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Entwurf

**Raumfahrttechnik –
Bodensysteme und Bodenbetrieb;
Englische Fassung FprEN 16603-70:2014**

Space engineering –
Ground systems and operations;
English version FprEN 16603-70:2014

Ingénierie spatiale –
Systèmes au sol et exploitation;
Version anglaise FprEN 16603-70:2014

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2014-08-08 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfes besonders zu vereinbaren.

Stellungnahmen werden erbeten

- vorzugsweise online im Norm-Entwurfs-Portal des DIN unter www.entwuerfe.din.de bzw. für Norm-Entwürfe der DKE auch im Norm-Entwurfs-Portal der DKE unter www.entwuerfe.normenbibliothek.de, sofern dort wiedergegeben;
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- oder in Papierform an den Normenausschuss Luft- und Raumfahrt (NL) im DIN, 10772 Berlin (Hausanschrift: Burggrafenstr. 6, 10787 Berlin).

Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevanten Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 136 Seiten

Normenausschuss Luft- und Raumfahrt (NL) im DIN

Nationales Vorwort

Dieses Dokument (FprEN 16603-70:2014) wurde vom Technischen Komitee CEN/CLC/TC 5 „Raumfahrt“ erarbeitet, dessen Sekretariat vom DIN (Deutschland) gehalten wird.

Dieses Dokument ist derzeit zum einstufigen Annahmeverfahren vorgelegt.

Dieses Dokument wurde speziell zur Behandlung von Raumfahrtsystemen erarbeitet und hat daher Vorrang vor jeglicher Europäischer Norm, da es denselben Anwendungsbereich hat, jedoch über einen größeren Geltungsbereich (z. B. Luft- und Raumfahrt) verfügt.

Das zuständige deutsche Normungsgremium ist der Arbeitsausschuss NA 131-10-01 AA „Interoperabilität von Informations-, Kommunikations- und Navigationssystemen“ im DIN-Normenausschuss Luft- und Raumfahrt (NL).

Änderungen

Gegenüber DIN EN 14737-1:2004-12 wurden folgende Änderungen vorgenommen:

- a) Norm-Nummer geändert.
- b) keinerlei Änderungen des Textes.

Nationaler Anhang NA (informativ)

3 Begriffe und Abkürzungen

3.1 Begriffe aus anderen Normen

Für die Anwendung dieser Norm gelten die Begriffe nach ECSS-S-ST-00-01.

Für die Anwendung dieser Norm gelten die folgenden Begriffe nach ECSS-E-ST-10:

Systemengineering

Für die Anwendung dieser Norm gelten die folgenden Begriffe nach ECSS-E-ST-10-02:

Prüfung/Inspektion

Test

3.2 Für diese Norm spezifische Begriffe

3.2.1

Einheit

Instanz

Kombination aus Bodensystemen und der zugehörigen Organisation des Personals bzw. der Operationen

3.2.2

Bodensegmentoperationen

Tätigkeiten im Zusammenhang mit Planung, Ausführung und Bewertung der Operationen des Bodensegments (oder von dessen Teilsätzen)

3.2.3

Bodensegment

für die Vorbereitung oder Ausführung der Missionsoperationen erforderliche Bodensysteme

3.2.4

Bodensegmentkunde

für die Beschaffung des Bodensegments verantwortliche Partei

ANMERKUNG Die Schnittstelle zwischen Bodensegmentkunde und Bodensegmentlieferant weist die Form einer Kunden-Lieferanten-Beziehung auf.

3.2.5

Bodensegmentlieferant

für die Lieferung des Bodensegments verantwortliche Partei

3.2.6

Bodensystem

integrierter Satz von Bodenfunktionen zur Unterstützung der vorbereitenden Tätigkeiten vor Missionsoperationen oder deren Durchführung

3.2.7**Zwischenfall**

eine Anfrage, Beobachtung oder Anomalie bei der Bereitstellung einer Dienstleistung, die sich auf eine Unterbrechung oder Qualitätsminderung der Dienstleistung bezieht oder diese verursacht oder verursachen kann

3.2.8**Mission**

spezifische durch ein Raumfahrtssystem zu erreichende Ziele, charakterisiert durch die zu erwartenden Produkte in Form der Quantität, Qualität und Verfügbarkeit

3.2.9**Missionserschließung**

Tätigkeit, bestehend aus Planung, Erzeugung, Nutzung und Bewertung der Produkte der Raumfahrtmission

3.2.10**Missionsinformationen**

Informationen im Zusammenhang mit dem Raumsegment und dem Bodensegment während der Phasen vor und nach dem Start

ANMERKUNG1 zum Begriff: Sie umfasst typischerweise das Design des Raumsegments und des Bodensegments, die Merkmale der entsprechenden Operationen, die Test- und Betriebsprozeduren in Bezug auf Raumsegment und Bodensegment sowie die Merkmale der Telemetrie und der Fernsteuerung.

ANMERKUNG 2 zum Begriff: Sie besteht aus vom Operationskunden und vom Bodensegmentlieferanten stammenden Quelldaten und den durch die Operationsteams erzeugten abgeleiteten Daten.

