Commercial SSA capability in Japan

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ABSTRACT

While the dependence on space expands in daily life, the risks for space systems are also increasing, caused by congested Space Debris, and contesting, challenging space activities. Reflecting these backgrounds, the Japanese government designated the Japan Ministry of Defense (JMOD) under the Basic Plan on Space Policy to develop an own operative space situational awareness (SSA) system, which is now planned to operate from the year 2023.

Apart from the government plans, when we pay attention to oncoming events, we find the mission assurance of the Japanese space systems may not be enough (in terms of surveillance), especially before 2023. For example, the Rugby World Cup 2019 and the Tokyo 2020 Olympic/Paralympics auto-mobility events deeply rely on the newly operating positioning system, and JMOD communication satellites are absolutely imperative to the self-defense forces of Japan.

As a responsibility from the commercial sector, starting from April 2018, NEC has started developing a commercial, independent SSA capability, which we call the NEC ComSpOC, in our satellite operation center in Tokyo, and has built a prototype system for our own operation based on commercial products provided by Analytical Graphics, Inc. NEC also as a satellite operator, we find SSA is important to support satellite operations. NEC also understands that contributing to the Space Traffic Management (STM) to partially cover and support future space operation activities, is an important role for the commercial sector. Since Japanese operators are relatively new and not trained enough in the SSA operations, NEC has also developed an evaluation and table top exercise (TTX) environment in the system, independent to the NEC ComSpOC operations, which will reinforce the mission assurance of the Japanese space systems.

In this paper, we will share the current status of Japanese commercial SSA capabilities, and update any progress we have achieved from SSA information utilization.

1. BACKGROUND

To most countries including Japan, space systems are an important infrastructure for both the commercial and national security sector. Space is utilized in Communication, Meteorology, Positioning, Navigation and Timing (PNT), Earth Observation (EO), Early Warning, etc. This means our daily life is deeply dependent on space systems. On the other hand, emerging risks caused by these activities, like generation of space debris and anti-satellite (ASAT) weapons (both kinetic and non-kinetic), are preventing us from using our global-commons sustainably and stably.

Aggressive military use of space is also an energetic area. For example, China's satellites with Rendezvous and Proximity Operation (RPO) capabilities, represented by Shijian 17(SJ-17), can be utilized as a Co-Orbital ASAT weapon, along with already presented Direct Ascent (DA) ASAT capabilities. As for Russia, LUCH/Olymp-K is known for its RPO activities to multiple communication satellites, which indicates similar performance as that of the U.S. Geosynchronous Space Situational Awareness Program (GSSAP) [1]. For DA-ASAT experiments, India's Mission Shakti, which targeted another Indian satellite in March 2019 is still fresh in mind. From these situations, SSA is getting more and more important in terms of self-defense [1].

Japan has re-accelerated its space development starting from the establishment of the Basic Plan on Space Policy. SSA activities were written in 2015 to start consolidating plans, establish organizations, and start operation by the early 2020s [2]. Complying with the plans, JMOD is now preparing the SSA system, which is to operate from 2023.

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To align and emphasize the countries unity, Japan Aerospace Exploration Agency (JAXA), Japanese space research and development agency, is also developing a new SSA system by replacing the existing JAXA SSA related facilities [3].

As for the JMOD, the "National Defense program Guidelines for FY2019 and beyond" indicates the necessary development of SSA systems and organizations for the mission assurance of the entire space system. In the "Mid-Term Defense Program (FY2019-2023)", specific names of the new units under JASDF were defined, along with new assets that will strengthen the capabilities in the Space Domain, like space-based optical telescopes and SSA laser ranging devices. Additionally, in order to use these capabilities continuously, JMOD will conduct necessary study and research, and newly introduce training devices to study and train responses to the vulnerabilities of Japanese satellites, and devices to grasp the state of electromagnetic interference against Japanese satellites [4][5]. Defense and national security demands in the space domain are ever-increasing.

NEC has approximately 60years experience in space systems development. NEC, also a satellite owner/operator (O/O) of self-developed EO satellites and ground control systems based in the NEC Satellite Operation Center (NSOC), recently launched an earth observation imagery providing service as part of the space utilization service business [6]. Like the other O/Os, when there is a possibility of collision with space debris or other satellites, the Combined Space Operation Center (CSpOC) will provide us with the Conjunction Data Messages (CDMs) and we will operate collision avoidance maneuvers (CAM) when necessary to protect our satellites. It is important that NEC is actually in a position to directly experience the threat of space debris in outer space.

