EUROPEAN COOPERATION

E CSS

FOR SPACE STANDARDIZATION

Space engineering

Ground systems and operations

ECSS Secretariat
ESA-ESTEC
Requirements & Standards Division
Noordwijk, The Netherlands

Foreword

This Standard is one of the series of ECSS Standards intended to be applied together for the management, engineering and product assurance 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. Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

This Standard has been prepared by the ECSS-E-ST-70C Working Group, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

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Change log

ECSS-E-70 Part 1A 25 April 2000 and ECSS-E-70 Part 2A 2 April 2001	First issues
ECSS-E-70B	Never issued
ECSS-E-ST-70C 31 July 2008	The present version (ECSS-E-ST-70C) is the evolution of ECSS-E-70 Part 1A "Ground systems and operations - Principles and requirement" and ECSS-E-70 Part 2A "Ground systems and operations - Document requirements definition", which are published now together in the present document. The following is a summary of the main changes: • **Process approach** In contrast to the phase-based approach of ECSS-E-70A, ECSS-E-ST-70C follows a rigorous process approach including: — Separation of operations engineering processes and ground segment engineering processes, with identification of the disciplines of Operations Engineering and Ground Segment Engineering — A projection of these processes on to an ECSS-M-10 model to capture lifecycle aspects of ECSS-E-ST-70C and relationships with the space system lifecycle. • **Procurement models** Like ECSS-E-70A is based on the Customer – Supplier concept of ECSS-S-ST-00. In line with the identification of major processes operations engineering and ground segment engineering; ECSS-E-ST-70C further identifies separate customer supplier relationships for each. It also acknowledges that there may be different procurement models, for example: — Operations supplier and ground segment supplier belong to same organisation. — Operations supplier may be a different entity from the ground segment supplier.

- **Harmonization with ECSS-E-ST-10C System engineering**

  ECSS-E-ST-70C is now consistent with the E-ST-10 series of standards: it makes cross-reference to E-ST-10 processes, where applicable to the GS development. It in general uses the same terminology for processes, documents and reviews.

- **Interfaces to spacecraft design/manufacture**

  The interfaces between spacecraft design/manufacture and ground segment engineering/operations engineering were reviewed, the main consequence being the addition of a new Document Requirements Definition, the CFISRD (see below).

- **Reference architecture**

  In contrast to E-70A, no reference architecture is assumed for the ground segment. Major generic ground segment functions are identified with no presumption on how they are grouped or distributed.

- **Document Requirements Definitions**

  The presentation of Document Requirements Definition has been brought into line with the latest guidelines from ECSS, and the Document Requirements Definition are included as normative annexes to ECSS-E-ST-70C.

- **The following new DRDs are provided:**

  — Mission analysis report (MAR)

  — Mission operations plan (MOP)

  — Customer furnished items and services requirements document (CFISRD)

  — Operations engineering plan (OEP)

  — Ground segment system engineering plan (SEP).

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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.

2
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.

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-10-06	Space engineering - Technical specification
ECSS-E-ST-40	Space engineering – Software general requirements
ECSS-M-ST-40	Space project management – Configuration and information management
ECSS-M-ST-70	Space project management - Integrated logistic support
ECSS-Q-ST-10-09	Space product assurance - Nonconformance control system
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.
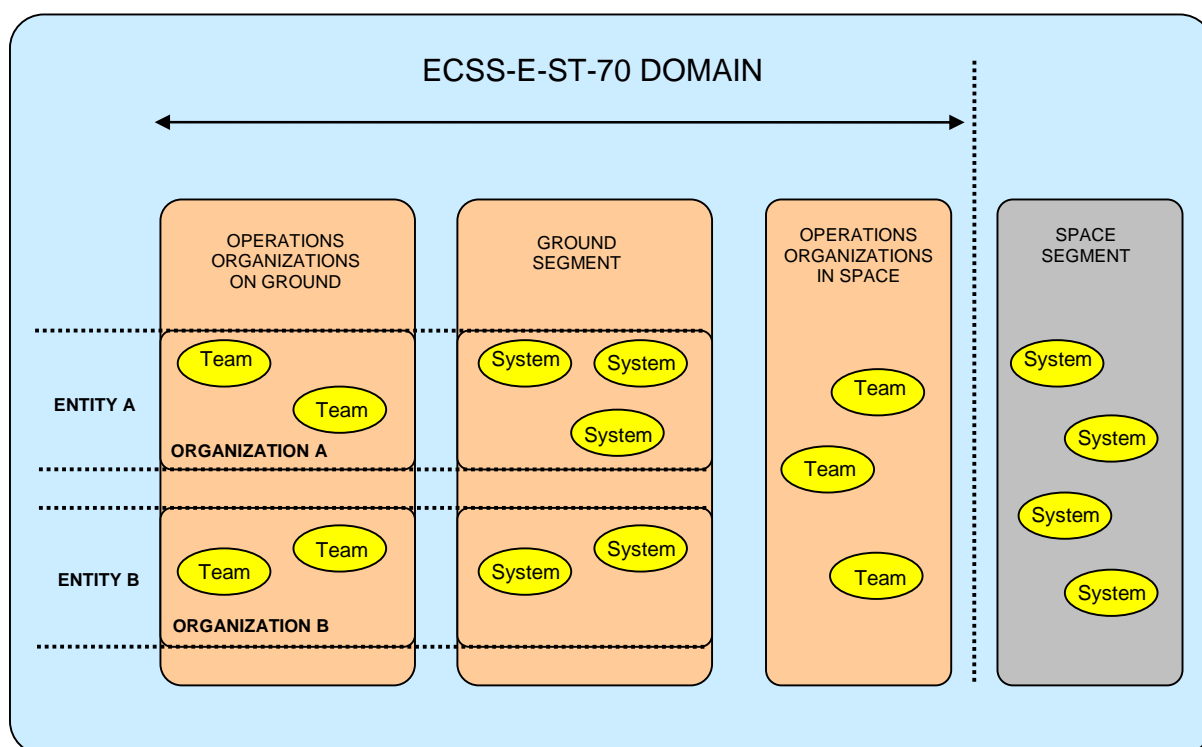
Figure 4-1: The ECSS-E-ST-70 domain

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.
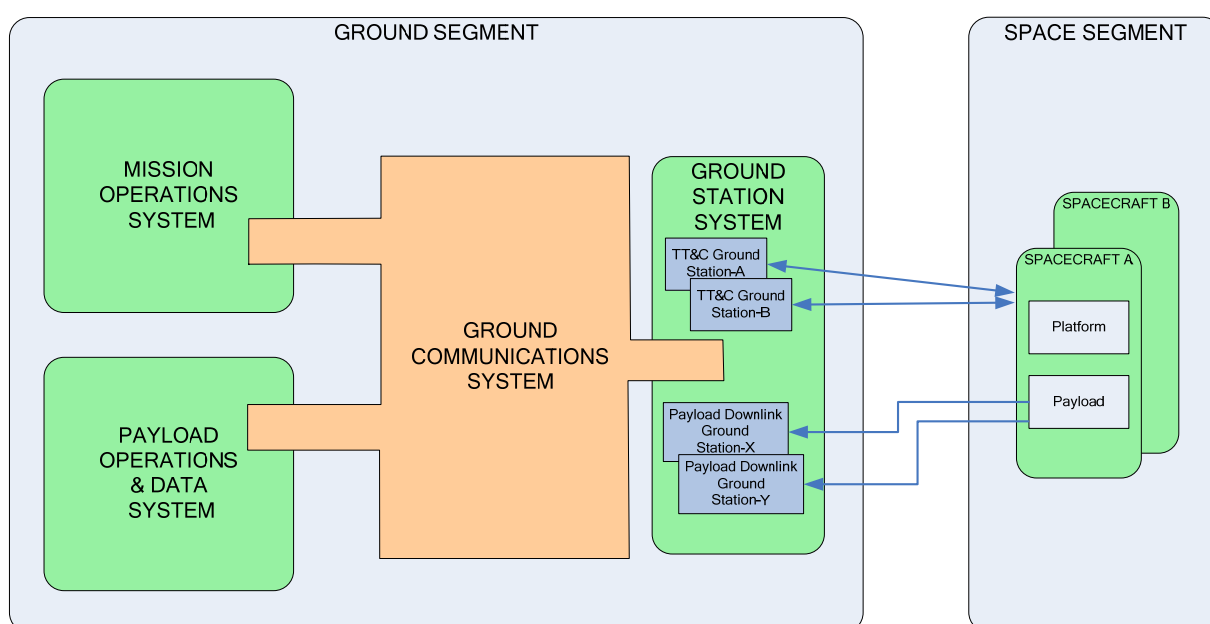
Figure 4-2: Ground segment systems

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.

5
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.
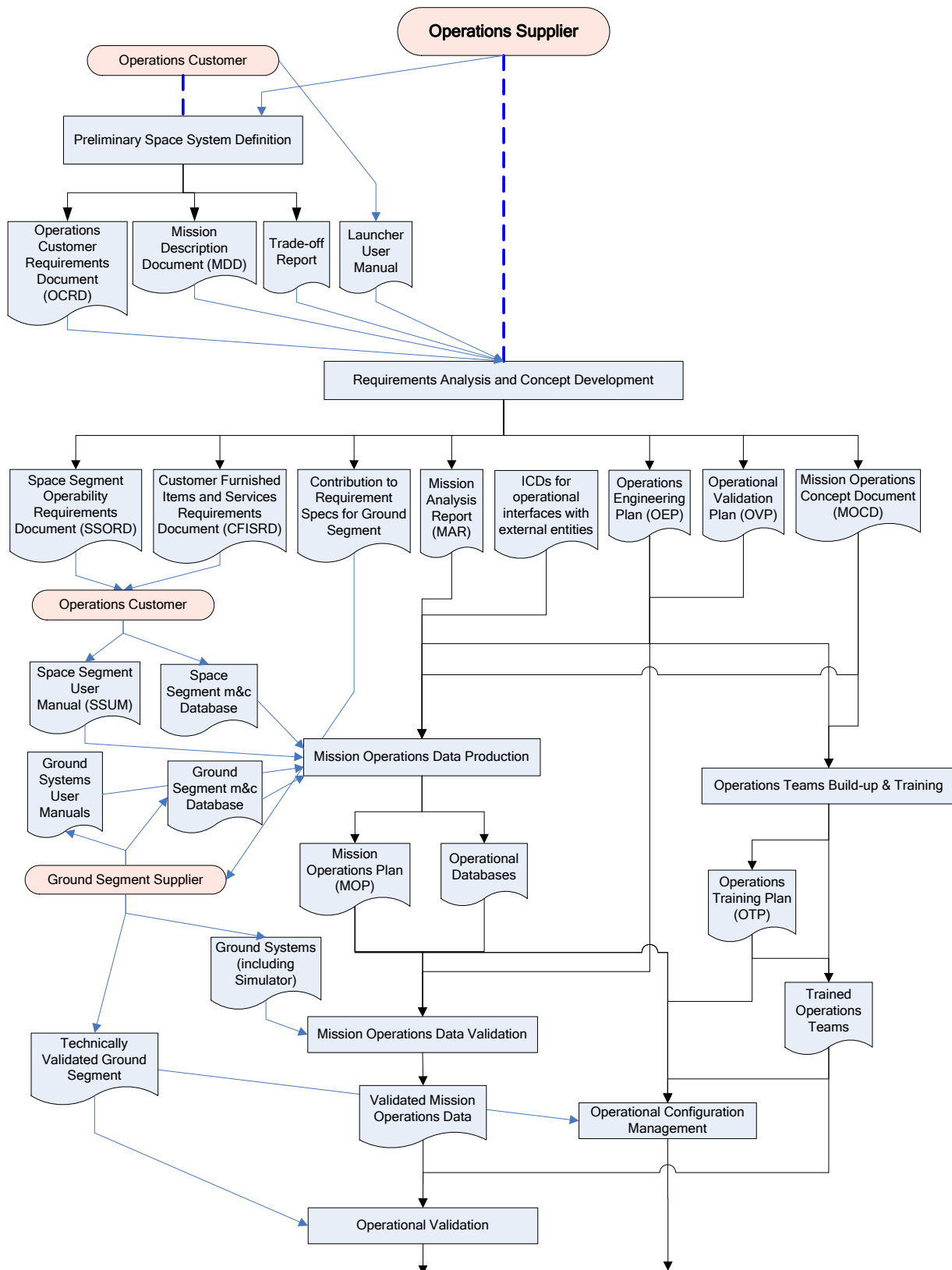
PART 1/2

Figure 5-1: Schematic of operations engineering process
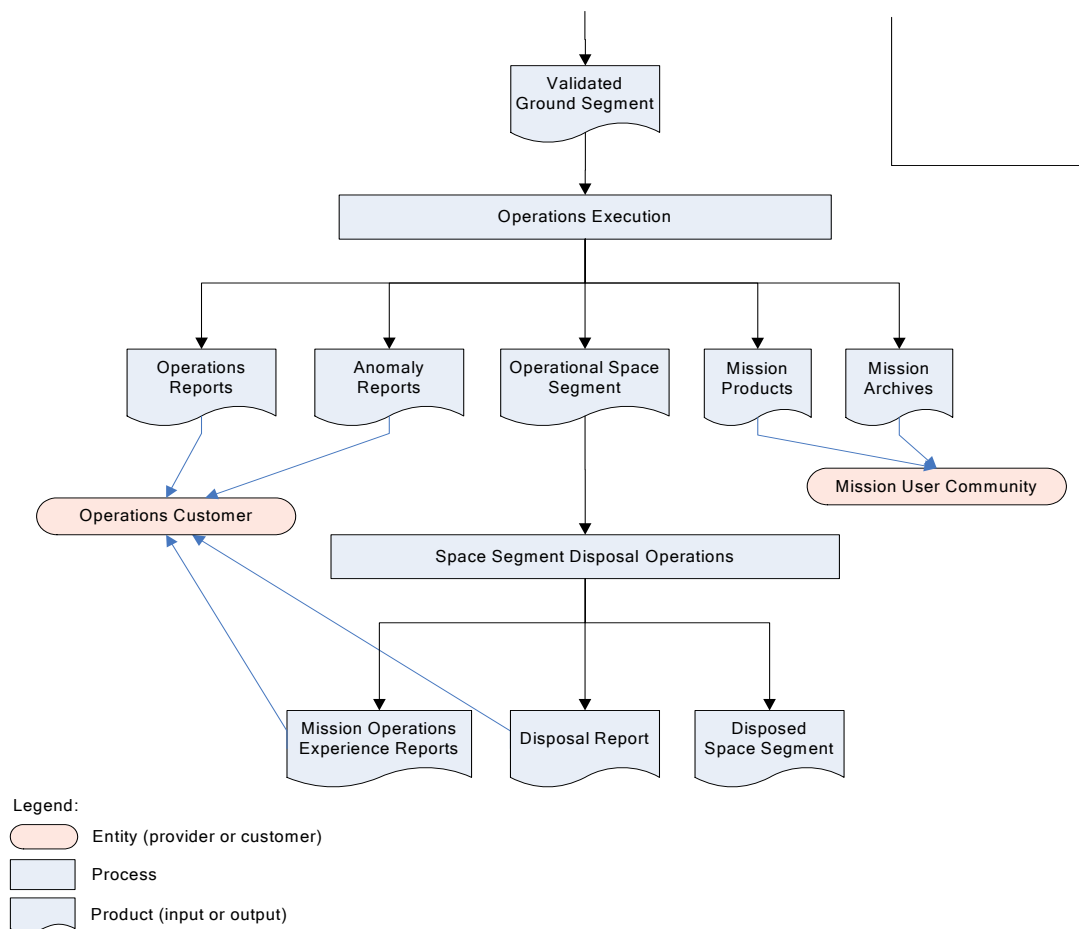
PART 2/2

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

5.2 Requirements analysis and concept development

5.2.1 Inputs

a. 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.

l.   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

5.6.2 Process description

a. Operational validation shall take place in a realistic operational context i.e. through representative operations scenarios supported by operational simulators, thereby demonstrating:

    1. Proper functioning and set–up of the entire ground segment including interfaces between systems and between entities.

    2. Correctness and adequacy of all mission operations data.

    3. Qualification of all operations and maintenance personnel.

    4. Ability of the operations teams to support the mission.

        NOTE 1   Operational validation demonstrates that ground segment systems and operational teams work together coherently to support anticipated mission operations.

