

**Technical presentation on
International Perspectives on Rendezvous and Proximity Operations in Space and Space Sustainability
Given at the United Nations Committee on the Peaceful Uses of Outer Space
Scientific and Technical Subcommittee
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**Brian Weeden, Technical Advisor
Secure World Foundation**



Thank you Mr. Chairman. Distinguished delegates, it is my privilege to have the opportunity to speak to you today regarding an emerging topic relevant to the work of this committee and the efforts of Secure World Foundation (SWF) over the last two years to begin a dialogue on some of the challenges this topic presents to space sustainability, security, and safety.

- RPO have been part of human spaceflight space activities since the very beginning
 - Apollo Lunar orbit rendezvous
 - Transfer of astronauts/cosmonauts to Salyut, Mir, and Skylab
 - Assembly of the International Space Station
- Over the last decade, these traditional RPO activities have been joined by a new category not involving humans
 - Satellite formation flying disaggregated constellations
 - On-orbit satellite servicing (OOS)
 - Active Debris Removal (ADR)

Rendezvous and proximity operations (RPO) are not new to space activities. They have been a part of human spaceflight since the very beginning of the Space Age. RPO activities involve the maneuvering of two or more space objects close to each other, opening up the opportunity for interactions between those objects. Lunar orbit rendezvous was critical to enabling the Apollo astronauts to land on the Moon. Rendezvous and docking is necessary to transfer astronauts to and from space stations and space labs, and was used to construct the International Space Station. Dozens of such RPO activities have been conducted by several spacefaring countries over the last sixty years.

However, over the last decade these classical RPO activities have been joined by a new category of RPO that does not involve humans. These new activities include satellite formation flying, on-orbit satellite servicing and refueling, and some of the proposed methods for actively removing space debris from orbit.

“New” RPO Activities Over Last Decade

- 2005: NASA DART spacecraft
 - Autonomous rendezvous with dead MUBLCOM satellite, ended up “bumping” it on accident
- 2005: U.S. Air Force XSS-11
 - Autonomous rendezvous and inspection of “several US-owned space objects near its orbit”
- 2007: DARPA Orbital Express
 - Demonstration of on-orbit servicing and refueling technologies involving RPO
- 2010: Swedish Space Corporation PRISMA
 - Two microsatellites demonstrating formation flying & rendezvous
- 2010: Chinese SJ-12
 - Rendezvous with SJ-06F for unknown reasons (probably inspection)

This slide presents a list of some of the major activities of this new category of RPO that have been carried out over the last decade. Most of these are technology demonstration activities that were conducted by a governmental organization as part of a process to develop specific capabilities. These capabilities range from the ability to autonomously detect, track and rendezvous with another spacecraft, conduct on-orbit inspection of space objects to look for the causes of malfunctions and anomalies, demonstration of on-orbit refueling and replacement of spacecraft parts, and demonstration of the ability of two objects to autonomously maintain a precise formation in space.

Planned Future ADR and OOS Activities

- **DARPA Phoenix**
 - Robotic rendezvous with dead communications satellites in GEO graveyard & recycling of large apertures into new communications satellites
- **Vivisat Mission Extension Vehicle (MEV)**
 - Robotic rendezvous and docking with active satellites in GEO belt for life extension, maneuver, or disposal services
- **StarTech ElectroDynamic Debris Eliminator (EDDE)**
 - Robotic vehicle moving up and down in LEO removing large amounts of small debris over several years
- **Swiss Space Center CleanSpace One**
 - Cubesat designed to remove another cubesat from orbit

This slide includes a list of some of the planned future RPO activities specifically for either on-orbit satellite servicing (OOS) or active removal of space debris (ADR). These include an effort to develop a robotic spacecraft that can recycle components from dead satellites into new satellites, a spacecraft that can dock with a commercial communications satellite to extend its lifespan, a spacecraft that can maneuver throughout low Earth orbit (LEO) to remove significant amounts of small space debris, and a cubesat designed to remove another cubesat from LEO.



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The Common Thread

- Three characteristics of these new activities
 - Involve two (or more) unmanned spacecraft
 - Occur in orbital regions above the traditional human spaceflight zone (below 500 km)
 - Include private sector actors instead of only governments

- They pose some significant legal and policy challenges
 - On-going national oversight of private sector activities
 - Liability, safety
 - Opportunity for mishaps, misperceptions, and mistakes
 - Will they be a positive or negative contribution to space sustainability?

