20 January 2015

English only

**Committee on the Peaceful Uses of Outer Space**
**Scientific and Technical Subcommittee**
**Fifty-second session**
Vienna, 2-13 February 2015
Item 7 of the provisional agenda*
**Space debris**

# National research on space debris, safety of space objects with nuclear power sources on board and problems relating to their collision with space debris

The present conference room paper contains submission received by the Secretariat from Japan, and includes additional pictures and figures not included in document A/AC.105/C.1/109/Add.1. The document is issued without formal editing.

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* A/AC.105/C.1/L.341.

Report on Space Debris Related Activities in Japan
(For UNCOPUOS/STSC February, 2015)

## 1. Overview

Corresponding to request from the OOSA, Japan reports here, the debris relating activities mainly conducted in the Japan Aerospace Exploration Agency (JAXA).

The total figure of the JAXA Space Debris Strategic Plan was introduced by the Secretariat in the UN paper A/AC.105/C.1/107 “National research on space debris, safety of space objects with nuclear power sources on board and problems relating to their collision with space debris” dated 16 November 2012.

Here, the following debris related activities conducted in JAXA during 2014 are selected as major progresses to introduce in the next section.

(1) Research on Conjunction Assessment (CA) and Collision Avoidance Maneuver (CAM) between JAXA satellites and debris
(2) Research on technology to observe LEO and GEO objects and determine their orbits
(3) In-situ Micro-Debris Measurement System
(4) Protection from impact of micro-debris
(5) Propellant tank easy to demise during re-entry
(6) Contribution on the ISO activities.

## 2. Status

### 2.1 Research on Conjunction Assessment (CA) and Collision Avoidance Maneuver (CAM) between JAXA satellites and debris

JAXA is receiving the conjunction notifications from JSpOC. For example, in September 2014, the number of notifications received was 27 which exceeded a specific conjunction threshold value. Since 2009, JAXA has executed 9 collision avoidance maneuvers for LEO spacecraft until September 2014.

In parallel, JAXA determines the orbit of space objects by using Kamisaibara radar and Bisei telescopes observation data, predicts close approaches using the latest orbit ephemerides of JAXA satellites, and calculates Probability of Collision (PoC) by our unique methods.

Also, JAXA evaluates the criteria for CA and CAM through our experiences. In our evaluations, the trends of each conjunction condition and of prediction errors due to perturbations (e.g. uncertainty in air drag) are analyzed.

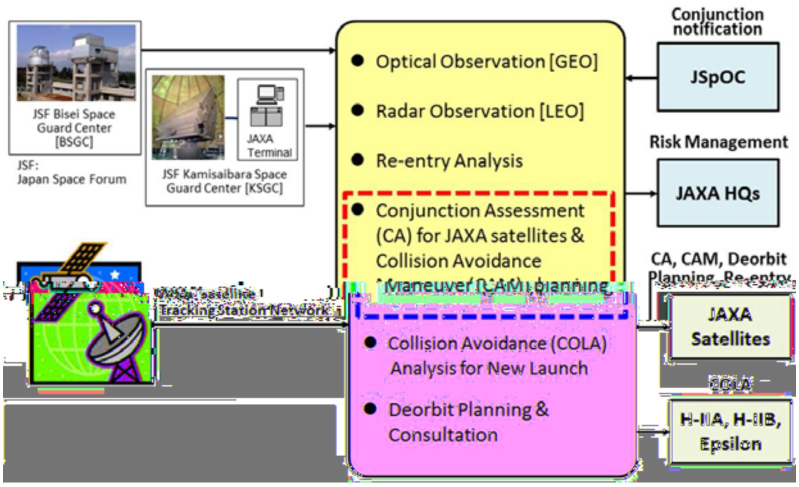



Fig.-1 the Activity for the Space Situation Awareness in JAXA

### 2.2 Research on technology to observe LEO and GEO objects and determine their orbits

Generally the observation of LEO objects is mainly conducted by radar system, but JAXA has been challenging to apply the optical system to reduce the cost for both construction and operation. Fig.-2 shows the system which consists of a lot of optical sensors to cover large regions of the sky. Survey observations using a 18 cm telescope and a CCD camera, one set of the system, showed that 30 cm-sized objects or larger at 1,000 km altitude were detectable with those sensors and 15 % of them were un-cataloged. For GEO observation, a FPGA board (Fig.-3) which can analyze 32 4K4K-frames with 40 seconds was developed and confirmed 14 cm-sized objects were detectable by analyzing CCD frames taken with a 1 m telescope at Bisei Spaceguard Center of Japan Space Forum. Now the limit size to detect the objects in GEO is reported as 1 m, this result can be said to be effective to detect small fragments caused by the break-ups in GEO region.

