

BS EN 16603-70:2015



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Space engineering — Ground systems and operations

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National foreword

This British Standard is the UK implementation of EN 16603-70:2015. It supersedes BS EN 14737-1:2004 and BS EN 14737-2:2004 which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/68, Space systems and operations.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Raumfahrtproduktsicherung - Bodensysteme und
Bodenbetrieb

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Foreword

This document (EN 16603-70:2015) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-70:2015) originates from ECSS-E-ST-70C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2015, and conflicting national standards shall be withdrawn at the latest by July 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document supersedes EN 14737-1:2004 and EN 14337-2:2004.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Ground systems and operations are key elements of a space system and play an essential role in achieving mission success. Mission success is defined here as the achievement of the target mission objectives as expressed in terms of the quantity, quality and availability of delivered mission products and services within a given cost envelope.

Mission success requires successful completion of a long and complex process covering the definition, design, production, verification, validation, post-launch operations and post operational activities, involving both ground segment and space segment elements. It involves technical activities, as well as human and financial resources, and encompasses the full range of space engineering disciplines. Moreover it necessitates a close link with the design of the space segment in order to ensure proper compatibility between these elements of the complete space system.

1

Scope

Within the framework of the overall engineering standards for space missions, this Standard contains the basic rules, principles and requirements applied to the engineering of the ground segment and mission operations, which form an integral part of the overall system implementing a space project.

This Standard also addresses the relationships between a customer and the ground segment supplier (GSS) and a customer and the operations supplier (OS).

The following topics are not considered:

- Ground systems (e.g. EGSE) and operations to support space segment verification which are covered within ECSS-E-ST-10-02.
- The launch segment and its operations.

This Standard has the following structure:

- definition of the ground segment and operations domain;
- requirements on ground segment engineering, i.e. the tasks required to design, implement and maintain a ground segment;
- requirements on operations engineering, i.e. the tasks required to prepare and carry out operations of a space project;
- identification of the relationships between the ground segment engineering and operations engineering processes and the space project lifecycle as defined in ECSS-M-ST-10.

This Standard may be tailored for the specific characteristics and constraints of a space project in conformance with ECSS-S-ST-00.

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system – Glossary of terms
EN 16603-10	ECSS-E-ST-10	Space engineering – System engineering general requirements
EN 16603-10-02	ECSS-E-ST-10-02	Space engineering – Verification
EN 16603-10-06	ECSS-E-ST-10-06	Space engineering - Technical specification
EN 16603-40	ECSS-E-ST-40	Space engineering – Software general requirements
EN 16601-40	ECSS-M-ST-40	Space project management – Configuration and information management
EN ISO 16091:2002	ECSS-M-ST-70	Space project management - Integrated logistic support
EN 16602-10-09	ECSS-Q-ST-10-09	Space product assurance - Nonconformance control system
EN 16602-80	ECSS-Q-ST-80	Space product assurance - Software product assurance

3

Terms, definitions and abbreviated terms

3.1 Terms defined in other standards

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply.

For the purpose of this Standard, the following terms and definitions from ECSS-E-ST-10 apply:

system engineering

For the purpose of this Standard, the terms and definitions from ECSS-E-ST-10-02 apply:

inspection

test

3.2 Terms specific to the present standard

3.2.1 **entity**

combination of ground systems and the associated personnel or operations organization

3.2.2 **ground segment operations**

activities related to the operations planning, execution and evaluation of the ground segment (or subsets thereof)

3.2.3 **ground segment**

ground systems necessary for the preparation or execution of mission operations

3.2.4 **ground segment customer**

party responsible for the procurement of the ground segment

NOTE The ground segment customer interfaces with the ground segment supplier through a customer-supplier relationship.

3.2.5 **ground segment supplier**

party responsible for the supply of the ground segment

3.2.6 ground system

integrated set of ground functions used to support the preparation activities leading up to mission operations or the conduct of mission operations itself

3.2.7 incident

in provision of a service, an enquiry, an observation or an anomaly, which relates to, causes or can cause, an interruption to, or a reduction in, the quality of the service

3.2.8 mission

specific objectives to be achieved by a space system as characterized by its expected products in terms of quantity, quality and availability

3.2.9 mission exploitation

activity consisting of the planning, generation, utilization and evaluation of the products of the space mission

3.2.10 mission information

information pertaining to the space segment and ground segment during the pre-launch and post-launch phases

NOTE 1 It typically includes space segment and ground segment design and operations characteristics, space segment and ground segment test and operations procedures, telemetry and telecommand characteristics.

NOTE 2 It is composed of source data originating from the operations customer and ground segment supplier and derived data produced by the operations teams.

3.2.11 mission operations

activities related to the operations planning, execution and evaluation of the combined space segment and ground segment during phases E and F of a space project

3.2.12 mission operations data

subset of the mission information used to execute the in-orbit operations

NOTE For example: Operations procedures, operations rules and monitoring and control databases.

3.2.13 mission products

products and services delivered by the space system

NOTE For example: Communications services, science data.

3.2.14 operational validation

test activities whose objective is to establish the readiness of the complete ground segment, including mission operations data, and operations personnel to support the space mission in-orbit by means of simulations and rehearsals

NOTE The completion of the operational validation process results in a qualified ground segment.

3.2.15 operations customer

party responsible for the procurement of the operations of the space segment and ground segment

NOTE 1 The operations customer interfaces with the operations supplier through a customer-supplier relationship.

NOTE 2 The operations customer and the ground segment customer are usually the same entity.

