Certification Requirements for SHM

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Outline

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- The Certification of Aircraft Products Including Structures and Systems
  - Developments & Processes for Certifiable Systems
  - SHM Architecture
  - Requirements for Certifiable SHM Systems
- Conclusions

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The Certification of Aircraft products Including Structures & Systems

Certification involves activities to obtain the approval of the appropriate Authority that the applicable airworthiness regulations and functional requirements are met.

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Aircraft Design & Maintenance Approaches

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Safe Life (SL) Approach

- SL is the standard approach in the UK adopted to minimize the need for in-service inspections. The pillars of SL are:
  - SL design
  - Safe life substantiation through tests and analysis
  - **Service Monitoring**
- In the UK a **Clear by Inspection** approach is adopted to enable life extension beyond the safe life or to overcome the threats of Accidental Damage (AD).

Damage Tolerance (DT) Approach. The pillars of DT are:

- Designs allowing the presence and growth of damage during determined service periods,
- Planned **DT Inspections** (at midlife) capable of assessing the levels of damage,
- Planned repairs capable of maintaining a target reliability, and assuring operational safety, during a following service period.

NDT/SHM Applications to satisfy the requirements for **Service Monitoring**, **Clear by Inspection** and/or **DT inspections**

Designing & Maintaining Airworthy Structures

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Military, UK

Civil, FAA

Regulations for Designing Airworthy Structures

Def Stan 00-970 P1 S3, to comply with RA5203 (2-3) & RA5105(1)	14CFR Part 25: §25.301 to §25.581

Threats to Structural Integrity

1. Fatigue/Usage Damage (FD): an inevitable consequence of usage (age)
2. Environmental Damage (ED) : a consequence of corrosive/erosive environments
3. Accidental Damage (AD): a consequence of random discrete events
   - 3.1 AD: hazardous events : overload events, hard landing events, etc.
   - 3.2 AD: structure interactions with objects: tool drops, rubbing wear, bird strikes, etc.

Regulations for Maintaining Structural Integrity

RA5724, RA5720(1) to RA 5720(6) and RA4200 to RA4265	14CFR Part 25: §25.571 & §25.1529, 14CFR Part 43 & Part 91 Subpart E

Processes for Maintaining Structural Integrity

1. Develop maintenance programme using RCM** & MSG-3 ***.	1. Industry & regulator develop MRBR* using MSG-3 logic and processes.
2. Develop Structural integrity programme.	2. Operators use MRBR to develop their maintenance programme.
3. Implement the programmes.	3. Operators implement ICA.

* MRBR: Maintenance Review Board Report, **RCM: Reliability Centred Maintenance

MSG-3: Maintenance Steering Group 3, * ICA: Instructions for Continued Airworthiness

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The Evolution of Civil Aircraft Products

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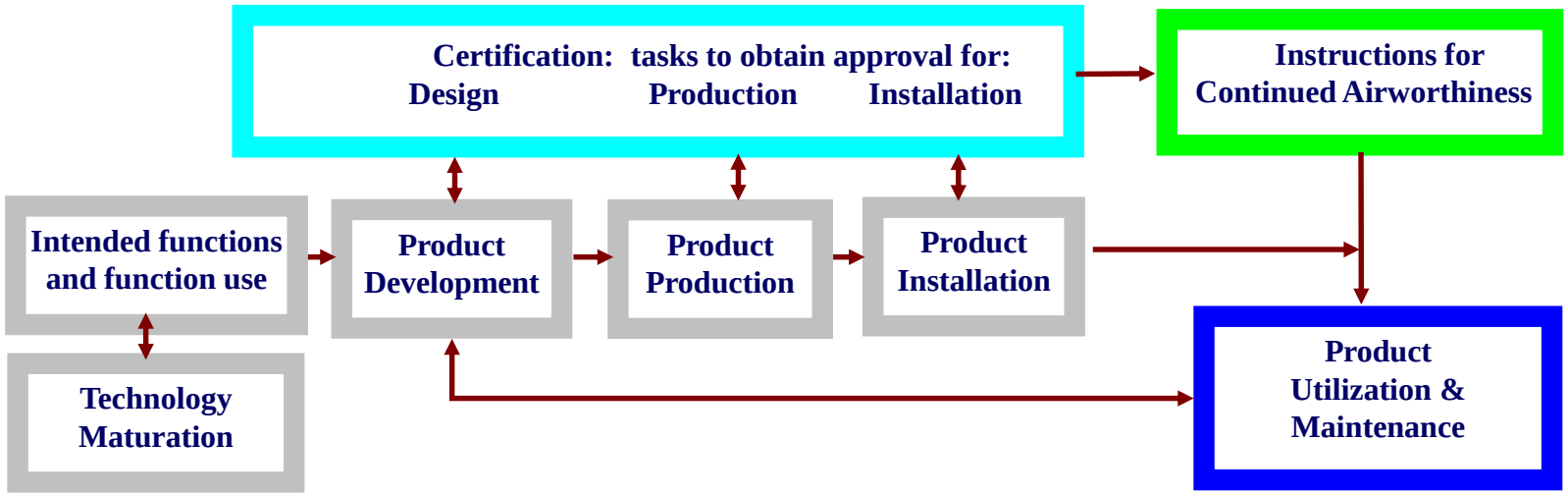

