ACHIEVING MEANS OF COMPLIANCE WITH TEST REQUIREMENT TRACEABILITY MATRIX (TRTM)

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1 Introduction

1.1 Purpose

A mutually agreed acceptable means of compliance is one of the important aspects of certification. Main Contractor should also specify the way of compliance to every requirement listed in the Type Approval/Certification Basis. The description on how compliance will be demonstrated, with proposed means of compliance and any selected guidance material shall be provided by the Main Contractor and agreed upon by CEMILAC. The description of the means of compliance should be sufficient to determine that all necessary data will be collected and compliance can be demonstrated.

1.2 Scope

The scope of the document is to provide guidelines to meet the AMC through Test Requirements Traceability Matrix (TRTM)

1.3 Applying the Document

The main contractor shall include these requirements in the Type Approval Basis (TAB) document along with the means of compliance. The Airworthiness Certification Plan (ACP) document shall cover the roles/responsibilities of Main Contractors/ D&D agencies/QA Department, the project milestones

1.4 Applicable Documents

1. DDPMAS Ver 1.0 Framework and Procedure for Design, Development and Production of Military Air systems and Airborne Stores dated Feb 2021.
2. IMTAR-21, Version 1.0 Indian Military Technical Airworthiness Requirements dated Feb 2021.

1.5 Definitions

Acceptable Means of Compliance (AMC)

AMC represents the preferred means by which the Technical Airworthiness Authorities (TAA) expect the intended requirement / criteria to be met.

a. **Design Organisation (DO)**

Design Organisations are organisations involved in the design & development and modification of Airborne Stores used in an Air System. DO shall be responsible for the through-life configuration management of the designed Air borne Stores. In context to this document, Airborne Store refers to the Avionics items / Ground Operational System (GOS) of UAS.

Ref : IMTAR - 21

b. **Main Contractor**

Main Contractor is the development/modification/ production agency who is entrusted with the total responsibility for development/modification /production/ delivery and follow on support of the Air System/ Airborne Store. When multiple agencies are involved, the respective roles and responsibilities may be defined in an agreement/ MoU among the agencies involved. Where there is no ambiguity or when used in a generic sense, the term Main Contractor is used throughout this document.

Ref : IMTAR – 21

c. **Test**

A quantitative procedure to prove performance using stated objective criteria with pass or fail results.

d. **Traceability**

The recorded relationship established between two or more elements of the development process. For example, between a requirement and its source or between a verification method and its requirement.

e. **Validation**

The determination that the requirements for a product are correct and complete. [Are we building the right aircraft/ system/ function/ item?]

f. **Verification**

The evaluation of an implementation of requirements to determine that they have been met. [Did we build the aircraft/ system/ function/ item right?]

g. **Specification**

A collection of requirements which, when taken together, constitute the criteria that define the functions and attributes of a system, component or item.

h. **Inspection**:

An examination of a system or item against a specific standard.

i. **Compliance**

Successful performance of all mandatory activities; agreement between the expected or specified result and the actual result.

j. **Conformance**

Established as correct with reference to a standard, specification or drawing.

k. **Acceptance**

Acknowledgment by the certification authority that a submission of data, argument, or claim of equivalence satisfies applicable requirements.

l. **Assurance**

The planned and systematic actions necessary to provide adequate confidence and evidence that a product or process satisfies given requirements.

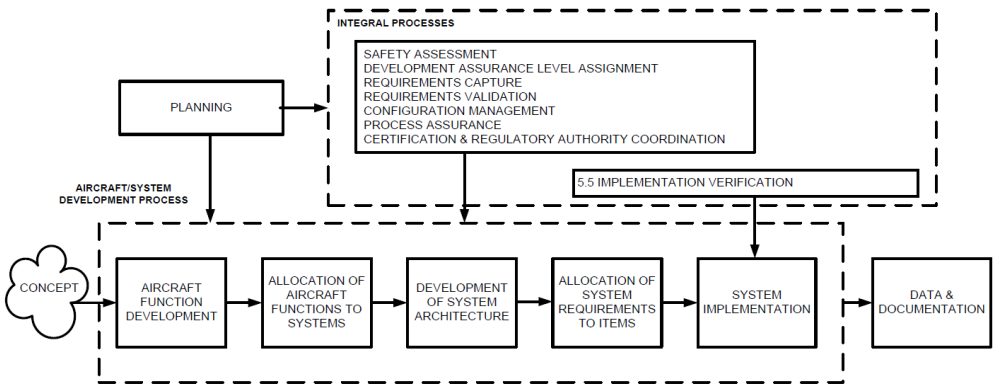
m. **Analysis**

An evaluation based on decomposition into simple elements.

