EUROPEAN COOPERATION

ECSS

FOR SPACE STANDARDIZATION

Space engineering

Verification guidelines

Foreword

This Handbook is one document of the series of ECSS Documents intended to be used as supporting material for ECSS Standards in space projects and applications. ECSS is a cooperative effort of the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards.

The material in this Handbook is defined in terms of description and recommendation how to organize and perform the work of verification of a space system product, as specified in the ECSS-ST-10-02.

This handbook has been prepared by the ECSS-E-HB-10-02 Working Group, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

Disclaimer

ECSS does not provide any warranty whatsoever, whether expressed, implied, or statutory, including, but not limited to, any warranty of merchantability or fitness for a particular purpose or any warranty that the contents of the item are error-free. In no respect shall ECSS incur any liability for any damages, including, but not limited to, direct, indirect, special, or consequential damages arising out of, resulting from, or in any way connected to the use of this document, whether or not based upon warranty, business agreement, tort, or otherwise; whether or not injury was sustained by persons or property or otherwise; and whether or not loss was sustained from, or arose out of, the results of, the item, or any services that may be provided by ECSS.

Table of contents

Tables

1
Scope

This handbook provides additional information for the application of the verification standard ECSS-E-ST-10-02C to a space system product.

This handbook does not contain requirements and therefore cannot be made applicable. In case of conflict between the standard and this handbook, the standard prevails.

This handbook is relevant for both the customer and the supplier of the product during all project phases.

To facilitate the cross-reference, this handbook follows as much as is practical, the structure of the standard and quotes the requirements, to make it self standing and easier to read (*the text from the standard is in italic*).

As the Standard applies to different products at different product levels from single equipment to the overall system (including space segment hardware and software, launchers and Transportation Systems, ground segment, Verification tools, and GSE) several examples of tailoring, to match the specificity of each application, are proposed in Annex B.

Specific discipline related verification aspects are covered in other dedicated standards and handbooks. In particular the detailed aspects for Testing are covered in the ECSS-E-ST-10-03 and in its corresponding handbook ECSS-E-HB-10-03.

The application of the requirements of the standard to a particular project is intended to result in effective product verification and consequently to a high confidence in achieving successful product operations for the intended use, in this respect this handbook has the goal to help reaching these objectives.

2
References

This document is the handbook corresponding to the Verification standard ECSS-E-ST-10-02C.

The following documents are referenced in this text or provide additional information useful for the reader.

ECSS-S-ST-00-01	ECSS system - Glossary of terms
ECSS-E-ST-10	Space engineering - System engineering general requirements
ECSS-E-ST-10-02	Space engineering - Verification
ECSS-E-ST-10-03	Space engineering - Testing
ECSS-E-ST-40	Space engineering - Software
ECSS-E-ST-50	Space engineering - Communications
ECSS-E-ST-70	Space engineering - Ground systems and operations
ECSS-E-HB-10-03	Space engineering - Testing guidelines
ECSS-E-TM-10-21	Space engineering - System modelling and simulation
ECSS-M-ST-10	Space project management - Project planning and implementation.
ECSS-Q-ST-10-09	Space product assurance - Nonconformance control system.
ECSS-Q-ST-20	Space product assurance - Quality assurance.
ECSS-Q-20-07	Space product assurance - Quality assurance for test centres.
ECSS-Q-ST-40	Space product assurance - Safety.
ECSS-Q-ST-60	Space product assurance - Electrical, electronic and electromechanical (EEE) components.
ECSS-Q-ST-70	Space product assurance - Materials, mechanical parts and processes.

3
Terms, definitions and abbreviated terms

3.1   Terms from other documents

For the purpose of this document, the terms and definitions from ECSS-ST-00-01 apply, in particular for the following terms:

validation

verification

3.2   Terms specific to the present handbook

3.2.1   acceptance stage

verification stage with the objective of demonstrating that the product is free of workmanship defects, is in accordance with the qualified design and is ready for its intended use

3.2.2   analysis

verification method performing a theoretical or empirical evaluation using techniques agreed with the customer

> NOTE   The selected techniques can typically include statistics, qualitative design analysis, modelling and computer simulation.

3.2.3   commissioning

verification and validation activities conducted after the launch and before the entry in operational service either on the space elements only or on the overall system (including the ground elements)

3.2.4   in-orbit stage

verification stage valid for projects for which in-orbit verification is performed, including the commissioning and verification activities which are delayed because the activation of a space element is performed later during the mission (e.g. for Interplanetary mission, lander).

3.2.5   inspection

verification method by visual determination of physical characteristics

> NOTE 1   Product characteristics include constructional features, hardware conformance to document drawing or workmanship requirements, physical conditions, software source code conformance with coding standards
>
> NOTE 2   See also ECSS-ST-00-01.

3.2.6   model philosophy

definition of the optimum number and the characteristics of physical models required to achieve confidence in the product verification with the shortest planning and a suitable weighing of costs and risks

3.2.7   post-landing stage

verification stage valid for projects for which post-landing verification is performed (e.g. for Multimission projects)

3.2.8   pre-launch stage

verification stage with the objective to verify that the flight article is properly configured for launch and capable of functioning as planned for launch

3.2.9   qualification stage

verification stage with the objective to demonstrate that the design fulfils the applicable requirements including proper margins

3.2.10   review-of-design

verification method using approved records or evidence that unambiguously show that the requirement is met (e.g. using design documents, design reports, technical descriptions, engineering drawings)

3.2.11   test

verification method by measurement of product performance and functions under representative simulated environments

> NOTE   See also ECSS-ST-00-01.

3.2.12   Verification Control Board (VCB)

a board composed of customer and supplier representatives that monitors the verification process and formally assesses the requirements verification close-out.

3.2.13   verification level

product architectural level at which the relevant verification is performed

3.3   Abbreviated terms

The following abbreviated terms are used within this document:

Abbreviation	Meaning
AIT	assembly, integration and test
AITP	assembly, integration and test plan
AIV	assembly, integration and verification
AIVP	assembly, integration and verification plan
AOCS	attitude and orbit control system

Abbreviation	Meaning
AR	acceptance review
ARPT	analysis report
BB	Breadboard
CDR	critical design review
CRR	commissioning result review
CP	commissioning plan
DM	development model
DRD	document requirements definition
ECSS	European Cooperation for Space Standardization
EEE	electronic electrical and electromechanical
EIDP	end item data package
ELR	End of Life Review
EM	engineering model
EMC	electromagnetic compatibility
EOL	end-of-life
EQM	engineering qualification model
FM	flight model
FMECA	failure mode effects and criticality analysis
FRR	flight readiness review
FS	flight spare
GPS	global positioning system
GSE	ground support equipment
H/W	Hardware
HFE	human factors engineering
I/F	Interface
IM	integration model
IRPT	inspection report
ISO	International Organisation for Standardisation
LRR	launch readiness review
LTM	Life Test Model
MU	mock-up
NCR	Non conformance report
NRB	Non conformance review board
OBDH	on-board data handling

Abbreviation	Meaning
ORR	Operations Readiness Review
P/L	Payload
PDR	preliminary design review
PFM	protoflight model
PRR	preliminary requirement review
PTR	post test review
QA	quality assurance
QM	qualification model
QR	qualification review
RCS	reaction control system
RF	radio frequency
RFW	request for waiver
ROD	review of design
RRPT	review of design report
S/C	spacecraft
S/W	software
SM	structural model
SRR	system requirements review
SS	subsystem
STM	structural-thermal model
SVF	software validation facility
TCL	test configuration list
ThM	thermal model
TPRO	Test Procedure
TRR	test readiness review
TRPT	test report
TSPE	Test Specification
TT&C	telemetry, tracking and command
VCB	verification control board
VCD	verification control document
VP	verification plan
VRPT	verification report

4
Verification principles

4.1 Introduction

ECSS-E-ST-10 states that verification demonstrates, through a dedicated process, that the deliverable system meets the specified requirements and is capable of sustaining its operational role during the project life cycle.

ECSS-E-ST-10-02 establishes the requirements for the verification of a space system product. It specifies the fundamental concepts of the verification process, the criteria for defining the verification strategy and the requirements for the implementation of the verification programme. It is intended to apply to different products at different levels, from single equipment to the overall system (including space segment hardware and software, ground segment, launchers and transportation systems, Verification tools and GSE).

Concerning the scope of the standard, it is useful to address at this point some frequently asked questions posed by users, in order to emphasize certain concepts and definitions imposed by higher level standards and by the accepted European practices enshrined within the standard.

4.2 Verification versus Validation

A question often posed is why, within European space projects, we mandate a "verification" programme as opposed to a "verification and validation" programme, as practiced in other engineering disciplines (e.g. software, ground segment).

In general terms verification addresses whether a product satisfies the requirements placed upon it, whilst validation addresses whether a product will satisfy the needs of its users, or as is often more simply said,

Verification proves the product is right.

Validation proves it is the right product.

The Verification Standard does not mandate the need for a separate programme of validation of space products, since product verification is performed against a set of requirements that also address the suitability of the product to fulfil the needs of its intended use. However, the standard does not prevent the execution of a separate validation activity if this is considered appropriate, as is practiced for example, in the operation or ground segment domains. Essentially the process to be followed is the same, although it addresses mainly the use of the product.

4.3 Applicability to all engineering domains

The verification standard is applicable to all engineering domains where space products are developed and as such it is viewed as an "umbrella" under which all domains are covered.

In order to use the standard in a specific engineering domain it is necessary to tailor the standard for that domain and where necessary, to make applicable the standards that define the verification requirements of that domain. A clear example is the verification of the ground segment and operations, whereby its verification is addressed specifically in ECSS-E-ST-70 (Ground systems and operations), by mandating specific verification (and validation) requirements and processes for the ground segment. The fact that ECSS-E-ST-10-02C addresses in detail the space segment does not preclude the use of the standard in other domains, subject to correct tailoring.

4.4 Development

The ECSS glossary defines development as the process by which the capability to adequately implement a technology or design is established before manufacture and that this process can include the building of various partial or complete models of the products in order to assess amongst other things, their performance.

Whilst it is obvious that testing and analysis activities occur during the product development process, they are not addressed by the standard because they are not formal requirement verification activities in the sense of the customer-supplier relationship and consequently do not fall within the mandate of ECSS verification standard.

5
Verification guidelines

5.1 Verification process

ECSS-E-ST-10-02C clause 5.1 specifies that:

a. The verification process shall demonstrate that the deliverable product meets the specified customer requirements and is capable of sustaining its operational role through:
1. Verification planning;
2. Verification execution and reporting;
3. Verification control and close-out.

The detailed objectives of the Verification process are as follows:

a. to demonstrate the qualification of design and performance, as meeting the specified requirements at the specified levels;

b. to ensure that the product is in agreement with the qualified design, is free from workmanship defects and acceptable for use;

c. to confirm product integrity and performance at particular steps of the project life cycle (e.g. launch, commissioning, mission events and landing).

While this process looks sequential in nature, it is in fact more complex because the verification process of a multi level product is conducted in a top down approach for the planning, while the execution and reporting is conducted bottom up. In addition, the verification control and close-out is conducted in parallel to the entire process.

The verification process activities are incrementally performed at various levels and in different stages, and utilizing a combination of the different verification methods as described in the following clause 5.2.

5.2 Verification planning

5.2.1 Verification approach

5.2.1.1 General

ECSS-E-ST-10-02C clause 5.2.1 specifies that:

a. The customer shall define the project requirements, verification objectives and constraints affecting the supplier verification process.

> *Note: For example, ground segment characteristics, launch service, envisaged end to end tests involving several suppliers. The usual general objectives are listed in clause 4.1.1 "Verification objectives".*

b.   The requirements specified in 5.2.2.1a shall always include those of the technical specification

c.   The supplier shall define the verification approach by conducting the following steps:
  1.   Identify and agree with the customer the set of requirements to be subject of the verification process;
  2.   Select the methods and levels of verification, associated model philosophy and verification tools;
  3.   Identify the stages and events in which the verification is implemented.

d.   The verification approach shall be defined by the supplier in the Verification Plan (VP) for approval by the customer prior to implementation.

e.   For each requirement to be verified, the verification strategy shall be defined in terms of the combination of the selected verification methods for the different verification levels at the applicable verification stages in the initial issue of the Verification Control Document (VCD also called verification matrix (see Annex B), for approval by the customer.

To reach the verification objectives a verification approach is defined in phases A and B of the project by analyzing the requirements to be verified, taking into account:

a.   design peculiarities and constraints,

b.   qualification status of candidate solutions (product category),

c.   availability and maturity of verification tools,

d.   verification (including test) methodologies,

e.   programmatic constraints, and

f.   cost and schedule.

The requirement criticality, in terms of technical and programmatic impacts on the verification implementation, should be assessed by the involvement of the verification team in the requirement definition process during phases A and B, since it drives the verification strategy.

The verification approach should allow:

a.   To ensure the definition of correct verification criteria for each requirement by participating in the preparation of product specifications.

b.   To assess the impact that verification has on the design (e.g. modularity, testability, and accessibility).

c.   To ensure a coherent approach to verification implementation throughout the various levels avoiding duplication of activities.

d.   To ensure early verification of critical items to reduce the risks of late failure identification.

e.   To ensure the coverage of the interface verification.

f.   To optimize the design and use of ground support equipment, simulators, test tools and test software (e.g. re-use between levels, stages and models).

g.   To optimize the use of test facilities.

h.   To plan for feedback to the verification activity from the commissioning results in case of multi-mission projects or recurring products.

i.   To consider innovative solutions that can reduce overall verification costs.

j.   To provide visibility and objective evidence of verifications performed.

The use of requirement categories and requirement traceability helps to ensure consistency between verification activities, and to avoid duplications or gaps in the entire verification.

In generating the verification approach, the supplier conducts the following verification steps (see Figure 5-1) while ensuring coherency across all verification levels

a.   Identify "What" are the products and requirements subject of the verification process;

b.   Identify "How" to verify them by a selected method of verification at a certain level on the basis of a determined model philosophy during the project implementation phases;

c.   Identify "When" to implement the verification steps through selected stages and events all along the project life cycle.
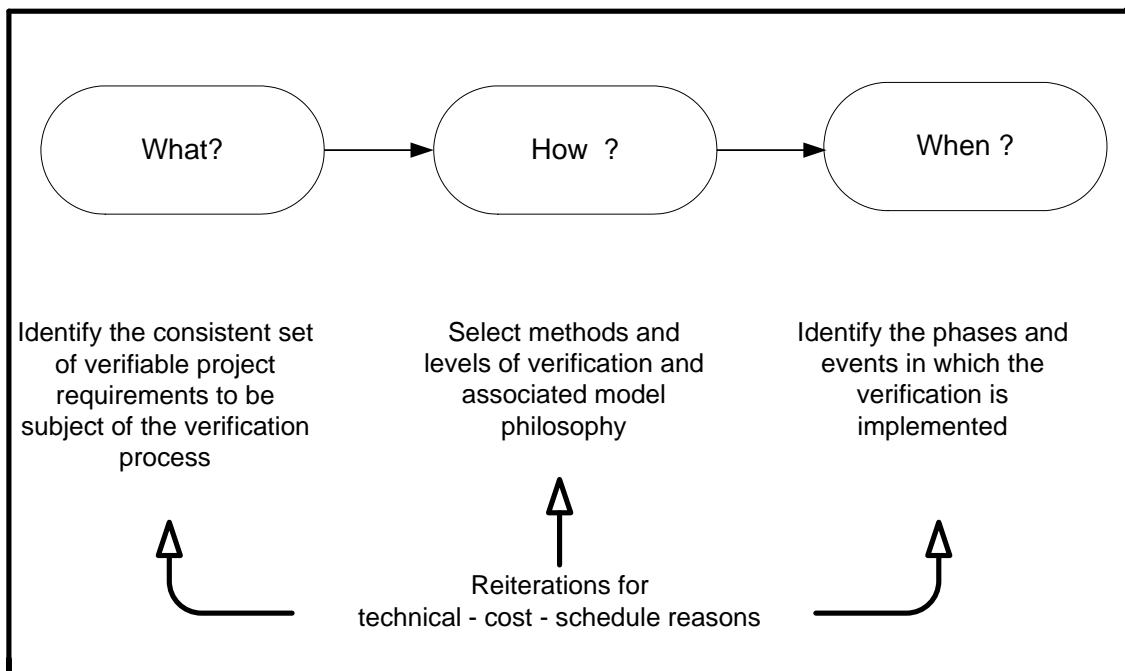
Figure 5-1: Basic verification approach

5.2.1.2   What

Requirements may be grouped in homogeneous category at this step if it facilitates subsequent work. The requirements applicable to a particular product are usually all contained in technical specifications (including interface requirements). A subset of some standards may be part of the set.

In order to facilitate the verification implementation, the project requirement should be:

a.   traceable,

b.   unique and associated to a proper identifier (preferably a unique requirement ID, in its absence a document and sub clause number,

c.   single and not a combination of several requirements,

d.   verifiable using one or more approved verification methods,

e.   unambiguous,

f.   referenced as necessary to other requirements (with applicable document and sub clause identification),

Some requirements are obvious in their verification execution (example: requirements to issue test procedures/reports). To limit the documentation and tracking effort these requirements should be identified and in agreement with the customer marked as "not to be tracked" in the VCD. This means

that these requirements are still applicable requirements but no formal verification report is issued and tracked in the VCD.

In other words a successful verification starts with a satisfactory set of requirements. Each requirement is seen as both the origin and the conclusion of the verification process, and treated as fundamental technical information rather than a constituent of a verbose text.

5.2.1.3   How

5.2.1.3.1   Overview

Then the supplier defines the verification approach in steps, generally conducted in an iterative process based on technical, cost and schedule considerations.

The verification planning activity should take into account the following elements:

a.   the product and specification trees;

b.   the applicable models;

c.   the estimated duration of procurement, design and manufacturing of each model;

d.   the utilization of models (in line with the model philosophy);

e.   the estimated duration of the integration of models;

f.   the selected test programme and sequences at different levels with estimated time and resources;

g.   the analysis, review-of-design and inspection activities combined on the basis of the verification strategies and estimated time and resources;

h.   the activities and time associated with the procurement of the verification tools to be used;

i.   the project milestones and the verification output.

5.2.1.3.2   Step 1 – method, level, model philosophy and verification tool.

After identification of the requirements to be verified the potential verification methods and alternatives in each particular case are assessed in the context of the overall flow, the testing techniques, and the analytical tools available.

The verification levels are selected, taking into account as a minimum the programmatic aspects specified below:

a.   standardized product levels (e.g. service modules);

b.   make or buy decisions (e.g. off-the-shelf products);

c.   reduction of overhead costs (e.g. deletion of subsystem level);

d.   responsibility.

Additionally to the aspects associated with a specific requirement (category), the following rules apply to the selection of levels of verification:

a.   In order to have an early feedback in the programme, verification of critical requirements (for instance related to new technologies) should be achieved at the lowest level of integration of the product to which the critical requirement applies.

b.   All physical or functional requirements for a given product should be verified on that product level.

c. Special attention should be given to the selection of levels of verification of external interfaces due to the potential impacts on the verification program.

d. In the case of verification by test, the use of actual interfaces is preferable to the use of simulators.

e. Duplication of verification activities on different levels should be avoided.

f. In addition to the combination of the verification activities between the different levels, the verification of complex functional chains (e.g. operational performances and mechanisms actuation) should include integrated end-to-end testing.

Models are selected by defining the optimum number and type of physical models to achieve a high confidence in the product verification, with the shortest schedule and a suitable balance of costs and risks. Model philosophy should be defined and frozen in project Phase A or B. Examples of model philosophies are prototype, protoflight or a mix of both, called hybrid model philosophy. This is further discussed in clause 5.2.5. The number of models is minimized and their reuse between different levels maximized to reduce costs. Parallel models are utilized in order to suitably separate the test activities from each other and consequently to reduce risks of schedule slippage.

The Design verification (qualification main objective) is carried out on the product which is representative of the end product configuration (e.g. prototype models, flight models in case of protoflight or hybrid approach).

The Workmanship verification (acceptance main objective) is carried out on the final products (e.g. flight models, and spares).

Customer approval is necessary when design parameters, are verified using development models.

5.2.1.3.3   Step 2 - facilities

Selection of the facilities according to their technical characteristics, location, availability and cost.

5.2.1.3.4   Step 3 - resources

Identification of the resources required.

5.2.1.4   When (stage and event)

The verification stages are selected taking into account:

a. the project characteristics,

b. the associated life cycle

c. the adopted model philosophy

Additionally to the aspects associated with a specific requirement (category), the following rules apply to the selection of stages of verification:

a. When due to the mission characteristics verification includes in-flight activities, the verification does not rely only on in-flight activities. Requirements are verified prior to the flight to the extent compatible with the acceptable risks and with the physical possibilities (e.g. microgravity).

b. All verifications associated with any stage should be completed prior to the start of the next stage. In particular, qualification is finished before the start of acceptance.

5.2.2 Verification methods

5.2.2.1 General

ECSS-E-ST-10-02C clause 5.2.2.1 specifies that:

> a. *Verification shall be accomplished by one or more of the followings verification methods:*
> 1. *test (including demonstration);*
> 2. *analysis (including similarity);*
> 3. *review-of-design;*
> 4. *inspection.*
> b. *All safety critical functions shall be verified by test.*
> c. *Verification of software shall include testing in the target hardware environment.*
> d. *For each requirement verified only by analysis or review-of-design, a risk assessment (part of the VP) shall be conducted to determine the level (major/minor) of the impact of this requirement on the mission.*
> e. *If the impact of the requirement is major, a risk mitigation plan (part of the VP) shall be defined which includes a cross check based on two independent analyses (in terms of model used and suppliers).*

Test is the preferred verification method as it provides generally a higher confidence in the verification of a product's performance and design. If a representative test cannot be conducted, then an analysis substitutes or complements it.

