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Space systems — Safety requirements — Part 3: Flight safety systems

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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 3.

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.

International Standard ISO 14620-3 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

ISO 14620 consists of the following parts, under the general title *Space systems — Safety requirements*:

— *Part 1: System safety*

— *Part 2: Launch site operations*

— *Part 3: Flight safety systems*

Introduction

Space launch activities generate unavoidable risks of injury to people, damage to property and the natural environment. International space treaties adopted by the United Nations impose legal liabilities on countries involved in launching space objects to provide compensation for certain injuries and damages incurred as the result of such launches.

This International Standard affects the safety of exposed people, property and environment as well as those countries and organizations conducting commercial or civil launch activities.

Space systems — Safety requirements — Part 3: Flight safety systems

1 Scope

This International Standard sets out the minimum requirements for Flight Safety Systems, including flight termination systems, tracking systems, telemetry data transmitting systems for commercial or civil launches of unmanned, orbital or sub-orbital vehicles. The intent is to minimize the risk of injury or damage to persons, property or the natural environment resulting from the launching of space objects.

This International Standard can be applied by any country, by any international organization, whether intergovernmental or not, and by any agency or operator undertaking the launching of space objects.

This International Standard is to be applied by any person, organization, entity, operator or launch authority participating in activities involving commercial or civil launches of unmanned, orbital or sub-orbital launches unless more restrictive requirements are imposed by the national or launch site authority.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO 14625, *Space systems — Ground support equipment for use at launch, landing, or retrieval sites — General requirements.*

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in the International Standard ISO 14620-2 and the following apply.

3.1
Flight safety system
combination of flight, ground, or space based hardware and software designed, installed and/or operated specifically for providing flight safety

NOTE This combination of equipment, facilities, procedures and personnel required to monitor operations, provide protection to personnel and property both foreign and domestic from any damage that may be caused from a non-nominal flight.

NOTE The flight safety system may include flight termination systems, telemetry data transmitting systems and range tracking systems.

3.2
Flight termination system
explosive or other disabling or thrust terminating equipment installed in a launch vehicle, plus any associated ground equipment, for terminating the flight of a malfunctioning vehicle or stage

3.3
Range tracking system
combination of flight, ground, or space based hardware and software designed, installed and/or operated specifically for tracking a launch vehicle

3.4
Safety envelope
area designated for launch and pre-orbital flight that is cleared of uninvolved persons or where the risk of injury, fatality or property damage to the public is below a designated threshold probability

3.5
Telemetry data transmitting system
combination of flight or space based hardware and software, designed, installed or operated for downlinking vehicle performance data to flight safety operators

3.6
Threshold probability
probability that loss or damage will exceed a specified level

NOTE It is a quantitative measure which represents the probability of occurrence associated with unlikely events or levels of damage due to launch related activities.

4 Symbols (and abbreviated terms)

FSS Flight safety system

FTS Flight termination system

GPS Global positioning system

GSE Ground support equipment

RTS Range tracking system

S&A Safe and arm

TDTS Telemetry data transmitting system

5 General requirements

5.1 All launch vehicles and spent stages shall incorporate tracking devices or establish means of tracking that enable real-time monitoring of vehicle position.

5.2 All guided launch vehicles shall incorporate a means of tracking that enables real-time monitoring of vehicle position and prediction of instantaneous impact points from launch through orbital insertion or mission completion.

5.3 All launch vehicles shall incorporate telemetry data transmitting systems for monitoring critical vehicle performance data, flight termination system and tracking system status that are capable of functioning throughout the launch phase until the end of range safety responsibility.

5.4 Any launch vehicle having a stage, motor or component capable of violating the defined safety envelope shall be equipped with a FTS that shall be capable of interrupting the flight of the vehicle if it diverts from its predicted flight trajectory and has sufficient energy to become a threat to public safety.

5.5 All launch vehicle telemetry and tracking systems shall be compatible with applicable spaceport and/or range ground equipment.

5.6 For launch vehicles and payloads containing radioactive materials proof of compliance with all applicable regulations governing radioactive materials shall be provided.

6 Flight termination system requirements

6.1 General

6.1.1 Any launch vehicle where a malfunction of the vehicle or any stage, motor, payload or component may generate an unacceptable hazard to public safety shall contain flight termination systems.

6.1.2 All launch vehicle stages capable of violating the defined flight safety envelope shall contain flight termination systems.

