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Space systems — Early operations —

Part 1: Spacecraft initialization and commissioning

Systèmes spatiaux — Opérations initiales —

Partie 1: Initialisation et prise en mains du véhicule spatial

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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.

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

ISO 10784-1 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

ISO 10784 consists of the following parts, under the general title *Space systems — Early operations*:

— *Part 1: Spacecraft initialization and commissioning*

— *Part 2: Initialization plan*

— *Part 3: Commissioning report*

Introduction

The three parts of ISO 10784 provide spacecraft (SC) manufacturers and operators with a specific form and format for writing SC initialization plans and commissioning reports required to configure and verify the SC to perform normal mission operations. Often, SC manufacturers and operators have defined these plans and reports uniquely for each programme, or regional, national and corporate organizations have unique initialization plans and commissioning reports. The three parts of ISO 10784 aim at establishing a common language and form for SC stakeholders. The use of one form and format will simplify stakeholder understanding of initialization and commissioning activities.

Space systems — Early operations —

Part 1: Spacecraft initialization and commissioning

1 Scope

A general definition of initialization is that it begins at separation of the spacecraft (SC) from the launcher. In some cases, a more exact definition will be that initialization begins in flight, upon planned change in mode or state of the SC from the launch configuration. Commissioning is completed when the SC, including its payload, is certified for initial mission operations. Prior to certification for mission operations, the SC is described as a test article in the three parts of ISO 10784. ISO 10784 does not include a requirement for contingency plans, but does include a statement of the need for contingency planning.

This part of ISO 10784 outlines general descriptive information for SC initialization and commissioning as might be appropriate for programme management, project engineering or programme test documentation. Since the SC is considered a test article at this phase of its operational life, ISO 17566 is used as a normative reference in constructing the initialization plan and the commissioning report. It provides SC manufacturers, SC operators and other stakeholders with a common language and form to verify and document spacecraft initialization and commissioning prior to normal SC mission operations.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10784-3:2011, *Space systems — Early operations — Part 3: Commissioning report*

ISO 17566, *Space systems — General test documentation*

ISO 24113:2011, *Space systems — Space debris mitigation requirements*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

3.1.1
commissioning
certification of a spacecraft as ready for mission operations

3.1.2
early operations
period from initialization to commissioning for mission operations

3.1.3
initialization
initial functional and operational checkout of a spacecraft following separation from the launch vehicle

3.2 Abbreviated terms

LV launch vehicle

PL payload

SC spacecraft

4 Introduction clause of an initialization plan or commissioning report

4.1 General

The introduction clause of an initialization plan or commissioning report shall provide general information about the technical content of the initialization plan and the commissioning report. It shall include a brief description of the initialization sequence. The overall initialization objective shall be described, and the criteria for the SC certification shall be stated.

4.2 Overall sequence of initialization events

This subclause of the introductory clause shall summarize the overall sequence of functional and operational sequences conducted to demonstrate the initial operational status of the spacecraft with respect to the operational environment and shall explain how the test in question fits into this sequence. The starting mode of the spacecraft shall be the same as the launch mode. The ending mode of the spacecraft shall be the initial operational mode.

4.3 Overall relations of commissioning functions

This subclause shall summarize the minimum overall relations and status of spacecraft functions demonstrated to verify the initial operational capability of the system.

4.4 Orbital-debris considerations in spacecraft initialization and commissioning

4.4.1 General

Orbital-debris generation is a major consideration during spacecraft initialization and will impose limitations. It is possible that limitations might be placed on both the spacecraft and the launch vehicle in this phase.

4.4.2 Hardware retention

Hardware retention requirements relevant during spacecraft initialization shall be addressed (see ISO 24113:2011, Subclause 6.1).

4.4.3 Avoiding damage

This subclause shall summarize the retention measures taken to avoid the release of hardware into space (see ISO 24113:2011, Subclause 6.1). Failure to control separation of space objects might result in later contact with, and damage to, the spacecraft.

4.4.4 Collision avoidance

This subclause shall summarize the measures taken for avoiding collisions. Collision avoidance recommendations relevant during spacecraft initialization are contained in the *IADC Space Debris Mitigation Guidelines*, Revision 1 (September 2007), Subclause 5.4.

