From Guideline to International Treaty for Rule of Law Concerning Mitigation of Space Debris ?

—Implications arising out from practices of space agencies—

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1. Introduction

Almost 3 years has passed since the Space Debris Mitigation Guidelines of the United Nations Committee on Peaceful Use of Outer Space (COPUOS)[2] (hereinafter referred to as "UN Debris Guidelines") has been endorsed by the General Assembly of the United Nations in 2007[3]. It seems that the "trend" of space law research is going to the next stage in order to discuss on the issue of the Space Traffic Management or rethinking the Moon Agreement, though looking precisely the implementation and practices of the UN Debris Guidelines is a highly important issue for the development of international space law. This issue is important because this is almost the first case which the bottom-up approach starts to work and this bottom-up approach contains the possibility to become a model successful case to form the practical rule in the area of international space law. This article is going to describe how each space agencies implement the UN Debris Guidelines and find out the current status and challenges of the state practices in order to drive forward the mitigation of space debris effectively.

2. Current Status of the Implementation of the UN Debris Guidelines

Rethinking Space Debris Mitigation Practices

In order to measure the current position of the UN Debris Guidelines, it is important to understand how far the Guidelines are complied by space agencies. Especially, the practices of the agencies of the nations holding launch vehicles,

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[1] This paper is only based on the personal view of the author and does not represent the view of the agency to which he belongs.
[2] United Nations publication, Sales No. E.99.I.17.
[3] OP.26 of A/RES/62/217.

because, consequently, the requirements from the launch vehicles will be *de facto* requirements for every payload. This importance is not necessary means because these practices will be one of the elements forming the international customary law. It is true that this kind of practices (of course only when it was evaluated as a state practice not just an agency practice) hold some possibilities to become an international customary law when these practices complied together with certain *opinio juris*. However, the main purpose of this article is to figure out how the UN Debris Guidelines are working practically as a daily rule of conduct of nations, but not to discuss the possibility or validity of state practices as the element of international customary law. Definitely, the international customary law is one of the important sources of international law, traditionally, but this is a rule which is going to apply into the international courts and slightly different from the rule of conduct, which nations refer it in its daily activities[4]. Furthermore, even in the international courts, the discussions on international customary law conclude as the problem of opposability between the parties[5]. In addition, the discussion regarding "soft law" is raising another question on this issue and there are no commonly accepted theories to expound the legal effect of resolutions of international organizations to the international customary law.[6]

Toward International Treaty?

There is another discussion regarding the debris mitigation. That is, which option is the most effective way to achieve the compliance of debris mitigation; the international treaty or another international regime? It is true that the international treaty is the most effective way to assure the compliance of international rules by using sanctions under international law for its breach. However, there is a major problem on the way before adopting a treaty. Most of the space fairing nations are negative for making another international treaty for the space area because of two reasons. First, since the technologies of space activities are still mainly developed by the government and the area of space are not really commercialized enough, the space fairing nations does not willing

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[4] Toshiki Mogami, "Kokusaihou ni okeru kouikihan to saibankihan (Rule of Conduct and Rule of Court in International Law)" in *Nihon to Kokusaihou no 100 nen (100 years of Japan and International Law), Book 1,* Sanseido (2001) pointed out the importance of this vision.

[5] In the Judgment of the ICJ in the North Sea Continental Shelf Cases (ICJ Report 1969, pp. 40-46); In Nicaragua Cases (ICJ Report 1986, para. 183-209).

[6] Bin Cheng, "United Nations Resolutions on Outer Space: 'Instant' Customary Law?", *Studies in International Space Law* 125, Oxford University Press, first published in 1997 ; Prosper Weil, "Towards Relative Normativity in International Law ?", 77 American Journal of International Law 413 (1983).

to be limited its activities in this potential area. Second, the space fairing nations have a series of lessons learned from the history of difficulties on international law making involving the problem of economic differences. The negotiation of the UN Convention on the Law of the Sea (UNCLOS) took more than 30 years after the first diplomatic meeting to conclude as a treaty and furthermore, its Part XI regarding the sea-bed was modified by the Agreement Relating to the Implementation of Part XI of UNCLOS about 10 years later from the adoption of UNCLOS itself. The Moon Agreement is also one of the treaties facing the hard situation with only 13 countries of ratification without any space fairing nations. These lessons made the space fairing nations negatively consider to choose the international treaty approach to regulate space activities.