The Evolution of UK Military Aircraft Products

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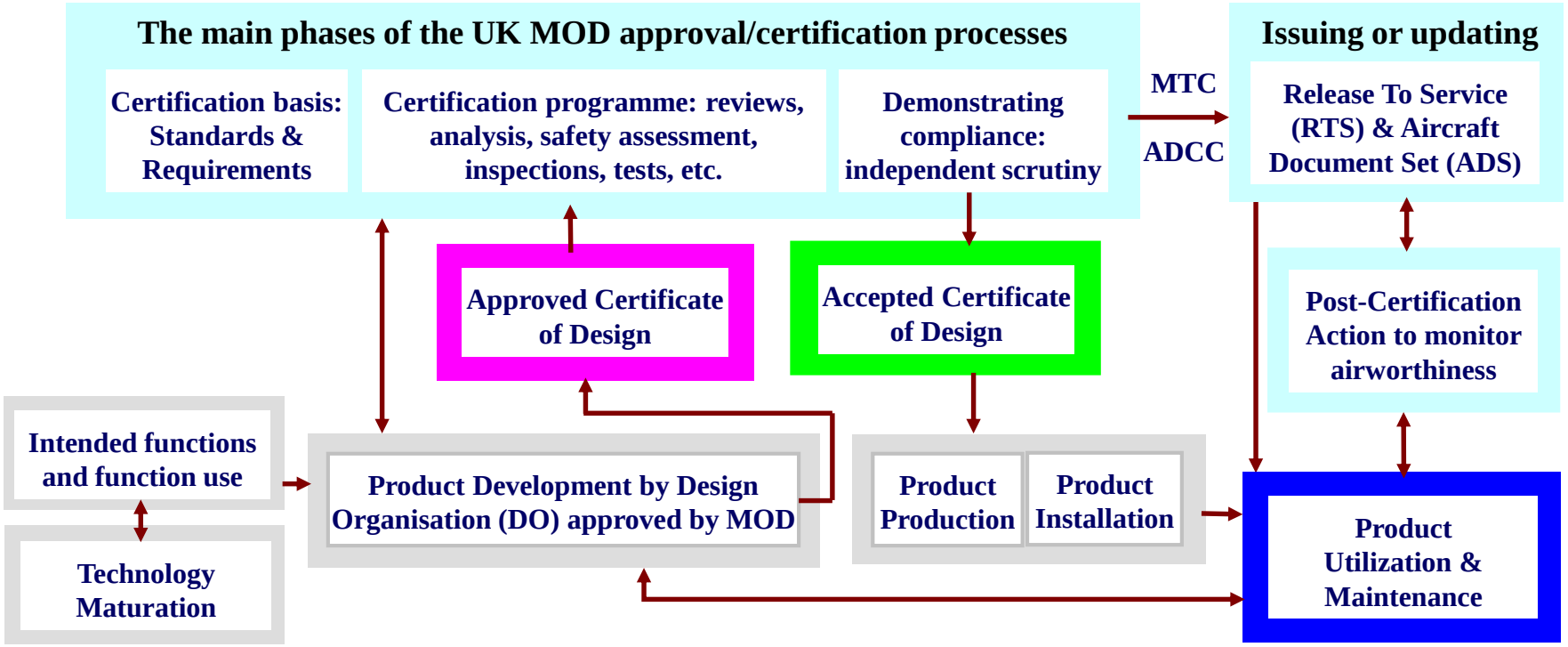

