Global Future Council on the Future of Space

Space Situational Awareness Data and Information Sharing Principles

BRIEFING PAPER

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The number of spacecraft orbiting Earth has increased rapidly in recent years, from fewer than 1,500 in 2014 to more than 9,800 today, and more than 80 nations are involved in space activity.[1] Satellites have become critical to the global economy, providing communications, timing, navigation and information services that support global industry. Individuals rely on satellites for their daily weather reports, directions and internet connectivity. While the increasing activity provides significant benefits to individuals on Earth, it also poses challenges for space safety and sustainability as space becomes increasingly congested and the risk of unintentional collisions increases.

Space situational awareness (SSA) – the ability to monitor the location of objects in orbit, predict their future location and warn of potential collisions – provides the foundation for space safety and sustainability.[2] Accurate SSA information promotes greater understanding of evolving conditions in space and prevents collisions that create harmful debris. SSA information and services also provide the foundation for the stability and predictability needed for the continued growth of the global space sector.

Information sharing among space actors improves the accuracy and effectiveness of SSA information and services. Space safety requires spacecraft operators around the world to communicate with SSA providers and with each other to avoid potential collisions. As the number of SSA providers worldwide grows, it is becoming increasingly important that these providers coordinate and share information to improve their predictions and avoid providing conflicting information to operators. There are significant opportunities for improving global SSA data and information sharing to support space safety and sustainability, even while protecting valid national security and commercial competitiveness interests.

Adopting the United Nations' (UN) *Guidelines for Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space* (specifically Guideline B1) has promoted consensus on the importance of SSA data sharing. Many industry and government best practices documents have reinforced the importance of this issue.[3] Yet significant gaps in data sharing remain. This paper identifies key actors and data to be exchanged and proposes principles for global SSA data and information sharing.

SSA data and information

Many actors in the space sector involved in providing and using SSA information and services could exchange various types of data and information to improve space safety.

SSA service providers to spacecraft operators: Governmental and private entities operate many sensors that observe objects in space. Meanwhile, private and governmental SSA service providers use these observations to generate and update a catalogue of space objects – a listing of objects in space and their locations at a given time. Because space objects generally move in predictable orbits, SSA providers can also conduct analyses of these observations over time to generate predictions of where space objects will be in the future and to identify potential collisions or conjunctions between objects. Timely provision of these conjunction warnings to satellite operators enables them to respond and avoid potential collisions.

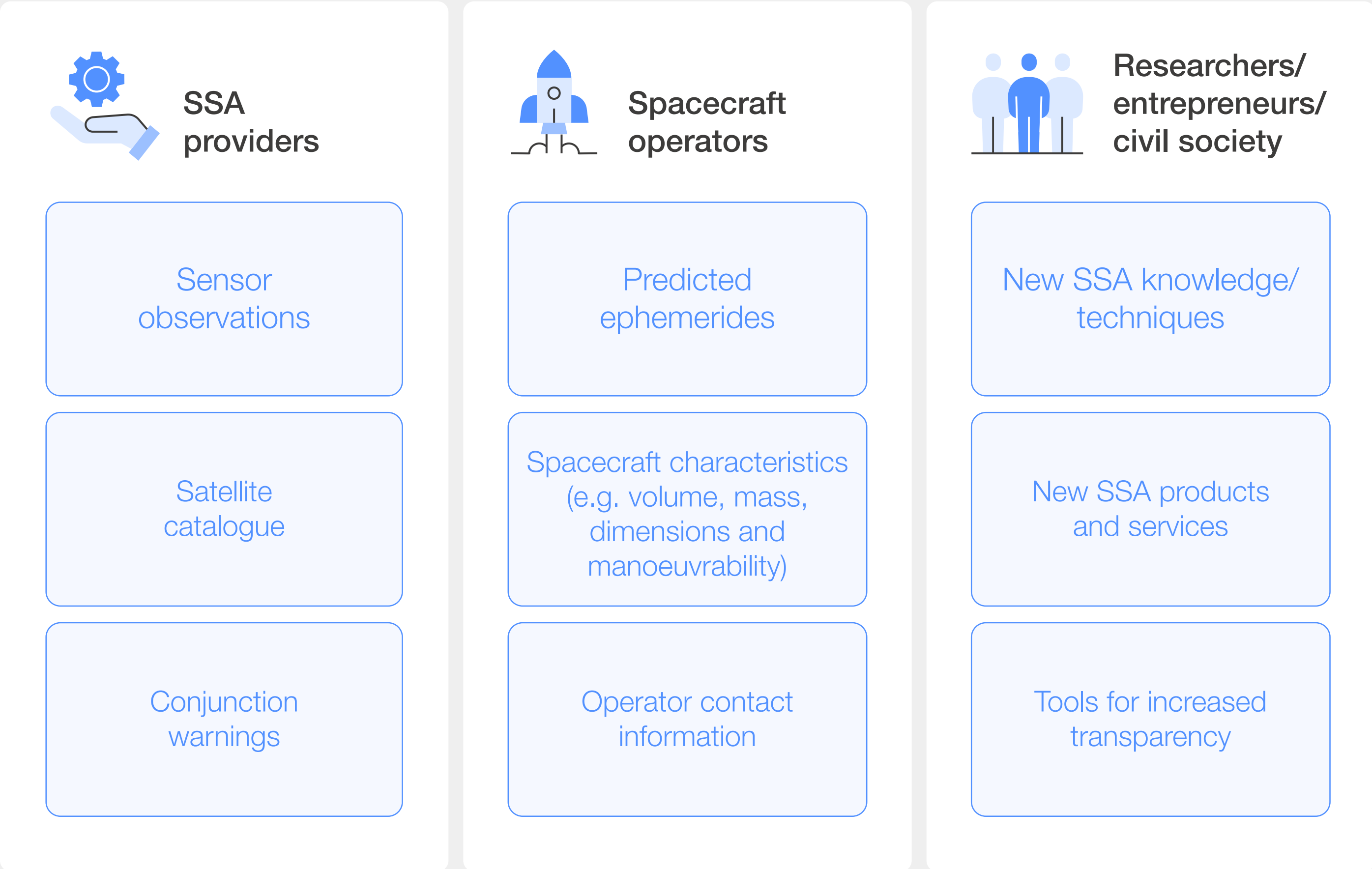
In addition to SSA information and services, SSA providers and organizations with relevant expertise may share their knowledge by providing training for spacecraft operators. Such training helps ensure that spacecraft operators can efficiently use the information and products provided.

