Operational Space Surveillance and Tracking in Europe

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ABSTRACT

This paper describes the creation and current functioning of the EU SST Consortium, starting from the "Decision of the European Parliament and the Council Establishing a Space Surveillance and Tracking Support Framework" adopted in April 2014. Following this Decision, the EU SST Consortium was created in 2015; it is composed of 8 Members States of the European Union, with five original partners (France, Germany, Italy, Spain and the UK), recently joined by three additional partners (Poland, Portugal and Romania) in December 2018. This Consortium of Member States is based upon a unique model of governance in the European Union, taking into account the highly sensitive civil-military aspects of the SSA domain which addresses important aspects of national sovereignty. This paper also describes the key functions composing the EU SST system, including its sensor network, the data processing function, and the three EU SST services provided to a growing community of European Users. Lastly, the paper provides some results on the system design studies of different SST architectures for the future led by the Consortium.

1 INTRODUCTION

The safety and security of the economies, societies, and citizens in Europe rely on space-based applications such as communication, navigation, and observation. Yet, due to the growing complexity of the orbital environment, space-based assets are increasingly at risk from collision with other operational spacecraft or debris. At the same time, objects may re-enter and cause damage on the ground. Mitigating these risks demands the capability to survey and track such objects and to provide this information to a variety of stakeholders.

For this purpose, a Space Surveillance and Tracking (SST) Support Framework was established by the European Union in 2014 foreseeing the creation of an SST Consortium. Since 2016 the SST Consortium and the European Union Satellite Centre have been working together to operate and further develop a European SST capability, known as EU SST.

This paper presents the SST Consortium by describing in further detail its creation and current functioning, its unique model of governance, the service provision model according to which it provides services to European users, as well as currently ongoing work for the preparation of future SST architectures.

2 THE EUROPEAN UNION SPACE SURVEILLANCE AND TRACKING SUPPORT FRAMEWORK

2.1 A European decision at the foundation of the EU SST Consortium

The Decision No 541/2014/EU of the European Parliament and of the Council of 16 April 2014 [1], is the foundation of the European Union Space Surveillance and Tracking (EU SST) Consortium. As a legal basis, this decision establishes a support framework for space surveillance and tracking which consists of networking and using existing national assets, including sensors and data processing capabilities, in order to provide operational services to European users. The founding decision and subsequent implementing acts prescribed the selection of participating Member States with relevant capabilities by the European Commission, who form the EU SST Consortium implementing the EU SST Support Framework

The general objective of the support framework is to contribute to ensuring the long-term availability of European and national space infrastructure, facilities and services which are essential for the safety and security of the economies, societies and citizens in Europe. It also seeks to prevent the proliferation of space debris. Moreover, the founding Decision stipulates that this support framework should be complementary to existing mitigation measures such as the IADC [2] or United Nations [3] space debris mitigation guidelines or other initiatives, in order to ensure the safety, security and sustainability of outer space activities. Therefore, all those objectives are concurrently contributing to the preservation of the orbital environment.

2.2 Establishment of a SST capability at European level with an appropriate level of autonomy

On a political level, the legal base of the EU SST support framework contains the objective to establish its SST capability with an 'appropriate' level of European autonomy [1]. This means that the Consortium pursues the goal of a complementary rather than a fully autonomous SST capability. Firstly, achieving full autonomy would necessitate massive investments. Moreover, reaching full autonomy would lead to a situation of duplication of United States' efforts. As the new US Space Fence is to enter into service early 2020, by aiming for a catalogue of 200,000 objects of more than 1-2 cm, complete autonomy in the SSA domain is neither desirable nor feasible for the European Union.

Therefore, this appropriate level of autonomy must be understood from the perspective of the EU SST support framework in a logic of partnership and cooperation between like-minded nations. As part of safeguarding the orbital environment, SSA represents a global and shared responsibility, where international collaboration remains a priority. The objective of the European SST Consortium is hence to contribute to the burden sharing of SSA, to act as a capable partner in the SSA domain, and to work collaboratively with other state actors, predominantly with the United States. To this end, both partners have already established a regular dialogue at expert level.

3 A UNIQUE MODEL OF GOVERNANCE

3.1 Dual dimension of the SSA domain

The SST Consortium is based upon a unique model of governance for multilateral space cooperation in the European Union. In fully acknowledging the potentially sensitive civil-military dimension of the SSA domain and related aspects of national sovereignty, all activities within the Consortium are undertaken without impinging on national security policies and bilateral agreements. Moreover, the Member States model allows the participating partners of the Consortium to continue to own, control and operate their national sensors. In order to facilitate this, civilian, military and security delegates from MoDs and space agencies working together across the various levels of the internal governance.