2 Verification and Validation

2.1 System Development Process

Airsystems and Airborne Stores development processes and very complex. These complex systems and integrated aircraft level functions present greater risk of undesirable, unintended effects (requirements determination and design errors) requiring a systematic and exhaustive V&V process. At the same time, it is generally not practical to develop a finite test suite for highly-integrated and complex systems which conclusively demonstrates that there are no residual development errors. The figure below give a typical development process of a complex airsystem.



2.2 Types of Verification & Validation

Several methods may be needed to support Verification & validation. These methods include: inspection, analysis, modelling & simulation, testing, similarity, and engineering review. Validation should consider both intended and unintended functions. Intended function requirements validation involves evaluation against objective pass/fail criteria. While the absence of unintended functions cannot be validated directly, ad hoc testing and targeted analyses can be used to reduce the probability of their presence.

2.2.1 Inspection

Inspection consists of visual examinations of process documents, drawings, hardware, or software to verify that requirements have been satisfied. Generally, a checklist or similar aid is used. Inspection that the system or item meets established physical implementation and workmanship is a typical type of inspection/review.

2.2.2 Analysis

An analysis provides evidence of compliance by performing a detailed examination (e.g., functionality, performance, safety) of a system or item. Evaluations of how the system or item is expected to perform in normal and non-normal conditions should be included. Analysis methods include, but are not limited to, those described in the following paragraphs. Coverage analysis is performed to determine the degree to which the requirements are addressed throughout the development and verification activities. This is typically implemented using some form of traceability.

2.2.3 Modelling & Simulation

Modelling of complex systems typically consists of a combination of computation and test; however, modelling deterministic systems behaviour may also be entirely computational. Modelling may be used for system parameter evaluation, to provide early system information, or other purposes.

2.2.4 Testing or Demonstration

2.2.4.1 Objective of Testing

Testing provides repeatable evidence of correctness by exercising a system or item to verify that the requirements are satisfied. Test adequacy Reviews (TARB) establish the applicability of the test cases to system or item requirements. Testing has the following two objectives:

a. To demonstrate that the system or item implementation performs its intended functions. Testing an intended function involves evaluation against objective pass/fail criteria established by the requirements.

b. To provide confidence that the implemented system does not perform unintended functions (i.e., not consciously part of the design) that impact safety. Ad hoc testing, and special vigilance during normal testing, may be used to identify unintended system or item operation or side-effects. It should be noted that complete absence of unintended function can never be established by test.

Tests are performed on all or part of the physical system or item or an appropriate validated model using procedures documented in sufficient detail so that a second

party could reproduce the test results. Problems uncovered during testing should be reported, corrective action tracked, and the modified system(s) and/or item(s) retested.

2.2.4.2 Test Plans and Report

For each test or group of tests, the following should be specified:

a. Required input variability should be considered in setting the test criteria.

b. Actions required and action order if time dependent.

c. The purpose or rationale for the test(s).

d. The requirements covered by the test(s).

e. Expected results and the tolerances associated with those results.

Test result data should contain the following:

a. The version of the test specification used.

b. The version of the system or item being tested.

c. The version or reference standard for tools and equipment used, together with applicable calibration data.

d. The results of each test including a PASS or FAIL declaration.

e. The discrepancy between expected and actual results.

f. A statement of success or failure of the testing process including its relationship to the verification program.

2.2.4.3 Test Facilities

Functionality may be provided in a system test facility which will improve the probability of detecting incorrect or unintended functions.

a. The hardware and software under test are present in the facility and representative software and hardware.

b. A model of the environment may be used to set inputs to the system under test in a way that is representative of actual service, using representations of user control inputs.

c. A model of the environment may receive the outputs of the system under test and calculate and present the system behavior in terms of the high level requirements.

d. The behaviour of the system under test is made plainly visible in terms of high level parameters.

e. The high level manual inputs are made repeatable to facilitate regression testing.

f. Significant events such as failure or warning messages, and failures to meet high level requirements are annunciated and logged.

Provision of the above functionality allows developmental testing for risk reduction using the models to generate the test results and interpret the results with a very high productivity, and a manageable means to perform unexpected results.

2.2.5 Similarity / Service Experience

Verification credit may be derived from design and installation appraisals and evidence of satisfactory service experience

on other aircraft using the same or other systems that are similar in their relevant attributes. This method should use documented experience along with engineering and operational judgment to demonstrate that no significant failures remain unresolved in these installations.