MTC: Military Type Certificate (MTC)
ADCC: Approved Design Change Certificate

Developments & Processes For Certifiable Products

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Key Development & Process Activities

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ARP4761

Aircraft Product Development

ARP4754

Intended Function and Intended Use

Safety Assessment:
a. Functional Hazard Assessment: identify & classify failures & hazards.
b. Preliminary Safety Assessment: establish safety requirements
c. Common Cause Analysis

Safety Assessment:
d. Safety Assessment: verify that the system as implemented meet the safety requirements

Product Architecture
Identify the product components and items; set relationships to join them to form the product.

Safety Requirements
Requirements to prevent failures
Development Assurance Levels to prevent errors
Detailed Requirements
Performance, Operational, Customer, Physical, Interface, Installation, Survivability, Maintainability & Derived Requirements.

Designs, Implementation, Test & Evaluation

Integration, Test, Evaluation & Flight tests

Instructions for Production, Installation, Maintenance & Operation

Validation: ensuring the correctness & completeness of requirements

Verification: ensuring correct implementation

Configuration Management

SHM Architectures

The Main Physical Components of IVHM/SHM Systems

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Onboard Sensing Entities

- Transducer (sensor)
- Transducer (actuator)
- Transducer connections

Transducers fitted on each defence product or on a fleet sample of the product

Ground-Based Components

- Enterprise data management
- Ground Stations
- Ground Databases
- Web-based applications
- Cloud stores and applications

Onboard or Ground-Based Processing, Analysis and Communication Entities

- Power components: power sources, power distribution and conversion
- Conditioning/processing hardware: filters, amplifiers, ADC, processors, controllers, memory, …
- Analysis software: signal processing, feature extraction, anomaly detection, diagnostic, prognostic, and decision support algorithms
- Communication: data buses, switches, data transfer removable media, transmitter/receive wireless media, satellite communication, …

Local data stores, displays, control and interface devices

Support Resources and workforces

Trained personnel, tools, depots, supply chain & spare inventory management, repair, calibration & testing, etc.
Products & IVHM Improvements: Resources and Specialists