In selecting the verification method/levels/stages the following guidelines are considered:

a. The selected method does not produce risks to personnel, flight hardware and facilities;

b. The selected method is feasible and the required facilities exist as far as possible.

c. The selection of the methods considers the level of confidence that can be achieved with a given fidelity, accuracy, and validity;

d. Analysis is used when flight conditions cannot be accurately simulated on the ground and/or when it is not economically feasible to test the entire spectrum of flight conditions. Analysis and test methods are very often complementary.

e. If several verification methods are possible with the same level of confidence on the verification results, the selection is oriented to minimize the required effort (impact on cost and schedule)

f. Verification of critical requirements (for instance related to new technologies) should be achieved as soon as possible (e.g. at the lowest suitable level) to have early feedback on the programme.

g. To bypass difficulties of testing (i.e. size of facilities, test representativeness) in presence of complex systems or to minimize expensive system testing a combined approach could be selected including test campaign at lower level and analysis at higher level.

h. In particular if environmental testing at higher level is impracticable or too costly, lower level testing should be carried out, completed by analysis, to demonstrate compliance with higher level requirements.

i. When mission characteristics require in-flight verification, the verification does not rely on on-orbit activities only; requirements are verified with proper methods prior to the first flight.

j. Internal and external interface verification is carried-out at the appropriate responsibility level. In case of testing the use of actual interfaces is preferable to the use of simulators.

k. The lower level verification should be completed prior to the associated higher level one.

l.   Duplication of verification activities on different levels should be avoided.

m.   The verification in any stage should be completed prior of the start of the next stage, in particular qualification should be finished before acceptance start.

n.   Final verification of software is performed by test in the target hardware environment.

o.   the verification of complex functional chains (typically operational performances and mechanisms actuation) should plan for an integrated end-to-end testing, in addition to the verification activities performed at lower levels

p.   All physical or functional requirements for a given product should be verified on that particular product level to the maximum extent feasible and reasonable.

q.   Attention should be paid to avoid over-testing, since parts and equipment are being tested at parts, equipment, subsystem and system level.

r.   Verification by similarity is an exceptional process, which can be applied only if all the conditions mentioned in Clause 5.2.2.3.b are met. It cannot be considered as a standard verification method.

The four verification methods are not necessarily applicable or efficient for all stages (and all the stages are not applicable to all the products). The following table provides a synthesis of the following requirements while adding some example.

Method	Test	Analysis	Review of Design	Inspection
Qualification stage	X	X	X	X
Acceptance stage	X			X
pre-launch stage	X			X
in-orbit stage (including commissioning)	X	X(1)	X(2)	X (3)
post-landing stage	X			X

(1) For example budgets (e.g. link, power, mass).

(2) In this case limited to the software change process for in-flight software or ground segment software.

(3) For manned spacecraft or for ground segment.

5.2.2.2   Test

ECSS-E-ST-10-02C clause 5.2.2.2 specifies that:

a.   *Verification by test shall consist of measuring product performance and functions under representative simulated environments.*

b.   *The analysis of data derived from testing shall be an integral part of the test and the results included in the test report.*

c.   *When the test objectives include the demonstration of qualitative operational performance, the execution shall be observed and results recorded.*

d.   *A test programme shall be prepared for each product in compliance with test requirements specified in ECSS-E-ST-10-03.*

e. The test programme shall be coordinated with the integration flow.

f. Tests performed as part of the integration flow to check quality and status of the in-progress configuration (including interfaces), having a formal verification purpose, shall be included in the test programme.

g. The test programme shall be defined in the Assembly, Integration and Test plan (AITP)).

Although the detailed requirements concerning testing are captured in the test standard ECSS-E-ST-10-03, the verification standard provides high level requirements for all verification methods in order to have a coherent verification approach

In defining the test programme the following guidelines are considered:

a. Critical products and interfaces are tested early in phase C/D of the programme.

b. Test flow and sequence are based on the possibility to detect potential failures and defects early in the test programme.

c. The balance of costs and risks is taken into account.

d. Work around plans and contingencies are taken into account.

e. Re-integration testing (also called regression testing) should be avoided.

f. Test feasibility should be confirmed in phase A or B of the programme.

g. The reuse of models, simulators and support equipment should be considered.

Tests are selected based on their effectiveness in verifying the specified requirements considering lessons learned, statistical data from past projects and state of the art test methods. The lessons learned and the statistical data (combining information on ground testing failures and flight anomalies) are useful to determine test effectiveness. Failures not detected during ground testing can end up as early flight failures.

The impacts of the de-integration and re-integration tests (also called regression tests) on the verification program are assessed. De-integration and re-integration are performed for various reasons e.g. fault-findings, during post landing phase in the case of multimission or to carry-out modifications or repairs.

Starting from the initial VCD, test matrices are established showing the correlation of requirements (categories) with the test to be performed at the different levels in the various verification stages. They identify the test verification events to be used for planning purposes.

Test is further addressed in the Test handbook.

5.2.2.3   Analysis

ECSS-E-ST-10-02C clause 5.2.2.3 specifies that:

a. Verification by analysis shall consist of performing theoretical or empirical evaluation using techniques agreed with the Customer.

> *Note: Techniques comprise systematic, statistical and qualitative design analysis, modelling and computational simulation.*

b. Verification by similarity shall be part of the verification by analysis.

c. Similarity analysis shall provide evidence that an already qualified product fulfils the following criteria:

1. The already qualified product was not qualified by similarity.

2. The product to be verified belongs to category A or to category B (defined in Table 5-1) but no testing is required to achieve qualification.

> *Note: Implicitly the product to be verified cannot belong to categories C and D equipment (defined in Table 5-1).*

> *d.   Similarity analysis shall define any difference that can dictate complementary verification activities.*
>
> *e.   An analysis programme shall be defined in the Verification Plan (VP).*
>
> *f.   An analysis programme shall be applicable to qualification and in-orbit stages only.*

An analysis programme compatible with the selected verification approach is defined on the basis of the verification strategies for the various requirements (categories). In defining the analysis programme the following guidelines are considered:

a.   The analytical technique is validated. The verification by analysis is dependant on the quality of the analytical techniques and on the experience gained in using them.

b.   Mathematical model used to perform the analysis should be verified, as far as possible, with laboratory data or in-flight data.

c.   When analysis is supported by test data, testing is performed on a representative model.

d.   The modelling system used is described, and its usage justified.

e.   The product configuration, to which the analysis applies, is identified.

f.   All boundary conditions are stated.

g.   All assumptions used in the analysis are stated.

h.   The field of investigation and the range of validity of the results are defined.

i.   The analytical uncertainty is taken into account such that specified performance is demonstrated with a defined margin.

j.   Analysis covers both the nominal and the worst case conditions.

k.   Analysis for verification may use existing analysis prepared for other purposes (e.g. design or requirement allocation)-

l.   Analysis can be used in support of test or vice versa.

m.   Analysis may be used at all verification levels.

Starting from the initial VCD, analysis matrices are established showing the correlation of the requirements (categories) with the analyses to be performed at the different levels. These matrices identify the analysis verification events to be used for planning purposes.

Sometime the expressions "qualification by similarity", or "verification by similarity" are used in an improper way. Verification by similarity is not an additional verification method on top of the 4 defined in the standard. A similarity analysis can be conducted on a product in order to provide evidence that it belongs to category A (as defined in Table 5-1). If it is achieved, then the new product is considered qualified (by similarity) as specified in clause 5.2.4.2. If the similarity analysis shows that the product belongs to category B, then the similarity analysis should provide sufficient information to allow determining the required delta qualification programme.

5.2.2.4   Review-of-design (ROD)

ECSS-E-ST-10-02C clause 5.2.2.4 specifies that:

> *a.   Verification by Review-of design (ROD) shall consist of using approved records or evidence (e.g. design documents and reports, technical descriptions, engineering drawings) that unambiguously show that the requirement is met.*
>
> > *Note: Examples of such approved records are design documents and reports, technical descriptions, and engineering drawings*
>
> *b.   A review-of-design programme shall be defined in the Verification Plan (VP).*

> c. *A review-of-design programme shall only be applicable in the qualification stage or in the in-orbit stage*

A review-of-design programme, compatible with the selected verification approach, is defined on the basis of the verification strategies for the different requirement (categories). In defining the review-of-design programme, the following guidelines are considered:

a. The activity should be carried out simultaneously with the product design reviews.

b. The activity may include the review of lower level records (e.g. requirement verified by test at a lower level).

Verification by review-of-design may be used at all verification levels.

Starting from the initial VCD, review-of-design matrices are established showing the correlation of the requirement categories with the review-of-design activities to be performed at the different levels. These matrices identify the review-of-design verification events to be used for planning purposes.

Review of design in the in-orbit stage is limited to the software change process See ECSS-E-ST-40 for more details.

5.2.2.5   Inspection

ECSS-E-ST-10-02C clause 5.2.2.5 specifies that:

> a. *Verification by inspection shall consist of visual determination of physical characteristics.*
>
>> Note: *Physical characteristics include constructional features, hardware conformance to document drawing or workmanship requirements, physical conditions, software source code conformance with coding standards.*
>
> b. *An inspection programme shall be defined in the Verification Plan (VP).*

Inspection can be complementary to review of design.

An inspection programme compatible with the selected verification approach and model philosophy is defined on the basis of the verification strategies for the different (categories of) requirement. In defining the inspection programme the following guidelines are considered:

a. The activity should be carried out together with quality assurance tasks during the manufacturing or integration process.

b. The activity may be performed by the crew during the in-orbit verification.

c. Inspection can be complementary to the review-of-design.

Verification by inspection may be used in all stages and all verification levels.

Starting from the initial VCD, inspection matrices are established showing the correlation of the requirement categories with the inspections to be performed at the different levels in the applicable verification stages. These matrices identify the inspection verification events to be used for planning purposes.

5.2.3   Verification levels

ECSS-E-ST-10-02C clause 5.2.3.1 specifies that:

> a. *Verification shall be accomplished through the selected verification levels.*
>
>> Note: *Usual levels are defined in 4.2.3*
>
> b. *When a requirement is fully verified at lower level, the traceability to lower level verification evidence shall be identified.*

c. Formal close-out of qualification and acceptance at lower levels shall be performed prior to close-out at higher level.

The number and type of verification levels depends upon the complexity of the project and on its characteristics (levels are generally derived from product and specification trees). The usual verification levels for a space project are:

a. Equipment (e.g. valves, batteries and individual electronic boxes);

b. Subsystem (e.g. electrical power, attitude control, structure, thermal control and software);

c. Element (e.g. launcher, satellite, ground segment);

d. Overall system (e.g. combined space and ground segments, manned infrastructure system).

Below the equipment level there is the parts and materials level. The general requirements for the evaluation, approval and procurement of parts and materials are defined in ECSS-Q-ST-60 and ECSS-Q-ST-70.

The identification of the verification levels is driven by technical and programmatic considerations (e.g. functional architecture and overhead cost) having in mind that verification is carried out against the applicable requirements under the responsibility of the organization upon which the requirements are placed.

5.2.4 Verification stages

5.2.4.1 General

ECSS-E-ST-10-02C clause 5.2.4.1 specifies that:

a. Verification shall be accomplished through the selection of the appropriate stages on the basis of project specificity from the following:
  1. qualification,
  2. acceptance,
  3. pre-launch,
  4. in-orbit (including commissioning),
  5. post-landing.
b. Qualification, acceptance and pre-launch stages shall be completed before launch.
c. When the verification programme includes an in-orbit stage, the verification shall not rely only on in-orbit activities.
d. When the verification programme includes a post landing stage, the verification shall not rely only on in-orbit activities or post landing activities.

Even if the verification programme includes an in-orbit stage or a post landing stage, the verification is conducted also before launch (this is shown with the entries in the Verification stages of the VCD relevant to pre-launch on-ground verification e.g. qualification, acceptance).

5.2.4.2 Qualification

ECSS-E-ST-10-02C clause 5.2.4.2 specifies that:

a. In the qualification stage the verification shall demonstrate that the design, including margins, meets the applicable requirements.
b. Qualification shall be carried-out on hardware and software which is representative of the product configuration in terms of design, materials, tooling and methods.
c. The qualification programme shall be prepared considering the product category according to heritage as defined in Table 5-1.

Table 5-1: Product categories according to heritage

(Table 5-1 of ECSS-E-ST-10-02)

Category	Description	Qualification programme
A	Off the shelf product without modifications and • subjected to a qualification test programme at least as severe as that imposed by the actual project specifications including environment and • produced by the same manufacturer or supplier and using the same tools and manufacturing processes and procedures	None
B	Off the shelf product without modifications. However: • It has been subjected to a qualification test programme less severe or different to that imposed by the actual project specifications (including environment).	Delta qualification programme, decided on a case by case basis.
C	Off the shelf product with design modifications Modification includes changes to design, parts, materials, tools, processes, procedures, supplier, or manufacturer	Delta or full qualification programme (including testing), decided on a case by case basis depending on the impact of the modification..
D	Newly designed and developed product.	Full qualification programme.

During this stage, verification activities are executed with the objective to demonstrate that the design being qualified and therefore that the flight product will fulfil the requirements in the expected environment. To cover the uncertainties in measurement and environment, margins are applied. Discipline specific margins (e.g. power, frequency, data rate, processor loading) are defined in the discipline specific standards. Test margins and tolerances are defined in the testing standard ECSS-E-ST-10-03. These margins have also to cover the aspect that the flight product has to survive the flight levels/stresses as well as the acceptance tests.

The qualification programme for Cat B product has mainly to cover the differences in the requirements, including the environment.

In case of a different supplier, changed processes or different parts, it also demonstrates that the final product still fulfils the requirements. The delta qualification programme therefore concentrates on these aspects.

Cat C products have design modifications with respect to the originally qualified design. The delta qualification programme in this case concentrates on the impact of these changes on the qualification. In case of major modifications a full qualification programme is performed.

5.2.4.3   Acceptance

ECSS-E-ST-10-02C clause 5.2.4.3.1 specifies that:

> a.   *In the acceptance stage the verification shall demonstrate that the product is free of workmanship errors and is ready for subsequent operational use.*
>
> b.   *Acceptance shall be carried-out on the final hardware and software.*

ECSS-E-ST-10-02C clause 5.2.4.3.2 specifies that:

> a.   *The acceptance article shall be manufactured in agreement with the qualified design.*
>
> b.   *The acceptance article shall perform as the qualified product.*

During this stage, verification activities are executed with the objective to demonstrate that the product under acceptance:

a.   conforms to its relevant qualified design,

b.   is not affected by defects that could be introduced during manufacturing or assembly, either by workmanship or by inadequate process,

c.   is able to fully provide its required functions and performances, as specified for flight.

This verification process applies on hardware and software in their full flight configuration.

5.2.4.4   Pre-launch

ECSS-E-ST-10-02C clause 5.2.4.4 specifies that:

> a.   *In the pre-launch stage the verification shall demonstrate that the product is properly configured for launch activities and early operations.*
>
> b.   *In the pre-launch stage the verification shall confirm that the product is capable of functioning as planned during launch and early operations.*

A number of activities are usually accomplished during the pre-launch stage. These activities are needed to demonstrate that the transportation to the launch site or any storage condition have not damaged the product , to put the flight product in its specific launch configuration, and to integrate it with the launcher vehicle where applicable, depending on the product level.

Test and inspection techniques are applied at this stage. They complement the verification activities completed at acceptance, where the real flight products and interfaces now replace the use of the simulators.

5.2.4.5   In-orbit

ECSS-E-ST-10-02C clause 5.2.4.5 specifies that:

> a.   *In the in-orbit stage the verification shall ensure no degradation occurred during the launch, early orbit phase, at periodical intervals and before specific operational use.*
>
> b.   *In the in-orbit stage the verification shall supplement/confirm ground verification by providing operating conditions which cannot be fully or cost effectively duplicated or simulated on ground.*
>
> c.   *In the in-orbit stage the verification shall characterize the system under operational conditions especially for the aspects that cannot be determined before the launch.*
>
> d.   *In the in-orbit stage the verification shall confirm that the space and ground elements are compatible with each other.*
>
> e.   *In the in-orbit stage the verification shall perform calibration and tuning activities specific to the mission payload.*
>
> > Note: *The working arrangement between the elements suppliers (e.g. satellite, ground segment) and the final customer defines the share of responsibilities*

for preparing, conducting and reporting the in orbit - commissioning activities. The completion of this stage allows declaring readiness for routine operations (Phase E2-exploitation).

The in-orbit stage is valid for projects where, due to their characteristics (e.g. mission or in-orbit operations), in-orbit verification is performed.

The space element supplier should update its analyses and mathematical models using in-orbit experience and the telemetry made available by the Customer (e.g. thermal, power, aero-thermal behaviour during re-entry, RF link budget).

Verification at periodical intervals concerns generally health check. The periodicity is mission dependent and agreed with the customer.

For GEO and LEO satellites, this verification during in-orbit stage is done during the commissioning shortly after the launch.

For other missions (e.g. moon, planets, comets, inter-planetary…), this verification may be delayed until reaching the targeted location(s) and environment(s).

5.2.4.6 Post-landing

ECSS-E-ST-10-02C clause 5.2.4.6 specifies that:

> a. *The verification in the post-landing stage shall address the product integrity and performance after the mission.*
>
> b. *In case the product is intended to be re-launched the verification shall address:*
> 1. *health check, at periodical intervals agreed with the customer, during storage periods;*
> 2. *the product performance after modification, repair or replacement;*
> 3. *the readiness for reuse.*

The post-landing stage is valid for projects that, due to their characteristics (e.g. multi-mission projects), post-landing verification is performed.

Many projects are actually facing a return to earth or a multi-mission scenario (e.g. re-entry demonstrators, NASA STS, the Logistics Modules for the ISS) and in the next future, it is expected that the re-usable launchers or the advanced crew transportation systems, including associated re-entry demonstrators, will see similar perspectives.

In this context the classical verification stages, completed with the in-orbit activities, are complemented by additional post-landing verification. In the case of a simple re-entry, it covers at least the product integrity and performance after the mission.

In case of subsequent mission, it covers at least the health checks during storage, the product performance after modification, repair or replacement and the readiness for reuse. For products to be re-launched, the verification programme is updated taking into account the previous flight verification programme and in-orbit experience. This program is established by reviewing and assessing existing documentation, on the basis of the requirements for the new flight and by inspecting the hardware and software to be re-flown.

5.2.5 Models and Models Description

5.2.5.1 Introduction

ECSS-E-ST-10-02C clause 5.2.5 specifies that:

> a. *The model philosophy shall be defined as part of the overall verification planning.*

During the development and verification process of a product various models are used. The model philosophy defines the optimum number and the characteristics of physical models required to

achieve confidence in the product verification with the shortest planning and a suitable weighing of costs and risks.

The following guidelines, relevant mainly to flight elements, are intended to help the definition of the models involved in the verification process and the selection of the associated model philosophy. This section starts with a description of the models (build status and use) involved in the verification process, then criteria are established how to select a model philosophy and examples of typical model philosophies are provided.

Clause 5.2.5.2 describes the various models; the ECSS Glossary ECSS-ST-00-01C section 3.3 gives the definition of the main ones.

5.2.5.2 Models description

5.2.5.2.1 General

Various types of models can be employed according to verification requirements. These models can either be hardware models, virtual models (software simulators and analytical models) or a combination of both (hybrid models). A short description of the major models used is given. These models are maintained under configuration control (except models used for development purposes). The Table 5-2 provides a schematic summary of the models with related objectives, representativity and applicability. The representativity of the models depends from their intended use.

5.2.5.2.2 Mock-Up (MU)

Mock-Ups are used in support of design definition for overall architecture analyses, configuration design and assessment, interface control and definition, human factors and human computer interface (HCI) assessment, operational procedures evaluation and layout optimization.

According to their representativity, mock-ups are classified as:

a.   Low fidelity: to be used in the initial verification phases (generally, mock-ups for human factors engineering requirement development activities or for validation of software HCI requirements).

b.   High fidelity: under configuration control in all areas where interface control and flight hardware manufacturing support is provided (e.g. area of utility routing, connector brackets and attach points).

The Mock-Ups can be incremental tools, i.e. they are progressively upgraded to reflect a final configuration.

Mock-Ups intended for human factors evaluation are also used in test campaigns such as parabolic flights, buoyancy and swimming pool tests. Their representativity depends on the type of test to be performed.

5.2.5.2.3 Development Model (DM)

In general the Development Models are used in the development areas of new design or where substantial redesign is performed. They are applicable to every type of product (e.g. electronic box, mechanisms, structural parts and thermal equipment) and can be subjected to functional and/or environmental testing. Development Models of subsystems are also envisaged such as: thermal control active control loop breadboards, attitude & orbit control system and guidance & navigation control benches. The DM is sometimes also called Bread Board model (BB)

5.2.5.2.4 Structural Model (SM)

The Structural Model is fully representative of the end product for structural aspects. It is used for qualification of the structural design and for mathematical models correlation. Generally, the system Structural Model consists of a representative structure, with structural dummies of the flight equipment. It also includes representative mechanical parts of other subsystems (e.g. mechanisms and solar panels). The SM is also used for a final validation of test facilities, GSE, and related procedures.

5.2.5.2.5 Thermal Model (ThM)

The Thermal Model is fully representative of the thermal properties of the end product. It is used for the qualification of the thermal design and for the correlation of mathematical models. Generally, the system Thermal Model consists of a representative structure with thermal dummies of the flight equipment. It includes also representative thermal parts of other subsystems.

5.2.5.2.6 Structural-Thermal Model (STM)

The Structural-Thermal Model combines the objectives of the Structural Model and Thermal Model. It consists, at system level, of a representative structure equipped with dummies of flight equipment. On the other hand, the Structural-Thermal Model can also be a Structural Model refurbished for thermal verification purposes after structural qualification (provided no potentially destructive tests have been performed on the Structural Model).

5.2.5.2.7 Suitcase Model

The Suitcase Model is intended to be used with the ground station for verifying correct TM reception, TC commanding and ranging. It is representative of the RF receiver and transmitter (including ranging) as well as the data handling part involved in the TM/TC protocol. This representativity is generally achieved with non-redundant EM equipment for the RF part and breadboard for the data handling part running the flight software with the correct space element identifier. See also ECSS-E-ST-10-03.

5.2.5.2.8 Electrical and Functional Model (EFM)

The Electrical and Functional models (sometimes called also integration models) are functionally representative of the end products in both electrical and software terms. They are used for functional and interface tests and for failure mode investigations. Some part can be simulated by software; the rest is using commercial parts.

5.2.5.2.9 Engineering Model (EM)

The Engineering Model is flight representative in form, fit and function, without high reliability parts and usually without full redundancy. The Engineering Model is used for functional qualification, failure survival demonstration (and parameter drift checking if military parts are used). The Engineering Model is also used for final validation of test facilities and GSE and the related procedures.

5.2.5.2.10 Engineering Qualification Model (EQM)

The Engineering Qualification Model fully reflects the design of the end product except for the parts standard (military grade parts can be used instead of high reliability parts, provided they are procured from the same manufacturer). The Engineering Qualification Model is used for functional performance qualification (including verification of procedures for failure detection, isolation and recovery and for redundancy management) and EMC testing. It may also be used for environmental testing if the Customer accepts the risk, in this case the Qualification Model (QM) rules applies.

