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LESSONS LEARNED FROM MARITIME DOMAIN AWARENESS FOR INTERNATIONAL SSA DATA SHARING

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ABSTRACT

The current limitations of space situational awareness (SSA) systems are well documented. At the heart of many of these limitations are issues of data sharing. Assets that can contribute to SSA exist around the world, however, data sharing between these systems is minimal.

The United States has taken steps toward increased SSA data sharing, but their capability is limited and the burden on one country to provide an SSA data sharing service is great. The European Union is working to make their SSA system compatible with the US system, but is in the early stages of doing so. Additionally, the Space Data Association is demonstrating a new model for increased sharing SSA data among both government and commercial satellite owner/operators,

Given these systems around the world and the work being done toward increased international collaboration, and in acknowledgement of the growing space debris problems that enhanced SSA could help mitigate, the idea of an internationally-based SSA system is growing in popularity. Many questions remain about such a system, including whether operation would lie in the military, civil or commercial realm; what types of data would be shared; how systems would achieve interoperability; who would be allowed access to data; and how security of data would be ensured.

Many of these questions have already been addressed in international data sharing realms outside of SSA. One such realm is Maritime Domain Awareness (MDA). Ship positional data is shared internationally through several mechanisms, including the Maritime Safety and Security Information System (MSSIS). Many lessons for a future international SSA system are held within the challenges and successes of the MSSIS data sharing mechanism.

This paper expands upon these lessons learned for a future international SSA system, along with examining where the parallels between SSA and MDA are helpful and where SSA poses challenges beyond those addressed in MDA where new procedures will be needed.

I. INTRODUCTION

As the number of entities operating assets in Earth orbit continues to increase, the attention paid to the need to operate in a sustainable manner has also increased. A central aspect of this attention is a focus on limiting the amount of debris in orbit. Much of this conversation has shifted to talk of active debris removal (ADR), given the seriousness of the situation and the need not only to prevent the creation of more debris, but also to remove already existing debris. However, there remains a need to consider how spacefaring entities can best track the objects currently in orbit, both to prevent as many collisions as possible, and to support any future ADR efforts. The tracking of objects in orbit is known as Space Situational Awareness (SSA).

Currently, the US military has the most comprehensive SSA capability in existence, including the largest and most widely distributed network of sensors, and the most comprehensive system of notifying external actors of potential collisions. However, this system has many shortcomings. A military entity does not necessarily place a premium on sharing data, often preferring to protect what it sees as sensitive data, which is an issue at play in the US system. Secondly, while the US has a widely distributed sensor network, large gaps in coverage exist, including no coverage in the southern hemisphere. Finally, in many cases the conjunction assessment and subsequent warnings provided by the United States are not of high enough quality to be actionable by entities who may want to maneuver their spacecraft to avoid a potential collision.

Despite these shortcomings, advances are being made in the realm of data sharing by the US and other entities. The US has in recent years expanded its SSA Sharing Program to provide Conjunction Summary Messages on close approaches for all active satellites that include more detailed data and analysis. The European Union is developing an SSA system that would not be a stand-alone entity, but would rather enhance the US system. This enhancement would need to be leveraged through increased international data sharing. Additionally, satellite operators have recently formed a new entity, the Space Data Association, to share satellite owner/operator data to increase awareness and decrease the risk of satellite collisions.

Beyond these efforts, the broader potential for an SSA system that better meets the growing needs of actors around the world is often discussed. One system posited is an International Civil Space Situational Awareness (ICSSA) system.[1] Such an ICSSA system has never been attempted, and poses numerous hurdles. However, as seen above, current trends show an interest in increased data sharing and international collaboration. Furthermore, international data sharing systems exist in other realms that could hold lessons for the establishment of such an SSA system. One such realm is Maritime Domain Awareness (MDA).

Ship positional data is shared internationally through several mechanisms. The focus of this paper will be the Maritime Safety and Security Information System (MSSIS). Many lessons for a future international SSA system are held within the challenges and successes of MSSIS data sharing.

