2025 Current status of debris protection design standard at JAXA

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ABSTRACT

We discuss the current status of debris protection design standards at JAXA. It highlights the collaborative efforts of JAXA, university researchers, computer analysts, and spacecraft manufacturers in conducting hypervelocity impact tests and numerical simulations. These efforts aim to create Japanese design guidelines to protect satellites from micrometeoroids and orbital debris (M/OD).

The guidelines serve as a comprehensive framework for designing impact protection measures, ensuring the safety and mission success of spacecraft in environments with micro-debris and meteoroids.

1 Introduction

We have been conducting hypervelocity impact tests and numerical simulations in order to create Japanese design guidelines that protect satellites against a certain degree of impact by micrometeoroids and orbital debris (hereinafter referred to as M/OD). Certain members of JAXA, university researchers, computer analysts, and spacecraft manufacturers formed a working group to investigate the impact effect of OD on critical parts and bumpers, by conducting hypervelocity impact (HVI) tests and analysis. The knowledge acquired is now being reflected in spacecraft design [1].

We plan to continue and extend our experimental and numerical investigations covering a wider and more diverse range of conditions, in order to complete the guidelines at JAXA for the purpose of protecting unmanned spacecraft against impacts from space debris and micrometeoroids.

2 Condition for assessment

We introduce this standard describes the assessment procedure for verifying the validity of the protection design of satellites and probes (hereinafter referred to as spacecraft) against risks of impact with M/OD which are 1 mm or less in size and whose impact probability and impact damage is not negligible.

To ensure the spacecraft mission in the environment of the micro-debris and meteoroid, the following points including the system design must be coordinated during the progress of the development of the system from the Mission Requirements Definition Phase.

(1) Consideration of debris density when determine the operational orbit altitude

(2) Consideration of the distribution of debris impact probability when determine the shape of spacecraft.

(3) Setting the policy concerning the allowable limit of impact risk (mission importance, rela-tionship with other redundant elements, etc.)

(4) Assessment in view of system design including the influence of loss of mass and layout change of components associated with impact protection measures (including allocation of re-sources)

(5) Setting a contingency plan including impact detection, damage monitoring, recovering, re-construction and isolation

This standard serves as guidance for impact protection design on the condition that the spacecraft has been defined in shape, dimensions, operational orbital characteristics and operational period considering above conditions.

3 Approach for data acquisition used for debris protection design

We have derived ballistic limit curves that can be used for combinations of structures and protective materials that are highly requested by spacecraft manufacturers.

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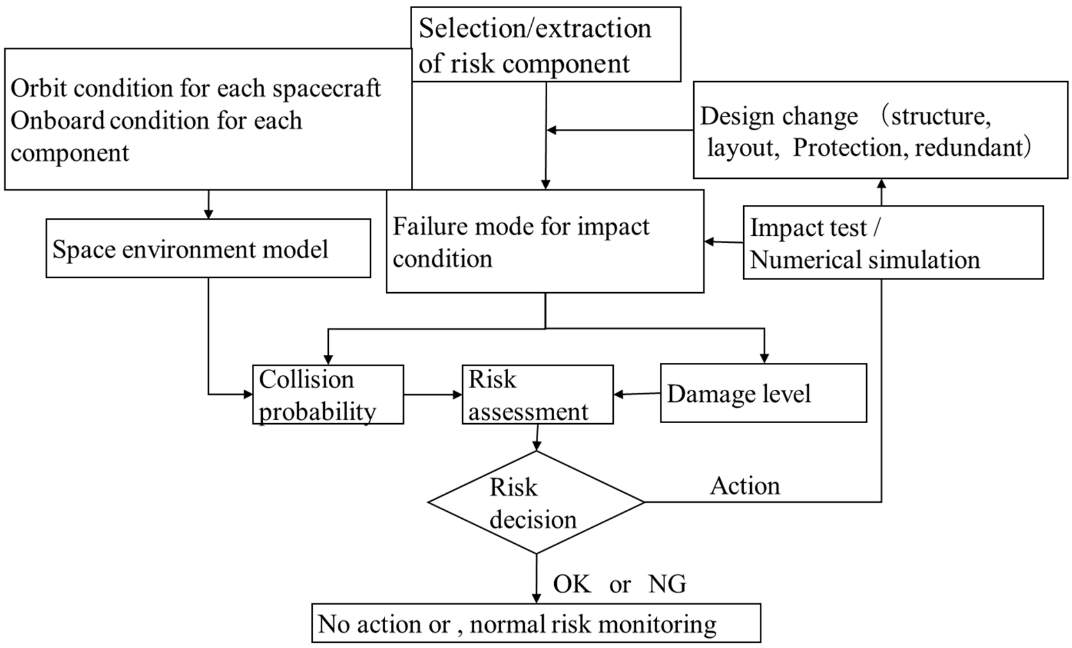