4.4.5 Conjunction analysis

This subclause shall summarize the conjunction analysis performed for the purpose of collision avoidance. Conjunction analysis recommendations relevant during spacecraft initialization are contained in the *IADC Space Debris Mitigation Guidelines*, Revision 1 (September 2007), Subclause 5.4.

5 Objectives of spacecraft initialization and commissioning

5.1 General

This clause shall detail the general and specific objectives in the context of the spacecraft and payload initialization. A minimum set of objectives for successful initialization shall be identified.

It is possible to conceive of simple spacecraft and missions and more complex spacecraft and missions. The user determines the number of operational phases for their unique programme. For example, a multi-phase mission to another planet might have an initialization and commissioning strategy matrix for the spacecraft initial earth orbit, another for the interplanetary phase and a third for insertion into orbit around the target planet.

5.2 Spacecraft initialization and commissioning strategy matrix

The strategy matrix shall define the strategies that will be used to demonstrate compliance with the SC operator's requirements related to the spacecraft in general and the payload in particular.

The required format for the strategy matrix is shown below with a notional sequence of events.

Table 1 — Initialization and commissioning strategy matrix

Event	Time	Operational requirement	SC or PL procedure	Prerequisites or constraints	Notes
Pre-launch					
Pre-1			Apply power to SC		
Pre-2			Load SC processor with flight software		
Pre-3			Upload separation orbit data		Orbit data should be in Earth-centred, Earth-fixed (ECEF) coordinates
Pre-4			Upload contact information		Upload at least three days of contact information
Pre-5			Verify count of commands on SC processor		
Pre-6			Verify that SC battery is fully charged		
Pre-7		Safe SC and PL for launch	Verify LAUNCH mode		
Pre-8			Remove power from SC		Unpowered launch
Post-launch					
1	Separation (S)	Record LV separation time and separation orbit data			Retrieve from launch service provider as soon after launch as possible

Table 1 (*continued*)

Event	Time	Operational requirement	SC or PL procedure	Prerequisites or constraints	Notes
2	S+00h05m00 s	Determine time of expected initial contact			
3			Turn on SC processor and load flight software	Triggered by LV separation switch	
4			Start communications queue for initial transmitter turn-on	Triggered by LV separation switch	
5		Ensure safe separation from LV			
6			Damp SC velocity and rotation rates sufficiently for solar-array deployment	Triggered by LV separation switch	
7			Deploy solar arrays	Triggered by LV separation switch	
8		Ensure operation of SC power supply	Point solar array towards sun	Triggered by LV separation switch	
9		Verify proper operation of all SC subsystems — Electrical power system	Verify that power sufficient	SC overhead of ground station	
10		Verify proper operation of all SC subsystems — Attitude determination and control system	Verify that solar array pointing at sun and that orbit data correct and propagating	SC overhead of ground station	
11		Verify proper operation of all SC subsystems — Flight software	Verify that clock correct	SC overhead of ground station	
12		Verify proper operation of all SC subsystems — Telemetry, tracking and commanding	Verify that commands being received in real time and being stored; verify command count and increment Verify that telemetry and other data being received in real time and being stored Download stored state of health of SC	SC overhead of ground station	

Table 1 (*continued*)

Event	Time	Operational requirement	SC or PL procedure	Prerequisites or constraints	Notes
13		Verify proper operation of all SC subsystems — Thermal	All components within allowed temperature range	SC overhead of ground station	
14			Control SC in OPERATIONAL mode	SC overhead of ground station	
15		Verify functionality of PL		SC overhead of ground station	Might be similar to SC verification sequence
16		Calibrate PL		SC in OPERATIONAL mode	
17			Control PL in OPERATIONAL mode		

6 Spacecraft configuration for spacecraft initialization and commissioning

6.1 General

This clause shall define how the spacecraft configuration, including the corresponding reference frame definition and mass properties, and relevant figures or references to relevant drawings, are described. When necessary, the description shall document how the configuration supports the overall initialization objectives.

6.2 Identification and general configuration

All major spacecraft subsystems shall be listed in a configuration matrix. Changes in the configuration matrix shall be made to reflect initialization events in the initialization and commissioning strategy matrix.