3.2.11**Missionsoperationen**

Tätigkeiten im Zusammenhang mit Planung, Ausführung und Bewertung der Operationen der Kombination aus Raumsegment und Bodensegment während der Phasen E und F eines Raumfahrtprojekts

3.2.12**Missionsoperationsdaten**

Teilsatz der Missionsinformationen zur Ausführung der Operationen in der Umlaufbahn

ANMERKUNG zum Begriff: Beispielsweise: Datenbanken zu(r) Prozeduren, Regeln, Überwachung und Kontrolle der Operationen.

3.2.13**Missionsprodukte**

durch das Raumfahrtssystem bereitgestellte Produkte und Dienstleistungen

ANMERKUNG zum Begriff: Beispielsweise: Kommunikationsdienste, wissenschaftliche Daten.

3.2.14**betriebliche Validierung**

Testtätigkeiten, deren Ziel darin besteht, mithilfe von Simulation und Proben die Bereitschaft des gesamten Bodensegments, einschließlich der Missionsoperationsdaten, sowie des für die Unterstützung der Raumfahrtmission in der Umlaufbahn verantwortlichen Personals zu bestimmen

ANMERKUNG zum Begriff: Der Abschluss des Prozesses der betrieblichen Validierung führt zu einem qualifizierten Bodensegment.

3.2.15**Operationskunde**

für die Beschaffung der Raumsegment- und Bodensegmentoperationen verantwortliche Partei

ANMERKUNG 1 zum Begriff: Die Schnittstelle zwischen Operationskunde und Operationslieferant weist die Form einer Kunden-Lieferanten-Beziehung auf.

ANMERKUNG 2 zum Begriff: Bei dem Operationskunden und dem Bodensegmentkunden handelt es sich in der Regel um dieselbe Einheit.

3.2.16

Operationslieferant

für die Vorbereitung und Ausführung der Raumsegment- und Bodensegmentoperationen verantwortliche Partei

3.2.17

Raumsegmentoperationen

Tätigkeiten im Zusammenhang mit Planung, Ausführung und Bewertung der Operationen des Raumsegments (oder von dessen Teilsätzen) in der Umlaufbahn

3.2.18

synthetischer Parameter

mithilfe eines Algorithmus aus der Telemetrie und weiteren Daten abgeleiteter Parameter

3.3 Abkürzungen

Für die Anwendung dieser Norm gelten die Abkürzungen in ECSS-S-ST-00-01 und die folgenden Abkürzungen:

Abkürzung	Bedeutung
ABM	Apogäumsmotor (en: apogee boost motor)
AIT	Baugruppe, Integration und Test (en: assembly, integration and test)
AOCS	Lage- und Bahnregelungssystem (en: attitude and orbit control subsystem)
ATV	automatisches Transferfahrzeug (en: automated transfer vehicle)
CCSDS	Beratender Ausschuss für Raumfahrt Daten-Systeme (en: Consultative Committee for Space Data Systems)
CFISRD	Dokument der kundenspezifischen Komponenten und dienstleistungsbezogenen Anforderungen (en: customer furnished items and services requirements document)
COTS	kommerzielles Standardprodukt (en: commercial off-the-shelf)
CRR	Kundenanforderungs-Review (en: customer requirements review)
DFT	Datenfluss-Test (en: data flow test)
DRD	Dokumenten-Anforderungsdefinition (en: document requirements definition)
EEPROM	elektrisch löschbarer programmierbarer Nur-Lese-Speicher (en: electrically erasable programmable read-only memory)
EGSE	elektrisches Bodendienstgerät (en: electrical ground support equipment)
ELR	Review am Ende der Lebensdauer (en: end-of-life review)
EM	technisches Modell/Engineering-Modell (en: engineering model)
FAT	Werksabnahmeprüfung (en: factory acceptance testing)

Abkürzung	Bedeutung
FDIR	Ausfallerkennung, Isolierung und Wiederherstellung (en: failure detection, isolation and recovery)
FM	Flugmodell (en: flight model)
FMEA	Fehlerart- und -auswirkungsanalyse (en: failure modes and effects analysis)
FMECA	Fehlerart-, -auswirkungs- und -kritikalitätsanalyse (en: failure modes, effects and criticality analysis)
FQR	Flugqualifikations-Review (en: flight qualification review)
FRR	Flugbereitschafts-Review (en: flight readiness review)
FS	Pflichtenheft (en: functional specification)
FTA	Fehlzustandsbaumanalyse (en: fault tree analysis)
GEO	geostationäre Umlaufbahn (en: geostationary orbit)
GS	Bodensegment (en: ground segment)
GSAITP	Baugruppen-, Integrations- und Testplan für das Bodensegment (en: ground segment AIT plan)
GSC	Bodensegmentkunde (en: ground segment customer)
GSCDR	kritisches Design-Review für das Bodensegment (en: ground segment critical design review)
GSCRD	Kundenanforderungs-Dokument für das Bodensegment (en: ground segment customer requirements document)
GSDDF	Bodensegments-Designdefinitionsakte (en: ground segment design definition file)
GSDJF	Bodensegment-Designbegründungsakte (en: ground segment design justification file)
GSEP	Bodensegment-Engineeringplan (en: ground segment engineering plan)
GSPDR	vorläufiges Design-Review für das Bodensegment (en: ground segment preliminary design review)
GSQR	Bodensegment-Qualifikations-Review (en: ground segment qualification review)
GSRD	Bodensegment-Anforderungsdokument (en: ground segment requirements document)
GSSRR	Review der Bodensegment-Systemanforderungen (en: ground segment system requirements review)
GSS	Bodensegmentlieferant (en: ground segment supplier)
GSVP	Bodensegment-Prüfplan (en: ground segment verification plan)

