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| IALA Guideline |

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Acceptance of VTS SYSTEMS

Edition 1.0

Document date

Revisions to this IALA Document are to be noted in the table prior to the issue of a revised document.

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# INTRODUCTION

This guideline provides general information for acceptance of VTS System. The acceptance of VTS sub-systems are defined in their respective guidelines.

## Objective of the Document

The objective is to provide a framework for acceptance of a VTS System.

It recommends procedures and activities that should demonstrate that a VTS System is working according to the agreed specifications (verification) and is suitable for the intended services (validation).

As a result, there will be a common understanding between the Customer and the Supplier about the set requirements and the procedures that demonstrate compliance.

## Definitions

ISO:9000-2005 - Quality Management Systems [5], sections §3.8.4 and §3.8.5, contain the following definitions:

**Verification**

*“Confirmation, through the provision of objective evidence, that specified requirements have been fulfilled”*

**Validation**

*“Confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled”*

Confirmation can comprise activities such as:

* Performing alternative calculations;
* Comparing a new design specification with a similar proven design specification;
* Undertaking tests and demonstrations; and
* Reviewing documents prior to issue.

For the purposes of this document, the following definitions apply:

**Test procedure**

A detailed sequence of steps to be executed to demonstrate compliance to a requirement.

**Test case**

A test procedure applied to a given system, or system component, in specified conditions.

## References

| [1] | IALA Recommendation V-119 | The Implementation of Vessel Traffic Services |
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| [2] | IALA Recommendation V-128 | Preparation of Operational and Technical  Performance Requirements for VTS Systems |
| [3] | IALA Guideline 1111 | Preparation of Operational and Technical Performance Requirements for VTS Systems |
| [4] | IEEE 1012-2016 | IEEE Standard for System, Software, and Hardware Verification and Validation |
| [5] | ISO 9000-2005 | Quality Management Systems |
| [6] | ISO 15288-2008 | Systems and Software Engineering – System life cycle processes |
| [7] | INCOSE-TP-2003-002-03.2.2 | INCOSE Systems Engineering Handbook. A Guide for System Life Cycle Processes and Activities, Ver. 3.2.2 October 2011 |

# VERIFICATION AND VALIDATION PROCESS

The verification and validation (V&V) process is intended to demonstrate the compliance of the VTS system, prior to operation, to the contractual requirements through a structured model.

Guideline 1111 [3] already provides an introduction to the verification and validation process, the planning and the acceptance testing. This section further elaborates the different phases and methods to serve as a reference for the subsequent sections of the document.

## Management of the process

### Strategic Planning

It is recommended to include a strategic plan for the validation and verification in the contractual documents. The detail and level of effort should be in agreement with the system complexity and criticality.

The VTS system acceptance strategic plan could include how acceptance will be organized, including logistic arrangements, test contents and order, dependencies between process steps including key milestones and criteria for provisional (if applicable) and final VTS system acceptance.

### Agreement on the requirement acceptance criteria

The basis for any acceptance process is an agreed set of requirements to be validated, the verification and validation methods, and an agreement on how to deal with non-compliance.

The requirements describe the operational scenarios, use cases, technical functions and performance of the system.

Requirements should:

* Be uniquely identifiable
* Have an acceptance criterion
* Be described in a SMART (Specific, Measurable, Achievable, Relevant, Time bound) way.

## Process Model

The V-Model (figure 1) is a way to structure a system development and implementation process from definition to final acceptance.

The left-hand side of the figure represents the system realisation from requirements, through design, to implementation.

The right-hand side represents the corresponding verification and validation processes which are addressed in this document.

