Summary of the 2017 AMOS Dialogue

SWF co-hosted a discussion on potential future scenarios for space situational awareness (SSA) at the fifth annual AMOS Dialogue. This small, invitation-only workshop co-hosted by the Maui Economic Development Board (MEDB) was held during the 2017 Advanced Maui Optical and Space Surveillance Technologies (AMOS) Conference, in Maui, Hawaii, Sept. 19-22, 2017.

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 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) is doing for the U.S. government. Discussion was not for attribution.

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 four different SSA scenarios given to the participants as possibilities. The third section details how the participants debated the most realistic versus the most desirable scenario; and gives the results of voting on possible scenarios at the end of the dialogue. NB: while this discussion supported work STPI is doing, the analysis and perspectives are by SWF.

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 one 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. Session 2 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 a strong opinion 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.

2017 AMOS DIALOGUE

Potential Future SSA Scenarios

The 2017 AMOS Dialogue focused on four scenarios that were created by STPI with feedback from SWF in order to highlight different potential futures for SSA and STM. The scenarios were designed to be archetypes created to generate dialogue, and were not intended to be predictive of what SWF or STPI anticipates will happen in the future. They differed by degree of government control (government vs private) and degree of internationalization (domestic vs international).

Note that for this event, a space traffic system was defined to have the following components: external environment (number of spacefaring countries and satellites); systems for data collection, data processing, and data sharing – these systems are commonly referred to as SSA; actions (decision-making and responses changes in the space environment); and oversight and coordination – commonly referred to as space traffic management.