3.2.16 operations supplier

party responsible for the preparation and execution of space segment operations and ground segment operations

3.2.17 space segment operations

activities related to the operations planning, execution and evaluation of the space segment (or subsets thereof) when in orbit

3.2.18 synthetic parameter

parameter derived from telemetry and other data via an algorithm

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
ABM	apogee boost motor
AIT	assembly, integration and test
AOCS	attitude and orbit control subsystem
ATV	automated transfer vehicle
CCSDS	Consultative Committee for Space Data Systems
CFISRD	customer furnished items and services requirements document
COTS	commercial off-the-shelf
CRR	customer requirements review
DFT	data flow test
DRD	document requirements definition

EEPROM	electrically erasable programmable read-only memory
EGSE	electrical ground support equipment
ELR	end-of-life review
EM	engineering model
FAT	factory acceptance testing
FDIR	failure detection, isolation and recovery
FM	flight model
FMEA	failure modes and effects analysis
FMECA	failure modes, effects and criticality analysis
FQR	flight qualification review
FRR	flight readiness review
FS	functional specification
FTA	fault tree analysis
GEO	geostationary orbit
GS	ground segment
GSAITP	ground segment AIT plan
GSC	ground segment customer
GSCDR	ground segment critical design review
GSCRD	ground segment customer requirements document
GSDDF	ground segment design definition file
GSDJF	ground segment design justification file
GSEP	ground segment engineering plan
GSPDR	ground segment preliminary design review
GSQR	ground segment qualification review
GSRD	ground segment requirements document
GSSRR	ground segment system requirements review
GSS	ground segment supplier
GSVP	ground segment verification plan
HCI	human–computer interaction
I/F	Interface
I/O	input/output
ICD	interface control document
IOOR	in–orbit operations review
ISS	International Space Station
LAN	local area network
LEO	low-Earth orbit
LEOP	launch and early orbit phase

LIT	listen-in test
LS	logistic support
LSP	logistics support plan
MAR	mission analysis report
MCR	mission close-out review
MDD	mission description document
MOCD	mission operations concept document
MOP	mission operations plan
MRT	mission readiness tests
OAR	operations anomaly report
OBDH	on-board data handling
OBSM	on-board software maintenance
OBSW	on-board software
OC	operations customer
OCRD	operations customer requirements document
OEP	operations engineering plan
OPS	operations
OQR	operational qualification review
ORR	operational readiness review
OS	operations supplier
OTP	operations training plan
OVP	operational validation plan
PCC	payload control centre
PDR	preliminary design review
PLUTO	procedure language for users in test and operations
PROM	programmable read-only memory
PRR	preliminary requirements review
PUS	packet utilization standard
RAM	random access memory
REP	report
RF	radio frequency
ROM	read-only memory
SGICD	space-to-ground interface control document
SPEC	specification
SPR	software problem report
SSC	space system customer
SSORD	space segment operability requirements document

SSS	space segment supplier
SSM	space system model
SSUM	space segment user manual
SVT	system validation test
TS	technical specification
TT&C	telemetry, tracking and command

4

Ground segment and operations domain

4.1 Overview

The domain of ECSS-E-ST-70 is shown in Figure 4-1 and is composed of two main components:

- **The ground segment** comprising all ground systems that are used to support the preparation activities leading up to mission operations, the conduct of operations themselves and all post-operational activities.
- **Operations organizations** comprising the human resources undertaking the mission preparation and mission operations tasks.

An entity is the combination of an operations organization and associated ground systems.

NOTE Examples:

- A control centre from which the elements of an operations organization control an element of the mission such as a space segment or ground station. In the case of space segment control, an element of the operations organization is the mission control team that uses the operations control system.
- A ground station and its operations and maintenance staff.

4.2 Operations organization

Operations organizations are comprised of teams. The composition, responsibilities and management of these teams varies between organizations and over time. The following personnel are typically involved in the teams:

- Operations managers;
- Spacecraft operators (astronauts, operations engineers, spacecraft analysts, spacecraft controllers);
- Payload operators (e.g. payload specialists, PIs);
- Mission planners;
- Flight dynamics engineers;
- Ground systems operators;

- Mission exploitation personnel (e.g. scientific/algorithm experts, end-user community liaison staff, product generation support staff);
- Ground systems maintenance engineers.