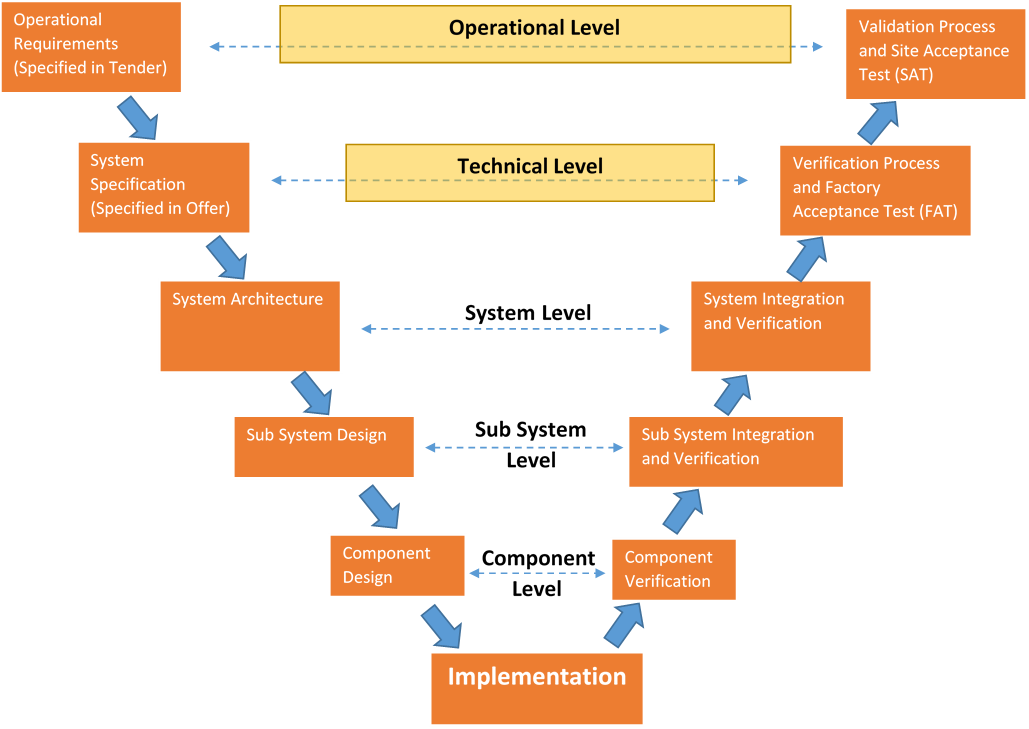


Figure 1: The V-Model

### Component verification

Goals:

* Evidence that sub-system component is compliant with the component design requirements.

The purpose of component verification is to verify that the specifications meet the requirements stated in the component design step. This is the lowest level verification step to ensure that there are no fundamental specific component issues before integration. This is typically done in the form of compliance statements, also stating the used validation methods. However, the Customer may want to witness and/or approve part of the process, such as:

* Type approval of individual equipment, as required by regulation
* Individual Hardware and Software specific verification tests
* Verification of components in preparation for Factory Acceptance Tests

Note that regulations may differ from country to country.

### Sub-system integration and verification

Goals:

* Assemble components according to sub system design specifications
* Evidence that individual sub-systems are compliant with the functional requirements

The purpose of sub-system verification is to verify the function and performance compliance of each sub-system. The Supplier usually performs this phase before further system integration. The extent of verification is highly dependent on the sub-system complexity and Customer specific requirement. Part of this process step is the verification of the interaction between system components.

### System Integration and verification

Goals:

* Assemble sub-systems in accordance with system architecture design
* Verify that the integrated system is performing according to system requirements

The extent of verification is highly dependent on the system complexity and customer specific requirement. Part of this process step is the verification of the interaction between sub-systems.

### Verification Process and Factory Acceptance Test (FAT)

Goal:

* Prior to installation, the functions and performance of the system are verified to ensure they are in accordance to the contractual requirement. This verification is performed on the Supplier’s or component vendor’s premises.

The execution of this phase is the Supplier’s responsibility. For items that are not commercial off the shelf (COTS), it usually ends with a Factory Acceptance Test (FAT).

The Factory Acceptance Test demonstrates, prior to shipping and as far as agreed, that the system conforms to contractual specifications. It should be noted that the FAT will not fully demonstrate the specifications required, as there are limitations to testing in a factory environment.

### Validation process and Site Acceptance Test (SAT)

Goals:

* Following installation and integration, the system is verified against the requirements that could not be demonstrated during FAT.
* Provide objective evidence that the system operates according to the specified requirements, thereby achieving its intended use in its operational environment

Prior to the installation, the Supplier and Customer should agree that preparatory work, such as civil works and structures, is satisfactorily completed.

Part of this process step is the visual inspection of the installation on site of the system.

After installation and setting-to-work, the SAT should take place. The purpose of the SAT is to confirm full operational and functional compliance.

Reasons for testing on site:

* Interaction with other systems
* Interaction with present infrastructure
* representative environment (e.g. geography)

Ideally, the SAT should not repeat the tests done at FAT.