        NOTE 2   For the LEOP operations teams, the LEOP network and associated personnel are also included.

b. Operational validation shall include:

    1. Simulations and rehearsals, where operational teams execute nominal and contingency operational scenarios from the MOP using the operational simulator in place of the real spacecraft.

    2. Mission readiness tests (MRTs) to validate the readiness of the ground stations to support the mission and to provide training for ground station operators and network staff.

    3. Data flow tests (DFTs) to validate the communications interfaces between ground stations and the control centre (telemetry, telecommand and tracking) and between other ground systems.

        NOTE   For example, payload data circulation.

    4. Tracking campaigns using already flying missions to validate the end-to-end ranging/Doppler system.

c. Operational validation shall be carried out in accordance with the operational validation plan (OVP).

d. The results of the operational validation activities, including recording of unexpected behaviour or events, shall be recorded in the operational validation report.

e. Following operational validation of the ground segment, a ground segment acceptance report shall be produced.

f. The ground segment supplier (GSS) shall support the operational validation tests and the production of the associated reports.

g. In conformance with ECSS-E-ST-10-02, major tests during operational validation shall be preceded and followed by formal reviews (i.e. test readiness review and post test review) to assess:

    1. whether conditions for a successful execution of the test are met, and

> 2. the results of the tests and implementation of any necessary actions.
>
> > NOTE   For example, corrections to the space segment design or impacts on subsequent activities such as the repetition of tests.

h. Following successful completion of the operational validation, the authority for ground segment change management shall be transferred to a formal change control board.

> NOTE   This is not restricted to mission-specific facilities, but also applies to infrastructure or shared facilities utilised by the mission e.g. LANs, firewalls, power supplies, cabling, buildings.

5.6.3   Outputs

a. The outputs of the operations validation process shall be the ones specified in Table 5-10.

Table 5-10 the outputs of the operations validation process

ID	Description	Producer
1	Operational validation report	Operations supplier
2	Ground segment acceptance report	Operations supplier
3	Fully validated ground segment, including personnel and procedures, ready for in–orbit operations and exploitation	Operations supplier

5.7   Operational configuration management

5.7.1   Inputs

a. The inputs to the operational configuration management process shall be the ones specified in Table 5-11.

Table 5-11: Inputs to the operational configuration management process

ID	Description	Provider
a	Validated ground segment	Ground segment supplier
b	Space segment elements in their final orbits, configured for mission exploitation	Operations supplier
b	Mission operations plan (MOP)	Operations supplier
c	Mission operations data	Operations supplier
d	Trained operations teams	Operations supplier
e	Operations training plan (OTP)	Operations supplier

5.7.2   Process description

a.   In accordance with the requirements for "Configuration management approach for operational phase" of ECSS-M-ST-40, the mission operations data shall be maintained in a functional state and remain under configuration control for the duration of the operations preparation and operations execution phases.

b.   In accordance with the requirements for "Configuration management approach for operational phase" of ECSS-M-ST-40, the space segment shall be maintained in a functional state and remain under configuration control for the duration of the operations execution phase.

c.   In case of changes to any configuration items, the equivalent processes as applied during the original design, development and verification shall be applied.

d.   Modifications to the space system shall be carried out under configuration management (change and configuration control), i.e. including

1.   definition of changes (requirements and specification), and

2.   implementation, verification, operational validation and formal authorization for use.

e.   Throughout the mission, the operations teams shall be maintained in an operational state, in terms of human resources and skills.

f.   In case of replacement of staff, the new members of the operations teams shall undergo formal training and operational exercises in a test environment (simulations) before working autonomously.

g.   Training plans and records shall be maintained throughout the routine operations phase.

5.7.3   Outputs

a.   The outputs of the operational configuration management process shall be the ones specified in Table 5-12.

Table 5-12: Outputs of the operational configuration management process

ID	Description	Producer
1	Configuration management records	Operations supplier
2	Operational training records	Operations supplier

5.8   Operations execution

5.8.1   Inputs

a.   The inputs to the operations execution process shall be the ones as specified in Table 5-13.

Table 5-13 Inputs to the operations execution process

ID	Description	Provider
1	Fully validated ground segment, including personnel and procedures, ready for in–orbit operations and exploitation	Operations supplier
2	Mission operations plan (MOP)	Operations supplier
3	Space segment user manual (SSUM)	Operations customer
4	Ground systems user manuals	Ground segment supplier

5.8.2   Process description

5.8.2.1   Introduction

Operations execution covers operations of the space segment and the ground segment from launch to disposal. Operations execution can be split into different phases depending on the criticality for the mission as follows:

• Critical phases

Critical phases include but are not limited to launch and early operations phase (LEOP), commissioning, planetary flyby or orbital insertion, rendezvous and docking, retrieval.

• Routine phases

Routing phases include but are not limited to mission exploitation, cruise, and hibernation.

5.8.2.2   Critical mission operations

a.   All space and ground segment control activities shall be executed in accordance with the plans and procedures as documented in the MOP for those phases.

b.   Operations teams shall:

1.   be composed of technical staff able to detect and respond to unexpected behaviour or events in line with the mission constraints and the FDIR approach defined in the SSUM, and

2.   include management staff to provide the necessary authorizations.

c.   Technical facilities shall be augmented as necessary to accommodate the additional operations staff.

NOTE   For example, by the use of common or multi-mission facilities such as control rooms.

5.8.2.3 Routine mission operations

a. Mission planning shall be performed in response to end-user requests and the operational and maintenance constraints of the space and ground segments.

b. Detailed operations schedules shall be produced from the mission planning.

c. Operations schedules shall be executed.

d. The execution of individual activities shall be verified.

e. Health monitoring of the space and ground segments shall be performed.

f. Monitoring and control data shall be archived for troubleshooting and performance analysis purposes.

g. The performance of the space and ground segments shall be evaluated, in support of the preparation of future operations and maintenance activities and for feedback to the OC.

h. Payload data shall be processed, archived and distributed to end users along with any necessary ancillary data.

i. Corrective actions or contingency procedures shall be invoked on detection of anomalies.

j. In case of a mission contingency not covered by the MOP, a new plan and procedure(s) shall be produced, validated and approved before being implemented.

k. In the event of a major space segment anomaly that prevents the realization of the mission objectives as defined in the OCRD, a revised mission plan shall be produced in consultation with the OC.

l. An anomaly review board shall be established to review and analyse space segment anomalies and to agree on corrective measures.

> NOTE   The anomaly review board can also involve experts from the OC and the SSS.

m. The anomaly review board shall also cover the duties of the "Nonconformance review board" as specified in ECSS-Q-ST-10-09.

5.8.2.4 Reporting

a. Operations status reports shall:

  1. Be produced on a periodic basis by ground segment entities.

  2. Identify the operations and maintenance activities carried out and anomalies detected during the reporting period.

  3. Be produced at a frequency agreed with the customer.

  > NOTE   The reporting frequency generally depends on the mission phase e.g. daily for LEOP or critical operations, weekly for routine operations.

b. An engineering assessment final report shall be issued after LEOP or critical operations.

c.   A commissioning report shall be produced at the end of the in-orbit commissioning.

d.   Performance reports on the space and ground segments (including trend analysis) shall be produced at suitable intervals to determine success in meeting the mission objectives.

> NOTE 1   For example, mission product throughput and quality from payload data processing facilities.
>
> NOTE 2   The reporting requirements of ECSS-Q-ST-10-09 apply in the case that the anomaly is shown to be a nonconformance.

e.   Space segment and ground segment anomalies shall be formally reported and documented in the form of an operations anomaly report (OAR) in conformance with Annex H.

f.   OARs shall be maintained for the entire life of the mission and tracked until closure.

g.   In order to provide feedback to the engineering of future space missions, reports addressing mission operations experience, lessons learned, spacecraft in–orbit performance and end-of-life tests shall be produced.

5.8.3   Outputs

a.   The outputs of the operations execution process shall be the ones specified in Table 5-14.

Table 5-14: Outputs of the operations execution process

ID	Title	Mnemonic	Producer
1	Space segment elements in their final orbits, configured for mission exploitation		Operations supplier
2	LEOP reports		Operations supplier
3	Commissioning report		Operations supplier
4	Routine operations reports		Operations supplier
5	Mission history data archive (e.g. telemetry, telecommand history)		Operations supplier
6	Space and ground segment plans and schedules		Operations supplier
7	Performance and trend analysis data and associated reports		Operations supplier
8	Mission products		Operations supplier
9	Operations anomaly reports	OAR	Operations supplier
10	Mission reports including: • mission operations experience; • summary of spacecraft in–orbit performance; • results of end-of-life tests		Operations supplier

5.9 Space segment disposal operations

5.9.1 Inputs

a. The inputs to space segment disposal operations shall be the ones specified in Table 5-15.

Table 5-15: Inputs to space segment disposal operations process

ID	Description	Provider
1	All space and ground segment functions to be used for carrying out the space system disposal operations	Operations supplier
2	Mission operations concept document (MOCD)	Operations supplier
3	Space segment user manual	Operations customer

5.9.2　Process description

a.　The space segment disposal operations process shall include:

1.　Disposal operations analyses.

2.　Development of products and processes for disposal.

3.　Processes validation.

4.　Final de–orbiting, ,re–entry or retrieval operations, and

5.　Disposal or recycling of retrieved space segment elements.

> NOTE 1　As defined in ECSS-E-ST-10, disposal constitutes the tasks, actions, and activities to be performed, and the system elements used, to ensure mission termination without degradation to the environment.

> NOTE 2　The initial disposal operations concept is provided via the MDD and OCRD and further elaborated in the MOCD.

b.　The disposal operations analysis shall cover methods for storage, dismantling, reusing, recycling or destruction of the space segment.

c.　The disposal operations analysis shall cover cost and organization of the disposal.

d.　Rules, procedures and timelines necessary to implement disposal operations shall be documented in a disposal operations plan (part of the MOP).

e.　The disposal operations plan shall comply with any space debris mitigation requirements imposed by the operations customer and with requirements imposed by the launch authority.

f.　Disposal of the space segment shall be performed in accordance with the disposal operations plan.

5.9.3　Outputs

a.　The outputs of the space segment disposal operations process shall be the ones specified in Table 5-16.

Table 5-16: Outputs of the space segment disposal operations process

ID	Description	Producer
1	Disposal operations plan	Operations supplier
2	Disposed space segment	Operations supplier
3	Space segment disposal operations report	Operations supplier

6
Ground segment engineering

6.1 Overview

This clause covers, in particular, the system engineering of the ground segment and its lower levels.

Figure 6-1 shows the main ground segment engineering processes which are:

- Ground segment definition, covering:

    — ground segment requirements engineering;

    — analysis and design of the ground segment;

    — definition of internal and external interfaces including space segment related aspects.

- Ground segment production, including acceptance of each ground system;

- Ground segment AIT and verification, covering the integration and testing of the individual ground systems, and progressively extending this to cover integration and verification of the whole ground segment;

- Ground segment maintenance;

- Ground segment disposal.

Logistics support activities, covering logistics engineering support activities during the complete mission life cycle are incorporated in the processes described here.
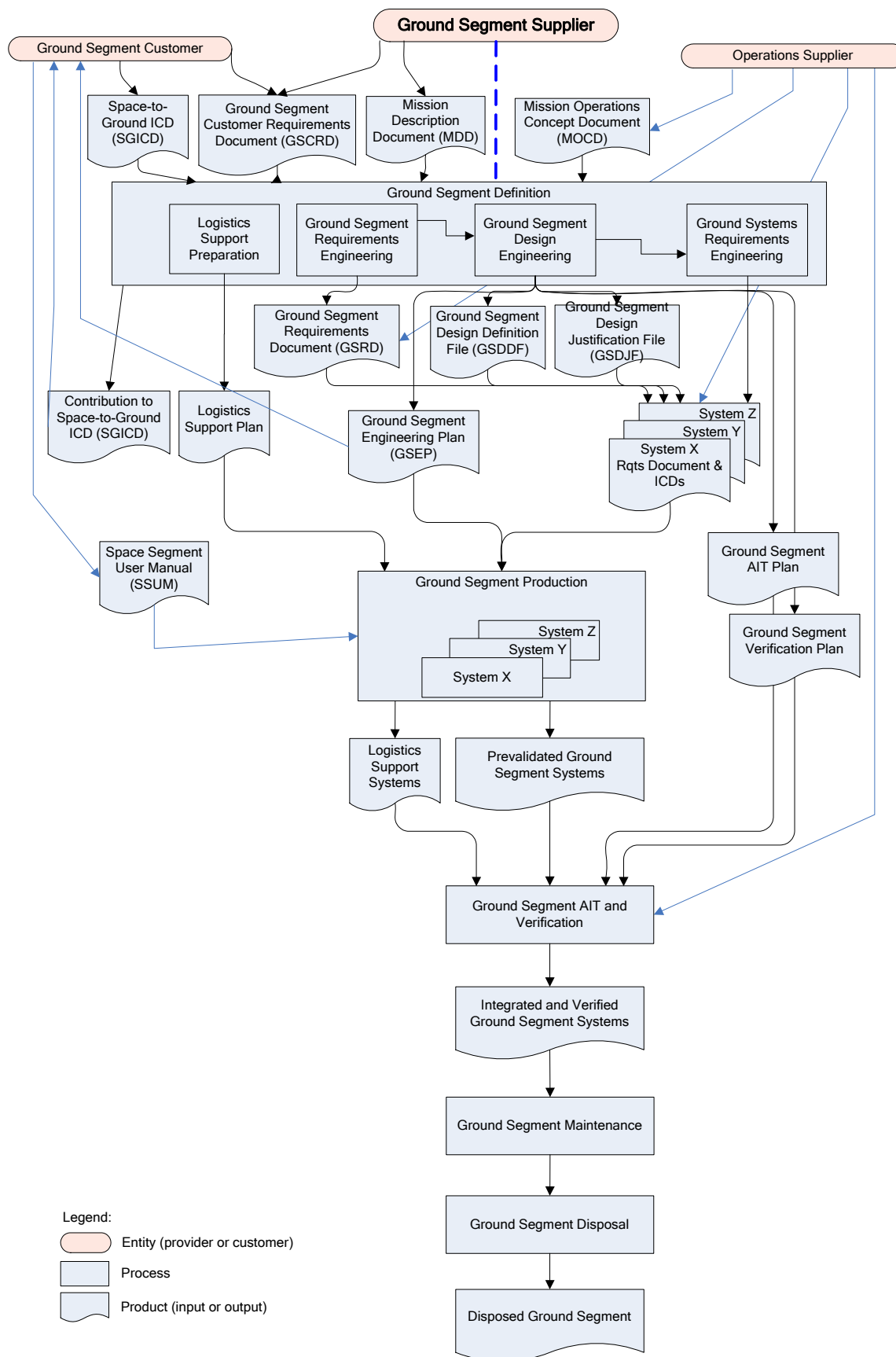
Figure 6-1: Schematic of ground segment engineering processes

6.2 Ground segment definition

6.2.1 Inputs

a. The inputs to the ground segment definition process shall be the ones identified in Table 6-1.

b. The contents of the ground segment customer requirements document (GSCRD) shall conform to Annex A.

> NOTE 1 The GSCRD corresponds to the "Initial technical specification" (TS) of ECSS-E-ST-10-06 tailored for the ground segment domain.