Spacecraft operators to SSA service providers: Satellite and other spacecraft operators should proactively seek to receive and use these SSA services (including conjunction warnings) in accordance with national law and regulations. Spacecraft operators also have a fundamental role to play in data sharing. Usually, spacecraft operators have more precise and timely information about the orbital location and trajectory of their spacecraft (spacecraft ephemerides) than SSA service providers do, and they inevitably know more about their own contact information and manoeuvre plans. SSA providers need all this information to supply timely warnings, and fellow operators need it to coordinate a response.

Owners or operators could supply SSA providers with these plans when planning manoeuvres. This would enable the incorporation of planned manoeuvres into the predictions of future spacecraft locations, thereby greatly enhancing the accuracy of conjunction analyses.

Such manoeuvres are nearly impossible to predict in advance with sensor observations alone. Satellite operators could also share information about their satellites (such as mass, volume, dimensions and information on their manoeuvre capabilities) that may improve the accuracy of conjunction analyses and the ability to coordinate. When an owner/operator shares this type of information, they benefit directly from improved accuracy of conjunction warnings related to their own spacecraft and contribute to improvements in SSA information for others.

FIGURE 1 **Roles and responsibilities in space situational awareness**



SSA service providers to SSA service providers: While sharing between SSA providers and spacecraft operators is essential, there are also significant benefits when SSA providers share information among themselves, particularly as the number of SSA providers around the world increases. By sharing conjunction warnings, different providers can identify misalignments in their collision predictions. This can help SSA service providers locate discrepancies in their understanding of the space environment (or in their differing thresholds for identifying issues of concern), increase alignment in the information they provide and update space catalogues. This would help to minimize the possibility of operators receiving conflicting information from different providers. In addition to the conjunction warnings, sharing information about the criteria used for carrying out the analysis (e.g. what volume of space is considered) and the threshold for generating a notification could help to enable greater mutual understanding.

While in many cases, the sharing of satellite catalogues or observations from SSA sensors may not be possible due to national security or commercial competitiveness issues, there are some potential cases in which these types of data and information can be shared. For example, information could be shared when it is collected by civil sensors, used for space flight safety or purchased under a license that allows for sharing. In these cases, data sharing among SSA providers can help to improve the quality of SSA information and products. Sharing observations is particularly useful if the locations, capabilities or technical means of collection of the sensors differ (for example, as they do between radar and telescopes).

SSA service providers could also play an important role in facilitating quick exchange of spacecraft operator information, because there are many more satellite operators than SSA service providers. Contact information and spacecraft characteristics, if available, could be collected by one SSA centre and made available to the rest, ensuring better coordination among SSA providers while reducing the burden on individual spacecraft operators. A more challenging but potentially fruitful step would be for SSA service providers to seek re-sharing licenses for the operational data (i.e. owner/ operator ephemerides) obtained from the satellite operators they serve. SSA service providers could also share ephemerides among themselves (including planned manoeuvres). This would

improve the assessment of the conjunction risk for two active satellites that rely on two different SSA service providers.

Researchers/entrepreneurs/civil society: While SSA providers and spacecraft operators are the primary actors in this realm, it is also important to note that others, such as researchers, entrepreneurs and members of the interested public have an important role as data consumers. When these entities have access to data made available by SSA providers or spacecraft owners/operators, they can generate new knowledge, develop new products and services, and increase transparency in ways that improve the safety and sustainability of the space environment. This helps to build trust among disparate actors.