3.2 SST Consortium and Cooperation

From 2015, the SST Consortium consisted of initially five EU Member States represented through their designated national entities: France (CNES), Germany (DLR), Italy (ASI), Spain (CDTI), and United Kingdom (UKSA). In early 2019, the European Commission accepted applications of three additional EU member states, and new agreements were signed to include Poland (POLSA), Portugal (GPSST), and Romania (ROSA). To facilitate service provision, the Consortium forms the so-called SST Cooperation with the EU Satellite Centre (SatCen). The SatCen acts as Front Desk, allowing users to register for SST services, transmitting service related information and products through the Service Provision Portal and providing user support through a dedicated Helpdesk.

The activities of the SST Consortium are articulated across three different levels, i.e. decision-making, management and working levels. The working level is sub-divided into various Work Packages and Tasks corresponding to operational, technological and R&D activities. The management layer coordinates the execution of these activities, and monitors administrative processes.

At decision-making level, three bodies oversee implementation of strategy, technology and security. The Steering Committee (STC) is responsible for the general guidance and management of the SST Consortium. It formulates policy and strategy objectives, decides on financial matters and handles engagement with the European Union, external stakeholders, and international interlocutors. The Technical Committee (TEC) guides the implementation of EUSST operations and R&D, verifies and validates consistency of activities with respect to the technical objectives, and provides technical expertise and analyses to inform strategic decision-making. Finally, the Security Committee ensures the use and secure exchange of SST data and SST information, and monitors security-related and data policy issues.

4 SERVICE PROVISION VALUE CHAIN

Operations run by the SST Consortium are structured around three main functions described in the founding decision, i.e. a sensor function, consisting of a network of Member State ground-based and/or space-based sensors to survey and track space objects; a processing function, processing and analysing SST data at national level to produce SST information and SST services; and a service function providing SST services to the EU user community such as spacecraft operators and civil protection authorities (Fig. 1).

After a period of Initial Operations from July 2016, in July 2018, the SST Consortium adopted an evolved service provision model. This allows a collective but specialized burden-sharing across the different SST functions, in order to avoid unnecessary duplications. The sensor function remains fully in the remit of the Member States. Other functions, in particular the European database and service provision to users, are performed by specific partners responsible for the European-level service provision and data processing side, while maintaining close interactions with the SST Consortium Member States, who all contribute data.

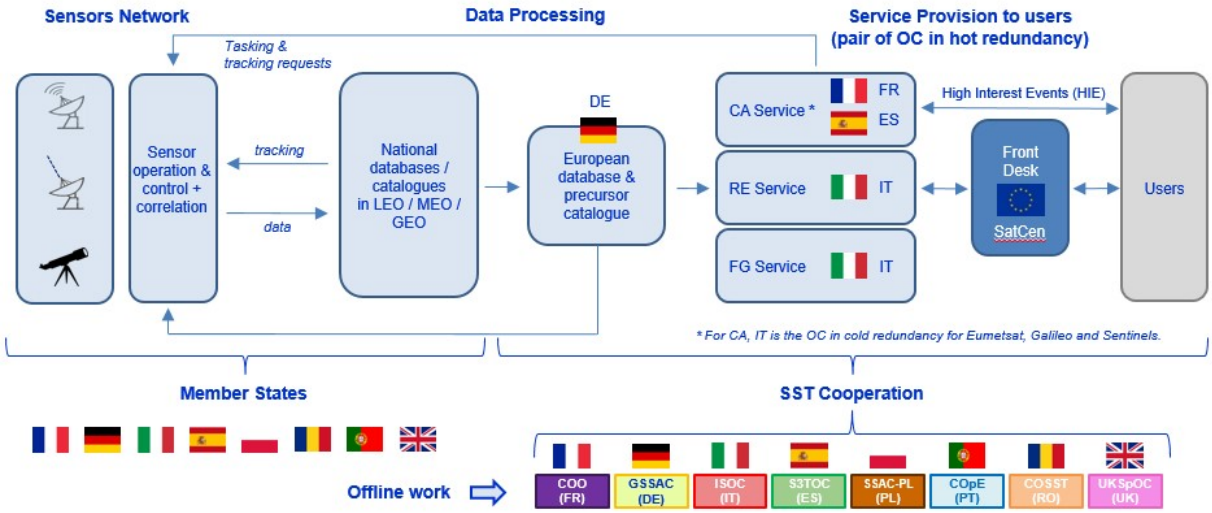

Fig. 1. Service provision model

4.1 Sensor operation

For the current period 2019-2021, the sensor network is composed of 5 surveillance radars, 7 tracking radars, 4 laser stations and an optical network of 35 telescopes (Fig. 2), providing coverage for all orbit regimes (LEO, MEO, HEO, GEO). They are mostly located in mainland Europe (Fig. 3), while some optical telescopes provide coverage from other locations in other parts of the world (Fig. 4).