Abkürzung	Bedeutung
HCI	Mensch-Computer-Schnittstelle (en: human-computer interaction)
I/F	Schnittstelle (en: Interface)
I/O	Eingabe/Ausgabe; Eingang/Ausgang (en: input/output)
ICD	Schnittstellenkontroll-Dokument (en: interface control document)
IOOR	Review für Operationen im Orbit (en: in-orbit operations review)
ISS	Internationale Raumstation (en: International Space Station)
LAN	lokales Netzwerk (en: local area network)
LEO	niedrige Erdumlaufbahn (en: low-Earth orbit)
LEOP	erste Phase einer Satellitenmission (en: launch and early orbit phase)
LIT	Hörprüfung (en: listen-in test)
LS	Logistikunterstützung (en: logistic support)
LSP	Logistikunterstützungsplan (en: logistics support plan)
MAR	Missionsanalyse-Bericht (en: mission analysis report)
MCR	Missions-Closeout-Review, Missions-Abschluss-Review (en: mission close-out review)
MDD	Missionsbeschreibungs-Dokument (en: mission description document)
MOCD	Missionsoperations-Konzeptdokument (en: mission operations concept document)
MOP	Missionsoperations-Plan (en: mission operations plan)
MRT	Missionsbereitschafts-Tests (en: mission readiness tests)
OAR	Operationsanomalie-Bericht (en: operations anomaly report)
OBDH	bordseitige Datenhandhabung (en: on-board data handling)
OBSM	bordseitige Softwarewartung (en: on-board software maintenance)
OBSW	bordseitige Software (en: on-board software)
OC	Operationskunde (en: operations customer)
OCRD	Anforderungsdokument der Operationskunden (en: operations customer requirements document)
OEP	Operations-Engineeringplan (en: operations engineering plan)
OPS	Operationen; Betrieb (en: operations)

Abkürzung	Bedeutung
OQR	betriebliches Qualifikations-Review (en: operational qualification review)
ORR	betriebliches Bereitschafts-Review (en: operational readiness review)
OS	Operationslieferant (en: operations supplier)
OTP	Operationsschulungsplan (en: operations training plan)
OVP	betrieblicher Validierungsplan (en: operational validation plan)
PCC	Nutzlast-Kontrollzentrum (en: payload control centre)
PDR	vorläufiges Design-Review (en: preliminary design review)
PLUTO	Sprache für Anwender von Test- und Bedienprozeduren (en: procedure language for users in test and operations)
PROM	programmierbarer Nur-Lese-Speicher (en: programmable read-only memory)
PRR	vorläufiges Anforderungs-Review (en: preliminary requirements review)
PUS	Standard für die Verwendung von Datenpaketen (en: packet utilization standard)
RAM	Speicher mit wahlfreiem/direktem Zugriff (en: random access memory)
REP	Bericht (en: report)
RF	Funkfrequenz (en: radio frequency)
ROM	Nur-Lese-Speicher (en: read-only memory)
SGICD	Kontroll-Dokument für Weltraum-Boden-Schnittstelle (en: space-to-ground interface control document)
SPEC	Spezifikation (en: specification)
SPR	Software-Problembericht (en: software problem report)
SSC	Raumfahrtssystemkunde (en: space system customer)
SSORD	Anforderungsdokument für Raumsegment-Bedienbarkeit (en: space segment operability requirements document)
SSS	Raumsegmentlieferant (en: space segment supplier)
SSM	Raumfahrtssystemmodell (en: space system model)
SSUM	Raumsegment-Benutzerhandbuch (en: space segment user manual)
SVT	Systemvalidierungstest (en: system validation test)
TS	Technische Spezifikation (en: technical specification)
TT&C	Telemetrie, Nachführung und Befehl (en: telemetry, tracking and command)

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English version

Space engineering - Ground systems and operations

Ingénierie spatiale - Systèmes sol et opérations

Raumfahrttechnik - Bodensysteme und Bodenbetrieb

This draft European Standard is submitted to CEN members for unique acceptance procedure. It has been drawn up by the Technical Committee CEN/CLC/TC 5.