## V&V Test Documentation

The V&V test documentation comprises the following:

1. Test Plan
2. Test Design
3. Test Procedures and Cases
4. Test Results

Refer to IEEE Std. 1012-2016 [4] for the detailed information of the V&V process.

The following sections describe these documentation in greater detail.

### Test Plan

The test plan describes how the Supplier intends to demonstrate compliance to the requirements.

It should include the scope, approach, resources, schedule, and responsibilities of the verification and validation process. It should be approved by the customer.

Goals:

* Agreement on planning and major milestones (e.g. FAT & SAT)
* Consideration of the logistical aspects (e.g. resources, possible dependencies, documentation, etc.)

### Test Design

The test design allocates a V&V method and the acceptance criteria to each and every requirement.

Goals:

* Agreement on specific verification and validation methods
* Agreement on acceptance criteria
* Ensure discrepancies are addressed

The basic verification and validation methods, applicable to the VTS system or its different elements and relevant in the different phase of the V-model, are the following:

* Inspection (I): An examination of the item against applicable documentation to confirm compliance with requirements. Inspection is used to verify properties best determined by examination and observation (e.g. paint colour, weight, physical dimensions, etc.).
* Similarity (S): Similarity is most appropriate where a design is being modified or is very similar to an existing verified system. When verifying by similarity, a common scenario is to perform an analysis to ensure the design and operational environment is similar enough to claim similarity.
* Analysis (A): Use of analytical data or simulations under defined conditions to show theoretical compliance. Analysis (including simulation) is used where verifying to realistic conditions cannot be achieved or is not cost-effective and when such means establish that the appropriate requirement, specification, or derived requirement is met by the proposed solution.
* Demonstration (D): A qualitative exhibition of functional performance, usually accomplished with no or minimal instrumentation. Demonstration (a set of verification activities with system stimuli selected by the system developer) may be used to show that the system or subsystem response to stimuli is suitable. Demonstration may also be appropriate when requirements or specifications are given in statistical terms (e.g. mean time to repair, average power consumption, etc.).
* Test (T): An action by which the operability, supportability, or performance capability of an item is verified when subjected to controlled conditions that are real or simulated. These verifications often use special test equipment or instrumentation to obtain very accurate quantitative data for analysis.
* Operational Trial (O): A period of time by which the system performance and reliability has to be proven according to Operational Procedure and reliability requirement.
* Certification (C): Written assurance that the product has been developed and can perform its assigned functions in accordance with legal or industrial standards. The development reviews and verification results form the basis for certification; however, outside authorities, without direction as to how the requirements are to be verified, typically perform certification (e.g. CE certification, UL certification, etc.)

The verification and validation cost generally increase when going down through the methods listed above, but also provides increased confidence that the requirement is actually met. The methods therefore involve balancing the most cost-effective mix of adequate testing against minimizing the risk of not meeting a requirement.

Apart from the V&V methodology, the acceptance criteria should be specified and there should be an indication of how discrepancies are handled. The criteria would differ depending on the criticality of the requirement to the entire system.

### Test Cases and Procedures

The test cases and procedures document contains an overview of the items and requirements to be tested. It includes the test’s inputs, conditions, test procedures and expected outcomes. This document is usually developed for a Factory Acceptance Test (FAT) and a Site Acceptance Test (SAT).

### Test Results

At each stage of acceptance, the test results document should at least include the:

* Tested requirement(s);
* Configuration details;
* Date of the test;
* Person(s) who performed/witnessed the test; and
* Outcomes of the test (e.g. Pass/fail, measurements, findings, etc.)

After successful completion of the V&V activities, the system is considered ready for operational use.

# Acceptance

## Factory Acceptance

### Introduction

The Factory Acceptance Test (FAT) demonstrates that the system conforms to contractual specifications, as far as is possible and as far as agreed with the Customer. The FAT is the Supplier responsibility and the Customer may elect to attend or to be represented at the FAT. The FAT will normally include Functional and Performance testing to agreed procedures.

The main reasons for testing in factory are:

* The availability of specific and specialised equipment
* Tests can be executed in a controlled environment. Therefore, testing is
  + Easier
  + Quicker
  + More precise
  + Repeatable
* It may be possible to perform more complete testing
* It may be possible to do destructive testing
* Testing in factory is generally cheaper

Personnel conducting the test should be familiar with set-up and operation of the system in test. The Customer’s representative(s), if in attendance, should be appropriately qualified to accept the system and understand issues that may arise during the testing. Safety Instructions should be noted.

