FINAL PROGRAM

International Interdisciplinary Congress on Space Debris Remediation

November 11 and 12, 2011

Faculty of Law, McGill University, Montreal, Canada
3644 Peel Street, Montreal, Canada

Organized by:
The McGill University Institute of Air and Space Law,
Montreal, Canada

Co-organized by:
The Cologne University Institute of Air and Space Law,
Cologne, Germany

The International Association for the Advancement of Space Safety,
Katwijk, the Netherlands

Sponsored by:
Erin J. C. Arsenault Trust Fund at McGill University
Canadian Space Agency, St. Hubert, Quebec, Canada
United Nations Office for Outer Space Affairs, Vienna, Austria

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To date, the first two of the Space Debris Congress series have focused on the mitigation aspects. The third Congress, slated to be held in Montreal on 11 and 12 November 2011, is intended to address the question of space debris remediation and on-orbit servicing of satellites. The congress will therefore explore the issues described herein, as well as other equally relevant matters, in the hope of garnering international attention to the issue. Participants will have the opportunity, following Chatham House rules, to brainstorm over a couple of days and ultimately, it is hoped that the congress will produce the basic constitutive elements of an international environmental declaration or treaty on outer space and what it should address in connection with debris remediation and on-orbit servicing of satellites. The report of the congress will be published, widely distributed and presented at appropriate international fora, including the UNCOPUOS. Participation in the congress is by invitation only.

CONGRESS OBJECTIVE

- To assess the current space debris situation and to determine what can be achieved by space debris remediation and on-orbit servicing of satellites;
- To examine various technical concepts and means, legal and economic aspects, operational and organizational requirements for space debris remediation and on-orbit servicing of satellites; and,
- To put forward specific and viable policy and regulatory steps (mechanisms) that may be considered by states and other stakeholders to facilitate the removal of pieces of space debris and the servicing of satellites on orbit.

➢ ***No registration fee for the invited speakers.***

PROGRAM

THURSDAY, 10 November 2011: Welcome Reception: 18.30 – 20.00 at Thomson House (basement hall): 3650 McTavish, Montreal.

DAY ONE: FRIDAY, 11 November 2011

	TOPICS and DESCRIPTIONS
08:00 – 09:00	Registration and Coffee-Tea
09:00 – 09:15 Opening Remarks: 1. Ram Jakhu (IASL, McGill, Canada) 2. Paul Dempsey (IASL, McGill, Canada) 3. Daniel Jutras (Dean Faculty of Law, McGill, Canada)	
09:15 – 10:45 Session 1 – Current Space Debris Situation: • To what extent can it be improved by space debris remediation? • Why is remediation necessary, for which areas of near-Earth orbit, and by when will it be necessary? • What should the goal of remediation be - stabilizing the debris population growth or protecting	

operational satellites?

Chair: Brian Weeden (Secure World Foundation, U.S.)
Reporter: Timiebi Aganaba (IASL, McGill, Canada)
Panellists:

1. Holger Krag (ESOC, Space Debris Office, Germany)
2. David Kendall (CSA, Canada)
3. David Wright (UCS, U.S.)

10:45 – 11:00	Refreshment Break

11:00 – 12:30

Session 2 – Technical Concepts and Means For Space Debris Remediation and On-Orbit Servicing (that are being conceived and/or developed, including those related to international Space Situational Awareness):

- What are their advantages and disadvantages as well as their legal and economic implications?
- What fundamental technologies and capabilities are needed to support debris remediation and on-orbit servicing?

Chair: David Kendall (CSA, Canada)
Reporter: Catherine Doldirina (IASL, McGill, Canada)
Panellists:

1. William H Ailor (Center for Debris Studies, U.S.)
2. Frank Teti (MDA, Canada)
3. Eugene Levin (STAR, Inc. U.S.)
4. Brian Weeden (Secure World Foundation, U.S.)
5. David Finkleman (Center for Space Standards and Innovation, U.S.)
6. Joseph N. Pelton (former Dean ISU, U.S.)

12:30 – 14:00	Lunch: Thomson House, 3650 McTavish, Montreal

14:00 – 15:45

Session 3 – Legal, Regulatory and Strategic Issues related to Space Debris Remediation and On-Orbit Servicing:

- What legal constraints will hinder the implementation of space debris remediation and how they ought to be resolved?
- Who defines whether an object is space debris and a candidate for remediation?
- What is the process for determining who is allowed to remediate a particular piece of debris?
- What are the liability considerations for accidents stemming from remediation activities?
- What is the legal status of the 'debris' with regards to jurisdiction, control and salvage?
- What are the intellectual property constraints?
- Do ITARs apply to space debris remediation and on-orbit servicing?
- What are the prospects for developing economic incentives for debris remediation?
- What are the strategic (military) implications of on-orbit servicing and debris removal?
- Does “shutter control” apply to spacecraft looking at other spacecraft?
- What form of international cooperation and organisational framework would be required to implement debris remediation and on-orbit servicing?