If this draft becomes a European Standard, CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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Table of contents

Foreword	9
Introduction.....	10
1 Scope.....	11
2 Normative references	12
3 Terms, definitions and abbreviated terms.....	13
3.1 Terms defined in other standards	13
3.2 Terms specific to the present standard	13
3.3 Abbreviated terms.....	15
4 Ground segment and operations domain.....	19
4.1 Overview	19
4.2 Operations organization.....	19
4.3 Ground systems	20
4.3.1 Introduction	20
4.3.2 Mission operations system.....	20
4.3.3 Payload operations and data system	21
4.3.4 Ground station system	22
4.3.5 Ground communications system	22
4.4 Engineering processes	22
4.5 Critical areas.....	23
5 Operations engineering	24
5.1 Overview	24
5.2 Requirements analysis and concept development	26
5.2.1 Inputs.....	26
5.2.2 Process description.....	27
5.2.3 Outputs	32
5.3 Mission operations data production	33
5.3.1 Inputs.....	33
5.3.2 Process description.....	33
5.3.3 Outputs	35

5.4	Mission operations data validation	35
5.4.1	Inputs	35
5.4.2	Process description	36
5.4.3	Outputs	36
5.5	Operations teams build-up and training	36
5.5.1	Inputs	36
5.5.2	Process description	37
5.5.3	Outputs	38
5.6	Operational validation	38
5.6.1	Inputs	38
5.6.2	Process description	39
5.6.3	Outputs	40
5.7	Operational configuration management	40
5.7.1	Inputs	40
5.7.2	Process description	41
5.7.3	Outputs	41
5.8	Operations execution	42
5.8.1	Inputs	42
5.8.2	Process description	42
5.8.3	Outputs	44
5.9	Space segment disposal operations	45
5.9.1	Inputs	45
5.9.2	Process description	46
5.9.3	Outputs	46
6	Ground segment engineering	47
6.1	Overview	47
6.2	Ground segment definition	49
6.2.1	Inputs	49
6.2.2	Process description	49
6.2.3	Outputs	53
6.3	Ground segment production	54
6.3.1	Inputs	54
6.3.2	Process description	54
6.3.3	Outputs	55
6.4	Ground segment AIT and verification	56
6.4.1	Inputs	56
6.4.2	Process description	57

6.4.3	Outputs	60
6.5	Ground segment maintenance	61
6.5.1	Inputs	61
6.5.2	Process description	61
6.5.3	Outputs	63
6.6	Ground segment disposal	63
6.6.1	Inputs to ground segment disposal	63
6.6.2	Process description	63
6.6.3	Outputs	64
7	Ground segment and operations lifecycle	65
7.1	General	65
7.1.1	The lifecycle	65
7.1.2	General requirements	67
7.2	Phase A: Mission and operational analysis, feasibility studies and conceptual design	67
7.2.1	Purpose of phase A	67
7.2.2	Processes during phase A	67
7.2.3	Milestones and reviews of phase A	68
7.3	Phase B: Preliminary design	68
7.3.1	Purpose of phase B	68
7.3.2	Processes during phase B	69
7.3.3	Milestones and reviews of phase B	70
7.4	Phase C: Detailed design	70
7.4.1	Purpose of phase C	70
7.4.2	Processes during phase C	70
7.4.3	Milestones and reviews of phase C	71
7.5	Phase D: Production, AIT and verification	72
7.5.1	Purpose of phase D	72
7.5.2	Processes during phase D	72
7.5.3	Milestones and reviews of phase D	74
7.6	Phase E: Mission operations	75
7.6.1	Purpose of phase E	75
7.6.2	Processes during phase E	75
7.6.3	Milestones and reviews of phase E	77
7.7	Phase F: Disposal	77
7.7.1	Purpose of phase F	77
7.7.2	Processes during phase F	77

7.7.3	Milestones and reviews of phase F	78
7.8	Summary of key documents and reviews.....	78
Annex A	(normative) Customer requirements document (CRD) - DRD.....	83
A.1	DRD identification	83
A.1.1	Requirement identification and source document.....	83
A.1.2	Purpose and objective.....	83
A.2	Expected response	83
A.2.1	Scope and content	83
A.2.2	Special remarks	85
Annex B	(normative) Mission analysis report (MAR) - DRD.....	86
B.1	DRD identification	86
B.1.1	Requirement identification and source document.....	86
B.1.2	Purpose and objective.....	86
B.2	Expected response	86
B.2.1	Scope and content	86
B.2.2	Special remarks	88
Annex C	(normative) Mission operations concept document (MOCD) - DRD	89
C.1	DRD identification	89
C.1.1	Requirement identification and source document.....	89
C.1.2	Purpose and objective.....	89
C.2	Expected response	89
C.2.1	Scope and content	89
C.2.2	Special remarks	93
Annex D	(normative) Operations engineering plan (OEP) - DRD.....	94
D.1	DRD identification	94
D.1.1	Requirement identification and source document.....	94
D.1.2	Purpose and objective.....	94
D.2	Expected response	94
D.2.1	Scope and content	94
D.2.2	Special remarks	96
Annex E	(normative) Space segment user manual (SSUM) - DRD	97
E.1	DRD identification	97
E.1.1	Requirement identification and source document.....	97
E.1.2	Purpose and objective.....	97
E.2	Expected response	97

