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Space systems — Unmanned spacecraft operational procedures — Documentation

Systèmes spatiaux — Procédures opérationnelles de véhicule spatial non habité — Documentation

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 23041 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

This International Standard prescribes a standard means to facilitate the sharing and exchange of beneficial information among organizations (the spacecraft manufacturer, the mission equipment supplier, the customer or the spacecraft operation centre) and their involvement with space operations and support. This International Standard provides a common interface to simplify space operations planning and reduce the effort needed to learn and deal with new space programmes and support organizations.

Space systems — Unmanned spacecraft operational procedures — Documentation

1 Scope

This International Standard establishes standards, current guidelines and uniform procedures to minimize duplication of effort between the customer, the agency, participating nations and the emerging commercial space community. This International Standard provides recommended practices for the development of space operations and support documentation, which should facilitate the sharing and exchange of beneficial information between organizations involved with space operations. This International Standard establishes a common interface to simplify space operations planning and reduce the effort needed to learn and work with new space programmes and support organizations.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
abbreviated checklist
comprehensive list of items and time schedule of tasks to be done that are needed to check each step-by-step task at the telemetry/command (TLM/CMD) console and at the network console

2.2
acquiring agency
organization that is planning and managing the development and acquisition contracts for the space system, understands the engineering and technical aspects of the system's operation and acts as a provider of particular equipment if necessary

2.3
customer
organization that uses the system under contract to the acquiring agency for a particular space system and acts as provider of particular mission equipment if necessary

2.4
developing agency
organization that develops the spacecraft and operation system under contract to the acquiring agency

NOTE One organization may constitute more than one of these agencies.

2.5
mission segment
ground system that consists of the facilities of mission data acquisition and processing

2.6
operations agency
agency responsible for the operations and maintenance of the space systems and organization to which the operations crew members belong

2.7
operations crew members
personnel who will be using the operations handbook to support space systems

2.8
separate and distinctive checklist
list that contains information to compensate the part of the operation facilities peculiar to the operations agency

2.9
spacecraft operation handbook
handbook that includes information needed for normal and contingent TLM/CMD operations

2.10
space system
system consisting of a space segment that includes a launch segment and a spacecraft segment and a ground segment that includes a tracking control segment and a mission segment

2.11
tracking control segment
ground system consisting of the facilities of spacecraft tracking, ranging and telemetry (TLM) monitor and command (CMD) control

NOTE The launch segment includes the pre-launch segment, the spacecraft segment includes the mission segment and the ground segment includes the facilities and operations handbook.

2.12
space system operation
operation that contains launch segment operation, spacecraft segment operation and tracking control segment operation

NOTE The launch segment operation includes pre-launch segment operation and the spacecraft segment operation includes the mission phase segment and the post-mission phase segment.

3 Symbols and abbreviated terms

AOCS	attitude and orbit control subsystem
AOS	acquisition of signal
BB	base band
CMD	command
EL	elevation angle
FCP	flight control procedure
FDIR	fault detection, isolation and reconfiguration
GCP	ground segment control procedure
IOT	in-orbit test
LEOP	launch and early orbit phase
LOS	loss of signal
MCL	mission (operation) checklist
OBC	onboard computer
OBDH	onboard data handling unit
OBS	onboard computer software

PS power subsystem

RF radio frequency

SOE sequence of events

SOP satellite operation procedure

STR structure

TCS thermal control subsystem

TLM telemetry

TTC tracking, telemetry and command subsystem

4 Documentation

4.1 General preparations

4.1.1 General

Unless otherwise specified, the operation handbook and checklists shall include a reproducible copy in a digital format specified by the acquiring agency. If the magnitude of the information to be included in the operation handbook is such that a single volume is not practical, then more than one volume may be used to provide the material. The operation handbook shall contain a revision record when the document is changed or revised.

4.1.2 Arrangement of material

The document shall contain a main table of contents. At the beginning of each clause, there shall be a subsidiary clause table of contents. The clause table of contents shall include the page number and title of each subclause or major subject headings.

When classified or proprietary information (needed for operation handbook) is involved, the same principles established for the treatment of the main table of contents shall be followed. The main table of contents shall contain numbers and titles of clauses with their initial page numbers, but shall not contain any classified or proprietary information.

EXAMPLE Operation crew members sometimes need detailed classified or proprietary design information of spacecraft for troubleshooting.

Space operation handbooks are normally unclassified. If the space system classification guide identifies the subjects as classified by the space systems operation crew members requirements, in accordance with current classification standards and for these classified subjects, the operation agency shall prepare a separate classified handbook or a classified supplement of the basic handbook.

The heading of the first or introductory paragraph of each clause shall be general in nature to facilitate including information concerning the main subject. Subordinate headings shall be definitive and identify the principal item that needs to be covered.

Wherever practical, text shall be simplified and decreased in quantity by the use of complementary artwork. All technical matter shall be written so that it is understandable by all personnel who are expected to use the handbook.

4.1.3 Illustration

The operation handbook shall contain the following illustrations:

a) general illustrations depicting the space system configuration;

b) illustrations to show clearly the layout of the space operations centre, including separate emergency/contingency facilities where applicable;

c) sufficient other illustrations and diagrams to show the major panels, cabinets, consoles, related equipment, etc. that the space operations crew personnel will use for operations;

d) sufficient diagrams, charts, schematics, etc. to depict the function, control and interrelationship of significant space system equipment.

Abbreviations, symbols, reference designations and colour coding references used in the space operations handbook shall also be specified, where applicable.

4.2 Space operation handbook

4.2.1 General

The space operation handbook shall provide the following:

a) General description of the space system giving the purpose, main features and particulars of the space system and supporting facilities [satellite segment, structure (STR), attitude and orbit control subsystem (AOCS), thermal control subsystem (TCS), tracking, telemetry and command subsystem (TTC), power subsystem (PS), payload communications subsystem and payload subsystem]; and a ground segment description giving both general and detailed information, including electrical power subsystem, environmental control subsystem, auxiliary equipment, communications, pre-launch segment, launch segment and mission life segment.

b) Operating functions giving general information, including the process and functional explanations, operations centre security procedures, changeover procedures, status and fault monitoring, activity coordination procedures, safety procedures, operations centre inspections and system test procedures, communications equipment procedures, ground system procedures, mission planning procedures, mission execution procedures and post-mission procedures.

c) Mission operating procedures giving detailed information and defining individual and crew responsibilities.

d) Segment contingency procedures giving troubleshooting guidelines and remedial actions.

e) Operating limitations giving a description of specific limitations.

f) Ground segment emergency procedures giving detailed emergency operations procedures and corrective action.

g) Crew duties and responsibilities giving the individual positions and duties required during nominal and off-nominal operations.

h) Vocabulary giving technical terms, definitions, acronyms and abbreviations.

