



The Secure World Foundation (SWF) co-hosted a discussion of the links between space situational awareness (SSA) and commercial rendezvous and proximity operations (RPO) and on-orbit satellite servicing (OOS). This was held at the sixth annual AMOS Dialogue, a small, invitation-only workshop co-hosted by the Maui Economic Development Board (MEDB) and SWF during the 2018 Advanced Maui Optical and Space Surveillance Technologies (AMOS) Conference, held on the Hawaiian island of Maui, Sept. 11-14, 2018.

The goal of the AMOS Dialogue series is to facilitate discussion among key stakeholders in SSA, thereby promoting greater collaboration and cooperation to enhance SSA for safe and responsible space activities. To accomplish this, the Dialogue brings together representatives from current and future SSA programs and initiatives around the world with a variety of end users and stakeholders so that they may exchange information and views in a not-for-attribution setting.

The topic of the 2018 AMOS Dialogue was the connection between SSA, RPO, and OOS. The group examined the new RPO technologies and capabilities being developed to support commercial OOS, and how they impact current SSA capabilities and practices. The group also debated what role SSA should play in the development of international standards for RPO and OOS, how SSA capabilities should evolve to support future RPO and OOS missions, and how SSA and RPO impact the development of future space traffic management regimes. The discussion was not for attribution.

The main takeaways from the Dialogue were that licensing for on-orbit activities is still a work in progress. The United States recently changed its licensing rules to allow [non-Earth imaging](#) (NEI), a key part of RPO and OOS, but licensing and oversight for other aspects of RPO and OOS are still being worked out. More work needs to be done to define the SSA needed to support commercial RPO and OOS, which will vary depending on the orbital regime and what the specific activity is that is being monitored. Discussions have started to be developed on industry best practices and standards for OOS/RPO, but as of yet have not incorporated a lot of the historical lessons learned from military RPO due to classification concerns. There was also agreement on the need to encourage and empower multiple private sector and governmental data providers to increase SSA capabilities, but also a recognition that the SSA world will need to find ways to deal with the “big data” challenges stemming from greatly increased SSA capabilities.

The first section of this report summarizes previous AMOS Dialogues in order to see how the conversation has evolved since SWF first started co-hosting these discussions in 2013. The second section of this report describes the discussion in the 2018 dialogue and how there are still many questions to be answered about what kind of SSA is needed for RPO/OOS activities to be successful and what role the government should be playing in providing that SSA.

## **PREVIOUS DIALOGUES**

In September 2013, the first AMOS Dialogue in Maui convened representatives from the current SSA sharing programs and initiatives around the world and a variety of end users and stakeholders. Topics addressed included the current status of SSA programs and sharing initiatives, identification of areas for further improvement or collaboration, gaps in coverage or meeting end user needs, and future steps.

Main takeaways from the discussion include that the space community needs to broaden its view not only of what SSA encompasses, but also of how to engage in burden-sharing and division of labor to arrive at a more complete and accurate SSA. No single entity, government, or company can provide the full SSA picture on its own. As the community works together toward improved SSA, it is also necessary to think about what comes next, which will require incorporating non-traditional partners and emerging space actors.

In February 2014, the first AMOS Dialogue in Japan was organized to foster dialogue among space situational awareness (SSA) providers and end users, thereby promoting greater collaboration and cooperation toward SSA-enabled safe and responsible space operations. The workshop convened representatives from the current SSA sharing programs and initiatives around the world with a variety of end users and stakeholders. Topics addressed included current status of SSA programs and sharing initiatives, identification of areas for further improvement or collaboration, gaps in coverage or meeting end user needs, and future steps.

In September 2014, the second AMOS Dialogue in Maui had two sessions that looked at the relationship between government and private sector SSA initiatives. The first session focused on current and near-term future government and commercial SSA initiatives, while the second session focused on how to improve collaboration between governmental and non-governmental SSA initiatives.

The main takeaway from the discussion was that it would be very useful to have a standard list of different types of SSA data or information that could be shared. This would help overcome the confusion caused by different people using SSA sharing to talk about sharing different things, such as raw data, sensor observations, element sets, or finished data products. There was also strong belief from many present that there needs to be a basic, publicly available set of SSA data that can be used to improve safety and conduct scientific research on the space environment.

