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Space systems — Space experiments — General requirements

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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 14619 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

This International Standard establishes the requirements for preparation of space experiments, execution of the experiment and processing of the collected data. Space systems have been used for solving various practical problems of humanity. The possibilities for expanding the use of these systems are far from being exhausted. At the same time, special studies are needed to identify these opportunities, and the results of these studies must be verified by space experiments. The space environment provides ideal conditions for certain scientific studies.

Expenditures for the experiments should be minimal for the initiator of the proposed practical applications of space systems. It often happens that an experiment is conducted on board a space system that is available and has already been in operation (i.e. the experiment becomes part of the operation of the space system itself). The space experiment is carried out using both hardware and software subsystems. This poses the problem of accomplishing two interrelated objectives:

- to ensure successful execution and performance of the experiment;
- to avoid interfering with an operational space system so as not to impair its functioning.

One method of solving this problem is to standardize the procedure for integrating (introducing) space experiments into the operational processes of the carrier space system. This International Standard specifies the procedures for the preparation on the ground for, the execution of, and the processing of the experimental results from space experiments carried out using a space system that is already operational.

Space systems — Space experiments — General requirements

1 Scope

This International Standard specifies the procedure for preparing and carrying out space experiments and processing the resulting data, and applies to both manned and unmanned space systems, excluding exploratory rockets with associated probes. It may be tailored to the specific needs of different kinds of experiments and their carrier space vehicles.

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 14300-1, *Space systems — Programme management — Part 1: Structuring of a programme*

ISO 14300-2, *Space systems — Programme management — Part 2: Product assurance*

ISO 14620-1, *Space systems — Safety requirements — Part 1: System safety*

ISO 14620-2, *Space systems — Safety requirements — Part 2: Launch site operations*

3 Terms and definitions

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

3.1

space experiment

SE

system of operations, actions, and/or observations performed in space with the objective of obtaining information on the subject under study

3.2

space experiment system

set of equipment designed for the performance of the space experiment and specifically integrated into the space system and support facilities

3.3

space experiment system designer

person responsible for the development, delivery, and performance of the SE system

3.4

space experiment project manager

person responsible for overall management of the space experiment programme

3.5

space experiment operations manager

person responsible for managing operations through all stages of the space experiment and for organizing the operations during the execution of the space experiment

3.6

space experiment scientific observation

method of collecting information and data during the functioning of space experiment instrumentation

4 SE organizational requirements

4.1 Phases

A space experiment shall be implemented by participants in accordance with the following phases:

- a) planning;
- b) development;
- c) execution;
- d) processing of the results and preparation of the final report.

4.2 Participants

The organization and execution of a space experiment shall be the responsibility of the following participants:

- a) SE operations manager;
- b) SE system designer;
- c) SE project manager.

4.3 Simultaneous operations

Several space experiments may be performed simultaneously in the same space system. The decision to combine the experiments shall be made by the SE project manager and shall be subject to agreement by the SE operations manager.

4.4 General modes

Execution of a space experiment in a space system shall be in accordance with the International Standards¹⁾ in the areas of programme management and safety, specifically ISO 14300-1, ISO 14300-2, ISO 14620-1, and ISO 14620-2.

5 Planning phase

5.1 General

The objective of operations at the planning phase of a space experiment shall be to assess the feasibility of conducting a particular space experiment in a particular space system. The organization of a space experiment shall be achieved through the following steps:

- a) preparation of a proposal;
- b) preparation of the input data on the space system;
- c) preparation of a technical assessment.

1) Provisions of ISO 14620-3, *Space systems — Safety requirements — Part 3: Flight safety systems*, currently under preparation will also be applicable.

5.2 Proposal

The proposal shall contain sufficient data to allow the project manager to assess the feasibility of implementing a particular space experiment in a particular space system. An example of a proposal for an SE is presented in Annex A.

5.3 Input data requirements

The SE project manager shall prepare the input data associated with the space system for an SE based on the information available in the proposal. The input data shall include the following information:

- a) size and mass parameters of the spacecraft into which the SE equipment will be integrated;
- b) basic operating conditions;
- c) power available on board the spacecraft for powering the SE equipment;
- d) characterization of devices for controlling the SE equipment;
- e) data handling and transmission;
- f) information on the ballistics and the modes of orientation of the spacecraft;
- g) on-board maintenance required for the SE equipment;
- h) existing space-system restrictions on the SE.