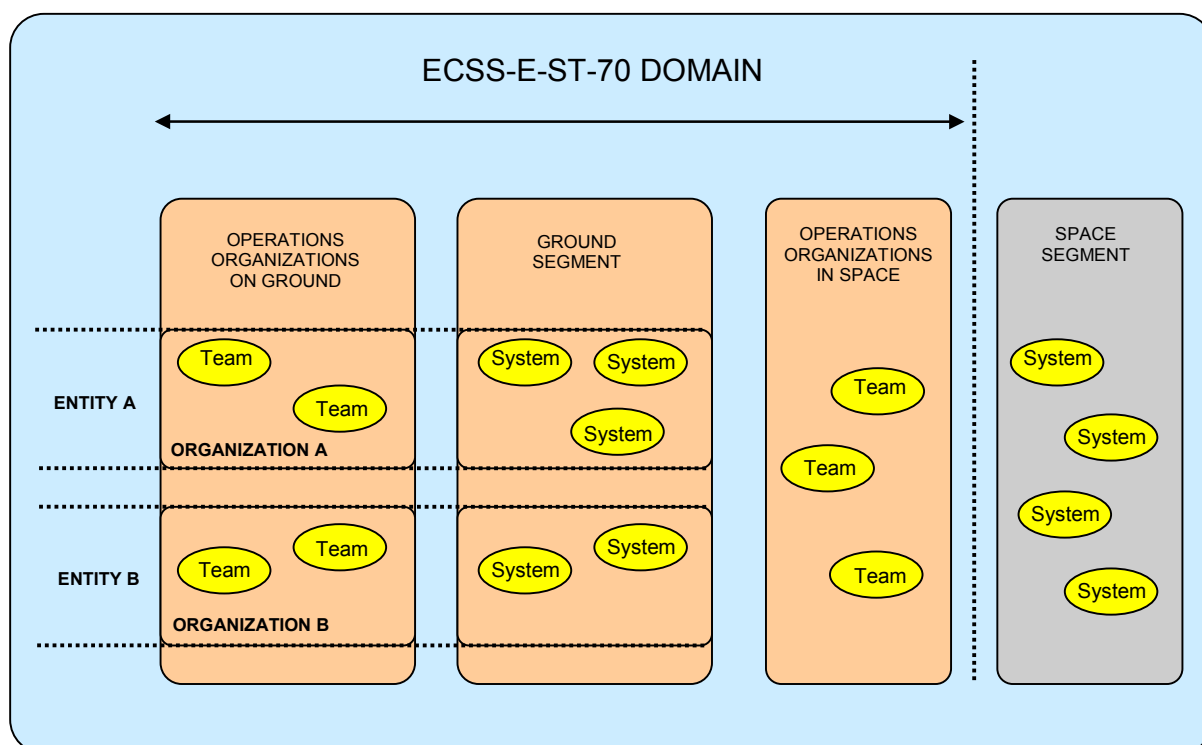


Figure 4-1: The ECSS-E-ST-70 domain

4.3 Ground systems

4.3.1 Introduction

The ground segment, as shown in Figure 4-2, typically consists of the following top-level systems which can be distributed across various centres depending on the chosen ground segment architecture:

- Mission operations system;
- Payload operations and data system;
- Ground station system;
- Ground communications system.

These top-level systems are further broken down during the design process.

4.3.2 Mission operations system

The mission operations system typically supports the following:

- Mission analysis;
- Operations preparation;

- Simulation;
- Mission planning and scheduling;
- Monitoring and control;
- Flight dynamics;
- On-board software maintenance and management;
- Data archiving;
- User services;
- Data product delivery;
- Performance analysis and reporting;
- Configuration management (space segment, ground segment, mission information);
- System maintenance.

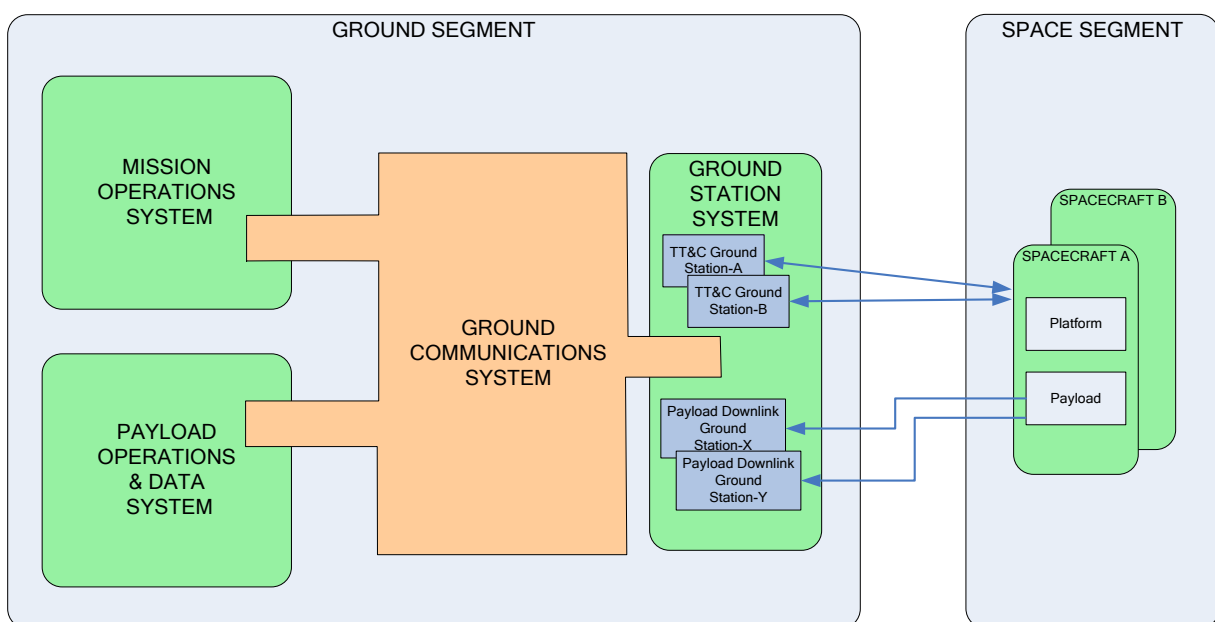


Figure 4-2: Ground segment systems

4.3.3 Payload operations and data system

The payload operations and data system is used to exploit the mission products and typically supports:

- Payload operations analysis;
- Payload operations preparation;
- Simulation;
- Payload operations planning and scheduling;
- Payload operations control;
- Payload data processing;
- Payload data archiving;
- User services;
- Data product delivery;

- Performance analysis and reporting;
- Algorithm tuning and development, verification and validation;
- System maintenance.