> NOTE 2 The ground segment customer consults with the end-user community to ensure that its requirements are appropriately captured in the GSCRD.

Table 6-1: Inputs to the ground segment definition process

ID	Title	Mnemonic	Provider
1	Ground segment customer requirements document	GSCRD	Ground segment customer
2	Mission description document	MDD	Ground segment customer
3	Mission operations concept document	MOCD	Operations supplier
4	Space–to–ground interface control document (draft)	SGICD	Ground segment customer

6.2.2 Process description

6.2.2.1 General

a. The process shall comprise the following sub-processes:

1. Ground segment requirements engineering

2. Ground segment design engineering

3. Ground systems requirements engineering

4. Logistics support preparation.

6.2.2.2 Ground segment requirements engineering

a. The ground segment requirements document (GSRD) shall be generated as an elaboration of the requirements of the GSCRD.

> NOTE 1 The GSRD is a tailored version of the Technical Specification (TS) of ECSS-E-ST-10-06.

NOTE 2   This also includes user requirements produced by the operations supplier (see clause 5.2.2.5).

b.   Requirements addressing the following topics shall be included:

1.   functionality;

2.   performance of the ground segment derived from the overall space system requirements;

3.   dependability of the ground segment derived from the overall space system requirements

4.   security of the ground segment;

5.   mission safety;

6.   operations and logistics support;

7.   internal and external interfaces;

8.   re–use of generic infrastructure elements;

> NOTE   For example, software systems, and ground station equipment.

9.   maintainability of hardware and software;

10.   location of ground systems and site diversity aspects;

11.   failure case operations and recovery and fall back (equipment and communication fault tolerance, automatic or manual recovery);

12.   system management (user administration, access authorization, equipment configuration, performance monitoring);

13.   configuration management;

14.   network design and management (stations and communications);

15.   commonality between ground systems;

> NOTE   For further guidance see Annex K.

16.   interoperability aspects.

> NOTE   For example, use of ground station capabilities of other agencies or suppliers.

6.2.2.3   Ground segment design engineering

a.   The results of the ground segment design engineering shall be documented in the ground segment design definition file (GSDDF).

> NOTE 1   The purpose of ground segment design engineering is to derive an architecture from the ground segment requirements and to develop the associated engineering plan.
>
> NOTE 2   The generic contents of the ground segment design definition file are defined in ECSS-E-ST-10.

b.   The ground segment architecture shall be defined down to the level of individual ground systems.

c. The architecture shall cover integrated logistics support systems in accordance with the "Requirements for control of logistic activities" of ECSS-M-ST-70.

d. The verification and validation approach and associated tools and data shall be defined.

e. Ground segment design shall include an analysis to assess the possibility of reuse of existing systems, including multi-mission infrastructure and customisations and modifications related thereto.

f. The ground segment design shall define the internal and external interfaces.

g. The critical elements of the ground segment in terms of mission success, of the associated reliability, availability, maintainability and safety requirements and risk-mitigation measures shall be identified.

h. The ground segment design justification file (GSDJF) shall document the justification of the design, including design trade-offs, requirement traceability matrices, results of analyses and assessments.

i. The engineering plan for the ground segment (GSEP) shall be developed in accordance with the requirements on "System engineering plan" of ECSS-E-ST-10.

> NOTE The GSEP describes the approaches, techniques, tools, organization, planning and scheduling of the technical effort to accomplish the ground segment objectives.

j. The following ground segment system level documents shall be developed:

1. The ground segment AIT plan.

2. The ground segment verification plan.

k. Contributions to the space-to-ground interface control document (SGICD) shall be prepared addressing:

1. RF interfaces.

2. Voice, video and high-rate data transmission.

> NOTE See AOS Networks and Data Links: Architectural Specification, CCSDS 701.0-B-2.

6.2.2.4 Ground systems requirements engineering

a. A ground system requirement document shall be produced for each ground system identified in the GSDDF, including where applicable integrated logistics support systems.

> NOTE 1 For technical specification see ECSS-E-ST-10-06.
> NOTE 2 The purpose of ground systems requirements engineering is to produce the requirements for each individual ground system identified in the GSDDF.

NOTE 3   This also includes user requirements produced by the operations supplier (see clause 5.2.2.5).

b.   Requirements of at least the following categories shall be covered :

1.   Functional;

2.   Performance;

3.   Interface;

4.   Design;

5.   Operational;

6.   Environment;

7.   Resource;

8.   Reliability, availability, maintainability and safety;

9.   Security;

10.   Verification.

c.   For software systems, the requirements engineering process of ECSS-E-ST-40, clause "Software requirement analysis" shall be applied.

d.   The traceability to the GSRD shall be included in each ground system requirement document.

e.   ICDs shall be generated for all external interfaces of each ground system.

NOTE   Internal interfaces i.e. those within each system are addressed in clause 6.3 as part of the ground system production process.

6.2.2.5   Logistics support preparation

a.   Logistics support activities shall be defined concurrently with the supported system.

NOTE   As specified in ECSS-M-ST-70, logistic support activities are an integral part of any system development.

b.   The objective of logistics support shall be to maintain the technical performance of ground systems and operations teams, whilst respecting safety constraints and optimising overall life cycle costs.

c.   A logistics support plan shall be generated which responds to the logistics support requirements contained in the GSCRD, addressing the following issues:

1.   Staffing, training and proficiency maintenance.

2.   Spares provisioning.

3.   Procurement of support equipment.

4.   Provision of software support.

5.   Packaging, handling, storage (PHS) and transport.

d. The logistics support plan shall identify the available or shared resources that can be deployed in support of the mission and those that are procured for the mission.

6.2.3 Outputs

a. The outputs of the ground segment definition process shall be the ones specified in Table 6-2.

Table 6-2: Output of the ground segment definition process

ID	Title	Mnemonic	Producer
1	Ground segment system requirements documents	GSRD	Ground segment supplier
2	Ground segment engineering plan	GSEP	Ground segment supplier
3	Ground segment design definition file	GSDDF	Ground segment supplier
4	Ground segment design justification file	GSDJF	Ground segment supplier
5	ICDs for external entities (part of the GSDDF)	ICDs	Ground segment supplier
6	Logistics support plan (draft)		Ground segment supplier
7	Ground systems requirements documents		Ground segment supplier
8	Ground segment AIT plan	GSAITP	Ground segment supplier
9	Ground segment verification plan	GSVP	Ground segment supplier
10	Contribution to the space-to-ground interface control document	SGICD	Ground segment customer

6.3   Ground segment production

6.3.1   Inputs

a.   The inputs to the ground segment production process shall be the ones specified in Table 6-3.

Table 6-3 Inputs to the ground segment production process

ID	Title	Mnemonic	Provider
1	Ground segment engineering plan	GSEP	Ground segment supplier
2	Ground segment design definition file	GSDDF	Ground segment supplier
3	Ground segment design justification file	GSDJF	Ground segment supplier
4	Ground segment AIT plan	GSAITP	Ground segment supplier
5	Ground segment verification plan	GSVP	Ground segment supplier
6	Logistics support plan (draft)		Ground segment supplier
7	ICDs for external entities	ICDs	Ground segment supplier
8	Ground systems requirements documents		Ground segment supplier
9	Space segment user manual*	SSUM	Ground segment customer
10	Space segment monitoring and control database*		Ground segment customer
* where applicable			

6.3.2   Process description

a.   For each GS system, the system engineering process of ECSS-E-ST-10, consisting of definition, production, AIT and verification, and maintenance, shall be applied (also recursively to lower levels), including the related documentation model.

> NOTE 1   The production process for the Ground Segment is implemented at the next lower level of decomposition, i.e. GS systems. This covers the procurement of those systems directly involved in operating the mission and also support systems or tools for testing, for maintenance, and for training of personnel.

> NOTE 2   For some missions, the operational simulator can be provided by the space segment supplier (or even by a third party). However, in the context of the production of the operational simulator, he is considered as a ground system supplier.

NOTE 3   In the context of the complete ground segment (i.e. all ground systems fully integrated), the ground segment supplier is responsible for all constituent ground systems vis-à-vis both the ground segment customer and the operations supplier.

NOTE 4   Appropriate international, European or national standards or regulations should be considered. Local organisational standards may also apply, where these reference the appropriate ECSS, international, European or national standards.

b.   The design of each ground system shall include an analysis to assess the possibility of reuse of existing systems, including related multi-mission infrastructure.

NOTE   For commonality considerations see Annex K.

c.   For software systems, ECSS-E-ST-40 and ECSS-Q-ST-80 shall apply.

d.   The supplier of each ground system shall support delivery, installation and on-site acceptance.

e.   Qualification/acceptance tests shall be performed against the contents of the corresponding ground system requirements document.

f.   Qualification/acceptance tests shall be performed in the defined target environment.

NOTE 1   Qualification can include a Factory Acceptance Test (FAT) at the system supplier's premises.

NOTE 2   Specific dedicated test facilities (hardware or software) can be developed or procured in parallel with the ground system itself for verifying functional performances and interface requirements.

g.   Acceptance test reports shall be produced for each ground system.

h.   User manuals shall be produced for each ground system.

i.   Maintenance manuals and procedures shall be produced for each ground system.

6.3.3   Outputs

a.   The outputs of the ground segment production process shall be the ones specified in Table 6-4.

Table 6-4: Outputs of the ground segment production process

ID	Description	Producer
1	Qualified ground systems	Ground system suppliers
2	Acceptance reports for each ground system	Ground system customer
3	User manuals for each ground system	Ground system suppliers
4	Maintenance manuals and procedures for each ground system	Ground system suppliers
5	Test and training tools	Ground system suppliers

6.4 Ground segment AIT and verification

6.4.1 Inputs

a. The inputs to the ground segment AIT and verification process shall be the ones specified in Table 6-5.

Table 6-5: Inputs to the ground segment AIT and verification process

ID	Description	Provider
1	Ground segment engineering plan	Ground segment supplier
2	Ground segment AIT plan	Ground segment supplier
3	Ground segment verification plan	Ground segment supplier
4	Logistics support plan	Ground segment supplier
5	Accepted ground systems ready for integration	Ground system suppliers
6	User and maintenance documentation for each ground system	Ground system suppliers
7	Test and training tools	Ground system suppliers
8	Integrated logistics support systems	Ground system suppliers
9	Space segment software code and associated documentation	Ground segment customer
10	Mission specific launcher interface control document	Ground segment customer
11	The spacecraft for ground segment compatibility tests	Ground segment customer
12	Representative space segment TM data samples	Ground segment customer
13	Suitcase	Ground segment customer
14	Preliminary set of mission operations data	Operations supplier

6.4.2   Process description

6.4.2.1   General

a.   The ground segment AIT activity shall:

    1.   Be performed using a preliminary set of mission operations data.

    2.   Be carried out in an incremental manner, starting from low-level subsystems up to ground segment level, including at each stage of the process:

        (a)   a verification test, to demonstrate the conformance of the system with its design specification and interfaces to other ground segment systems, and

        (b)   a validation test, to provide a preliminary confirmation that it is fit for use.

b.   The ground segment verification activity shall:

    1.   Follow the ground segment integration, addressing the ground segment systems as a whole.

    2.   Result in:

        (a)   demonstrating the conformance of the ground segment to the requirements and design specifications,

        (b)   verifying the functional coherence of the ground systems and their compatibility,

        (c)   verifying the compatibility of the ground segment with the space segment,

        (d)   verifying the compatibility of the ground segment with the external ground entities, by carrying out a series of end–to–end tests which involve external interfaces of the ground systems, and

        (e)   providing a preliminary confirmation of the conformity of the ground segment systems as a whole with their intended use, by exposing them to realistic operational conditions.

        NOTE   For verification activities see ECSS-E-ST-10-02.

c.   The integrated logistics support systems shall be integrated and validated in conformance with the "Requirements for control of logistic activities" of ECSS-M-ST-70.

d.   When validating the integrated logistics system it shall be ensured that the support elements are usable in the operational environment in conformance with the "Requirements for control of logistic activities" of ECSS-M-ST-70.

e.   Any subsequent modifications to the ground systems shall necessitate non-regression testing during which the ground segment shall undergo verification (activity 6.4.2.1b).

        NOTE   Figure 6-2 shows the overall ground segment AIT and verification process. The final activity

shown in Figure 6-2, ground segment operational validation, is part of operations engineering (see clause 5.6) but is included here to give an overall view of the entire approach.
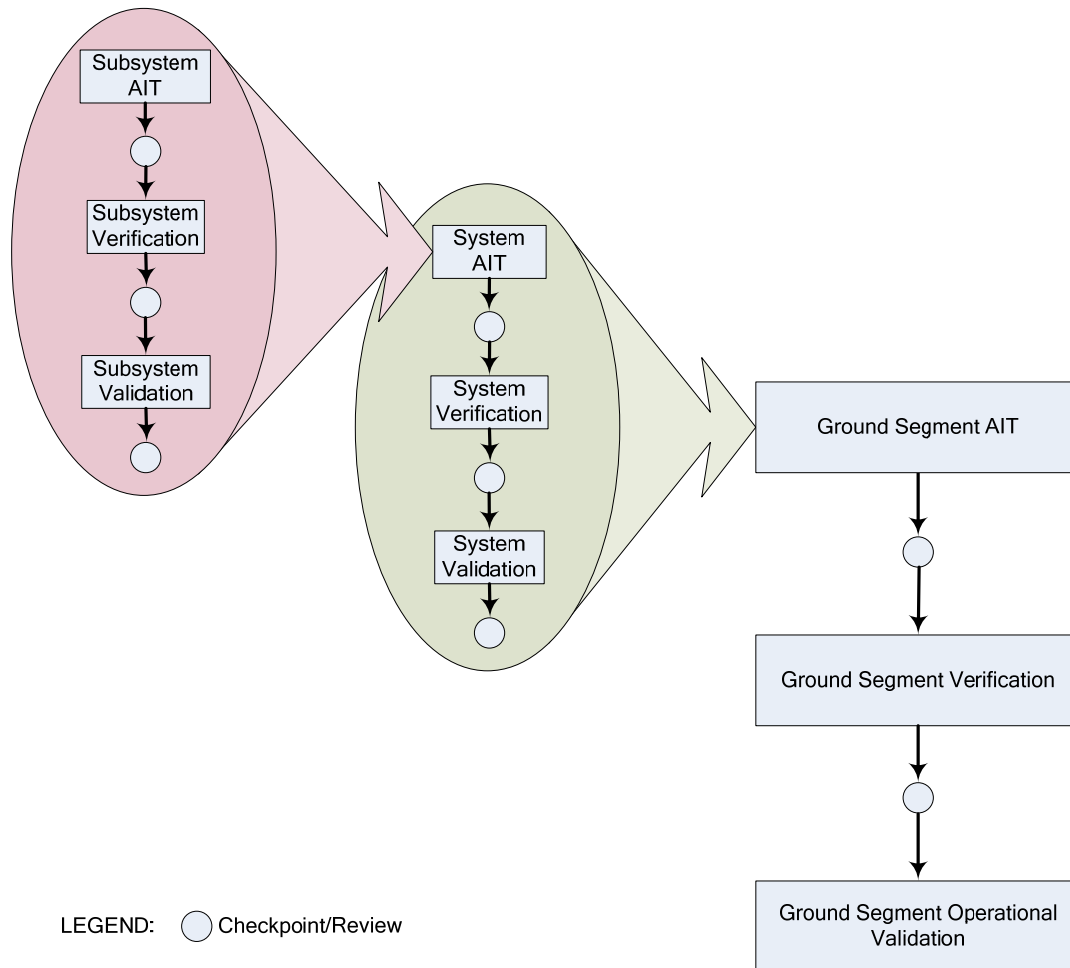
Figure 6-2: Ground segment AIT and verification

6.4.2.2   Ground segment AIT

a.   Ground segment AIT shall be documented in the ground segment AIT plan, by a set of test procedures and in reports covering all stages of the process.