5.4 Technical assessment

5.4.1 General

The technical assessment of the SE shall be prepared by the SE operations manager and the SE system designer, in co-ordination with the SE project manager. The technical assessment shall include the following sections:

- a) SE tasks;
- b) requirements for SE equipment;
- c) requirements for equipment designed to support scientific observations;
- d) requirements for ground support for the SE;
- e) technical requirements for the carrier space system;
- f) responsibilities of the SE participants;
- g) scientific and engineering justification for the SE (as an annex to the technical assessment).

5.4.2 SE objectives

This section of the technical assessment shall include information on the subject under study, scope of the study (the type and number of scientific observations), the form(s) of data recording and the data quality during the SE.

5.4.3 Requirements for SE equipment

This section of the technical assessment shall include a description of the following:

- a) SE equipment and its application;
- b) SE equipment modules and their applications;
- c) requirements for the equipment parameters critical for accomplishing the SE objectives, including the requirements for the detection, isolation, and repair of malfunctions;
- d) mock-ups, instrumentation, design documents, and operations manuals included in the deliverables.

5.4.4 Requirements for scientific-observation support devices

This section of the technical assessment shall include descriptions of the following items:

- a) hardware components and applications developed to monitor the conditions external to the spacecraft preparatory to conducting scientific observations (e.g. creating the target situation, conducting control measurements) and also for processing the data obtained during the performance of the SE;
- b) requirements for the hardware developed to support the scientific observations and for the application of the integrated hardware.

5.4.5 Requirements for the ground-support facilities for an SE

This section of the technical assessment shall include the following items:

- a) the basic programme and procedural documents for the SE;
- b) the procedure and schedule for development, fabrication, testing, and delivery of equipment, equipment mock-ups, and instrumentation, together with the relevant documents;
- c) a description of the types and objectives of stand-alone and end-to-end testing of the equipment after its integration into the spacecraft and into the mock-ups;
- d) a summary of the main operations and time constraints for the preparation of the ground support facilities to prepare for scientific observations and a description of the equipment for processing the results;
- e) a description of the requirements and time constraints for the development of special mathematical support for scientific observations and for processing the results;
- f) a summary of potential emergencies and measures for handling emergencies.

5.4.6 Technical requirements for an SE

This section of the technical assessment shall include a description of the following:

- a) spacecraft capabilities required to ensure proper performance of the equipment (spacecraft design, power-supply system, data handling and transmission, conditions of functioning and maintenance on-board the spacecraft, scope and accuracy of parameter measurements, the normal operating values of various factors for the equipment needed to carry out an experiment, and the main hazards and safety measures);
- b) requirements dictated by the integration of the SE into the carrier space system (e.g. material out-gassing, contamination, thermal and other types of interfaces);
- c) requirements for consumables (lists of consumables and refills and of materials to be returned to earth (including their size and weight characterization, and the condition of the recovered materials);

- d) spacecraft capabilities required to carry out scientific observations, including the following:
 - 1) radio ground-communication stations,
 - 2) maintenance of spacecraft orbit and attitude,
 - 3) orientation and stabilization of the equipment needed for the experiment,
 - 4) scheduling parameters for scientific observations,
 - 5) crew operations necessary, if applicable;
- e) requirements for the ground preparation complex (problem to be solved by the SE; requirements for scientific observations, monitoring and data recording);
- f) requirements for the spacecraft crew (i.e. requirements for training in the activities needed during the performance of the SE and scientific observations).

5.4.7 SE participants' responsibilities

This section of the technical assessment shall list the SE participants, their basic responsibilities at various stages of the SE, and their general responsibilities for performance of the SE.

5.4.8 Scientific and engineering support of an SE

This section of the technical assessment shall describe the scientific objectives, the equipment and technical requirements, the interfaces with the launch vehicle, the programme of flight operations and the data processing.