5.2.5.2.11   Qualification Model (QM)

The Qualification Model fully reflects the end product design in all aspects. The Qualification Model is used for complete functional and environmental qualification tests. It is used only for equipment and subsystems newly designed or when a delta qualification for adaptation to the project is performed. The QM sees qualification test levels and durations as specified in ECSS-E-ST-10-03. Qualification Model is not intended to be used for flight.

5.2.5.2.12   Life Test Model (LTM)

The Life Test Model is used to demonstrate by testing that the product can achieve the required lifetime and perform the required quantity of cycles. For qualification the tests are performed in the environment specified for qualification. This model is required for mechanisms, if a protoflight approach is applied and a high number of operation cycles are required. Life Test Models can not be used for flight.

5.2.5.2.13   Proto-Flight Model (PFM)

The Proto-Flight Model is the flight end product on which a partial or complete protoflight qualification test campaign is performed before flight. The protoflight models only see acceptance or protoflight test levels and durations as specified in ECSS-E-ST-10-03. Limited life constraints, especially when mechanisms are present, are evaluated as for any flight model.

5.2.5.2.14   Flight Model (FM)

The Flight Model is the flight end product. It is subjected to formal functional and environmental acceptance testing. The FM sees acceptance test levels and durations as specified in ECSS-E-ST-10-03.

5.2.5.2.15   Flight Spare (FS)

The Flight Spare is the spare end product for flight. It is subjected to formal acceptance testing. Refurbished qualification product can be exceptionally used as Flight Spare.

5.2.5.2.16   Function oriented model

The function oriented model is dedicated to the qualification of particular functional requirements. It reflects the end product design in the aspects subject to the qualification. The definition of this model depends on project characteristics and verification requirements. Examples of function oriented models are

— aerodynamic models,

— robotics and automation models, and

— ground segment functional models.

5.2.5.2.17   Training model

The training model is dedicated to development and training of activities (including flight procedures). Therefore, it is usually a functional representative of the flight model modified to be capable to function under natural gravity. For example, training model can be used to:

— train flight crew and ground personnel,

— develop and verify procedures,

— establish training records, and

— perform baseline data collection.

For the ground segment, it means an environment with sufficient fidelity to allow achievement of objectives.

5.2.5.2.18 Virtual and hybrid models

In the functional and electrical domain, simulation models are used for development and verification. These models exist either in pure software configuration (simulators) or in a combination of software and hardware components. Their composition may change in course of the project life cycle. A particular case of such model is the Software Verification Facility (SVF) addressed in clause 5.2.6.3. A detailed definition is given in ECSS-E-TM-10-21A (System Modelling and Simulation).

5.2.5.2.19 Human related models

These models are dedicated to the qualification of particular human factors engineering requirements. Their representativity is limited, depending on qualification objectives.

5.2.5.2.20 Ground segment specific models

These models are dedicated for a particular purpose in the verification process of the ground segment and operations, for example:

— A model, composed of a subset of the ground segment plus a satellite simulator, to develop and verify procedures, and the Human Machine Interface (HMI).

— A model to validate the telecommand (TC) and housekeeping telemetry (TM) data processing, as well as the associated procedures, on a representative TM/TC environment, before applying it on the operational environment. In that case, a satellite simulator is part of the setup.

— A model to validate the payload telemetry data processing on a representative environment before applying it on the operational environment. In that case, a payload data simulator may be required, in particular before the launch.

— A training model (see 5.2.5.2.16).

Table 5-2 : Summary model definitions

Model	Objectives	Representativity	Applicability	Remarks
Mock-Up (MU)	• I/F layout optimization/ assessment • Integration procedure validation • Accommodation checks	• Geometrical configuration • Layouts • Interfaces	System/element levels	According to their representativity MU's are classified as: • Low fidelity • High fidelity (to be maintained under configuration control)
Development Model (DM)	Confirmation of design feasibility	• Total conformity with functional electrical & S/W req. in agreement with verif. objectives (size, shape & I/Fs could not be representative)	All levels	• Development testing • Sometime it is also called breadboard (BB)
Structural Model (SM)	• Qualification structural design • Validation of structural mathematical model	• Flight standard with respect to structural parameters • Equipment structural dummies	• SS level (structure) • Sometime it could be considered system level if involves other SS or is merged with the system test flow	Qualification testing
Thermal Model (ThM)	• Qualification of thermal design • Validation of thermal mathematical model	• Flight standard with respect to thermal parameters • Equipment thermal dummies	• SS level (thermal control) • Sometime it could be considered system level if involves other SS or is merged with the system test flow	Qualification testing
Structural-Thermal Model (STM)	SM & ThM objectives	• SM & ThM representativity • Equipment thermo structural dummies	System level	Qualification testing
Suitcase Model	Simulation of functional & RF performances	• Flight design • Commercial parts • Functional representativity	• Equipment level • System level	Space to ground interface testing
Electrical and Functional Model (EFM)	• Functional development • S/W development • Procedure validation • Prepare flight test programme • Closed loop tests	• Functional representativity • Commercial parts • Simulators of missing parts	All levels	• Development or qualification testing • It could be considered something in between a mock-up and an EM • Sometime is called also Integration Model

Model	Objectives	Representativity	Applicability	Remarks
Engineering Model (EM)	Functional qualification failure survival demonstration & parameter drift checking	• Flight representative in form-fit-function • without high reliability parts and usually without redundancy	All levels	Partial functional qualification testing
Engineering Qualification Model (EQM)	• Functional qualification of design & I/Fs • EMC	• Full flight design • MIL-Grade parts procured from the same manufacturer of high reliability parts	All levels	Functional qualification testing
Qualification Model (QM)	Design qualification	• Full flight design & flight standard	• Equipment level • SS level	Qualification testing
Life test Model (LTM)	Qualification of lifetime	• Flight representative with respect to the qualified function	Equipment level	• Model for mechanisms in a protoflight approach with lifetime requirements • Can not be used for flight
Protoflight Model (PFM)	• Flight use • Design qualification	Full flight design & flight standard	All levels	Protoflight qualification testing
Flight Model (FM)	Flight use	Full flight design & flight standard	All levels	Acceptance testing
Flight Spare (FS)	Spare for flight use	Full flight design & flight standard	Equipment level	Acceptance testing
Function oriented model	Qualification against the applicable functional requirements	Flight representative as necessary for the limited qualification objectives	All levels	Qualification testing oriented to a specific function or requirement
Training model	Flight training baseline data	Flight representative with modifications to allow for normal gravity operation	All levels	Qualification testing oriented to specific HFE requirements
Virtual and hybrid models	Development and verification of specific aspects	Virtual or physical flight representativity as necessary for the applicable verification objectives	All levels	• Composition may change in course of the project life cycle • Often replaces pure hardware models
Human related models	Qualification against the applicable HFE requirements	Flight representative as necessary for the limited qualification objectives	All levels	Qualification testing oriented to specific HFE requirements
ground segment specific models	Verification process of the ground segment and operations	Representative as necessary for the applicable verification objectives	Ground segment	See also ECSS-E-ST-70

5.2.5.3   Model philosophies description

5.2.5.3.1   Introduction

The model philosophy defines the optimum number and the characteristics of physical models required to achieve confidence in the product verification with the shortest planning and a suitable weighing of costs and risks

The model philosophy is defined by means of an iterative process which combines programmatic constraints, verification strategies and the integration and test programme, taking into account the development status of the candidate design solution.

The various issues to be considered are shown in Figure 5-2.
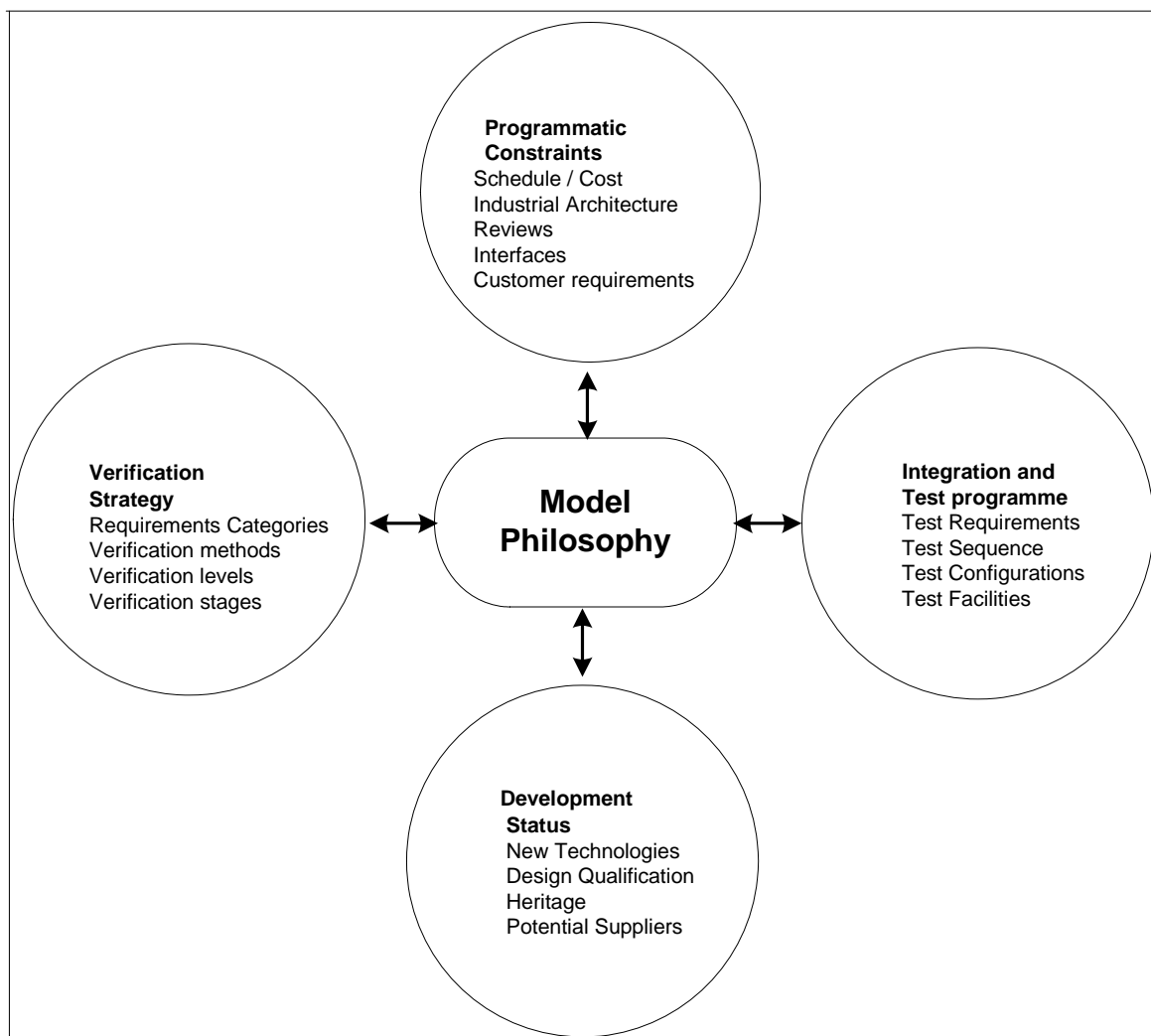
Figure 5-2: Parameters for Model Philosophy definition

The starting point is the development status of the products. Development of a new product with new technology requires an extensive model philosophy which allows full qualification. On equipment level, breadboards and development models are used to identify problems at an early stage. For qualification a dedicated model is used. On system level EMs are used which have on one side a high fidelity but avoid the cost and schedule impact of high reliability parts in QMs and FMs.

The model philosophy is also influenced by the verification and the test strategy. For specific verification tasks, specific test models can be required.

On the other hand the model philosophy strongly influences the schedule. A sequential use of a model on different levels and for different purposes can increase the schedule duration, whereas parallel work on various models can shorten it.

Also industrial structure may affect the model philosophy, in particular additional model maybe necessary. It is good practice to have clear interfaces, responsibilities and deliveries

The selection of a model philosophy for a specific project is always a balance between the cost and the schedule of the program and the risk which can be taken. Cost increases if specific models are necessary for early verification or check of critical aspects Several types of model philosophies can be employed according to verification requirements. A short description of the major model philosophies utilized in the verification process is given in what follows.

5.2.5.3.2   Prototype philosophy

This approach is generally used in projects for which all affordable measures are taken to achieve minimum risk. The usual characteristics of these projects are:

a.   new or complex design,

b.   impossibility to be recovered or repaired after launch, and

c.   special mission requirements.

The prototype approach makes extensive use of the aforementioned defined models to cover verification needs. The disadvantage is high cost. The advantages of this approach are

a.   low risks,

b.   capability to perform parallel activities on different models,

c.   completion of qualification activities prior to acceptance, and

d.   capability to use QM or EQM (see Table B-1) as integration spare during higher level activities.

On the basis of project requirements, the related model philosophy is tailored.
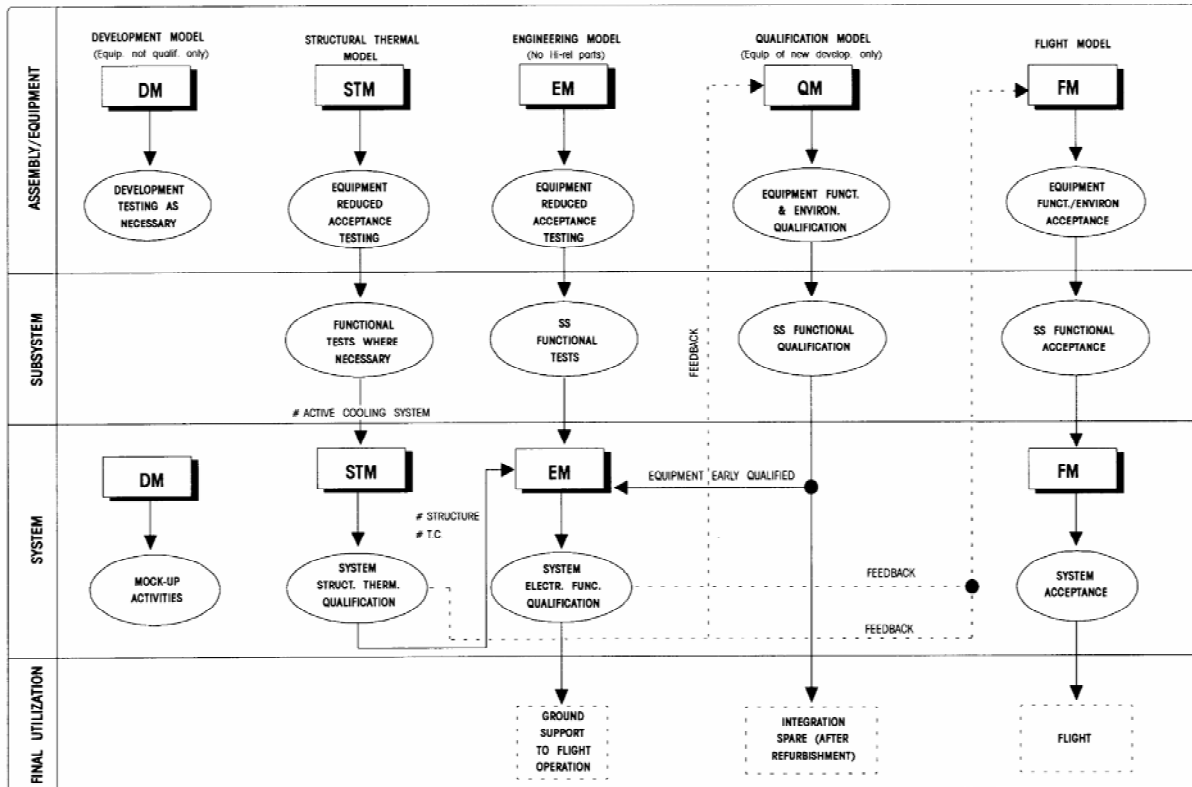
Figure 5-3: Example of Unmanned project model philosophy

Figure 5-3 and Figure 5-4 show examples of prototype philosophies for unmanned and manned projects respectively. In the figures the different models and their flow at several verification levels together with the respective test activities and the final utilization are identified.

In particular the Figure 5-3 shows the common case in which, after the thermal and structural qualification, parts of the STM (namely structure and thermal control) are utilized to complete the satellite level EM, in addition to EM/QM equipment. It is important to note that after the system electrical or functional qualification the EM is used for ground support to flight operation. Feedback from qualification on the FM manufacturing is also taken into account.

Figure 5-4 shows an example of model philosophy for a manned transportation project, in which element level mock-ups are utilized for interface and layout optimization and human factor engineering dedicated verification. High fidelity mock-ups are used in conjunction with IM (i.e. special case of EFM) for crew training on ground.

In addition, after system functional, thermal and structural interface verification between elements, EQM and STM are used for flight simulation on ground. The FM is subjected to an orbital flight test for final in-orbit verification.

Figure 5-4: Example of Manned project model philosophy

5.2.5.3.3   Protoflight model philosophy

This approach is applied to projects whose characteristics are:

a.   no critical technology is employed in the design,

b.   qualified products are extensively used, and

c.   compromise is permitted to reduce cost by accepting a moderate level of risk.

The pure protoflight approach is based on a single model (protoflight model: see Figure 5-5) to be flown after it has been subjected to a protoflight qualification and acceptance test campaign (see ECSS-E-ST-10-03 for details).

The advantage of this approach is its lower cost. The disadvantages are

a.   increased risk,

b.   serial activity flow on the same model,

c.   mixed qualification and acceptance activities, and

d.   no integration spares.

In the event of recurring units the following is taken into account:

a. The recurring unit can be FM only if there is no modification, or if modifications are minor to the extent that no delta qualification test is necessary.

b. Otherwise the recurring unit is PFM.

Figure 5-5 shows an example of protoflight model philosophy for a project having also incorporated subsystem activities into the system responsibility, formally deleting the subsystem verification level.

In this example, EQM is utilized at equipment level for pre-qualification (whenever necessary).
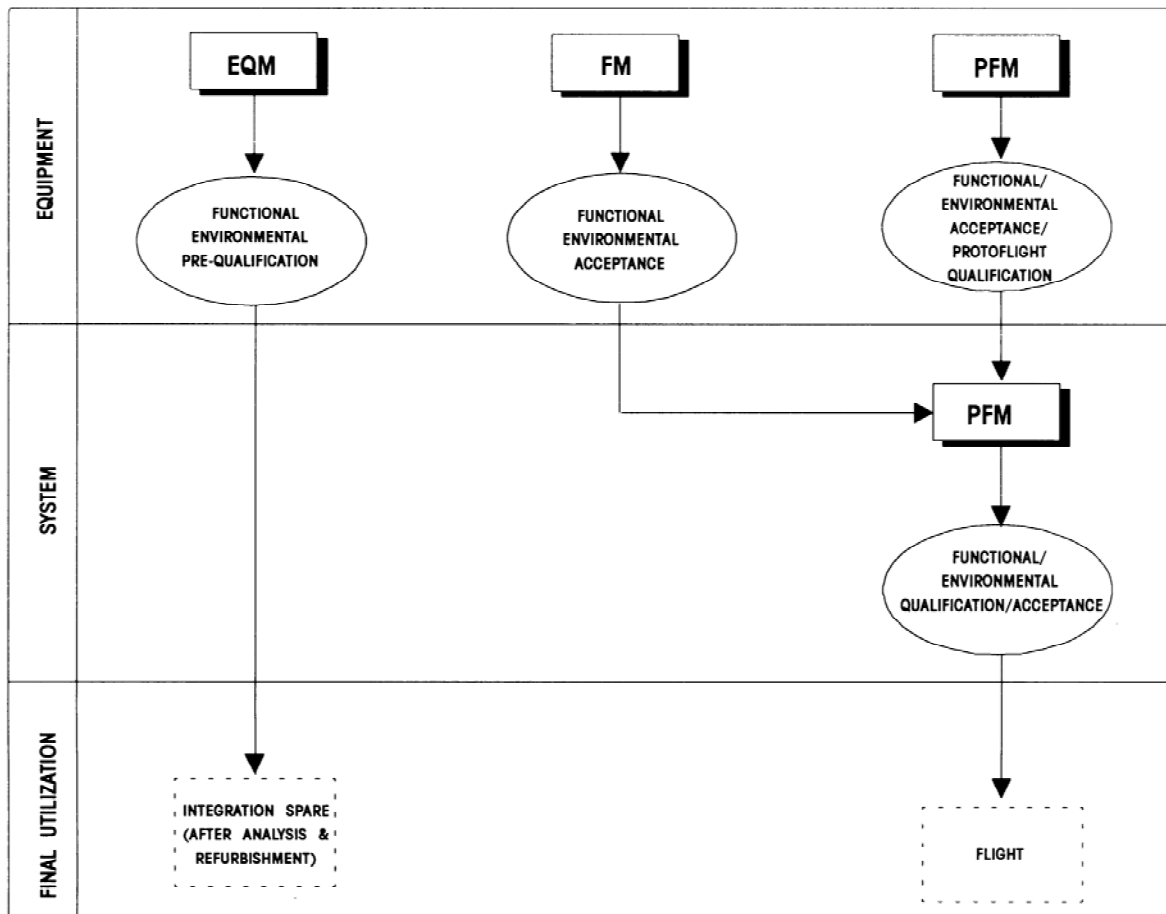
Figure 5-5: Example of Protoflight model philosophy

5.2.5.3.4 Hybrid model philosophy - Hybrid model philosophy (hardware oriented)

The hybrid philosophy is a compromise between prototype and protoflight approaches. The hybrid model philosophy is used in projects where advanced qualification activities are performed in areas of new design or in areas having a critical impact on the verification programme. The hybrid approach always results in a protoflight model be flown after a protoflight test campaign whose scope is reduced with respect to that of the pure protoflight approach (see ECSS-E-ST-10-03). Specific qualification tests in the critical areas are carried out on dedicated models (see Figure 5-6). In these areas only acceptance testing is performed on the PFM. The advantages and disadvantages of this approach lie between those of the prototype and the protoflight approaches in terms of risks, costs and schedule. It represents a good compromise; in fact this is the reason why it is often selected. In particular, in the hybrid approach it is feasible to

a. perform some parallel activities,

b.   use QM and EQM (if planned in the model philosophy) as integration spares during high level activities, and

c.   conform to the delivery dates of high reliability components and accommodate possible use of commercial components.