6.3 Deviations from the planned configuration

Deviations of the general test article configuration from the flight configuration that are critical for the qualification of the SC with respect to the launch environment shall be identified (see ISO 10784-3:2011, Subclause 8.2). The qualification logic with respect to the overall system qualification of those items that are not in the flight standard category shall be explained.

6.4 Functional configuration

The state of the physical systems of the SC shall be described and compared to the expected SC launch configuration. Any change of functional configuration in the course of the initialization sequence shall be mentioned. The functional configuration addresses the operational mode of the SC and the state of the major electrical systems, including, but not limited to, radio-electrical, pyrotechnic, attitude control and thermal subsystems.

7 Spacecraft initialization plan

7.1 General

This clause shall define how the overall control facility configuration, as run during initialization, is described. In addition, the control facility, its location and the sequence date(s) shall be indicated.

7.2 Spacecraft configuration

7.2.1 General

This subclause defines how the spacecraft configuration is described.

7.2.2 General configuration

The general initialization set-up shall be briefly outlined, including relevant figures or references to relevant drawings. This outline shall include concise information about equipment, instrumentation, interfaces with the SC, environmental conditions, the data acquisition system and any specific infrastructure required to perform the initialization sequence.

7.2.3 Interface configuration

Special emphasis shall be given to the description of the interface between the control facility and the SC if the behaviour of the SC during initialization can be affected by a non-operational interface. In this case, the initialization results clause (see ISO 10784-3:2011, Clause 11) shall explain how the characteristics of the interface affect the initialization results.

7.2.4 System modes and states

SC configuration may change when in different modes such as launch mode, safe mode or operational mode. The SC systems states will change dependent on mode. Modes and states shall be included in the SC configuration description.

7.3 Initialization constraints and limitations

Potential constraints related to operational or safety limitations of the control facility shall be indicated when these limitations have an effect on the initialization and commissioning objectives. The nature of these limitations shall be explained in the initialization plan description clause (see ISO 10784-3:2011, Clause 10) and in the initialization results clause (see ISO 10784-3:2011, Clause 11).

8 Spacecraft commissioning report

8.1 General

This clause defines how the initialization flow, prediction analyses, input data and instrumentation are described.

8.2 Approach and methodology

A description of the logic behind the initialization plan approach and of the methods used shall be provided.

8.3 Event flow

The various steps of the initialization plan shall be listed, with the corresponding levels and durations relative to the nominal goal (full level, nominal duration).

8.4 Supporting analyses

A general description of the analyses performed in support of the initialization plan execution shall be provided, together with the references of the corresponding documentation.

8.5 Input parameters, tolerances, and limits

For each step, the actual initialization plan input data shall be provided in numerical and/or tabular form, as appropriate. The corresponding tolerances and limits related to the performance of the control facility and associated control system shall be clearly indicated (including alarm levels and abort limits).

8.6 Instrumentation

The complete list of measurement devices used during initialization shall be provided, including the following information: instrument identification, measurement type, calibration method, measurement range and tolerances, and exact location with respect to the reference frame of the SC. When useful, a drawing of the arrangement of the measurement devices shall be provided.

8.7 Success criteria

The criteria for the success of initialization shall be listed, and their applicability shall be defined for each step of the initialization sequence.

8.8 Evaluation of results

Initialization results shall be evaluated with respect to the corresponding minimum set of SC operational requirements to be verified within the initialization plan and the verification strategies that will be employed to ensure that these requirements are satisfied. Any non-compliance shall be treated separately. The verification of undertested systems shall be demonstrated by selecting one or several of the following alternatives: evaluation of delta-qualification results, evaluation of subsystem results, verification by similarity or verification by analysis.

8.9 Deviations

Any anomaly in the execution of the initialization plan or any failure of the SC shall be the subject of a specific report including a full description of the anomaly or failure, the various steps undertaken to correct the problem, and the logic retained for subsequent verification of the SC.

8.10 Conclusion

A final conclusion shall be provided in the light of the launch environment, with confirmation that the relevant initialization requirements have been met.

Bibliography

[1] ISO 14303, *Space systems — Launch-vehicle-to-spacecraft interfaces*

[2] ISO 15863, *Space systems — Spacecraft-to-launch-vehicle interface control document*

[3] IADC-02-01, *IADC Space Debris Mitigation Guidelines*, Revision 1 (September 2007)

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