6.1.3 FTS reliability shall be set at 0.999 at the 95% confidence level, or shall be compliant with the quantitative flight safety objectives if the later are more stringent.
The reliability should be established by analysis of all components and supporting test data.

6.1.4 The FTS shall be capable of rendering all powered stages and any other propulsive system of the vehicle non-propulsive.

6.1.5 Liquid propellant

a) The FTS of a liquid propellant space vehicle shall provide both engine shutdown and destruct capability for each stage.

b) A rapid burning of toxic propellants shall be initiated to consume as much propellant as possible before impact.

c) Non-toxic propellants can be scattered in the upper Earth atmosphere.

6.1.6 Solid propellant

a) The FTS destruct charges of a solid propellant space vehicle shall be designed to destroy the pressure integrity of the motor.

b) The destruct action shall cause a condition of zero thrust, zero lift and zero yaw, or any residual thrust shall cause a tumbling action such that no significant lateral or longitudinal deviation of the impact point could result.

6.1.7 The FTS shall be designed such that termination action of one stage will not sever or inhibit functioning of FTS circuitry or ordnance on other stages.

6.1.8 The FTS shall be designed to function properly under dynamic environmental and mechanical forces greater than those that would result in the structural break-up of the vehicle.

6.1.9 FTS components shall function independently of any other system on the vehicle or payload.

6.1.10 FTS components shall be isolated from other vehicle components to the extent that normal or abnormal functioning of the other vehicle components does not inhibit or activate the FTS components.

6.1.11 FTS active components, electrical cables, batteries, ordnance lines and destruct charges shall be redundant unless otherwise approved by the national or launch site authority.

6.1.12 Redundant ordnance components, signal cables and electrical power cables shall be physically separated from each other by the maximum distance possible and mounted in different orientations or on different axes where technically feasible.

6.1.13 FTS electrical and ordnance components shall have their operating and service life specified.

6.1.14 The launch vehicle operator shall verify the FTS has sufficient service life for the specified mission prior to launch.

6.1.15 For externally controlled FTS, antenna and command receivers and decoders shall be compatible with the used GSE (gain, coverage, operating frequencies, bandwidth, and insertion loss).

6.1.16 For externally controlled FTS, all equipment shall be adequate to assure a radio-frequency propagation path from the command transmitter/antenna system to the launch vehicle antenna.

6.1.17 For externally controlled FTS, the response time of each function shall be between 4 and 25 milliseconds.

6.1.18 For externally controlled FTS, the FTS antenna system shall have adequate radio coverage over 95% of the radiation sphere.

6.2 FTS safe and arm devices

6.2.1 For launch vehicles where propulsive ignition occurs before first motion, the FTS S&A devices shall be armed prior to arming launch vehicle and payload ignition circuits.

6.2.2 For launch vehicles where propulsive ignition occurs after first motion, the FTS S&A devices shall contain an ignition interlock which shall be designed such that ignition cannot occur unless at least one of the FTS arming devices is in the armed position.

6.2.3 No FTS S&A device shall produce a terminate output as the result of a single component failure.

6.2.4 FTS S&A devices shall be capable of being functionally tested after installation but prior to launch.

6.2.5 FTS S&A devices shall incorporate a device capable of providing a remotely controlled means of interrupting power to the destruct ordnance firing circuit.

6.2.6 FTS S&A devices shall be designed to interrupt the direct path from destruct command output signal to the ordnance destruct charges.

6.2.7 Redundant means shall be provided to remotely safe FTS S&A devices.

6.3 FTS ordnance

6.3.1 FTS ordnance shall be capable of being safed for any ground operation.

6.3.2 The FTS destruct ordnance train, including all ordnance components and appropriate interfaces or air gaps, shall be designed to initiate with the energy level provided from the arming or initiating device, propagate through the ordnance train to the destruct charges and to render the propulsion system non-propulsive.

6.3.3 Ordnance items and others that are conductive and interface with ordnance shall be kept at the same voltage potential through grounding.

6.3.4 FTS ordnance components shall have a service life equal to or greater than that of the vehicle if the components are installed on the stage at the time of stage manufacture.