Figure 5-6 shows an example of hybrid model philosophy for a scientific satellite in which payload instrument verification levels similar to the spacecraft subsystem verification levels are defined. It is important to note that

a.   the decoupling of the STM activities from the EM activities enables programme flexibility and reduction of schedule risks,

b.   the protoflight approach for the instruments advances availability of the Payload EM for the satellite functional qualification test campaign,

c.   the EQM or PFM is qualified at equipment level, depending on its development status,

d.   a suitcase model and the software validation facility at satellite level can be used to verify specific interface performance, and

e.   a mock-up structure can be used for the EM configuration.

5.2.5.3.5   Hybrid model philosophy (including virtual models)

Current development in modelling and simulation techniques supports partial or total replacement of the EM by software models. This approach is already used in the engineering and design phase (see ECSS-E-TM-10-21A (System Modelling and Simulation). In this approach the system starts with a pure numerical representation in which critical components are gradually replaced by hardware product (breadboards or EMs). This configuration is often called Functional Verification Test bench (FVT) as it provides the means to perform the functional verification normally performed on an EM.

The advantage is a continuous flow from design into verification which avoids a break due to unavailable hardware. The disadvantage is that there always remains a level of uncertainty no matter how well the simulation represents the actual final product.

This approach also allows the reuse of the structure from the STM after refurbishment for the flight model, resulting in lower cost.

5.2.5.3.6   Perspectives in Model Philosophy

The choice of model philosophy is strongly influenced by the type of project. In the case of one-of-a-kind projects (typically scientific missions), the tendency is to go in the direction of a pure protoflight approach supported by virtual models (where the qualification campaign is carried-out by analysis or directly on the flight hardware). In the case of a series of satellites (e.g. constellation), a pure prototype approach is normally used where a QM undergoes a full qualification test campaign and the recurring FMs see only a limited acceptance campaign (this increases the frequency of the production).

5.2.5.4   Product matrix

On the basis of the selected model philosophy and of the qualification status of the product, a product matrix is prepared. The product is normally classified according to the product categories defined in *Table 5-1*. The type and the extent of the test programmes for each category also depend on the project model philosophy. The requirements for the test programme definition are provided in ECSS E-ST-10-03. The product matrix identifies for each product the related qualification status and the models to be used.

Table 5-1 shows an example of product matrix at satellite level.
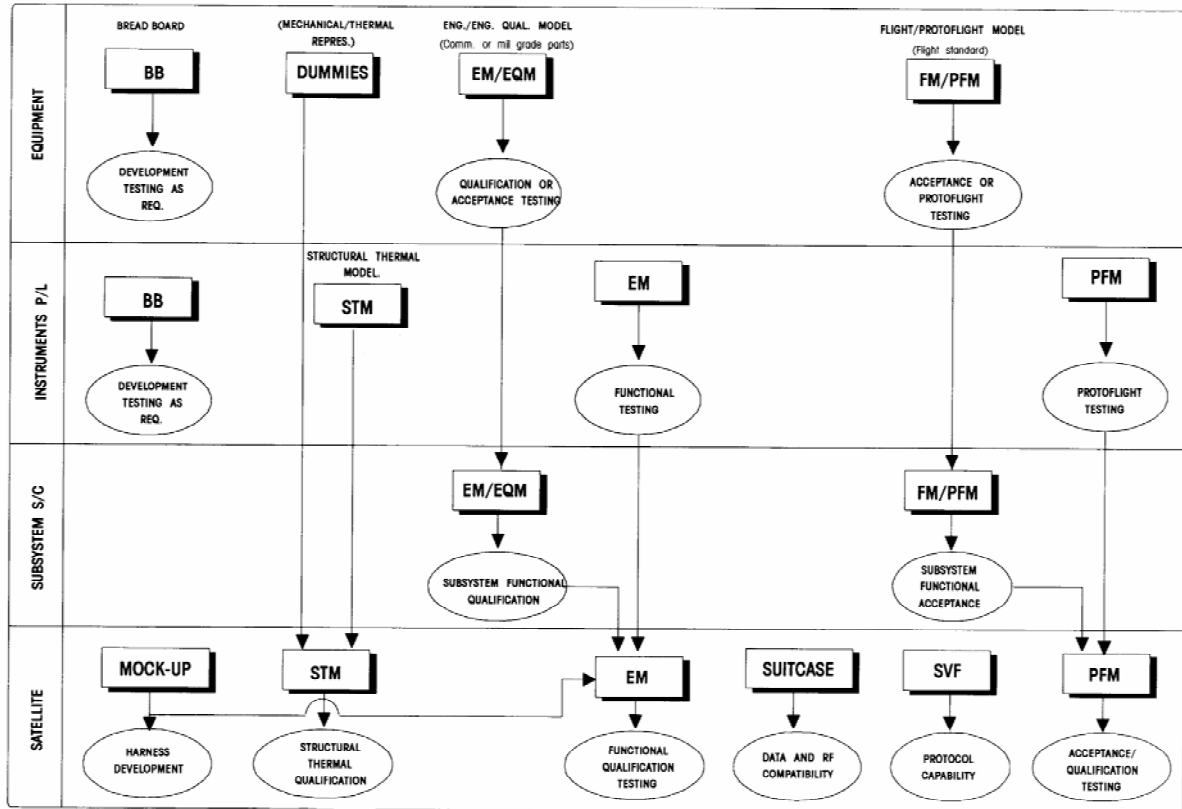
Figure 5-6: Example of Hybrid model philosophy

Table 5-3 : Example of a product matrix as viewed with a satellite perspective

No.	Subsystem/Instrument	Qual. Status	STM	EM	PFM	SP	Remarks
1	Structure	D	1		1	*	* STM Spare
2	Thermal control	D	1	*	1	1	* STM Spare
3	AOCS						
	• Coarse sun sensor	A	2*	1	2		* Dummy
	• Star tracker	A	3*	1	3		* Dummy
	• Star tracker electr.	A	3*	1	3		* Dummy
	• Gyro package	A	1*	1	1		* Dummy
	• Gyro electronic	A	4*	1	3		* Dummy
	• Reaction wheel	A	1*	1	4		* Dummy
	• Wheel drive electronic	A	1*	1	1		* Dummy
	• Actuator gyro electronic	A	1*	1	1		* Dummy
	• Flap assembly	D	2*	1	2**		* Dummy ** PFM
	• Control electronic	D	1*	1	1**		* Dummy ** PFM
4	RCS						
	• Tanks	B(A)	8*	8**	8		* Dummy ** from STM
	• Thrusters	A	12*	1	12		* Dummy
	• Thrusters bracket	D	4*	4**	4		* Dummy ** from STM
	• Latch valves	A	11*	1	11		* Dummy
	• Filter	A	1*	1	1		* Dummy
	• Flow meter	D	1*	1	1		* Dummy
	• Fill & drain valves	A	3*	1	3		* Dummy
	• Valve brackets	D	2*	2**	2		* Dummy ** from STM
	• Pressure transducers	A	3*	1	3		* Dummy
	• Pipework	D	1*	1**	1		* Dummy ** from STM
5	Power						
	• Power control unit	C	1*	1**	1		* Dummy ** EQM
	• Battery regulator unit	A	1*	1	1		* Dummy
	• Battery mgt unit	A	1*	1	1		* Dummy
	• Pyro drive unit	C	1*	1**	1		* Dummy ** EQM
	• Power distribution unit	D	1*	1	1**		* Dummy ** PFM
	• Battery	A	2*	2	2		* Dummy
6	OBDH						
	• Central terminal unit	A	1*	1	1		* Dummy
	• Common pulsed distr. unit	A	1*	1	1		* Dummy
	• Digital bus unit	A	4*	4	4		* Dummy
	• Intelligent control unit	C(D)	2*	2**	2**		* Dummy ** EQM
	• Mass memory unit	D(C)	1*	1	1		* Dummy ** PFM
	• Remote bus interface	A	2*	2	2		* Dummy
7	Solar array						
	• Deployable panel	D	2*	1	2		* Dummy
	• Yokes	D	1*	1**	2		* Dummy ** from STM
	• Mid-panel body	D	3*	1	1		* Dummy
8	TT&C						
	• Transponder	C	2*	1**	2		* Dummy
	• RF distribution unit	A	1*	1	1		* Dummy
	• Antenna	D	3*	1	3**		* Dummy ** 1PFM ** 2EQM
9	Harness	D	1	1	1		
10	Gradio instrument	D	1*	1	1**		* Dummy ** PFM
11	GPS		1*	1	1**		* Dummy ** PFM
12	Boom	D	1*	1**	1		* Dummy ** from STM
13	Magnetometer		1*	1	1**		* Dummy ** PFM

5.2.6 Verification tools

5.2.6.1 General

ECSS-E-ST-10-02C clause 5.2.6.1 specifies that:

> a. *Tools to be used to support the implementation of the verification process shall be identified.*
>
> b. *All verification tools shall be verified for their intended use.*
>
> c. *The degree of verification applied to tools used to support the verification programme shall be established.*
>
> > Note: *This requirement does not imply that formal verification is performed for all verification tools (e.g. tools of common use).*
>
> d. *Formal verification procedures shall be established and applied to tools which are specified as deliverable items.*

Verification tools include Ground Support Equipment, simulators, virtual models, test benches, analytical tools, test facilities, communication tool as required for the scope of ECSS-E-ST-50 standards (e.g. suitcase, NDIU), clamp band, TM recorder, RF recorder, tools to support SVT, tools to exchange data between satellite and Mission control centre before launch (e.g. NDIU), database, TM/TC list, satellite simulator and in orbit/commissioning tools. The standard and the handbook cannot address the details of all of them individually but gives high level requirements applicable to a class of tools.

Since verification results strictly depend on the quality of these tools, special attention is paid to their design and verification.

The compatibility between system and lower level verification tools should be ensured to enable system activities to be built upon the next lower level activities (e.g. re-use of test procedures).

5.2.6.2 Ground Support Equipment (GSE)

ECSS-E-ST-10-02C clause 5.2.6.2 specifies that:

> a. *All Ground Support Equipment (GSE) shall be verified under expected environmental conditions and operational constraints.*
>
> b. *The compatibility of the interfaces of the Ground Support Equipment (GSE) with flight products and facilities shall be verified by test.*
>
> c. *The prevention of damage on the flight product due to Ground Support Equipment (GSE) failure shall be verified.*
>
> > Note: *For hazards to personnel, flight hardware, facilities and environments related to GSE, see ECSS-Q-ST-40.*
>
> d. *Ground Support Equipment (GSE) that is modified or used in a new application shall be re-verified or re-validated.*

Space segment Ground Support Equipment (GSE) are used to support assembly, integration, test, handling, transport, storage, launch campaign and post-flight activities. GSE that connects to space equipment follows the same interfacing standards as the flight equipment and has adequate protection to prevent damage to the space equipment (mechanically and electrically). In particular mating and de-mating of physical connections is closely monitored.

GSE is also built to comply with safety standards imposed by the countries in which it will be used. GSE is validated for use on FM spacecraft through use of simulators and earlier models of the space element.

Any equipment part of the operational Ground Segment interfacing physically with a flight product (e.g. during a pre-launch compatibility test) has to follow the requirements on GSE as well.

5.2.6.3 Software validation facility (SVF)

ECSS-E-ST-10-02C clause 5.2.6.3 specifies that:

> a. *The SVF shall be verified by comparing the performance of the simulation models with the specified performance of the product or environment to be simulated.*
>
> b. *Any flight hardware or software product simulated by the SVF shall be finally verified against the measured performance of the actual flight product.*

The Software Validation Facility (SVF) is one of the test benches capable to support all phases of onboard software test and validation including:

a. modelling of the software operating environment (including the capability for margins and error injection),

b. verification of the onboard software in operational conditions, using non-intrusive methods, debugging and trouble-shooting of onboard software The SVF is used prior to the integration of the software into the target hardware during the software development activity, as a tool to support independent software validation and to support software maintenance (e.g. during in-orbit stage).

5.2.6.4 Simulators

ECSS-E-ST-10-02C clause 5.2.6.4 specifies that:

> a. *Simulators shall be validated to demonstrate that the simulator characteristics are representative of the simulated product to the extent required for the verification to be supported.*

Simulators are used at all levels to simulate products, functions, environments or interfaces in absence of the real hardware and software during integration and test activities. Simulators of physical characteristics (e.g. 3-D digital mock-ups) are used to support integration activities in terms of accessibility demonstration, handling, interfaces with launcher, GSE and facilities etc. Simulators of functional characteristics (e.g. virtual functional models) are used to support verification activities in terms of simulating missing equipment, test procedure validation, support equipment interfaces, etc.

Simulators are also used whenever the actual system constituents are not available. Example of simulators and their uses can be:

— I/F simulators: structural interface devices, integration testing.

— Environmental simulators: environmental testing, operational scenario validation (e.g. solar chambers, water submersion model).

— System (full or partial e.g. satellite) simulators: operational scenario validation, procedure verification, operations training, mission simulations, joint integrated simulations.

Depending on the individual mission and purpose, model fidelity can range from mock-up to simple front-end fidelity or to flight representative.

5.2.6.5 Software tools for verification by analysis

ECSS-E-ST-10-02C clause 5.2.6.5 specifies that:

> a. *Suitability of previously validated analytical software tools shall be assessed for the intended application.*
>
> b. *Non-validated analytical software tools shall be subjected to a validation process prior to their use.*

Software tools are utilized to carry out the analytical verification in domain such as thermal, mechanical, fluid dynamics, optical, EMC, flight dynamics and link budget. The use of existing and validated tools is the preferred approach.

5.2.6.6   Integration & test facilities and test tools

ECSS-E-ST-10-02C clause 5.2.6.6 specifies that:

a.   *The capability of the integration and test facilities and test tools to perform their intended function in terms of performance and calibration shall be verified as part of the overall integration and test process.*

   Note: See ECSS-Q-ST-20-07 for test facilities.

Integration and test facilities and test tools are used to support the integration and test programme of the space and ground segment, as well as at system level.

5.2.7   Verification process phasing

5.2.7.1   General

ECSS-E-ST-10-02C clause 5.2.7 specifies that:

a.   *The verification process shall be phased with the project life cycle, in accordance with ECSS-M-ST-10*

b.   *Verification planning to assess feasibility and support programmatics shall start in the early phases (e.g. during phase A).*

c.   *The preliminary verification planning shall cover all products and requirements by the end of phase B.*

d.   *Verification planning shall be completed by the end of Phase C.*

   Note: Covering all verification stages e.g. pre-launch, in-orbit (including commissioning) and post landing.

e.   *Verification execution and reporting shall be incrementally carried out through the project life cycle starting from phase C.*

f.   *Verification control shall start with the initial issue of the verification control document (VCD) during phase B.*

g.   *Verification close out status shall be assessed and approved by the customer for each product at the end of each stage.*

   Note: E.g. qualification close out status at the end of the qualification stage during the Qualification Review (QR).

On the basis of the logic of the verification process, a verification planning that synchronizes the verification activities with the project milestones and programmatic constraints is established and agreed with the customer.

Figure 5-7 shows an example of the verification process with its output in relation to the project phases and milestones.
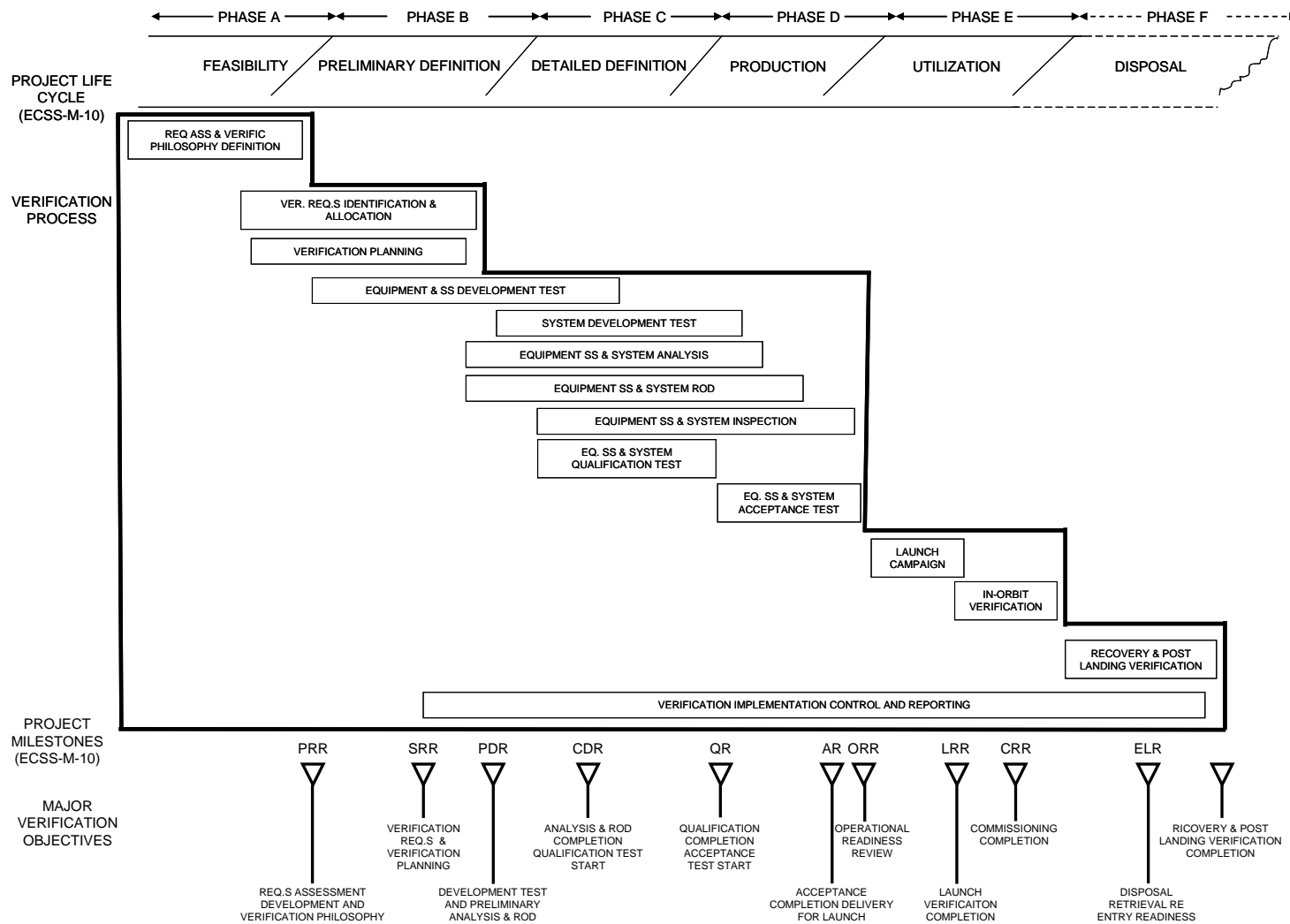
Figure 5-7: Example of verification process phasing with the project life cycle

5.2.7.2   Phase A

During the feasibility phase (Phase A) the verification activities are focused on the assessment of the general project requirements and on the definition of the development and verification approach, including the model philosophy and the associated product matrix.

The results are discussed at the Preliminary Requirement Review (PRR) in order to assess the feasibility of the development and verification programme.

The verification personnel should be involved in order to follow a concurrent engineering approach which avoids separation between design and verification.

5.2.7.3   Phase B

During the preliminary definition phase (Phase B) in parallel with the system definition and design, particular effort is spent in supporting the requirements generation and allocation in order to have a consistent set of verifiable and traceable requirements at all levels. This work includes the preparation of verification matrices that form the basis of subsequent verification planning and control. In particular, the environmental requirements are used as an input to generate the project test requirement specification applicable to the different verification levels.

The applicable requirements may be grouped in categories and, for each (group of) requirements, a verification strategy is generated based on the detailed verification methods, levels and stages, and the coherence of the overall verification approach is checked. These strategies support the identification of the verification tasks (in terms of objectives, characteristics, success criteria and supporting tools), that form the core of the assembly integration and verification plan. The same strategies are inputs for lower level planning. The verification approach is also included as fundamental part of the System Engineering Plan (SEP).

Usually, in Phase B, lower level activities are also initiated. In particular some C/D development tests are anticipated for critical items. In addition, it is a good practice to prepare the verification control documents at the different levels, in order to arrive to a more reliable phase C/D programmatic assessment. The output of phase B, in particular verification requirements and planning, are discussed at the System Requirement Review (SRR) and at the Preliminary Design Review (PDR) in order to freeze system design and implementation concepts.

5.2.7.4   Phase C

With the start of the detailed definition phase (Phase C) the detailed design is initiated, so particular attention is paid to accessibility, testability, handling and transport in order that integration can be performed in the most effective way and that the GSE design can be optimized. In this phase, development tests are carried out.

Preliminary verification by analysis and review-of-design are executed at lower levels and the results discussed at the relevant Preliminary Design Review (PDR). During the same phase the equipment manufacturing starts on the basis of the frozen design.

Verification by inspection activities start during the lower level manufacturing process. The activities related to the procurement of the planned verification tools are also initiated and their availability assured for the relevant activities.

The integration activities on the system models (e.g. STM and EM) start in accordance with the relevant integration & test specifications and procedures.

The system monitoring and control of lower level verification activities is continued in parallel and results are fed to the verification data base.

The phase C is normally terminated with the critical design review (CDR) where analysis and review-of-design activities are completed and qualification tests are terminated at lower levels and initiated at higher level. Usually the CDR authorizes the flight unit manufacturing (i.e. the start of the next phase).

5.2.7.5   Phase D

The production phase (Phase D) completes the qualification and acceptance activities from the lowest to the highest levels. In particular integration and test are carried out and controlled through the relevant reviews and the corresponding verification reports are prepared.

The verification close-out is documented through the Verification Control Documents (VCD), frozen by the Verification Control Boards (VCB). They are presented at the Qualification Review (QR) and Acceptance Review (AR) which declare the completion respectively of the qualification and acceptance activities. For a multi-mission project, a multi-mission qualification review is often additionally identified.

The part of the Verification Plan (VP) dealing with in-orbit verification (and in particular the commissioning) is refined and reviewed at the ORR.

5.2.7.6   Phase E

The utilization phase (Phase E) includes launch campaign and commissioning in-orbit verification. The evaluation of the verification results of the pre-launch campaign is addressed at the Launch Readiness Review (LRR), while the evaluation of the verification results of the LEOP and early in-orbit stage are addressed at the Commissioning Result Review (CRR).

Additional reviews may be necessary when in-orbit verification includes delayed activities associated to events of particular mission (e.g. interplanetary mission).