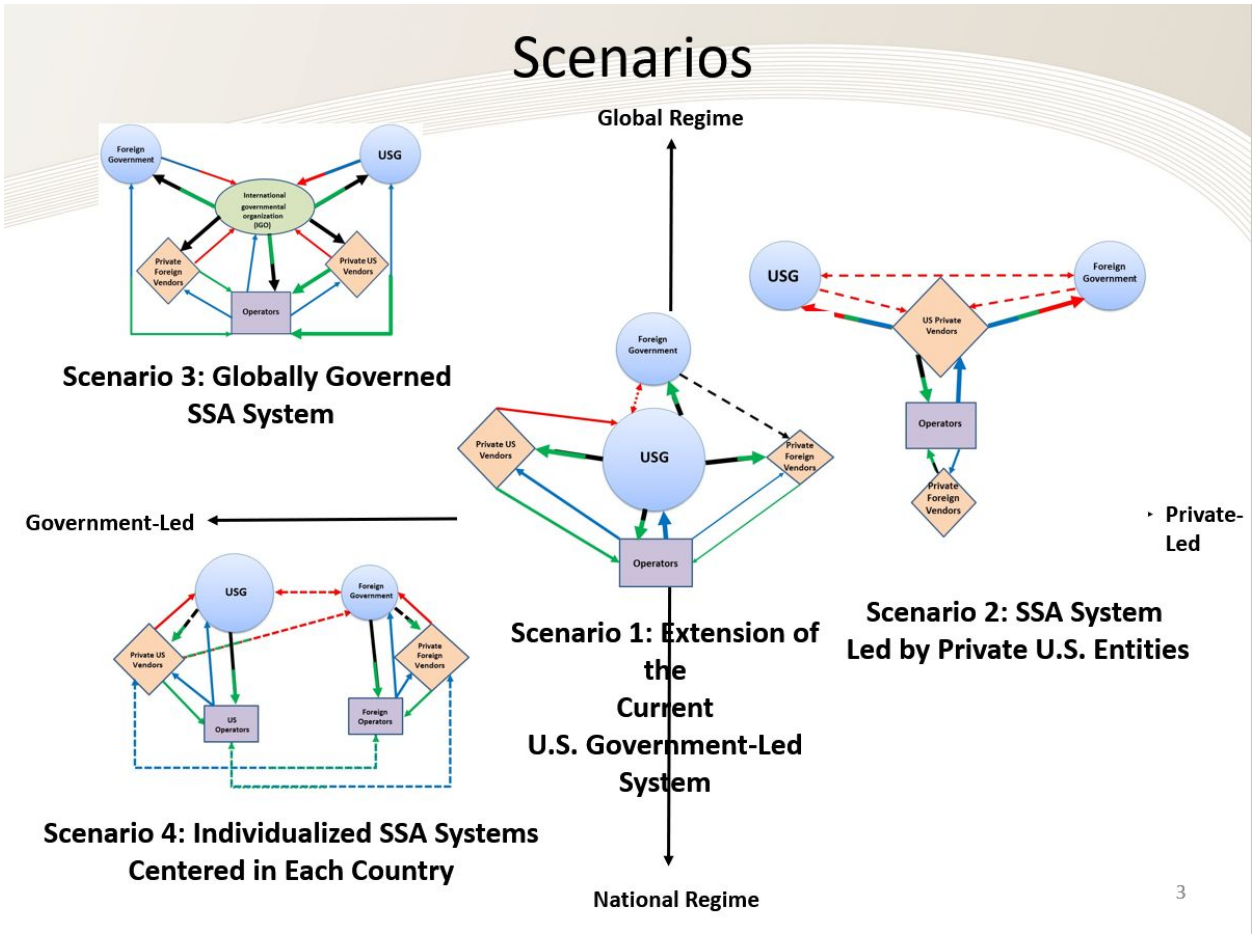

Figure 1. Scenarios used in the workshop.

Scenario 1: Extension of the Current U.S. Government-Led System

In this scenario, the United States Government (USG), through either a military or civilian lead agency, remains the primary source of SSA data and services for the global space community. USG-owned sensors would remain the primary source of data for the USG catalog, supplemented with data from private and foreign government sensors. The USG would continue issuing conjunction and collision warnings for free, as it does today.

Scenario 2: Private Sector-Led SSA System Dominated by U.S. Entities

In this scenario, a consortium of primarily U.S. companies is the primary provider of SSA data. The U.S. consortium would collect and process data and provide SSA data and services to operators and governments that are either members of the consortium or otherwise pay for information services (similar to the Space Data Association [SDA] today). The

consortium would get SSA information at all levels from mainly non-governmental providers, but also may incorporate data from governments of all participating countries. The consortium would build an in-house database and sell products and services to entities willing and able to purchase them.

Scenario 3: Globally Governed SSA System

In this scenario, the main source of SSA data is a global, government-led SSA system with centralized operations fed by government and private nodes spread worldwide. Notably, this scenario differs from Scenario 2 in that the SSA provider here in Scenario 3 is government-led, whereas the SSA system in Scenario 2 is privately led. Data collection, fusion, and global database generation in this scenario would be led by an international intergovernmental organization (IGO), such as the United Nations or International Telecommunication Union (ITU). This database would be open and transparent and all participating stakeholders would have access to the data. Operators around the world would develop their own processing and decision-making tools based on this open-source database or they would be supported by other private entities dedicated to interpreting data on behalf of operators.

Scenario 4: Many National SSA Systems

In this scenario, each government owns and runs SSA and STM systems, sharing data as they see fit. SSA would be inexpensive enough that each country can have its own system without depending on the USG or other international private or public databases. The USG catalog would contain data mostly from USG sensors, supplemented with data from U.S. private vendors. Similarly, foreign governments would use data from their own sensors or from domestic or international private vendors. The USG might still provide free services to the world similar to what it currently does; however, other countries would no longer depend on the services.

Session One: The Most Realistic Future for SSA

The conversation began with a few questions of the participants, intending to shape the discussion. Which of the scenarios is most realistic, and why? What are the technological and policy drivers for the realistic scenario to be realized? What are the implications of the most realistic scenario for foreign governments, U.S. government, private companies, international relations, and other stakeholders?