> NOTE   The AIT Plan can be incorporated in the SEP or can be a standalone document.

b.   The ground segment AIT plan shall:

1.   Include the steps from the receipt of the first integration release to the completion of integration.

2.   Cover the following aspects:

(a)   The execution of each of the tests covered by the test specifications and production of the associated test documentation;

(b)   the sequence in which the individual systems are integrated, taking account of expected readiness;

(c)   the use of test systems or simulators;

(d)   the integration with individual external elements;

(e)   the relationship between these tests and planned pre–releases of the systems for ground segment AIT purposes.

c.   The results of the tests performed during ground segment AIT shall be assessed at a post test review.

6.4.2.3   Ground segment verification

a.   Ground segment verification shall cover:

1.   Conformance of the ground segment, including its constituent systems, to its design requirements and specifications.

2.   Ensuring adequacy of the maintenance manuals and maintenance procedures for operations, conformance with the SGICD and with the ICDs for external interfaces, and

3.   validation of the operational adequacy of the ground segment.

b.   The OS shall support the corresponding validation tests and the production of the associated reports, including ground segment verification reports and a ground segment preliminary acceptance report.

> NOTE   The different stages of ground segment acceptance are addressed in clause 7.5.3.

c.   Verification of the ground segment shall include verification of its compatibility with the space segment.

> NOTE   This can include the use of the following test resources:
>
> - suitcase representative of spacecraft hardware and software equipment for testing RF and telemetry, telecommand and tracking protocols and format compatibility between space segment and the ground stations;
> - operational simulator including realistic software models of the space segment elements (e.g. emulators for complex software elements) and in some cases real spacecraft components (hybrid simulator);
> - representative space segment telemetry data samples;
> - access to the spacecraft on ground during space segment AIT activities and at the launch site, involving as far as is technically feasible, tests of all ground systems and functions.

d.   For the space-to-ground compatibility tests, at least two periods shall be provided of a duration that is commensurate with the complexity of the space segment and with an interval between them allowing correction of potential ground segment problems found during the first period of tests.

> NOTE   In addition, "listen-in" tests are generally provided on an opportunity basis. These are open-loop tests where telemetry generated during the space segment AIT programme is routed to the mission control centre.

e.   The space–to–ground segment compatibility tests shall include the mission operations data and the corresponding ground systems elements.

> NOTE   For example, mission operations data can include monitoring and control databases, operational procedures and command schedules.

f.   The results of the tests performed during ground segment verification shall be assessed through a formal review process, the ground segment qualification review (GSQR).

6.4.3   Outputs

a.   The outputs of the ground segment AIT and verification process shall be the ones specified in Table 6-6.

Table 6-6: Outputs of the ground segment AIT and verification process

ID	Description	Producer
1	Verified ground segment ready for operational validation	Ground segment supplier
2	Ground segment integration reports including test results (part of GSDJF)	Ground segment supplier
3	Ground segment verification reports (part of GSDJF)	Ground segment supplier
4	Ground segment preliminary acceptance report	Operations supplier

6.5 Ground segment maintenance

6.5.1 Inputs

a. The inputs to the ground segment maintenance process shall be the ones specified in Table 6-7

Table 6-7: Inputs to the ground segment maintenance process

ID	Title	Mnemonic	Provider
1	Ground segment requirements document	GSRD	Ground segment supplier
2	Ground segment engineering plan	GSEP	Ground segment supplier
3	Logistics support plan		Ground segment supplier
4	Ground segment design definition file	GSDDF	Ground segment supplier
5	Ground segment design justification file	GSDJF	Ground segment supplier
6	Ground systems design documentation (including the integrated logistics support systems)		Ground segment supplier
7	Maintenance manuals and procedures for each ground system		Ground system suppliers

6.5.2 Process description

6.5.2.1 Introduction

The maintenance process contains the activities and tasks of the ground segment maintainer. The objective is to ensure the correct operation of the ground segment in line with its availability and performance requirements. This process also includes obsolescence management and can include the migration activities for example as computer equipment or operating systems reach their end of service.

The activities provided in this sub-clause are specific to the maintenance process; however, the process can utilize other processes in this Standard, for example if a migration involves redevelopment or if certain processes have to be repeated for e.g. non-regression testing. If the ground segment engineering processes (clauses 6.2 to 6.4) are utilized, the term supplier there is interpreted as maintainer.

6.5.2.2 Process description

a. Regular performance monitoring shall be undertaken in order to identify trends or degradations indicating the need for preventive maintenance

b. Performance monitoring results shall be recorded in performance reports.

c. Routine maintenance shall be planned and undertaken in accordance with maintenance procedures accompanying the delivered system.

> NOTE For example, lubrication of moving parts, replacement of limited lifetime items, and software log file purging.

d. Maintenance activities shall be recorded in a maintenance log.

e. The incident management process shall log incidents and restore normal service operation in line with availability requirements.

f. Problem management shall:

1. Provide reactive fault diagnosis and proactive trend analysis to identify, record, report on and rectify root causes of incidents and prevent future incidents and problems.

2. Liaise closely with incident management and ensure that identified problems are logged and communicated.

3. Generate corresponding change requests.

g. Change management shall cover:

1. Impact assessments.

2. Planning and implementation of change requests.

3. Production of new releases.

4. Management of introduction of new releases into operational systems.

> NOTE For change management see ECSS-M-ST-40.

h. Configuration management shall cover:

1. The maintenance of a configuration management database.

2. Support of configuration documentation.

3. Management of configuration items.

> NOTE 1 For configuration management see ECSS-M-ST-40.
>
> NOTE 2 Configuration items include hardware components, network components, software components including also COTS, documentation, configuration data, mission operations data.

i. Obsolescence management shall cover the monitoring of the obsolescence of the systems and the planning and implementation of replacements or upgrades.

6.5.3 Outputs

a. The outputs of the maintenance process shall be the ones specified in Table 6-8.

Table 6-8 Outputs of the maintenance process

ID	Description	Producer
1	Performance reports	Ground segment supplier
2	Maintenance logs	Ground segment supplier
3	Incident records	Ground segment supplier
4	Change requests	Ground segment supplier
5	Problem records	Ground segment supplier
6	Release plans	Ground segment supplier
7	Release deliveries	Ground segment supplier
8	Configuration management database	Ground segment supplier

6.6 Ground segment disposal

6.6.1 Inputs to ground segment disposal

a. The input to the ground segment disposal process shall be the one specified in Table 6-9.

Table 6-9: Input to the ground segment disposal process

Description	Provider
Fully operational ground segment at the declared end of the mission	Operations supplier

6.6.2 Process description

a. The disposal engineering process shall include

    1. Disposal analyses.

    2. Development of products and processes for disposal.

    3. Processes validation.

    4. Disposal or recycling of ground systems.

        NOTE   As defined in ECSS-E-ST-10, disposal constitutes the tasks, actions, and activities to be performed, and the system elements used, to

7
Ground segment and operations lifecycle

7.1 General

7.1.1 The lifecycle

In accordance with the ECSS life cycle defined in ECSS-M-ST-10, the ground segment engineering processes are allocated to phases, which proceed in sequence and each of which ends in a formal review. As shown in Figure 7-1, the individual ground segment lifecycle phases are not necessarily aligned with those of the space system, however there are strong interdependencies. The operations engineering processes are also shown on Figure 7-1 demonstrating how operations engineering influences the ground segment engineering lifecycle.

NOTE 1   ECSS-E-ST-10 defines the space system as constituting the space segment, the ground segment and the launch segment. The space system level is also commonly referred to as the mission-level.

NOTE 2   In Figure 7-1, the phasing of the ground segment and operations lifecycles with the space system lifecycle is typical and can vary in detail from mission to mission.

For each phase, this clause identifies the processes, milestones and major review(s). No contractual acceptance reviews are shown, since these can be associated with different milestones depending on the procurement approach.

The space system level reviews shown in Figure 7-1 are defined in ECSS-M-ST-10. The reviews specific to the ground segment and operations are defined within this Standard.

OBJECTIVE	Mission/operational analysis and feasibility	Ground segment preliminary design	Ground segment detailed design	Ground segment production	Ground segment AIT	Operational validation	LEOP and commissioning	Routine operations	Disposal
Operations Engineering Processes	Mission analysis → Define operational interfaces → Perform operations analysis and develop operations concept → Specify user requirements		Prepare mission operations data			Validate mission operations data	Train teams & validate full ground segment / Acquire orbit and mission configuration and in-orbit commissioning	Operate and exploit mission in-orbit	Dispose of space segment
Operations Reviews	CRR					OQR ORR			
Ground Segment Engineering Processes	Identify characteristics and constraints and assess feasibility	Identify requirements on the ground segment and define the ground segment baseline	Complete ground segment design down to level of ground systems and initiate production	Procure ground segment systems	Assemble, integrate and test ground segment	Verify ground segment	Maintain ground segment		Dispose of ground segment
Ground Segment Reviews		GSSRR GSPDR	GSCDR			GSQR			
Ground Segment Phase	A	B	C			D			

SPACE SYSTEM LEVEL PHASES AND REVIEWS

0 — A — B — C — D — E1 — E2 — F

MDR   PRR   SRR   PDR   CDR   QR/AR   FRR   CRR   IOORs   MCR
ORR   LRR   ELR

Figure 7-1: Ground segment and operations phases

7.1.2 General requirements

a. The GSC, the OC, the GSS and the OS shall be represented in the ground segment and operations reviews.

b. Ground segment reviews and operations reviews should be combined wherever practical.

> NOTE In particular where the GSS and OS are part of the same entity.

c. For missions of an incremental nature (such as ISS or the European ATV), the ground segment and operations lifecycle and phases identified in this clause shall apply to each mission increment.

> NOTE Incremental means comprised of a series or sequence of repeated missions using the same ground (or space) infrastructure.

7.2 Phase A: Mission and operational analysis, feasibility studies and conceptual design

7.2.1 Purpose of phase A

During this phase, the requests initially expressed by the GSC and the OC are analysed in order to identify and characterize the ground segment, in terms of operational feasibility and needs, expected performance and reliability, availability, maintainability and safety objectives.

An evaluation of the operational constraints involved in the mission is performed in this phase.

Many of the activities performed during this phase, and continued or elaborated during later phases, are contributions to space system level activities. The activities concerned are those relating to mission analysis, operations concept definition and the definition of space-to-ground interfaces.

7.2.2 Processes during phase A

a. The main processes specified in Table 7-1 shall be carried out during phase A.

Table 7-1: Processes and outputs of phase A

ID	Ground Segment Engineering	Operations Engineering	Outputs	Reviews
1		Mission analysis (clause 5.2.2.1)	Draft issue of mission analysis report (MAR) covering the various proposed solutions, see Annex C	CRR
2		Operational analysis and concept development (clause 5.2.2.2)	Mission operations concept document (MOCD) (draft), see Annex D	CRR
3	Ground segment design engineering (clause 6.2.2.3)		Preliminary inputs to space–to–ground interface control document (SGICD) (draft)	CRR
4		Operational interfaces definition (clause 5.2.2.3)	Space segment operability requirements document (SSORD) Customer furnished items and services requirements document (CFISRD)	CRR
5	Ground segment design engineering (clause 6.2.2.3)		Preliminary version of GSEP, including identification of the necessary ground systems and assessment of use or sharing of planned or existing facilities	CRR

7.2.3   Milestones and reviews of phase A

a.   The feasibility studies and conceptual design phase shall be concluded by the customer requirements review (CRR), with the main objectives of assessing the completeness of the customer requirements and reviewing the draft operations concept and ground segment baseline.

> NOTE   The CRR follows successful completion of the space system PRR.

7.3   Phase B: Preliminary design

7.3.1   Purpose of phase B

The purpose of this phase is to refine the ground segment baseline, to confirm its capability to meet the ground segment requirements and to prepare the necessary procurements for the production of the ground segment. In parallel, the mission operations concept is further developed.

7.3.2   Processes during phase B

a.   The main processes specified Table 7-2 shall be carried out during phase B.

Table 7-2: Processes and outputs of phase B

ID	Ground Segment Engineering	Operations Engineering	Outputs	Reviews
1	Ground segment requirements engineering (clause 6.2.2.2)	Contribution to ground segment and ground systems requirements specification (clause 5.2.2.4)	Ground segment requirements document (GSRD)	GSSRR
2	Ground segment design engineering (clause 6.2.2.3)		Contributions to the space–to–ground interface control document (SGICD)	GSSRR
3	Logistics support preparation (clause 6.2.2.5)		Logistics support plan (preliminary)	GSSRR
4		Mission analysis (clause 5.2.2.1)	Mission analysis report (MAR)	GSSRR GSPDR
5		Operational analysis and concept development (clause 5.2.2.2)	Mission operations concept document (MOCD)	GSSRR GSPDR
6		Operations engineering plan production (clause 5.2.2.4)	Operations engineering plan (OEP) (preliminary)	GSPDR
7	Ground segment design engineering (clause 6.2.2.3)		Ground segment design definition file (GSDDF) (preliminary)	GSPDR
			Ground segment design justification file (GSDJF) (preliminary)	GSPDR
			Ground segment engineering plan (GSEP) (preliminary)	GSPDR
			Ground segment AIT plan	GSPDR
			Ground segment verification plan	GSPDR
8	Ground systems requirements engineering (clause 6.2.2.4)	Contribution to ground segment and ground systems requirements specification (clause 5.2.2.4)	Ground systems requirements documents	GSPDR
			ICDs for external entities (preliminary)	GSPDR

7.3.3 Milestones and reviews of phase B

a. A ground segment system requirements review (GSSRR) shall be held during phase B.

b. The purpose of the GSSRR shall be to approve the ground segment requirements such that preliminary design and the definition of requirements on the individual ground systems can proceed.

c. Phase B shall end with a ground segment preliminary design review (GSPDR), which follows the successful completion of the space system PDR.

d. The purpose of the GSPDR shall be to approve the preliminary ground segment design and to select the ground segment main supplier.

7.4 Phase C: Detailed design

7.4.1 Purpose of phase C

The purpose of the ground segment design phase is to complete the design of the ground segment to the level of individual systems and to start production.

Phase C includes the definition of the operations organization and the start of production of mission operations data (operational procedures, monitoring and control databases and detailed mission analysis).

7.4.2 Processes during phase C

a. The main processes specified in Table 7-3 shall be carried out during phase C.

Table 7-3: Processes and outputs of phase C

ID	Ground Segment Engineering	Operations Engineering	Outputs	Reviews
1	Ground segment requirements engineering (clause 6.2.2.2)		Inputs to space–to–ground interface control document (SGICD) in final version	GSCDR
2	Ground segment design engineering (clause 6.2.2.3)		Ground segment design definition file (GSDDF)Ground segment design justification file (GSDJF) Ground segment engineering plan (GSEP) in final version	GSCDR
3	Ground segment production (clause 6.3)		Ground systems design documents	GSCDR
4		Operations engineering plan production (clause 5.2.2.4)	Operations engineering plan (OEP)	GSCDR
5		Operational interfaces definition (clause 5.2.2.3)	Space segment operability requirements document (SSORD) in final version	GSCDR
			Customer furnished items and services requirements documents (CFISRD) in final version	GSCDR
6		Mission analysis (clause 5.2.2.1)	Mission analysis report (MAR), including preliminary sequence of events	GSCDR
7		Mission operations data production (clause 5.3)	Mission operations plan (preliminary)	
			Space and ground segment monitoring and control databases (preliminary)	

7.4.3   Milestones and reviews of phase C

a.   Phase C shall be concluded by the ground segment critical design review (GSCDR).

b.   The purpose of the GSCDR shall be to establish acceptance by the customer of the detailed ground segment design.

7.5 Phase D: Production, AIT and verification

7.5.1 Purpose of phase D

The purpose of the phase is to procure all ground systems and to integrate them into an operational ground segment ready to support the in–orbit operations and exploitation of the space segment.