The paper will begin with a brief overview of MSSIS and then analyze its applicability to an international SSA data sharing system. This paper expands upon these lessons learned for a future international SSA system, by examining where the parallels between SSA and MDA are helpful, where SSA poses challenges beyond those addressed in MDA and where new procedures will be needed.

II. MARITIME SAFETY AND SECURITY INFORMATION SYSTEM

MSSIS is a freely-shared, unclassified, near real-time data collection and distribution network dealing primarily with Automatic Information System (AIS) data. MSSIS was established in 2006 by the US Navy with the goal of promoting multilateral collaboration and data sharing among international participants toward the end of increasing maritime safety and security. MSSIS includes over 50 countries sharing AIS data and tracks over 6,000 ships.[2]

The International Maritime Organization (IMO), through the International Convention of the Safety of Life at Sea (SOLAS), requires ships meeting certain requirements to transmit AIS data.[3] AIS data is short-range for the most part, though recent discoveries demonstrated the ability to use satellite AIS data to communicate over greater distances. Vessels of MSSIS member countries are required to transmit AIS to shore-based receiving stations and other nearby ships for the purpose of promoting navigational safety.[4]

MSSIS deals primarily in AIS data and has, in the past, not been concerned with attempting to integrate multiple sources of positional data. However, the MSSIS system is currently testing the integration of satellite AIS (S-AIS) data into the system. This integration faces a latency issue, with satellite data at times being twenty hours old, compared to the ten-second age of ground-based data.[5] Work is also being done currently in the maritime domain awareness realm to encourage the integration of multiple types of data, including AIS, synthetic aperture radar, and optical data.[6]

MSSIS data is only accepted from those governments who are members of MSSIS. Data sources may be a single sensor or an entire Vessel Tracking Network.[7] There is no fee for membership, and through a contract, members agree to not distribute data to non-authorized recipients of the data.[8]

While it does not deal exclusively in it, MSSIS has been based largely on AIS data, which is already being broadcast as required by SOLAS. As mentioned above, other types of data are available that could support MSSIS and some of these options are being explored, but MSSIS has found value in primarily dealing with one type of data, specifically a type whose broadcast is already mandated by another mechanism.

MSSIS takes AIS data already being transmitted and passes it to users in near real-time.[9] The data maintains its original, internationally recognized format. No processing, alteration, or storing of the data occurs. MSSIS provides security for data transmitted through the system, while maintaining ease of access, by using password-protected, Internet-based sharing of data through encrypted data links.[10] MSSIS uses the client software Transview, which was developed by the Volpe Center (part of the U.S. Department of Transportation) and serves as a common system interface and vessel tracking display for users. This software is provided to members free of charge.[11]

III. LESSONS LEARNED FOR INTERNATIONAL SSA DATA SHARING

Many of the lessons MSSIS holds fall in the realm of fostering broader participation in data sharing. Several characteristics of MSSIS demonstrate how data sharing can be increased. However, MSSIS also clearly demonstrates that many tradeoffs will likely be necessary in order to realize increases in data sharing. The following section highlights the elements of a system that foster increased participation in data sharing and what tradeoffs exist. In conclusion, though, any increase in data sharing, whether accompanied by tradeoffs or not, contributes to greater overall awareness and is worthwhile.

Multiple methods exist for broadening participation in international data sharing mechanisms

First, use of a standard international data format can increase data sharing. MSSIS makes use of such international standards in two ways. The backbone of the MSSIS program is the mandate from SOLAS that AIS data be transmitted from ships meeting certain specifications. Reliance on such an external mechanism not only guarantees a source of data, but also names a common format for that data. Second, MSSIS has chosen to deal primarily in the AIS data whose transmission is mandated by SOLAS. Instead of working to incorporate multiple types of data, MSSIS works primarily in AIS data. Additionally, MSSIS does not alter the data, but rebroadcasts it in its original internationally-recognized format.