E.2.1	Scope and content	97
E.2.2	Special remarks	104
Annex F	(normative) Operational validation plan (OVP) - DRD.....	105
F.1	DRD identification	105
F.1.1	Requirement identification and source document.....	105
F.1.2	Purpose and objective.....	105
F.2	Expected response	105
F.2.1	Scope and content	105
F.2.2	Special remarks	107
Annex G	(normative) Mission operations plan (MOP) - DRD	108
G.1	DRD identification	108
G.1.1	Requirement identification and source document.....	108
G.1.2	Purpose and objective.....	108
G.2	Expected response	108
G.2.1	Scope and content	108
G.2.2	Special remarks	110
Annex H	(normative) Operations anomaly report (OAR) - DRD	111
H.1	DRD identification	111
H.1.1	Requirement identification and source document.....	111
H.1.2	Purpose and objective.....	111
H.2	Expected response	111
H.2.1	Response identification	111
H.2.2	Scope and content	111
H.2.3	Special remarks	113
Annex I	(normative) Operations procedures - DRD	114
I.1	DRD identification	114
I.1.1	Requirement identification and source document.....	114
I.1.2	Purpose and objective.....	114
I.2	Expected response	114
I.2.1	Response identification	114
I.2.2	Scope and content	114
I.2.3	Special remarks	117
Annex J	(normative) Customer furnished items and services requirements document (CFISRD) - DRD.....	118
J.1	DRD identification	118
J.1.1	Requirement identification and source document.....	118

J.1.2	Purpose and objective.....	118
J.2	Expected response	118
J.2.1	Scope and content	118
J.2.2	Special remarks	122
Annex K	(informative) Commonality considerations	123
K.1	General.....	123
K.2	Software	123
K.3	Spacelink interfaces.....	124
K.4	Mission operations data	124
K.5	Commonality of software framework and hardware infrastructure	124
Annex L	(informative) ECSS-E-ST-70 level 3 standards	126
Bibliography		128

Figures

Figure 4-1:	The ECSS-E-ST-70 domain	20
Figure 4-2:	Ground segment systems.....	21
Figure 5-1:	Schematic of operations engineering process	25
Figure 6-1:	Schematic of ground segment engineering processes	48
Figure 6-2:	Ground segment AIT and verification	58
Figure 7-1:	Ground segment and operations phases.....	66

Tables

Table 5-1	Inputs to the requirements analysis and concept development process.....	27
Table 5-2:	Outputs of the requirements analysis and concept development process.....	32
Table 5-3:	Inputs to the mission operations data production process.....	33
Table 5-4:	Outputs of the mission operations data production process.....	35
Table 5-5:	Inputs to the mission operations data validation process	35
Table 5-6:	Outputs of the mission operations data validation process	36
Table 5-7:	Inputs to the operations teams build-up and training process	37
Table 5-8:	Outputs of the operations teams build-up and training process.....	38
Table 5-9:	Inputs to the operations validation process	38
Table 5-10	the outputs of the operations validation process	40
Table 5-11:	Inputs to the operational configuration management process	40
Table 5-12:	Outputs of the operational configuration management process	41
Table 5-13	Inputs to the operations execution process.....	42
Table 5-14:	Outputs of the operations execution process	45

Table 5-15: Inputs to space segment disposal operations process.....	45
Table 5-16: Outputs of the space segment disposal operations process	46
Table 6-1: Inputs to the ground segment definition process.....	49
Table 6-2: Output of the ground segment definition process.....	53
Table 6-3 Inputs to the ground segment production process	54
Table 6-4: Outputs of the ground segment production process.....	56
Table 6-5: Inputs to the ground segment AIT and verification process.....	56
Table 6-6: Outputs of the ground segment AIT and verification process.....	60
Table 6-7: Inputs to the ground segment maintenance process.....	61
Table 6-8 Outputs of the maintenance process	63
Table 6-9: Input to the ground segment disposal process.....	63
Table 6-10: Outputs of the ground segment disposal process	64
Table 7-1: Processes and outputs of phase A	68
Table 7-2: Processes and outputs of phase B	69
Table 7-3: Processes and outputs of phase C	71
Table 7-4: Processes and outputs of phase D	73
Table 7-5: Processes and outputs of sub-phase E1	76
Table 7-6: Processes and outputs of sub-phase E2	76
Table 7-7: Processes and outputs of phase F	77
Table 7-8: Key ground segment and operations documents and reviews at which they are deliverable.....	79
Table 7-9: Ground segment and operations reviews	81

Foreword

This document (FprEN 16603-70:2014) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN (Germany).

This document (FprEN 16603-70:2014) originates from ECSS-E-ST-70C.

This document is currently submitted to the Unique Acceptance Procedure.

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

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

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.

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

Terms, definitions and abbreviated terms

3.1 Terms defined in other standards

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

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

system engineering

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

inspection

test

3.2 Terms specific to the present standard

3.2.1 **entity**

combination of ground systems and the associated personnel or operations organization

3.2.2 **ground segment operations**

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

3.2.3 **ground segment**

ground systems necessary for the preparation or execution of mission operations

3.2.4 **ground segment customer**

party responsible for the procurement of the ground segment

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

3.2.5 **ground segment supplier**

party responsible for the supply of the ground segment

3.2.6 ground system

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

3.2.7 incident

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

3.2.8 mission

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

3.2.9 mission exploitation

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

3.2.10 mission information

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

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

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

3.2.11 mission operations

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

3.2.12 mission operations data

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

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

3.2.13 mission products

products and services delivered by the space system

NOTE For example: Communications services, science data.