7.5.2 Processes during phase D

a.   The main processes specified in Table 7-4 shall be carried out during phase D:

Table 7-4: Processes and outputs of phase D

ID	Ground Segment Engineering	Operations Engineering	Outputs	Reviews
1		Mission analysis (clause 5.2.2.1)	Mission analysis report (MAR) in final version	GSQR
2	Ground segment production (clause 6.3)		Qualified ground systems	
			Test and training tools	
			Qualification test report for each ground system	GSQR
			User and maintenance documentation for each ground system	
3	Ground segment AIT and verification (clause 6.4)		Qualified ground segment and mission operations data	GSQR
			Ground segment maintenance and logistics plan	GSQR
			Ground segment AIT reports	GSQR
			Ground segment qualification report	GSQR
4		Mission operations data production (clause 5.3)	Mission operations plan	
			Space and ground segment monitoring and control databases	
5		Operational validation plan production (clause 5.2.2.6)	Operational validation plan (OVP) in final version	COR
6		Mission operations data validation (clause 5.4)	Validated mission operations plan (MOP)	COR
			Validated space segment monitoring and control database	COR
			Validated ground segment monitoring and control database	COR
			Mission operations data validation test reports	COR
7		Operations teams build–up and training (clause 5.5)	Operations training plan (OTP) in final version	COR
			Training material	
			Trained operations teams	
8		Operational validation (clause 5.6)	Operational validation reports	ORR
			Fully validated ground segment, including personnel and procedures, ready for in–orbit operations and exploitation	

7.5.3 Milestones and reviews of phase D

a. Phase D shall be subdivided into four main sub-phases (see Figure 7-1) as follows:

    1. Ground segment production.

        NOTE   This activity concentrates on the production and procurement of the ground systems.

    2. Ground segment AIT and verification.

    3. Mission operations data validation.

    4. Operational validation

b. For practical reasons, the sub-phases of clause 7.5.3a may overlap.

        NOTE   For schematic simplicity, they are shown as sequential in Figure 7-1.

c. Ground segment AIT and verification shall terminate with a ground segment qualification review (GSQR).

        NOTE 1   For ground segment AIT and verification see clause 6.4.

        NOTE 2   The GSQR ensures that the ground segment conforms to its technical requirements and that all conditions are met for proceeding with the operational validation activities

        NOTE 3   GSQR can constitute the preliminary acceptance for the ground segment.

d. Mission operations data validation shall end with a critical operations review (COR).

e. The COR shall:

    1. ensure that mission operations data has been validated, and

    2. ensure that documentation is available to start the training and operational validation.

        NOTE   When possible, the GSQR and COR can be combined into a single review.

f. Operational validation, as specified in clause 5.6, shall constitute the operational qualification of the whole ground segment.

g. The operational validation shall end with the operational readiness review (ORR).

        NOTE   For project phasing and planning see ECSS-M-ST-10.

h. The ORR shall:

    1. Ensure that the programme of simulations and rehearsals has been satisfactorily completed.

    2. Ensure that the ground segment is ready for operations.

    3. Ensure that all procedures have been validated.

    4. Ensure that operations teams are ready for operations.

5.   Authorize use of the ground segment for space segment in–orbit operations.

NOTE   The ORR normally also constitutes the final acceptance of the ground segment.

i.   The results of the ORR shall be presented at the flight readiness review (FRR).

NOTE   For project phasing and planning see ECSS-M-ST-10.

7.6   Phase E: Mission operations

7.6.1   Purpose of phase E

The purpose of phase E is to operate the space system in accordance with the MOP, maintain the ground segment in accordance with the logistics support plan and ground systems maintenance documentation and to handle any space system anomalies that occur.

If changes in the space segment or ground segment during phase E result in the need to modify mission operations data or ground systems, these changes are developed, verified and validated as during the earlier phases (i.e. using the same processes).

The phase is divided into two sub-phases in accordance with ECSS-M-ST-10:

•   Sub-phase E1 which is an overall test and commissioning phase of the space and ground segments.

•   Sub-phase E2 which is the utilisation phase itself.

7.6.2   Processes during phase E

a.   The main processes specified in Table 7-5 shall be carried out during sub-phase E1.

The main processes specified in

b.   Table 7-6 shall be carried out during sub-phase E2.

Table 7-5: Processes and outputs of sub-phase E1

ID	Ground Segment Engineering	Operations Engineering	Outputs	Reviews
1		LEOP operations (clause 5.8.2.2)	Space segment elements in their final orbits and configured for commissioning operations; LEOP report	FQR
2		Commissioning operations (clause 5.8.2.2)	Commissioned space segment; Commissioning report	FQR
3		Ground segment operations (clause 5.8.2.3)	Ground segment elements configured for operations	FQR

Table 7-6: Processes and outputs of sub-phase E2

ID	Ground Segment Engineering	Operations Engineering	Outputs	Reviews
1		Space segment routine in–orbit operations (clause 5.8.2.3)	Routine operations reports; Mission history data archive (e.g. telemetry, telecommand history);	IOORs
		Planning and scheduling of space segment and of supporting ground segment entities	Space segment plans and schedules;	
		Space segment performance and trend analysis	Performance and trend analysis data and associated reports;	
		Payload utilization operations, data acquisition and distribution	Mission products - payload products;	
		Handling of space and ground segments anomalies	Operations anomaly report (OAR), see Annex I	
2		Operational configuration management (0)	Trained ground teams	IOORs
3		Ground segment operations (clause 5.8.2.3)	Ground segment elements configured for operations	IOORs
4	Ground segment maintenance (clause 6.5)		Fully operational ground systems	IOORs
5		Mission operations data production (clause 5.3)	Mission operations plan (sections pertaining to disposal of space and ground segments)	ELR

7.6.3 Milestones and reviews of phase E

a. Phase E1 shall be concluded by the flight qualification review (FQR). This review shall be held after completion of the space segment in–orbit commissioning, in order to assess performance of the space and ground segments and declare readiness for in–orbit exploitation.

b. During the utilisation phase (E2) in–orbit operations reviews (IOORs) shall be held on a regular basis to assess the performance of the space system, i.e. both space segment and ground segment .

> NOTE For example, on a yearly basis.

c. Phase E2 shall be concluded by the end-of-life review (ELR), which shall verify that the mission has completed its useful operation or service and that the procedures for disposal are in place.

7.7 Phase F: Disposal

7.7.1 Purpose of phase F

During phase F the space segment is withdrawn from service, after preparation and planning in liaison with the space segment customer. This can include transferring the spacecraft to another orbit, with eventual landing or destructive re–entry.

7.7.2 Processes during phase F

a. The main processes specified in Table 7-7 shall be carried out during phase F:

Table 7-7: Processes and outputs of phase F

ID	Ground Segment Engineering	Operations Engineering	Outputs	Reviews
1		Preparation and execution of mission termination and space segment disposal operations (clause 5.9)	Disposed space segment Space segment disposal operations report	MCR
2	Preparation and execution of ground segment disposal (clause 6.6)		Disposed ground segment Ground segment disposal report	MCR
3		Documentation of mission operations experience (clause 5.8.2.4)	Mission reports including, for example, mission operations experience, summary of spacecraft in–orbit performance, results of end-of-life tests	

7.7.3   Milestones and reviews of phase F

a.   Phase F shall be concluded by the mission close–out review (MCR).

b.   The purpose of the MCR shall be to assess the performance of the services provided and to confirm proper disposal of space and ground segments.

7.8   Summary of key documents and reviews

Table 7-8 provides a list of the key ground segment and operations documents and the ground segment and operations reviews at which different releases of the documents are deliverable.

Table 7-9 provides a summary of the major ground segment and operations reviews.

Table 7-8: Key ground segment and operations documents and reviews at which they are deliverable

Domain	Type	Title	Mnemonic	Reference	CRR	GSSRR	GSPDR	GSCDR	GSQR	COR	ORR	FRR	FQR	IOOR	ELR	MCR
SSYS	MISC	Mission description document	MDD	ECSS-E-ST-10	A											
SSYS	REQ	Operations customer requirements document	OCRD	Annex B	F	A										
SSYS	REQ	Ground segment customer requirements document	GSCRD	Annex B	F	A										
SSYS	I/F	Space segment user manual	SSUM	Annex F						A						
SSYS	REP	Trade-off report		ECSS-E-ST-10	A											
SSYS	I/F	Launcher user manual			F											
SSYS	I/F	Space–to–ground interface control document	SGICD	ECSS-E-ST-10	P	F		A								
SSYS	REQ	Space segment operability requirements document	SSORD	ECSS-E-ST-70-11	F			A								
SSYS	REQ	Customer furnished items and services requirements document	CFISRD	Annex K	F			A								
GSEG	REQ	Ground segment requirements document	GSRD	ECSS-E-ST-10 -06		F										
GSEG	SPEC	Ground segment engineering plan	GSEP	ECSS-E-ST-10	P		P	F								
GSEG	I/F	ICDs for internal and external entities		ECSS-E-ST-10			P	F								
GSEG	SPEC	Ground segment design definition file	GSDDF	ECSS-E-ST-10			P	F								
GSEG	SPEC	Ground segment design justification file	GSDJF	ECSS-E-ST-10			P	F								
GSEG	PLAN	Ground segment configuration management plan		ECSS-M-ST-40			P	F								
GSEG	PLAN	Ground segment AIT plan	GSAITP	ECSS-E-ST-10-02			P	F								
GSEG	PLAN	Ground segment verification plan	GSVP	ECSS-E-ST-10-02			P	F								
GSEG	REP	Ground segment configuration status report							F							
GSEG	REP	Ground segment integration and test reports		ECSS-E-ST-10-02					F							
GSEG	REP	Ground segment verification reports		ECSS-E-ST-10-02					F							
GSYS	REQ	Ground systems requirements documents		ECSS-E-ST-10-06			F									
GSYS	I/F	Ground systems user and maintenance manuals							F							
LS	PLAN	Logistics support plan	LSP				P		F							
OPS	REP	Mission analysis report	MAR	Annex C	P	F	F	F	F							

Domain	Type	Title	Mnemonic	Reference	CRR	GSSRR	GSPDR	GSCDR	GSQR	COR	ORR	FRR	FQR	IOOR	ELR	MCR
OPS	MISC	Mission operations concept document	MOCD	Annex D	P	F	F									
OPS	SPEC	Operations engineering plan	OEP	Annex E			P	F								
OPS	PLAN	Operational validation plan	OVP	Annex G						F						
OPS	PLAN	Operations training plan	OTP							F						
OPS	PLAN	Mission operation plan	MOP	Annex H						F	A	A			A	
OPS	REP	Operational validation reports								F	F	F				
OPS	REP	LEOP reports											F			
OPS	REP	Commissioning report											F			
OPS	REP	Performance reports												F		
OPS	REP	Routine operations reports												F		
OPS	REP	Operations anomaly report	OARs	Annex I										F		
OPS	REP	Mission reports														
OPS	REP	Disposal operations reports														F

Legend:

Domain:
SSYS: Space system level document
GSEG: Ground segment level document
GSYS: Ground system level document
LS: Logistics support document
OPS: Operations document

Type:
I/F: Interfaces level documents (internal or external)
MISC: Miscellaneous
PLAN: Plan
REP: Report
REQ: Requirements document
SPEC: Design specification

Release:
A: Issue of the document approved by the customer
F: Final issue of the document approved by supplier and provided for information to the customer
P: Preliminary issue of the document

Table 7-9: Ground segment and operations reviews

Review ID	Review title	Review objective	Date	Chaired by
CRR	Customer requirements review	To assess the completeness of the customer requirements and review the draft operations concept and ground segment baseline	End of phase A	Operations customer and ground segment customer
GSSRR	Ground segment system requirements review	To approve the ground segment requirements such that preliminary design and the definition of requirements on the individual ground systems can proceed	During phase B, at the completion of the ground segment requirements engineering activity	Ground segment customer
GSPDR	Ground segment preliminary design review	To approve the preliminary ground segment design and to select the ground segment main supplier	End of phase B	Ground segment customer
GSCDR	Ground segment critical design review	To establish acceptance by the customer of the detailed ground segment design	End of phase C	Ground segment customer
GSQR	Ground segment qualification review	To ensure that the ground segment conforms to its technical requirements and that all conditions are met for proceeding with the operational validation activities	During phase D, at the end of ground segment AIT and verification	Ground segment supplier
COR	Critical operations review	To ensure that all mission operations data has been validated and that all documentation is available to start the training and operational validation phase	During phase D, at the end of mission operations data validation	Operations customer
ORR	Operational readiness review	To ensure full readiness of the ground segment for in orbit operations, and to authorize its utilization for space segment in-orbit operations. To ensure that all procedures have been validated and that operations teams are ready for operations.	End of phase D, after completion of operational validation	Operations customer
FQR	Flight qualification review	To assess the performance of the space and ground segments after in–orbit commissioning and to declare readiness for in–orbit exploitation	End of phase E1, after the completion of the commissioning activities	Operations customer and ground segment customer

Review ID	Review title	Review objective	Date	Chaired by
IOORs	In–orbit operations reviews	To carry out a regular assessment of the performance of the space system, i.e. both space segment and ground segment	During phase E2 on a regular basis (e.g. yearly)	Operations customer and ground segment customer
ELR	End-of-life review	To verify that the mission has completed its useful operation or service and that the procedures for disposal are in place	End of phase E2	Operations customer and ground segment customer
MCR	Mission close–out review	To assess the performance of the services provided and to confirm proper disposal of space and ground segments	End of phase F	Operations customer and ground segment customer

Annex A (normative)
Customer requirements document (CRD) - DRD

A.1 DRD identification

A.1.1 Requirement identification and source document

This DRD is called from ECSS-E-ST-70 requirements 5.2.1b. and 6.2.1b.

A.1.2 Purpose and objective

The objective of the customer requirements document (CRD) is to provide all essential top-level assumptions, constraints and operational requirements for the mission to allow the supplier(s) of the ground segment and/or operations to design the ground segment and/or to develop an operations concept.

A.2 Expected response

A.2.1 Scope and content

<1> Introduction

a.   The introduction shall describe the purpose and objective of the CRD.

<2> Applicable and reference documents

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

<3> Mission overview

a.   The CRD shall describe:
1.   the main objectives and characteristics of the space mission;
2.   the spacecraft;
3.   the instruments on-board;

4.   the ground segment that is foreseen for the control and operations of the spacecraft, the instruments and the ground segment itself;

5.   the operations that are foreseen to achieve the goal of the space project.

<4>   Project responsibilities

a.   The CRD shall describe the distribution of responsibilities within the space project, including the responsibilities of the space project customer and those of the ground segment supplier and/or operations supplier.

<5>   Major project milestones

a.   The CRD shall summarize the major project milestones relating to the space segment and the ground segment.

<6>   Mission constraints

a.   The CRD shall describe any constraints or other essential mission information that impacts on the design of the ground systems or the mission operations, including:

1.   the launch vehicle, the launch site location, the ascent trajectory and the injection characteristics;

2.   the main orbital parameters for each distinct orbital phase i.e. wherever the orbit changes significantly;

3.   identification of each distinct operational phase and any constraints on the use of the ground segment for the phase;

4.   any constraints imposed on the ground segment by the satellite, for example, uplink and downlink RF frequencies, on-board antenna patterns.

<7>   Mission operations requirements

a.   The CRD shall list the high level requirements on mission operations and, by derivation, on the ground segment, at a level sufficient to define the mission operations concept.

> NOTE   This drives the major decisions concerning the design and deployment of the ground segment.

b.   The requirements shall be organized according to the following operations functional breakdown:

1.   mission planning and scheduling;

2.   monitoring and control;

3.   performance monitoring and evaluation;

4.   flight dynamics;

5.   payload operations and data management:

(a)   payload operations planning;

(b)   payload operations control;

(c)   payload data processing;

(d)   payload data archiving;

(e)   user services;

(f)   data product delivery;

(g)   performance analysis.