6.3.5 FTS ordnance component service life shall be dated from the time of component acceptance.

6.4 Ground support equipment

6.4.1 GSE shall provide verifiable safety inhibits.

6.4.2 GSE inhibits and inhibit controls shall be independent shall not share the same failure modes.

6.4.3 All GSE and flight ordnance shall be capable of being safed for ground operations.

6.4.4 System failures which could lead to catastrophic events shall be dual fault tolerant (three inhibits).

6.4.5 A reliable means of continuously monitoring the status of the FTS shall be provided from pre-launch through to lift-off in order to verify the armed status of each FTS S&A device, the health and status of the FTS and other associated components (command receiver/decoders, firing units, batteries, etc.), proper functioning of the destruct simulator, power transfer switch status, hold fire control switch (stop launch sequencer) and status of the range command transmitter carrier (on/off).

6.4.6 GSE used for checkout of the airborne range safety equipment shall be calibrated on a periodic basis in accordance with the flight safety rules of the launch site.

6.4.7 For externally controlled FTS, the flight safety system shall be designed to interrupt the flight of a launch vehicle in the launch phase if the vehicle deviates from its predicted flight trajectory and it has sufficient energy to become a threat to public safety.

7 Range tracking system requirements

7.1 Description

The range tracking system is an integral part of the flight safety system which assists flight safety operators in protecting the public from errant vehicle flights.

7.2 Requirements

7.2.1 All expendable launch vehicles and sub-orbital vehicles shall have an approved means of tracking the vehicle’s trajectory throughout flight.
The RTS may use various ground-based or vehicle incorporated tracking modes to provide accurate tracking information.

7.2.2 The RTS shall provide real-time data from which position and velocity can be determined.

7.2.3 The RTS shall be designed to operate under the worst predicted flight environment.

7.2.4 The RTS shall be protected from internal and external interference, such as electromagnetic energy, which could inhibit the operation of the system.

7.2.5 The RTS shall be capable of providing real-time indications of malfunctions of any components compromising operation of the system.

7.2.6 All RTS electrical components shall have their operating and storage life specified.

7.2.7 The use of RTS electrical components in any mission shall not exceed the specified storage life.

7.2.8 Transponder systems used on vehicles shall be capable of operating within the parameters established for operation of the tracking facilities.

7.2.9 Space based translators or receivers, such as GPS, shall be independent of any on board guidance system.

7.2.10 Design RTS reliability shall be 0.995 at the 95% confidence level for transponder systems and 0.999 at the 95% confidence level for space based systems such as GPS, or shall be compliant with the quantitative flight safety objectives if the later are more stringent.
The reliability should be established by analysis of all components and supporting test data.

7.2.11 The RTS shall be tested, verified and certified as capable of performing throughout the designated mission.

8 Telemetry data transmitting system requirements

8.1 Description

The telemetry data transmitting system is an integral part of the range safety system which assists flight safety operators in analyzing flight data and protecting the public from errant vehicle flights.

8.2 Requirements

8.2.1 All launch vehicles shall have a TDTS to provide vehicle performance data to flight safety operators.

8.2.2 The TDTS shall be capable of providing uninterrupted data from lift-off through orbital insertion, mission completion or until range responsibility for safety has been fulfilled and terminated.

8.2.3 The TDTS shall be capable of acquiring, storing, processing and providing data in real-time.

8.2.4 Telemetry data shall include data relevant to position and tracking, FTS status, RTS status, vehicle performance, engine and control information.

8.2.5 The TDTS shall be capable of providing real-time indications of malfunctions of any components compromising operation of the system.

8.2.6 Sufficient TDTS data shall be obtained to determine the adequacy of the flight safety system throughout flight and to support pre-flight and post-flight analyses.

8.2.7 The airborne telemetry system shall be compatible with the ground-based telemetry stations.

8.2.8 The TDTS shall be designed to operate under the worst predicted environments.

8.2.9 The TDTS shall be protected from internal and external interference, such as electromagnetic energy, which could inhibit the operation of the system.

8.2.10 All TDTS electrical components shall have their operating and storage life specified.

8.2.11 The use of TDTS electrical components in any mission shall not exceed the specified storage life.

8.2.12 Design TDTS reliability shall be 0.995 at the 95% confidence level, or shall be compliant with the quantitative flight safety objectives if the later are more stringent.
The reliability should be established by analysis of all components and supporting test data.

8.2.13 The TDTS shall be tested, verified and certified as capable of performing throughout the designated mission by the director of range safety.