The verification close-out is documented through the verification control documents (VCD), frozen by the verification control boards (VCB).

5.2.7.7   Phase F

During the disposal phase (Phase F), the re-entry and re-orbiting activities are authorized with an End-of-Life Review (ELR) and the recovery and post landing verification are evaluated during a dedicated review.

5.2.7.8   Verification flow

A detailed flow of the verification activities is shown in Figure 5-8, Figure 5-9 and Figure 5-10.

.
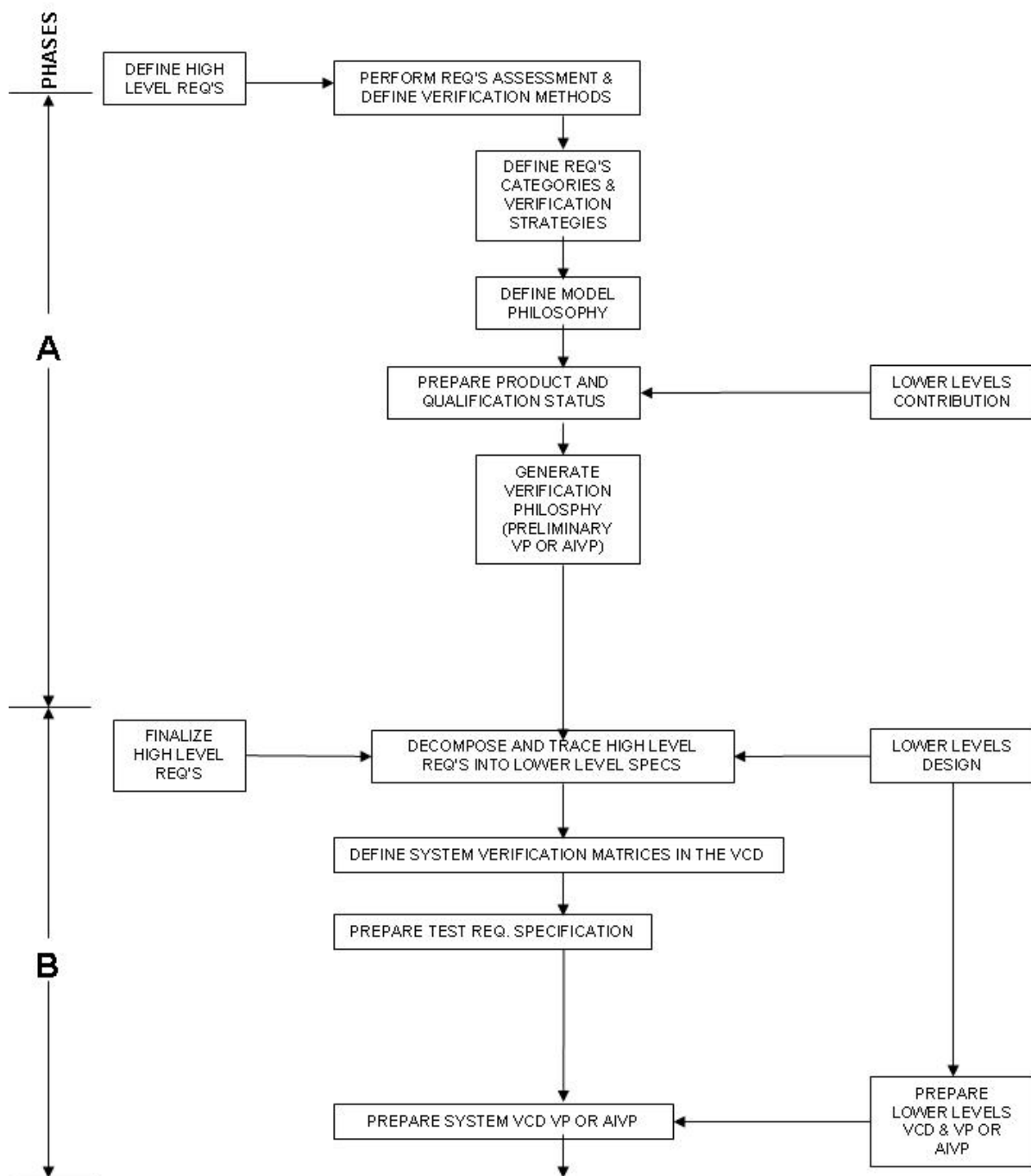
Figure 5-8: Verification activities flow (Phases A/B)
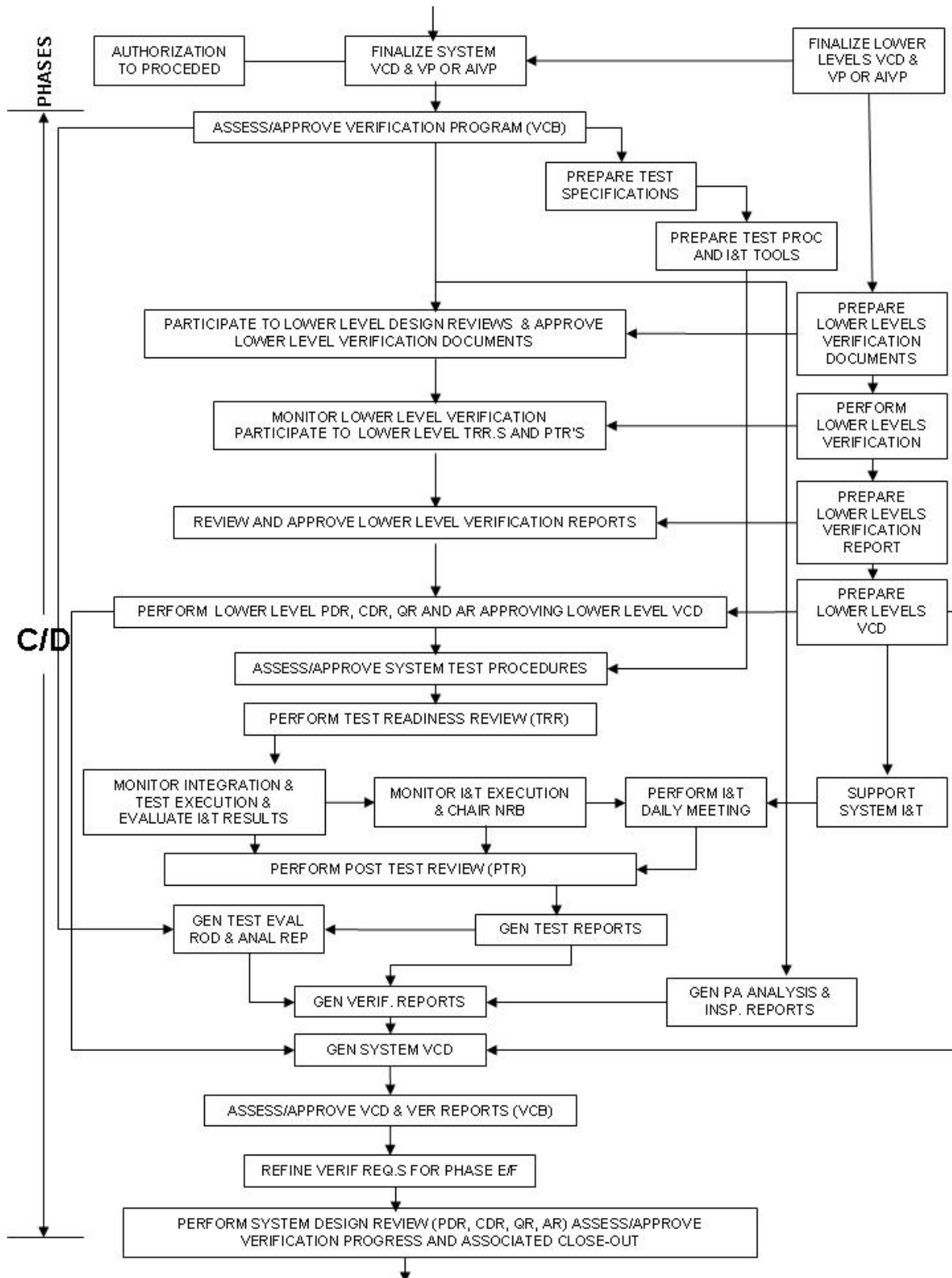
Figure 5-9: Verification activities flow (Phases C/D)
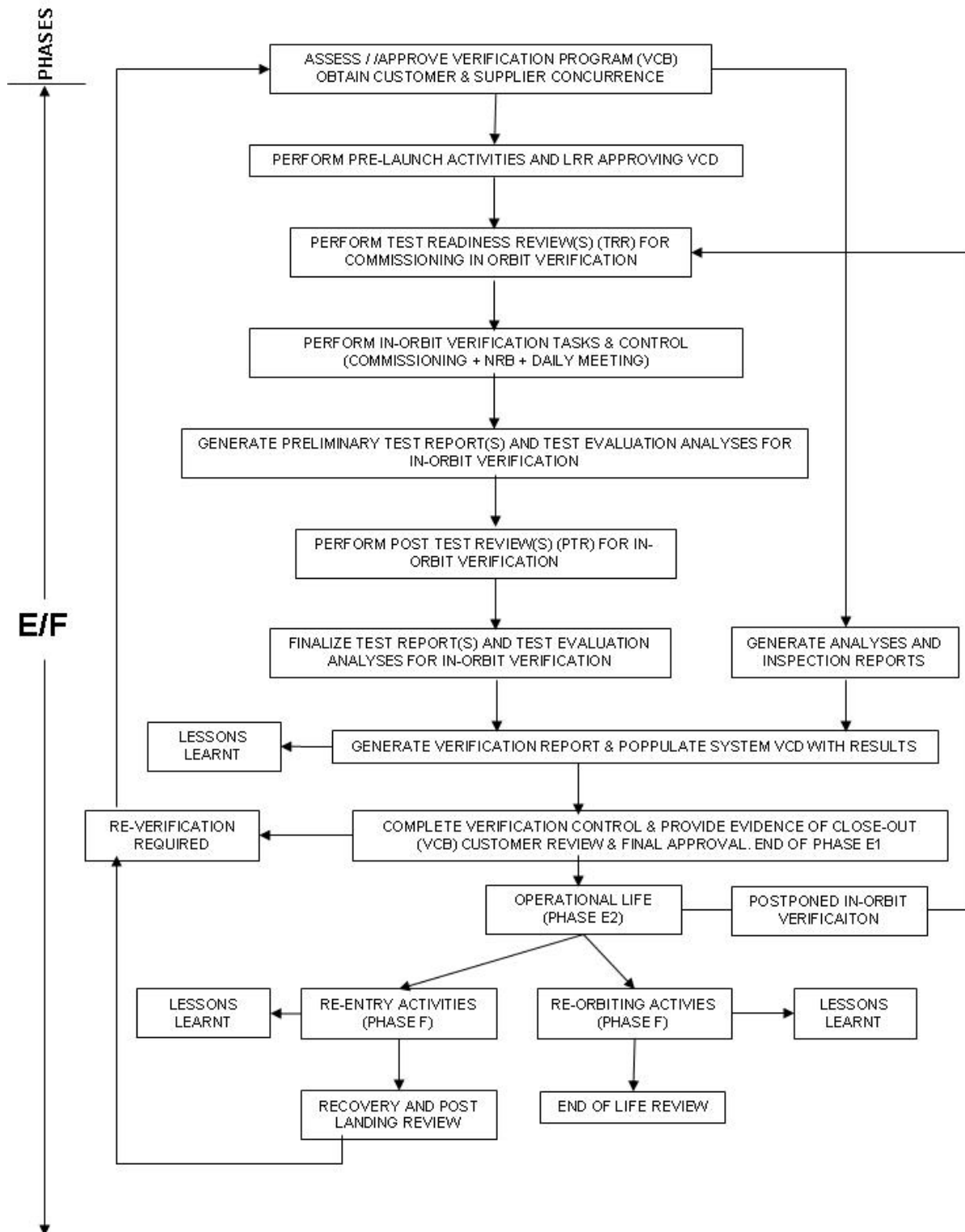
Figure 5-10: Verification activities flow (Phases E/F)

5.3 Verification execution and reporting

5.3.1 General

ECSS-E-ST-10-02C clause 5.3.1 specifies that:

> *a. The supplier shall assign clear responsibility for the implementation of the verification programme.*
>
> *b. The requirements for the test preparation and execution including Test Readiness Review (TRR) and Post Test Review (PTR) shall be as per ECSS-E-ST-10-03*
>
> *c. When nonconformity is detected during the verification process, a Nonconformance Report (NCR), in conformance with Annex A of ECSS-Q-ST-10-09, shall be raised and processed according to ECSS-Q-ST-20*
>
> *d. The verification results shall be recorded by the supplier in reports for review by the Verification Control Board (VCB) through the VCD.*

The verification process activities are incrementally performed at different levels and in different stages applying a coherent bottom-up strategy and utilizing a suitable combination of different verification methods. In particular the verification by test is carried-out on different physical models in agreement with the selected model philosophy. When doing this, the following should be kept in mind:

a. The Non-conformance review board (NRB) evaluates the impacts on the verification programme.

b. A failure questionnaire should be used to collect statistical information for entry into a database containing verification lessons learnt as a result of verification activities.

The verification control board (VCB) is defined in clause 5.4.2.

An example of verification team responsibilities is given in clause 5.3.2.

The verification process execution & reporting ensures:

a. traceability of all requirements to the verification process elements (methods, levels, stages, documentation, close-out, etc.),

b. visibility of coherence between products and levels,

c. monitoring of the verification process throughout the project life cycle,

d. identification of impacts at the various levels in case of change of requirements or criticality's during lower level verification, and

e. integration into the higher level of the lower level verification data.

5.3.2 Example of verification team responsibility and interfaces

5.3.2.1 Verification team responsibility

The verification team, irrespective of the specific company organization (i.e. the fact that its duties are performed by one or more groups in the company) is responsible for:

a. verification management and interfaces with the customer for verification aspects;

b. contribution to project reviews;

c. requirement allocation and traceability support;

d.   the preparation of the VCD in term of methods, levels and stages definition;

e.   the preparation of the verification philosophy and VP (or the verification part of the AIV plan);

f.   the review/approval of the AIT Plan (or the AIT part of the AIV Plan)

g.   VCD population and verification data base management;

h.   providing the chairman for the verification control board;

i.   the monitoring of lower level verification documentation;

j.   participation in lower design and test reviews;

k.   the review and approval of lower verification documentation;

l.   the preparation of test specifications and the review/approval of the Test Procedure;

m.   the preparation of the review-of-design, analysis and inspection procedures;

n.   providing the chairman for the test review boards (TRR and PTR);

o.   evaluating the integration and test execution and participation in the non-conformance review board (NRB);

p.   the review/approval of test, analysis, inspection and Review-of-design reports

q.   the preparation of the verification reports;

5.3.2.2   Relationship with specific engineering disciplines

Coordination and coherence of the contribution of specific engineering disciplines to the verification process is assured by the verification team. In particular the following from the specific engineering disciplines is normally envisaged:

a.   support to ensure that the requirements are verifiable;

b.   ensure high level requirements decomposition, when necessary, to have individually measurable parameters;

c.   support in the preparation of the VCD in term of methods, levels and stages definition;

d.   embedding the verification approach inside the technical specification;

e.   support to verification control board (VCB);

f.   support in test specifications preparation;

g.   participation in lower level verification monitoring;

h.   review and approval of test procedures;

i.   participation in reviews;

j.   monitoring of system integration and test execution in order to evaluate test results;

k.   execution of analysis and review-of-design, and preparation of the relevant reports;

l.   support in phase E/F verification requirements generation.

5.3.2.3   Relationship with product assurance and quality control

The verification team works in cooperation with the product assurance and quality control team. In particular the following support from the product assurance and quality control is normally envisaged:

a.   support in the preparation of the VCD in term of methods, levels and stages definition;

b.   participation in lower level verification monitoring;

c.   participation in reviews;

d.   monitoring of integration and test execution and chairing of NRB;

e.   execution of analysis and inspection, and preparation of the relevant reports;

f.   monitoring of phase E/F operations.

5.3.2.4   Relationship with project management and product/quality assurance

The verification team works in cooperation with the project management and product/quality assurance teams. In particular the following support is normally envisaged:

a.   support in verification planning and model philosophy;

b.   support in monitoring and control of resources and schedule;

c.   support in management of changes;

d.   preparation of test configuration list;

e.   participation in lower level verification monitoring;

f.   participation in reviews.

5.4   Verification control and close-out

5.4.1   General

ECSS-E-ST-10-02C clause 5.4.1 specifies that:

> a.   *The implementation of the verification process shall be controlled by the Verification Control Board (VCB).*
>
> b.   *The verification process control shall be supported by a computer based verification database.*
>
> c.   *The verification database shall be delivered to the customer in an electronic form to be agreed with the customer.*
>
> d.   *The supplier shall provide to the customer verification evidence for the customer's applicable requirements agreed to be verified, independently from the level where verification has been accomplished.*

The verification control board (VCB) is defined in clause 5.4.2. The verification process is controlled in its execution and declared completed by the Verification Control Board (VCB) when, based on objective evidence, the product is verified against the identified requirements and the associated verification objectives fully reached.

The use of a computer based database enables immediate and flexible reporting of data in support of the verification documentation, avoidance of repetitive jobs and minimization of errors. It should support the whole verification process and thus contain for the requirements to be verified at least all the information to be published in the VCD. It should also allow exchanging or sharing these data between customer and supplier. The content and format as deliverable is specified and agreed with the customer.

The implementation of the verification programme is controlled and monitored following:

a.   A day-by-day verification control approach oriented to identify potential problems, to reduce the risk of cost increase and schedule slippage.

b.   Formal control and review boards (TRR, PTR and VCB).

In order for the VCD to be reviewed at customer level, it is necessary to have adequate synthesis of the verification close-out status as stated in the DRD.

5.4.2   Verification control board (VCB)

ECSS-E-ST-10-02C clause 5.4.2 specifies that:

a.   *A Verification Control Board (VCB), with participation of customer and supplier representatives, shall be established to incrementally assess the achievements and the status of the verification process.*

   Note: The VCB is set-up in relation to the complexity and the extents of the verification activities.

b.   *The verification process shall be considered completed when the Verification Control Board (VCB) confirms that:*

1.   *documented evidence is recorded in the VCD,*

2.   *identified requirements have been verified*

3.   *associated product verification objectives are reached*

c.   *The conclusions of the VCB shall be submitted for approval to the customer's contractual authority.*

d.   *The Verification Control Board (VCB) shall assess the verification status with a periodicity agreed with the customer, along the project life cycle.*

   Note: The results of the VCB are at least presented on the occasions of project reviews as defined in ECSS-M-ST-10.

e.   *The Verification Control Board (VCB) shall endorse the final issue of the Verification Control Document (VCD).*

The VCB meets, along the project life cycle, with a periodicity agreed between customer and supplier as soon as the evidence, of the verification close-out, is available (as a minimum in the occasions of the project reviews). In these meetings the supplier shows the verification status evidence and asks for the concurrence of the customer.

Other members of the VCB are not specified in the standard, but should include relevant experts from the supplier and customer and QA representatives.

5.4.3   Re-verification

ECSS-E-ST-10-02C clause 5.4.3 specifies that:

a.   *The extent of the re-verification to be performed shall be determined by Supplier and agreed with the customer, in the following cases:*

1.   *failure and repair as decided by Non-conformance Review Board (NRB);*

2.   *unplanned disassembly or demating;*

3.   *refurbishment, maintenance or design changes;*

4.   *changes of requirements after initial verification;*

5.   *long duration storage;*

6.   *flight use of qualification hardware.*

b.   *The Verification Control Document (VCD) shall be updated by the supplier to record as open, those requirements subject to re-verification until this is performed and closeout agreed by the customer.*

The planned verification process may change due to any of the events listed above. In these circumstances the need for re-verification is considered and agreed between supplier and customer. The new verification planning is reflected in a new version of the VCD.

6
Verification documentation

6.1 Introduction

The verification process and its implementation activities are documented by means of a specific set of verification documents:

a. Verification plan (VP), see clause 6.2

b. Assembly, integration and test plan (AITP), see clause 6.2.3.1 and ECSS E-ST-10-03

c. Verification control document (VCD), see clause 6.2.2

d. Test specification (TSPE), see clause 6.3.7.1 and ECSS E-ST-10-03

e. Test procedure (TPRO), see clause 6.3.7.2 and ECSS E-ST-10-03

f. Test report (TRPT), see clause 6.3.1 and ECSS-E-ST-10-03

g. Analysis report (ARPT), see clause 6.3.2 and ECSS-E-ST-10

h. Review of design report (RRPT), see clause 6.3.3

i. Inspection report (IRPT), see clause 6.3.4

j. Verification report (VRPT), see clause 6.3.5

The list above is a compromise between minimizing documentation effort to meet cost constraints and the requirement to properly trace the verification events, which is fundamental in order to reduce risks and to facilitate recovery actions in case of problems. The verification process documentation is summarized in Figure 6-1.

The Verification Matrix is no longer considered a separate document (see clause 6.2.2).