6.   on-board software maintenance;

7.   other mission-specific operations functions.

c.   For the GSCRD, requirements of the following classes shall be included for each major functional heading:

1.   functional;

2.   performance;

3.   availability;

4.   operational;

5.   interface;

6.   design (implementation);

7.   reliability;

8.   maintainability;

9.   safety;

10.   security;

11.   human-computer interaction (HCI).

> NOTE   Usually the requirements for a given function differ according to mission phase.

A.2.2   Special remarks

a.   Where the ground segment supplier and operations supplier belong to the same organization, the ground segment customer requirements document (GSCRD) and the operations customer requirements document (OCRD) may be combined into a single document.

b.   For large distributed ground segments, the GSCRD may be separated into self-contained documents addressing specific entities.

> NOTE   For example:
> - A flight operations segment and a payload data segment (e.g. Envisat or ERS).
> - A mission control centre and a science operations centre (e.g. observatory missions like XMM or Integral).
> - Ground control segment and mission data segment (e.g. Galileo).

Annex B (normative)
Mission analysis report (MAR) - DRD

B.1   DRD identification

B.1.1   Requirement identification and source document

This DRD is called from ECSS-E-ST-70 requirement 5.2.2.1c.

B.1.2   Purpose and objective

The objective of the mission analysis report (MAR) is to provide all the information on the mission characteristics, in particular its orbit and attitude, in sufficient detail for the planning and execution of mission operations. The MAR also provides input to the spacecraft and mission design.

B.2   Expected response

B.2.1   Scope and content

<1>   Introduction

a.   The introduction shall describe the purpose and objective of the MAR.

<2>   Applicable and reference documents

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

<3>   Mission requirements and constraints

b.   The MAR shall identify all pertinent requirements and constraints arising from the following:

    1.   the mission definition, including the scientific objectives;

    2.   the spacecraft platform and payload design;

    3.   data recovery and data circulation;

    4.   the selected launcher;

    5.   orbit and ground station network.

<4>   Mission overview

a.   The MAR shall provide a description of the baseline mission, summarises the basic characteristics of the spacecraft and the launch vehicle and identifies the different mission phases, their characteristics and duration.

<5>   Launch and early orbit phase

a.   For the selected launch vehicle, the MAR shall describe:

   1.   launch window characteristics (general, seasonal, daily);

   2.   launch target orbit

   3.   launch sequence of events;

   4.   eclipses during the launch phase;

   5.   ground station coverage;

   6.   launcher injection errors.

b.   For the early orbit phase, the MAR shall describe:

   1.   ground station coverage;

   2.   orbit determination concept and navigation analysis (station selection, data types, tracking schedule);

   3.   strategy for operational orbit acquisition

      NOTE   For example, drift orbit (LEO missions), ABM firing (GEO missions), and escape/injection (interplanetary missions).

<6>   Transfer phase (interplanetary missions)

a.   The MAR shall provide the following information:

   1.   ground station coverage;

   2.   eclipse phases and daily durations;

   3.   Earth occultation phases;

   4.   attitude control strategy;

      NOTE   For example, to maintain antenna Earth-pointing, to respect thermal control constraints.

   5.   payload operational constraints;

      NOTE   Sensor blinding by Earth or Sun.

   6.   transfer manoeuvre strategy.

<7>   Injection into planetary orbit (interplanetary missions)

a.   The MAR shall provide the strategy for planetary insertion or planetary flyby.

<8>   Routine phase (operation in final orbit)

a.   For Earth-orbiting missions, the MAR shall describe:

1.   characteristics of the operational orbit including its evolution as a function of time;

2.   orbit determination concept and navigation analysis (station selection, data types, tracking schedule);

3.   collision avoidance strategies

>   NOTE   For example, for constellation missions.

4.   seasonal eclipse phases and daily durations;

5.   ground station coverage;

6.   payload operations strategy;

7.   payload operational constraints

>   NOTE   For example, sensor blinding by Earth or Sun.

8.   data circulation strategies.

b.   In the case of interplanetary missions, the MAR shall describe also:

1.   Earth occultation phases;

2.   orbit phasing, orbit change requirements to achieve planetary surface coverage or planetary moon encounter/flyby.

<9>   Propellant budgets

a.   The MAR shall document the propellant budget for orbit control including routine orbit change manoeuvres (and delta-V manoeuvres in the case of interplanetary missions).

B.2.2   Special remarks

None.

Annex C (normative)
Mission operations concept document (MOCD) - DRD

C.1 DRD identification

C.1.1 Requirement identification and source document

This DRD is called from ECSS-E-ST-70 requirement 5.2.2.2b.

C.1.2 Purpose and objective

The objective of the mission operations concept document (MOCD) is to define the operations concepts for the various phases of the mission, covering both the space segment and the ground segment.

C.2 Expected response

C.2.1 Scope and content

<1> Introduction

a. The introduction shall describe the purpose and objective of the MOCD.

<2> Applicable and reference documents

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

<3> Mission operations requirements and constraints

<3.1> General

a. The MOCD shall provide all the essential input information that drives or constrains the operations concepts.

<3.2> Mission description

a. The MOCD shall describe the scope of the mission, its objectives and the top-level requirements on its operations.

> NOTE This information is derived from the mission analysis report and the customer requirements document.

<3.3> End-users

a. The MOCD shall identify all distinct categories of mission end-user and describe the data products, services, associated availability and delivery requirements.

<3.4> Programmatic and operational constraints

a. The MOCD shall identify any constraints relating to the design of the ground segment or its operation, including:

1. the re-use of existing ground segment elements or infrastructure;

2. the use of remote facilities for operation or maintenance of part of the space or ground segments, such as experimenter-provided control facilities or industry-provided facilities for software maintenance;

3. the use of customer furnished items developed as part of the space segment programme and to be re-used for operations.

<3.5> Relationships with other missions/programmes

a. The MOCD shall describe the relationship of the mission with other missions or programmes, including:

1. membership of a family of missions of the same or similar design or based on the same spacecraft platform;

2. membership of a multi-national or coordinated multi-mission programme;

3. agreements for the ground segment to support other concurrent missions or programmes or to process data from other missions.

<3.6> External dependencies or interfaces with other organizations

a. The MOCD shall describe the operational interfaces with other agencies, companies or other third parties.

<4> Space segment characteristics

a. The MOCD shall describe the capabilities and characteristics of the space segment platform, payload(s) and the space link subnet, including:

1. on-board autonomous functions;

2. the mechanisms for on-board generation, storage and downlink of mission data products;

3. the end-user services to be provided.

NOTE   The objective is to capture all the salient operational characteristics that are needed for the analysis of the operations processes.

<5>   Mission operations concepts

<5.1>   General

a.   The MOCD shall describe the mission operations concepts for each distinct mission phase, according to the top-level breakdown of operations processes as defined in C.2.1<5.2> to <5.6>.

> NOTE   It is recognized that not all these processes are applicable for each mission phase and the corresponding process can therefore be omitted. For example, mission exploitation processes are not normally undertaken during the LEOP. Also:
>
> - there can be additional mission-specific operations processes;
> - the concept for realizing a given process can be the same for several mission phases, in which case it is not repeated, but it is defined once and referenced as needed.

b.   The MOCD shall identify how to realize the operations processes with the ground systems and operations personnel.

c.   The MOCD shall also identify:

1.   Reuse of existing operational capabilities and services.

> NOTE   For example, there can be a mission requirement to re-use specific existing infrastructure, possibly modified or extended for the mission;

2.   Areas where existing operational capabilities cannot satisfy the concept, i.e. new developments are needed;

3.   Areas where trade-offs are needed.

> NOTE   For example, if it is not obvious whether to realize a given operational process by ground-based automation or manually by an operator.

<5.2>   Planning processes

a.   The MOCD shall describe the concept for the planning and scheduling of space and ground segment operations, including:

1.   user request management;

2.   space segment routine operations;

3.   ground segment maintenance requests;

4.   constraints management;

5. resources management (space and ground);

6. conflict resolution;

7. space segment operations scheduling;

8. ground segment operations scheduling.

<5.3> Operations execution processes

a. The MOCD shall describe the concept for the implementation of scheduled operations for the space and ground segment, including:

1. schedule execution;

2. procedure execution;

3. manual commanding;

4. command pre-transmission validation and uplink management;

5. command verification;

6. schedule and command history archiving;

7. space and ground segment health monitoring;

8. failure detection, isolation and recovery (FDIR).

<5.4> Evaluation processes

a. The MOCD shall describe the concept for evaluating the success of executed operations and for monitoring the performance of the space segment, including:

1. data analysis processes (trend analysis, forecasts);

2. monitoring of resource availability and utilization with provision of feedback to the planning processes described earlier;

3. report production (automated report production, routine operations reporting, anomaly reporting).

<5.5> Mission exploitation processes

a. The MOCD shall describe the concept for the generation, archiving and delivery of mission products to the end-users in a timely manner, including:

1. data transmission between ground entities;

2. data processing on ground;

    NOTE   For example, generation of mission products.

3. data delivery to the end-user;

4. data archiving, cataloguing and retrieval;

5. feedback to mission planning;

    NOTE   For example, to report achieved versus planned
            data acquisition.

<5.6>   Support processes

a.   The MOCD shall describe the concepts for all other activities performed in support of operations that are not covered by any of the above categories, including:

    1.   orbit and attitude determination and maintenance;

    2.   orbital and geometric events prediction;

    3.   ground station coverage predictions;

    4.   monitoring and control database maintenance;

    5.   ground software maintenance;

    6.   on-board software maintenance.

C.2.2   Special remarks

None.

Annex D (normative)
Operations engineering plan (OEP) - DRD

D.1 DRD identification

D.1.1 Requirement identification and source document

This DRD is called from ECSS-E-ST-70 requirement 5.2.2.4a.4.

D.1.2 Purpose and objective

The objective of the operations engineering plan (OEP) is to define the approach, methods, procedures, resources and organization to co-ordinate and manage all technical activities necessary to prepare for, validate and execute mission operations in conformance with the customer's requirements.

The OEP is part of the project management plan (as defined in ECSS M-ST-10).

D.2 Expected response

D.2.1 Scope and content

<1> Introduction

a. The introduction shall describe the purpose and objective of the OEP.

<2> Applicable and reference documents

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

<3> Mission overview

a. The OEP shall describe:

1. the main objectives and characteristics of the space mission;

2. the intended operational concept that fulfils the mission objectives;

3. an overview of the ground segment to be deployed for the mission, including internal and external entities.

<4> Operations engineering lifecycle and reviews

a. The OEP shall identify the following:

1. the major milestones driving the operations engineering processes;

2. the operations engineering lifecycle phases;

3. the principal operations reviews and their objectives;

4. the operations engineering critical path.

<5> Operations engineering processes

a. For each operations engineering process, the OEP shall define:

1. The inputs, either from previous phases/processes or from ground segment engineering processes or external inputs;

   NOTE   For example, data provided by the operations customer.

2. The engineering approach for each activity, including:

   (a) the manpower requirements in terms of staff numbers and specific skills levels and experience;

   (b) the tools to be utilized, identifying existing items, tailoring required of existing infrastructure items, special-to-project facilities;

   (c) other resources required for the execution of the activity, such as support services (documentation, project control, software support, maintenance), travel budget;

3. The interrelations with other engineering disciplines (space system level, space segment, ground segment engineering, quality assurance, logistics)

4. The outputs of the process.

b. As a minimum, the following operations engineering processes shall be covered:

1. Mission analysis and system studies;

2. Operations analysis and concept development;

3. Flight Dynamics (i.e. orbit and attitude determination and control);

4. Mission operations data production;

5. Mission operations data validation;

6. Operational validation;

7. Operations teams training;

8. Operations execution, covering all mission phases from launch through disposal.

Annex E (normative)
Space segment user manual (SSUM) - DRD

E.1   DRD identification

E.1.1   Requirement identification and source document

This DRD is called from ECSS-E-ST-70 requirement 5.3.1b.

E.1.2   Purpose and objective

The objective of the space segment user manual (SSUM) is to provide the space segment design and operational information and data that is used by the ground segment supplier and operations supplier to prepare and implement mission operations.

The SSUM DRD as given in this Annex covers that part of the SSUM that is relevant to Mission Operations.

E.2   Expected response

E.2.1   Scope and content

<1>   Introduction

a.   The introduction shall describe the purpose and objective of the SSUM.

<2>   Applicable and reference documents

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

<3>   Mission definition

<3.1>   Mission description

a.   The SSUM shall provide a general description of the mission and identification of the content of phases from launch to disposal.

\<3.2\> Mission analysis constraints

a. The SSUM shall describe all space segment constraints to be included in mission analysis.

\<3.3\> Mission phases and purposes

a. The SSUM shall provide the results of analyses for positioning and for in-orbit operations, taking into account satellite constraints.

    1. Results of analyses for positioning (or initial orbits):

        (a) pre-launch configuration;

        (b) launch window (variations over one year);

        (c) satellite or launch vehicle separation sequence;

        (d) positioning strategy;

        (e) accuracy for attitude and orbit determination;

        (f) chronological order of nominal operational sequences;

        (g) visibility of the ground stations used;

        (h) detailed analysis of high-risk sequences;

        (i) fuel consumption.

    2. Results of analyses for in-orbit operations:

        (a) in-orbit flight control strategy;

          NOTE   For example, change of position, phasing.

        (b) fuel consumption;

        (c) consequences that the environment can have on operational sequences.

          NOTE   For example, sensor blinding, and eclipses.

    3. Results of analyses for space segment disposal operations.

\<4\> Satellite description

\<4.1\> Design summary

a. The design summary shall include the following:

    1. summary of the satellite design, showing the definition of the platform subsystems, the distribution of functions and the major interfaces between them;

    2. a block diagram of the space segment;

    3. a top-level description of the on-board software architecture, for the platform subsystems and payload elements;

    4. description of the objectives of the payload as a whole and (where applicable) of each individual experiment or instrument;

    5. description of nominal payload operations scenarios and any constraints on payload operations.

NOTE   For example, mutually exclusive modes of operation, power or resource sharing.

<4.2>   System-level autonomy

a.   The system-level autonomy shall include the following:

1.   description of system-level autonomy provisions in the areas of mission management and fault management;

2.   definition, for each autonomous function, of the logic or rules used and the interfaces with the on-board subsystems or payload and the ground.

NOTE   For example, inputs, and reporting mechanism.

<4.3>   System-level configurations

a.   The system-level configurations shall include the following:

1.   drawings of the overall satellite configuration in all mission phases;

NOTE   Launch, separation, following deployments;

- definition of the satellite reference axes system(s);
- drawings of the platform and equipment layouts.

<4.4>   System-level budgets

a.   The system-level budgets shall provide the distribution (or allocation) of the following budgets, per platform subsystem or payload, or per mission phase:

1.   satellite mass evolution;

2.   satellite mass properties evolution;

3.   power consumption for all operational modes;

4.   power available in different mission phases;

5.   thermal budget and constraints and predictions;

6.   RF links (down and up);

7.   telemetry and telecommand date rates;

8.   memory;

9.   timing (including allocation between space and ground segments);

10.   propulsion system data;

11.   attitude measurement sensor data;

12.   pointing accuracy in routine phase;

13.   pointing accuracy in manoeuvre phase;

14.   alignment;

15.   outages resulting from satellite operations.

NOTE   For example, pointing accuracy degradation during a manoeuvre or degraded performance during an eclipse.

<4.5>   Satellite-to-ground interface specifications

a.   Provide a cross-reference to the applicable version of the SGICD.

<4.6>   System-level operations

<4.6.1>   Mission timelines

a.   The SSUM shall include:

1.   Baseline event timelines for each mission phase from separation from the launcher until the start of routine operations (i.e. LEOP, commissioning, payload calibration).