3.2.14 operational validation

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

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

3.2.15 operations customer

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

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

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

3.2.16 operations supplier

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

3.2.17 space segment operations

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

3.2.18 synthetic parameter

parameter derived from telemetry and other data via an algorithm

3.3 Abbreviated terms

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

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

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

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

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

4

Ground segment and operations domain

4.1 Overview

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

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

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

NOTE Examples:

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

4.2 Operations organization

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

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

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

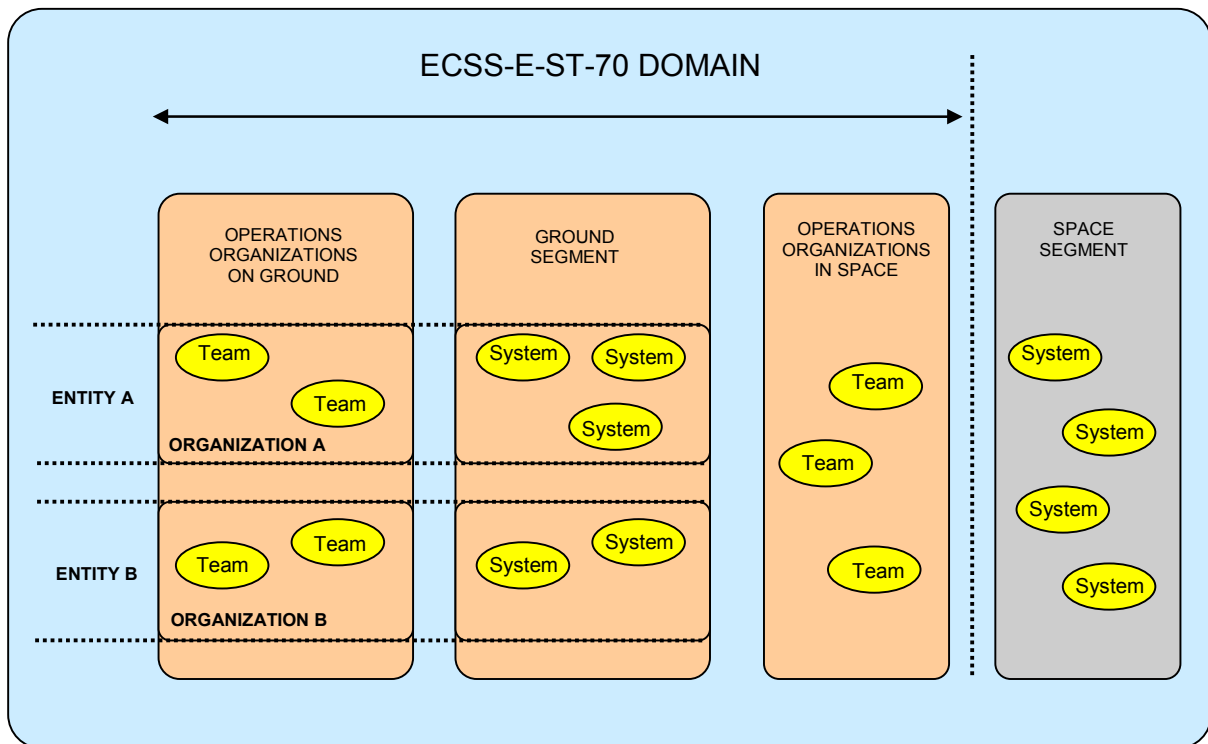


Figure 4-1: The ECSS-E-ST-70 domain

4.3 Ground systems

4.3.1 Introduction

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

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

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

4.3.2 Mission operations system

The mission operations system typically supports the following:

- Mission analysis;
- Operations preparation;

