General

JERG-0-047A (E)

Safety Standard for Controlled Re-entry

Revision A

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Japan Aerospace Exploration Agency (JAXA)

This is an English translation of JERG-0-047A. Whenever there is anything ambiguous in this document, the original document (the Japanese version) shall be used to clarify the intent of the requirement.

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1. Purpose

The Japan Aerospace Exploration Agency (JAXA) established this standard for re-entry vehicles undergoing re-entry operations, from orbit to the ground, to avoid unacceptable risk to the public and the environment.

The requirements related to orbital debris mitigation documented in the applicable document (2) are still applicable unless contradicted by the requirements herein.

2. Applicability

This standard is applicable to re-entry vehicles developed and/or operated by JAXA. The term “re-entry vehicle” in this standard is defined as follows.

- A vehicle that is designed and planned to land on Earth after re-entering from orbit. In case there are supporting flight systems that are required to achieve a nominal re-entry sequence, those flight systems are also within the scope of compliance to this standard.
- A vehicle that re-enters to the designated area on Earth from orbit for safe disposal.

The following re-entry vehicles are exempted from the application of this standard.

- Manned systems.
- Winged systems.

This standard may be applied to a winged vehicle whose control capability in the atmosphere is more like a capsule. In the case of application for such vehicles, applicable paragraphs will be determined on a case-by-case basis.

This standard may be partially applied to re-entry from the planetary orbit. Application of each paragraph will be determined based on the mission characteristics. Examples include the following.

- The risk of natural re-entry is relatively low because loss of re-entry function will result in no re-entry rather than uncontrolled natural re-entry.
- Collision avoidance is unfeasible because of the current tracking capability.

The risk for ground operators who work in the vicinity of or within the footprint for search and recovery shall be evaluated per the standard system safety approach documented in the applicable document (1).

3. Applicable and reference documents

3.1. Applicable documents

The following documents are applicable where referred to. All documents shall be the latest version unless otherwise specified.

(1) JMR-001 System Safety Standard.
(2) JMR-003 Space Debris Mitigation Standard.
(3) (Intentionally Blank).
(4) 規定第 15-11 号 危機管理室設置規程 (Rule for risk control office).
(5) 規程第 16- 3 号 安全審査委員会規程 (Rule for safety review committee).
(6) ICAO Annex 15 Aeronautical Information Services.

3.2. Reference documents

(1) NASA-STD-8719.14A Process for Limiting Orbital Debris

4. Fundamental methodology for public safety

The following methodology is the basis of this standard to minimize the risk to the public caused by the attempt at controlled re-entry. It is also important to satisfy risk acceptance criteria as the result of the safety measures examined based on the applicable document (1).

(1) Minimize human casualty risk by keeping the public away from the expected re-entry area, utilizing proper notification systems such as for air and maritime traffic.
(2) The execution of the re-entry maneuvers can be done when achieving to ensure the safe controlled re-entry. In other words, ensuring all objects fall within the controlled area.

5. Functional requirements for controlled re-entry

5.1. Flight system

The flight system shall have the following functions:

(1) Function that determines the trajectory and attitude of a spacecraft.
(2) Telemetry that will notify system state to the ground within a necessary interval for the support of the Go / No-go decision.
(3) Command acquisition from the ground for execution of a re-entry maneuver.
(4) Function to prevent unintentional execution of a re-entry maneuver.

5.2. Ground system

The ground system shall have the following functions:

(1) Function to validate the trajectory and attitude of a spacecraft.

(2) Function to permit or command execution of a re-entry maneuver.

6. Planning and pre-operational assessments

6.1. Determination of the planned re-entry area

6.1.1. Within the territory of a nation

In case that any part of the planned re-entry area is within the territory of a nation, the plan must comply with the regulation, safety requirements, and/or direction of the responsible government officials.

6.1.2. Outside of territory

Any part of the planned re-entry area:

(1) shall be at least 100 km away from the coast line;

(2) should be outside of any Exclusive Economic Zone (EEZ) practically as far as possible;

(3) should be clear of heavy traffic routes, where the heavy traffic routes should be determined from information from officials in charge of the related regions;

(4) should be clear of any offshore plants such as oil and natural gas Installations, where naval warnings and information from the International Seabed Authority (ISA) would be recommended references.

6.2. Expected re-entry area (Footprint)

The footprint shall consider the following assumptions and conditions.

(1) The footprint shall envelope the three-sigma dispersion area for all harmful fragments. Three-sigma dispersion is calculated based on the variance of initial conditions such as velocity and angle, and dispersion of the atmospheric concentration.

(2) Any parameter other than (1) would also be included in three-sigma calculation in case that the parameter and its deviation would have a significant effect on the size or location of the area.

(3) For re-entry vehicles that utilize aerodynamic control in the atmosphere, the footprint shall envelope a touchdown point based on the maximum navigation capability, or three-sigma of the nominal control function.

(4) A fragment with at least 15 J of kinetic energy shall be considered in the calculation of the footprint.

(5) The trajectory upstream and downstream of the footprint in the same orbit should not go over a metropolitan area to minimize the risk of high or low delta-V at the re-entry maneuver.