4.2.2 Overview

4.2.2.1 Front material

Front material shall include the bulleted list items in Figure 1. The cover/title page, list of effective pages, verification status sheets, table of contents, list of illustrations and list of tables shall be similar to the format of this recommended practice with details for preparation at the discretion of the acquiring agency.

NOTE The list of effective pages contains the revision of each page and revised date; the verification status sheets contain the stage of the document (i.e. WD, CD, review) and approved date.

The foreword shall discuss the various aspects of the operation handbook. Such discussion shall include the scope of the operation handbook and indicate the technical proficiency expected of the various space operations crew personnel. The foreword shall also indicate special interest items, e.g. new development items and critical operation items.

4.2.2.2 Requirements for clauses

Each operation handbook shall include the clauses listed in Figure 1. Additional clauses may be added if required. If a clause is not applicable, the title of that clause shall appear on the last page of the previous clause along with a notation that the clause is not applicable or that information will appear when it becomes available. The title of the clause shall appear in the main table of contents with an appropriate notation.

As appropriate, each clause shall have separate sections for information pertaining to satellite support during

a) pre-launch period,

b) launch early orbit,

c) operations in nominal mode,

d) operations in degraded mode (period when the satellite is no longer fully operational but is still on orbit), and

e) post-mission phase (satellite end-of-life process).

The format for the presentation of the text, the amplified procedures and the abbreviated checklists shall be at the discretion of the acquiring agency. The format shall present the crew procedures in a simple, concise and understandable layout, consistent with space system requirements. For systems using digitized technical data, the visual template and the text shall be formatted so the screen presentation will be identical to the printed data.

If the operations agency does not require a printed page of the visual display, the visual display format shall comply with the style and format of a printed page. Each page of the emergency procedures clause shall have dialogue box and icon markings on all pages. An example is shown in Figure 2.

Warning marks and contingent check segments shall be selected by the operation agency.

Where possible, amplified procedures and checklists developed for a particular space system shall be standardized.

Front material

- *Cover/title page*
- *List of effective pages*
- *Verification status sheets*
- *Table of contents*
- *List of illustrations*
- *List of tables*
- *Foreword*

Clause 1 Space system description

Clause 2 Space system operating functions

Clause 3 Mission operating procedures

Clause 4 Space segment contingency procedures

Clause 5 Operating limitations

Clause 6 Ground segment emergency procedures

Clause 7 Crew duties and responsibilities

Clause 8 Vocabulary

Figure 1 — Standard sequence for space operation handbook

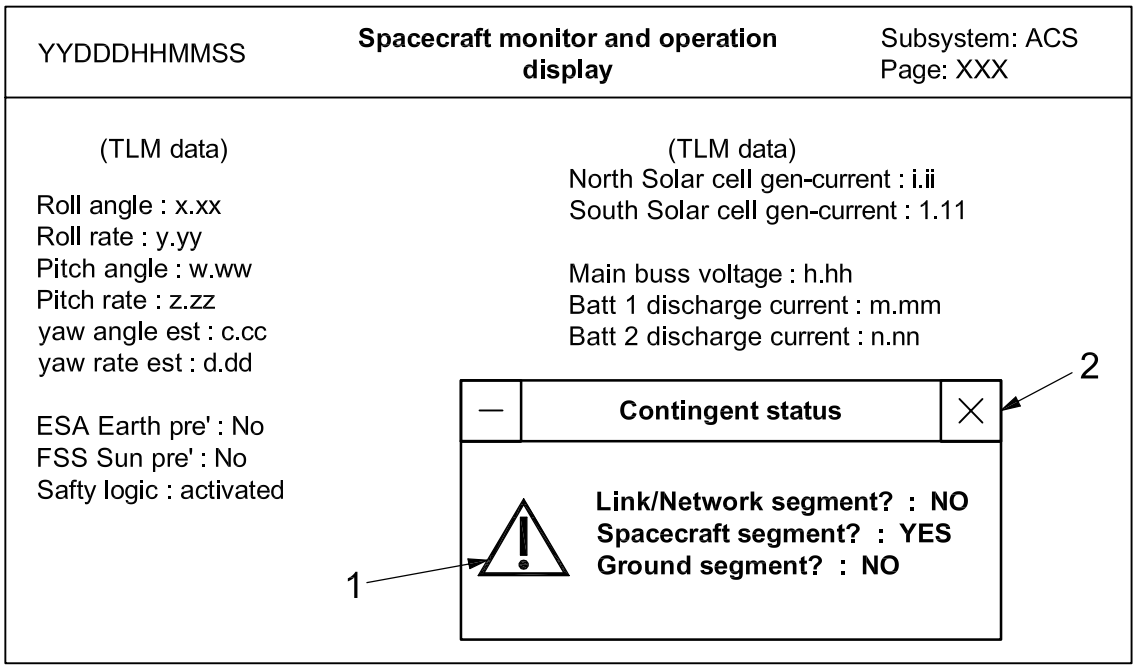

Figure 2 — Visual display page of an emergency procedure

4.2.3 Space system description (Clause 1 of handbook)

4.2.3.1 General

Clause 1 shall consist of a system description and a description of supporting facilities designed for general orientation. The narrative shall state the purpose and describe the main features and leading particulars for the space system.

The descriptions of system and supporting facilities shall contain sufficient detail to provide a single source handbook of general system information. Illustrations shall clarify a particular system or reduce the verbiage necessary for explanation and aid in understanding the system. Clause 1 shall consist of several subclauses: satellite segment description, ground segment description, pre-launch segment description, launch segment description and the mission life segment (including the post-mission phase and the reduced operation phase).

The satellite developing agency (i.e. satellite manufacturer) shall provide the documentation, i.e. satellite operational handbook (SOOH). By extracting the needed information from SOOH and other sources, the operation agency shall provide FCPs (see example in Table A.2).

4.2.3.2 Satellite segment

4.2.3.2.1 General

A general description of the satellite segment shall include the following subsystems: structure; attitude and orbit control; thermal control; tracking, telemetry and command; power; payload/mission communication; payload; and OBDH. Subsequent clauses shall describe in greater detail the subsystems peculiar to that satellite segment. Such information shall include a general discussion of satellite segment operations to include a description of major subsystems. The description shall be of sufficient detail to provide an understanding of the purpose and function of the subsystems, their relation to overall system operations and such additional information to enable the crew member to understand subsystem functions peculiar to the overall system. Highly complex satellite segments may require a stand-alone satellite segment operations handbook. Illustrations shall be used to simplify the explanation of system interrelation and component function. Separate appendices or handbooks shall describe, as needed, each of the satellite segment subsystems, depending on the volume of the telemetry and command material provided.