4.3.4 Ground station system

The ground station system provides the physical link with the space segment while in-orbit. The following are supported, where applicable:

- Telemetry reception, storage and distribution;
- Telecommand transmission;
- Tracking, ranging, Doppler and meteorological data acquisition;
- Station monitoring and control;
- Time management;
- Network management and scheduling;
- Data distribution;
- System maintenance.

4.3.5 Ground communications system

The ground communications system provides the interconnections between systems, for example between ground stations and mission control facilities. The following are supported, where applicable:

- Data distribution;
- Voice and video communication;
- System maintenance.

4.4 Engineering processes

Two major engineering disciplines are involved in ground systems procurement and operations:

- Operations engineering which encompasses activities involved in the preparation and execution of mission operations;
- Ground segment engineering which comprises the activities involved in the definition, design, production, AIT and verification and maintenance of the ground segment for a specific mission.

These are presented as separate process chains, however there are many links between them which imply close cooperation between the two disciplines starting at the definition/requirements phase. Both engineering disciplines contribute to the definition of requirements for the space segment as well as to the review of the on-board design.

4.5 Critical areas

In order to cost-effectively ensure mission success, this Standard covers the coordination established during the phases of the space system project, between space and ground segment, and between ground segment entities, as these are often under different responsibilities. Critical areas include:

- Definition of overall mission concepts at space system level with due consideration being given to ground segment and operations aspects;
- Spacecraft operability and maintainability;
- Adequacy of inputs delivered by the operations customer (OC) to the mission operations teams;
- End-to-end validation of the complete space system;
- Re-use, to the maximum possible extent, of space segment operations knowledge and data (e.g. telemetry and telecommand definitions procedures) between space segment design, space segment AIT and mission operations;
- Commonality between processes and services of the ground segment and also between space segment AIT and mission operations;
- Security and safety;
- Ground and space-to-ground communications design and cost.

These areas are taken into account in the definition of the ground segment engineering and operations engineering activities, as appropriate.

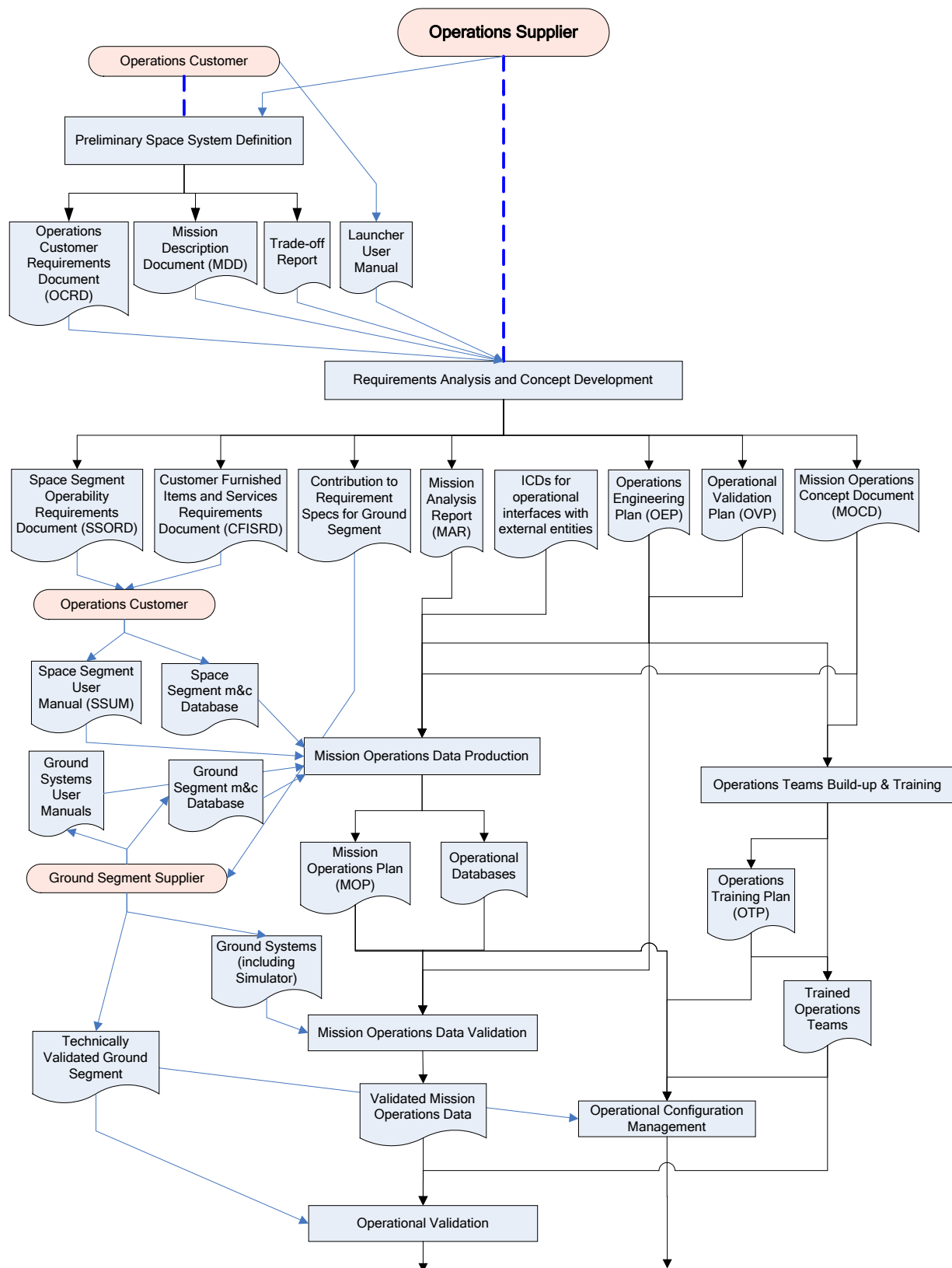
Operations engineering

5.1 Overview

Figure 5-1 shows the main operations engineering processes, which are:

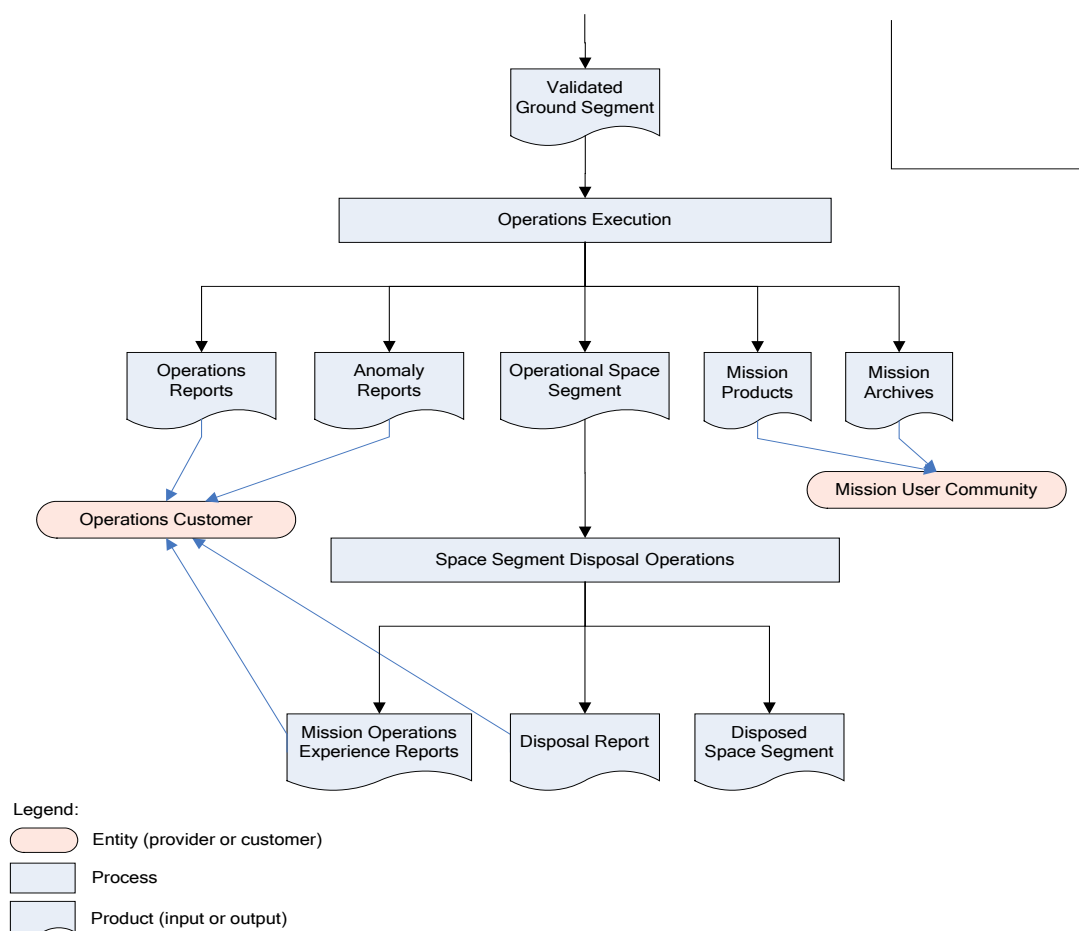
- Requirements analysis and concept development;
- Mission operations data production;
- Mission operations data validation;
- Operations teams build-up and training;
- Operational validation;
- Operational configuration management;
- Operations execution (LEOP, commissioning, routine phase operations);
- Space segment disposal operations.

NOTE Operations engineering covers operation of both the space segment and ground segment.



PART 1/2

Figure 5-1: Schematic of operations engineering process



PART 2/2

Figure 5-1: Schematic of operations engineering process (Cont'd)

5.2 Requirements analysis and concept development

5.2.1 Inputs

- The inputs to the requirements analysis and concept development process shall be the ones specified in Table 5-1.

NOTE 1 The production of the OCRD, MDD and trade-off report are space system level phase 0 activities for which both ground segment engineering and operations engineering expertise is needed.

NOTE 2 The mission description document contains the mission analysis, system description and operations scenarios (for each considered mission concept).

NOTE 3 The trade-off report provides a summary of the different mission concepts considered at space system level, the criteria used to assess them and the justification for the selected solution.

NOTE 4 The mission description document and trade-off report are defined in ECSS-E-ST-10.

Table 5-1 Inputs to the requirements analysis and concept development process

ID	Title	Mnemonic	Provider
1	Operations customer requirements document	OCRD	Operations customer
2	Mission description document	MDD	Operations customer
3	Trade-off report		Operations customer
4	Launcher user manual		Operations customer

- b. The contents of the operations customer requirements document (OCRD) shall be in conformance with Annex A.

NOTE 1 The OCRD corresponds to the “Initial technical specification” (TS) of ECSS-E-ST-10-06, tailored for the operations domain.