Chair: Ram Jakhu (IASL, McGill, Canada)
Reporter: Timiebi Aganaba (IASL, McGill, Canada)
Panellists:

1. Sergio Marchisio (University of Rome, Italy)

2. Armel Kerrest (Faculté de Droit de Bretagne Occidentale, France) 3. Sa'id Mosteshar (London Institute of Space Policy and Law, U.K.) 4. Matthew Schaefer (University of Nebraska, U.S.) 5. Michael Mineiro (NOAA, U.S.)	
15:45-16:00	Refreshment Break
16:00-17:45 Session 3 – Legal, Regulatory and Strategic Issues …continue 1. Tare Brisibe (OnAir, Switzerland) 2. Phil Meek (Retired, USAF, U.S.) 3. Ajey Lele (IDSA, India) 4. Duncan Blake (DoD, Australia)	
19:00 - 22:00	Dinner: Restaurant Il Campari Centro, 1177 Rue de la Montagne, Montréal

DAY TWO: SATURDAY, 12 November 2011

08.30 - 09:00	Coffee - Tea
09:00 - 10:45 Session 4 – Organizational and Operational Requirements: • Who should undertake space debris remediation? • What is needed to reduce the risk of mishaps, misperceptions, and mistrust? • What are specific transparency and confidence building measures, norms of behaviour, and best practices for debris remediation? • How do you handle the economics and funding? **Chair:** Ray Williamson (Secure World Foundation, U.S.) **Reporter:** Diane Howard (IASL, McGill, Canada) **Panellists:** 1. Karl Doetsch (Doetsch International Space Consultants, Canada) 2. Richard H Buenneke (State Department, U.S.) 3. Richard Tremayne-Smith (SWF, U.K.) 4. Tommaso Sgobba (IAASS, the Netherlands) 5. Yukihito Kitazawa (IHI, JAXA, Japan) 6. LI Bin (Beihang University, PRC)	
10:45 - 11:00	Refreshment Break
11:00 - 12:45 Session 4 - Organizational and Operational Requirements……. continue 1. Jean-Marc Chouinard (CSA, Canada) 2. Thomas Gillon (Foreign Affairs, Canada) 3. Richard DalBello (INTELSAT, U.S.) 4. Joan Johnson-Freese (Naval War College, U.S.) 5. Jean-Francois Mayence (Federal Office for Science Policy, Belgium) 6. Philip De Man (Leuven Centre for Global Governance, Belgium)	
12:45 - 14:00	Lunch: Thomson House, 3650 McTavish, Montreal

14:00 - 15:30 Session 5 – Discussion and Adoption of Regulatory Principles and Proposals (Declaration) for Space Debris Remediation and On-obit Servicing: • What is needed at the international level? Regional? National? • What can be done through existing for mechanisms and what needs to be created? **Chair:** Paul Dempsey (IASL, McGill, Canada) **Reporter:** Yaw Nyampong (IASL, McGill, Canada) **Panellists:** Chairs of previous sessions	
15.30-15.45	Refreshment Break
15.45-17.15 Session 5 – Discussion and Adoption – continues…. & …Wrap-up	

Observers: *Registration fee of $150 CAN payable by cash or check (in the name of Institute of Air and Space Law) at the time of registration.*

1. Giovanna de Marco, European Space Agency, the Netherlands
2. Michel Doyon, Canadian Space Agency, Canada
3. David S. Kang, ATK Space, U.S.
4. Geoffrey Languedoc, Canadian Aeronautics & Space Institute, Canada
5. Ashlyn Milligan, Department of National Defense, Canada
6. Daniel Rey, Canadian Space Agency, Canada
7. Dennis Woodfork, Office of the Deputy Secretary of Defense, U.S.
8. Michelle Ancona Reynolds, IASL, McGill, Canada
9. Maxime Puteaux, IASL, McGill, Canada
10. Samuel Vaillancourt, Mechanical Engineering, McGill, Canada

Organizing Committee:

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Tommaso Sgobba (President, IAASS, the Netherlands)
Ray Williamson (Executive Director, Secure World Foundation, U.S.)