In September 2015, the third AMOS Dialogue in Maui focused on Space Traffic Management (STM), and specifically how to build upon the current SSA and conjunction assessment practices coordinated by the U.S. military towards a more robust system that has greater civil agency and international involvement and data sharing between governments and satellite operators.

Main takeaways from the discussion include a strong focus on norms and the important role that they play in establishing a stable and predictable space environment. Also crucial is the amount of data available to all actors in space, since it is important to get a baseline level of information to all satellite operators. The emerging commercial presence is going to have to be a big part of the equation. The question of coordinating national regulations with international efforts was

raised, as was the need to internationalize the conversation to include the BRICS (Brazil, Russia, India, China, and South Africa) at future Dialogues. Finally, it was agreed that there needed to be better engagement between the small satellite community and the SSA community to help correct what was perceived by many as a lack of communication and shared knowledge between the two groups.

In September 2016, the fourth AMOS Dialogue in Maui discussed the SSA challenges posed by small satellites, with the goal of identifying steps that can be taken by both small satellite operators and SSA providers to improve the detection, tracking, and identification of small satellites to enhance conjunction assessment and collision avoidance.

Main takeaways from the discussion include the concern of long-term effects of smallsats on SSA capabilities and analysis, the equal concern about unnecessarily limiting smallsats through onerous regulation, and worries about SSA sharing in general that also apply to smallsats.

The topic of the 2017 AMOS Dialogue was the future of SSA and how it might support future space traffic management (STM) regimes. The group discussed four theoretical scenarios for future STM regimes, how current trends compare with the scenarios, implications for governments and commercial operators, and policy considerations. The discussion supported a study the Science and Technology Policy Institute (STPI) was doing for the U.S. government. USG wants industry to come forward with best practices and standards.

Main takeaways were that the current USG-centric SSA system, followed by a series of national SSA systems, were perceived as being most realistic, but a globally-governed SSA system was thought to be most desirable. Yet many participants did not see the U.S. government entirely leaving SSA. Trust was an issue that was raised again and again, as well as the technical challenges of sharing data. Also coming up repeatedly was the need for guidance at the international level, not necessarily enforcement, which would have to be done at the national level.

## **2018 AMOS DIALOGUE: THE LICENSING PROCESS AND SSA**

The 2018 Dialogue started off with a discussion of U.S. regulatory reform, civil SSA, and satellite servicing. This conversation gave an overview of U.S. government efforts to reform and modernize oversight of commercial space activities and develop civil SSA capabilities and how they interact with commercial satellite servicing.

The discussion then segued into an overview of several different commercial OOS missions currently being planned or developed, and how they plan to conduct RPO. Finally, it led to a discussion of how existing government and commercial SSA capabilities and STM oversight frameworks can support planned commercial OOS and RPO activities, and what future SSA capabilities and STM frameworks might need to be developed.

Overall, it was felt that it is better to have industry-level activities to develop best practices and norms than company-level activities, as it is to the overall commercial sector's benefit to be involved in conversations about what is considered to be good behavior on orbit. The private

sector participants noted that they do not want a permission-less environment: they want some degree of regulatory certainty from governments to provide reassurance to investors and insurers and to create a predictable legal environment.

When it comes to innovative new commercial activities, it was pointed out that the U.S. government wants industry to come forward earlier in their process about new ideas and new concepts, as that would incentivize the government to start thinking about it would provide oversight, and the more time it has to consider these new concepts, the better.

A topic of discussion was whether restrictions in U.S. licenses would drive companies overseas. It was commented that companies are still motivated by patriotism and potential U.S. government business, both of which are strong incentives to keep business within the United States if the licensing regime allows. While the U.S. licensing process currently requires multiple agency visits - to the FCC for a spectrum license, to the FAA for launch operations and payload review (if launching on a U.S. launch vehicle), and/or to NOAA if the sensor is capable of imaging Earth - the United States is hoping to create a one-stop shop for regulations in the near future.

One area that has undergone significant change in the United States is non-Earth imaging (NEI). It was noted that the first license application that prompted rules about NEI was from a university that wanted to use its own cubesat to image another of its own cubesats. The United States used to prohibit licensees from performing space-to-space remote sensing, but recently changed that to allow NEI with some conditions. U.S. companies are now allowed to do space-to-space imaging of better than 3x3 pixels resolution with consent of the owner of the object being imaged. For resolutions lower than 3x3 pixels, consent is not needed but the data can only be distributed if it matches an object in the public satellite catalog maintained by the U.S. military.