NOTE 2 The operations customer consults with the end-user community to ensure that its requirements are appropriately captured in the OCRD.

5.2.2 Process description

5.2.2.1 Mission analysis

- a. Mission analysis shall characterize the following aspects:

1. Launcher constraints.
2. Ground station characteristics.
3. Spacecraft constraints.
4. Mission-specific constraints.

NOTE For example: Station-keeping window for geostationary spacecraft, orbit phasing for low-Earth-orbiting (LEO) spacecraft).

5. Payload constraints.
6. Data flow constraints.

NOTE 1 Mission analysis provides information about how the mission is flown, in sufficient detail for the planning and execution of mission operations.

NOTE 2 Mission analysis also provides input to the spacecraft and mission design.

NOTE 3 The mission analysis process is carried out in cooperation with the space segment supplier's operations team.

- b. The mission analysis shall supply the following information:
 - 1. Launch window prediction.
 - 2. Spacecraft and launch vehicle separation sequence.
 - 3. Launch target orbit.
 - 4. Positioning or manoeuvring strategy.
 - 5. Orbit determination concept and navigation analysis (station selection, data types, tracking schedule).
 - 6. Schedule of operational events (covering both nominal scenarios and planned contingencies), from which the detailed operations schedules used to execute the mission are derived.
 - 7. Ground station coverage.
 - 8. Detailed analysis of high risk sequences.
 - 9. Risk of interference with spacecraft already in operation.
 - 10. Delta-V budget.
 - 11. Impact of space environment on operational sequences.
 - NOTE For example: Sensor blinding, eclipses.
 - 12. Payload operations strategy.
 - 13. Data circulation scheme.
- c. The output of the mission analysis shall be the mission analysis report (MAR) in conformance with Annex B.

5.2.2.2 Operational analysis and concept development

- a. Operational analysis shall consist of the following:
 - 1. Assess the consistency and completeness of the customer requirements.
 - 2. Assess the operational feasibility of the mission.
 - 3. Identify the main drivers for the development of the mission operations concept.
 - 4. Define the mission operations concept and derive requirements for the corresponding operations engineering activities and the supporting ground segment (and any necessary in-orbit infrastructure).
 - 5. Contribute to the definition of ground segment internal and external interfaces (and any necessary in-orbit infrastructure).
- b. The output of these tasks shall be the mission operations concept document (MOCD) in conformance with Annex C.

5.2.2.3 Operational interfaces definition

- a. Space segment operability requirements shall be identified to ensure that the space segment can be operated during nominal situations and foreseeable contingency situations, in accordance with the mission requirements and objectives in terms of the quantity, quality and availability of mission products.
- b. The space segment operability requirements identified in clause 5.2.2.3a. shall be compiled in the space segment operability requirements document (SSORD).

NOTE ECSS-E-ST-70-11 defines space segment operability requirements for various classes of space missions. The SSORD is a tailored version of this standard.

- c. The on-board mission operations services shall be defined, in consultation with the operations customer, together with their capability sets and the corresponding service requests (telecommands) and service reports (telemetry).

NOTE ECSS-E-ST-70-41 defines a number of standard on-board mission operations services covering the requirements of various classes of space missions and can be tailored for this purpose. Alternatively, a standalone document can be produced defining the services deployed for the mission or they can be included in the SGICD.

- d. Operational interfaces with external entities shall be identified and documented in “operational ICDs” including:
 - 1. Information on points of contact.
 - 2. Type and availability of services that can be expected on both sides of the interface.
 - 3. Format and method of data exchanges.
- e. Operational ICDs shall subsequently form part of the MOP (see clause 5.3).
- f. Deliverable items and support services from the OC throughout the ground segment life cycle shall be identified in the Customer Furnished Items and Services Requirements Document (CFISRD) including requirements for the delivery of the following:
 - 1. Space segment documents and information used in the implementation of the ground segment and subsequent mission operations.

NOTE For example: Space segment user manual (SSUM), space segment detailed design documents, spacecraft monitoring and control database.

- 2. Procedures applicable for in-orbit operations validated during the space segment AIT programme.

3. Provision of representative space segment telemetry and telecommand data samples (including payload data).
4. Provision of suitcase for testing compatibility between space segment TT&C and ground stations.
5. Access to the space segment when on ground, for the validation of the compatibility between the ground and space segments.
6. Support to, or supply of, the operational simulator and space segment models, along with test and training tools used for the validation of the ground segment.
7. Provision of on-board software and associated documentation.
8. Data processing tools to be incorporated into the mission operations system.

NOTE For example, data decommutation for mission-specific telemetry encoding, derived parameter algorithms.

9. Software development environment, validation tools such as validation test benches, documentation and engineering support used for the maintenance of the on-board software during operations execution.
10. Provision of space segment engineering support for the ground segment design phases (in particular testing and support to ground segment reviews) and during phases E and F.
11. Provision of space segment engineering support for the in-orbit control of the mission during designated phases.
12. Provision of site infrastructure.

NOTE 1 For example, accommodation of operations staff when working at payload or space segment suppliers' sites.

NOTE 2 The OC is the conduit to the operations supplier (OS) for external deliverable items and services even though these can originate from other parties e.g. the space segment supplier (SSS).

- g. The contents of the CFISRD shall be in conformance with Annex J.
- h. Contributions from both operations engineering and ground segment engineering expertise shall be provided for the definition of space segment interfaces.

5.2.2.4 Operations engineering plan production

- a. An operations engineering plan (OEP) shall be developed describing the following:
 1. The detailed schedule for the production and validation of mission operations data.