2.   Baseline event timeline for daily activities during the routine phase and any other repeat cycle of routine operations.

3.   Baseline event timelines for any subsequent critical (or non-routine) phases during the mission.

NOTE   For example, eclipse, phases, manoeuvres, planetary, and encounters.

4.   Baseline event timeline for space segment disposal operations.

b.   Each timeline shall contain a detailed description (i.e. down to the level of each single operational action) of the complete sequence of operations to be carried out, including a description of the rationale behind the chosen sequence of events, a definition of any constraints and the interrelationships between operations in the sequence.

<4.6.2>   System-level modes

a.   The SSUM shall describe all nominal and back-up modes (at the system level), including:

1.   their purpose (i.e. circumstances under which they are used),

2.   operational constraints,

3.   resource utilization,

4.   the expected satellite behaviour within each mode,

5.   the definition of the associated modes for each platform subsystem and payload, and

6.   ground monitoring requirements.

b.   The SSUM shall describe the allowable mode transitions and the operations procedure corresponding to each such transition.

c.   Cross-reference shall be made to subsystem or payload modes and procedures defined elsewhere in the SSUM.

<4.6.3> System-level failure analysis

a. The SSUM shall provide the results of the system-level failure modes and effects analysis (FMEA) or failure modes effects and criticality analysis (FMECA) and the resulting list of single-point failures.

b. Event combinations potentially leading to an undesirable end event shall be identified by means of a fault-tree analysis (FTA).

<5> Platform subsystems and payload description

<5.1> Subsystem/payload design summary

a. For each satellite platform subsystem and for each payload the SSUM shall describe the subsystem including:

1. the overall functions of the subsystem and the definition of its operational modes during the different mission phases;

2. description of any subsystem-level management functions, fault management concept and redundancy provisions;

3. a summary description of the component units/equipment and on-board software including the functions which each supports;

4. subsystem functional block diagrams and a diagram showing the source of telemetry outputs and the sink of telecommand inputs;

5. interfaces;

6. budgets.

<5.2> Unit or equipment design definition

a. For each satellite platform subsystem and for each payload the SSUM shall provide the following for each unit:

1. a detailed design description, including block diagrams, functional diagrams, logic and circuit diagrams;

2. physical characteristics including location and connections to the satellite structure, axes definition and alignment, dimensions and mass properties;

3. principle of operation and operational constraints of the unit or equipment.

4. If a unit is composed of many complex elements or modules, it may be necessary to provide a lower level of breakdown.

<5.3> Subsystem/payload software (where applicable)

a. For each satellite platform subsystem and for each payload the SSUM shall include:

1. Description of software design

2. Subsystem software

3. Application process service software

4. Memory map

b. For the software design, the SSUM shall describe the organization of the subsystem software and the physical mapping of software onto subsystem hardware;

c. For the subsystem software, the SSUM shall describe the details of each component of the subsystem software i.e. scheduler, interrupt handler, I/O system, telecommand packet handling system, telemetry packet handling system, including for each component its functions, component routines, input/output interfaces, timing and performance characteristics, flowcharts and details of any operational constraints.

d. For the application process service software, the SSUM shall:

1. describe the services implemented making cross-reference to ECSS-E-ST-70-41 "Telemetry and telecommand packet utilization", as tailored for the mission.

2. summarize all telemetry and telecommand structures including the conditions under which they are generated, the generation frequency, content and interpretation.

e. For each memory block, a map shall be provided showing RAM and ROM address areas, areas allocated for program code, buffer space and working parameters.

<5.4> Subsystem/payload performance

a. For each satellite platform subsystem and for each payload the SSUM shall describe:

1. all subsystem performance characteristics,

2. the expected performance degradation as a function of time during the mission, and

3. the resulting impact in terms of modifications to operational requirements or constraints.

<5.5> Subsystem/payload telemetry and telecommand lists

a. For each subsystem, the following lists shall be provided for each satellite platform subsystem:

1. a list of the housekeeping telemetry parameters.

2. a list of the telecommands.

b. Each housekeeping telemetry shall have a functional description with validity conditions, telecommand relationship, and all technical information necessary for using it;

c. Each telecommand shall have a functional description with utilization conditions, command parameters (syntax and semantics) and execution verification in telemetry.

NOTE 1 For example, pre-transmission validity, criticality level.

NOTE 2 This data is provided within the space segment monitoring and control database, which shall formally constitute part of this SSUM.

<5.6>   Subsystem failure analysis

a.   T For each satellite platform subsystem and for each payload the SSUM shall describe:

1.   Identification of potential subsystem failures by means of a systematic failure analysis (based on a subsystem FMEA/FMECA and FTA).

2.   Identification of the methods by which the ground segment can identify a failure condition from analysis of the telemetry data and isolate the source of the failure.

<5.7>   Subsystem/payload operations

a.   For each satellite platform subsystem and for each payload the SSUM shall describe:

1.   subsystem modes;

2.   nominal operational procedures;

3.   contingency procedures.

b.   Subsystem modes shall be defined for all distinct nominal and back-up modes of the subsystem including:

1.   purpose (i.e. conditions under which each shall be used);

2.   operational constraints;

3.   resource utilization;

4.   the definition of the associated modes for each subsystem unit, equipment and software function;

5.   ground monitoring requirements.

6.   Identification of the allowable mode transitions and any subsystem-level operational constraints.

c.   Nominal operational procedures shall be defined for each nominal mode transition identified under clause E.2.1<5.7>b.6.

d.   For each procedure described in clause c, the following shall be provided:

1.   an introduction describing the purpose of the procedure and the mission phase(s) or conditions when applicable;

2.   the body of the procedure, structured according to operational steps, including:

(a)   pre-conditions for the start of the step defining, where applicable:

(b)   satellite system-level or subsystem-level pre-requisites;

     NOTE   For example, configuration and resource requirements, such as power and fuel.

- satellite attitude and orbit pre-requisites;

- ground system pre-requisites;

(c)   telecommands to be sent;

(d)   telemetry data to be monitored to verify correct execution of the step;

(e)   interrelationships between steps;

> NOTE   For example, conditional branching within the procedure, timing requirements or constraints, hold and check points.

(f)   conditions for completion of the step.

e.   Contingency procedures shall be defined for each (time and safety critical) failure condition identified in the subsystem failure analysis (based on FMEA/FMECA and FTA).

> NOTE   This can utilize a nominal operational procedure already identified in E.2.1<5.7>c.

f.   For contingency procedures, the same details shall be provided as for nominal operational procedures in E.2.1<5.7>d.

g.   Where the recovery method for a failure or group of failures is mode, mission, or phase dependent, separate procedures shall be described for each mode/mission phase.

<5.8>   Payload data definition

a.   For each operational mode of the payload, the sensor output data, the conditions under which it is generated, its contents, and data rate shall be described, for each satellite platform subsystem and for each payload.

b.   The on-board processing performed on the sensor data and the algorithms used for this shall be described.

c.   The data processing algorithms necessary to interpret the payload telemetry on-ground shall be provided.

E.2.2   Special remarks

None.

Annex F (normative)
Operational validation plan (OVP) - DRD

F.1 DRD identification

F.1.1 Requirement identification and source document

This DRD is called from ECSS-E-ST-70 requirement 5.2.2.6c.

F.1.2 Purpose and objective

The operational validation plan (OVP) defines how the ground segment and operations are validated, subsequent to ground segment AIT, in order to satisfy the operational requirements contained in the customer requirements document (CRD).

F.2 Expected response

F.2.1 Scope and content

<1> Introduction

a. The introduction shall describe the purpose and objective of the OVP.

<2> Applicable and reference documents

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

<3> Overview

<3.1> Operational validation objectives, schedule and success evaluation

a. The OVP shall include:

1. a statement of the operational validation objectives;

2. a presentation of the overall structure and schedule for the operational validation, including major milestones;

3. identification of any constraints or mission-specific considerations;

4. identification of the mechanisms and criteria to be used for measuring and evaluating the success of the operational validation.

<3.2> Operational validation management

a. The OVP shall describe the management structure for the conduct of the operational validation, including the individual responsibilities of the following operations teams (as applicable):

1. the mission operations team;

2. the ground operations team;

3. the flight dynamics team;

4. the mission exploitation team.

5. the simulations officer(s);

6. any independent QA group that is involved in the operational validation.

<3.3> Reviews

a. The OVP shall describe the procedures for conducting the operational readiness review (ORR).

<4> Simulations and rehearsals

a. The OVP shall describe the plan of simulations and rehearsals, comprising the overall timetable of simulations with an indication of any sequencing and interdependencies between simulation sessions.

b. The OVP shall describe the briefing and de-briefing procedures.

c. For each individual simulation session or rehearsal, the following shall be described:

1. identification of the operational teams involved, the team members and their location;

2. the operational scenarios being simulated/rehearsed with explicit reference to the mission operations plan (MOP) timelines or procedures that are to be used;

3. the ground segment elements (especially control room facilities) to be used and their configuration i.e. hardware, software and database version numbers;

4. the test tools to be used and their configuration status;

   NOTE   For example, operational simulator.

5. the times of the briefing, the expected duration of the simulation session and the expected times of the de-briefing.

<5> **Ground segment readiness tests**

a.   The OVP shall describe the ground segment readiness test plan, mission readiness tests (MRTs), data flow tests (DFTs), including:

1.   an overall test plan, and

2.   for each individual test:

(a)   the test timetable (start time, duration),

(b)   the test configuration including, for instance, the identification of all ground segment systems or equipment to be used and initialization requirements as applicable,

NOTE   For example, hardware, software and database versions.

(c)   any applicable test constraints,

(d)   manpower resources, and

(e)   the test procedures to be used (cross-reference may be made to other documents).

<6> **Records and reports**

a.   The OVP shall describe the contents of the following records and reports and list the mechanisms and responsibilities for their production and subsequent maintenance and storage:

1.   simulation logs;

2.   simulation reports;

3.   ground segment readiness test reports;

4.   operational validation anomaly records;

5.   operational validation actions status records.

F.2.2   Special remarks

None.

Annex G (normative)
Mission operations plan (MOP) - DRD

G.1   DRD identification

G.1.1   Requirement identification and source document

This DRD is called from ECSS-E-ST-70 requirement 5.3.2k.

G.1.2   Purpose and objective

The mission operations plan (MOP) contains all the rules, procedures and timelines necessary to implement the in-orbit operations for the mission during all mission phases in accordance with the mission objectives and respecting any constraints imposed by the design of the space and ground segments. It also contains rules and procedures for the conduct of contingency operations. The MOP is elaborated from the operational information for the space and ground segments contained in the space segment user manual (SSUM) and the relevant user manuals for the ground segment systems.

G.2   Expected response

G.2.1   Scope and content

<1>   Introduction

a.   The introduction shall describe the purpose and objective of the MOP.

<2>   Applicable and reference documents

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

<3>   Mission management

<3.1>   Introduction

a.   Provides a summary of the mission, the ground segment and the overall operations concept. It shall also present the overall MOP structure and rationale.

<3.2>   **Mission rules**

a.   The MOP shall contain the rules and criteria governing the conduct of mission operations, including:

1.   launch hold criteria;

2.   the principles and mechanisms for the routine and foreseen contingency operations of the mission;

3.   rules and criteria for emergencies and anomalies not covered by existing contingency procedures. This relates to situations arising from multiple or unforeseen failures for which no pre-defined recovery action exists;

4.   rules and criteria for transferring operations between different authorities (where applicable);

5.   mission termination criteria.

<3.3>   **Mission operations management**

a.   The MOP shall present the organization, responsibilities and location of the parties and teams involved in the mission operations during each mission phase.

        NOTE   For example, control centres or control rooms.

b.   An organisational chart shall be provided for each operational team, including the names and positions of each individual.

c.   The following shall also be defined:

1.   mechanisms for confirming the readiness to proceed with operations (briefing) and for reviewing the progress of execution of operations (de-briefing;

2.   the reporting channels for routine operations and the mechanisms deployed for anomaly reporting;

3.   mechanisms for on-call support and the procedures for invoking them.

d.   The MOP shall include the operational ICDs defining the interfaces with external operations entities, such as other Agencies providing ground segment or space segment elements.

        NOTE   For example, ground stations, payloads.

<3.4>   **Configuration management and change control**

a.   Defines the procedures for instigation, approval, implementation and control of any modifications to the ground segment following the pre-launch configuration freeze.

<4>   **Mission phase operations**

a.   For each mission phase, the following shall be provided:

1.   a description of the operations phase including a list of major events and timings;

2.   a description of the operations implementation strategy for the mission phase and the consequent structure and content of the remainder of this clause of the MOP;

3.   timelines of operations, containing:

(a)   a definition of each operational activity;

(b)   the planned start time (absolute or relative);

(c)   identification of the operational position that executes or monitors the activity;

(d)   an identification of the background activities to be conducted by each of the supporting operations teams;

NOTE   For example, flight dynamics.

(e)   a cross-reference to operations procedures contained elsewhere in the MOP;

(f)   briefing and de-briefing breakpoints.

<5>   Operations procedures

a.   The MOP shall contain the procedures for the nominal and contingency operations of the space and ground segments.

b.   A matrix shall be provided indicating for each procedure the mission phase(s) to which it is applicable, and the authorization status of the procedure (validated or not validated).

c.   Operations procedures shall be organized hierarchically with a structure that reflects the level of the operation (system-level, subsystem-level).

d.   Operations procedures can call up other procedures as necessary.

<6>   Hand-over procedures

a.   The MOP shall contain the procedures for hand-over of operations between different authorities (where applicable).

b.   The responsibilities of the different authorities involved shall be described.

G.2.2   Special remarks

a.   Where a given ground entity is operated completely independently, the operations for that entity should be described in a self-contained sub-plan of the MOP.

Annex H (normative)
Operations anomaly report (OAR) - DRD

H.1 DRD identification

H.1.1 Requirement identification and source document

This DRD is called from ECSS-E-ST-70 requirement 5.8.2.4e.

H.1.2 Purpose and objective

An operations anomaly report (OAR) is generated to document a departure from expected performance during operation. This pertains to the operation of either the space or the ground segment. The purpose of an operations anomaly report is to provide all necessary evidence and supporting material concerning a detected anomaly (including recovery actions undertaken, where applicable) to allow the recipients to analyse the anomaly and, where requested, to propose a workaround solution or further recovery action.

H.2 Expected response

H.2.1 Response identification

a. Each OAR shall bear the name of the mission and shall have a unique (mission-level) identification number.

H.2.2 Scope and content

<1> Preliminary elements

a. The OAR shall include:

1. Description of the operational context in which the anomaly was detected.

   NOTE   For example, SVT, LEOP, and commissioning phase.

2. Identification of the suspected problem source

   NOTE   For example, ground subsystem, on-board subsystem or equipment or unit.

3. Descriptive title.

4. Date and time of occurrence or, if this is unknown, the time of anomaly detection.

5. Severity of the anomaly in terms of operational impact on the ground or space segment as one of the following:

    (a) No impact: The anomaly has no impact on the primary mission objectives

    (b) Minor impact: The anomaly has no significant operational impact on the mission.

        NOTE   For example, an operational error that caused a transient loss of data or service, which has since been restored, falls into this category.

    (c) Major impact: The anomaly has a substantial impact on the mission objectives, or compromises the future safety of the mission or the available redundancies.

6. The names and designations (titles) of the originator(s) of the OAR.

7. The name, position and signature of the manager authorising the report.

8. Distribution list, listing the names, titles and locations of all parties who are designated to receive a copy of the OAR.

9. Version control, documenting the issue number (where applicable) and date of issue of the OAR.

10. Status, indicating whether action is required in response to this report, or whether the report is provided for information purposes only, and indicating the name (designation) of the actionee.

