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Guidelines on space debris removal

空间碎片在轨清除指南

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Foreword

This document was drafted in accordance with the rules given in GB/T 1.1-2020, Directives for standardization - Part 1: Rules for the structure and drafting of standardizing documents.

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

1 Scope

This document establishes the general principles for the on-orbit removal of space debris and provides guidance on the technical scheme, the mission process, the post-mission assessment, and mission notification and disclosure of information.

This document applies to the removal of space debris of centimetre scale and above in Earth orbits, low, medium and high.

2 Normative references

The following document contains provisions which, through normative reference in this text, constitute indispensable provisions 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.

GB/T 34513, Space debris mitigation requirements

3 Terms and definitions

For the purposes of this document, the terms and definitions given in GB/T 34513 and the following apply.

3.1 active space debris removal, ADR - the technical activity of removing space debris, such as a spacecraft that has failed, from its operating orbit by human intervention, so as to mitigate the deterioration of the space environment.

3.2 space debris removal service vehicle - a spacecraft designed to detect, approach and capture space debris actively and, using propulsion, to remove it from its original operating orbit, so eliminating its long-term threat to the space environment.

3.3 implementation plan for active removal of space debris - the comprehensive and workable plan drawn up according to the on-orbit characteristics of the space debris for the successful execution of one or a series of removal missions, covering the technical route, the mission process, the composition of the system, mission coordination and international cooperation.

3.4 probability of successful removal - the likelihood of achieving the objective of an active space debris removal mission.

3.5 capture method - the technical means used to establish a physical connection with the space debris. 3.6 de-orbit method - the technical means used to remove the space debris from its original operating orbit.

3.7 active de-orbit - the technical process of deliberately and artificially changing the operating orbit of space debris, by applying externally controllable propulsion or using a controllable physical mechanism, so that the debris enters the atmosphere and burns up ahead of time under control, or is transferred to another operating orbit.

3.8 passive de-orbit - the de-orbit method in which the space debris changes its original flight orbit by means of an attached unpowered de-orbit device, using space environment factors such as the gravity of the Earth, the rarefied atmosphere, solar radiation and the

geomagnetic field.

3.9 post-mission disposal, PMD - the orbital disposal process carried out by a spacecraft after it has completed its on-orbit mission. Note: for a geostationary satellite this generally means transfer to a graveyard orbit; for a low-orbit satellite, re-entry into the atmosphere of the Earth and burn-up.

3.10 natural orbital decay - the process by which a space object in orbit, subject only to the space environment, gradually and naturally descends until it re-enters the atmosphere of the Earth.

3.11 collision avoidance - the process by which a spacecraft avoids the risk of collision with space objects such as other spacecraft, rocket bodies and space debris.

3.12 responsible party for space debris - the entity that bears the main responsibility for the generation of the space debris and for its safe disposal.

3.13 provider of space debris removal services - the entity that develops or uses a space debris removal service vehicle and provides active removal services.

3.14 regulatory authority for space debris - the national or international governmental entity that undertakes the coordination, review and approval responsibilities at each phase of a space debris removal mission.

4 Abbreviated terms

For the purposes of this document the following abbreviated terms apply. GEO: Geostationary Earth Orbit. HEO: Highly Elliptical Orbit. LEO: Low Earth Orbit. MEO: Medium Earth Orbit.

5 General principles

The on-orbit removal of space debris follows these principles: a) the target space debris is chosen by preference from the space debris in the space debris risk grade catalogue published by the nationally authorized body; b) a comprehensive assessment of the feasibility and safety of the removal technical scheme is carried out, the assessment finds it feasible, and the probability of successful removal is high; c) during the service the safe operation of other on-orbit spacecraft is not affected, collisions are avoided and the generation of new debris is avoided.

6 Technical scheme

6.1 Overview. The provider of space debris removal services and the responsible party for the space debris jointly draw up the implementation plan for the active removal of the space debris, on the basis of data sources of high confidence.

6.4 c) Besides choosing the capture and de-orbit methods suited to the geometric dimensions and the motion characteristics of the space debris, the optical characteristics, the electromagnetic characteristics and the structural material of the debris should also be considered, as constraints on the tracking and detection equipment of the removal service vehicle and on the approach and capture. Taken as a whole, the capture method and the de-orbit method of each type of space debris have their own range of application, and the technical maturity and the mission risk have to be considered together with the particular scenario.

Among the passive de-orbit methods, the drag-augmentation method increases the area-to-mass ratio of the space debris so as to raise the effect of atmospheric drag in low orbit and accelerate the descent and re-entry into the atmosphere, using devices such as a de-orbit sail or a drag-augmentation balloon; drag-augmented passive de-orbit applies mainly to the region below 600 km.

7 Mission process

7.1 Division into phases. The on-orbit removal process includes but is not limited to the phases of long-range rendezvous, close approach and capture, de-orbit disposal and active withdrawal.

a) Long-range rendezvous. Under guidance from the ground, the removal service vehicle approaches the space debris to be removed. Outside the safe distance, the relative navigation and tracking equipment on the vehicle detects the debris and the navigation, guidance and control system of the vehicle switches to autonomous closed-loop mode. By controlling parameters such as the relative position and the relative velocity with respect to the debris, the vehicle approaches to within the set range relative to the debris and keeps station with it, establishing the conditions for carrying out the subsequent mission.

b) Close approach and capture. The removal service vehicle approaches to the vicinity of the space debris and carries out directed observation, completing the collection of basic information about the debris. It then approaches to the working distance of the capture device, completes the capture of the debris and establishes a reliable physical connection.

c) De-orbit disposal. The removal service vehicle carries out de-orbit disposal of the space debris, achieving an active or passive de-orbit manoeuvre, such as de-orbiting under tow, de-orbiting while holding the debris, or installing a drag-augmentation device. d) Active withdrawal. Having carried out the removal mission, the vehicle releases the physical connection with the debris and moves away along a safe corridor. Where necessary, directed observation of the separated debris is carried out to confirm its de-orbit state.

7.2 Points to be considered at each phase. To reduce unexpected risk, the removal service vehicle should consider the following points while carrying out the removal mission: a) once the space debris to be removed has been selected, plan the mission execution window,