### Test Execution

The items to be tested include

* + Physical Configuration Audit
  + Inspection of workmanship and regulatory compliance
  + Functional test of the equipment
  + Parameter adaptation
  + Performance test of the equipment

The outcome of a FAT should be recorded in a test report or certificate. This may include

* References to project name, customer, software revisions, hardware revisions, parts and serial numbers etc.;
* List of instruments and their calibration status;
* Functional test results including verification of safety measures;
* Performance test results;
* Signatories.

After the FAT, the Supplier should ensure that any issues that arise are addressed.

## On-Site Acceptance

### Introduction

On-site V&V should demonstrate the proper functioning of the VTS System after installation and addresses those requirements that can only be tested in the operational environment. It takes into account the outcome of the Factory Acceptance Test and demonstrates that the installed VTS System complies with the agreed requirements and applicable regulations. On-site V&V may include inspections, functional checks and performance measurements.

In general, on-site acceptance testing comprises VTS System and sub-systems using different technologies and competent persons for the respective technologies.

### Pre-conditions for site acceptance test

Before the start of on-site V&V, it is suggested to check the following:

* + Site access and physical security
  + Construction works
  + Facilities such as power supplies (grid / non-grid / backup) and environmental conditioning
  + Safety measures, such as proper grounding, fire- and lightning protection.
  + Ergonomics
  + Network connections, on-site and, if required, off-site

### Test Execution

Testing may comprise one or more sub-systems:

* + Physical Configuration Audits
  + Inspection of workmanship including regulatory compliance
  + Test of equipment and sub-system installation
  + Test of sub-system integration, including networking
  + Setting to work, parameter adaptations, and tuning
  + Functional tests
  + Performance tests

### Outcomes

The outcomes of a SAT should be recorded in a test report or certificate. These typically include:

* + References to project name, customer, software revisions, hardware revisions, parts and serial numbers etc.;
  + List of instruments and their calibration status;
  + Functional test results including verification of safety measures;
  + Performance test results;
  + Open issues and corrective actions; and
  + Signatures.

During the SAT, the Customer and the Supplier should discuss any open issues and agree on appropriate corrective actions to be taken towards acceptance.

### Formal Registration

It is recommended to register the test outcomes for:

* + Each sub-system individually; and
  + The complete site as a whole.

Based on the completion and outcomes of on-site testing, the Customer and Supplier should agree when to start VTS System level V&V testing.

# VTS System Verification and Validation

## Introduction

VTS System verification and validation is the highest level of the whole V&V process. After successful completion, the VTS System is demonstrated to comply with the set requirements and to be fit for operational use.

In general, only the identified system-level requirements need to be demonstrated during the system-level V&V. Sub-system and equipment-level requirements are assumed to have been demonstrated during their respective SATs and FATs. The Customer and Supplier may agree, however, to have certain (critical) sub-system tests demonstrated again.

## Verification and validation of Functional and Performance Requirements

It is recommended to base verification on measured performance data using real targets/objects. This involves the collection of appropriate reference data against which the performance can be evaluated.

Measurements, made from a live situation, should be analyzed taking into account the influence from the environment, such as sea state and weather conditions. They may substantially impact system behavior.

It may be necessary to simulate data and events to demonstrate system performance limits or unusual conditions.

Availability and, in particular, reliability could be demonstrated during an agreed defect liability period after completion of the VTS System V&V. During this period, in which the system is operational, no changes in configuration should be made, except to correct observed problems, and a record should be kept of any issues. After the defect liability period is elapsed, Customer and Supplier should agree about final acceptance of the VTS System.

Furthermore, availability requirements are usually addressed by having fallback/mitigation functions and redundant configurations to ensure continued operation when equipment or even complete sub-systems fail. Simulated failures can be used to verify these requirements.

## Verification Items

The customer may verify that the following documents have been issued:

* Equipment test reports and compliance certificates
* Sub-system test and calibration reports.
* System documentation, such as design documents, operational and maintenance manuals.

## Validation Items

Validation items are largely defined by the specific sub-systems that make up the VTS system under test. In addition, there may be specific customer requirements.

Requirements that generally need to be validated at system-level are overall system functionality including

* Human-Machine interface and the presentation of the traffic image
* The Surveillance functions of the VTS system from various sources
* Adequate coverage of the VTS area by sensors and communication means
* Availability and reliability.