Concerning to the "ToR on the Long-Term Sustainability of Outer Space Activities of the STSC" (A/AC.105/C.1/L.307)

Procedure for Risk Assessment & Identification of Best Practices to Support the WG for Sustainability

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Sustainability of Space Activities means that of Human Society To ensure the benefit, all the **Benefit of Space Activities** threat /risk should be identified and assessed in the WG. **Communication Broadcasting Meteorological Satellites Satellites Earth Observation Satellites** Satellites, etc. Monitoring **TV & Telephone** Typhoon, Tsunami Monitoring in the remote islands Volcano, Environmental Pollution **Keeping Links** in the Disaster 火山の活動、大気・海洋汚 Monitoring Resources in Marine 流、豊プラン このテレビ、電話通信 and Land Communications 中継 in the mountain area 非常災害時の Monitoring Plants Monitoring Monitoring の受信障害の Land Utilization 間部の受信障害の解 Harvest 植物の成青状態 Assisting to an a start

Navigation

SCOPE

• In the ToR of WG provides clear idea, and defines the following seven areas to be studied.

WBS defined in the ToR

- (a) Sustainable space utilization supporting sustainable development on Earth
- (b) Space debris
- (c) Space weather
- (d) Space operations
- (e) Tools to support collaborative space situational awareness
- (f) Regulatory regimes
- (g) Guidance for new entrants in the space arena
- Based on the idea in ToR, Japan would like to introduce here the approach on more detailed subjects to be discussed.
- This paper introduces the concept of the approach and the study result.

Fig.-1 Proposed Procedure





Table-1: Threats, their Results, Current Status

Threat		Results	Current Status	
Quality & Reliability Assurance		Failure, Explosion	Usually, quality and reliability control program are applied to the spacecraft design and operation.	
Induced Environment		Malfunction	All the space operators are expected to pay attention on these aspects.	
Natural Environment (Solar flux, Electromagnetic, Plasma, neutral gas, etc.)		Radiation effects, etc.	Natural environment is informed by the regional warning centers of ISES. It is expected that the Space Weather Forecasting Service will be improved reflecting the discussion in the related agenda items in COPUOS.	
	Fragments of break-ups	Collision and Malfunction	Warning of conjunction with fragments are being sent frequently. Notification of break-up event should be sent. And distribution data of fragments is expected to be sent immediately.	
M Env	Collision with large objects	Collision and Break-up	Collision avoidance maneuver needs information of operation status and points of contact of approaching spacecraft.	
an-made vironment	Collision with tiny objects	Collision and Malfunction	There are no reliable environment models for small debris Tiny debris has high collision probability, and poses un-ignorable risk to the ordinal satellites. Cost effective (mass effective) measures are expected.	
	Impact on the ground	Ground casualty	To ensure the ground safety from re-entering spacecraft, design measures to reduce casualty is encouraged. To know the risk of high risk re-entering objects, its physical property should be informed.	

Fig.-3 STEP-2: Identification of Risk Factors



Concept of STEP-3, 4 & 5 Risk Analysis, Contingency Planning, Identification of Best Practices

- 1. STEP-3: Assess the risk by the probability and the influence, and identify the items for which risk magnitude is not small.
- 2. STEP-4: For each major risk, review the contingency plan, and identify the subjects to be improved.
- 3. STEP-5: Assess the subjects to be identified as the best practices



Table-2 STEP-3: Risk Assessment

	Factors	Influence	Probability	Risk Magnitude
1	Quality & Reliability Assurance	Loss of function	Quality & Reliability differ depending on manufacture	Risk : Various -Probability: Large -Influence: Various -Control level is varied
2	Natural Environment	Loss of mission	Several spacecraft per ten years have terminated mission	Risk: Medium -Probability: Large -Influence: Medium -Monitoring & notification
3	On-orbital Break-up	Collision, and Deterioration of environment	About 200 break-up events have been observed	Risk: Large -Probability: Large -Influence: Large Action: Being promoted
4	Collision with large objects	Break-up, and Deterioration of environment	Satellite to satellite collision occurred once; the probability could increase	Risk: Medium -Probability: Small -Influence: Large - Action: Insufficient
5	Collision with micro- debris	Loss of function	Failure rate is controlled to be less than 0.01 in some countries	Risk: Medium -Probability: Large -Influence: Medium -Action: Insufficient
6	Impact of re-entering objects	Casualty on the ground	Number of casualties are controlled to be less than 0.0001 in some agencies	Risk: Un-ignorable -Probability: Small -Influence: Medium - Action: Insufficient



Preventive	Modeling	Weather models have been developed. The models for higher and lower region are being developed in NICT/Japan.
Actions	Design & Operation Measures	Radiation hardness designs are being developed, also, other design measures have been taken.
Detection of Threat	•Monitoring •Detection of Threat •Warning	Monitoring and warning services are available by the ISES. Study in ISWI and WMO is necessary.
Corrective	Analysis and Planning of Actions	Each space operator has its contingency plan.
Action	Risk Avoidance	The electric system may be shut-off. Space crew will hide behind the structures.
Permanent Action	Subject to be Discussed in WG	expected that the "International Space Warning vice" will be continued and improved.