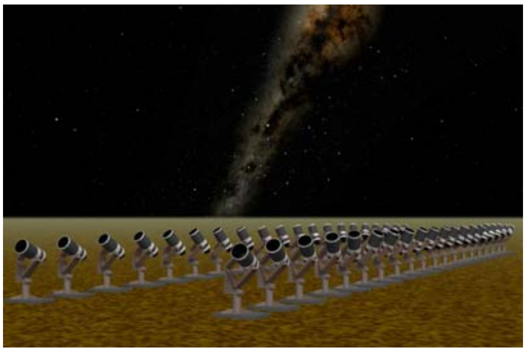


**Fig.-2 The array of the optical sensor at one site. In order to detect many LEO objects two times, two narrow rectangle regions are observed by changing observational direction of each optical sensor.**

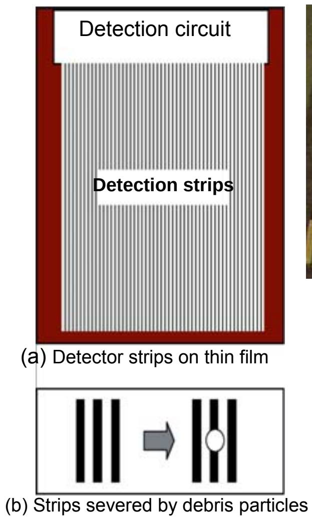
**Fig.-3 The FPGA board manufactured by Technoscope which can analyze 32 4K4K-frames with 40 seconds.**

## 2.3 In-situ Micro-Debris Measurement System

For micro-debris (sub-millimeter class) which cannot be detected on the ground, JAXA is developing an on-board detector for in-situ measurement. This sensor is the first to use conductive (resistive) lines. Fig.-4 shows the sensing principle and Fig.-5 shows the Engineering Model (EM).

If this were supplied to many spacecraft, the acquired data could help to improve the debris environment model. An improved flight model will be launched with HTV-5 in 2015. Now the environmental tests and impact verification tests have finished. Fig.-6 shows the mounting position of the Space Debris Monitor on HTV.

Currently there are few measures to know the situation of tiny debris and meteoroid in the outer space, in spite that it is essential for risk assessment for survivability against debris impact, and for taking cost-effective protection design for spacecraft. It is strongly expected and welcome that the world space agencies would launch this devices attaching to their spacecraft, sharing the data, and contribute on improvement of the debris and meteoroid models.




Numerous thin, conductive strips are formed with a fine pitch on a thin polyimide film (of nonconductive material). A dust particle impact is detected when one or more strips are severed by the perforation. **[US patent registered]**

**Fig.-4 Sensor principle**

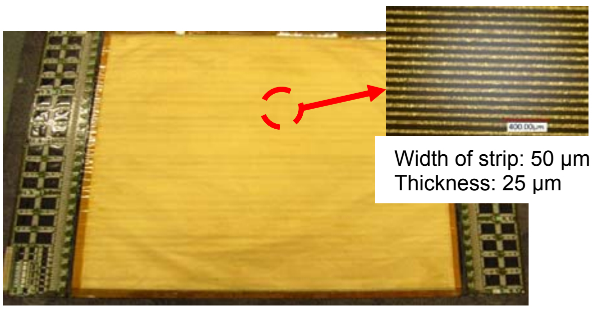



**Fig.-5 Engineering Model**


**Fig.-6 Flight experiment on HTV**

## 2.4 Protection from impact of micro-debris

The amount of micro-debris (less than 1 mm in diameter) increased in low earth orbit. The impact of micro-debris can inflict critical damage on a satellite because its impact velocity is 10 km/s on average.

To assess debris impact on a satellite, JAXA is conducting hypervelocity impact testing and numerical simulations for structure panels and bumper shield materials. Internal damage to structure panels has also been investigated by numerical simulations.

The results of this research are reflecting on the “Space Debris Protection Design Manual” (JERG-2-144-HB) (original version was published in 2009, and was revised in 2014 ).

JAXA has developed a debris impact risk assessment tool named “TURANDOT”. TURANDOT analyzes debris impact risks against three-dimensional model of a spacecraft. This tool was updated to apply ESA’s latest debris environment model (MASTER-2009).