2.3 Verification & Validation Matrix

A verification matrix or an equivalent tracking document should be produced to track the status of the verification process. The level of detail of this matrix should depend on the development assurance level of the system or item being verified.

While the specific format may be determined by the applicant, it should contain, at least:

a. Requirement,

b. Associated Function,

c. Verification Method(s) Applied,

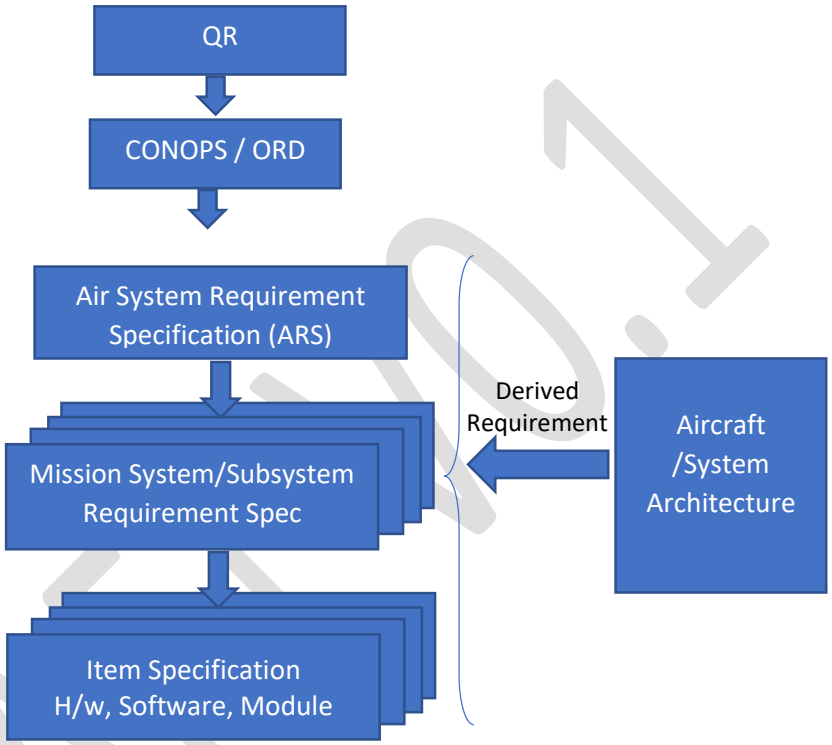
d. Verification Procedure and results reference(s),

e. Verification Conclusion (i.e. Pass or Fail, verification coverage summary).