BACKGROUNDER

As a direct result of mankind's exploration and use of outer space since the dawn of the space age, a massive amount of space debris (i.e., non-functional, man-made objects and component parts thereof) have been placed in outer space. Over the last few decades, the rate at which human activities in space has led to the creation of space debris has increased at an exponential level and a number of developments account for this. With the immense technological advancements that have been recorded lately, outer space has become relatively more accessible to an ever more increasing number of actors. As such, human exploration missions, experimental and scientific missions, as well as satellite application missions involving the use of small, micro, nano, and even "special get away satellites" have been on the rise in recent years. As a result, the sheer number of space objects being launched into orbit has dramatically escalated, and in the absence of globally uniform and systematic procedures for maneuvering space objects in orbit for collision avoidance purposes, the resulting environment has been one in which conjunctions between orbiting space objects have been rather commonplace. In addition to the foregoing, recent years have witnessed the intentional creation of huge amounts of space debris by certain space-faring nations particularly in the low earth and polar orbits.

The uncontrolled rate of proliferation of space debris poses major risks to the sustainability of mankind's access to, exploration and use of outer space, and in the ultimate analysis, to the very survival of mankind on earth. First, the possibility of physical destruction of critical space-based assets has increased manifold times as the amount of space debris in orbit has also increased. Hundreds of communications, navigation, meteorological, remote sensing and surveillance satellites in orbit, valued at billions of US dollars are therefore at risk of loss due to the increased probability of collision with space debris. Also at risk are the numerous critical services on earth provided or enabled by these satellites – environmental monitoring (e.g., climate change and marine pollution), fishing, agriculture, global banking, safety and navigation of air and maritime transport, as well as various other civil and military information technology networks – to mention but a few. Secondly, the feasibility of conducting manned space missions in the future has been (and continues to be) severely compromised by the uncontrolled creation of massive amounts of debris in space. It is reported for instance that a chip of paint as small as .1mm in size orbiting in space at speeds of 7 kilometers per second could prove fatal if it hits an Astronaut in space.

Although the existing state of technology has made it possible for mankind to place all kinds of objects in space, there are only a few technologies and mechanisms in existence today that can be (and are indeed) used for the proper disposal of such objects after they have served their purpose or have become dysfunctional. One such mechanism is to move a space object that has come to the end of its useful life into an (usually higher) orbit that is designated as a disposal or graveyard orbit. Another option is to return the space object to earth after its useful life. Yet another complementary initiative is to establish and implement a uniform global regime for maintaining space situational awareness (SSA) and for Space Traffic Management (STM) among the multitude of stakeholders with assets based in space. Indeed, the international space-faring community, acting under the auspices of the Inter-Agency Space Debris Coordinating Committee (IADC) and the United Nations Committee on Peaceful Uses of Outer Space (UNCOPUOS), has promulgated a series of guidelines that lay down specific recommended measures to be implemented by all space actors so as to mitigate or reduce the possibility of creating space debris during the conduct of space activities. These guidelines incorporate the foregoing and such other relevant mechanisms. The value of the guidelines and the means by which their universal implementation can be achieved were assessed at the first two space debris congresses held in Montreal and Cologne in 2009 and 2010 respectively.

A common significant feature of the various space debris mitigation guidelines is that they all focus on, and emphasize the mitigation (or reduction) of the rate at which *new* pieces of space debris are generated during the conduct of space activities. However, the growing consensus among experts in this field suggests that, in order to really protect the space environment and guarantee the long-term viability of mankind's exploration and use of outer space, an active process for the removal of *existing* pieces of debris from space – space remediation – is required in addition to the mitigation efforts, in view of the massive amount of debris already in existence in outer space. Closely related to space debris remediation is the concept of on-orbit servicing of satellites. The argument is that if space objects that have malfunctioned or expended their fuel supply could be serviced and brought back into operation while in orbit, then this would enhance their maneuverability and forestall their abandonment thereby reducing the rate at which space debris is created.

Active space debris remediation will require the development of technologies that will enable the return to earth (or disposal by other means) of pieces of space debris in a voluntary and controlled manner. Presently, such technologies are only just emerging and they include: (1) using Ground-Based Lasers (GBLs) to fire pulses at pieces of debris in order to quickly move them into orbits where the pull of gravity will facilitate their

eventual decay and de-orbit; (2) designing Solar sail arrays (or devices) that would robotically attach themselves to larger pieces of space debris in low earth orbit in order to facilitate their decay over time; (3) deploying tethered nets around smaller pieces of space debris in order to speed up their rate of decay and de-orbit; (4) spraying frozen gas mists into low earth orbits from specially deployed satellites for the purpose of gathering up and bringing down smaller pieces of orbital debris; (5) using specially designed technological robots to clamp onto pieces of space debris and to throw them into orbits where their rapid degradation will be guaranteed; and, (6) shooting very sticky adhesive balls composed of substances such as resins or aerogels unto larger pieces of debris so as to alter their orbits and eventually bring them into orbits where they will rapidly decay.