A certain level of documentation tailoring may be utilized to reduce the costs, on the basis of the specific circumstances agreed between customer and supplier. For example:

a. The Verification Plan and the AIT Plan can be combined in a single document called Assembly Integration and Verification Plan (AIV Plan), maintaining the entire set of unique information of the two documents.

b. The Verification Plan and AIT Plan can be reduced to a single Test Plan (e.g. at equipment level, when the verification is mainly by test).

c. The AIT plan can include the Test Specifications (e.g. in the case of a product without the need of complex tests).

d. The Test Specification can include the Test Procedures (e.g. when the procedure is simple).

e. The VCD can include the information of the Verification Reports (e.g. for the case of single verification method).
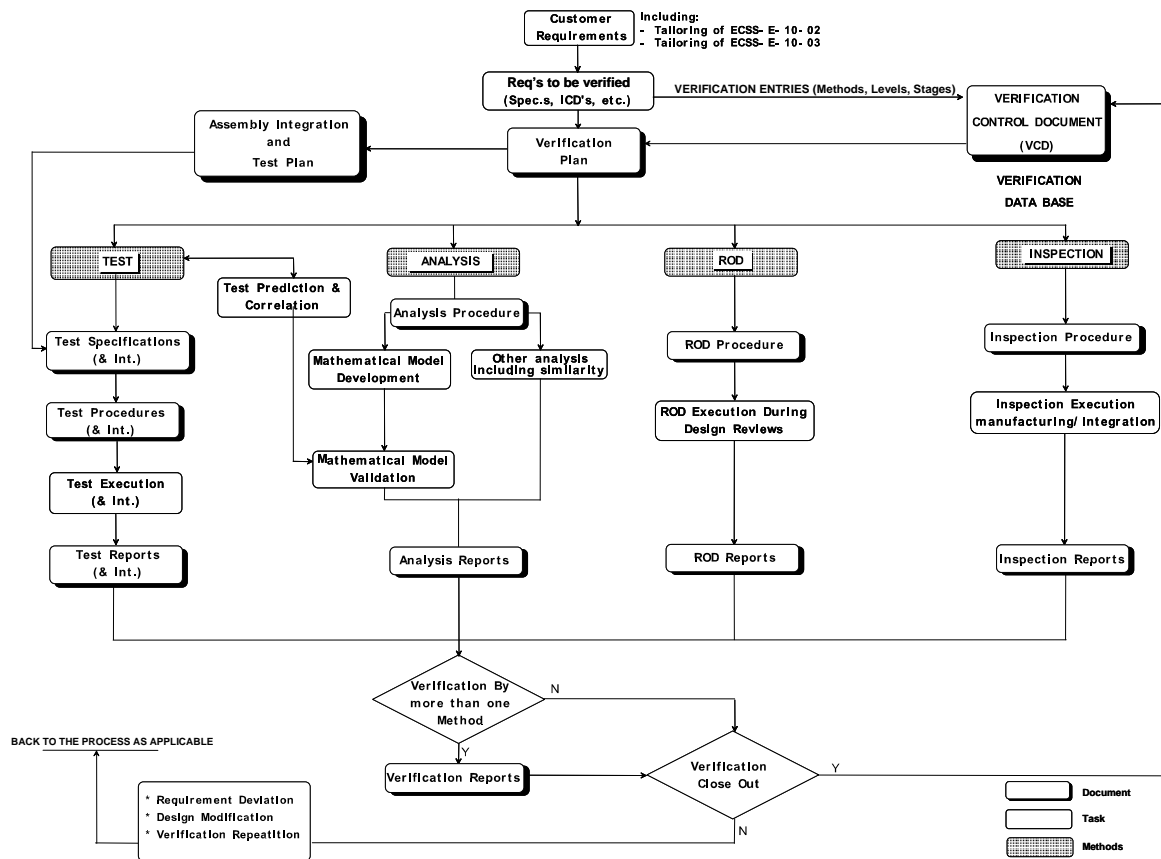
The arrows represent the logical connection between documents and major tasks, and not the complete process flow.

Figure 6-1: Verification documentation

Taking as an example a system thermal requirement to be verified with a thermal balance test and the associated analysis in the qualification stage, the following documentation steps take place:

a. The requirement is identified in the relevant system specification together with its verification entries (i.e. "T" and "A" methods at "System" level in "Qualification" stage) before being documented in the VCD.

b. The system VP and AITP Plans define the relevant verification events and associated flows (i.e. thermal balance test and thermal analysis), outlining them in the dedicated activity sheets.

c. The specific test requirements, which take into account project general test requirements contained in the test requirement specification (i.e. tailoring of the ECSS-E-ST-10-03), are subsequently detailed in a thermal balance test specification which is followed by test procedures with the relevant step-by-step instructions.

d. The test results are summarized in the dedicated test report.

e. In parallel the required analysis is carried out in relation to the test activities (i.e. test prediction/correlation) and the results presented in the relevant analysis report (including the flight predictions).

f. The synthesis of the performed verification activities (test plus analysis) is described in the verification report.

g. The system verification control document progressively records the status of the verification implementation and finally gives the evidence of the requirement verification close-out.

6.2   Verification planning documents

6.2.1   Verification plan (VP)

6.2.1.1   General

ECSS-E-ST-10-02C clause 5.2.8.1 specifies that:

> a.   *The supplier shall provide a Verification plan (VP) for the reviews as agreed with the customer*
>
> > *Note: Guidelines are in Annex G.*
>
> b.   *The contents of the Verification plan (VP) shall be in conformance with the DRD in Annex A.*
>
> > NOTE   The quoted annexes above refer to the standard.

The VP is the master plan for the project verification process and serves to demonstrate how the requirements are verified by a coherent implementation approach.

It is created on the basis of the specification of the product to be verified and its associated initial VCD (see clause 6.2.2), taking into account the development philosophy, the applicable standards, the programmatic constraints and the availability of tools and facilities. The level of detail varies with the type of product and in relation to the actual phase of the project.

It is the starting point for the AIT Plan (see ECSS-E-ST-10-03) containing the test programme whilst the Analysis, Review of Design and Inspection programmes are usually directly contained in the VP.

The VP is issued for the different project reviews starting with preliminary versions at PRR/SRR in order to explain the verification approach and support programmatic evaluation. The content will be phased, as shown in annex A, in order to meet the project review objectives.

For each section of the DRD provided in ECSS-E-ST-10-02C Annex A, the requirements are recalled at the beginning of the section in italics. It is then followed by guidance whenever considered relevant.

6.2.1.2   VP DRD explanation

6.2.1.2.1   Introduction

> a.   *The VP shall contain a description of the purpose, objective, content and the reason prompting its preparation.*
>
> b.   *Open issues, assumption and constraint relevant to this document shall be stated and described.*

6.2.1.2.2   Applicable and reference documents

> a.   *The VP shall list the applicable and reference documents in support to the generation of the document.*

The applicable documents are normally the product specification, the related standards (e.g. ECSS-E-ST-10-02 and ECSS-E-ST-10-03) and any other documents cross-referenced in the text to the extent indicated in the text.

The reference documents provide additional information to the authors and readers (e.g. this handbook).

The document to be produced are addressed in clause 6.2.1.2.11.

6.2.1.2.3   Definitions and abbreviations

a.   The VP shall list the applicable dictionary or glossary and the meaning of specific terms or abbreviations utilized in the document.

6.2.1.2.4   Verification subject

a.   The VP shall briefly describe the subject of the verification process.

The product to be verified is identified and briefly described to allow understanding its role, main functions and breakdown.

6.2.1.2.5   Verification approach

a.   The VP shall describe the basic verification concepts and definitions (methods, levels and stages).

Defining methods, level and stages is a fundamental step of preparing the verification plan. The selectable methods are defined in the standard, whilst the level and stages can be tailored for the specific application.

6.2.1.2.6   Model philosophy

a.   The VP shall describe the selected models and the associated model philosophy, product matrix.

See clause 5.2.5 above.

6.2.1.2.7   Verification strategy

a.   The VP shall describe the selected combination of the different verification methods at the applicable verification levels and stages, in general and for each requirement type/group (including software).

b.   The allocation of the requirements to the specific verification tasks shall be given.

These strategies may be summarized in dedicated tables (see Figure 6-2 and Figure 6-3).

Figure 6-2 shows an example of the summary table for each requirement group at the selected levels.

Figure 6-3 shows an example of the verification strategy for one single requirement group (Data Management) including levels/steps and specific models/events.

Requirement category	S/C level	Module level	Equipment level
Configuration			
Launcher interfaces	I	I, T	R, I
Ground segment interfaces	R, A, T	R, A	R, T
Payload interfaces & perfor.	R, A, I, T	R, A, I, T	N/A
Configuration/physical prop.	R, A, I	R, A, I, T	R, T, A, I
Light tightness	I, R	I, R, T	I, R
Data Manag.			
Data handling	T, A	T, A	R, T, A, I
S/W functions	T, A, R	T, A	R, T, A, I
Mechanical			
Venting	A	A	R
Mechanical	T, A	T, A	T, A
Mechanisms & pyro	T, A	T, A	A, I, T, R
Radiation protection	A	A	A
GNC			
Attitude and orbit control	T, A	T, A	T, A
Propulsion			
Reaction control	T, A	T, A	T, A
Communication			
Radio Frequency	T, A	T, A	T, A
Thermal			
Thermal	T, A	T, A	T, A

Legend:
T = Test, A = Analysis, I = Inspection, R = Review of Design

Figure 6-2: Example of Verification Strategies per Group/level

Figure 6-3: Example of verification strategy for a single Requirement Group

6.2.1.2.8   Verification programme

a.   *The VP shall document the verification activities and associated planning in the applicable verification stages.*

b.   *Analysis, review-of-design, inspection and test programmes should be detailed through dedicated activity sheets, or through reference to the AIT Plan.*

Figure 6-4 shows examples of the overall verification planning.

Figure 6-5 and Figure 6-6 show examples of activity sheets.

	1st YEAR				2nd YEAR				3rd YEAR				4th YEAR				5th YEAR			
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
PROJECT PHASES																				
●PHASE B																				
●ADVANCED C/D																				
●PHASE C/D																				
●PHASE E/F																				
MAJOR REVIEWS																				
●SRR			SRR		SVM/PLM/PDR'S															
●PDR			SPDR						EQUIPMENT CDR'S				SVM/PLM/CDR's							
●CDR'S					EQUIPMENT FDR'S								SCDR							
●QR																SDR				
●FAR																	SFAR			
●LRR																	SLRR			
PAYLOAD INSTRUMENTS AVAILABILITY																				
●STM																				
●EQM																				
●PRM																				
STM ACTIVITIES																				
●EQT.DESIGN/PROC./MFG/TEST																				
●MODULES A/T																				
●SYSTEM A/T																				
EQM ACTIVITIES																				
●EQT.DESIGN/PROC./MFG/TEST																				
●MODULES A/T																				
●SYSTEM A/T																				
PFM ACTIVITIES																				
●EAT.DESIGN/PROC./MFG/TEST																				
●MODULES A/T																				
●SYSTEM A/T																				
●LAUNCH CAMP.																				

Figure 6-4: Example of verification planning

AS-H100A   EVA WORKSITE ANALYSIS

OBJECTIVE

The aim of the analysis is to study the work site layout for EVA in COLUMBUS.

REQUIREMENTS TO BE VERIFIED

It is linked to the requirements:

3.7.2.1.1 CENTERING   [EQ/A]

Integrated external payload crew mobility aids or grasp points shall be designed to accommodate the 50th percentile American female to 95th percentile American male anthropometric measurements.

3.7.2.1.1.1   Crew Mobility Aids : when working in a foot restraint position   [EQ/A]

Crew mobility aids or grasp points shall be placed within 24 inches to the left or right of the body centerline when working in a foot restraint position as described in Figure 3.7.2.1.1.1¿1.

3.7.2.1.1.2   Crew Mobility Aids : crewmember's two-handed work envelope   [EQ/A]

Crew mobility aids or grasp points shall be placed within 18 inches above or below the center of the crewmember's optimum two¿handed work envelope as described in Figure 3.7.2.1.3¿1.

3.7.2.1.2 EXTRAVEHICULAR ACTIVITY CREWMEMBER FIELD OF VIEW   [EQ/A]

Integrated external payload equipment, displays, and markings required to be seen to perform EVA tasks shall be located within the field of view of the Extravehicular Mobility Unit (EMU) as defined in Figure 3.7.2.1.2¿1.

ACTIVITY CONDITIONS

The analysis will be supported by software simulation. The software models of SSRMS, EMU (including work envelope), EVA equipment will be representative for dimensions and kinematics capabilities/limitations.

TASKS DESCRIPTION

The analysis will include as a minimum the following aspects:
- Identification of EVA interfaces.
- Identification and verification of access direction and EVA support i.e. APFR based on SSRMS or APFR located on structure
- Identification and verification of access of the EVA glove to the relevant EVA crew interface.
- Identification of EVA crew member posture and verification EVA I/Fs are within the EVA work envelope and within the field of view.
- Definition of required EVA supports (Handrails / APFR / Tether points/) and verification of their correct location and orientation to support the crew member with respect to the requirements.
- Verification of non-interference of the surrounding hardware to the EVA activity.
- Identification and verification of adequate EVA interfaces for P/L removable parts to be transported in EVA.

RESOURCES REQUIRED:

The S/W JACK in connection with 3D DMU will be used for the analysis.
The following personnel shall be involved .....

PLANNED DURATION

The expected duration is 20 working days

Figure 6-5: Example of activity sheet for analysis programme

TASK 31000 - PFM IST 1

OBJECTIVE
The aim of the IST 1 is to ensure the integrity and functionality of all subsystems/Instruments installed onto the platform and to verify the correct operation of the fully integrated Satellite in a series of representative mission modes including back-up modes.
It will be taken as reference for the further ISTs performed after the environmental test campaign.
Validation of SDB as well.

REQUIREMENTS TO BE VERIFIED
It is linked to the requirements:

ACTIVITY CONDITIONS
Initial configuration:
The S/C PFM will be on the RSS. The removable panels will not be present but the Structure Support Rod (SSR) will be mounted.
The DFACS missing units will be simulated by the EGSE (GMFE and Real Time Simulator).
Final configuration:
As per Initial Configuration
Build Standard:
PFM S/C: PFM Platform without wings and related mounted units, FM SSTI Receivers, PFM SREM, PFM Gradiometer

TASKS DESCRIPTION
The IST will include:
• System activation verification
• System operative modes and transitions verification both autonomous and initiated by external commands, including the back-up mode;
• Sunlit/Eclipse Transition and viceversa verification
• Orbits main mission profile (Autonomy functional check)
• Equipment health check
• Satellite specific system functional/performances verification:
−verification of the power conditioning, distribution capabilities and power consumption for different operating configurations
−verification of the spacecraft reconfiguration following commanded switch-over between main and redundant units (redundancy management)
−verification of TLM and TLC management (i.e. real time and time delay commands, S-Packets formatting, TM data coding etc....)
• IPA & MPA verification

RESOURCES REQUIRED
Integration Room (Class 100.000).
MGSE: HTA, HCB, MAP, SBS, RSS, SSR, Hand Cart with standard tools.
EGSE: Power SCOE, GMFE, RTS, RF SCOE, CORE EGSE , SSTI SCOE, ...
The following personnel shall be involved .....

PLANNED DURATION
The expected duration is 20 working days

Figure 6-6: Example of Activity Sheet for Integration and Test Programme

6.2.1.2.9   Verification tools

a.   *The VP shall describe high level definitions of the verification tools to be used, such as S/W facilities, special tools, simulators, analytical tools.*

6.2.1.2.10   Verification control methodology

a.   *The VP shall describe the proposed methodology to be utilized for verification monitoring and control. including the use of a verification data base.*

6.2.1.2.11   Documentation

a.   *The VP shall list the involved verification documents and describe their content.*

The DRDs of ECSS-E-ST-10-02 and ECSS-E-ST-10-03 are the involved verification documentation

6.2.1.2.12   Organization and management

a.   *The VP shall describe the responsibility and management tools applicable to the described verification process.*

b.   *It shall describe the responsibilities within the project team, the relation to product assurance, quality control and configuration control (including anomaly handling and change control) as well as the responsibility sharing with external partners.*

c.   *The relevant reviews shall be planned and responsibilities described.*

6.2.2   Verification control document (VCD)

6.2.2.1   General

ECSS-E-ST-10-02C clause 5.2.8.2 specifies that:

a.   *The supplier shall provide a Verification Control Document (VCD) for the reviews as agreed with the customer*

> *Note: Guidelines are provided in Annex G.*

b.   *The contents of the initial issue of the Verification Control Document (VCD) shall be in conformance with the DRD in Annex B.*

ECSS-E-ST-10-02C clause 5.4.4.1 specifies that:

a.   *The content of the completed Verification Control Document (VCD) shall be in accordance with the DRD in Annex B.*

b.   *The supplier shall update the Verification database within one week of the approval of a report.*

c.   *The intermediate issues of the Verification Control Document (VCD), reflecting the current status of the verification database, shall be made available to the Verification Control Board (VCB) upon request.*

d.   *The intermediate issues of the Verification Control Document (VCD), reflecting the current verification and compliance status, shall be delivered at each formal review as agreed with the customer*

> *Note: Guidelines are provided in Annex G.*

e.   *The final issue of the Verification Control Document (VCD) shall be submitted to the Verification Control Board (VCB) after the approval of the last report, within the time frame agreed with the customer.*

> NOTE   The quoted annexes above refer to the standard.

The VCD provides traceability during the phase B, C, D and E of how and when each requirement is planned to be verified and is actually verified.

The initial issue of the VCD is prepared for each product specification at the selected verification levels. It is an input to the preparation of the verification plan by listing all the requirements to be verified with the selected methods in the applicable stages at the defined levels. In the past, this issue was called the verification matrix document.

The initial issue of the VCD is completed along the project life cycle to provide evidence of the implementation of the Verification process. In particular the Verification Control Data Sheets (VCDS) are progressively filled (see example in Figure 18).

A specific issue of the VCD is released for each stage of the verification (e.g. at the end of the Qualification Stage, the VCD contains all the close-out records relevant to qualification activities).

It should be noted that in case of recurrent products based on the same qualification, the VCD for the acceptance is relevant to each single product even if the qualification stage is valid for all.

In summary the VCD provides, with the support of the Verification Data Base, the following:

a.   traceability of relationships between requirements,

b.   traceability of all requirements to the verification process (methods, levels, stages, planning documentation, reports, waivers, closeout, and compliance etc.),

c.   visibility of the coherence across products and levels,

d.   monitoring of the verification process throughout the project life cycle,

e.   identification of impacts at the various levels in case of change of requirements or criticality's during lower level verification,

f.   integration into the higher level of the lower level verification data.

The VCD is formally agreed with the customer. The VCD becomes part of the EIDP, as detailed in ECSS-Q-ST-20.

For each section of the DRD provided in ECSS-E-ST-10-02C Annex B, the requirements are recalled at the beginning of the section. *The quoted text is in italic.* It is then followed by guidance whenever considered relevant.

6.2.2.2   VCD DRD explanation

6.2.2.2.1   Introduction

a.   *The VCD shall contain a description of the purpose, objective, content and the reason prompting its preparation.*

b.   *Open issues, assumptions and constraints relevant to this document shall be stated and described.*

c.   *The VCD content shall be phased with the product life-cycle such that the initial issue contains the verification matrix, intermediate issues cover the planned on-ground verifications and their executions evidence (in particular for qualification and acceptance completion), the in-orbit and post landing activities; final issue provides evidence of the close-out of the overall verification process.*

6.2.2.2.2   Applicable and reference documents

a.   *The VCD shall list the applicable and reference documents in support to the generation of the document.*

The applicable documents are normally the product specification, the related standards (e.g. ECSS-E-ST-10-02) and any other documents cross-referenced in the text to the extent indicated in the text.

The reference documents provide additional information to the authors and readers (e.g. this handbook).

6.2.2.2.3   Definitions and abbreviations

a.   *The VCD shall list the applicable dictionary or glossary and the meaning of specific terms or abbreviations utilized in the document.*

6.2.2.2.4   Verification subject

a.   *The VCD shall describe the verification control approach applied to the product, the involved documentation, and the computerized tool, used to support the process:*

b.   *The VCD shall include the requirements to be verified (with reference to the specifications involved), call up the verification methods, levels and stages definitions and explain the verification close-out criteria.*

The subject is the description of the verification control approach and not of the product itself.

6.2.2.2.5   Verification summary status

a.   *Each issue of the VCD shall summarize the current Verification Close-out status.*

Example of the close-out status table is provided in Figure 6-7.

METHODS	STAGES	PROJECT: ZZZ			
		LEVELS			
		EQ	SS	EL	SY
T	Q	X(Y)	X(Y)	X(Y)	X(Y)
	A	X(Y)	....	....	....
	IO	X(Y)	N/A	....	....
A	Q	....	....	....	....
R	Q	....	....	....	....
I	Q	....	....	....	....
	A	....	....	....	....

NOTE: X = Planned   Y = Executed   N/A = Not Applicable

Figure 6-7: Example of the close-out status table

6.2.2.2.6   Verification control data

a.   *The VCD shall collect in the form of a matrix, for each requirement, the following verification information:*

1.   *Requirement identifier,*

2.   *Requirement text*

3.   *traceability between requirement,*

4.   *Levels and stages of verification,*

5.   *methods,*

6.   *link to the relevant section of the verification plan and any planning document,*

        Note: For example, test specification.

7.   *References to any documentation that demonstrates compliance to the requirements,*

        Note: For example, report, analysis, waivers, RFD, NCR, NRB, customer closeout records.

8.   *Status of Compliance (yes, no, partial),*

9.   *Close-out status (open / closed),*

10.   *Reasons of the close-out status,*

b.   *The initial issue of the VCD shall contain a verification matrix limited to:*

1.   *Requirement identifier,*

2.   *Requirement text,*

3.   traceability between requirement,

4.   Levels and stages of verification,

5.   methods,

6.   link to the relevant section of the verification plan.

Figure 6-8 shows an example of the Verification Control data sheet.

Figure 6-8: Example of VCD sheet

6.2.3   Other verification planning Documents

6.2.3.1   Assembly, Integration and Test plan (AITP)

ECSS-E-ST-10-02C clause 5.2.8.3 specifies that:

a.   The supplier shall provide the AITP for the reviews as agreed with the customer

> *Note: Guidelines are provided in Annex G.*

b.   The Assembly, Integration and Test plan (AITP) shall be in accordance with the DRD in ECSS-E-ST-10-03.

> NOTE   The quoted annex above refers to the standard.

The AIT plan contains the assembly, integration & test programme for all models, the AIT activity sheets, the relevant planning, the selected test facilities, the involved documentation and the AIT management & organization. The AIT plan is the master plan for the AIT process.

If agreed with the customer:

a.   The plan for Assembly and Integration may be separated from the plan for the Test. This is normally done in specific circumstances such as project with a complex production cycle (e.g. for launcher).

b.   The AIT Plan may contain only the test programme. This is normally done for certain lower level products, such as simple equipment.

6.2.3.2   Test Requirement Specification

The test requirement specification was a system support specification, containing the general test requirements in terms of type of tests, sequences, margins, duration's, tolerances, screening policy and methodology. It was applicable to all verification levels through the relevant product specifications (e.g. system, subsystem and equipment specification).

Since the release of verification and testing standard at issue B, the test requirement specification is replaced by the ECSS-E-ST-10-03 tailored to the specific application.

6.3   Verification execution and reporting documentation

6.3.1   Test report (TRPT)

6.3.1.1   General

ECSS-E-ST-10-02C clause 5.3.2.1 specifies that:

> a.   *The test report (TRPT) shall be submitted to the Verification Control Board (VCB) after the test completion, within the time frame agreed with the customer.*
>
> b.   *The content of the Test report (TRPT) shall be in accordance with the DRD in Annex C.*
>
> c.   *The supplier shall provide the Test reports (TRPT) for the reviews as agreed with the customer*
>
> > *Note: Guidelines are provided in Annex G.*
>
> d.   *A Test report (TRPT) shall be provided for each Test verification task as identified in the VP or AITP.*
>
> > NOTE   The quoted annexes above refer to the standard.