4.2.3.2.2 Structure subsystem (STR)

The STR information shall include a description of the structural components with dimensions and particular data concerning component locations, plus the location of other subsystems, if necessary, to afford a better understanding of the satellite construction.

4.2.3.2.3 Attitude and orbit control subsystem (AOCS)

The AOCS information shall include a brief description of the purpose and type of attitude control and give a more detailed description of the components and their respective functions, including sensor unit, regulator unit and actuator unit (which includes the thrusting unit). Illustrations shall be used to simplify the explanation of system interrelations and component functions.

4.2.3.2.4 Thermal control subsystem (TCS)

The TCS information shall include a description of the environmental control systems, list the type of controls employed (i.e. active or passive) and give sufficient detail on the operations and configuration of the environmental control components to provide an understanding of system operations. Illustrations shall be used to simplify the explanation of system interrelations and component functions (e.g. heater, radiator).

4.2.3.2.5 Tracking, telemetry and command subsystem (TTC)

The TTC information shall include a description of the antenna unit, radio frequency (RF) unit, tracking and ranging unit, base band (BB) unit/telemetry (TLM) command (CMD) and control systems, command groups, individual command sequences and type and individual telemetry data. The TTC shall give sufficient detail on operations and configuration of command and control components to provide understanding of the system operations. Illustrations shall be used to simplify the explanation of system interrelations and component functions.

4.2.3.2.6 Power subsystem (PS)

The PS information shall include a description of the power system, distribution system, storage system, power control and sufficient detail on operations and configuration of power system components to provide an understanding of the system operations. Illustrations shall be used to simplify the explanation of system interrelations and component functions.

4.2.3.2.7 Payload/mission communication subsystem

The payload/mission communication subsystem information shall include a description of the payload/mission communication subsystem (antenna unit, RF unit) and its function with operational configuration.

4.2.3.2.8 Payload subsystem

The payload subsystem information shall include a description of the payload subsystem, mission sensors, data formatting, data recording and data playback control processors. Sufficient detail on operations and configuration of payload subsystem components shall provide an understanding of system operations. Illustrations shall explain the simplified system interrelations and component functions.

4.2.3.2.9 Onboard data handling unit (OBDH)

The OBDH information shall include a description and configuration of the OBC and OBS that provides an understanding of system operations and the following functions:

a) TTC, payload data handling (i.e. data formatting for packet/de-packet);

b) satellite attitude data processing (i.e. satellite attitude error check and regulation);

c) FDIR for satellite safety and survivability (i.e. error source detection and recovery; prevents drain on satellite electronic power resource, satellite attitude missing);

d) automatic, autonomous and robotic data processing for payload mission operation.

The illustrations shall explain the simplified system interrelations of each function and related subsystems.

4.2.3.3 Ground segment

4.2.3.3.1 General

A general description of the ground segment (which includes facilities and operations handbook) shall include the physical layout, with location and function of mission data processing, data archive, telemetry data processing, radar subsystems, ground sensors, recorder subsystems, security, personnel access and power systems. Detailed discussions shall include the data processor, data storage, telemetry processor, data switching, external interfaces, antenna/array, transmitter, receiver and associated support equipment required for system configuration as they support space operations crew member operations. Highly complex ground systems can require a stand-alone ground system operations manual. Illustrations shall explain the simplified system interrelations and component functions.

The ground segment developing agency (i.e. ground segment manufacturer) shall provide the ground segment operational manuals (see Table A.3) and the operation agency shall provide the ground segment procedures (GSP, see Tables A.3 and A.4), operation agency's operation crew and/or operation teams.

4.2.3.3.2 Electrical power subsystem

A description of the electrical power subsystem shall include normal, standby, emergency and uninterruptible power sources, with a description of distribution components, switch gear and power-generating equipment.

4.2.3.3.3 Environmental control subsystem

A description of the environmental control subsystem shall include the environmental control subsystem for the space operations centre and equipment areas, and a general description of the heating and ventilating equipment and associated maintenance support equipment. A description shall include the equipment interface with the alarm and detector system.

4.2.3.3.4 Auxiliary equipment

A description of the auxiliary equipment shall include equipment that is required by the operator to perform other subsystem functions, such as fire detection/suppression, environmental sensing and security detection.

4.2.3.3.5 Communications

A description of the communications systems shall include, but not be limited to, higher authority, payload communication control and payload data process, tracking, telemetry and command control, secure/non-secure voice, secure/non-secure data, multiplexing/de-multiplexing systems and inter-site, intercom and administrative communications systems. A description shall address any crew activity regarding normal, emergency, or malfunction operations in the applicable clause. Highly complex communications systems can require a stand-alone communications system operations handbook. Illustrations shall explain simplified system interrelations and component functions.

4.2.3.4 Pre-launch segment

The pre-launch segment shall provide information consistent with what operations personnel need to know for the type of pre-launch phase support needed. Information shall also include the ground segment schedule, the work with an overview of the pre-launch event sequence and the constraints resulting from the pre-launch ground segment test (i.e. data system test with database verification) and the interface test between space segments (i.e. radio frequency and base band compatibility test and the data interface test).

4.2.3.5 Launch segment

The launch segment shall provide information consistent with what operations personnel need to know for the type of launch and early orbit phase (LEOP) support needed. Information shall also include an overview of the launch sequence plus telemetry, boost phase programmed events and other launch phase items as appropriate. If information needed by operations personnel and provided in the preceding satellite segment and ground segment sections is different during the launch phase, those differences shall be identified in this clause as appropriate.

4.2.3.6 Mission life segment

The mission life segment shall describe the in-orbit test (IOT) phase, the mission phase and post-mission phase operations. In the mission phase the operations agency executes every mission duty operation and in the post-mission phase the operations agency executes degraded mode operations. This clause shall provide information consistent with what operations personnel need to know for the type of mission phase support and post-mission phase support needed. If post-mission phase support is to be provided, information shall include an overview of the post-mission operation with operation items and time limits.

4.2.4 Space system operating functions (Clause 2 of handbook)

4.2.4.1 General

The space system operating functions clause shall emphasize the process required to bring the system to full operational capability, status monitoring, alarm/anomaly response by the limit check defined in the database system (DB), mission planning, mission execution by the event go/no-go judgement by SOE and post-mission activity through LEOP, IOT, mission and post-mission phase.

In the IOT phase, the developing agency and operating agency shall check the on-orbit performance and function of bus equipment and mission equipment. After the check, the developing agency shall hand over satellite operation to the operating agency.

