2020 AMOS Dialogue

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Since 2013, Secure World Foundation (SWF) has partnered with the Maui Economic Development Board (MEDB) to hold an invite-only workshop that promotes collaboration and cooperation on space situational awareness (SSA). This year's Dialogue took place virtually on Sept. 21, 2020, following the 2020 Advanced Maui Optical and Space Surveillance Technologies (AMOS) Conference. 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 2020 AMOS Dialogue discussed data fusion and other science and technology (S&T) priorities for improving SSA and space traffic management and how those priorities can be addressed through policy and international collaboration. The discussion took place under Chatham House Rule: topics addressed could be used in materials prepared by SWF and/or MEDB in their future endeavors but would not be attributed to any given speaker.

The major takeaway from this year's Dialogue was that data fusion technologies need to be a key area of S&T focus. Increasing autonomy of satellites will be a significant challenge, particularly as more of them start using constant thrust propulsion that pose complications for traditional astrodynamics propagation. For remediation of space debris, it is clear that the government should be taking the next steps to fund ADR technology development and put in place policies to enable it. The space community collectively has spent a lot of time thinking and admiring the problem, but not enough moving ahead. Getting a piece of the solution is better than waiting to get the whole problem solved, so we must move along to experimentalism vs staying stuck in analysis.

The Dialogue began with a discussion of recent steps taken by the U.S. Department of Commerce (DOC), which is striving to implement the national space traffic management policy called for in Space Policy Directive (SPD)-3 without imposing burdens on commercial

innovation. One of the things they are considering is what lessons can be learned from other fields' attempts to manage data, such as remote sensing or weather data. As well, research and development (R&D) was identified as a key part of finding research gaps. There is an interest in putting commercial data into the Open Access Data Repository (OADR) which DOC is putting together to ease the sharing of SSA data.

Questions posed to the group to kick off the conversation about science and technology priorities for SSA and STM included how should SSA data be formatted, and how can the SSA community be incentivized to use standard formats. How can transparency be encouraged? What requirements are needed to build an STM system? How can we work toward technology and policy levels? What can be learned from data management in other fields? How does the evolving relationship between the Space Force, DOC, and industry shape this?

It was noted that there is not much R&D funding (academically) for SSA. Orbital debris is a critical challenge and needs more R&D investment That includes R&D into better methods to track, identify, and characterize debris objects. Another R&D challenge is reducing the uncertainty of element sets and being able to accurately track small objects that are currently untrackable.

There also needs to be more R&D into ADR (remediation) technologies, which is made harder by the lack of market for debris remediation. For remediation, there are different types possible (small/large pieces of debris, different orbits, different contact methods, etc.) as well as questions about. the role of the private sector versus the government in doing R&D for remediation and how to increase the TRL of promising techniques.

It was pointed out that this challenge is just getting increasingly complicated with the growth of active satellites on orbit. One participant noted that there were 1000 more active satellites at the 2020 AMOS Dialogue than there were at the previous year's meeting. This is a strong impetus to make those hard decisions in R&D.

Other participants noted that it was easy to focus on sensors because they are hardware, but over time data will become a commodity and the focus should also be on fusion/analysis. When discussing data fusion, there is a certain level of uncertainty there. It was argued that we need to get away from maneuver plans being proprietary and that data fusion needs to happen at the observations level rather than at the element set level because of the challenges in understanding the uncertainty. It was asserted that the key for data fusion comes from the standards world.

The assertion was made that whatever ensemble model is used here is wrong until we can keep up with how the spacecraft are changing their thrust. Current tools use basic Keplerian laws and make predictions based on natural perturbations only. More maneuverability requires more data

and we will likely have to move to much shorter propagation/prediction times. As satellites become more autonomous, it will be harder to get insight into how satellites will respond/react.

One example given of an entity that currently fuses together data from various models is the National Weather Service (NWS). The NWS does ensemble modelling when it releases those "spaghetti" charts of tropic storm tracking. It and its international partners use 14 different models, which vary in their accuracy. Some are better at the beginning of a storm, some are better at the end; some are better over the Pacific or the Atlantic; some are better over the ocean or as you get close to shore. But they are combined together to get the best future prediction. By fusing the data but also using many different models all at once with that data, you can often get around whose data or model is the best.