To consider this situation realistically, the purpose, of course, is not to formulate the international treaty itself but to achieve the effective governance of the space activities. At this point the most important notion is to find out how can we reach the way that the space fairing nations are willing to be governed by themselves. The point is not the level of legal binding but the flexibility and feasibility of the framework. The best way is to be based on the practices of their space agencies practices, because they are the pioneers and still the top runners of space activities.[7]

Practices in Space Agencies

From the aforementioned reasons, this article decided to focus on the practices of space agencies obtaining launch vehicles of the implementation of UN Debris Guidelines.

There is no doubt that the countries and regions which hold its own launch vehicle is only the following 6; the United States, Russian Federation, Europe, Republic of China, India and Japan. As I mentioned above, if the debris mitigation requirements are strictly stated in the requirements of these 6 countries and regions, it means that almost all of the space objects are required to do so, because no payload can be launched without using these launch

[7] Steven A. Mirmina analyzed 3 options to redress the proliferation of space debris; a voluntary adherence regime, a UN-based approach and a code of conduct; and argued that the code of conduct approach is the most effective one, in "Reducing the Proliferation of Orbital Debris: Alternatives to a Legally Binding Instrument", 99 American Journal of International Law 649 (2005). However, now after 3 years from the adoption of the UN Debris Guidelines, it is possible to say that the UN based-approach based on a voluntary adherence regime in IADC served as generation of "best practices" toward the "code of conduct" approach and the IADC and UN Guidelines are beginning to be a *de facto* code of conduct among the space agencies of the space fairing nations.

vehicles requiring space debris mitigation by their users' manual[8]. That is to say, the compliance of the UN Debris Guidelines from these 6 parties can be equal to the effectiveness of the Guidelines practically. For example, since almost half of the satellites launched in Japan are developed by JAXA, and all of the satellites launched in the territory of Japan were launched by the H-IIA or H-IIB launch vehicle developed by JAXA. As the requirement from the launch vehicle to the payload, these satellites are required to apply the JMR-003A for their development. JAXA is supporting a small satellites piggy-back launch program for universities and commercial entities' projects which contribute to foster education and human resources using the excess capacity of the launch of its own satellite. Even for these small satellites, it is required to follow the JMR-003A through the "H-IIA Users' Manual". Since these requirements, such as JMR-003A of JAXA, are originally comes from the safety requirements for launch and flight, it is natural to be improved in each space agencies which contains launch vehicles. So that, it will be practical to examine how these requirements in space agencies require the debris mitigation measures in order to see how the UN Debris Guidelines has been complied.

Table-1 compares the UN Debris Guidelines and the Guidelines of Inter-Agency Space Debris Coordination Committee (hereinafter referred to as "IADC Guidelines"), which was quoted by the UN Debris Guidelines, and the requirements of space agencies of Japan, the United States, Europe and Russia. The IADC Guidelines is quoted by the UN Guidelines at almost all of the points regarding the technologies and the UN Guidelines just designate 7 principles arising out from the IADC Guidelines so that the important document in terms of technology is the IADC Guidelines. At this point, it is safe to say that comparing the IADC Guidelines and the requirements of space fairing nations will provide us some practical results.

[8] As for JAXA, every payload shall be designed, manufactured and assembled following the "H-IIA users' manual", JERG-0 .

Table-1 Recommendations / Requirements in Major World Debris Mitigation Standards (1/2)

Generated by Dr. Akira Kato, Technologist of Safety and Mission Assurance Department, JAXA