Second, MSSIS is an unclassified system dealing in non-sensitive data. Entities that may be concerned about withholding data on classified assets may participate fully in the system while not having to share any data they do not wish to. While transmission of MSSIS data is encrypted, and members sign an agreement to not redistribute the data, there is not a high assumption of privacy of AIS data. Entities wanting to increase their awareness through sharing are receiving non-sensitive data without concerns about being asked to share their own or protect others' more sensitive data.

Third, MSSIS members must contribute their data in order to receive data back from the system. Countries are encouraged to participate through the incentive of receiving the benefit of data shared by all MSSIS members. Contributing one's own data is the only ongoing requirement for receiving data back from the system (the one time requirement of installing a receiving station must also be met as discussed below), so countries are encouraged to contribute data as a relatively simple method of receiving all MSSIS data in return. To reiterate, because the transmission of AIS data is already mandated by SOLAS, this is not a barrier to entry.

Finally, when the cost of the system is borne by one actor, costs for other members are kept low, thereby encouraging broader participation. MSSIS was initiated by the US Navy, and is operated by the US Department of Transportation's Volpe Center, both of whom bear the cost of the system. As such, there is no membership fee to join MSSIS and the client software is provided to members free of charge. The only cost for members is the instillation of the receiving station, which is a simple and inexpensive process. Thus, barriers to entry are kept low for a wide range of nations.

<u>Tradeoffs exist when a system encourages broad participation</u>

Each of the aspects of the MSSIS system outlined above that encourages international data sharing also gives something up in order to do so. It is instructive to identify these tradeoffs that would likely exist in an SSA data sharing system that aims to foster broader participation.

First, reliance on an external mechanism to mandate sharing of the data in question limits flexibility of how a new system may be formed. Additionally, reliance on a certain type of internationally recognized data limits the added benefit that may come from incorporating multiple types of data into a single system. As mentioned, MSSIS is considering expanding the types of data used in its system, as multiple types of data exist that could contribute to fuller maritime domain awareness. The same is true in SSA; so choosing to deal in only one type of data or one data format may limit the greater awareness achievable through the system.

Secondly, by dealing only in unclassified data, a certain portion of assets will be left out of the awareness picture. If positional information and avoiding collisions is the only goal, then there is reason to believe that those operating classified assets will invest in keeping their assets out of others' paths. However, there may be other reasons that having such assets within the system rather than external to it would be beneficial.

Third, while offering data to only those who contribute their own data likely plays a large role in increasing membership, it does inherently limit the distribution of the data to a subset of stakeholders. This is currently an area where the US SSA Sharing Program and the SDA are taking different approaches. The US has chosen to provide conjunction warnings to all operators regardless of their participation in the SSA Sharing Program, while the SDA only provides data to its members. Thus, the issue of who receives system data poses significant tradeoffs in both MDA and SSA that will need to be weighed carefully in the future.

Finally, a system whose cost is borne entirely by one actor has its downsides as well. All members are reliant on that actor continuing funding, support, and maintenance of the program. This is a prominent issue in the realm of SSA, where the negative aspects of a US-based system are widely acknowledged. MSSIS demonstrates that the benefits of one actor providing a data sharing mechanism are strong enough for this type of system to have emerged in the maritime domain as well. Thus, those wishing to move away from this model in the SSA realm will need to provide strong evidence to overcome this method that occurs in multiple arenas. The US SSA Sharing Program and the SDA again demonstrate two different ways of approaching this tradeoff in the SSA realm.

<u>Any increase in data sharing can increase overall awareness</u>

MSSIS may easily be categorized as a successful program that has increased overall maritime domain awareness internationally. Despite the tradeoffs listed above, MSSIS adds value by increasing sharing of certain types of data sharing among its members. MSSIS is not the only system working to increase awareness in the maritime realm, nor is it seeking to be. It serves a specific purpose and its self-imposed limitations have allowed its success in the specific realm of AIS data sharing. Thus, it can be seen that a system does not need to attempt to provide a complete picture of a domain in order to add value. Sharing of specific types of data among specific types of users may be a key short term step to fuller awareness, or may be one of several mechanisms contributing to a complete picture in the long term. MSSIS shows us that efforts do not need to be hampered by accepting limitations in a system.