2. The mission operations team organisation for both the operations preparation and operations execution phases.
3. The recruitment profile for the mission operations team, showing how staff are phased-in (and out) and identifying any potential time-sharing or role-sharing with other concurrent missions.
4. The contents of the OEP shall be in conformance with Annex D.

NOTE 1 The purpose of the OEP is to provide all the technical information needed to cost the operations manpower and to provide the basis for the timely recruitment of the mission operations team.

NOTE 2 Where the ground segment supplier and operations supplier belong to the same organization, the ground segment engineering plan (GSEP, see clause 6.2.2.3) and the OEP can be combined into a single document.

5.2.2.5 Contribution to ground segment and ground systems requirements specification

- a. User requirements shall be produced for the ground segment and for each ground segment system.

NOTE 1 The partitioning of the ground segment into ground systems is part of the ground segment design engineering process (see clause 6.2.2.3)

NOTE 2 These requirements are an elaboration of, or are complementary to, those contained in the OCRD

- b. User requirements shall be produced for tools to be used for system and mission operations data validation and training and simulation purposes.
- c. User requirements shall address operational aspects including the following:

1. The functionality and performance of the ground systems in order to plan, schedule, monitor and control, and evaluate the performance of the space and ground segments.
2. Automation requirements reflecting the operations concept and staffing profiles foreseen for different mission phases.
3. Operations centralization and decentralization aspects.

NOTE For example, remote monitoring and control.

4. User management.

NOTE For example, login, privileges.

5. HCI considerations.

5.2.2.6 Operational validation plan production

- a. An operational validation plan (OVP) shall be produced for the operational validation of the ground segment systems and the mission operations data.
- b. The OVP shall cover:
 1. Test preparation activities.
 2. Technical and managerial resources used for execution of the tests.
 3. Test strategies, methods and scenarios.
 4. Test pass or fail criteria.
 5. Post-test activities.

NOTE For example, reporting, handling of non-conformances.

- c. The contents of the OVP shall be in conformance with Annex F.

5.2.3 Outputs

- a. The outputs of the requirements analysis and concept development process shall be the ones specified in Table 5-2.

Table 5-2: Outputs of the requirements analysis and concept development process

ID	Title	Mnemonic	Producer
1.	Mission analysis report	MAR	Operations supplier
2.	Mission operations concept document	MOCD	Operations supplier
3.	Space segment operability requirements document	SSORD	Operations supplier
4.	Customer furnished items and services requirements document	CFISRD	Operations supplier
5.	ICDs for operational interfaces with external entities		Operations supplier
6.	Operations engineering plan	OEP	Operations supplier
7.	User requirements for the ground segment and the ground segment systems including validation, training and simulation tools (part of the corresponding requirements specifications)		Operations supplier
8.	Operational validation plan	OVP	Operations supplier

5.3 Mission operations data production

5.3.1 Inputs

- a. The inputs to the mission operations data production process shall be the ones specified in Table 5-3.
- b. The space segment user manual (SSUM) contents shall conform to Annex E.

NOTE The SSUM includes information used for the operation of the space segment and essential inputs for the design of the ground segment.

Table 5-3: Inputs to the mission operations data production process

ID	Title	Mnemonic	Provider
1	Mission analysis report	MAR	Operations supplier
2	Mission operations concept document	MOCD	Operations supplier
3	ICDs for operational interfaces with external entities		Operations supplier
4	Space segment user manual	SSUM	Operations customer
5	Space segment detailed design documents		Operations customer
6	Space segment monitoring and control database		Operations customer
7	Ground systems user manuals		Ground segment supplier
8	Ground segment monitoring and control database		Ground segment supplier
NOTE Some inputs to operations engineering processes come from ground segment engineering (see clause 6) and vice-versa.			

5.3.2 Process description

- a. Information for the in-orbit monitoring and control of the space segment (including payload/on-board instruments) and for the monitoring and control of the supporting ground segment shall be documented in the mission operations plan (MOP).

NOTE For example, procedures, rules, plans and schedules.

- b. The MOP shall include the following information:
 1. Definition of the operational organization and responsibilities, of the decision making process, and of the major mission rules;

2. The sequence of main mission events for all critical mission phases, including ground stations visibility and major space segment operations;
3. Operations schedules for all mission critical operations defining the timed sequence of:
 - (a) operational activities executed by each operations team member;
 - (b) the interfaces with other team members, the interfaces with external entities (including, for ground entities, the identification of the configuration);
 - (c) the constraints and dependencies with respect to external events.

NOTE For example, critical mission operations include phases such as LEOP, commissioning and also include mission-specific operations such as planetary fly-bys and orbit insertions.

4. Operations procedures covering nominal and contingencies operations for both the space segment and ground segment.
 5. Procedures for space and ground segment disposal.
- c. Where a given entity is operated independently, the operations for that entity should be contained in a sub-plan of the MOP.
 - d. Each operations procedure shall include the level of authorization needed for performing the procedure, its applicability, the execution conditions and constraints (pre, during and post execution).
 - e. Space segment operations procedures shall be established by expanding the procedures provided by the OC in the SSUM to include ground-segment-specific aspects.
 - f. The monitoring and control databases of the ground systems shall be populated with the mission-specific data used to drive monitoring and control processing for both the space and ground segments.

NOTE This includes mission planning data, on-board control procedures (OBCPs), telemetry and telecommand definitions, display definitions, on-board software images and patches.