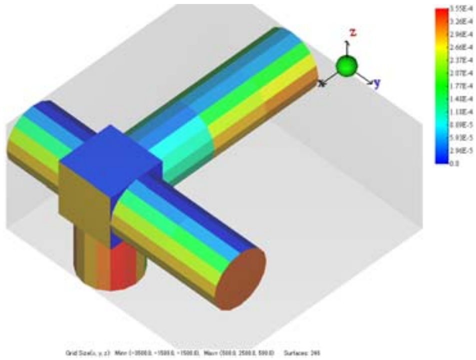


**Fig.-7 an example of out from TURANDOT**

## 2.5 Propellant tank easy to demise during re-entry

A propellant tank is usually made of titanium alloy which is superior because of light weight and good chemical compatibility with propellant. But its melting point is so high that such a propellant tank would not demise during re-entry, and it would pose the risks of ground casualty.

JAXA conducted research to develop an aluminum-lined, carbon composite overwrapped tank with a lower melting temperature. As a feasibility study JAXA conducted fundamental tests including a liner material aluminum compatibility test with hydrazine propellant and an arc heating test. JAXA is now conducting Trial production for the shape of Trial #1 (Fig.-8) which is a shorter size compared to Nominal tank as shown in Fig.-9. Before the CFRP wrapping, fundamental tests were conducted to determine the filament winding parameters by the specimens imitated at the cylinder part of aluminum liner shown in Fig.-10. Next step is scheduled for Trial manufacturing of nominal size tank and the qualification test. Once it would be qualified we could enjoy lower cost and shorter manufacturing lead time than previous titanium tanks.

**Fig.-8 Dome shell (Tirial #1)**

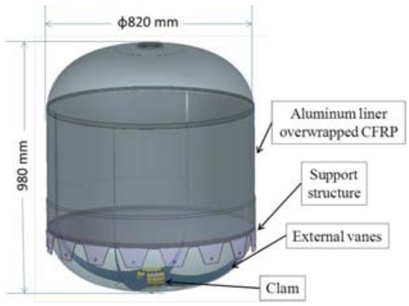



**Fig.-9 Concept of CFRP propellant tank**

**Fig.-10 CFRP overwrapping test**

2.5 Contribution on the ISO activities

In the ISO/TC20/SC14 (Technical commiittee / Sub-commiittee on the Space system and operation ), many debris related standards have been developed. Those standards consist of a core standard, namely “ISO-24113: Space Debris Mitigation Requirements”, and several lower layered standards which provide detail manners, procedures or techniques to support the core standards. Adding to those set of standards, Japan proposed to develop more comprehensive technical report to support engineers for design of spacecraft system, sub-system and components, and space operators. It is “TR-18146: Space Debris Design and Operation Manual for Spacecraft (draft title)”(Fig.-11). This TR (Technical Report) will suggest timely application of mitigation measures in each developing phase and also recommend the best practices for major sub-systems and components to comply with the requirements.

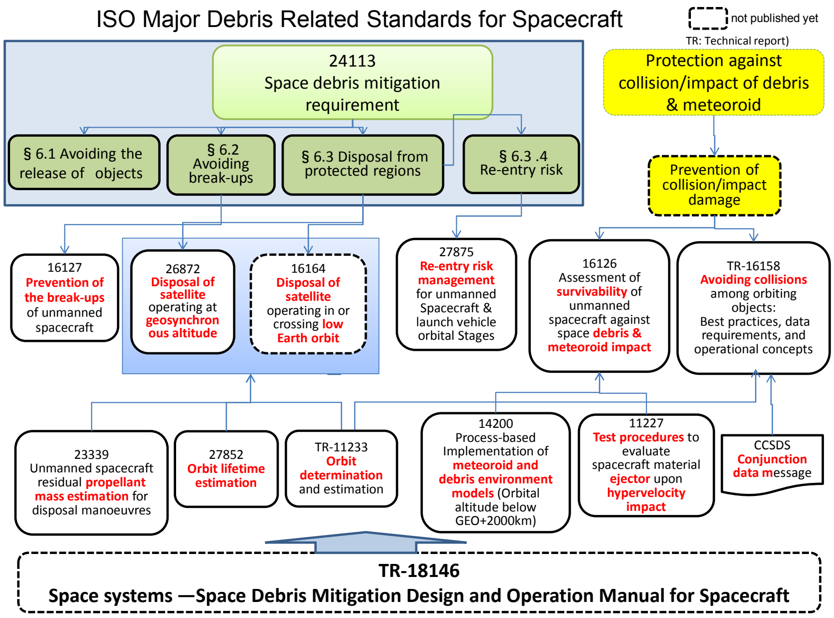


Fig.-11 Major Debris related Standards in ISO