Clause 2 shall contain a functional explanation of the mission and contingency, i.e. SOOH Vol. 2 shall contain data needed for the space segment (see Table A.1, satellite nominal and contingent operation description in LEOP, IOT and control for initial acquiring mission orbit) and emergency procedures contained in other clauses (in the ground segment) of the handbook. Flow diagrams shall support text as needed. The functional description shall include the following, as applicable:

a) when the procedure shall start and terminate;

b) where the procedure shall activate, e.g. rack, console, or other location;

c) the time usually required for the system to complete a function;

d) what is accomplished by the procedure;

e) prerequisites for procedure execution;

f) procedure peculiarities, if any;

g) when it is possible (or prohibited) to accomplish the procedure;

h) identification of the crew interface and actions required to operate the function.

Where possible, common titles shall identify crew procedures common to all space systems (i.e. complex entry and exit, crew changeover briefings, activity co-ordination briefings). Amplified procedures shall tell who, what, when, where, why and how. Most procedures in Clause 2 and in Clause 3 shall be in checklist format.

4.2.4.2 Operations centre security procedures

Amplified security procedures shall include functions accomplished by the relief crew and duty crew necessary for personnel identification, classified inventory, check of warning devices (if applicable) and specified equipment, as applicable to the space system.

4.2.4.3 Changeover procedures

Crew changeover procedures and briefings shall facilitate the assumption of duties by the relief crew. These procedures shall include briefings and procedures that will enable both the duty crew and the relief crew to review, examine and determine the system status during the course of the changeover. Procedures and briefings shall include material which assists in accomplishing an effective crew changeover.

4.2.4.4 Status and fault monitoring

With regard to SOE event processing and satellite health status, space system status and fault monitoring received at the space operations centre can be presented by console indications, printouts and alarms. For abnormal indications, the operator shall receive instructions on the best method of prioritizing crew actions and reacting to the indications. Instructions shall provide clear directions for the space operations crew

member to understand and react to these stimuli and to be able to perform normal, emergency, and malfunction procedures to isolate the condition and maintain maximum space system capability. SOE (see Table A.1) describes the sequence of procedures with the timing constraints in order to realize an operation and refers to the FCP and GCP to be executed. In order to perform status and fault monitoring, each agency shall require the following:

a) checking and recording of the deviations from the reference and reporting of its influence;

b) selection of the report format of the status data card/characteristics sheet;

c) maintenance of the DB value (see Table A.3) by the operating agency after the review by the developing agency to obtain the appropriate reference.

4.2.4.5 Activity coordination procedures

Activity coordination procedures shall include information required by space operations crew members to accomplish their duty assignments. Information shall advise space operations crew members of scheduled activities, operational and maintenance support tasks, emergency procedures and administrative matters. An activity coordination briefing shall be held before operating the system equipment or performing any on-site maintenance or servicing task. The purpose of an activity coordination briefing is to ensure that safe and correct procedures are followed during the performance of any function involving on-site equipment. It is the responsibility of the briefing official to ensure that personnel are thoroughly briefed on all aspects of the activity to be conducted. This briefing shall include, but not be restricted to, communications and normal, malfunction, emergency and contingency procedures in progress or anticipated.

4.2.4.6 Safety procedures

The safety procedures shall include rules for evacuation of the operation crew and on-site safety briefings for visiting personnel. The procedures shall include information sufficient in scope to advise visiting personnel of existing site hazards, alert procedures, hazardous operations scheduled or in progress and danger areas. The procedures shall describe the escort/visitor relationship, location of safety equipment, reaction to announced emergency conditions and communications procedures.

4.2.4.7 Operations centre inspections and system test procedures

Inspections and system test procedures shall provide the space operations crew during alert with a verification of system capability and system status. The extent and complexity of these procedures shall depend on the particular space system. In each case, the amplified procedures in this clause and applicable corresponding abbreviated checklist shall contain complete verification procedures for determining system capability and system status. System test procedures shall augment the verification of system status and enhance the ability of the space operations crew member to isolate problems and restore the space system to full operational posture. If deemed necessary by the acquiring agency, an abbreviated checklist shall include these procedures.

The operations handbook shall include verification/inspection procedures performed by persons other than space operations crew members.

Equipment status verified by crew personnel during the verification/inspection shall include mission-essential equipment. Verification/inspection procedures for equipment requiring less frequent status verification shall be in other space system technical orders.

4.2.4.8 Communications equipment procedures

Communications equipment procedures shall include the descriptions of activities required to inspect, start up, initialize and operate equipment and to perform diagnostic tests. These procedures shall also include requirements for isolating communications equipment from space system equipment. Either the operations agency or the acquiring agency may request a stand-alone operation handbook for complex or highly integrated communications equipment.

4.2.4.9 Ground system procedures

The ground system procedures shall include the descriptions of activities required to inspect, start up, initialize, configure and operate equipment and to perform diagnostic tests. These procedures also include the requirements for isolating ground systems from communications equipment. Either the operations agency or the acquiring agency may request a stand-alone operations handbook for complex or highly integrated ground systems. The ground system procedures include ground segment nominal operation procedure and contingency procedure that includes error finding, identifying and isolating the most probable system malfunctions that could occur during mission operations and recovery functions including switching to a redundant system corresponding to the style of their ground segment.

4.2.4.10 Mission planning procedures

Mission planning procedures shall include the necessary actions to be performed by the space operations crew to achieve the long- and short-term mission planning necessary to accomplish all mission requirements. Amplified procedures and the applicable corresponding abbreviated checklist shall contain sufficient detail to ensure all aspects of mission planning are accomplished.

4.2.4.11 Mission execution procedures

Mission execution procedures shall contain mission execution requirements to be accomplished by space operations crew personnel. These procedures shall be in sufficient detail to direct space operations crew personnel in accomplishing mission execution of space assets. These procedures shall include the methods needed to identify and correct system anomalies.

4.2.4.12 Post-mission procedures

Post-mission procedures shall contain post-mission requirements to be accomplished by space operations crew personnel. These procedures shall be in sufficient detail to direct space operations crew personnel in accomplishing shut-down and reporting procedures (if applicable to the space system).

4.2.5 Mission operating procedures (Clause 3 of handbook)

Mission operating procedures shall contain detailed information for satellite and related ground segment operation required by the space operations crew in the performance of normal and contingent operational duties. It shall include briefings and procedures to be conducted during normal and contingent case duty shift, mission planning, mission execution, post-mission, training operations, mission verification and such other operations as may be applicable or specifically required by the acquiring, operations, or owner agency. (e.g. SOOH Vol. 8 describes nominal and contingent mission operation and related ground facility).

Clause 3 shall consist of normal and contingent operational briefings and procedures required of space operations crew personnel during the course of a duty shift. The procedures shall identify requirements from the point of crew arrival on-site, during daily or recurring tasks and until crew departure following completion of the duty shift.