Potential SHM Architectures for Manned Aircraft Operations

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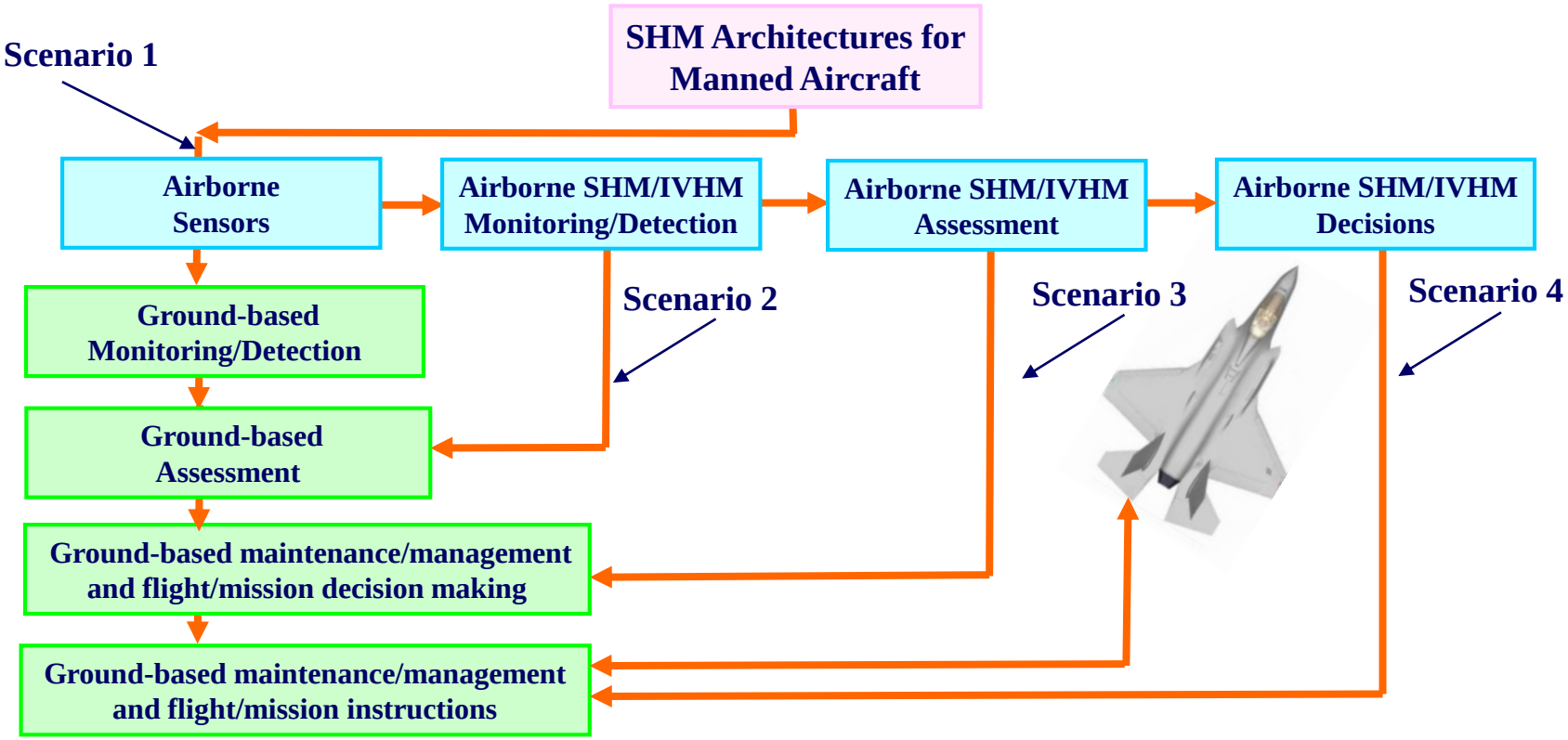

Requirements for Certifiable SHM Systems

SHM Requirements

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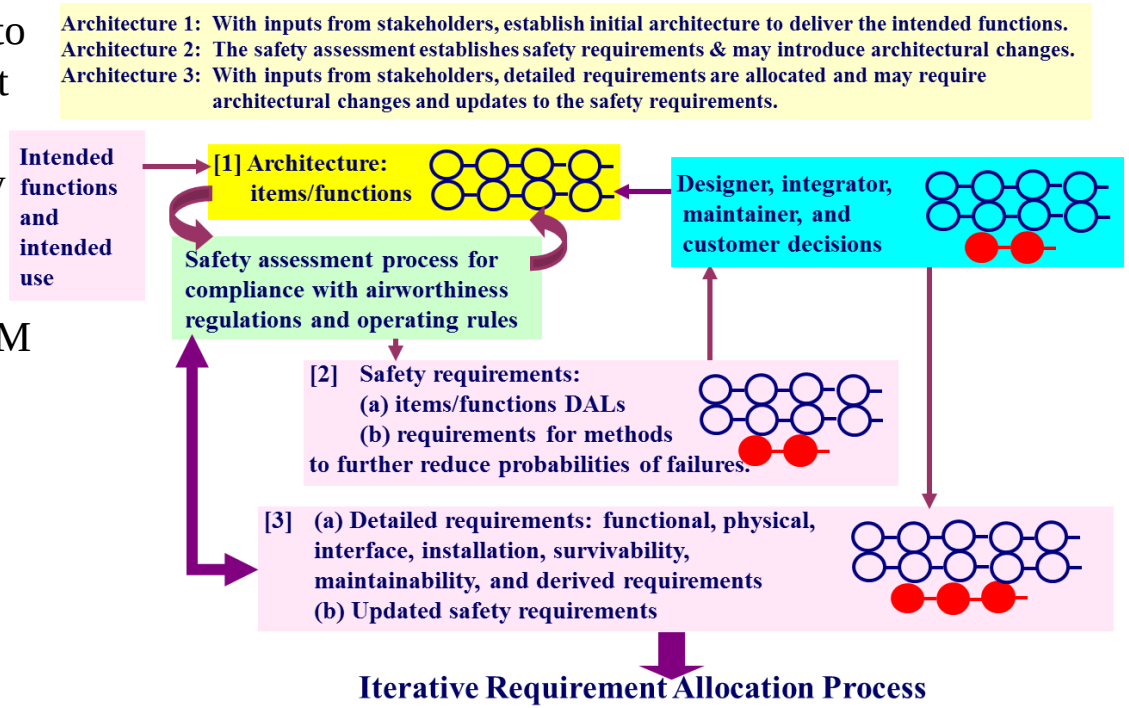
Each requirement should be traceable to a parent or rationale, unambiguous, not redundant, has a unique interpretation, can be validated, and can be physically implemented and verified.