To really decide what is the most realistic future for SSA, first, the question must be asked, SSA for what and whom? It was also noted that we always need more observations. The technology is there, we just need more of it, which would allow more players to contribute even in a boutique way. In order to use SSA data for regulations, there has to be trust and confidence in data.

According to the GAO, the USG spends $1 billion/year on SSA, so that is the price to do the "gold standard" for the world, although many others noted that same or similar SSA capabilities are already offered by commercial entities for far less. The USG still needs to do it for national security needs, but it could be optimized through scenario 2 with private companies creating products and processing data.

One participant felt that the most realistic scenario is whatever takes the least amount of agreement. The transaction costs of coming to an agreement were seen as a significant barrier.

There was significant debate among participants if any one scenario was "right." Some noted that in scenarios 1 and 4, the USG would not want to give up its control of data sources. Others noted that scenarios 1, 2, 4 were most likely to arise/co-exist. For example, there could be a situation where you have USG military doing national security related SSA, while civilian or commercial entities do that for spaceflight. But what is needed for global governance was not a global system necessarily, but a regime that would set up rules for how to share data and trust each other as SSA sources. One participant noted that scenario 4 is unrealistic and unlikely, unless you have a loose definition of what counts as SSA. What do you need to have an SSA system: does one telescope count, for example? Another participant felt that none of the scenarios is the right one.

One participant commented that while scenario 1 is what we have today, scenario 4 can happen any time another country wants their own scenario 1. Not all countries will want to have their own system, so we will probably continue to see some of 1 where the USG provides the data.

It was pointed out that when discussing data-sharing, the question should be raised as to what is actually meant by that. For example, there are many more users of SpaceTrack.org than satellites on orbit, so it is probably not just operators who use or want SSA data. Who is this data going to? One speaker asserted that it is not just access to technology, but how you use it, and that there needs to be discussions about capacity-building and technical aspects of data-exchange.

One participant argued to exclude scenario 2 entirely, as STM is much more than data exchange. In regards to data sharing, Scenario 1 represents the situation we have today and they could see retaining that a little bit, combined with some aspects of scenario 4. There is a need for some sort of global vision so that something like Scenario 3 can include interests of all stakeholders and could be the way forward for management and governance. It would provide guidance, not necessarily enforcement.

Scenario 3 was argued by one participant to seem the least likely, as international agreements take forever. That would change only if there was some sort of crisis event. Another participant put it another way, in that scenario 3 seems like what ought to be. A lot of countries want to do their parts, but don't have the resources. This participant also didn't see USG ever getting to the

point where they fully trust outside information. Another participant noted that it requires an international governmental organization to direct the USG and did not see that happening. Yet another argued that scenario 3 could just be an international umbrella organization that allows meetings to take place. It wouldn't create governance – just allow for discussions. A global construct of cooperation could lead to this and it could even be a commercial-led consortium. There are discussions in Vienna about a possible version of scenario 3, but that version has fundamental flaws, namely, a lack of infrastructure and money.

There was a quick discussion about the Space Data Association (SDA). It was created because of perceived gaps in the current version of scenario 1, as it is lacking the ability to do forward-looking processing (event maneuvers). As SDA evolved, they perceived additional gaps (lack of transparency). SDA needs its SSA network to work from different sets of sensor and processes (for safety of flight). It is not really relevant to scenario 2, as AGI pulls from sensors all over the world. The operator is self-funding SSA and has a critical understanding of the processes being built, which is something that a USG-led system can't do.

One speaker noted that the SSA requirements environment is being driven by smaller and more numerous satellites; when cheaper SSA data can be accessed, it can have a huge amount of impact on the products being derived from that data. Another noted that the space environment is changing, partially due to more countries wanting to take a role in SSA (whereas they previously had relied very heavily on the United States). Europe wants to have autonomy in it in order to understand it and get more involved.

