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Space systems — Disposal of Orbital Launch Stages

# Scope

This standard focuses on disposal of launch vehicle stages used during launch of payloads to be operated in space where the launch stage is left in orbit after separation from the deployed payload.

End-of-mission disposal of launch vehicle stages broadly means removing the stage from the region of space where satellites are operating so as not to interfere or collide with these other users of space in the future.

ISO 24113 provides six options for spacecraft or orbital launch stage disposal. This International Standard specifies techniques for planning and executing space hardware disposal that are consistent with ISO 24113 requirements, reflect current internationally accepted guidelines, and consider current operational procedures and best practices.

# 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 24113, *Space Systems – Space Debris Mitigation*

ISO 27852, *Orbit lifetime estimation*

ISO 27875, *Space Systems -- Re-Entry Risk Management for Unmanned Spacecraft and Launch Vehicle Orbital Stages*

# Informative references

# ISO 26872, *Disposal of satellites operating at geosynchronous altitude*

# Terms and definitions

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

4.1

decay orbit

an orbit which will result in the re-entry of the space system within the specified time

4.2

decay phase

the period that begins at the end of the operational phase of a space system, when it has been placed into its decay orbit, and ends when the space system has performed a re-entry. Only applies for space systems performing re-entry.

**4.3**

**direct re-entry**

a deorbit maneuver where the space object is targeted so that re-entry will occur in a specific location. This generally means that the object re-enter the earth’s atmosphere less than one orbit revolution from the time of initiation of the deorbit maneuver.

4.3

passivation

depletion of energy sources (e.g., venting propellants, discharging batteries) to minimize the possibility of an explosive, debris-producing event

4.4

deorbit maneuver

the action of moving a space system to a trajectory that will immediately re-enter the atmosphere

4.5

re-orbit maneuver

the action of moving a space system to its decay orbit or to its disposal orbit

# Abbreviated terms

EOMDP End Of Mission Disposal Plan

LSDP Launch Stage Disposal Plan

# Primary requirements

**6.1 Launch Provider/Payload Owner Coordination**

The spacecraft mission designer and the launch provider shall jointly design the launch phase of the mission to enable disposal of the launch stage. Specifically:

1. The spacecraft mission designer shall specify the desired deployment conditions to the launch service provider.
2. Using the information provided by the spacecraft mission designer, the launch service provider shall develop a candidate launch and spacecraft deployment scenario and for that scenario shall provide an estimate of the orbit lifetime of all orbital launch stages released during launch and deployment of the owner’s spacecraft (see ISO 27852 Orbit lifetime estimation);
3. The launch service provider shall estimate the casualty expectation for an uncontrolled reentry of all orbital stages provided by the launch service provider. The casualty expectation for an uncontrolled reentry of each launch vehicle stage shall be computed as specified in ISO 27875. Based on this estimate, the spacecraft mission designer shall specify which of the hardware disposal options defined in ISO 24113 shall be used for stage disposal.
4. The launch service provider and the spacecraft mission designer shall iterate on the payload deployment/stage separation conditions and select deployment/separation conditions such that the spent stage can meet an appropriate disposal requirement as specified in Section 1 of this document.

**6.2 Selection of disposal option**

1. If the launch stage after payload deployment will be in an orbit with a perigee altitude of less than 2000km, the casualty expectation for a random re-entry of the launch vehicle stage shall be computed as specified in ISO 27875.
2. If the casualty expectation is lower than the value specified in ISO 24113, the stage may be placed in a final orbit that will decay within 25 years (see ISO 27852 Orbit lifetime estimation). If the casualty expectation exceeds the value specified in ISO 24113, the stage shall be either re-entered into a safe area via a controlled deorbit maneuver or shall be moved to an orbit where the space system shall remain outside of the LEO and GEO protected regions for a period of at least 100 years.
3. If the launch vehicle stage is to be left in an orbit where disposal by orbit decay or direct re-entry is not an available option, the launch stage shall be left in a final orbit where the stage will remain outside of both the LEO and GEO protected regions for a period of at least 100 years.

In all cases except direct reentry, the stage shall be passivated after the final disposal maneuver is completed.