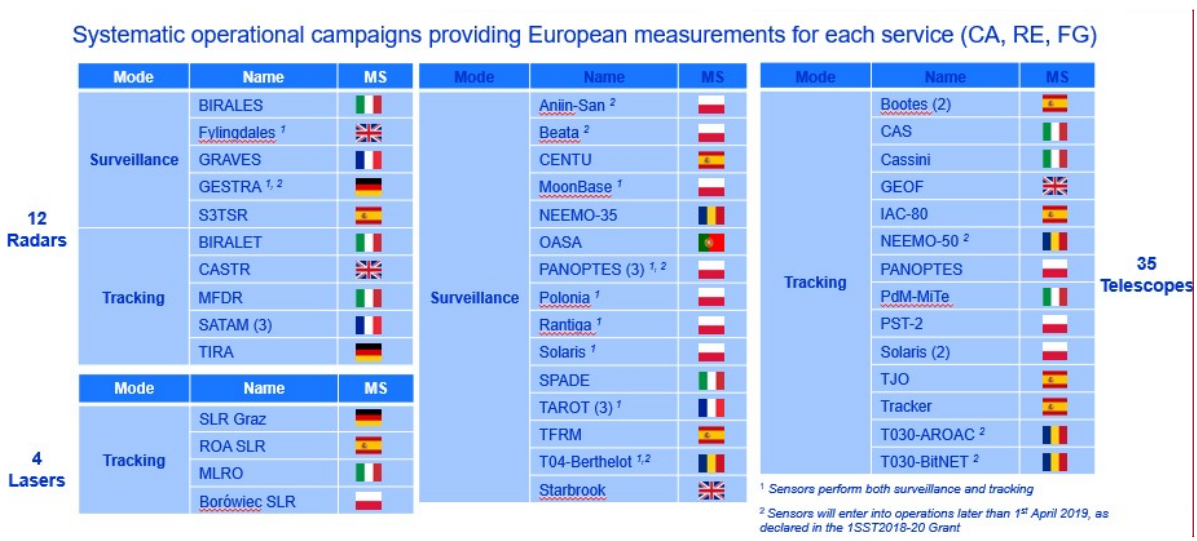

Fig. 2. EU SST sensor network

Fig. 3. EU SST sensor network – European distribution

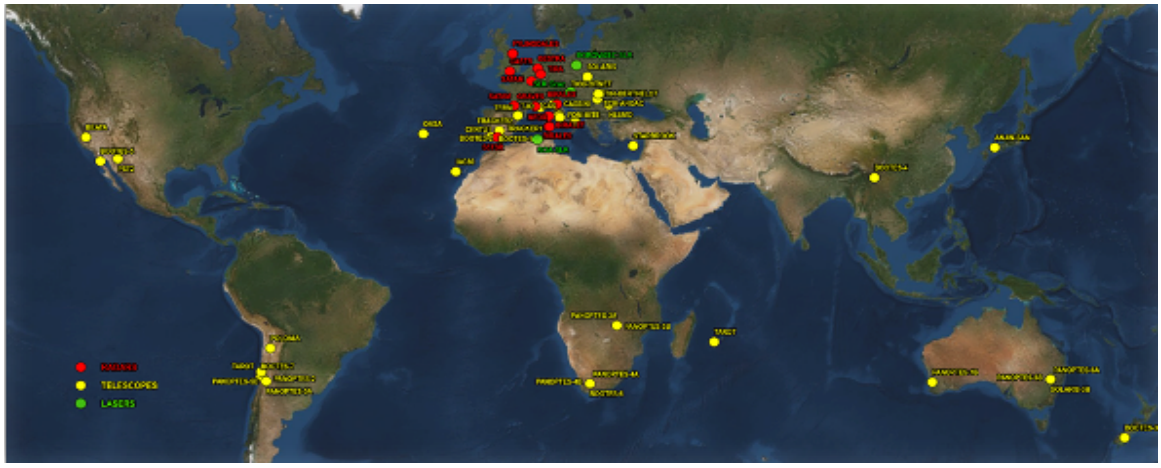

Fig. 4. EU SST sensor network – Worldwide distribution

Members of the Consortium contributing those assets took the commitment to share data, on a regular basis or upon request, depending on the sensor type – e.g. on a daily basis for survey telescopes and survey radars, and in quasi real-time (daily or on request) for tracking radars, tracking telescopes and lasers. Moreover, there are systematic operational observation campaigns providing European measurements for each high interest event (CA) and upon request of the Operation Centre in charge of the service (CA, RE, FG).

Annual operations reviews are performed, where the contribution of each sensor to service provision is assessed for availability, frequency of data sharing and quality of the data. At the end of this process, only the most useful sensors for service provision with high quality data provided on a regular basis among the members of the Consortium are retained.

4.2 Data Exchange & Data Policy

Data coming from the network of sensors are shared among the members of the Consortium via their respective Operations Centres (OCs). The manual process for sharing this data, employed in the past, is now evolving as part of the development of a dedicated European Database which entered into operation in April 2019. It serves as a common platform for data sharing between the members of the Consortium.

This database is the starting point for the building and maintenance of a European catalogue of space objects, where measurements will be correlated and combined in order to determine and refine the orbit of space objects. This European catalogue precursor is currently in development and represents a fundamental element of European cooperation between Member States in the area of SSA.

As the Consortium shares data through the European database and will be processing that data into a European precursor catalogue, there is a need to ensure the efficient use of data while acknowledging national security constraints. All Consortium Member States have general security agreements for the protection of classified material with each other, constituting the prerequisite for any exchange of classified documents or other material. Moreover, all Member States concluded – or are in the process of finalizing – specific bilateral SSA data sharing agreements with the US, covering the bilateral exchange of unclassified SSA data. France, Germany, and the United Kingdom also have bilateral SSA data sharing agreements with the US that additionally cover the bilateral exchange of classified SSA data, as well as liaison officers in US Joint Force Space Component Command (JFSCC), Vandenberg. Finally, France and Germany are currently the only Consortium MS that concluded a bilateral SSA data sharing agreement with each other, covering the exchange of both unclassified and classified SSA data.