6.3. Expected number of casualties (Ec)

The expected number of casualties (Ec) shall satisfy the following criteria considering all fragments with at least 15 J of kinetic energy.

- The criterion defined in the applicable document (2), as a total of the cases (1) through (3).
- The criterion defined in annex1, as a total of the cases (1) and (3).

(1) Successful re-entry with all fragments within the expected re-entry area. [Casualties inside the footprint, if any.]

(2) Natural re-entry resulting from the loss of re-entry function. [System reliability for re-entry related functions are taken into account in the calculation.]

(3) Unsuccessful (failed) re-entry that causes the footprint fall outside of the planned location. [Probability of failure during re-entry maneuver is taken into account in the calculation.]

Note: annex1 is not available to the public.

6.4. Consideration for operational sequence

The operational sequence for re-entry shall consider the monitoring of health status of the flight system as possible to continue in late as practical.

6.5. Availability of command and telemetry

(1) Communication links for command and telemetry shall be available until completion of the re-entry maneuver. Communication links shall be capable of transmitting all necessary data for validation as required in section 6.4.

(2) Telemetry of the flight system should be monitored as long as it is available, even after the re-entry maneuver.

7. Notification for air and maritime traffic safety

The following notification process should be followed to minimize risk for air and maritime traffic. Notification basically includes area and time to be cautious.

(1) For air traffic: The notification processes utilizing the Aeronautical Information Package (AIP) and Notice to Airmen (NOTAM) are defined in the applicable document (6). Detailed processes and procedures should be coordinated with the appropriate government official. Information regarding

any modification affecting air traffic control should be communicated immediately per the agreed procedure.

(2) For maritime traffic: Several notification processes (e.g. NAVAREA, NAVTEX and so on) are in place. Detailed processes and procedures should be coordinated with the appropriate government official.

8. Collision avoidance during the re-entry sequence

Collision avoidance against any space object shall be implemented per the applicable document (2), paragraph 5.5.2.

9. Operational requirements

9.1. Preparation of a controlled re-entry

The following readiness shall be confirmed before a re-entry operation.

(1) Facility and equipment utilized for re-entry. Interface checkout shall also be completed.
(2) All nominal and off-nominal procedures, and necessary training.
(3) Communication procedure and/or a manual including an emergency plan.
(4) Notification as defined in section 7.

9.2. Determination of Go / No-go

Go or No-go shall be determined at an appropriate time in the re-entry sequence as described in section 6.4. Controlled re-entry may not be allowed if there is no possibility of a proper re-entry maneuver per the following status information.

(1) Trajectory (position and velocity) and attitude.
(2) Health status of necessary functions (such as navigation control and propulsion system) for controlled re-entry.

9.3. Execution

(1) The status information of the flight system, ground system, and other related systems shall be continuously monitored until execution of the re-entry maneuver.
(2) In case of abort and retry, the readiness for re-entry operation detailed in section 9.1 shall be reconfirmed.

9.4. Post re-entry

(1) The actual touchdown location of a system and/or a footprint calculated from the result of re-entry burn will be communicated, if necessary.

(2) If any part of the flight system falls outside of the expected re-entry area and could be within the territory of a nation, the necessary warning shall be given to the government officials. It should also be confirmed that there is no danger to aircraft, ships, or other vehicles due to off-nominal re-entry even outside of territory. The emergency plan may be used, if required.

(3) In an off-nominal situation that the flight system is incapable of performing controlled re-entry, the emergency plan will be used based on the expected risk of natural re-entry.

10. Safeguarding action for fallen objects or materials

If there are any fallen objects or materials that could be a threat to public safety on the ground, safeguarding action such as recovery, decontamination, and cleaning shall be implemented.

11. Environmental effects

The assessment is necessary to do for the expected fallen objects (fragments) on the ground in the planned re-entry area. The countermeasures for it shall be taken when impact of safety is expected.

12. Authority

The JAXA Safety Review Committee defined in the applicable document (5) is the authority for the approval of requirements herein.

13. Organization

There shall be an organization responsible for the execution of controlled re-entry. This organization will ensure that the upper level management is informed immediately of any safety issues or mishaps.

14. Definition of technical terms

The following definitions are specifically used in this standard.

Re-entry vehicle	:	• A vehicle that is designed and planned to land on Earth after re-entering from orbit. In case there are supporting flight systems that are required to achieve a nominal re-entry sequence, those flight systems fall under the application of this standard. • A vehicle that re-enters to the designated area on Earth from orbit for safe disposal. Manned systems are exempted from the application of this standard.
Re-entry maneuver	:	The maneuver that moves the vehicle into the re-entry trajectory. Maneuvers for parking or interim orbits are not part of a re-entry maneuver.
Expected number of casualties (Ec)	:	The quantitative human casualty risk associated with fallen objects on the ground in the event of spacecraft re-entry. A detailed definition is given in the applicable document (2), paragraph 3.1(15).
Planned re-entry area	:	Designated area indicated with a closed borderline on a map, which is investigated and evaluated as a possible landing location of a vehicle and all objects generated through a re-entry breakup event.
Expected re-entry area	:	Calculated area within which a vehicle and all objects generated through a re-entry breakup event must touchdown, based on the parameters expected for the actual timing of the re-entry event.