Global space sector agreement on SSA data sharing principles would greatly improve space safety and sustainability. However, as noted above, there will be some situations in which legitimate concerns about security or competitiveness may limit what data can be shared. Many government SSA systems that provide space safety products and services rely on military and private data. These military and private SSA sensor operators may not be able to make their raw observations broadly available (for example, due to national security sensitivities or because companies rely on sensor data sales for revenue generation). Similarly, some spacecraft operators consider certain aspects of their spacecraft design or operations to be proprietary. However, SSA providers and spacecraft operators should aim to make data as open as possible in the interest of the common goal of avoiding collisions and maintaining space sustainability. They should only restrict access to and use of data to the extent necessary to address a specific concern.

When considering whether data needs to be restricted for security purposes, guidance developed for the sharing of geospatial data is helpful.[4] This guidance suggests that data holders should consider the specific risks to security and the uniqueness of the information. Can the information be obtained in another way – observed directly or obtained from another source? Actors should also consider the net benefit of disseminating data. Even if the sensitive information poses a risk to security and is unique, do the security risks outweigh the societal benefits of sharing the data?

Similar considerations – of specific impacts and uniqueness of the data – may be relevant when considering whether data is proprietary or sensitive to businesses. Best practices developed in coordination with the American Institute for Aeronautics and Astronautics (AIAA) suggest that if a feature or approach is discoverable after launch, then it should be shared explicitly before launch. Entities purchasing data and information from non-government SSA providers should consider different options relating to the sharing rights provided under the licence.

In either case, it is worth noting that even when data is determined to be sensitive or proprietary, it may be possible to change it. Removing sensitive aspects, providing only a portion of the data, decreasing the precision of the data or releasing the data only to verified users could enable sharing.

SSA data and information sharing principles

- SSA data and information should be made open by default while remaining consistent with national laws and regulations. When restricting access to information, SSA providers or spacecraft operators should have a clear reason for withholding data and consider making changes to the data to enable its release, thereby supporting space safety and sustainability.

- Spacecraft owners/operators should share up-to-date contact information, ephemerides, manoeuvre plans and spacecraft characteristics (including size, mass, dimensions and manoeuvre capabilities) as openly as possible.

- Spacecraft owner/operator information should be provided to at least one SSA provider. This provider should then make the data available to all other SSA providers.

- Government SSA providers should share conjunction warnings, and, to the extent possible while remaining consistent with security and commercial competitiveness, share information about their satellite catalogues and sensor observations.

SSA data sharing implementation

To enable effective data sharing and mitigate the risk of misunderstandings, data formats should be standardized according to international interface control documents. *The Blue Books of the Consultative Committee for Space Data Systems* (CCSDS) is an example of such a document.

Furthermore, for SSA data sharing principles to be effective, it is essential that states operating SSA systems commit to some level of data sharing and engage in dialogue to advance a framework for collaboration. Such a group could also consider technical and organizational implementation, which would require significant efforts on the national and international level. It will be crucial to develop efficient processes and mechanisms to exchange this data, and consider issues related to data quality and standards. The recommendations above require that SSA providers develop interfaces that allow them to efficiently ingest data from spacecraft operators. Nations may also consider the role that domestic licensing processes can play in implementing these data and information sharing principles.

Implementation of the principles will require that SSA service providers develop mechanisms for sharing this information with other centres around the world in a timely manner. This may involve international organizations. For example, the UN's *Guidelines for Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space* suggest that national point of contact information may be shared via the UN Office for Outer Space Affairs (UNOOSA). Regardless of the organizational and technical approach chosen, these mechanisms must be flexible, as the global SSA sector is rapidly changing.

Successful examples of global data sharing already exist (for example, the Space Data Association), but more needs to be done. Achieving meaningful global SSA data and information sharing is critical to the future of space technologies. Members of the global space community should adopt the data and information principles above and commit to exploring and discussing potential frameworks and mechanisms for sharing.

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Endnotes

1. Union of Concerned Scientists. (2023). *UCS Satellite Database*. https://www.ucsusa.org/resources/satellite-database.

2. Different organizations have adopted different definitions for space situational awareness. Monitoring of the space environment and identification of potential collisions are common among these. Some entities also include additional elements, such as monitoring of Near Earth Objects (NEOs) and impacts of space weather. An example of a more expansive definition of SSA is that given by the Space Safety Coalition. This definition states that SSA is "the understanding, knowledge, characterization, and maintained awareness of the space environment: artificial space objects, including spacecraft, rocket bodies, mission-related objects and fragments; natural objects such as asteroids (including Near Earth Objects or NEOs), comets and meteoroids, effects from space weather, including solar activity and radiation; and potential risks to persons and property in space, on the ground and in air space, due to accidental or intentional re-entries, on-orbit explosions and release events, on-orbit collisions, radio frequency interference, and occurrences that could disrupt missions and services": Space Safety Coalition. (2024). *Best Practices of Space Operations*. https://spacesafety.org/best-practices/.

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4. U.S. Federal Geographic Data Committee. (2005). *Guidelines for Providing Appropriate Access to Geospatial Data in Response to Security Concerns.* https://www.fgdc.gov/policyandplanning/Access%20Guidelines.pdf.