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All of these recent and proposed activities share three common characteristics. They involve two or more unmanned spacecraft, they occur in orbital regions above the traditional altitude for human spaceflight activities (typically below 400 kilometers), and they include private entities in addition to or instead of government entities. As a result, these activities present significant legal and policy challenges in addition to the technical engineering challenges. These non-technical challenges include national mechanisms for on-going oversight of private sector activities, concerns about the liability and safety of RPO activities, and increased opportunity for mishaps, misperceptions, and mistakes.

These future RPO activities, if conducted in a responsible manner, could be a positive contribution to the long-term sustainability of outer space activities. On the other hand, if conducted in an irresponsible manner, the same activities could have negative consequences for space sustainability. Thus, we believe that RPO are an important topic for this Committee and other forums to address in the coming years.

Over the last two years, Secure World Foundation has undertaken a significant effort to begin a discussion of how to manage these activities in a responsible and sustainable manner. Throughout 2012 and 2013 we worked with a variety of partners to organize a series of international events that focused on the RPO aspects of ADR and OOS. These events were international and multi-stakeholder in nature and involved a mix of public conferences and private workshops.



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Promoting Cooperative Solutions for Space Sustainability

Our Contribution

- SWF organized a series of events in 2012 and 2013 to further discussion and investigation of these issues
 - Focus on active debris removal (ADR) & on-orbit satellite servicing (OOS)
 - International and multi-stakeholder in nature
 - Mix of public conferences and private workshops
- Three main goals
 - Enhance public and international awareness of planned ADR and OOS activities
 - Engage stakeholders in a dialogue on addressing some of the main legal and policy challenges these activities pose
 - Bring together those in the private sector planning these activities with those in government creating policy and law

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These events were organized with three main goals in mind: to enhance the public and international awareness of planned and potential future ADR and OOS activities; to engage stakeholders in a dialogue on addressing some of the main legal and policy challenges these activities pose; and to bring together those private sector actors planning these activities with those in government creating policy and law.

- June 2012, Washington, DC
 - SWF participated in the satellite servicing conference and workshop organized by DARPA
 - International participation, broad examination of planned projects and key issues
- October 2012, Brussels Belgium
 - SWF and Ifri co-organized public conference on OOS and ADR
 - European perspectives, focus on ADR
- November 2012, Washington, DC
 - SWF organized scenario-based workshop
 - Brought together commercial sector with government regulators and policymakers
 - Identified several gaps between existing regulation/licensing and planned private sector activities

The first events were held in Washington, DC, in June 2012. SWF participated in a public satellite servicing conference and private workshop organized by the Defense Advanced Research and Projects Agency (DARPA). These events focused on a broad examination of planned OOS projects and key issues from a variety of international participants.

In October 2012, SWF partnered with the Ifri, a Paris-based think tank, to organize a public conference in Brussels, Belgium. The conference focused on European perspectives on RPO issues and in particular the challenges involved with ADR.

In November 2012, SWF held a private workshop in Washington, DC, to discuss future ADR and OOS scenarios. The workshop brought together private sector representatives with government regulators and policymakers and identified several gaps between existing national regulatory and licensing mechanisms and planned future private sector activities.



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Events

- February 2013, Singapore
 - SWF and Singapore Space and Technology Association (SSTA) co-organized public conference and private workshop on OOS and ADR
 - Asia-Pacific perspectives, focus on security and TCBMs
- September, 2013, Beijing
 - Paper presentation at the 2013 International Astronautical Congress
- November 2013, Washington, DC
 - Capstone panel discussion


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In February 2013, SWF partnered with the Singapore Space and Technology Association (SSTA) to hold both a public conference and a private workshop on OOS and ADR. These events focused on an Asian-Pacific perspective on these issues, as well as on transparency and confidence building measures (TCBMs).

In September 2013, SWF presented a paper at the 2013 International Astronautical Congress in Beijing, China, that summarized the main conclusions from these activities and provided some recommended steps going forward. Finally, in November 2013, SWF held a capstone panel discussion in Washington, DC, that reiterated the findings presented in the IAC paper and also included perspectives from DARPA on the Phoenix program.