4.3 Service provision

Three types of services are provided to users:

- **Collision Avoidance (CA)** consists of risk assessment of collisions between spacecraft or between spacecraft and space debris and the generation of collision avoidance alerts.

  The CA service is provided by the French and Spanish operational centres, working together as nominal and back-up in hot redundancy, with a single operational interface between the nominal operational centre and the user. It includes:

  - the automatic acquisition, checks and analysis of all sources of incoming information, e.g. Conjunction Data Messages (CDM) from the US (18th Space Control Squadron), or autonomously generated by EUSST, and the ephemeris from spacecraft operator;
  - the detection of High Interest Events (HIE), i.e. close approaches which need to be further analysed because of their high level of risk, based on thresholds, on scaled probability of collision and geometry, defined by the S/C operator;
  - observation campaigns in case of HIE, making use of EU SST sensors to refine the orbit of the secondary object;
  - direct interaction with the user in case of alert (according to thresholds defined by the spacecraft operator), and support provided to the spacecraft operator to determine an avoidance action (if needed).

  The EU SST Consortium offers a tailored collision avoidance service at European level based on the joint capabilities of its members, such as France with a 40-years legacy in satellite operations and significant flight dynamic expertise.

- **Re-Entry Analysis (RE)** consists of risk assessment of uncontrolled re-entry of objects and space debris into the Earth's atmosphere and generation of related information, including estimation of timeframe and likely location of possible impact.

  The RE service is provided by the Italian OC and includes two main products. The first product is a list of upcoming re-entries, published with regular updates every 2-3 days on the EUSST Service Provision Portal. This list covers objects for which a re-entry epoch within the next weeks (up to 30 days) has been computed. Users are notified about updates and can access the information at any time.

  The second product is a re-entry warning report, in which information is provided at least 3 days in advance of the re-entry and updated as needed. Users are actively notified and are provided with the details on the re-entry (object details, estimated re-entry ground track, and uncertainty window). A final re-entry report confirming re-entry is also generated.

- **Fragmentation Analysis (FG)** consists of the detection and characterization of in-orbit fragmentations, break-ups or collisions.