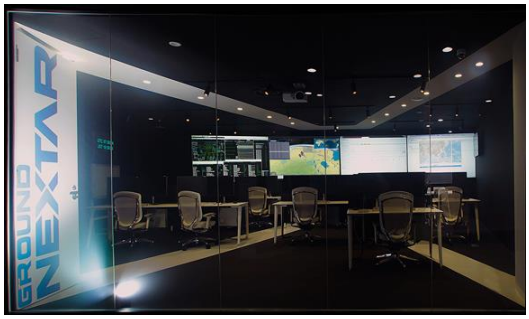

Fig. 1. NEC Satellite Operation Center (NSOC) [6]

2. DEVELOPMENT OF A COMMERCIAL SSA CAPABILITY IN JAPAN

As the space environment grows to a more contested, congested and competitive domain, and when the activities vary from probabilistic events like conjunctions and intentional events like ASAT weapons, it is important for the O/Os to understand the space situation in a timely manner and also voluntarily. Also the large amount of executively emerging space objects are definitely going to give impact to the governmental sector, currently in charge of SSA.

As a responsibility from the commercial sector, NEC and NEC Aerospace Systems Ltd. (NAS) have started developing a commercial, independent SSA capability, which we call the NEC ComSpOC, in our satellite operation center starting from April 2018. We have built an operational system as a prototype based on commercial products provided by Analytical Graphics, Inc. in the established center for our own SSA operation. The observation data into the system is fed from the commercial sensor network. Although the number of monitoring space objects is limited in this prototype, this capability is completely based on a commercial technology.

Fig. 2 shows the system configuration of the NEC ComSpOC prototype system. The features are as follows;

- NEC data center, where the prototype system is built, is resistant to disasters like earthquakes and infrastructure failures like a power outage.
- The backup center enables continuous operation in case of facility contingencies.
- With the system redundancy, the operation environment is possible to continue operation even when a system failure occurs.
- Observation data comes from the commercial sensor network via the secure line between the sensor network and the data center.
- Each center is connected by a secure network.
- The evaluation and training environment which is separated from the operation environment enables testing,

evaluation, training and table top exercise (TTX) without affecting the operation environment.

- The space event simulator can generate some space events for evaluation and training.

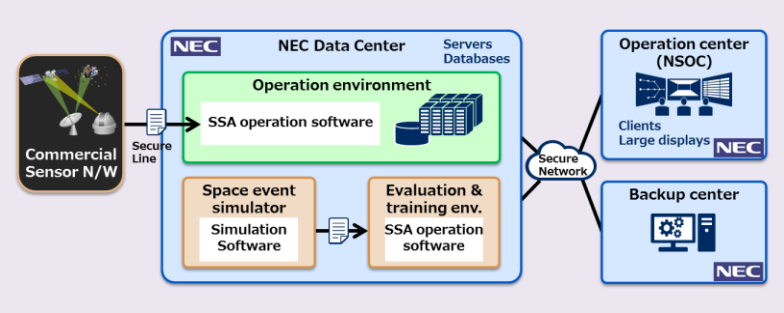

Fig. 2. System configuration of the NEC ComSpOC prototype system

3. CURRENT ACTIVITIES

In this section, we would like to introduce some of the activities taking place using the prototype system in NEC ComSpOC.

As a satellite operator, where we find SSA important for satellite daily operations, we started to support our NEC owned satellite using our SSA functions shown below;

- Orbit analysis of our satellite, and failure analysis for anomaly situations.
- Issuing CDMs by ourselves and supporting detailed assessments for CAM operations.
- Accumulating capabilities for more complex future satellite operation supports and SSA operations.

In addition to the supporting of satellite operations and the technical evaluation so far, we started experimental regularly SSA operation in order to become proficient in SSA operation. From this year, we have been monitoring some space objects to be capable to understand any changes or detect anomalies in outer space by ourselves. The knowledge and know-how for SSA operation is stored into NEC ComSpOC. Through this activity, the daily operation results are provided as a report, and it is improved daily.

NEC is a satellite operator as said previously, and also a company responsible for space development and public infrastructure sustainability. Therefore, we must consider further effective use of SSA information in both the civil and defense/security area. As using space expands further in the future, SSA information is expected to become more open along with the transition to STM. Currently, NAS is working to develop some SSA data utilization applications which use SSA information as an input data by using the commercial SSA system, and is evaluating those apps [7]. These applications will continue to improve for the future, and will help SSA operators to make analyses and to make quicker decisions, resulting an increasing demand for SSA data utilization applications in the future.

4. FUTURE PROSPECTIVES

Apart from the development plans of the government, when we pay attention to oncoming events, we find the mission assurance of the Japanese space systems may not be enough (in terms of surveillance), especially before 2023. For example, the Rugby World Cup will be held in 2019, and there will be auto-mobility events that deeply rely on the new operating positioning system for the Tokyo 2020 Olympic/Paralympics.