Operational procedures shall define individual and crew responsibilities and provide amplified procedures sufficient to ensure complete, accurate and timely accomplishment of these functions. This clause shall contain simplified procedures, such as operations centre security. This clause shall explain complex or lengthy procedures in amplified procedures format.

The contents of Clause 3 shall include those crew briefings and procedures required to determine system status, maintain operational capability, execute mission, conduct post-mission operations and ensure secure operations.

4.2.6 Space segment contingency procedures (Clause 4 of handbook)

The contingency procedure shall primarily make it possible to establish whether a contingency originates from the space segment or ground segment. After any necessary troubleshooting operation (making clear the error

source in space or in the ground segment), the operating agency shall isolate the error source and recover satellite capability.

Space segment contingency procedures shall enable a space operations crew to identify and isolate the most probable system malfunctions that could occur during mission operations. These procedures shall include troubleshooting guidelines for internal and external problems (solar flares, interference for Earth sensor unit, noise figure of thermal noise to ground tracking antenna, etc.). Those systems that have redundant or backup equipment shall provide the required procedures to maintain the operational status of the system. Clause 4 shall contain remedial actions by the direction of the acquiring agency. For ease of reference, malfunctions shall be listed by subsystem and in order of impact on space operations or on operational mission status. See Table A.1, Vol. 2: Satellite nominal and contingent operation description in LEOP, IOT (includes control for initial acquiring mission orbit).

Clause 4 shall contain information for the identification, isolation and correction of system malfunctions that occur. It shall include space system operations crew procedures. The information shall be of sufficient scope to include corrective procedures for abnormal conditions (induced by internal and/or external conditions) and shall be in sufficient detail to enable crew personnel to accomplish appropriate procedures using authorized technical data or under the direction of the competent technical authority (system engineers, command post, etc.). Malfunction identification procedures shall be developed for ready reference to a particular malfunctioning system and the malfunction indication within that system. The procedures shall be as direct and simple as possible, consistent with the action necessary to remedy the malfunction. The information shall indicate the effect of the malfunction on the system, probable cause and corrective action. In Clause 4, the space system shall present standardized malfunction analysis procedures insofar as possible.

4.2.7 Operating limitations (Clause 5 of handbook)

Operating limitations shall contain those limitations that impose a restriction, affect system accuracy or otherwise adversely affect system operations or system capability.

Clause 5 shall contain operating limitations imposed as a result of system configuration, operational consideration and environmental restrictions, as applicable. It shall include a description of each specific limitation and its application to the space system. In discussing limitations, applicable tables and graphs shall be included, as needed. A classified supplement to the operations handbook shall include operational limitations of a classified nature.

4.2.8 Ground segment emergency procedures (Clause 6 of handbook)

Ground segment emergency procedures shall specify the procedures to be followed in meeting emergencies that might reasonably occur. These procedures shall limit those emergency conditions, personnel actions and safety factors that could reasonably reduce the possibility of personnel injury or safety rule violations. Clause 6 shall include required crew reactions to correct or contain emergency conditions or prohibit crew actions in accordance with established directives. Clause 6 shall clearly define safety hazards, emergency operational procedures and emergency situations to ensure crew recognition of an emergency condition occurring during any phase of space operations.

Clause 6 shall limit those space operations crew emergency procedures necessary to ensure safe recovery in the event of a critical malfunction or emergency condition occurring during mission operations. If appropriate, procedures shall include information prohibiting certain crew actions which, if accomplished, would violate established space system safety directives. Information shall be included to enable crew members to recognize a hazardous condition and take appropriate action.

Clause 6 shall include procedures designed for crew identification of emergency conditions, corrective action, and emergency operations procedures. Additional safety information may be included; it shall be restricted to items of personnel safety (i.e. high voltages, high pressures and environmental hazards), but shall not include items of a purely first-aid nature.

Clause 6 shall include textual material, amplified procedures and an abbreviated checklist for emergencies that the crew can normally expect to encounter during duty shifts or maintenance activity. The amplified procedures shall include sufficient textual material to define the immediate effect the emergency condition will

have on system capability and actions that are within the crew's capability to restore mission effectiveness. Clause 6 shall include procedures, as applicable to the space system, for use during a fire or overheat situation, hazard situation, security system violations, or space system safety violations.

4.2.9 Crew duties and responsibilities (Clause 7 of handbook)

Clause 7 shall specify those crew positions and duties required to operate space systems during the nominal and off-nominal operations that are required by each operating agency corresponding to the style of their ground segment. It shall include the title, duties, and responsibilities of individual space operations crew positions. It shall include information furnished by the operations agency and shall contain no information for which engineering responsibility could become an issue.

4.2.10 Vocabulary (Clause 8 of handbook)

As needed, the operations handbook shall contain a vocabulary list. The vocabulary list shall include technical terms, definitions, acronyms, symbols and abbreviations used in the handbook and shall be arranged in alphabetical order.

Naming convention shall facilitate simple and correct access and use as standard, throughout a satellite project avoiding error and saving time (i.e. same name or mnemonic in all the documentation from the manufacturer to the operator and in compliance with the database).

4.3 Classified material/document

The format, content and revision of the classified space operations material shall be identical to the unclassified space operations material that it supports. Arrangement and presentation of classified data shall be in accordance with the applicable requirements established for the unclassified handbook and such additional requirements as determined by the acquiring agency. A foreword shall cover the scope and content of the classified handbook.

The acquiring agency shall plan to publish a classified and unclassified handbook only when necessary. Both handbooks shall be completely cross-referenced to one another. The method of referencing shall be identical in that the title pages and tables of contents shall reference one another.

4.4 Abbreviated checklists and step-by-step procedures

4.4.1 Abbreviated checklists

The abbreviated checklist applies when the acquiring or operations agency specifies separate abbreviated checklists. Under the supervision of the acquiring agency, the contractor and the owner and/or operations agency shall jointly prepare abbreviated checklists for use with space operations systems. The owner shall verify the checklist procedures prior to final publication. Unless authorized, preliminary procedures should not be published to support operational requirements of the owner agency. Checklists shall contain only that information necessary to safely and effectively accomplish the required task. The checklist shall show only what to do and when to do it, not how to do the work. The checklist shall also include the identification of the amplified procedure from which the checklist is derived. The owner shall prepare an abbreviated operations checklist when one or more of the following conditions exist:

a) communication between individuals is necessary to control or monitor task progression;

b) there is potential damage to, or degradation of, equipment that would reduce operational readiness or adversely affect mission capability;

c) there is potential injury to personnel unless prescribed procedures are followed;

d) the task is critical to mission accomplishment.