 **Major Themes**
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- Current international legal and policy framework does not forbid ADR or OOS, but does not specifically address several areas
 - ADR and OOS activities are in a legal/policy/regulatory “grey area” with lots of uncertainty
 - Uncertainty is an obstacle to investment and innovation
- Hypothetical discussions of the legal and policy challenges are only useful only to a point
 - Useful for framing issues and discovering gaps
 - Have limited value for figuring out how to address those gaps
 - Targeted discussions focused on specific, real-world examples or projects are more useful


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Several key themes emerged from the discussions and presentations across all of these events. First, while the current international legal and policy framework does not forbid debris removal or satellite servicing activities, it also does not address some of the key issues. Several aspects of these activities are in a legal, regulatory, and policy “grey area” with significant amounts of uncertainty. This uncertainty is an obstacle to innovation and investment in these capabilities that many see as essential to the long-term sustainability of space activities.

Second, purely theoretical discussions of potential legal and policy challenges regarding debris removal and satellite servicing are useful but have their limits. They are useful for framing issues and discovering potential gaps, but are of limited value for figuring out how to address those gaps. Targeted discussions focused on specific, real-world examples or projects are more useful for addressing specific areas of concern.



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Major Themes (2)

- **Transparency and Confidence Building Measures (TCBMs) are crucial for safety, security, and sustainability**
 - Need to improve Space Situational Awareness (SSA) for all space actors
 - Need to enhance coordination between space actors
- **Important to develop norms of behavior**
 - Improving safety (best practices, sharing of lessons learned)
 - Minimizing the opportunities for misperceptions, mishaps & mistrust
- **Need to involve all the relevant stakeholders in developing national and international regulatory mechanisms, TCBMs, and norms**

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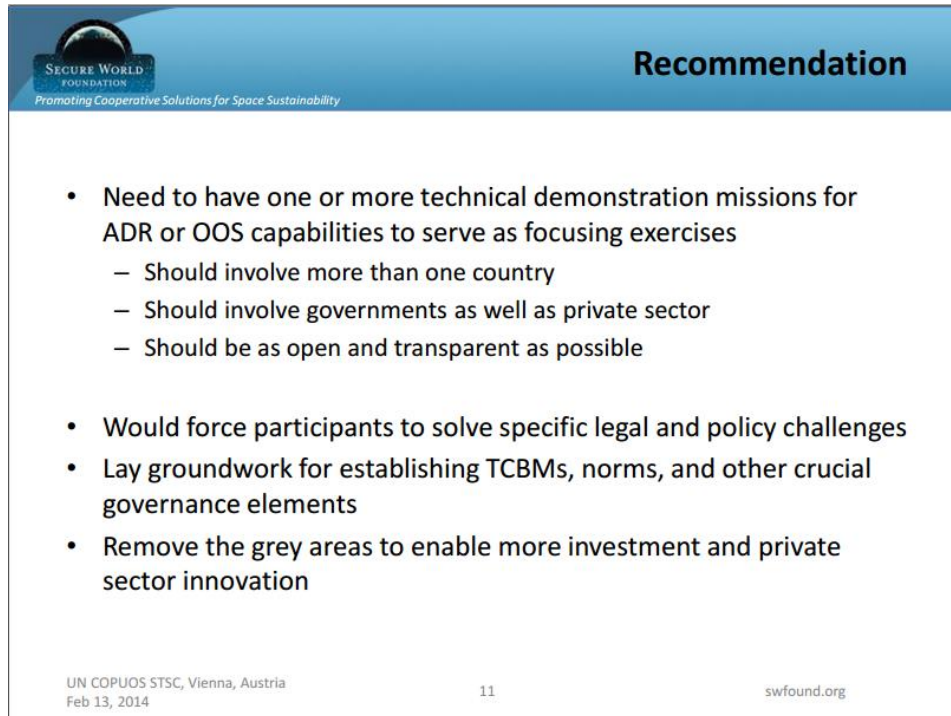
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Third, the discussions reinforced the importance of TCBMs for security, safety and sustainability. Of particular interest is improving space situational awareness (SSA) for all space actors as well as the need to enhance coordination between space actors. At the moment, only a few States have any significant SSA capabilities, and it is very difficult for anyone to monitor certain types of ADR and OOS activities from the ground.