IV. ADDITIONAL CHALLENGES SPECIFIC TO SSA DATA SHARING AND AREAS OF FURTHER STUDY

Many of the parallel challenges and considerations between awareness in the maritime realm and SSA have been identified above. However, several aspects of SSA will pose unique challenges. Whereas MSSIS data can be useful to members in its originally broadcast format, it is likely that an SSA system will inherently need to also analyze the data in order to add value and produce the desired end product. Most nations that operate satellites would not have full capability to analyze satellite positional data if it were made available to them in its raw format. Thus, an analysis aspect of an SSA system may be necessary, with the product of the system not being basic data itself, but information about potential collisions based on that data. Data sharing mechanisms in other realms that have different end state products would be beneficial to examine. Specifically, mechanisms that add value to incoming data could hold valuable lessons.

It is also likely that any SSA data sharing system will need to deal more directly with users in the form of targeted conjunction notifications than is present in MSSIS. Data sharing mechanisms that work directly with end users on a regular basis would be worthwhile models.

Other areas may need further extrapolation and analysis for their particular relevance to the SSA realm. For instance, how a system handles liability issues was not discussed here, but is an important concern. Liability in the areas of ensuring the quality of data accepted into the system and that data is used in appropriate ways are both critical. Furthermore, examining models that operate on both sides of the tradeoffs identified above would be valuable—one type of data versus multiple types of data, only non-sensitive data versus including sensitive data and assets, accepting data from and providing data to all users versus only to contracted members, and the cost of the system being borne by one user versus multiple users.

Examination of Long Range Identification and Tracking of Ships—another system in the maritime domain—would highlight further lessons from a system that has chosen to operate at different points along the spectrum of these tradeoffs.

V. CONCLUSION

Numerous lessons may be learned from the realm of maritime domain awareness for SSA data sharing on an international scale. Current trends and proposed systems such as an International Civil SSA system demonstrate that one step on the way to a better international SSA capability is to increase international data sharing. In order to increase data sharing, participation in cooperative systems needs to increase. In this regard, MSSIS is a successful model that shows that participation in such systems can be increased and does lead to better awareness. However, this increased participation comes with tradeoffs. Despite these tradeoffs, we have seen that any increase in data sharing can contribute to more complete awareness in a given realm.

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[1] For discussion of such a system, see Weeden, Brian and T.S. Kelso, "Analysis of the Technical Feasibility of Building an International Civil Space Situational Awareness System," 2009 IAC in Daejeong, South Korea, October 12-16, 2009, accessed at http://swfound.org/media/1719/iac-09_bw.pdf. Accessed on May 1, 2011.

[2] National Maritime Domain Awareness Coordination Office Wiki: MSSIS entry, accessed at http://www.gmsa.gov/twiki/bin/view/Main/MssisInformation.

[3] "All ships of 300 gross tonnage and upwards engaged on international voyages and cargo ships of 500 gross tonnage and upwards not engaged on international voyages and passenger ships irrespective of size shall be fitted with an automatic identification system (AIS)…" Safety of Life at Sea Convention, as amended Dec 13, 2002, Chapter V, Regulation 19.

[4] "Maritime Security and Navigation," U.S. Department of State website, http://www.state.gov/e/oes/ocns/opa/maritimesecurity/.

[5] Interview with Will Quintana, Department of Transportation Volpe Center, February 3, 2012.

[6] This work is happening through the Maritime Domain Awareness Implementation Directive of PPD-4,

interview with Dr. John Mittleman, Naval Research Laboratory, February 10, 2012.

[7] Earles, Marion. "International Space-Based AIS and Data Extraction Backbone: High Level Requirements," CANEUS International, 2010.

[8] Will Quintana Interview.

[9] MSSIS homepage, Department of Transportation Volpe Center, at https://mssis.volpe.dot.gov/Main/home/.

[10] National Maritime Domain Awareness Coordination Office Wiki: MSSIS entry.

[11] Will Quintana Interview.