Checklist data shall include instructions that duplicate, in abbreviated form, the corresponding actions contained in the amplified procedures. The data shall consist of a step-by-step format and shall be limited to the material necessary to accomplish the action. The data shall have a triple-column format: crew duty position performing the step in the first column; step number in the second column; and actions to be performed in the third column. Placard information and responses shall be printed in upper case letters or figures (e.g. COMMUNICATIONS LINK OUT). Step-by-step presentations need not consist of complete sentences. Leaders, e.g. SATELLITE CONTROL CONSOLE, shall be inserted between columns on the left side of the page.

References to applicable operations or maintenance manual clauses and subclauses required to correct a malfunction or continue a mission operation shall be listed immediately following the task. Inclusion of such additional data shall be limited to information that is essential to accomplishing the tasks.

The reverse side of checklist pages that are intentionally left blank shall not contain a statement to that effect. Numbers of the blank pages shall appear on the preceding page immediately following that page number and separated by a slash (/).

EXAMPLE 317/318, 318 being the blank page.

When a page numbering sequence is broken as a result of pages being deleted because of a change, the list of effective pages shall reflect the update. A statement indicating the deletions shall be placed in the bottom margin of the preceding page or the top margin of the following page to show the reason for the break in page number continuity. The statement shall be in the following form: “All data on Page XX deleted.” When changes to a function within the emergency procedures checklist result in addition or deletion of steps within the function, the revised and reissued entire function shall avoid any break in sequential page or step numbering and prevent any pages or major portions of any page within the function from being blank.

Acquiring agencies shall ensure that inclusion of special notices is kept to an absolute minimum consistent with procedural requirements. When included, warnings, cautions and notes shall precede the action to which they refer.

4.4.2 Step-by-step procedures

In lieu of separate abbreviated checklists, the step-by-step procedures used by space operations crews shall be available for lengthy or critical procedures or both. The contractor and the owner and/or operations agency shall jointly determine which procedures are step-by-step. Step-by-step procedures shall contain only that information necessary to accomplish the required task safely and effectively. The step-by-step procedures shall have the following characteristics.

a) Each step-by-step procedure shall start at the top of a page.

b) Step-by-step procedure titles shall be at either the top or bottom of each page.

c) All illustrations shall appear at the end of the clause to which they apply.

d) Narrative procedures shall appear at the beginning of the appropriate clauses and the step-by-step procedures shall follow sequentially.

e) Each step of the procedure shall be numbered. There shall be no lettered sub-steps in the step-by-step procedures.

f) Procedures shall consist of numbered clauses.

g) Introductory text (lead-in clauses) shall not be included in step-by-step procedures, but shall appear in the appropriate clause.

h) Lead-in statements referring to particular items of equipment or alternative actions shall be underlined.

i) Where lead-in statements reference nomenclature and steps, the nomenclature shall appear first and applicable steps shall follow.

j) Amplification of steps shall be included only when necessary.

k) Information applying to several steps shall appear as a note or lead sentence, as applicable.

l) Step-by-step procedural steps shall contain actions to be checked, observed, or verified and arranged in order of performance.

m) Applicable cautions and warnings pertaining to personnel injury or equipment damage shall be included in the procedure.

n) Prior to final publication, step-by-step procedures shall be verified.

A separate and distinctive checklist shall be prepared that covers appropriate emergency-amplified procedures and mission continuation procedures as contained in Clause 4. The emergency procedures checklist shall be restricted to those crew procedures required to safeguard the equipment, prevent injury to personnel, or continue mission functions involving hazardous conditions or operations. Pages within this checklist shall have the same format as the normal procedures checklist (see examples in Tables B.1, B.2 and B.3).

Annex A
(informative)

The operational documentation tree and procedure

A.1 General

This annex lists the kinds of operational handbook that include the description and the process used for space segment satellite operation and ground segment operation.

The satellite-developing agency (i.e. satellite manufacturer) shall provide the documentation [i.e. satellite operational handbook (see example in Table A.1)], which is often a descriptive documentation of the satellite and also provides input for FCPs (see example in Table A.2), and which shall be written and qualified by the operation agency's operation crew and/or operation teams.

The ground-segment-developing agency (i.e. ground segment manufacturer) shall provide the documentation of ground segment operational manuals (see ground station configuration manual in Table A.3) and GCPs (see Tables A.3 and A.4), which are written by the operation agency's operation crew and/or operation teams.

A.2 Configuration of operational document

The operational documents needed for space segment satellite operation and ground segment operation include the four handbooks/manuals shown in Figure A.1 and Tables A.1 to A.4.

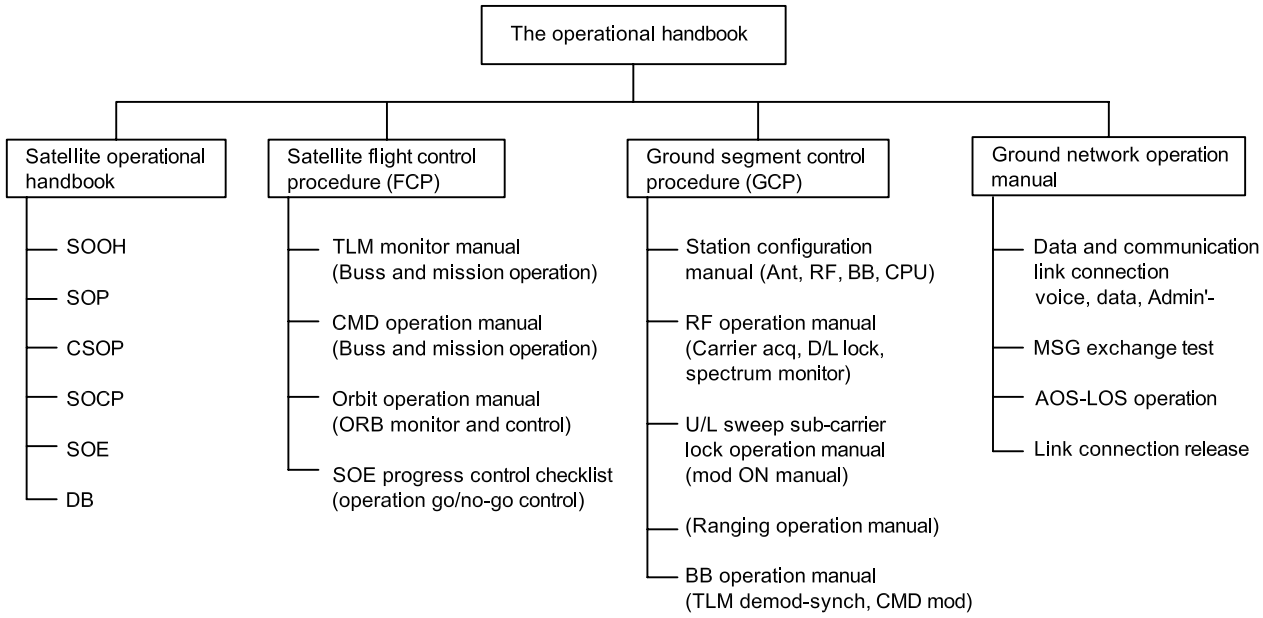

Figure A.1 — Example 1: The operational handbook tree — JAXA case

A.3 Elements

The following abbreviations and acronyms are used in Tables A.1 to A.3.