<2>   Introduction

a. The OAR shall provide a description of the anomaly and the recovery actions taken to date, including:

1. A summary of the operational impact;

2. A summary of recovery actions taken;

3. An indication of whether this is the first occurrence of the anomaly.

<3>   Details of the anomaly

a. The OAR shall provide a description of the anomaly, together with all supporting material required for a full understanding and further analysis by the report recipients, and including the following:

1. A cross-reference to any previous occasion(s) on which the same anomaly occurred (quoting OAR numbers);

2. Details of the on-going and immediately preceding actions which can have contributed to the anomaly;

3. Details of the prevailing ground segment and space segment configuration before, during and after the anomaly.

b. Supporting material may be provided in the form of:

1. Telemetry reports (display hardcopies, printouts, retrieval reports),

2. Telecommand history file reports (printouts, electronic reports),

3. Operational logs,

   NOTE   For example, console log.

4. Event logs, and

5. Mission-specific data, such as star-tracker maps, payload images.

<4>   Actions taken

a. The OAR shall provide a detailed chronicle of any actions taken in reaction to the anomaly.

b. Supporting material may be provided in the form of:

1. Telecommand history file reports (printouts, electronic reports),

2. Telemetry reports (display hardcopies, printouts, retrieval reports),

3. operational logs, and

   NOTE   For example, console log.

4. Event logs.

<5>   Operational impact

a. The OAR shall describe the impact (if any) of the anomaly on on-going or planned operations, including:

1. Details of outages of services or communications with the space segment;

2. The re-planning or re-scheduling undertaken to date;

3. The impact on available redundancies.

<6>   Recommendations

a. The OAR shall propose a course of action for further investigation and resolution of the anomaly:

1. Either internally by the ground segment and operations supplier, or

2. By external parties.

b. A schedule for anomaly investigation or resolution shall be indicated.

H.2.3   Special remarks

None.

Annex I (normative)
Operations procedures - DRD

I.1 DRD identification

I.1.1 Requirement identification and source document

This DRD is called from ECSS-E-ST-70 requirement 5.3.2l.

I.1.2 Purpose and objective

An operations procedure is an elementary component of the mission operations plan that defines the actions to achieve a specific operational objective. The complete set of operational procedures covers all planned operations for the space and ground segments. An operations procedure is a "building block" used in the construction of the actual operations to be performed in a given mission phase. An operations procedure may be called up by a mission timeline, an automatically executing schedule, another procedure or it can be initiated manually.

I.2 Expected response

I.2.1 Response identification

a. Each operations procedure shall have a unique identification number.

I.2.2 Scope and content

<1> General

a. An operations procedure shall be composed of the elements specified in I.2.2<2> to I.2.2<8>.

> NOTE   These requirements relate to any representation of the procedure that is presented to a human user, i.e. either in hardcopy form or on a visual display.

<2>   Preliminary elements

a.   An operations procedure shall include:

1.   Title: A short descriptive title for the procedure.

2.   Version control: The version number and date from which the operations procedure is applicable.

3.   Author: The names of the author(s) of the operations procedure.

<3>   Introduction

a.   An operations procedure shall:

1.   Describe the objective of the procedure,

2.   Include the context in which the procedure can be executed (or called up), a description of the goal of the procedure and all possible results,

3.   Include explanatory figures or diagrams.

> NOTE   The introduction is for informative purposes only and does not belong to the "executable" part of the procedure.

<4>   Required operational authority

a.   An operations procedure shall indicate any special operational authorization required for manual execution of the procedure.

> NOTE   For example, the following can be specified: "This procedure may be executed by the spacecraft controller only with the written authority of the spacecraft operations manager."

<5>   Expected duration

a.   An operations procedure shall state how long it takes to execute the procedure.

<6>   Pre-conditions

a.   An operations procedure shall list all conditions to be satisfied before procedure execution can be started.

b.   An operations procedure may also indicate conditions under which start of the procedure is prohibited

c.   Pre-conditions shall refer to one or more of the following:

1.   Mission phase;

2.   Ground segment configuration;

3.   Space segment configuration;

4.   Orbit position or environmental conditions;

5.   Status of other procedures.

<7> Procedure body

<7.1> General

a. The procedure body shall contain the executable elements that achieve the goal of the procedure.

b. The procedure body shall be composed of building blocks called "steps".

> NOTE Steps can either be executed in sequence or in parallel.

c. The structure of a step, as specified in I.2.2<7.2>, shall be similar to that of a procedure itself, i.e. it can have pre-conditions, an executable body and post conditions (see below).

> NOTE If a procedure has no constituent steps, it is equivalent to having a single step that comprises the complete procedure body.

d. The procedure body may also contain a contingency element that manages contingency situations that are detected during the course of execution of the procedure..

<7.2> Procedure step

a. For each step of the procedure the sequence of activities to be performed shall be described.

> NOTE 1 For example, activities can be:
> - uplink telecommand;
> - initiate command stack or pre-defined command sequence;
> - execute ground segment command (for example, "select system display");
> - check specific telemetry values;
> - wait: either until (absolute time), for (delta time), whilst (condition true or not true);
> - mission-specific activities.
>
> NOTE 2 "Delta time" is a relative time, e.g. measured from the time of the completion of the previous activity.

<7.3> Contingency element

a. The procedure shall contain the information about what to do in case of contingency.

> NOTE This is necessary for those steps for which the system cannot be left as it is (e.g. when some critical on-board protection has been disabled as part of the execution, or when an activity started as part of this procedure has to be aborted when it goes wrong, as in an orbital manoeuvre).

b. In case that contingency actions are specified, the procedure shall contain information covering how to:

1. Restore the system configuration (space segment and ground segment) such as to allow the procedure main body to continue its execution (i.e. by first suspending the procedure body, then executing the contingency action and then resuming the procedure body);

2. Achieve the goal of the procedure in a different manner to the one followed by the procedure body (i.e. by first suspending the procedure body, then executing the contingency action and then stopping the procedure); or

3. Abort the procedure if it is not possible to recover from the detected contingency (i.e. by first suspending the procedure body, then executing the contingency action and then aborting the procedure).

<8> Post conditions

a. An operations procedure shall define how to verify that the goal(s) of the procedure are achieved, once the execution of the body of the procedure is completed.

b. Following verification, the status of the procedure shall be one of the following:

1. procedure terminated, success confirmed, or

2. procedure terminated, procedure failed (including reasons).

I.2.3 Special remarks

None.

Annex J (normative)
Customer furnished items and services requirements document (CFISRD) - DRD

J.1   DRD identification

J.1.1   Requirement identification and source document

This DRD is called from ECSS-E-ST-70 requirement 5.2.2.3g.

J.1.2   Purpose and objective

The objective of the customer furnished items and services requirements document (CFISRD) is to identify the deliverable items and support services required from the operations customer during all phases: operations preparation, operations validation, pre-and post-launch mission operations.

J.2   Expected response

J.2.1   Scope and content

<1>   Introduction

a.   The introduction shall describe the purpose and objective of the CFISRD.

<2>   Applicable and reference documents

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

<3>   Mission information

a.   The CFISRD shall identify the different classes of mission information to be delivered by the OC, and specify the:

1.   Detailed contents list;

2.   Delivery media and format;

3.   can refer to a generic or mission specific ICD

4. Pre-delivery validation requirements;

5. Delivery schedule for different issues (versions) expressed in terms of links with the ground segment development and operations preparation schedules;

b. Mission information classes shall include:

1. The space segment users manual (SSUM), see also Annex F;

2. Space segment detailed design documents;

3. The data required for monitoring and control of the space segment (including procedures), which are formally part of the SSUM - this includes typically:

4. Operating procedures and sequences;

5. TM/TC database (e.g. formats, descriptions, limit thresholds, validity, constraints, verification);

6. Other databases for in-flight operations (e.g. OBCPs, tables for on-board SW generation);

7. Algorithms for the derivation of synthetic parameters;

8. Algorithms for telemetry data interpretation on ground;

9. The flight dynamics database.

<4>   Suitcase

a. The CFISRD shall define the requirements for the delivery of the suitcase, covering:

1. Content of delivery

    NOTE   For example, hardware, software, documentation, delivery note, and software problems reports/lists/database.

2. Delivery schedule;

3. Support services.

    NOTE   For example, maintenance and operation of the suitcase, training, troubleshooting.

<5>   Space segment models

a. The CFISRD shall define the requirements for the delivery of space segment models (hardware or software) for integration into an operational simulator, covering:

1. Scope and fidelity of models;

2. Specification of the ICD between the models and the operational simulator kernel;

3. Pre-delivery validation requirements;

4. Content of the delivery

<8> Pre-launch access to the space segment

a. The CFISRD shall identify the access required to the space segment to permit pre-launch listen-in tests (LITs, telemetry data reception only) and space-to-ground compatibility tests (SVTs), together with associated support from the OC, covering:

1. Definition of test scope and objectives;

2. The number and type of tests;

3. Duration and schedule;

4. Requirements for review by the OC of test plans and procedures;

5. Support required for test preparation, including pre-configuration of the space segment for each test session;

6. Support required for test execution, including implementation of local measures to ensure safety of the space segment at all times, de-configuration of the space segment at the end of each test session;

7. Support required for test evaluation.

<9> Provision of pre-launch technical assistance

a. The CFISRD shall identify the requirements for pre-launch technical assistance from the OC, covering:

1. preparation of responses to detailed questions relating to the space segment design and operation, monitoring and control databases and SSUM;

   NOTE   Questions originating from, for example, operational simulator developers, operations staff, flight dynamics staff.

2. review of the MOP timelines, schedules and procedures (both nominal and contingency);

3. training of operations staff in the space segment design and operations including scope, topics to be covered, number of sessions, duration, schedule;

4. on-site participation of project support teams in the pre-launch simulations programme: Scope, scenarios to be simulated, duration and schedule.

<10> Provision of post-launch technical support

a. The CFISRD shall identify the requirements for post-launch technical support from the OC, covering:

1. On-site participation of project support teams during LEOP and commissioning phase operations, including responsibilities, required skills, schedule for support;

2. On-call engineering support to mission operations at the mission control centre: response time as a function of mission phase;

3. Call-out engineering support for satellite anomaly recovery operations at the mission control centre, including response time as a function of mission phase;

4. Off-site support for analysis of satellite anomalies, including inputs to be provided to the OC (in particular anomaly reports, in accordance with Annex H), definition of close-out report, and response times.

J.2.2 Special remarks

None.

Annex K (informative)
Commonality considerations

K.1　General

Ground segments are frequently built using existing systems including multi-mission infrastructure. It is important that the design considers how such systems are re-used including customization and extension, i.e. modifications and additions.

A more comprehensive classification of reuse is as follows:

* between the flight segment and the ground segment, in particular the space link interface elements and mission operations data;

* between space projects, in particular the commonality of software having the same functional role in different systems;

> NOTE　　For example, monitoring and control, flight dynamics, planning systems.

* "middleware" and low-level software and hardware infrastructure common to the different subsystems required by a given space project ground segment.

It is important to note that these areas of commonality are not mutually exclusive. In fact they appear at different phases of a ground segment project, the first one being mostly relevant in phases A and B and the last two being more relevant during development by the GSS (phases C and D).

K.2　Software

* The reuse of software should comply with the requirements on "Reuse of existing software" of ECSS-Q-ST-80.

* The main software systems to be considered for commonality are:

    — the mission operations system;

    — the payload operations and data system;

    — the EGSE system;

    — the ground station monitoring and control, data storage and distribution functions;

    — simulation, test and training tools which include real–time behavioural software models of the space segment or some of its elements.

- The main functional elements that can be reused include:

  — monitoring;

  — commanding;

  — monitoring and control database management;

  — operations procedures preparation, management and execution;

  — data archiving and distribution;

  — performance evaluation;

  — on–board software management and maintenance (both software and hardware), and

  — human–computer interactions (HCI).

K.3 Spacelink interfaces

The EGSE used during ground tests and the ground stations both have interfaces to the space segment via the space link. Even though these interfaces usually differ at the physical interface layer, a significant part of the interface functions may be common.

Commonality between EGSE and the ground stations for the following space link interface functions should be considered:

- downlink signal reception;

- uplink signal radiation;

- downlink data processing;

- uplink data processing.

K.4 Mission operations data

- Much of the mission information (e.g. monitoring and control data definitions, displays) is common to several areas; spacecraft manufacturer, satellite check-out and mission operations. For technical, economic and risk-reduction reasons, mission operations data should be reused as far as possible.

- Monitoring and control systems deployed in these different areas should be compatible in terms of their monitoring and control databases, to facilitate the reuse of space segment monitoring and control data.

K.5 Commonality of software framework and hardware infrastructure

In most ground segment projects, the various elements of a ground segment are partitioned into subsystems which usually correspond to different engineering specializations, e.g. the communication network (WAN, LANs), monitoring and

control system, flight dynamics system, implemented by telecommunications, software and flight dynamics engineers respectively.

Whenever possible, it should be attempted to establish common software frameworks and a common hardware infrastructure to reduce development and maintenance costs. For example, if both monitoring and control and flight dynamics applications have a need to archive data, it could make sense to ensure that the archiving system is common. Similarly, common software tools or routines can be used, for example, for HCIs, database access, communication protocols, throughout all software systems.

Annex L (informative)
ECSS-E-ST-70 level 3 standards

Table L-1 identifies the level 3 standards in the Ground Systems and Operations domain and describes the scope of each standard.

Table L-1 ECSS-E-ST-70 level 3 standards

Number	Title	Scope
ECSS-E-ST-70-01	On-board control procedures	Defines the requirements to be fulfilled by on-board services for the handling of on-board control procedures (OBCPs). Additionally, it identifies requirements on the life cycle for development and maintenance of on-board control procedures and specifies the essential characteristics of a language for defining OBCPs
ECSS-E-ST-70-11	Space segment operability	Defines requirements for the space segment to enhance and ensure its operability in-orbit. High level requirements are grouped accordingly to operability classifications such as Observability, Commandability, Safety and Fault Tolerance, Flexibility, etc., whilst detailed requirements are organised according to on-board function or applicable equipment/subsystem.
ECSS-E-ST-70-31	Monitoring and control data definition	Defines the monitoring and control data to be delivered by a supplier to a customer at any level of space system integration and test as well as to mission operations. It concerns the "what" of the delivery (i.e. the semantics and data formats) rather that the "how" (i.e. the delivery mechanism). The standard defines a formal framework, namely the Space System Model (SSM), for capturing the data pertaining to the space system itself.
ECSS-E-ST-70-32	Test and operations procedure language	Defines the requirements to be satisfied by a common procedure language for the satellite check-out and mission operations domains. The standard also defines a language (PLUTO) that satisfies these requirements. This definition formalises the structure and behavioural aspects of procedures as well as identifying the set of language constructs that comprises the language.
ECSS-E-ST-70-41	Telemetry and telecommand packet utilization	The packet utilization standard (PUS) defines the application-level interface between ground and space in order to satisfy operational concepts covering satellite check-out and mission operations. It defines a number of standard on-board services satisfying these operational concepts and, for each service, identifies a minimum implementation (minimum capability set) and optional extensions. It also defines standard service requests (telecommands) and service reports (telemetry packets) for the operations of each service.

Bibliography

ECSS-S-ST-00   ECSS system – Description, implementation and general requirements

ECSS-E-ST-10-02   Space engineering – Verification

ECSS-E-ST-70-01   Space engineering – On-board control procedures

ECSS-E-ST-70-11   Space engineering – Space segment operability

ECSS-E-ST-70-31   Space engineering – Ground systems and operations – Monitoring and control data definition

ECSS-E-ST-70-32   Space engineering – Test and operations procedure language

ECSS-E-ST-70-41   Space engineering – Telemetry and telecommand packet utilization

ECSS-M-ST-10   Space project management – Project planning and implementation

CCSDS 701.0-B-2   Advanced Orbiting Systems, Networks and Data Links: Architectural Specification