		Measures	IADC Guidelines	UN Guidelines	JAXA (JMR-003A)	NASA (NPR 8719.14)	US Gov. STD Practice (and NPR 8715.6A)
Mission Related Objects		Operational Debris	Addressed in 5.1	Addressed in Rec-1	Required	(1) LEO: >1mm (decay within 25 years, and total < 100 object-years) (2) GEO: > 5cm (decay -500km within 25 years)	> 5 mm (decay within 25 years)
		Slag from solid motor					
		Pyrotechnics					
		secondary ejector					
On-orbital Break-ups		Intentional Destruction	Addressed in 5.2.3	Addressed in Rec-4	Required	(1) <100 object-years (for > 10 cm) (2) Fragments > 1mm shall be limited 1 year (3) Fragments > 1mm, collision with operating S/C shalll be limited < 10^{-6},	
		Accident during Operation	Addressed in 5.2.2 (Monitoring)	Addressed in Rec-2	Required (Monitoring)	Probability of BU < 10^{-3}	Required
		Post Mission Break-up (Passivation, etc.)	Addressed in 5.2.1	Addressed in Rec-5	Required	Required	Required
Collision		with Large Objects	Addressed in 5.6	Addressed in Rec-3 (CAM, COLA)	Required (CAM、COLA)	< 0.001 (with > 10 cm)	
		with Small Objects	Addressed in 5.6		Required	disposal success > 0.01	
Post Mission Disposal	GEO	Reorbit at EOL	235 km+ (1,000·Cr·A/m) e < 0.003	235 km+ (1,000·Cr·A/m)	Addressed in Rec-7	235 km+ (1,000·Cr·A/m) e < 0.003 Success Probability > 0.9 100 years' guarantee	>36100 km (> 300km + GEO)
		GEO Lower Limit	-200 km	< -500 km (within 25 years)		GEO - 500 km	
		Protected Inclination	-15< latitude <15 deg.			-15< latitude <15 deg	
	LEO (MEO)	Reduction of Orbital Lifetime	Addressed in 5.4 (Recommend 25 years)	Recommend EOL Lifetime < 25 years	Addressed in Rec-6	Total period <30 years, EOL Lifetime <25years, Success Probability >0.9	EOL Lifetime <25 年
		Transfer to Graveyard		Required		2,000 km ～ (GEO-500 km) (exclude 19,100 - 20,200 km)	2,000 - 19,700 km 20,700-35,300 km
		On-orbital Retrieval	Addressed in 5.4	Required		Retrieve within 10 years	Retrieve within 10 years
		Ground Casualty	Addressed in 5.4	Ec < 10^{-4}	Addressed in Rec-6	Ec < 10^{-4}, (Count impact energy> 15 J)	Ec < 10^{-4}

Abbreviations: a : semi-major axis, Cr :solar reflection coefficient, A/m: Area Mass Ratio, Ec: Number of Casualty, e: eccentricity, EOL: End of Operation Life, Rec: Recommendation

Note: "Success Probability" for disposal $P(D|M)$ is a conditional probability expressed by $P(D|M)=\frac{P(M\cap D)}{P(M)}$,

here, P(M) = (mission success probability), and $P(M\cap D)$ = (probability of correctly performing both mission and disposal phases).

Table-1 Recommendations / Requirements in Major World Debris Mitigation Standards (2/2)

		Measures	European Code of Conducts for Space Debris Mitigation	ESA (April 2008) Space Debris Mitigation for Agency Projects	RASA	ISO (24113)
Mission Related Objects		Operational Debris	Required	Required	Required	Required
		Slag from solid motor	Slag < 0.01mm (Changed to 1mm)	Slag < 1mm		Required
		Pyrotechnics	Objects < 0.01mm	Particles < 1mm		Combustion Products < 1 mm
		secondary ejector	Required (SD-DE-07)		Required	
On-orbital Break-ups		Intentional Destruction	Required (SD-DE-04)	Required	(Allowed just before the impact to the Earth)	Required
		Accident during Operation	Probability of BU < 10^{-3} (SD-DE-05)		Required	Probability of BU < 10^{-3}
		Post Mission Break-up (Passivation, etc.)	Required Inner Press. < 50% of critical Press. Dispose within 1 year Success Probability > 0.9	Required (to be conducted < 2 months)	Required	
Collision		with Large Objects	Required	Risk Assessment	Risk Assessment	
		with Small Objects	(Recommended by other document)		Risk Assessment	
Post Mission Disposal	GEO	Reorbit at EOL	235 km+ (1,000·Cr·A/m) e < 0.003 Success Probability > 0.9 100 years' guarantee	235 km+ (1,000·Cr·A/m) Success Probability >0.9	235 km+ (1,000·Cr·A/m)	235 km+ (1,000·Cr·A/m) e < 0.005
		GEO Lower Limit		-200 km		
		Protected Inclination	-15< latitude <15 deg.	-15< latitude <15 deg.		-15< latitude <15 deg.
	LEO (MEO)	Reduction of Orbital Lifetime	EOL Lifetime < 25years Success Probability >0.9	EOL Lifetime < 25years Success Probability >0.9	EOL Lifetime < 25years	EOL Lifetime < 25years
		Transfer to Graveyard	Required	Required		(Excluding Galileo orbit)
		On-orbital Retrieval				
		Ground Casualty	Required	Ec < 10^{-4} (Excluding France)	Required (Poisoned material)	Ec < 10^{-4}