- g. Mission exploitation operations data shall be established.

NOTE This includes data/product processing databases, data dissemination user databases.

- h. For flight dynamics, a schedule of activities shall be established indicating the flight dynamics events in the context of the MOP events.
- i. Before formal delivery to the OS, the OC shall ensure that the inputs provided by the OC undergo verification against representative models of the space segment.
- j. The verification mentioned in requirement 5.3.2i shall be applied to at least:

1. the space segment monitoring and control database, and
 2. the space segment procedures contained in the SSUM.
- k. The contents of the MOP shall be in conformance with Annex G.
1. The contents of operations procedures shall be in conformance with Annex I.

5.3.3 Outputs

- a. The outputs of the mission operations data production process shall be the ones specified in Table 5-4.

Table 5-4: Outputs of the mission operations data production process

ID	Title	Mnemonic	Producer
1	Mission operations plan	MOP	Operations supplier
2	Space segment monitoring and control database		Operations supplier
3	Ground segment monitoring and control database		Operations supplier

5.4 Mission operations data validation

5.4.1 Inputs

- a. The inputs to the mission operations data validation process shall be the ones specified in Table 5-5:

Table 5-5: Inputs to the mission operations data validation process

ID	Title	Mnemonic	Provider
1	Mission operations plan	MOP	Operations supplier
2	Space segment monitoring and control database		Operations supplier
3	Ground segment monitoring and control database		Operations supplier
4	Operational validation plan	OVP	Operations supplier
5	Ground systems (monitoring and control elements)		Ground segment supplier
6	Operational simulator		Ground segment supplier

5.4.2 Process description

- a. Mission operations data shall be validated.

NOTE 1 The validation of the mission operations data demonstrates the correctness of the data and its compatibility with the space segment.

NOTE 2 For some data, verification by inspection is sufficient (e.g. parameter descriptions, non-testable procedures).

- b. Validation shall use test tools representative of the space segment design.

NOTE The major test tool is an operational simulator.

- c. Validation shall be performed using a flight representative space segment, invoking all:

1. Operations procedures and telecommands.
2. Operational modes of the spacecraft (including non-nominal modes).
3. Spacecraft redundancies;

NOTE 1 Subject only to the limitations imposed whilst operating space segment elements on the ground.

NOTE 2 The tests supporting this validation are sometimes referred to as System Validation Tests (SVTs).

- d. The results of validation tests and the status of validation of each data item shall be reported and recorded.

5.4.3 Outputs

- a. The outputs of the mission operations data validation process shall be the ones specified in Table 5-6.

Table 5-6: Outputs of the mission operations data validation process

ID	Title	Mnemonic	Producer
1	Operations data validation test reports		Operations supplier
2	Validated mission operations data		Operations supplier

5.5 Operations teams build-up and training

5.5.1 Inputs

- a. The inputs to the operations teams build-up and training process shall be the ones specified in Table 5-7:

Table 5-7: Inputs to the operations teams build-up and training process

ID	Title	Mnemonic	Provider
1	Mission analysis report	MAR	Operations supplier
2	SSUM	SSUM	Operations customer
3	Mission operations concept document	MOCD	Operations supplier
4	Mission operations plan	MOP	Operations supplier
5	Ground systems user manuals		Ground segment supplier
6	Verified ground segment ready for operational validation		Ground segment supplier
7	Operational simulator		Ground segment supplier
8	Validated mission operations data		Operations supplier

5.5.2 Process description

- a. The operations of the mission and of the supporting ground segment shall be carried out by teams.

NOTE A typical organization comprises:

- Mission control team, in charge of the overall control of the mission and of its space segment.
- Flight dynamics team, providing support to the mission control team for orbit and attitude determination, prediction of orbit and orbital events, preparation of orbital and attitude manoeuvres and calibration of attitude sensors.
- Ground operations teams, in charge of the operations and maintenance of the supporting entities (e.g. ground stations, ground communications subnet, mission control centre).
- Mission exploitation team, in charge of the planning and processing and distribution of payload data and related ancillary data.
- Ground segment support teams, composed of ground systems experts providing support to the ground operations teams.
- Space segment support team, composed of space segment experts providing support to the mission control team.

- b. Roles and responsibilities shall be defined, for each team member, for each mission phase.
- c. The operations teams shall be assigned and trained such that they are familiar with the mission and the supporting facilities before the start of operational validation.
- d. The training programme shall be documented in the operations training plan (OTP).
- e. Training shall comprise theoretical and practical training including realistic simulations, rehearsals of operational scenarios and contingency cases for the ground segment and the space segment.
- f. Training records shall be maintained for each team member.

5.5.3 Outputs

- a. The outputs of the operations teams build-up and training process shall be the ones specified in Table 5-8.

Table 5-8: Outputs of the operations teams build-up and training process

ID	Title	Mnemonic	Producer
1	Operations training plan	OTP	Operations supplier
2	Fully manned and trained operations teams		Operations supplier
3	Training records		Operations supplier

5.6 Operational validation

5.6.1 Inputs

- a. The inputs to the operations validation process shall be the ones specified in Table 5-9.

Table 5-9: Inputs to the operations validation process

ID	Title	Mnemonic	Provider
1	Verified ground segment ready for operational validation		Ground segment supplier
2	Operational simulator		Ground segment supplier
3	Validated mission operations data		Operations supplier
4	Validated mission operations plan	MOP	Operations supplier
5	Fully manned and trained operations teams		Operations supplier
6	Operational validation plan	OVP	Operations supplier