As part of TCBMs, participants in our discussions felt strongly that developing norms of responsible behavior were crucial to improving safety and minimizing the opportunities for misperceptions, mishaps, and mistrust. Developing best practices and sharing of lessons learned were highlighted as important building blocks for responsible behavior.

Finally, there was consensus among all those involved on the need to involve all relevant stakeholders in the process of developing norms, best practices, and international and national regulatory mechanisms. At the national level, there needs to be dialogue between various government agencies with competence for space activities and between the government, the private sector, and civil society. This process needs to happen as early as possible in the planning stage. At the international level, there needs to be an opportunity for emerging and

developing space States to participate, should they so choose, in the development of norms and best practices. This would significantly increase the legitimacy of any resulting norms and also provide guidance to States in the process of developing their national policy and regulatory mechanisms.



Recommendation

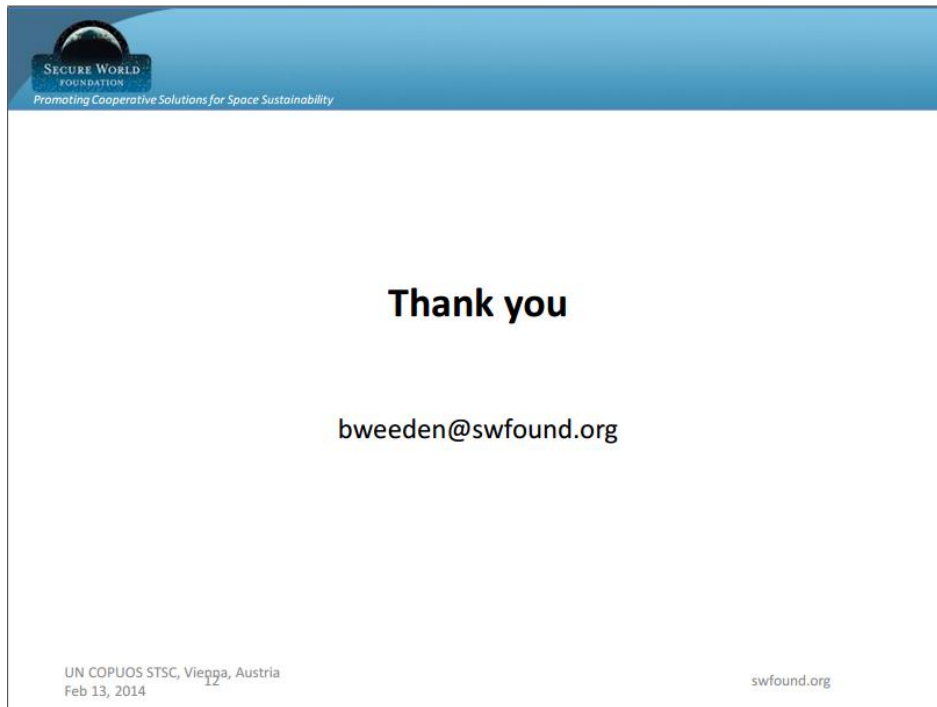
- **Need to have one or more technical demonstration missions for ADR or OOS capabilities to serve as focusing exercises**
 - Should involve more than one country
 - Should involve governments as well as private sector
 - Should be as open and transparent as possible
- **Would force participants to solve specific legal and policy challenges**
- **Lay groundwork for establishing TCBMs, norms, and other crucial governance elements**
- **Remove the grey areas to enable more investment and private sector innovation**

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Overall, many participants in these various events highlighted the importance of one or more technical demonstration missions for resolving the specific legal and policy challenges raised by ADR and OOS. Ideally, such demonstration missions would involve more than one country and both government and private sector actors. The demonstration missions would provide concrete examples of these activities and opportunities for the relevant actors to solve those challenges. In doing so, the technical demonstration mission would lay the groundwork for establishing the mechanisms, TCBMs, and norms necessary for future RPO to occur in a safe, secure, and sustainable manner.



In closing, there was consensus among the participants that ADR, OOS, and other types of emerging RPO activities will be a key part of future human activities in space. Addressing the legal and policy challenges that these activities pose is critical to not only enabling them, but also ensuring that they contribute to the safety, security, and long-term sustainability of the space activities.

Thank you for your time and consideration.

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