3 Test Requirements Traceability Matrix

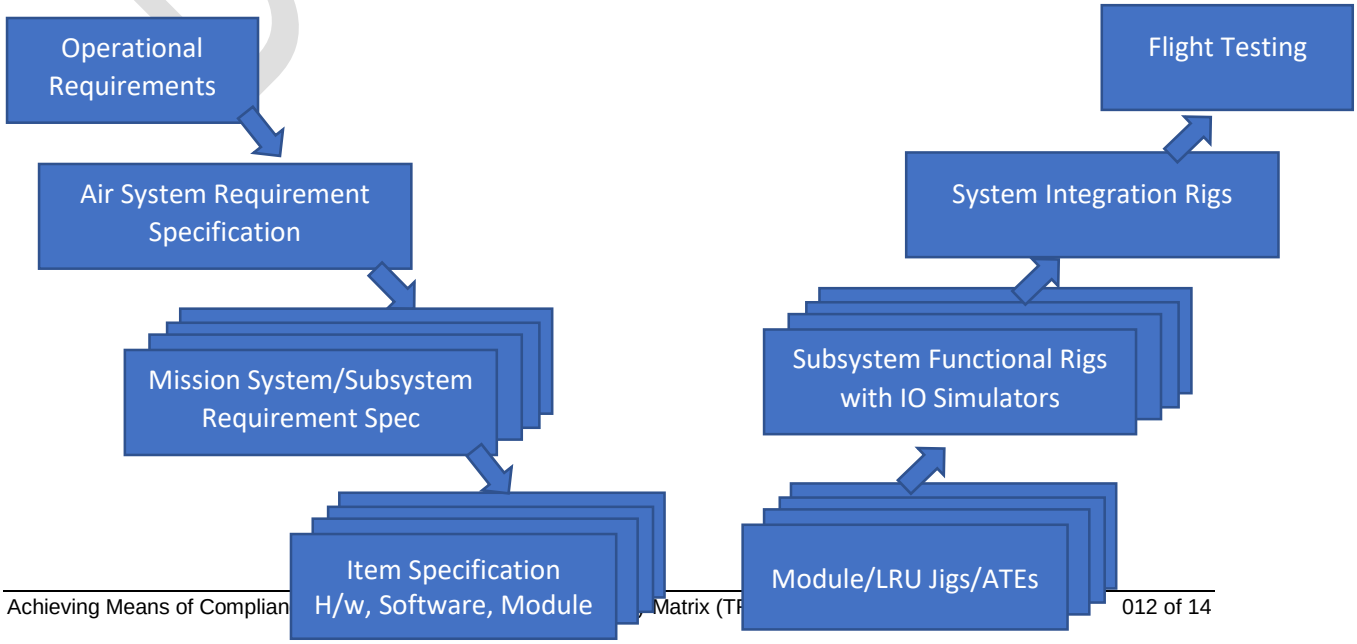
3.1 Requirements Capturing – Hierarchy

For a complex programme, the requirements are systematically allocated from aircraft functional level to the lowest configurable item. A typical hierarchy is given below:



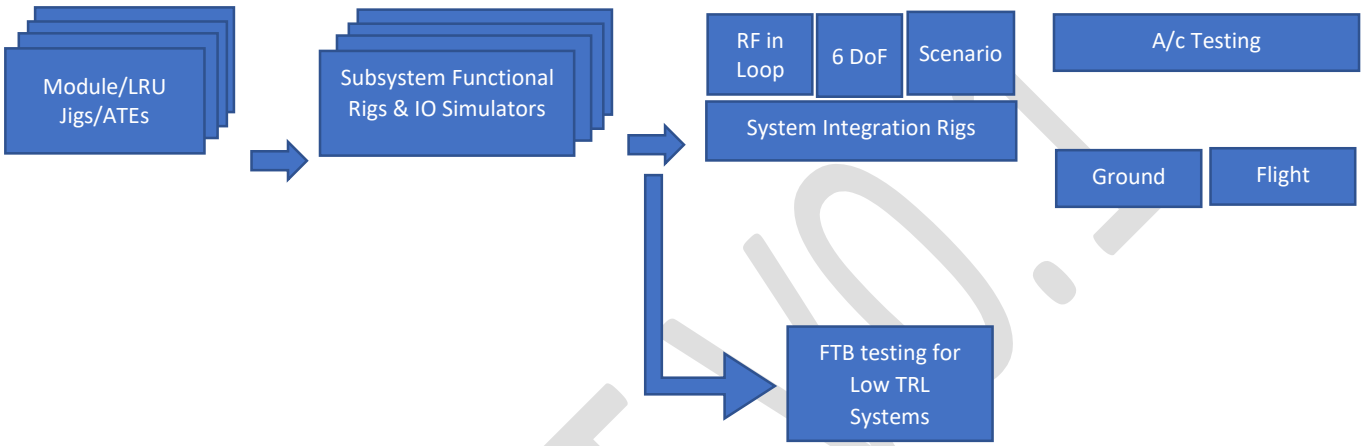
3.2 Testing Levels

Typically, developed and derived requirements are tested in a variety of test facilities. A typical approach to testing is given in the figure below.



3.3 Test Environments

There can be more than one environment that can be used to test. Each environment has to be identified. Such test facilities need to be approved in accordance with IMTAR-21 Subpart T1.



3.4 Capturing Test Requirements Traceability Matrix

A comprehensive manner to capture the verification and validation is called the Test Requirements Traceability Matrix. A typical format of the Test Requirement Traceability Matrix is given below.

Req ID	Inspection	Analysis	Modelling & Simulation	Similarity	Lab Testing		Aircraft Testing	
					LRU/Sub-system	System Integration	Ground	Flight

Sample TRTM is given in annexure -1.

Annexure-1: Sample TRTM

Req ID	Inspection	Analysis	Modelling & Simulation	Similarity	Lab Testing		Aircraft Testing	
					LRU/Sub-system Rig	System Integration	Ground	Flight
Req-1 : Dimension	✓							
Req-2 Max Number of Targets		✓	✓					
Req-3 Sensitivity					✓ Test Env-1			
Req-4 Data Fusion			✓			✓ Test Env-2		
Req-5 Fungus Test				✓				
Req-6 EMI/EMC Co-existence			✓		✓ Test Env-3		✓ Test Env-4	
Req-7 Performance with ground clutter								✓ FTB
Req-8 Point Accuracy under manoeuvres			✓					✓ Actual A/c

Note: All the requirements should preferably have covered by anyone means before flight trials.