CSOP	contingency SOP
CPU	central processing unit of computer
D/L	down-link
DB	database that includes satellite data and related data for ground segment
FCP	flight control procedures that include satellite tracking control operation manual
GCP	ground segment control procedures that include tracking station operation manual
IOT	in-orbit test
MNVR	manoeuvre
MSG	message
OBC	on-board computer
RNG	orbit ranging (range, range rate and azimuth/elevation angle of ground tracking antenna measuring)
SOCP	satellite on orbit checkout procedure used in IOT
SOE	sequence of (operational) events
SOOH	satellite on orbit operational handbook
SOP	satellite operation procedure
U/L	up-link

Table A.1 — Example 2: Satellite operational handbook

Name	Contents	Comments
SOOH	(Satellite on orbit operational handbook) — Vol. 1: Satellite description of performance and function. — Vol. 2: Satellite nominal and contingent operation description in LEOP, IOT (includes control for initial acquiring mission orbit). — Vol. 3: Normal phase (mission phase) operation. — Vol. 4: TLM data description. — Vol. 5: CMD data description. — Vol. 6: Satellite drawing; block diagram with TLM outlet and CMD inlet in each subsystem component. Timing chart description in controller and OBC. — Vol. 7: Satellite data book that lists database source. — Vol. 8: Descriptions and operational requirements for mission equipment and related ground facility).	Separated in volumes for the convenience of the operator's handling.
SOP	(Satellite operation procedure) Presents operating CMD and related TLM data change to be monitored with time constraints data and off-nominal status specifications.	Data change is specified by limit check DB.
CSOP	(Contingency SOP) Presents operating CMD and related TLM data change to be monitored to separate and/or recover from error status.	Includes crew's contingent work flow.
SOCP	(Satellite on orbit checkout procedure) Developing agency use to check satellite on orbit performance and functions before satellite hand-over in IOT phase.	
SOE	(Sequence of events) Presents orbital events (eclipse, visibility of satellite), satellite operational events (AOS, attitude and orbit control, solar array paddle deployments, imaging data acquisition of satellite, LOS), and ground segment operation events (satellite tracking control software operation, RF operation, network switching). Satellite operation crew and engineer mainly refer to SOE, and mission conductor uses additional ground segment event checklist.	See Table A.2, operational event progress control checklist.
DB	(Database) Database that includes satellite data and related data for ground segment (TLM monitor limit value, TLM engineering unit conversion factor, CMD definition data, RF transponder delay data for orbit determination, gas-jet systems thruster performance data, amount of usable propellant for attitude and orbit control).	The database is often supplied by the satellite manufacturer with the satellite information and completed by the operation team with ground segment and operation data.

Table A.2 — Example 3: Satellite flight control procedure (FCP) (manual)

Name	Contents	Comments
TLM monitor manual	The TLM monitor operator uses the manual at his monitor console and consists of the following three parts with recommended TLM quick-look display and TLM data graphical trend display monitor. — Part 1: Eventual monitor description In LEOP, IOT satellite operation phase, in pre-AOS check, in post-LOS check and CMD transmission monitor events (in each satellite event monitor, i.e. MNVR monitor). — Part 2: Normal operation monitor description Housekeeping cyclic monitor check through mission phase. — Part 3: Contingency monitor description Description to find out and report off-nominal status and describe possible tentative process for separate and/or recover from error status before satellite designer/developer's arrival.	
CMD operation manual	The manual describes the operation workflow. The CMD operator uses at his monitor console. Corresponding to SOE, the manual describes how to configure the required CMD sequence from the SOP and/or individual CMD installed electrically in the ground computer system and transmit and monitor the CMD reception in the satellite receiver unit.	CMD operator shall refer to SOOH Vol. 5: CMD data description.
Orbit operation control manual	The manual describes the operation workflow and the flight dynamics software workflow that includes ranging, orbit determination and propagation, MNVR planning, MNVR CMD parameter set-up for SOP and CMD operator. The manual describes the method of post MNVR orbit control and thruster efficiency evaluation. The manual describes MNVR contingency judgement from the perspective of thrust time duration versus its efficiency.	
Operational event progress control checklist	Mission conductor uses the manual (checklist) to judge go/no-go check of a satellite event (SOE) and related ground segment event (RF acquisition, network switching operation, software operation, etc.) processing.	

Table A.3 — Example 4: Ground segment control procedure (GCP) (manual)

Name	Contents	Comments
Station configuration manual	The manual summarizes station operation items, RF operation, BB operation, network switching, computer system operation for satellite tracking control. The manual describes the station operation mode, timing chart and signal/data line/network drawing. a) Local control: controlled at each equipment panel. b) Console control: station configuration changed from console. c) Remote control: station configuration changed from another site (i.e. changed from tracking control centre). d) Operational description and performance of each item of equipment.	Mainly GCP means station configuration manual.
D/L carrier acquisition manual	The manual describes the operation workflow. The manual describes the D/L carrier lock procedure.	
U/L sweep and sub-carrier acquisition manual	The manual describes the operation workflow. The manual describes the method of U/L sweep and sub-carrier lock (PLL) procedure by modulator ON.	
BB operation manual	The manual describes the received TLM demodulation, TLM flame/bit synch lock and data transmission to station computer. The manual describes the method of CMD modulation and CMD transmission to the satellite.	

Table A.4 — Example 5: Network operation manual

Name	Contents	Comments
Communications link connection procedure	The procedure describes the network switching and communications link connection among stations.	
Test data transmission and connection procedure	The procedure describes the test data transmission and confirming process: voice, administrative message and test data transmission.	Acknowledge, encode/decode, etc. test.
AOS-LOS operation procedure	The procedure describes the TLM/CMD/RNG operation workflow.	
Communications link release procedure	The procedure describes the link release procedure.	

Annex B
(informative)

Mission checklist (MCL)

B.1 General

This annex lists the procedures used to exchange administrative and technical information for the satellite operation among organizations.

The MCL is a series of steps used to conduct satellite operations in each visible pass between the following: NASA–NASDA, NOAA–NASDA, ESA–NASDA, CNES–NASDA and CEE–NASDA.