A test report is prepared for each test corresponding to a VP or AITP Test Activity Sheet or to a Test Specification.

The principal purpose is to provide the customer with the evidence of the test activity performed for verification close-out of the relevant requirements. It responds to the requirements contained in the product specification and in the test specification (see ECSS-E-ST-10-03) and the test procedure (see ECSS-E-ST-10-03). In case of environmental tests, pertinent data about the test facility is also given. It is an input to a verification report in the case of multi-method verification.

It may include results coming from many test procedures e.g. a Test Report for a FM environmental test normally includes also the as run procedures of the associated functional tests.

In some cases, a first issue of the document may only contain the raw results with the preliminary engineering assessments whilst the final issue contains the complete engineering evaluation.

The test report including its engineering assessment may be complemented with a more detailed analysis report.

For each section of the DRD provided in ECSS-E-ST-10-02C Annex C, the requirements are recalled at the beginning of the section. *The quoted text is in italic.* It is then followed by guidance whenever considered relevant.

6.3.1.2   TRPT DRD explanation

6.3.1.2.1   Introduction

  a.   The TRPT shall contain a description of the purpose, objective, content and the reason prompting its preparation.

  b.   Open issues, assumptions and constraints relevant to this document shall be stated and described.

6.3.1.2.2   Applicable and reference documents

  a.   The TRPT shall list the applicable and reference documents in support to the generation of the document.

The applicable documents are normally the product specification, the test specification, the test procedure(s), the related standards (e.g. ECSS-E-ST-10-02, ECSS-E-ST-10-03) and any other documents cross-referenced in the text to the extent indicated in the text.

The reference documents provide additional information to the authors and readers (e.g. this handbook).

6.3.1.2.3   Definitions and Abbreviations

  a.   The TRPT shall list the applicable dictionary or glossary and the meaning of specific terms or abbreviations utilized in the document

6.3.1.2.4   Test results

  a.   The TRPT shall contain the test results with supporting data (including the test execution dates, the as run procedure, and the test facility results).

  b.   The TRPT shall contain the analysis of test data and the relevant assessment

  c.   The TRPT shall provide a synthesis of the test results.

6.3.1.2.5   Anomalies

  a.   The TRPT shall include the list of deviations to the test procedure, the non-conformance including failures and the problems.

6.3.1.2.6   Conclusions

  a.   The TRPT shall summarize

  1.   the test results, including:
     (a)   the list of the requirements to be verified (in correlation with the VCD),
     (b)   traceability to used documentation,
     (c)   conformance or deviation including references and signature and date),

  2.   the comparison with the requirements and.

  3.   the verification close-out judgement

  b.   Open issues shall be clearly stated and described

  c.   Separate test analyses shall be cross-referenced.

The requirement close-out may be summarized in a separate table to be prepared for each pertinent requirement or group of requirements (see Figure 6-9).

Program: SATELLITE   CI Identifier: 1-000-1*AIVDB Report*
Test Report Id.: SAT-RP-001   Page: 1 of 2

Test Report Sheet

Title: Physical Properties Test   Stage: QUALIFICATION
Level: SYSTEM   Status: Closed

Specification ID: SAT-SPEC-001   Iss/Rev: 1/-
Specification Name: SATELLITE SYSTEM SPECIFICATION

Requirement Number: 4.1
Requirement Header: Mass

Text and Verification Matrix:

The Satellite System shall not exceed 2 t.

Stage	SY	SS	-
QUAL	T.A	A	-
ACC	T		-
PRE-LAUNCH	-	-	-

	ID	HEADER	STATUS
Grouping:	G-MASS-T	Physical Properties	C
Activity Sheet:	A-4.1.2	Physical Properties	C
Specification:	SAT-TS-001	Physical Properties System Spec	-
Procedure:	SAT-PR-001	Physical Properties Procedure	-

Program: SATELLITE   CI Identifier: 1-000-1*AIVDB Report*.
Test Report Id.: SAT-RP-001   Page: 2 of 2

VERIFICATION DESCRIPTION:

The Requirement has been verified by a means of a test at system level as part of the physical Properties System Test which is combined with system mass budget analysis based on the equipment test results.

VERIFICATION RESULTS:

Dry satellite mass 1,5 t in line with the expected results. Verification successfully closed-out.

Prepared /Date	Checked/ Date	AIV Appr./ Date
Mr. One	Mr. Two	Mr. Three

Figure 6-9: Example of test report sheet

6.3.2 Analysis report (ARPT)

6.3.2.1 General

ECSS-E-ST-10-02C clause 5.3.2.2. specifies that:

> a. *The Analysis report (ARPT) shall be submitted to the Verification Control Board (VCB) after analysis completion, within the time frame agreed with the customer.*
>
> b. *The Analysis report (ARPT) shall be in conformance with the DRD in Annex Q of ECSS-E-ST-10.*
>
> c. *The supplier shall provide an Analysis report (ARPT) for the reviews as agreed with the customer*
>
>> *Note: Guidelines are provided in Annex G.*
>
> d. *An Analysis report (APRT) shall be provided for each Analysis verification task identified in the VP.*

> NOTE   The quoted annex above refers to the standard.

Analysis without verification objectives are out of scope the ECSS-E-ST-10-02 standard. But for documentation simplification reasons the Analysis Report DRD has been kept at E-10 level with clear identification in its content of the specific aspects linked to verification objectives.

The following considerations are therefore applicable to the Analysis Report version for Verification.

The Analysis Report is prepared for each analysis corresponding to an analysis Activity Sheet of the VP.

It contains proper evidence that the relevant requirements are verified and the indication of any deviation.

It is an input to a verification report in the case of multi-method verification.

Its applicable documents are normally the product specification, the verification plan, the document containing the analysis rules, the related standards (e.g. ECSS-E-ST-10-02) and any other documents cross-referenced in the text to the extent indicated in the text .

Its reference documents provide additional information to the authors and readers (e.g. this handbook).

The requirement close-out may be summarized in a separate table to be prepared for each pertinent requirement or group of requirements (see Figure 6-10).

Figure 6-10: Example of an analysis report sheet

6.3.3   Review-of-design report (RRPT)

6.3.3.1   General

ECSS-E-ST-10-02C clause 5.3.2.3 specifies that:

> a.   *The Review-of-design report (RRPT) shall be submitted to the Verification Control Board (VCB) after the Review-of-Design completion, within the time frame agreed with the customer.*

   b. *The Review-of-design report (RRPT) shall be in conformance with the DRD in ECSS-E-ST-10-02C Annex D.*

   c. *The supplier shall provide a Review-of-design report (RRPT) for the reviews as agreed with the customer*

     Note: Guidelines are provided in Annex G..

   d. *A Review-of-design report (RRPT) shall be provided for each Review-of-design verification task identified in the VP.*

    NOTE The quoted annexes above refer to the standard.

The review-of-design report (RRPT) is prepared for each review-of-design task corresponding to a review-of-design activity sheet of the VP. Its principal purpose is to provide the customer with the evidence of satisfactory completion of review- of-design for verification close-out of the relevant requirements. The review-of-design report can cover the activity relevant to the verification of several requirements in the case that the event is unique (for example review-of-design performed during a project design review).

It is an input to a verification report in the case of multi-method verification.

For each section of the DRD provided in ECSS-E-ST-10-02C Annex D, the requirements are recalled at the beginning of the section. *The quoted text is in italic.* It is then followed by guidance whenever considered relevant.

6.3.3.2 RRPT DRD explanation

6.3.3.2.1 Introduction

   a. *The RRPT shall contain a description of the purpose, objective, content and the reason prompting its preparation.*

   b. *Open issues, assumptions and constraints relevant to this document shall be stated and described.*

6.3.3.2.2 Applicable and reference documents

   a. *The RRPT shall list the applicable and reference documents in support to the generation of the document.*

The applicable documents are normally the product specification, the verification plan, the document containing the review of design rules, the related standards (e.g. ECSS-E-ST-10-02) and any other documents cross-referenced in the text to the extent indicated in the text.

The reference documents provide additional information to the authors and readers (e.g. this handbook).

6.3.3.2.3 Definitions and Abbreviations

   a. *The RRPT lists the applicable dictionary or glossary and the meaning of specific terms or abbreviations utilized in the document with the relevant meaning.*

6.3.3.2.4 Review-of-design summary

   a. *The RRPT describes the review-of-design activity in terms of method and procedures used.*

6.3.3.2.5 Conclusions

   a. *The RRPT shall summarize*

     1. the review-of-design results, including

       1. the list of the requirements to be verified (in correlation with the VCD),

       2. traceability to used documentation,

3.   conformance or deviation including references and signature and date,

2.   the comparison with the requirements and

3.   the verification close-out judgment.

b.   Open issues shall be clearly stated and described..

The requirement close-out may be summarized in a separate table to be prepared for each pertinent requirement or group of requirements (see Figure 6-11).

Figure 6-11: Example of review-of-design report sheet

6.3.4   Inspection report (IRPT)

6.3.4.1   General

ECSS-E-ST-10-02C clause 5.3.2.4 specifies that:

a.   The Inspection report (IRPT) shall be submitted to the Verification Control Board (VCB) after the inspection completion, within the time frame agreed with the customer.

b.   The Inspection report (IRPT) shall be in conformance with the DRD in Annex E.

c.   The supplier shall provide an Inspection report (IRPT) for the reviews as agreed with the customer

Note: Guidelines are provided in Annex G.

d.   An Inspection report (IRPT) shall be provided for each Inspection verification task identified in the VP.

NOTE   The quoted annexes above refer to the standard.

The Inspection Report is prepared for each inspection verification task corresponding to an Inspection Activity Sheet of the VP. The principal purpose is to provide the customer with the evidence of the performed inspection activity in verification close-out of the relevant requirements. The inspection report can cover the activity relevant to the verification of several requirements in case that the event is unique (for example an inspection of several I/F requirements).

It is an input to a verification report in the case of multi-method verification.

For each section of the DRD provided in ECSS-E-ST-10-02C Annex E, the requirements are recalled at the beginning of the section. *The quoted text is in italic.*

It is then followed by guidance whenever considered relevant.

6.3.4.2   IRPT DRD explanation

6.3.4.2.1   Introduction

> a.   *The IRPT shall contain a description of the purpose, objective, content and the reason prompting its preparation.*
>
> b.   *Open issues, assumptions and constraints relevant to this document shall be stated and described.*

6.3.4.2.2   Applicable and reference documents

> a.   *The IRPT shall list the applicable and reference documents in support to the generation of the document.*

The applicable documents are normally the product specification, the verification plan, the document containing the inspection rules, the related standards (e.g. ECSS-E-ST-10-02) and any other documents cross-referenced in the text to the extent indicated in the text.

The reference documents provide additional information to the authors and readers (e.g. this handbook).

6.3.4.2.3   Definitions and Abbreviations

> a.   *The IRPT shall list the applicable dictionary or glossary and the meaning of specific terms or abbreviations utilized in the document with the relevant meaning.*

6.3.4.2.4   Inspection summary

> a.   *The IRPT shall describe the product configuration data of the inspected item.*

6.3.4.2.5   Conclusions

> a.   *The IRPT shall summarize:*
>> 1.   *inspection results, including:*
>>> a.   *the list of the requirements to be verified (in correlation with the VCD),*
>>> b.   *traceability to used documentation,*
>>> c.   *inspection event location and date,*
>>> d.   *expected finding,*
>>> e.   *conformance or deviation including proper references and signature and date,*
>> 2.   *comparison with the requirements, and*
>> 3.   *verification close-out judgement.*
> b.   *Open issues shall be clearly stated and described*

The requirement close-out may be summarized in a separate table to be prepared for each pertinent requirement or group of requirements (see Figure 6-12).

Figure 6-12: Example of an inspection report sheet

6.3.5 Verification report (VRPT)

6.3.5.1 General

ECSS-E-ST-10-02C clause 5.3.2.5 specifies that:

   a. The supplier shall prepare a Verification report (VRPT) when more than one of the defined verification methods are utilized to verify a requirement or a specific set of requirements.

   b. The Verification report (VRPT) shall be in accordance with the DRD in Annex F.

   c. The Verification report (VRPT) shall be submitted to the Verification Control Board (VCB) after the completion of the last contributing verification activities, within the time frame agreed with the customer.

   d. The supplier shall provide a Verification report (VRPT), for the reviews as agreed with the customer

   Note: Guidelines are provided in Annex G.

   NOTE   The quoted annexes above refer to the standard.

The VRPT reports the approach followed and how the verification methods were combined to achieve the verification objectives. The verification report can cover the verification of several requirements.

The VRPT is prepared on the basis of the initial Verification Control Document (VCD) and the associated Verification Plan (VP), considering the results of the relevant test, analysis, review-of-design and inspection reports.

For each section of the DRD provided in ECSS-E-ST-10-02C Annex F, the requirements are recalled at the beginning of the section. *The quoted text is in italic.* It is then followed by guidance whenever considered relevant.

6.3.6 VRPT DRD explanation

6.3.6.1.1 Introduction

    a.   *The VRPT shall contain a description of the purpose, objective, content and the reason prompting its preparation.*

    b.   *Open issues, assumptions and constraint relevant to this document shall be stated and described.*

6.3.6.1.2 Applicable and reference documents

    a.   *The VRPT shall list the applicable and reference documents in support to the generation of the document.*

The applicable documents are normally the product specification, the verification plan, the related standards (e.g. ECSS-E-ST-10-02), all the elementary reports (i.e. test, analysis, review of design and inspection) used to build this report and any other documents cross-referenced in the text to the extent indicated in the text.

The reference documents provide additional information to the authors and readers (e.g. this handbook).

6.3.6.1.3 Definitions and Abbreviations

    a.   *The VRPT shall list the applicable dictionary or glossary and the meaning of specific terms or abbreviations utilized in the document with the relevant meaning Verification subject.*

6.3.6.1.4 Verification results

    a.   *The VRPT shall describe the verification approach, the associated problems and results with reference to the relevant test, analysis, review-of-design and inspection reports.*

    b.   *The VRPT shall identify the deviations from the verification plan.*

6.3.6.1.5 Conclusions

    a.   *The VRPT shall list the requirements to be verified (in correlation with the VCD).*

    b.   *The VRPT shall summarize verification results, the comparison with the requirements and the verification close-out judgement.*

    c.   *Open issues shall be clearly stated and described.*

The requirement close-out may be summarized in a separate table to be prepared for each pertinent requirement or group of requirements (see Figure 6-13).

```
┌─────────────────────────────────────────────────────────────────────────┐
│ Program: SATELLITE    CI Identifier: 1-001-01 AIVDB Report                │
│                                                                           │
│ Ver. Report Id.: sat-rp-006                              Page: 1 of 1     │
│                                                                           │
│                      Verification Report Sheet                            │
│                                                                           │
│ Title:        MASS                    Stage:   QUALIFICATION              │
│ Level:        System                  Status:  Closed                     │
│                                                                           │
│ Specification ID: SAT-SPEC-001              Iss/Rev: 1/-                   │
│ Specification Name: Satellite System Specification                        │
│                                                                           │
│ Requirement Number: 4.1          Methods: T, A                           │
│ Requirement Header: Mass                                                   │
│                                                                           │
│                                                                           │
│ VERIFICATION DESCRIPTION:                                                 │
│ The requirement has been verified at system level by means of a combination│
│ of Test and Analysis as described in the attached Test and Analysis Report │
│ Sheets (included in the respective reports: SAT-RP-001 and SAT-RP-002)     │
│                                                                           │
│                                                                           │
│                                                                           │
│                                                                           │
│ VERIFICATION RESULTS:                                                     │
│ The Verification has been successfully completed, dry satellite mass 1,5 Tons,│
│ estimated overall satellite mass through analysis 1,9 Tons.               │
│                                                                           │
│                                                                           │
│ !BELOW ONLY PAPER PART TO BE WRITTEN BY THE USERS!                        │
├─────────────────────────────────────────────────────────────────────────┤
│   Prepared /Date        Checked/ Date         AIV Appr./ Date            │
│   ┌──────────┐          ┌──────────┐          ┌──────────┐               │
│   │ Mr. One  │          │ Mr. Two  │          │ Mr. Three│               │
│   └──────────┘          └──────────┘          └──────────┘               │
└─────────────────────────────────────────────────────────────────────────┘
```

Figure 6-13: Example of verification report sheet

6.3.7   Other verification execution and reporting Document

6.3.7.1   Test Specification (TSPE)

ECSS-E-ST-10-02C clause 5.3.2.6 specifies that:

  a.   *The supplier shall provide the Test specifications (TSPE) for the reviews as agreed with the customer*

          Note: *Guidelines are provided in Annex G.*

b.   *The Test specifications (TSPE) shall be in conformance with the DRD in Annex B of ECSS-E-ST-10-03.*

NOTE   The quoted annex above refers to the standard.

An example is given in the corresponding handbook (ECSS-E-HB-10-03).

The test specification is prepared for each test corresponding to a VP or AITP Test Activity Sheet with the objective to detail the test requirements for special purposes (e.g. to interface with a test facility). The test specification reflects an intermediate step in the test process definition between the overall planning (VP or AITP) and the specific test procedure(s).

The test specification contains the specific test activity objectives, the selected approach, the article configuration, the set-up description, the necessary GSE, the equipment and instrumentation, the conditions for the activity, the required facilities, the sequence of activities with the detailed verification requirements, the success criteria, the organization and responsibilities, the involved documentation, the relationship with product assurance activities, the schedule.

If agreed with the customer, the test specification may be combined with the AIT or the AIV plan. This normally depends on the actual project requirements.

6.3.7.2   Test Procedures (TPRO)

ECSS-E-ST-10-02C clause 5.3.2.6 specifies that:

c.   *The Test procedures shall be in conformance with the DRD in Annex D of ECSS-E-ST-10-03.*

d.   *The supplier shall provide the Test procedures (TPRO) for the reviews as agreed with the customer*

Note: Guidelines are provided in Annex G.

NOTE   The quoted annex above refers to the standard

An example is given in the corresponding handbook (ECSS-E-HB-10-03).

The test procedure provides detailed step-by-step instructions for conducting test activities in agreement with the test specification. The test procedure contains the activity objective, the applicable documents, the references to the relevant test specification, the participants required, the article & tools configuration list and the step-by-step procedures.

The Test Specification can include the Test Procedures (e.g. when the procedure is simple).

6.3.7.3   Miscellaneous

ECSS-E-ST-10-02C clause 5.3.2.6 specifies that:

e.   *The rules for the analysis, inspection and review of design shall be defined in writing before their execution.*

Note: For example, analysis, inspection or review of design procedures.

These rules can be stated in self standing documents (e.g. procedures) or embedded in the VP.

6.3.7.3.1   Analysis Procedure

This document should contain at least the following information:

a.   requirements to be verified by this analysis

b.   analytical tool to be used (SW programme)

c.   short analytical model definition

d.   source of input data (e.g. test reports, assumptions, drawings,…)

6.3.7.3.2   Inspection Procedure

This document should contain at least the following information:

a.   requirements to be verified by this inspection

b.   product to be inspected

c.   inspection method and required tools (if any)

d.   when the inspection is performed (e.g. before, during or after integration)

6.3.7.3.3   Review of Design Procedure

This document should contain at least the following information:

a.   requirements to be verified by this review

b.   documents to be reviewed (e.g. drawings, diagrams, manuals,..)

6.3.7.3.4   Additional documentation

In addition, the following documents are usually part of the verification process to provide traceability and event record:

a.   test configuration lists (TCL);

b.   end-item data packages (EIDP);

c.   logbooks (including work items and deviation work items);

d.   non-conformance reports (NCR);

e.   request for waivers (RFW);

f.   manuals, simulation plans and verification tools documentation.

6.3.8   Other close-out documents

ECSS-E-ST-10-02C clause 5.4.4.2 specifies that:

> *a.   The supplier shall make available to the customer for consultation the evidences mentioned in the VCD in addition to the deliverable reports.*

The VCD is a summary document containing references to deliverable and not deliverable documentation.

In this second case the customer has normally the right to access the necessary documentation for consultation purposes.

Annex A
Verification documents delivery per review

ECSS-E-ST-10-02C Annex G (informative) states that:

> *The verification documents are delivered by the supplier to the customer at each review either for information or for approval, with the identified maturity, as per table G-1.*
>
> *Note: This implies that the DRD template can be adopted, but not followed.*

> NOTE   The quoted annex and table above refer to the standard.

Before an ITT, the customer should tailor this table to the specificities of the project, level and product to allow proper cost estimate by the supplier.

During the working arrangements negotiation, an agreement should be finalised between the customer and the supplier on the tailoring of this table.

This table intends to cover the overall system as well as the space and ground segments However, when the standard is applied at a level below the overall system, some reviews are generally not relevant (e.g. ORR, FRR, LRR and CRR).

Depending of the product characteristics, some documents may be combined to reduce costs or even ignored if not relevant.

The requirement and design reviews may be simplified or even suppressed depending upon the product maturity, e.g. when a product is already existing or even "off the shelf".

Some document are mentioned for a given review for programmatic purpose (e.g. VP at PRR) to prepare the proposal of the following phase.

Pure software products have to follow the deliverable list of ECSS-E-ST-40.

ECSS-E-ST-10 also mention requirement traceability and justification activities starting in phase A which are sometimes called verification but are out of the scope of this standard.

Annex B
Verification Standard Tailoring

When viewed from the perspective of a specific project context, the requirements defined in the Standard should be tailored to match the genuine requirements of a particular profile and circumstances of a project (e.g. space element, ground segment, launcher, overall system or lower level product). It is normally done under the customer responsibility, before business agreement award, even if the supplier may provide contribution during the proposal phase.

> NOTE   Tailoring is a process by which individual requirements of specifications, standards and related documents are evaluated, and made applicable to a specific project by selection, and in some exceptional cases, modification of existing or addition of new requirements.

The following table indicates in which circumstances the standard should be tailored:

— According to the mission/product type (e.g. Commercial Application Satellite, Scientific Interplanetary probe, Habitable space infrastructure, transportation system, etc.)

— According to the phase of the mission (e.g. phase A,B, C, D, E, F)

— According to the product verification level (e.g. system, subsystem, equipment)

The following table gives also examples for the tailoring of the standard for specific products such as:

— A lower level product without software (e.g. hardware equipment).