6 Development of an SE

6.1 Objectives and work stages

The objectives during the development stage of the SE shall be as follows:

- a) co-ordination of the technical and logistical concepts aimed at ensuring the performance and safety of operations at this stage and at future stages;
- b) delivery of the equipment, programme and technical documents;
- c) preparation of the hardware for the ground support of the scientific observations and for the processing of the results;
- d) preparation of the space system for carrying out the SE;
- e) the development of the SE itself, which shall include the following stages:
 - 1) development of the programme and the technical support,
 - 2) design and engineering of the equipment,
 - 3) integration of the SE into the flight programme.

6.2 Development of the programme and technical support

The programme and the technical support for the SE shall include programmes, procedures, and instructions for performance of certain work activities during the preparation for and performance of the SE, and in processing the resulting data. The main programme and technical documents are the SE programme plan and the SE procedure.

6.3 SE programme plan

6.3.1 General

The SE programme plan shall be prepared jointly by the SE project manager and the SE participants, and shall include the following sections:

- a) purpose;
- b) facilities and equipment;
- c) preparation of the experiment on the ground;
- d) procedure for carrying out the experiment;
- e) organization of the support structure for the scientific observations;
- f) processing of the experimental results;
- g) definition of SE participants' responsibilities and interfaces;
- h) list of documents.

6.3.2 Purpose

This section of the SE programme plan shall include the following:

- a) description of the objects under study and the nature of the SE;
- b) definition of the objective of the SE;
- c) definition of individual areas to be studied during the SE.

6.3.3 Facilities and equipment

This section of the SE programme plan shall include descriptions of the following:

- a) the equipment and support facilities (space, airborne, maritime, etc.) used to prepare for and carry out the experiment;
- b) the experimental equipment and components, both on board the spacecraft and in the support facilities;
- c) the equipment used for recording the data obtained during the SE.

6.3.4 Preparation on the ground

This section of the SE programme plan shall include descriptions of the following:

- a) types and application of ground test operations, and control and measurement operations with the equipment integrated into the spacecraft and its mock-ups;
- b) requirements for such operations;

- c) procedure for the exchange of data obtained during the ground preparation of the equipment;
- d) crew training programme.

6.3.5 Procedure

This section of the SE programme plan shall include the following:

- a) the procedure for delivery of the equipment and consumables to the spacecraft;
- b) a description of the main operations for installation, preparation, and maintenance of the equipment on-board the spacecraft and the requirements for these operations;
- c) requirements defining the conditions necessary for the execution of the scientific observations, including the position of the spacecraft relative to that of the support facilities, the sequence of the basic operations to be performed during the preparation for and performance of the scientific observations, and the required orientation of the spacecraft;
- d) the scheduling requirements for the scientific observations and for maintenance of the equipment;
- e) the scope of the research and the procedure for the transfer of the SE results to earth;
- f) details of potential emergencies and measures for handling them.

6.3.6 Organization and support of scientific observations

This section of the SE programme plan shall include a description of the following:

- a) operational groups formed from representatives of the SE participants, and the composition, location, and objectives of these groups, and procedures for their co-operation;
- b) types of operations to be performed on the ground preparatory to the scientific observations, the nature of these operations, and the procedures for carrying them out;
- c) procedure and schedule for data transfer during the preparations and during the scientific observations themselves;
- d) requirements for the organization of communications.

6.3.7 Processing of the experiment results

This section of the SE programme plan shall include a description of the following:

- a) the data or materials to be obtained during the SE;
- b) the data format to be used and the procedure to be used to transfer materials to the SE operator;
- c) the nature of and processing procedure for the data or materials obtained;
- d) procedure and deadline for the preparation of the reports containing the results of the SE.

6.3.8 SE participants' responsibilities

This section of the SE programme plan shall include a list of the SE participants and their responsibilities at each stage of the SE, and define their functions and interfaces.

6.3.9 List of documentation

This section of the SE programme plan shall contain a list of the documentation and the procedures for processing the programme and of the technical and performance documents to be prepared by the SE participants for execution and support of the SE.

6.4 SE procedure

The procedure for an SE shall be the responsibility of the SE operations manager, in accordance with the technical assessment for the SE, the programme for the SE, and the operations manuals for the equipment, and shall be co-ordinated with the SE participants. The procedure for the SE shall specify these sequences of operations:

- a) within the spacecraft;
- b) for the SE equipment;
- c) for the crew's activity in carrying out the SE.