a) IADC-02-01: IADC Space Debris Mitigation Guidelines, (Revised September 2007, Revision 1),
b) Space Debris Mitigation Guidelines of the COPUOS, United Nations Office (Resolution of 22 December 2007)
c) JAXA-JMR-003: Space Debris Mitigation Standard, (will be revised B in October 2010).
d) NASA-STD-8719.14: Process for Limiting Orbital Debris (Approved: 2007-08-28)
e) NPR 8715.6A: NASA Procedural Requirements for Limiting Orbital Debris, (Effective 19 February 2008)
f) European Code of Conduct for Space Debris Mitigation (28 June 2004, Issue 1.0)
g) ESA: Space Debris Mitigation for Agency Projects, ESA/ADMIN/IPOL(2008)2,Director General's Office (1 April 2008)
h) Russia: National Standard on the Russian Federation, General Requirements on Space Systems for the Mitigation of Human-Produced near-Earth Space Pollution
i) ISO-24113 Space Debris Mitigation (DIS) (published by the end of 2010).

Note: CNES uses European Code of Conduct since 2004 instead of its former "Space Debris - Safety requirements (MPM-50-00-12)"

First of all, looking at the Table-1 as a whole, it is notable that the agencies' guidelines signify an equally equivalence than that of the IADC. In particular, the most critical requirement for satellites, because it affects the payload weight, the requirement regarding re-orbit at EOL is also required by all agencies. To add, every requirements requires to take 235 km+(1,000 · Cr · A/m) which is the same requirement of the IADC Guidelines. Not only that the requirement of NASA set this requirement as 300Km which is sever than that of the IADC. (Actually it doesn't differ so much because after calculating the formula above, it reaches almost 300Km.)

The compliance of the UN Debris Guidelines and IADC Guidelines were decided to keep its transparency manner by voluntary presentation of member states in the Legal Subcommittee of the COPUOS. In 2009, the first three presentations for that were held by Japan[9], Germany[10] and ESA[11]. These presentations will be a signal to measure how much each nation are feeling that the UN Debris Guidelines are necessary to be complied.

Japan was presented that the regulation of space debris is complied through JAXA Space Debris Mitigation Standard which is one of technical management requirement in JAXA. The presentation also pointed out that "Although there aren't enough governmental regulations or laws, the contractors of JAXA, applicants for piggy back payloads, and commercial space users show good compliance with JAXA standard or UN Guidelines in other words." This means that in Japan as a whole is feeling that the UN Guidelines are necessary to comply.

The presentation of ESA emphasizes how the space debris problems are dangerous and pointed out that they contain the requirements on management level, design level and the operation level following the UN Guidelines. They valuate themselves that these policies are suitable with the UN and IADC Guidelines. This means that ESA itself and its member states are feeling the necessary of compliance of the UN Guidelines.

The German presentation mentions that there are two other documents among the European Countries regarding this issue. The first one is the

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[9] Masahiko Sato, "Space Debris Mitigation Mechanism in Japan -The Case in JAXA" presented in the Forty-eighth session of Legal Subcommittee of COPUOS.
[10] Uwe Wirt, "UN-Space Debris Mitigation Guidelines - National Implementation Mechanism" presented in the Forty-eighth session of Legal Subcommittee of COPUOS.
[11] Ulrike M. Bohlmann, "Requirements on Space Debris Mitigation for ESA projects" presented in the Forty-eighth session of Legal Subcommittee of COPUOS.

European Code of Conduct on Space Debris Mitigation (hereinafter referred to as the "ECoC") and the second one is the European Cooperation for Space Standardization (hereinafter referred to as the "ECSS"). The ECoC is a political document adopted by the European Union (EU) and applied to the space activities of the member states. The German presentation also pointed out that it's the National Mitigation Guidelines is made suitable with the ECoC. On the other hand, the ECSS is a technical standard for space activities in Europe and it was implemented in DLR Standard Product Assurance Requirements Catalogue. The presentation mentioned that these Guidelines are applied to the contractor of DLR, where most of the German space activities are conducted, and complied with every missions of DLR. This means that Germany is feeling necessary to comply with the UN Guidelines.