— A lower level pure software product.

— A space element (e.g. commercial or scientific satellite) or a major subset of it (e.g. payload, platform).

— A satellite ground support equipment (GSE).

— An expendable launcher.

— A ground segment or a major constituent of it.

— An overall system (satellites plus ground segments).

In the table a <u>YES</u> means that tailoring is possible according to the projects and products characteristics, while a <u>NO</u> indicates that the requirements should not be tailored.

Table B-1: Tailoring guidelines and some examples per product type

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
5.1 VERIFICATION PROCESS										
a. The verification process shall demonstrates that the deliverable product meets the specified customer requirements and is capable of sustaining its operational role through: 1. Verification planning; 2. Verification execution and reporting; 3. Verification control and close-out.	No	No	No	No	No	No	No	No	No	No
5.2 VERIFICATION PLANNING										
5.2.2 Verification methods										
5.2.2.1 General										
a. Verification shall be accomplished by one or more of the following verification methods: 1. test (including demonstration); 2. analysis (including similarity); 3. review-of-design; 4. inspection.	No	No	No	No	No	No	No	No	No	No
b. All safety critical functions shall be verified by test.	No	No	No	No	No	No	No	No	No	No
c. Verification of software shall include testing in the target hardware environment.	No	No	No	No	No	No	No	No	No	No
d. For each requirement verified only by analysis or review-of-design, assessment analysis (part of the VP) shall be conducted to determine the level (major/minor) of the impact of this requirement on the mission	Yes	Yes	No	No	No	No	Yes	No	Yes	No
e. If the impact of the requirement is major, a risk mitigation plan (part of the VP) shall be defined which includes, a cross check based on two independent analyses (in terms of model used and suppliers)	Yes	Yes	No	No	No	No	Yes	No	Yes	No
5.2.2.2 Test										
a. Verification by test shall consist of measuring product performance and functions under	No	No	No	No	No	No	No	No	No	No

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
representative simulated environments.										
b. The analysis of data derived from testing shall be an integral part of the test and the results included in the test report.	No	No	No	No	No	No	No	No	No	No
c. When the test objectives include the demonstration of qualitative operational performance the execution shall be observed and results recorded.	No	No	No	No	No	No	No	No	No	No
d. A test programme shall be prepared for each product in compliance with test requirements specified in ECSS-E-ST-10-03.	Yes	No	No	No	Yes	No	Yes	No	Yes	No
e. The test programme shall be coordinated with the integration flow.	No	No	yes	Yes	No	No	No	No	No	No
f. Tests performed as part of the integration flow to check quality and status of the in-progress configuration (including interfaces), having a formal verification purpose, shall be included in the test programme.	No	No	yes	Yes	No	No	No	No	No	No
g. The test programme shall be defined in the Assembly, Integration and Test plan (AITP).	Yes	No	yes	Yes	Yes	No	No	No	No	No
5.2.2.3 Analysis										
a. Verification by analysis shall consist of performing theoretical or empirical evaluation using techniques agreed with the Customer. 　　NOTE　Techniques comprise systematic, statistical and qualitative design analysis, modelling and computational simulation.	No	No	No	No	No	No	No	No	No	No
b. Verification by similarity shall be part of the verification by analysis.	No	No	No	No	No	No	No	No	No	No
c. Similarity analysis shall provide evidence that an already qualified product fulfils the following criteria: 1. The already qualified product was not qualified by similarity. 2. The product to be verified belongs to category A or to category B (defined in Table 1) but no testing is required to achieve qualification. 　　NOTE　Implicitly the product to be verified cannot belong to categories C and D equipment (defined in Table 5-1).	Yes	No	No	No	Yes	No	Yes	No	Yes	Yes
d. Similarity analysis shall define differences that can dictate complementary verification activities.	Yes	No	No	No	Yes	No	Yes	No	Yes	Yes

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
e. An analysis programme shall be defined in the Verification Plan (VP).	No	No	No	No	No	No	No	No	No	No
f. An analysis programme shall be applicable to qualification and in-orbit stages only.	No	No	No	No	No	No	No	No	No	No
5.2.2.4 Review-of-design										
a. Verification by Review-of design (ROD) shall consist of using approved records or evidence (e.g. design documents, and reports, technical descriptions, engineering drawings) that unambiguously show that the requirement is met. NOTE: Examples of such approved records are design documents and reports, technical descriptions, and engineering drawings.	No	No	No	No	No	No	No	No	No	No
b. A review-of-design programme shall be defined in the Verification Plan (VP).	No	No	No	No	No	No	No	No	No	No
c. A review-of-design programme shall only be applicable in the qualification stage or in the in-orbit stage.	No	No	No	No	No	No	No	No	No	No
5.2.2.5 Inspection										
a. Verification by inspection shall consist of visual determination of physical characteristics. NOTE: Physical characteristics include constructional features, hardware conformance to document drawing or workmanship requirements, physical conditions, software source code conformance with coding standards.	No	No	No	No	No	No	No	No	No	No
b. An inspection programme shall be defined in the Verification Plan (VP).	No	No	No	No	No	No	No	No	No	No
5.2.3 Verification levels										
a. Verification shall be accomplished through the selected verification levels. NOTE: Usual levels are defined in 4.2.3	No	No	No	No	No	No	No	No	No	No
b. When a requirement is fully verified at lower level, the traceability to lower level verification evidence shall be identified.	No	No	No	No	No	No	No	No	No	No
c. Formal close-out of qualification and acceptance at lower levels shall be performed prior to close-out at higher level.	No	No	No	No	No	No	No	No	No	No

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
5.2.4 Verification stages										
5.2.4.1 General										
a. Verification shall be accomplished through the selection of the appropriate stages on the basis of project specificity from the following: 1. qualification, 2. acceptance, 3. pre-launch, 4. in-orbit (including commissioning), 5. post-landing.	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
b. Qualification, acceptance and pre-launch stages shall be completed before launch.	No	No	No	No	No	No	No	No	No	No
c. When the verification programme includes an in-orbit stage, the verification shall not rely only on in-orbit activities.	No	No	No	No	No	No	No	No	No	No
d. When the verification programme includes a post landing stage, the verification shall not rely only or in-orbit activities or post landing activities.	No	No	No	No	No	No	No	No	No	No
5.2.4.2 Qualification										
a. In the qualification stage the verification shall demonstrate that the design, including margins, meets the applicable requirements.	No	No	No	No	No	No	No	No	No	No
b. Qualification shall be carried-out on hardware and software which is representative of the end item configuration in terms of design, materials, tooling and methods.	No	No	No	No	No	No	No	No	No	No
c. The qualification programme shall be prepared considering the product category according to heritage as defined in Table 5-1 of the standard "Product categories according to heritage"	Yes	No	No	No	Yes	No	Yes	No	Yes	Yes
5.2.4.3 Acceptance										
5.2.4.3.1 General										
a. In the acceptance stage the verification shall demonstrate that the product is free of workmanship errors and is ready for subsequent operational use.	No	No	No	No	No	No	No	No	No	No

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
b. Acceptance shall be carried-out on the final hardware and software	No	No	No	No	No	No	No	No	No	No
5.2.4.3.2 Acceptable article										
a. The acceptance article shall be manufactured in agreement with the qualified design.	No	No	No	No	No	No	No	No	No	No
b. The acceptance article shall perform as the qualified product.	No	No	No	No	No	No	No	No	No	No
5.2.4.4 Pre-launch										
a. In the pre-launch stage the verification shall demonstrate that the product is properly configured for launch activities and early operations b. In the pre-launch stage the verification shall confirm that the product is capable of functioning as planned during launch and early operations.	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes
5.2.4.5 In-orbit										
a. In the in-orbit stage the verification shall ensure no degradation occurred during the launch, early orbit phase, at periodical intervals and before specific operational use.	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	No
b. In the in-orbit stage the verification shall supplement/confirm ground verification by providing operating conditions which cannot be fully or cost effectively duplicated or simulated on ground.	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	No
c. In the in-orbit stage the verification shall characterize the system under operational conditions especially for the aspects that cannot be determined before the launch	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	No
d. In the in-orbit stage the verification shall confirm that the space and ground elements are compatible with each other	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	No
e. In the in-orbit stage the verification shall perform calibration and tuning activities specific to the mission payload . NOTE: The working arrangement between the elements suppliers (e.g. satellite, ground segment) and the final customer defines the share of responsibilities for preparing, conducting and reporting the in orbit - commissioning activities. The completion of this stage allows declaring readiness for routine operations (Phase E2-exploitation).	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	No

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
5.2.4.6 Post-landing										
a. The verification in the post-landing stage shall address the product integrity and performance after the mission.	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

b. In case the product is intended to be re-launched the verification shall address:
  1. a health check, at periodical intervals agreed with the customer, during storage periods;
  2. the product performance after modification, repair or replacement;
  3. the readiness for reuse.
	Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes

5.2.5 Models										
a. The model philosophy shall be defined as part of the overall verification planning.	No	No	No	No	No	No	No	No	No	No
5.2.6 Verification tools										
5.2.6.1 General										
a. Tools to be used to support the implementation of the verification process shall be identified.	No	No	No	No	No	No	No	No	No	No
b. All verification tools shall be verified for their intended use.	No	No	No	No	No	No	No	No	No	No
c. The degree of verification applied to tools used to support the verification programme shall be established. NOTE: This requirement does not imply that formal verification is performed for the verification tools (e.g. tools of common use).	No	No	No	No	No	No	No	No	No	No
d. Formal verification procedures shall be established and applied to tools which are specified as deliverable items.	No	No	No	No	No	No	No	No	No	No
5.2.6.2 Ground Support Equipment (GSE)										
a. All Ground Support Equipment (GSE) shall be verified under expected environmental conditions and operational constraints.	Yes	No	No	No	Yes	No	No	No	Yes	Yes
b. The compatibility of the interfaces of the Ground Support Equipment (GSE) with flight products and facilities shall be verified by test.	Yes	No	No	No	Yes	No	No	No	Yes	Yes

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
c. The prevention of damage on the flight product due to Ground Support Equipment (GSE) failure shall be verified. NOTE: For hazards to personnel, flight hardware, facilities and environments related to GSE, see ECSS-Q-ST-40.	Yes	No	No	No	Yes	No	No	No	Yes	Yes
d. Ground Support Equipment (GSE) that is modified or used in a new application shall be re-verified or re-validated.	Yes	No	No	No	Yes	No	No	No	Yes	Yes
5.2.6.3 Software validation facility (SVF)										
a. The SVF shall be verified by comparing the performance of the simulation models with the actual performance of the product or environment to be simulated.	Yes	No	Yes	Yes	No	No	Yes	No	Yes	Yes
b. flight hardware or software product simulated by the SVF shall be finally verified against the measured performance of the actual flight product.	Yes	No	Yes	Yes	No	No	Yes	No	Yes	Yes
5.2.6.4 Simulators										
a. Simulators shall be verified to demonstrate that the simulator characteristics are representative of the simulated product to the extent required for the verification to be supported.	No	No	No	No	No	No	No	No	No	No
5.2.6.5 Software tools for verification by analysis										
a. Suitability of previously validated analytical software tools shall be assessed for the intended application.	No	No	No	No	No	No	No	No	No	No
b. Non-validated analytical software tools shall be subjected to a validation process prior to their use.	No	No	No	No	No	No	No	No	No	No
5.2.6.6 Integration & test facilities and test tools										
a. The capability of the integration & test facilities and test tools to perform their intended function in terms of performance and calibration shall be verified as part of the overall integration and test process. NOTE: See ECSS-Q-ST-20-07 for test facilities.	No	No	No	No	No	No	No	No	No	No

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
5.2.7 Verification process phasing										
a. The verification process shall be phased with the project life cycle, in accordance with ECSS-M-ST-10.	No	No	No	No	No	No	No	No	No	No
b. Verification planning to assess feasibility and support programmatics shall start in the early phase (e.g. during phase A).	No	Yes	No	No	No	No	No	No	No	No
c. The preliminary verification planning shall cover all products and requirements by the end of phase B.	No	Yes	No	No	No	No	No	No	No	No
d. Verification planning shall be completed by the end of Phase C. NOTE: Covering all verification stages e.g. pre-launch, in-orbit (including commissioning) and post landing.	No	Yes	No	No	No	No	No	No	No	No
e. Verification execution and reporting shall be incrementally carried out through the project life cycle starting from phase C.	No	Yes	No	No	No	No	No	No	No	No
f. Verification control shall start with the initial issue of the verification control document (VCD) during phase B.	No	Yes	No	No	No	No	No	No	No	No
g. Verification close out status shall be assessed and approved by the customer for each product at the end of each stage. NOTE: E.g. qualification close out status at the end of the qualification stage during the Qualification Review (QR).	No	Yes	No	No	No	No	No	No	No	No
5.2.8 Verification planning documents										
5.2.8.1 Verification plan (VP)										
a. The supplier shall provide a Verification plan (VP) for the reviews as agreed with the customer NOTE: Guidelines are in Annex G.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
b. The contents of the Verification plan (VP) shall be in accordance with the DRD in Annex A.	No	No	No	No	No	No	No	No	No	No
5.2.8.2 Verification Control Document (VCD)										
a. The supplier shall provide a Verification Control Document (VCD) for the reviews as agreed with the customer	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
NOTE: Guidelines are in Annex G.										
b. The contents of the initial issue of the Verification Control Document (VCD) shall be in accordance with the DRD in Annex B	No	No	No	No	No	No	No	No	No	No
5.2.8.3 Other verification planning Document										
a. The supplier shall provide the AITP for the reviews as agreed with the customer NOTE: Guidelines are in Annex G. The Assembly, Integration and Test plan (AITP) shall follow the DRD defined in ECSS-E-ST-10-03.	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
b. The Assembly, Integration and Test plan (AITP) shall follow the DRD defined in ECSS-E-ST-10-03.	No	No	No	No	No	No	No	No	No	No
5.3 VERIFICATION EXECUTION AND REPORTING										
5.3.1 General										
a. The supplier shall assign clear responsibility for the implementation of the verification programme.	No	No	No	No	No	No	No	No	No	No
b. The requirements for the test preparation and execution including Test Readiness Review (TRR) and Post Test Review (PTR) shall be as per ECSS-E-ST-10-03.	Yes	No	No	No	Yes	No	Yes	Yes	Yes	No
c. When nonconformity is detected during the verification process, a Nonconformance Report (NCR), in conformance with Annex A of ECSS-Q-ST-10-09, shall be raised and processed according to ECSS-Q-ST-20	No	No	No	No	No	No	No	No	No	No
d. The verification results shall be recorded by the supplier in reports for review by the Verification Control Board (VCB) through the VCD.	No	No	No	No	No	No	No	No	No	No
5.3.2 Verification execution and reporting documentation										
5.3.2.1 Test report (TRPT)										
a. The test report (TRPT) shall be submitted to the Verification Control Board (VCB) after the test completion within the time frame agreed with the customer.	No	No	No	No	No	No	No	No	No	No
b. The content of the Test report (TRPT) shall be in accordance with the DRD in Annex C.	No	No	No	No	No	No	No	No	No	No
c. The supplier shall provide the Test reports (TRPT), for the reviews as agreed with the	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
customer NOTE: Guidelines are in Annex G.										
d. A Test Report (TRPT) shall be provided for each Test Verification Task as identified in the VP or AITP	No	No	No	No	No	No	No	No	No	No
5.3.2.2 Analysis report (ARPT)										
a. The Analysis report (ARPT) shall be submitted to the Verification Control Board (VCB) after the analysis completion within the time frame agreed with the customer.	No	No	No	No	No	No	No	No	No	No
b. The Analysis report (ARPT) shall be in accordance with the DRD in ECSS E-ST-10C Annex Q.	No	No	No	No	No	No	No	No	No	No
c. The supplier shall provide an Analysis report (ARPT), for the reviews as agreed with the customer NOTE: Guidelines are in Annex G.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
d. An Analysis Report (ARPT) shall be provided for each Analysis Task as identified in the VP.	No	No	No	No	No	No	No	No	No	No
5.3.2.3 Review-of-design report (RRPT)										
a. The Review-of-design report (RRPT) shall be submitted to the Verification Control Board (VCB) after the review-of-design completion within the time frame agreed with the customer.	No	No	No	No	No	No	No	No	No	No
b. The Review-of-design report (RRPT) shall be in accordance with the DRD in Annex D.	No	No	No	No	No	No	No	No	No	No
c. The supplier shall provide a Review-of-design report (RRPT), for the reviews as agreed with the customer NOTE: Guidelines are in Annex G.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
d. A Review-of-Design Report (RRPT) shall be provided for each Review of Design Task as identified in the VP	No	No	No	No	No	No	No	No	No	No
5.3.2.4 Inspection report (IRPT)										
a. The Inspection report (IRPT) shall be submitted to the Verification Control Board (VCB) after inspection completion within the time frame agreed with the customer.	No	No	No	No	No	No	No	No	No	No

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
b. The Inspection report (IRPT) shall be in accordance with the DRD in Annex E.	No	No	No	No	No	No	No	No	No	No
c. The supplier shall provide an Inspection report (IRPT), for the reviews as agreed with the customer NOTE: Guidelines are in Annex G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
d. An Inspection Report (IRPT) shall be provided for each Inspection Verification Task as identified in the VP	No	No	No	No	No	No	No	No	No	No
5.3.2.5 Verification report (VRPT)										
a. The supplier shall prepare a Verification report (VRPT) when more than one of the defined verification methods are utilized to verify a requirement or a specific set of requirements.	No	No	No	No	No	No	No	No	No	No
b. The Verification report (VRPT) shall be in accordance with the DRD in Annex F.	No	No	No	No	No	No	No	No	No	No
c. The Verification report (VRPT) shall be submitted to the Verification Control Board (VCB) after the completion of the last contributing verification activities within the time frame agreed with the customer.	No	No	Yes	No	No	No	No	No	No	No
d. The supplier shall provide a Verification report (VRPT), for the reviews as agreed with the customer NOTE: Guidelines are in Annex G	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5.3.2.6 Other verification execution and reporting Document										
a. The supplier shall provide the Test specifications (TSPE) for the reviews as agreed with the customer NOTE: Guidelines are in Annex G.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
b. The Test specifications (TSPE) shall be in conformance with the DRD defined in Annex B of ECSS-E-ST-10-03.	No	No	No	No	No	No	No	No	No	No
c. The Test procedures shall be in conformance with the DRD defined in Annex D of ECSS-E-ST-10-03.	No	No	No	No	No	No	No	No	No	No
d. The supplier shall provide the Test procedures (TPRO) for the reviews as agreed with the	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
customer NOTE: Guidelines are in Annex G.										
e. The rules for the analysis, inspection and review of design shall be defined in writing before their execution. NOTE: For example, analysis, inspection or review of design procedures.	No	No	No	No	No	No	No	No	No	No
5.4 VERIFICATION CONTROL AND CLOSE-OUT										
5.4.1 General										
a. The implementation of the verification process shall be controlled by the Verification Control Board (VCB).	No	No	No	No	No	No	No	No	No	No
b. The verification process control shall be supported by a computer based verification database.	No	No	No	No	No	No	No	No	No	No
c. The verification database shall be delivered to the customer in an electronic form to be agreed with the customer	No	No	No	No	No	No	No	No	No	No
d. The supplier shall provide to the customer verification evidence for the customer's applicable requirements agreed to be verified, independently from the level where verification has been accomplished.	No	No	No	No	No	No	No	No	No	No
5.4.2 Verification control board (VCB)										

a.   A Verification Control Board (VCB), with participation of customer and supplier representatives, shall be established to incrementally assess the achievements and the status of the verification process.
        NOTE: The VCB is set-up in relation to the complexity and the extents of the
                 verification activities.
	No	No	No	No	No	No	No	No	No	No

b.   The verification process shall be considered completed when the Verification Control Board (VCB) confirms that:
    1   documented evidence is recorded in the VCD,
    2.   identified requirements have been verified
    3.   associated product verification objectives are reached
	No	No	No	No	No	No	No	No	No	No

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
c. The conclusions of the VCB shall be submitted for approval to the customer's contractual authority.	No	No	No	No	No	No	No	No	No	No
d. The Verification Control Board (VCB) shall assess the verification status with a periodicity agreed with the customer, along the project life cycle. NOTE: The results of the VCB are at least presented on the occasions of project reviews as defined in ECSS-M-ST-10.	No	No	No	No	No	No	No	No	No	No
e. The Verification Control Board (VCB) shall endorse the final issue of the Verification Control Document (VCD).	No	No	No	No	No	No	No	No	No	No
5.4.3 Re-verification										
a. The extent of the re-verification to be performed shall be determined by Supplier and agreed with the customer, in the following cases: 1. failure and repair as decided by Non-conformance Review Board (NRB); 2. unplanned disassembly or demating; 3. refurbishment, maintenance or design changes; 4. changes of requirements after initial verification; 5. long duration storage; 6. flight use of qualification hardware.	No	No	No	No	No	No	No	No	No	No
b. The Verification Control Document (VCD) shall be updated by the supplier to record as open, those requirements subject to re-verification until this is performed and closeout agreed by the customer.	No	No	No	No	No	No	No	No	No	No
5.4.4 Verification control and close-out documentation										
5.4.4.1 Verification Control Document (VCD)										
a. The content of the completed Verification Control Document (VCD) shall be in accordance with the DRD in Annex B.	No	No	No	No	No	No	No	No	No	No
b. The supplier shall update the Verification database within one week of the approval of a report.	No	Yes	Yes	No	No	No	No	No	No	No
c. The intermediate issues of the Verification Control Document (VCD), reflecting the	No	No	No	No	No	No	No	No	No	No

ECSS-E-ST-10-02C Verification Requirement	per Product/ Mission	per Phase	per Level	Specific product type						
				Space HW	Space SW	Space element	GSE	Launcher	Ground segment	Overall System
current status of the verification database, shall be made available to the Verification Control Board (VCB) upon request.										
d. The intermediate issues of the Verification Control Document (VCD), reflecting the current verification and compliance status, shall be delivered at each formal review as agreed with the customer NOTE: Guidelines are in Annex G.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
e. The final issue of the Verification Control Document (VCD) shall be submitted to the Verification Control Board (VCB) after the approval of the last report within the time frame agreed with the customer.	No	No	No	No	No	No	No	No	No	No
5.4.4.2 Other close-out documents										
a. The supplier shall make available to the customer for consultation the evidences mentioned in the VCD in addition to the deliverable reports.	No	No	No	No	No	No	No	No	No	No