THE TECHNICAL CHALLENGES POSED ON THE SST SERVICES BY THE "NEW SPACE" ERA, THE ITALIAN POINT OF VIEW

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ABSTRACT

The space assets are changing due to Space Democratization. The growth of the population of on orbit debris, together with a strong increase of the Space Service Volume, is becoming an issue, which needs innovative solutions.

In Italy there is a strong commitment to further evolve competences and services in Space Situational Awareness to face the challenges posed by the new scenario. This leap ahead will be achieved through the evolution and provision of a complete set of services, with cooperation of institutions (Italian MoD and ASI)

and industry, including a strong support from university, as well.

To that extent, we report the most relevant evolutions needed, in term of requirements, processing capabilities and enabling technologies, to evolve and update the current models, procedures and infrastructures for the delivery of "new" services.

The paper also analyses how the space and ground based commercial sensors can contribute with this respect.

1 NEW ACCESS TO SPACE

A new era for the use of outer space is coming, carrying out both great opportunities and new issues.

Space is already the place hosting a number of important assets and services (telecommunications, earth observation - EO, navigation, science, and meteorology). Telespazio already has been engaged in the past on the topic of protection of HVA (High Value Assets) in Space [1], with a specific focus on the impact that the failure induced by meteoroids, debris and space weather events on satellites can have on the services on ground, mainly telecommunications, electrical grids and transports. Today the situation is getting more and more complex, due to the fact that easiness of access to space, the availability of low cost space graded technologies, the miniaturization of equipment and satellites and the possibility of accessing space also for emerging spacefaring nations is multiplying the crowd of objects which could endanger safe access and operations in space (Fig.1). Prevision of a dramatic increase of the potential of collision in space (Fig. 2) and increment in the debris population (Fig. 3) if appropriate countermeasures are not taken into consideration and best practices are not introduced in the life cycle of utilization of space.

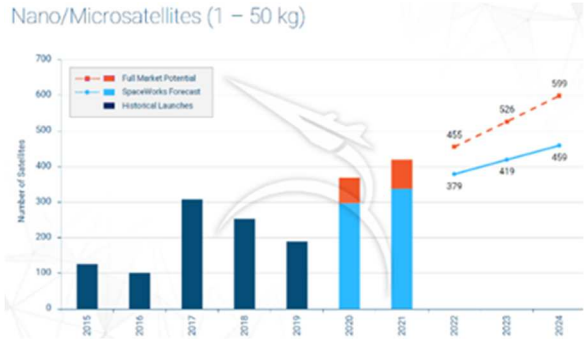

Figure 1 - Satellite Launch History and Market Forecast [2]

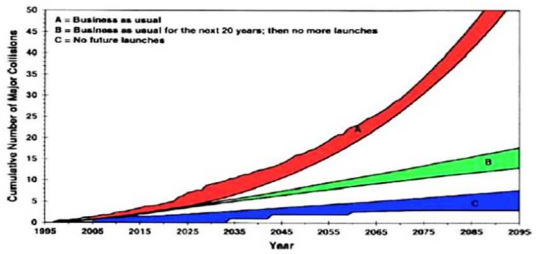

Figure 2- Earth orbiting space debris evolution [3]

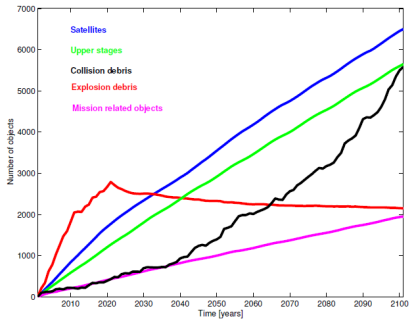

Figure 3

The mitigation of the threats posed by the new scenario can be managed also improving the "operational" protection of space assets, so generating the need to increase the global space awareness. Therefore, the concept of Space Surveillance and Tracking needs to evolve, on one side, toward the concept of Space Domain Awareness, but the "New Space" is also pushing for the establishment of a global Space Traffic Management (STM) framework, which should face technical as well as regulatory challenges [4][5][6].

Safety and long-term sustainability of space access cannot be considered separately from Space Security and the need to improve resilience of space assets, on which the vital services of the Nations critically relies.

2 SSA CAPABILITIES IMPROVEMENT AND SERVICE EVOLUTION

In the Fig. 4 below are reported some of the emerging needs to be addressed in the "New Space" era to mitigate the issues related to overcrowding of space.

Each of these topics implies the improvement of capabilities or constitute a prerequisite to manage problematic areas.

As an example, Space Traffic Coordination, and the related aspect of Legal Issues to be solved for secure data sharing, constitute an enabler for better managing and mitigating the threats posed by Mega Constellations and new space activities.