  The FG service is provided by the Italian OC and includes two products. The first product is a "short-term" report, provided as soon as possible and reporting on the occurrence of the event and any useful co-related information (e.g. detected number of objects, etc.). Then, a "medium-term" report provides all additional available information (additional objects, orbit data, etc.), possibly complemented with a Gabbard Diagramme and the fragments cloud evolution.

In this service provision model describe in Figure 1, the other members remain prepared to lend support with regular sharing of data through the European database, but also across the three services in offline collaboration and analysis.

4.4 Users

EU SST services are provided free of charge to European users and are available 24/7 on the Service Provision Portal under the responsibility of the EU SatCen. The services are delivered to a growing European community of users, composed of EU Member States including their space agencies, public research bodies or academia, European institutions, public and private spacecraft owners and operators, and public entities concerned with civil protection.

As of end of September 2019 those services are provided to a total of 106 users, from 60 different organizations and 18 EU Member States. There are 45 users registered for the CA services belonging to 22 different organizations. In total, 131 spacecraft (41 in LEO, 30 in MEO, 60 in GEO) of the European Union and its Member States – civil, military and commercial – are registered to be protected from the risk of collision covering all orbit regimes. For the RE service, there are 70 users from 46 distinct organizations, and for the FG services, 60 users from 39 organizations are registered.

Beyond operational interactions, there is a regular exchange with this European user community, in order to capture their needs and requests and further improve the services.

5 ARCHITECTURE STUDIES – PREPARING THE FUTURE

In parallel to operational activities, dedicated work of research and development is being undertaken to prepare the future, improve the performance of SST at European level and reach increased levels of autonomy, while ensuring that any significant investments are based on consolidated studies. To this end, architecture studies were set up to simulate numerous scenarios, composed of one or several sensors (both existing or under development), addressing their individual and collective level of performance.

The initial results of those architecture studies show that in GEO, the Consortium would have by 2021 the capability to catalogue most of the objects of a size above 35 cm in the GEO arc. Full autonomy in GEO seems to be a realistic objective in a near future at European level.

In LEO, different surveillance radars proposed by Member States were simulated with different levels of performance depending on the upgrades to be performed. The upgraded network (Fig. 5) will detect more than 16,000 objects bigger than 7 cm. All radars combined will provide more than 40,000 tracks on a daily basis, allowing the cataloguing of more than 6,000 objects, including 35% of objects larger than 10 cm.

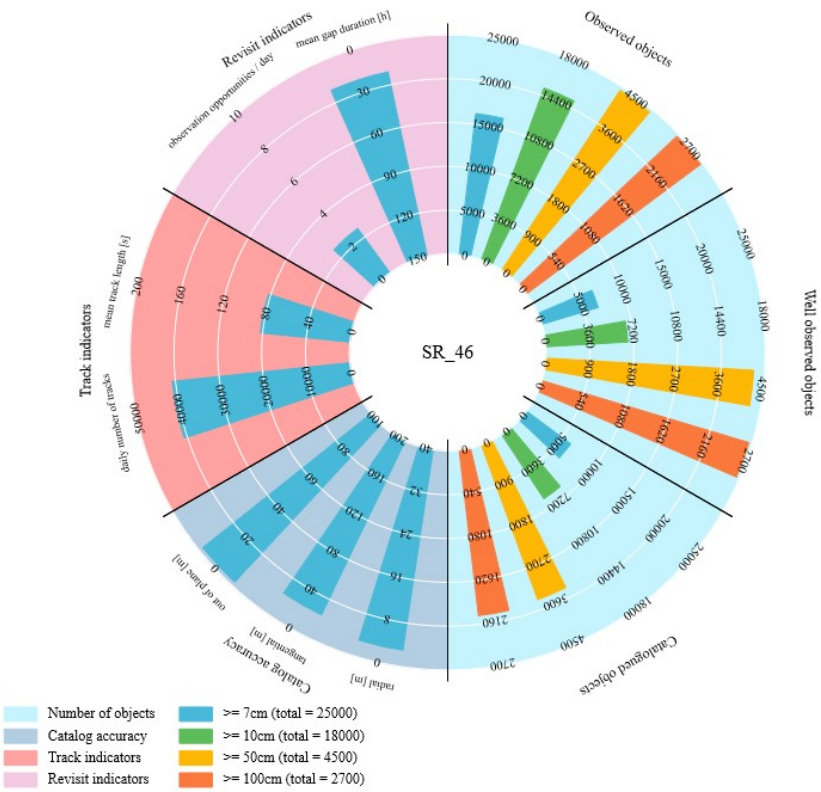

Fig. 5. Performance chart of an expected EU SST survey radar network by 2021

Moreover, the performance of several networks studied at the 2028 timeframe (Fig. 6) includes the simulated orbital population considering the inclusion of constellations and cubesats based on current forecasts. In this scenario, more than 32,000 objects bigger than 7 cm will be detected by the network. All radars combined will provide more than 200,000 tracks on a daily basis, allowing the cataloguing of more than 19,500 objects, including 65% of objects larger than 10 cm.