As I described in this section, the space agencies in most of the space faring nations have their own standards for space debris mitigation in a suitable manner of the UN and IADC Debris Guidelines. Furthermore these agency guidelines are revised according to the revision of the IADC Guidelines[12]. These facts suggest, those we don't have enough data of China and India, at least in 4 space failing nations, the UN Debris Guidelines are almost complied and since there are the countries which hold the space transportation measure, there are no exaggerations to say that the UN Debris Guidelines are almost practically complied among nations. Since the purpose to establish the UN or IADC Debris Guidelines is to mitigate space debris in order to maintain the environment of space and ensure the safety of space activities in the future, making *de facto* standard by gathering these practices in the international community in spite of making an international treaty will be one of the most practical way to achieve the purpose. This sequence is already on the way.

3. Complement Measures of the Bottom-up Approach

As mentioned in this paper, the space faring nations have taken national efforts to implement UN or IADC Debris Guidelines for publicly licensed commercial and/or civil licensed space activities. Incorporation of Debris Guideline into domestic policy and regulatory procedures, mechanisms or structures varies according to each State, its level and type of space activity.

Besides those space fairing nations mentioned before, the following is brief and specific information on the domestic implementation of Guidelines in

[12] For example, JAXA Debris Mitigation Standard, JMR-003A, will be revised in 2010 and become JMR-003B.

China and India.

China has no explicit legal standards regarding space debris. However, systematic policy statements , plans and regulating mechanism pertaining to space debris issues in Chinese government and State-owned space ventures are in existence. China has been in the process of implementing Space Debris Mitigation Standards. Interim measures are also in place as requirements for Space Debris Mitigation issued in 2005 as industrial standards. Chinese debris mitigation efforts have been evolved through focusing on space situational awareness, spacecraft protection/survivability, and debris mitigation, and through registration and licensing regulations for civil space objects including debris mitigation requirements.

India has implemented the space debris mitigation measures just like launch vehicle final stage passivation, re-orbiting of GSO satellites, de-orbiting of LEO satellites, minimization of mission related debris through design, and participation in international exercises involving estimating the re-entry of de-orbiting objects. ISRO has been in charge of the responsibility for implementing space debris mitigation measures.

Through those space faring nations efforts to implementing the Guidelines, good practices have been elaborated for de facto standard to the space activities in national and international level as mentioned before.

However, there are many other nations got involved in the space activities, they are still in the process for implementing the Guidelines. It would be very important issues for international community to establish the common understanding and agreement to implement any guidelines or rules concerning of mitigation of space debris for future development of space activities.

New development for future guidelines and rule?

As COPUOS established in June of 2010, the Working Group on the Long-term Sustainability of Outer Space Activities, it will examine the long term sustainability of outer space activities in all it aspects, taking account the concerns of all countries, in particular those developing countries, and consistent with peaceful use of outer space. The work will take into consideration current best practices, operating procedures, technical standards and policies associated with the safe conduct of space operations, from the pre-launch to the end-of-life phase. This WG will not address new legal regime

for the conduct of activities in outer space besides taking as its legal framework the existing UN treaties and principles governing the activities of States in the exploration and use of outer space. In the case of the mitigation of space debris, WG will produce a set of voluntary recommended guidelines that could be applied by international organizations, non-governmental entities, individual States and States acting jointly to reduce collectively the risk to space operations for all space faring actors.

According to the WG objective and output, any recommended guidelines safe operations should maintain or improve the safety of spaceflight operations and protect space environment....., remain voluntary and not be legally binding under international law, nor provide specific penalties for failing to follow them ,....be consistent with the relevant activities and recommendations of other working groups of the Committee and its Subcommittees, the Inter-Agency Space Debris Coordination Committee and other relevant international organizations.

It could produce in long range efforts of discussion the best practice guidelines as in the case of space debris issues through bottom-up approach.

Space faring nation's role for best practice guidelines and rules

In order to elaborate to best practice guidelines and rule for space activities including mitigation of space debris, it would be very important for the space faring nations to collaborate and cooperate with other nations, especially developing countries for their implementation of Guidelines or rules. They need technology transfer, human resource development and financial support from the space faring nations, especially from space agencies and research entities.

Even though there could be any restrictions and rules for export and import of space related products and technology, we should have more collaboration and cooperation mechanism and systems to overcome the common problems just like mitigation of space debris safety of space operations.

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