The point was raised that any SSA system would need more observations and that is simply a matter of capacity. But this additional data can contribute a lot to what is already being done for SSA. For example, some of the commercial actors are looking at doing video of GEO, something that's not being done by the USG system as part of its standard SSA system. From one participant's perspective, scenarios 1 and 4 most realistic, as their country is a large landmass with a very widespread population that depends on space capabilities. They want to contribute (4) but not be excluded by a US-led system (1).

Other countries may not trust the United States (Russia, China). We see examples of this with their creation of their own versions of space-based position, navigation, and timing (PNT) constellations (lending itself to scenario 4). Another participant countered this that while Russia and the Joint Space Operations Center (JSpOC) are not best buddies, they do have common interests in things like civilian spaceflight safety, which could lead to discussions about cooperation. Also, at the UN level, Russia has been pushing for a version of scenario 3.

At a recent U.S. military workshop, one participant noted that they were looking at non-traditional data sources, for reasons of both national security and spaceflight safety. Now there is needed an algorithm to manage new databases and so forth. The trustworthiness of

network is the question, but the speaker pointed out that there are lots of opportunities on the civil/commercial side. It was also noted that the National Geospatial Intelligence Agency (NGA) has been able to take advantage of non-traditional sources of data – why can't the rest of the USG? In some ways, we are slowly starting to see that, where the government is doing the initial investment and then augmenting it with outside sources; for example, we see it a little with space weather.

One participant noted that in regards to having more data for an SSA system, there should be a request put out for crowd-sourcing a catalogue, as it could be pretty accurate. Another asked how do we leverage the data coming from non-USG sources? In some cases, operators are waiting for policy to catch up so they can take advantage of these new sources of SSA.

Deep down, one participant commented that the core issue driving this discussion is concerns about failure of the system. The possibility of causing grave harm is not going into decision-making about SSA. Owner-operators are not avoiding objects – they are getting lucky. Some orbits are a critical global resource and should be treated accordingly.

The question was asked of the group that if there is general agreement that there will be progression from scenario 1 to scenario 4, what are the implications for operators?

It was noted that the FAA does not fly satellites or launch vehicles, but it needs certainty of data because it has enforcement responsibilities. Scenario 4 is where they would go to for that certainty; crowdsourcing would fail because everyone wants to sell the same data. Air traffic control is a combination of 3 and 4, as it is a series of internationally agreed upon standards that are administered through national agencies; currently, only a few countries have national regulations for space, so we are a ways out from that being even a possibility. The current space law framework leads to similar outcome for STM because launching states are responsible for oversight of private sector activities.

It was argued that we should look at the ITU as an organization that depends upon international collaboration but gives only advice, not regulations. Instead, for the United States at least, the FCC does the regulations. Another example of governance being recommended at the international level but carried out at the national level: maritime norms require you to report hazards, but the enforcement mechanism goes to the U.S. Coast Guard.

One speaker felt that in terms of increasing access to space, we really needed to look at the business model for who pays. Who will pay for the environment to be maintained and allow for continued access? It doesn't necessarily have to be just space-faring nations – nations can realize how dependent they are on services provided by space assets and want to contribute to SSA. Alternatively, a country could have an SSA system (a telescope perhaps?) and not be

space-faring. Or another option is that a country could be reliant on space technology but not care about SSA, instead focusing on simply having access to that space technology.

Session Two: The Most Desirable Future for SSA

This section of the Dialogue also started off with some questions of the participants. Which of the scenarios is the most desirable, and why? What are the metrics of desirability? What technologies or policies are needed to reach the most desired scenario? What would the implications of the most desirable scenario be on foreign governments, the U.S. government, private companies, international relations, and other stakeholders?

One participant made the argument that scenario 1 is the least desirable, in that it wasn't designed for the role it has today in SSA, but rather grew organically. If we were to sit down and design a system, it is more likely that it would look like scenario 4. There was some disagreement about this assertion, with one participant responding that a few years ago, the USG had the option of choosing to continue to be the gold standard, just as with GPS, so that everyone could use it and we could control the capability.