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

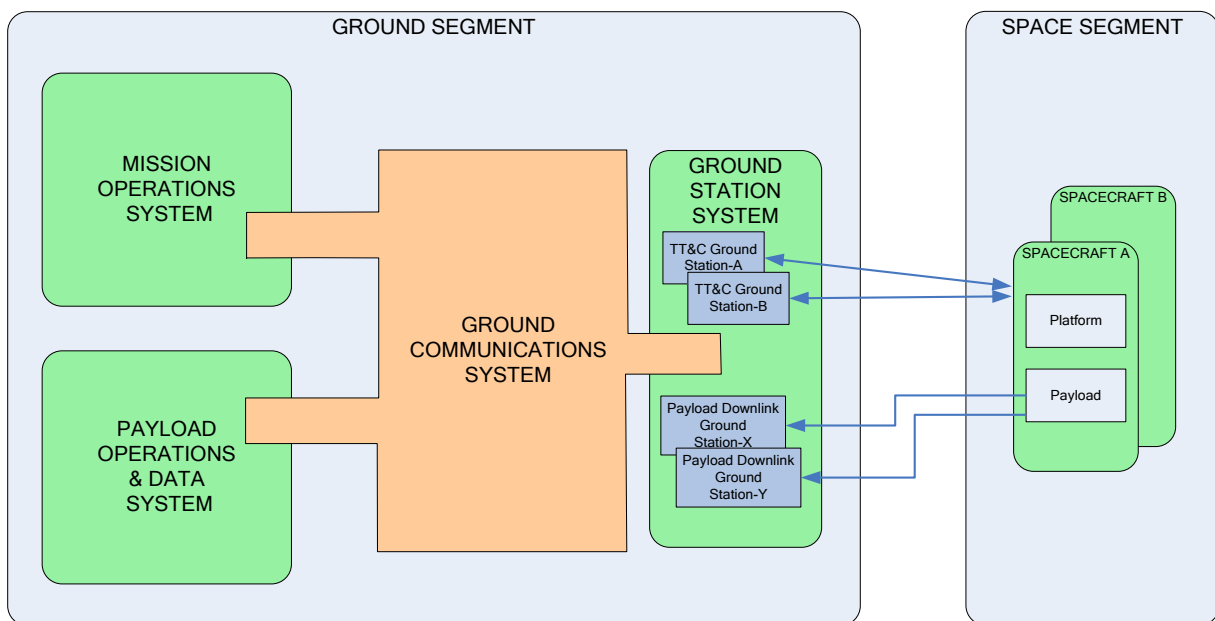


Figure 4-2: Ground segment systems

4.3.3 Payload operations and data system

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

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

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

4.3.4 Ground station system

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

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

4.3.5 Ground communications system

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

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

4.4 Engineering processes

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

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

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

4.5 Critical areas

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

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

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

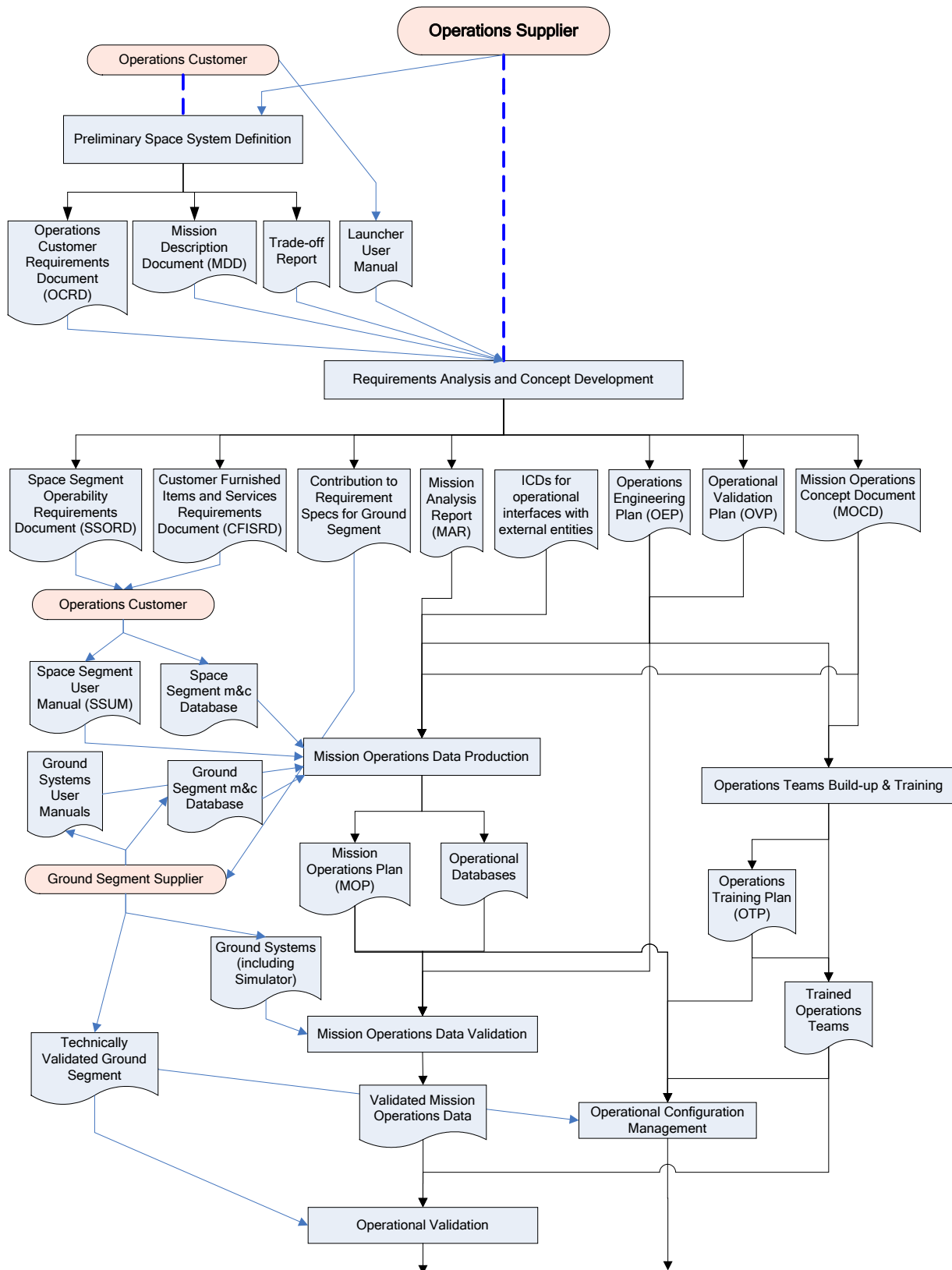
Operations engineering

5.1 Overview

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

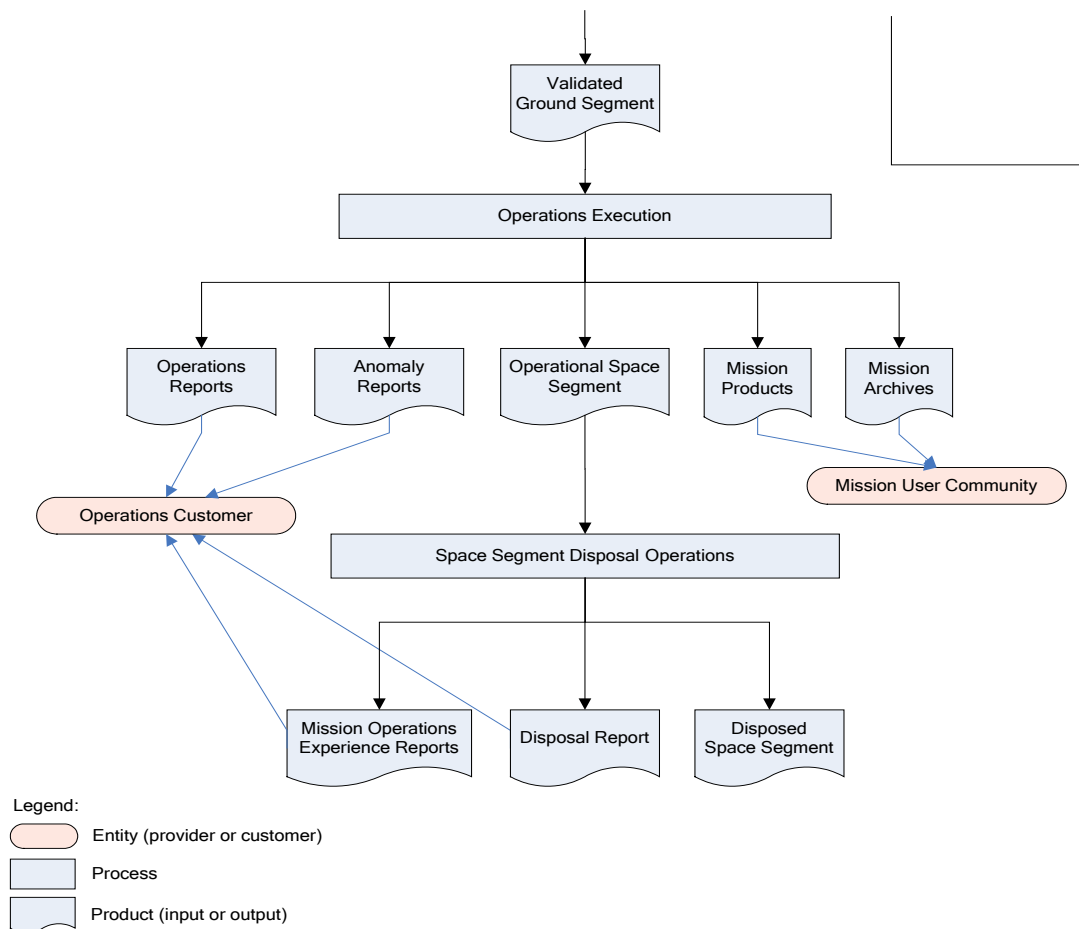
- Requirements analysis and concept development;
- Mission operations data production;
- Mission operations data validation;
- Operations teams build-up and training;
- Operational validation;
- Operational configuration management;
- Operations execution (LEOP, commissioning, routine phase operations);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

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



PART 1/2

Figure 5-1: Schematic of operations engineering process



PART 2/2

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

5.2 Requirements analysis and concept development

5.2.1 Inputs

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

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

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

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

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

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

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

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

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

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

5.2.2 Process description

5.2.2.1 Mission analysis

- a. Mission analysis shall characterize the following aspects:

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

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

5. Payload constraints.
6. Data flow constraints.

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

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

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

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

5.2.2.2 Operational analysis and concept development

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

5.2.2.3 Operational interfaces definition

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

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

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

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

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

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

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

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

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

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

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

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

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

5.2.2.4 Operations engineering plan production

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

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

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

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

5.2.2.5 Contribution to ground segment and ground systems requirements specification

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

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

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

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

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

NOTE For example, remote monitoring and control.

4. User management.

NOTE For example, login, privileges.

5. HCI considerations.

5.2.2.6 Operational validation plan production

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

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

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

5.2.3 Outputs

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

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

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

5.3 Mission operations data production

5.3.1 Inputs

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

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

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

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

5.3.2 Process description

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

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

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