On-orbit servicing of satellites will, on the other hand, require the development of advanced technologies that will enable specially designed service module spacecraft to dock with, and carry out repairs or refueling on, malfunctioning or otherwise disabled satellites in orbit. Although these technologies are still in a very nascent stage of development, contracts are already being signed for their implementation. It has been reported, for instance, that Canada's Department of National Defence (DND) has entered into a contract with MacDonald, Dettwiler and Associates (MDA) for the latter to provide operation and maintenance support for DND's yet to be deployed Sapphire Satellite system. As conceived, the Sapphire system will consist of a space-based sensor that is intended to provide space situational awareness of objects in deep space from 6,000 to 40,000 km from Earth, and to also provide timely relevant and accurate tracking data on Earth-orbiting objects in space. A similar contract has been entered into between MDA and Intelsat.

The implementation of the concepts of active space remediation and on-orbit servicing of satellites raises a number of technical, economic, strategic, legal, institutional and regulatory challenges that must be addressed at the very outset in order to ensure their continued feasibility. First and foremost, the issue of how to precisely define what constitutes an object of space debris for purposes of removal ought to be urgently revisited. It is significant to note in this regard that the existing regime of international space law consisting primarily of the provisions of the five space treaties adopted under the auspices of the UNCOPUOS does not address or define space debris. Indeed, the definitional problem envisaged in the active removal of space debris has its roots in the provisions of these treaties. According to the currently applicable law, any object that is launched into outer space is a "space object", and the appropriate state (being the launching state or the state of registration of the object as the case may be) is obliged to maintain continuing supervision and control over the object as long as it remains in

outer space. Beyond continuing supervision and control, the treaties are silent as to the ownership status of such space objects, particularly when they have been apparently abandoned in space by the appropriate state thereof following their failure or at the end of their useful life. The issue becomes even more complicated when such space objects disintegrate into smaller components while in outer space. Such complications are attributable to the difficulty in identifying whom the appropriate state(s) are in order to obtain their consent for removal. Some international consensus needs to be achieved on this issue even before considering the technical viability of the emerging remediation and on-orbit servicing technologies.

Secondly, it is not farfetched to envisage the multiplicity of responsibility- and liability-related concerns that would arise in the course of the proposed implementation of the two concepts. Thus, for instance, there will be immense liability implications not addressed by the existing regime of international space law if, in a state's unilateral effort to remove from space or service its own space object in situ, a functional space object launched and operated by another state is instead inadvertently damaged or plucked from its orbital location and brought to the earth undamaged. In the latter situation, it can be argued that the liability provisions of the current regime would not apply in such a situation since, strictly speaking, no damage has been caused in outer space, in the air space or on the surface of the earth. This example underscores the undeniable fact that during the era in which the current regime of space law was promulgated, it was impossible to predict what would happen in the future and make specific rules addressing futuristic space applications and their unique liability implications. Accordingly, the existing regime only provides a broad flexible framework that allows for the development of specific rules as and when needed. Specific rules on responsibility and liability in connection with the conduct of space debris remediation and on orbit servicing activities are obviously required at this stage.

Closely related to the responsibility and liability concerns is the question of what institutional or organizational framework would best serve the needs and aspirations of the global space-faring community vis-à-vis space debris remediation and on-orbit servicing of satellites. Stated specifically, the issue turns on the type of entity that could be empowered to optimize the development of the emerging technology and its actual use in the removal of space debris from earth orbit or servicing in situ. A number of options could be considered, each with its unique strengths and weaknesses. Existing United Nations Agencies such as the International Telecommunication Union (ITU), the International Civil Aviation Organization (ICAO), the International Atomic Energy Agency (IAEA), the UN Institute for Disarmament Research or the UN Office for Outer Space Affairs (OOSA) could be given the international mandate to undertake this task.

Alternatively, an international intergovernmental space debris removal organization, modeled along the lines of Intelsat or Arianespace could be established by agreement between states and entrusted with the performance of this task. Various other alternatives need to be explored.

In view of all the foregoing, it is abundantly clear that we are at the threshold of a new epoch in which preservation and restoration of the environment of outer space as opposed to its indiscriminate use is increasingly becoming the prevailing order of the day. Given the numerous concerns envisaged in the active removal of debris from outer space, it would seem that the best means of achieving some international consensus on a way forward would be the negotiation and adoption of an international treaty specifically addressing all aspects of environmental preservation and restoration in space. Such a treaty would, as a matter of necessity, focus both on preventing (or at least reducing) the generation of new pieces of space debris and, as well, on the remediation or removal of existing pieces of debris from space.