Those numbers will be further refined through analyses on added-value of those upgrades and investments, as well as on the optimization and prioritization of sensors in order to define the architecture offering best value for money. This next step will also take into account New Space, e.g. assessing recent developments of mega constellations.

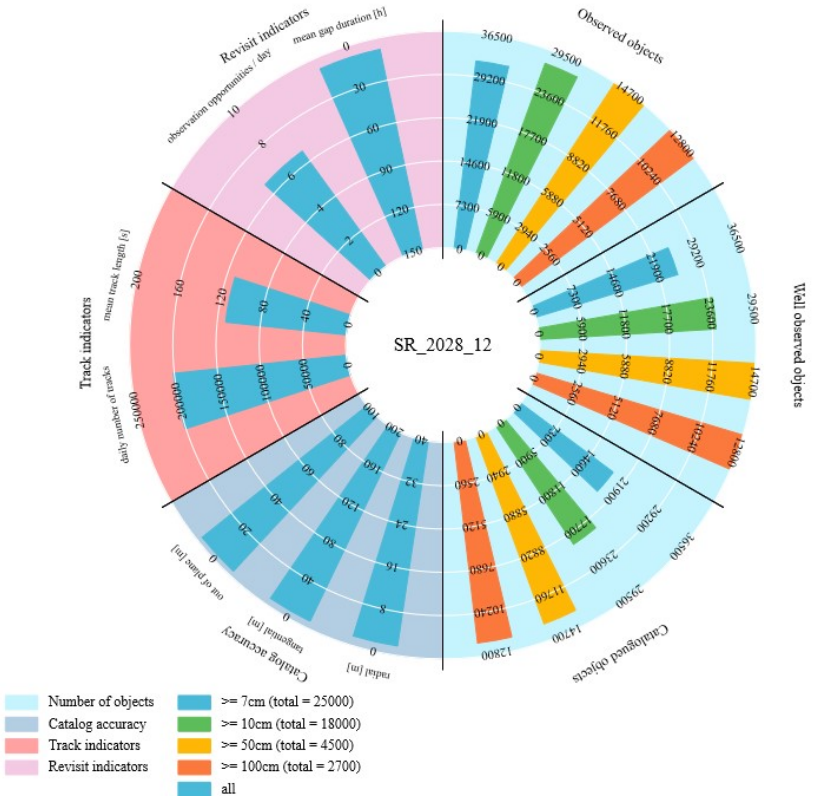

Fig. 6. Performance chart of an expected EU SST survey radar network by 2028

6 CONCLUSION

As the European Union prepares its next budget for the period of 2021-2027, a Space Regulation [4] was proposed by the European Commission, gathering the EU space programs (Galileo, Copernicus, SSA, etc.). The proposal acknowledges Space as a strategic sector for the EU, and expresses the objective to "reinforce Europe's autonomy in accessing and using space in a secure and safe environment […] and [to] strengthen Europe's role as a global actor." [4]. The impact assessment [5] supporting the regulation recognizes that the EU must "mitigate dependence on external actors to build, launch and operate satellites [and] preserve its freedom of action and autonomy of decision." [5].

In this context, the proposed space program aims to enhance the protection and tracking of satellites in space (SST, SSA). While this regulation is still under negotiation, the content of the proposal preserves the current governance model of a Consortium or partnership of EU Member States. The philosophy and mechanisms of internal governance will hence most probably remain largely unchanged.

Finally, given the duality of the SSA domain and the increased importance attributed to security aspects underlying the upcoming EU program, the evolution of EU SST will also be contextualized by further European Union initiatives in defence cooperation such as the European Defence Fund (EDF) and Permanent Structured Cooperation (PESCO). It remains subject to discussion how these will be utilized by European actors to address SSA elements while avoiding duplication of key capabilities.

7 REFERENCES

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8 DISCLAIMER

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