Fig.-4-2 Contingency Plan for Natural Environment

Preventive Actions	Modeling	Distribution of fragments has been modeled.	
	Monitoring	Periodical monitoring of the S/C.	
Detection of Threat	Detection of generation of threat	Send warning when detecting breakup in operating satellites.	
	Warning	Fragment distribution data is expected to be provided as immediately as possible.	
Corrective	Analysis and Planning of Actions	Orbit characteristics of fragments should be registered and shared.	
Action	Risk Avoidance	Put off launches until the situation is cleared.	
Permanent	Prevent Break-ups	Break-up accidents should be prevented. Intentional destruction should be prohibited	
Action	Prevent the Chain Reaction of Collision	Remove large debris to prevent the chain reaction of collision.	
Subject to be Discussed in WG (1) Immediat (2) Fragment (3) Prevention		te warning when detecting break-up. t distribution data should be provided timely. on of a chain reaction of collisions (in future)	
Fig4-3 Contingency Plan for On-orbit Break-up			

	Modeling	Orbital characteristics of debris are available.	
Preventive Actions	Design & Operation Measures	Conjunction assessment tools and avoidance procedures will be prepared. Propellant for collision avoidance will be prepared.	
Detection	Monitoring	Conjunction assessment should be done to detect collision risk.	
of Threat	Warning	Warning for close approach should be sent to both of the operators.	
Corrective Action	Risk Avoidance	International registry of operators and contact information for coordination.	
		Coordination for avoidance.	
Permanent Action	Remove Large Objects	Remove large debris, which are the source of chain reaction of collision.	
Subject to be Discussed in WG(1) International registry of operators and contact information.			
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Fig.-4-4 Contingency Plan for Collision with Large Objects



Fig.-4-5 Contingency Plan for Collision with Micro-debris



Fig.-5 STEP-5: Subjects and Candidates for Best Practices

Subjects indentified in STEP-4

(1) Encouragement of quality control

(1) Immediate warning when detecting breakup in operating satellites.

- (2) Information on fragment distribution is expected as immediately as possible.
- (3) Prevention of a chain reaction of mutual collisions in useful orbit regions.

(1) International registry of operators and contact information.

(1) Encouragement of micro-debris survey, and improvement of the debris models.

- (2) Encouragement of protection design.
- (1) Encouraging a design considering re-entry safety.
- (2) Sharing information on high-risk re-entering objects.

Best Practices

Information Sharing

a) operational situationb) risk of re-entryc) environment information

International Contribution

a)notification of break-up b)orbital data of fragments

International Cooperation

a)improvement of statistical
debris model
b)removal of existing large
objects

International Standards a)ISO Space System STD b)standard procedure for risk avoidance (CAM, re-entry, etc.)

Conclusion

- A) <u>To ensure the benefit from space activities, all</u> <u>threats /risks should be identified and assessed in</u> <u>the WG.</u>
- B) <u>A risk analysis and contingency planning will</u> <u>effectively induce the items to be discussed in the</u> <u>WG.</u>
- C) All the work will not be done in the WG.

<u>For some subjects, it will be efficient for the WG to</u> <u>define what should be done, and allocate the work</u> <u>to the other agenda items in COPUOS, or other</u> <u>appropriate organizations.</u>

[Reference Table] Work Allocation & Sharing Among World <u>Authorities</u> to Develop & Encourage the Best Practices



D)Fundamental Solutions

Emergency

Encouragement

b)standard procedure for ris oidance (CAM, re-entry, etc.) ISO and other international bodies

Table-3 Allocation of the subjects into the ToR (1/2)

Title	Contents of work	
(a) Sustainable	(i) The contribution of space science and technology to sustainable	
space	development on Earth	
utilization	(ii) The concept of sustainable development extended to the domain of	
supporting	outer space	
sustainable	(iii) Technical capacity-building for developing countries	
development on Earth	(iv) Equitable access to the limited resources of outer space	
	(i) Measures to reduce the creation and proliferation of space debris	<u>Add-3</u>
	*1. <u>Prevention of a chain reaction of mutual collisions among large</u>	
	<u>debris from useful orbit regions (altitude: 800 km)</u>	
	(ii) Collection, sharing, and dissemination of data on space objects	
	*1. Objects detectable from ground observation facilities	
	*2. Encouragement of surveying micro-debris in international	
(b) Space	cooperation, and improvement of debris models, especially those	
debris	for micro-debris	
	(iii) Re-entry	
	*1 Re-entry notifications regarding substantial space objects	
	*2. Encouragement of a design considering re-entry safety (easy to	Add-6
	demise by selecting adequate materials, controlled re-entry etc.)	
	*3 Sharing information on high-risk objects for re-entry	Add-7
	or <u>shuring mornauton on men risk objects for re entry</u>	19

Table-3 Allocation of the subjects into the ToR (2/2)

	(i) Collection, sharing, and dissemination of data	
(c) Space	(ii) Sustaining global observation capability	
weather	(iii) Measures to mitigate the impact of space weather phenomena on operational space systems	
	(i) Collision avoidance processes and procedures	
(d) Space	(ii) Pre-launch and pre-maneuver notifications	
operations	(iii) Common standards, best practices, and guidelines	
	(i) International, multinational, or national registry of operators and contact information	
(e) Tools to support	(ii) International, multinational, or national data centers for the storage and exchange of information on space objects and operational information	
collaborative space situational awareness	 (iii) Information-sharing procedures. <u>*1. Immediate warning on a voluntary basis when detecting break-up by</u> <u>malfunction in operating satellites.</u> <u>*2. Information on fragment distribution is expected to be provided as</u> <u>immediately as possible.</u> 	Add-1 Add-2
(f) Regulatory	(i) Adherence to existing treaties and principles on the peaceful uses of outer space	
regimes	(ii) Regulating space activities of the Member State nations	
(g) Guidance for new entrants in	(i) Technical standards, best practices, and lessons learned for the successful development and operation of space systems, from the pre-launch phase to the end-of-life phase	
the space	*1. Encouragement of protection design.	Add-5
arena	(ii) Microsatellites and smaller satellites	20