Figure 1. Risk assessment flow for M/OD

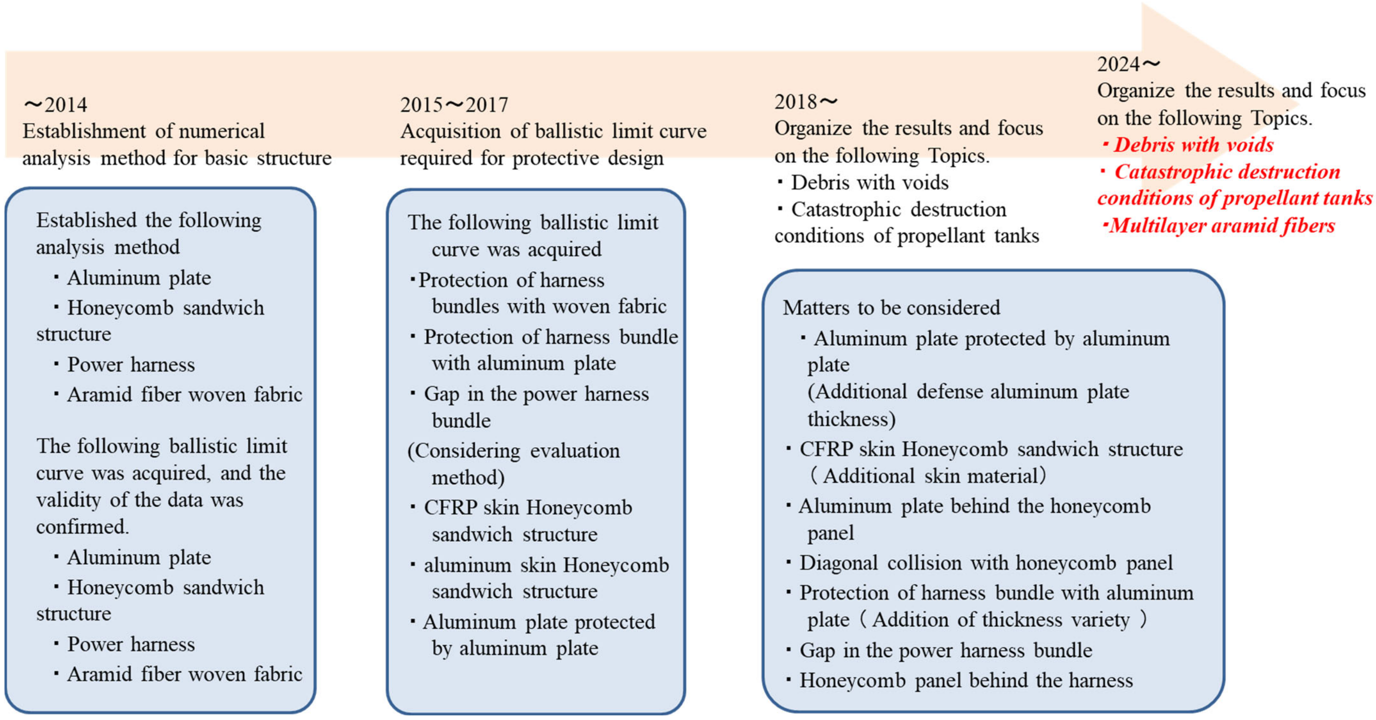

Figure 2. Achievements and plans overview

4 Current status

After last year, we organize the results and focus on the following 3Topics.

・ Debris with voids

・ Catastrophic destruction conditions of propellant tanks

・Multilayer aramid fibers

We have been examining the penetration limits of spacecraft surface materials such as aluminum and CFRP used in spacecraft structures, as well as the effectiveness of protective materials such as protective harnesses.

We will continue to examine the penetration limits of new surface materials and protective materials, as well as the mechanisms that lead to spaecraft fragmentation, not just penetration.

5 REFERENCES

1. JMR-003 Space Debris Mitigation Standard

2. JERG-2-144 Micro-debris Impact Survivability Assessment Procedure