Thank you for your attention

- ***Questions?***

Dedicated to innovation in aerospace

Fully engaged

NLR - Netherlands Aerospace Centre



Anthony Fokkerweg 2
1059 CM Amsterdam
The Netherlands

p) +31 88 511 31 13
e) info@nlr.nl i) www.nlr.org

Voorsterweg 31
8316 PR Marknesse
The Netherlands

p) +31 88 511 44 44
e) info@nlr.nl i) www.nlr.org