**6.3 Disposal maneuver planning**

A Launch Stage Disposal Plan (LSDP) shall be developed, maintained and updated in all phases of mission and launch system design and shall be included in the overall End of Mission Disposal Plan (EOMDP) defined in ISO 24113. The LSDP shall include:

1. details of the nominal orbit where the launch stage is to be separated from the payload,
2. a statement of the stage disposal method to be utilized (retrieval, controlled re-entry, augmented decay, natural decay or re-orbit) and background information supporting the selection of this method,
3. identity of systems and capabilities required for successful completion of the stage disposal action,
4. estimates of the propellant, power, controllability, and communications required for any stage disposal or re-orbit maneuver,
5. verification that the selected mission design leaves the launch stage with sufficient propellant, power, controllability, and communications capability for disposal after payload separation in order to meet the reliability for disposal requirement specified in 5.1.
6. if direct reentry is selected, identification of the geographic area where the stage will reenter
7. if re-orbit to an orbit where the stage will not enter the LEO or GEO protected region for 100 years is selected, details of the final orbit and the rationale for its selection,
8. a time line for the disposal (and reentry, if direct reentry is selected) action, and a list of those individuals and/or entities to be notified prior to the disposal action and a timeline for notification,
9. the plan and timeline for passivating the launch stage if direct reentry is not selected as a disposal option, and
10. documentation of the completion of the disposal actions, including confirmation that the actions were successful and the final disposition of disposed hardware.

## 6.4 Reliability for disposal

The launch mission and launch stage shall be designed such that the probability of completing the disposal action, including remaining propellant, power, controllability, communications, and loss of redundancy, equals or exceeds 0.95 at the time to execute the disposal action. Details of the design that provides the basis for the probability estimate shall be included in the LSDP (see ISO 26872 Annex A for an example of how this probability may be computed).

## 6.5 Criteria for executing disposal action

Launch stage disposal shall be scheduled as soon as practical after release of the payload.

If it is determined that the impact of executing the disposal action will result in an increased probability of the launch stage causing debris within the protected region then it shall be acceptable to forego the disposal action. (An example of this is the scenario where, after launch, a problem is identified with the de-orbit propulsion system, which is deemed likely to result in a catastrophic loss of the launch stage. In this case it would be better not to use the propulsion system and hence not to execute the disposal action)

## 6.6 Contingency planning

Should insufficient propellant remain or a system or other failure occur preventing execution of the selected disposal action, before critical systems are lost every effort shall be made to

1. select an alternative decay orbit that minimizes the duration of the decay phase, or
2. select an alternative disposal orbit that has as low a probability of future interference with the LEO and GEO protected regions as possible.

The rationale for and the results of any such disposal action or inaction shall be documented and included in the LSDP. The final state of the Launch stage shall be included.

## 6.7 Exceptions

No disposal action shall be required for all pre-existing launch stage designs, where incorporation of a disposal method into the design of the launch stage is infeasible.

# Disposal planning requirements

##  Determination whether the disposal must be a controlled maneuver

If the launch stage has been selected for a re-entry then determination of whether the disposal must be a controlled maneuver shall be in accordance with ISO 27875 Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages.

## 6.2 Estimating orbit lifetime

If the launch stage has been selected for an uncontrolled re-entry, then the decay phase duration shall be computed by calculating the orbit lifetime of the initial decay orbit, in accordance with ISO27852 Orbit lifetime estimation. The time the launch stage remains in orbit shall be limited as specified in ISO24113.

## 6.3 Computing the time in disposal orbit

If the launch stage has been selected for a disposal orbit then the time that the launch stage remains outside of the protected region shall be calculated in accordance with ISO27852 Orbit lifetime estimation. The time duration in the disposal orbit shall be counted from the point at which the re-orbit maneuver is complete to the first time at which the perigee of the orbit is less than the upper bound of the LEO protected region or the apogee is greater than the lower bound of the GEO protected region.

# Mission planning coordination

## Launch provider and spacecraft mission planner coordinate objectives relative to disposal

Once the spacecraft mission designer has specified a desired deployment orbit the launch provider may then present options for launch stage disposal. In some instances, the specified deployment orbit may not lead to satisfactory disposal options. The launch provider may then explore alternative deployment orbits that offer much better conditions for disposal of the launch stage. If the spacecraft is to perform significant propulsive maneuvers subsequent to deployment (e.g. orbit raising, inclination change, drift rate change, etc.), then an alternative deployment may be equivalent to the spacecraft mission planner. A typical example would be a tradeoff between orbital inclination and perigee altitude for a transfer orbit deployment, in which the velocity required to achieve the spacecraft final orbit remains unchanged. This type of coordination can lead to mutually beneficial solutions in terms of mission objectives and launch stage disposal.