In discussing the role of SSA to support commercial RPO activities, it was noted that kind of SSA that is needed is different depending on the orbital regime and what the activity is that is being monitored. The orbital environment is different in LEO than in GEO, and it is a mistake to treat the data that is needed for each orbital regime as the same. SSA in general is currently not providing sufficient information to be able to price insurance or investment based on risk, but RPO might be one area where you do have enough SSA to be able to estimate risk. However, participants did not see the investment in the science to help develop the information foundation for such a risk assessment yet. Additionally, it was noted that space insurance is heavily reactive, largely because there isn't really a claim history to use, and insurers are still competing on price and "following" the data. It was also noted that cameras are good for close-up inspection but not for space surveillance, so sensors for one capability don't always automatically track for the other one.

International aspects of space-to-space imaging came up as a possibly sticky area in the future. For example, satellites conducting RPO and OOS will come across satellites of other countries and companies and likely image them, even if accidentally. There needs to be a discussion about how to handle that data collection and dissemination, and whether there needs to be notification or consent procedures.

## **BEST PRACTICES FOR RPO/OOS**

The group agreed that best practices should not be based on one company or country's capabilities, but currently the bulk of RPO and OOS missions have been done by the United States. Basing best practices on just U.S. practices could lead to problems later on, as other countries may not have the same capabilities but will be held to the ad hoc standards.

The U.S Department of Defense (DoD) has a lot of experience and lessons learned in RPO, but also a lot of restrictions preventing them from sharing those lessons publicly or with industry due to classification. The participants discussed how that was a major challenge that needed to be overcome, as those experiences should be part of the conversation to show safe and responsible actions. Some participants remarked that the DoD continues to act like its satellites are operating in a vacuum, but in reality they are being observed and they need to accept that. One complication that was raised is that DoD's mission has an inherently military focus, which means the best practices they develop might not always apply to commercial activities.

The conversation then turned to the level of SSA capabilities needed to support RPO/OOS. The participants debated whether the situation will drive governments to improve their SSA offerings, or whether RPO/OOS operators will have to purchase commercial SSA. In either case, legal disputes are likely to arise from commercial RPO/OOS activities and answering those will require much bigger quantity and better quality of data than currently exist. From a government oversight perspective, there are also questions about how safety requirements would feed into government acquisitions systems and how to confirm control and safety, which might be different in far field vs near field. Participants noted that the current restrictions on NEI might hinder the commercial sector's ability to fill in governmental SSA gaps.

## **DATA, DATA, DATA**

Overall, there was agreement on the need to encourage and empower multiple data providers. As one participant commented, eyes really do need to be everywhere. This is important because no one should believe any one single source of data, not even the DoD catalogue. It also lead to a larger conversation about how data can make RPO/OOS transparent and predictable. The participants discussed what the information requirements are for doing so, such as the level of fidelity needed to determine near misses or other anomalies, and how to encourage public reporting of mishaps in a responsible manner. Even more specifically, is observation of a mishap proof that best practices are not being followed? It was noted that in other domains, these issues have taken decades to sort out. On-site inspections are a crucial part of chemical/nuclear safety: is there a need for a space equivalent? Participants commented that it also comes down to what you are trying to regulate, whether that is safety, control of an object, or verification of following the results. The SSA data that is required for safety is different from data required to verify success of RPO activities. Finally, it is not just a matter of having data but also being able to analyze and make use of that data.

The group also noted that end of life activities are important as well in discussing standards for commercial RPO and OOS. There is a line where de-orbiting makes sense, but after that, what?

What is the guideline for proper disposal for the no-man's land between LEO and GEO? What are the risks and how should they inform the licensing procedures? And what are the SSA needs to verify that the end of life is being performed according to the standard or licensing requirement?

At the end, the group discussed how the increase in SSA capabilities being driven by commercial RPO and OOS will also need to include more focus on "big data" and analytics. The SSA world will need to figure out how to manage a growing amount of data from disparate sources and process it to provide useful information. In doing so, the SSA sector might find value in looking at how other fields have tackled similar challenges.