Several participants said that they saw it evolving from scenario 1 to scenario 4, skipping 3. The question was asked, if scenario 4 is the future, what does that mean? Will governments be able to afford it? Will it raise the cost of space to a point where it limits access to space? Alternatively, governments may see it as useful for STEM development domestically. Or some nations may want their own sense of awareness, if not their own capability. If the most desirable from the USG perspective is scenario 4, then the USG needs to plan for more bilateral relationships (as opposed to scenario 3, which would be more multilateral engagement).

One participant asserted that the most desirable scenario is 3 with a system that provides reliable information that nation states can use to perform STM functions. Could it be the most efficient one though? Would it maybe be more efficient to try multiple things to figure out what the best solution is?

The most desirable end state probably depends on what the needs are: a desirable end-state for national security (scenarios 1 and 4) is probably different from that for safety of spaceflight (scenario 3) or SSA for preservation of the space environment.

It was noted that countries with the most investment in space will try to shape the SSA framework, but otherwise, it's hard to get people to care about this issue in order to take actions, citing the aphorism that satellites don't have mothers. It might help with messaging to figure what is the problem that you are trying to solve. Is it to make sure you don't lose GEO as a resource? Is it so that the telecommunications industry won't lose money?

One participant asked about what is the true risk. In air traffic control, you are trying to prevent the loss of life. What is the harm that's going to motivate investment for SSA/STM? One answer is that while there is not the potential for direct loss of life, there is a high chance of indirect loss of life and large costs to disruption on Earth. Plus, if something happens, we will feel the effects for years – generations if it's at GEO. Another response dealt with the cost of losing something like weather forecasting for hurricanes. All in all, there is a real challenge in communicating what the impacts are to non-space people. It is hard to get non-space people to understand the risks, particularly the risks to GEO. There could be a collision there – what would happen then? There are so many more satellites in GEO – what are their end of life plans? It's an important discussion to have.

At the end of the discussion, the moderator called for a vote to get a sense of what the group was perceiving to be the most realistic versus the most desirable SSA scenario. NB: not everyone who participated in the discussion voted.

[Vote where everyone gets two votes]

Most realistic

Scenario 1	15
Scenario 2	3
Scenario 3	0
Scenario 4	15

Most desirable

Scenario 1	1
Scenario 2	4
Scenario 3	14
Scenario 4	9

[Vote where everyone gets one vote.]

Most realistic

Scenario 1	14
Scenario 2	0
Scenario 3	0
Scenario 4	6

Most desirable

Scenario 1	0
Scenario 2	2
Scenario 3	10
Scenario 4	8

Conclusions

Overall, there was a consistent dubiousness about the USG, or any government, giving up control entirely of SSA data/sources to commercial or international entities. Many speakers recognized that there is SSA needed to national security needs and for spaceflight safety, which means that some of the SSA needed to be done in-house, while some of it could be done by outside sources.

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. Models such as

ICAO, where there's international agreement on standards which are then implemented through national regulation, were cited as the most realistic.

Another takeaway was to broaden existing notions of what constitutes SSA capabilities. Typically, we think of SSA as some sort of complicated network of advanced radar, telescopes, and processing capabilities; but if we want to distribute SSA responsibility more/share the SSA burden, depending on how one looks at it, one should be willing to have SSA input from smaller states with lesser capabilities. A sole telescope providing data, for example, could be a valuable contribution if enough of them are networked together.

Quite a few participants seemed to think that most realistically, we would see an evolution from scenario 1 to scenario 4, skipping scenario 3. Scenario 3 was almost universally determined to be the most challenging scenario to see any progress with, and yet it was also deemed to be the most desirable.

There are essential questions left to answer: what is the role of the government in providing SSA data? Do commercial SSA providers do things that the government is not/cannot? Can SSA and data-sharing truly be international? And how do we encourage investment in an issue where so few non-space people are fully cognizant of the risk?