6.5 Equipment development

The development of the system shall be the responsibility of the SE designer. This stage involves the selection of off-the-shelf equipment and the development of new custom-made equipment for carrying out the SE. All SE equipment shall be delivered to the SE operator with the necessary service equipment, mock-ups and operations manuals.

6.6 Integration of the SE into the flight programme

6.6.1 General

The SE project manager together with the SE participants shall implement the following comprehensive measures:

- a) development of the design and operations manuals for the space system as regards the specifics of the SE;
- b) development of the flight programme;
- c) ground stand-alone and comprehensive testing of the SE equipment to be integrated into the spacecraft;
- d) space crew training;
- e) preparation of the ground-control equipment and the receiving and processing equipment for data transmitted via the space-system communications.

6.6.2 SE flight programme

The flight programme shall be tailored to the needs of each individual SE programme that will be integrated into the space system and shall contain the following:

- a) objectives of the experimental studies;
- b) nature of the SE and the equipment required;
- c) scope of the studies and the schedules for the scientific observations;
- d) procedure for the transfer of the SE results to the SE operators.

7 Conduct of an SE

7.1 General

Operations during the execution of the experiment shall be the responsibility of the SE operations manager jointly with the SE participants, according to the flight-research programme. If necessary, the SE operations manager shall form operational groups made up of representatives of the SE participants to support operations at the ground control and data receiving centres.

The operations under the responsibility of the SE operations manager shall include the following:

- a) preparation for the scientific observations;
- b) support for the scientific observations on board the spacecraft during the SE;
- c) gathering and distribution of the data obtained during the SE;
- d) issuance of status reports.

Status reports shall include progress reports on the SE and summary reports issued at the completion of a stage of the flight-research programme.

7.2 Progress report

The SE operator shall prepare a progress report on the SE jointly with other SE participants as soon as possible. The report shall be circulated according to the distribution list included in the SE programme and shall include the following:

- a) brief description of the SE executed;
- b) information on the scientific observations conducted and a list of the data obtained;
- c) analysis of the performance of the equipment;
- d) evaluation of crew performance;
- e) preliminary SE results;
- f) suggestions for changes to the SE (updating the technical requirements or the scope of the studies) or for the repair, restoration, or preventive maintenance of the equipment if the SE is to be used at a later stage.

7.3 Summary report

The SE project manager with participation of the SE operator shall prepare a summary report after completion of a stage of the flight-research programme. This summary report shall include the following:

- a) information on the performance of the experiments that were scheduled for this stage;
- b) rationale for any deviations from the flight-research programme;
- c) evaluation of the equipment performance to ensure the SE objectives were accomplished;
- d) list of preparations for the next stage;
- e) list of the materials recovered from the spacecraft.

Annex A (informative)

Contents of a proposal for a space experiment

A.1 Title (justification for the experiment)

A unique title should be provided for the proposal to identify the experiment.

A.2 Summary of the proposers

This section of the proposal should mention the names, positions, and addresses of the scientists and laboratories participating, together with their scientific objectives, budget, etc.

A.3 Scientific and engineering description of the experiment

This section of the proposal should include the following:

- a) scientific objectives (in the international context of the scientific disciplines);
- b) equipment and technical requirements (description of equipment, operations performance, conformity to the scientific objectives, weight, dimensions, power requirements, data-gathering requirements, data standards, cleanliness, location on board the spacecraft, and other technical requirements);
- c) interfaces (mechanical, thermal, and electric) with the launch vehicle if necessary;
- d) programme of flight operations (including in-orbit calibration);
- e) data processing.

A.4 Management plan

This section of the proposal should include details of the following:

- a) work breakdown structure;
- b) project management (roles of individual and laboratory participants and of the commercial companies, the involvement of experienced specialists);
- c) development plan, including application, configuration, and testing of the launch facilities if necessary;
- d) plan for each piece of equipment being developed and the calibration to be performed before the flight;
- e) time schedule relative to the development plan for the launch facilities;
- f) any hazardous items;
- g) configuration and document management;
- h) information management system (document updating, summary data, meetings, etc.).

A.5 Cost (financing system)

This section of the proposal should include cost estimates and funding proposals.

A.6 Quality assurance

This section of the proposal should include quality standards, reliability, availability, maintainability, safety, and assessment of compliance with the requirements of the envisaged launch vehicle.

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