MASAAG Paper 123 identifies 31 SHM generic requirements from which a complete set of high and low level requirements can be generated, validated, implemented and verified.



MASAAG Paper 123, Development, Validation, Verification and Certification of Structural Health Monitoring Systems for Military Aircraft," The UK Military Aircraft Structural Airworthiness Advisory Group.

Google Search for MASAAG Paper 123, MAA, DSTL or follow the link:

https://www.gov.uk/government/publications/military-air-systems-integrity-management-related-documents

SHM Requirements

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Intended Function/Performance Requirements

[1]-[2] The SHM intended function (s) should be decomposed to its elementary functions and clearly stated along with clear identification of the its purpose and how it will be used. **[3]** A Development Assurance Level (DAL) should be assigned to each elementary function based on the adverse consequences of the failure of the elementary function on airworthiness … **[4]** Quality characteristics should be assigned to each elementary function. **[5]** A system architecture that can deliver the intended function(s) with the required qualities at acceptable costs should be developed …

Safety/Airworthiness Requirements

[6] The SHM system must comply with applicable airworthiness regulations …

Personnel Health, Safety, and Performance

[7]-[9] The SHM system should not adversely affect the **environment [9]** or **[7] the health** and **[9] the performance** of manufacturers, crew members, passengers, maintainers, or public personnel

Safety Analysis Process

[10] A safety analysis process should be adopted to identify the potential failure conditions of SHM functions and items, classify each failure based on its effects, and introduce, if required, SHM safety requirements to ensure that the SHM architecture meets the aircraft safety requirements

Development Assurance Process

[11] A Development Assurance process should be adopted to establish levels of confidence that development errors contributing to or causing failure conditions have been minimized to acceptable low levels with sufficient degrees of rigour.

SHM Requirements

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SHM Survivability/Environmental Requirements

[12]-[17] Each SHM component should survive its manufacturing, repair, and installation environments … Over a specified survivability period (failure-free period), each SHM airborne component should survive its surrounding environments … and within the intended system operational environments, perform its allocated functionality with quality consistent with its intended function and its DAL level. The failure-free period should be long enough to maintain aircraft safety and operational reliability at acceptable costs … The SHM ground-based equipment should survive their environments including transportation and handling environments, …

Operational Requirements

[18] Concept of Operations, [19] Electro-magnetic Compatibility, [20]- [22] Data Requirements

[23]–[25] System Configuration, Calibration, and Self-Diagnostics, [26] Maintainability Requirements* , [27]*Personnel Qualification and Training Requirements

Physical, Interface and Installation Requirements

[28]-[29] The Weight, Size, and Power of SHM,

[2-]-[31]Interface and Installation Requirements

Conclusions

- The certification efforts include tasks to obtain the approval of the appropriate Authority/Regulator after demonstrating, witnessing & confirming that applicable airworthiness regulations and functional requirements are met.
- The aim of MASAAG Paper 123 is to provide general guidance on how to validate, verify, and certify SHM systems by imperative considerations of the regulations of the appropriate regulator and his accepted standards.
- The paper guidance contents do not constitute a UK policy or regulatory requirements. The MOD regulations and the means of compliance with these regulations are those published and updated by MAA. For aircraft products including SHM and similar systems, the UK default specifications and requirements are those stated within the UK defence standards.
- MASAAG Paper 123 must only be considered as a best practice guidance paper.

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Thank You
Questions?

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