B.2 Configuration of MCL

The MCL corresponds to the transmission protocol and type of data to be transmitted, as shown in Figure B.1 and Tables B.1 to B.3.

B.3 Elements

The following abbreviations and acronyms are used in this annex.

AOS	acquisition of signal
CEE	centre for space studies, *Universidad de Chile*
CMD	command
CNES	*Centre National d'Etudes Spatiales* (France)
DD:HH:MM:SS	days from the epoch day:hours:minutes:seconds
D/L	down-link (S/C to ground)
DSA	disable
EL	elevation angle of tracking antenna
ENA	enable
ESA	European Space Agency
GDS	Goldstone satellite tracking and control station JPL/NASA
GW	gateway for X.25
ID	identification
INT102	INT = initial phase (LEOP) SOP, sequence number 102
	1 = orbital revolution count (count up at ascending node)
	02 = procedure number
JPL	Jet Propulsion Laboratory
LOS	loss of signal
MCL	mission checklist
MNVR	manoeuvre

N	newton
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency (Japan)
NOAA	National Oceanic and Atmospheric Administration
S/C	spacecraft
SOM	station operation manager (e.g. NASA = JPL, CNES = TLS/Toulouse, ESA = ESOC)
SOP	satellite operation procedure (the set of CMD sequence and related TLM data variation to be monitored)
ST	satellite tracking and control station: track satellite, acquire TLM data and transmit CMD (e.g. NASA = GDS, CNES = CNES Kourou, ESA = Perth) SOE sequence
TC	satellite tracking and control centre: direct STs (where sample ST–SOM–TC relation is shown in Figure B.1)
TCP/IP	transmission control protocol/internet protocol
THR	thruster
U/L	up-link (ground to S/C)

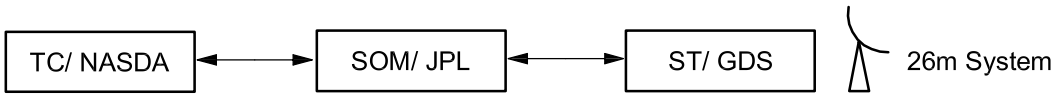

Figure B.1 — NASDA–NASA JPL/GDS case

Table B.1 — Example 1: Step-by-step operation procedure: MCL/X.25

Timing	From	To	Event ID	Message	Comment
AOS − 20 min	SOM	ST	1	Confirm ST is ready to support	
	TC	ST	1A	Inform ST support requirement in this visible pass	
AOS − 15 min	TC	ST	2	Send “connection request” from GW to ST for TLM and CMD	X.25
	ST	TC	2A	ST transmits test TLM data	
	TC	ST	2B	Confirm receipt at GW	
	TC	ST	2C	Send “SYSTEM ALIVE” messages to ST	
AOS − 10 min	ST		3	Terminate transmission of test TLM data and configure for real-time support	U/L, D/L polarity, etc.
	TC		3A	Key in receipt TLM display console ID at GW	TC in house only
	TC		3B	Key in CMD transmit console number at GW	TC in house only
AOS	ST		4	AOS	
	TC		4A	Confirm receipt TLM at GW	
	SOM	TC	4B	Announce ST AOS time	HH:MM:SS
EL > 5°	SOM	TC	5	Report carrier-up and sweep at EL greater than 5° time	Detect EL angle 5° crossing
	TC	ST	5A	CMD transmission for satellite operation by SOE/SOP	
EL < 5°	SOM	TC	5B	Report carrier-down at EL < 5° time	Detect EL angle 5° crossing
LOS	ST		6	LOS	
	SOM	TC	6A	Announce ST LOS time	HH:MM:SS
	TC		6B	Clear ID and release TLM display console at GW	TC in house only
	TC		6C	Send “connection release” from GW to ST for TLM and CMD	X.25
	TC	SOM	7	Announce next voice contact day and time	DD:HH:MM:SS

Table B.2 — Example 2: Step-by-step operation procedure: MCL / TCP/IP

Timing	From	To	Event ID	Message	Comment
Few hours before	TC	ST	0	Communications link connection for the TLM and CMD and check	TCP/IP
AOS − 20 min	TC	ST	1	Confirm ST is ready to support	
	TC	ST	1A	Inform ST support requirement in this visible pass	
AOS − 15 min	ST	TC	2	ST transmits test TLM data	
	TC	ST	2A	Confirm receipt at GW	
	TC	ST	2B	Send “SYSTEM ALIVE” messages to ST	
AOS − 10 min	ST		3	Terminate transmission of test TLM data, and reconfigure for real-time support	U/L, D/L polarity, etc.
	TC		3A	Key in receipt TLM display console number at GW	TC in house only
	TC		3B	Key in CMD transmit console number at GW	TC in house only
AOS	ST		4	AOS	
	TC		4A	Confirm receipt TLM at GW	
	SOM	TC	4B	Announce ST AOS time	HH:MM:SS
EL > 5°	SOM	TC	5	Report carrier-up and sweep at EL > 5° time	Detect EL angle 5° crossing
	TC	ST	5A	CMD transmission for satellite operation by SOE/SOP	
EL < 5°	SOM	TC	5B	Report carrier-down at EL < 5° time	Detect EL angle 5° crossing
LOS	ST		6	LOS	
	SOM	TC	6A	Announce ST LOS time	HH:MM:SS
	TC		6B	Clear ID and release TLM display console at GW	TC in house only
	TC	SOM	7	Announce next voice contact day and time	DD:HH:MM:SS

Table B.3 — Example 3: Step-by-step operation procedure: SOE/SOP

Timing	From	To	Event ID (SOP number)	Event	Comment
AOS + 10 min	TC	TC	1 (INT101)	First AOS operation: S/C status check	NASDA only
AOS + 1,5 h	TC	ST	2 (INT102)	First AOS CMD: Earth sensor ON, coherent mode ENA, fuel tank/line heater ON	
AOS + 2,0 h	TC	ST	3 (INT103)	Solar array paddle hold	
MNVR − 1,0 h	TC	ST	4 (INT104)	Catalyst bed heater ON, latching valve operation	
MNVR time	TC	ST	4A (INT105)	20 N THR firing	20 N thruster (20 N THR) test MNVR
MNVR + 20 min	TC	ST	5 (INT106)	Solar array paddle slew and start the sun tracking	
LOS − 40 min	TC	ST	6 (INT107)	Coherent mode DSA	For next NASDA station
LOS − 30 min	TC	TC	7 (INT108)	Pre-LOS operation S/C status check	NASDA only

The procedure of event ID 5A in MCL shall be replaced by this SOE/SOP in Example 1 and Example 2.

Bibliography

[1] AIAA/ANSI R-024-1993, *Recommended Practice for Space Operations and Support Documentation*

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