As the space environment grows to a more contested, congested and competitive domain, the NEC ComSpOC not only supports NEC owned satellite collision avoidance maneuver (CAM) operations, but may be ultimately essential to the mission assurance of the Japanese space systems, in terms of surveillance. NEC may experimentally be able to provide civil SSA services which can monitor dangerous debris and satellites behaving suspicious activities to protect the important Japanese satellites.

The Japanese satellites, such as the Quasi-Zenith Satellite System (QZSS) which is in service, Kirameki (X-band Communication Satellite) used for JMOD's satellite communication and Himawari (Meteorological Satellite), are all located in GEO, and we believe that these satellites should preferentially be monitored from the Japanese regional area. The necessity of concentrating on LEO activities, coming from geographical reasons, may be another unique

requirement. We think that it is an important role to enhance the surveillance capabilities by adding various sensors globally on commercial business. In the future, when the SSA information application under development is ready to use, it leads to expand the utilization of SSA information, and to enhance the accessibility of SSA information as an open data.

NEC also understands that contributing to SSA and STM, to partially cover and support future space operation activities, is an important role for the commercial sector. In the United States, it is decided that the control of STM will be transferred from U.S. Department of Defense (DOD) which was responsible for SSA operations over many years to U.S. Department of Commerce (DOC) by Space Policy Directive (SPD) in 2018.

SSA information needs to be open and freely usable to achieve future STM. Backing this fact, in the United States, some satellites orbits which was previously un-listed in the catalog is currently disclosed, and the Data Repository plan to share and release the data between government and commercial sector was announced. These activities are a part of open architecture for government and commercial sectors to cooperate with each other. Based on these activities, we believe that the collaboration between government and commercial sectors on SSA service in Japan is necessary.

Fig. 3 shows an idea of the future collaboration concept. With the increasing threat of debris, SSA information has been provided to public by the US military in the past, but in recent years there has been a trend toward military activity in the world. We understand that military activities such as Military Mission and Defense/Security, Space C2 (command and control) and the exchange of information with a high level of confidentiality between multiple countries are the roles of the government and the Ministry of Defense. The commercial sector will be able to share the burden of services for some general satellite operators. As a result, SSA-related government organizations in Japan can concentrate more on security activities, and the commercial sector will be able to fulfill their responsibilities in this way in order to continue to use space in the long term.

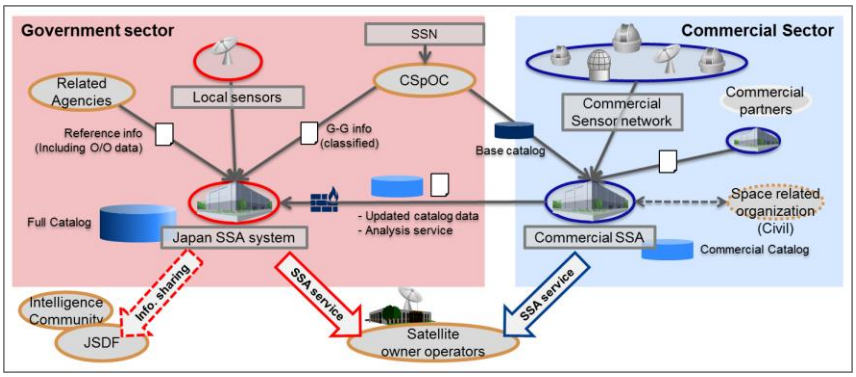

Fig. 3. Idea of a government-commercial collaboration concept

Since Japanese operators are relatively new and not trained enough for SSA operations, we understand that it is necessary to provide training environment for SSA operators.

While we find this type of collaboration, essential for structuring a globally compatible Space Traffic Management (STM) concept, we have also noticed the importance of local customization for a stress-less and locally unique operation. These include the necessary robustness and resilience of the system and additional functions like the TTX for training and evaluation, which shall cover the lack of SSA operation experience in Japan. NEC ComSpOC has also an evaluation and TTX environment in the system that is independent of the normal operation of SSA. By utilizing this environment, we believe that if SSA operators can evaluate SSA data, be trained, and become familiar, they will indirectly improve SSA operational capabilities in Japan and strengthen the mission assurance of space systems.

5. SUMMARY

NEC has developed the NEC ComSpOC, as a commercial prototype system for SSA operations for the future. We are accumulating knowledge and know-how for SSA through the NEC ComSpOC trial operation, and also are developing some SSA data utilization application proposals. NEC ComSpOC can provide a training environment for SSA operators, and can output the data that can be used by those SSA data utilization applications.

Heading to the STM concept, we suppose that government-commercial cooperation will be key in the near future and expect the concept of the G-C collaboration framework to be realized in Japan. We hope NEC's activities as the commercial sector can contribute to the sustainable safer use of space, and the development and exploitation of space.

6. REFERENCES

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