There was also a comment about the time horizon for solving these SSA/STM challenges. A participant noted that we need to move from theoretical discussions to actual experiments and creating a piece of the solution instead of waiting for perfection. One participant described this as deciding to solve tomorrow's traffic problem with today (or yesterday)'s infrastructure, but we have to do so because we can't wait for more exquisite sensors.

The discussion turned to how other organizations were determining their S&T priorities. In general, it is complicated in Europe. To begin, there are different scales of national programs involved, as well as an intergovernmental organization (the European Space Agency, ESA) and a supranational organization (the European Union, EU). All these actors are in disparate areas, which makes it hard to coordinate. S&T programs are also being affected by COVID and Brexit: Europe faces a shortage of R&D funding in general.

ESA's is an R&D agency and that is currently its focus for SSA. It is looking into the quality of measurement, as it gets hundreds of conjunction warnings a day, which it needs to take seriously. There is a lot of effort associated with this, which can be overcome with models and enriched with non-surveillance information on the object itself (whether it is maneuverable or non-maneuverable, for example). In regard to active debris removal (ADR), ESA can't make it mandatory, as the technology is not there yet.

Discussions moved on to the EU, which files its efforts under research and innovation. 60% of the budget is dedicated to this. The EU has about 150 satellites they follow, and data fusion is a hot topic, as they need to share information for surveillance and tracking which comes from different sources of data.

Another international organization brought up was the Inter-Agency Space Debris Coordination Committee (IADC). It looks at how different agencies evaluate/assess compliance and how they treat uncertainty.

In regard to automated collision avoidance, it was brought up that machine learning might be applied there and that experience outside the space domain might be helpful for ideas that are promising.

The question was raised about which is more important, quantity or quality of data? Some argue that quality is more important. But the UK Space Agency (UKSA) found that there is a lack of observations in low Earth Orbit (LEO), as the main providers right now are government radars that are constrained. So the UK funded a commercial entity to do this.

The group also discussed complications in how to share data. How do you share data that does not demand large amounts of processing? How do you share data across different levels of sharing agreements? How do individual owners/operators like to receive data? How does classification of data affect this? It was noted that while complicated, this can be sorted out: the International Virtual Observatory Alliance (IVOA) has a set of protocols so it can share data, for example.

Participants also highlighted the importance of building debris mitigation plans into satellite mission design from the very beginning: to design for a satellite's demise, give it propulsion, etc. Another important debris mitigation step is to stop Russian and United States' upper stages from exploding. Compliance with existing mitigation requirements is crucial, as is updating space safety guidelines to keep pace with risk modeling, tracking, and characterization. There is a need for better understanding of lethal non-trackables, as well as tracking and identification of small satellites.

In discussing remediation, it becomes almost a chicken and egg issue, where legislators say the technology isn't ready, while the technologists argue that there is no legislative pull or cover for their work. The cycle can be broken by having governments fund ADR demonstration missions to raise the TRL of existing concepts. In general, governments have the responsibility to lead on this due to the lack of a clear commercial inventive. However, the commercial sector also has a role to play here as well and markets may develop over time.

We need a different mindset in how we view orbital populations. It was posited that a more rigorous job must be done of classifying types of objects and identifying behavior over time in order to understand where objects will be in the future.

Finally, it was noted that harmonization of standards (at both the commercial and government level) was happening, but there are different efforts because there is not consensus as to what those standards should be. Accordingly, the route to consensus harmonization may take a while. One encouraging note is that a lot of independent groups have similar composition, which may expedite getting to consensus somewhat. One standard that was discussed extensively was whether it would be required that satellites above 400 km can maneuver for spaceflight safety (specifically, to protect astronauts on the ISS and any other space station that might be in orbit).

About Secure World Foundation

Secure World Foundation (SWF) is a private operating foundation dedicated to the secure and sustainable use of space for the benefit of Earth and all its peoples. SWF engages with academics, policy makers, scientists, and advocates in the space and international affairs communities to support steps that strengthen global space sustainability. It promotes the development of cooperative and effective use of space for the protection of Earth's environment and human security. https://swfound.org