Figure 4

The enhancement of the capabilities related to Space surveillance and tracking (*Augmented SSA*) represents the first enabler to be considered in order to increase the capability of mitigating and managing the threats coming from the space debris.

The improvements in the knowledge of orbits of potentially dangerous RSO (Resident Space Objects), will give the possibility of a more effective risk assessment, based on more accurate orbit determination and propagation.

In addition to enhancement of SST, the development of an European STM concept need, to integrate additional components, for a more complete space environment characterization, like forecasting of SWE which effects on spacecrafts operability,

SWE information layers contribute to increase Accuracy and Sat Control, as solar events may impact on

- *Satellite Drag,*
- *Impact on On board GNSS,*
- *Satellite Communications,*
- *On board Electronics.*

Sources of orbital perturbations, influenced by solar activity / Space Weather (SW) are:

- SRP (Solar Radiation Pressure) (mainly impacting on high altitude orbits, e.g. GEO),
- Atmospheric drag (low LEO), which can be influenced by solar activity.

The integration of SWE data is example on how the integration of data coming from different sources and available sensors can contribute to enhance SST towards a more comprehensive Space Domain Awareness (SDA).

3 THE INDUSTRIAL SERVICES EVOLUTION PERSPECTIVE

Telespazio has a long heritage in the operation SST domain related to the activity performed in support of the operations of national High Value space assets (eg.:Cosmo-Skymed). For this purpose an accurate process to manage the complete Collision Avoidance cycle has been developed, from risk assessment up to Collision Avoidance manoeuvers execution, following the steps which can synthesized in the Fig. 5

The these capabilities are now in evolution along two main directions:

- ***Automation of Collision Avoidance and Risk assessment services***
- ***Collision Avoidance as a Service*** (CaaaS).

The first point is related to the need to manage the increasing number of potential collision alerts generated by the increase of space traffic, while Collision Avoidance as a Service, in a new space economy often driven by startups with lack of experience, represents an added value for the whole operator's community in support of space market safety.

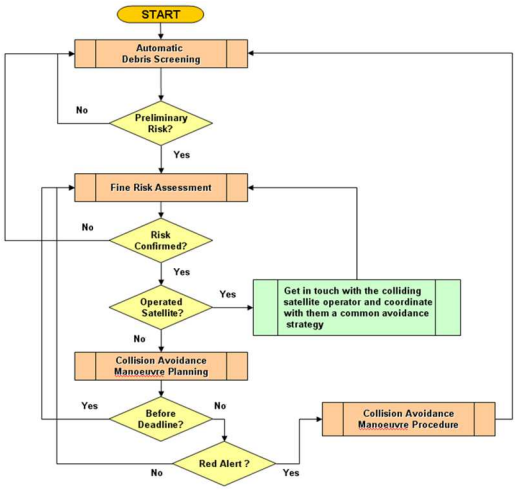

Figure 5

Operators are often able to manage Collision Avoidance information, but, having infinite possibilities due to orbits, covariance, relative geometries, mission specific constraints, the decision making process remains the prerogative of very experienced operators

The CaaaS as initiative has the goal to support all those customer that for several reasons want rely on professional services without the need to put in place dedicated expertise and infrastructure in their organization.

The service is able to dramatically shorten the decision timing providing in a single run the results that a skilled operator usually obtains with several attempt using different tools. Also a novice operator, being completely relieved of the responsibility of the choice of timing, size and direction, can select the most appropriate actions just analyzing the computation results, without having the need to know deeply the entire physics requested by the task. In addition the service has to suggest a possible approach to a maneuver.

It is based on the common Collision Data Message provided by both JspOC/EUSST integrated by information sources from others providers.

To that extent, the integration with commercial space data providers, the participation to commercial initiatives and the integration with space-based sensors is the approach that Telespazio is following to further evolve his offer in SST domain; the objective is to develop Space Intelligence applications and services aiming at completely characterizing the Space Domain.

Industrial companies and commercial service providers are expected to play a growing role in space safety and security, according to the general trend of space commercialization.
Telespazio's participation in the initiative launched by the Canadian company NorthStart Earth and Space fits into this context.

4 INTEGRATION OF SPACE BASED SENSORS DATA & SERVICES

To improve sustainability, reducing cost and taking the pace of the evolving complexity, it is important to include external commercial entities able to guarantee *state of the art* technologies and the right level of trustiness and confidentiality. Since 2018, the USA Government paved the way for the engagement of industrial entities in the STM/SDA arena [7].
This is the ecosystem in which the NorthStar initiative stems out, with the involvement of the Space Alliance [8], to deliver high value SSA services to institutional and commercial stakeholders, guaranteeing integration and interoperability with already existing systems.

For this purpose, NorthStar has designed a constellation of 40 satellites that will be placed in multiple planes in a near polar orbit. In order to supply a set of preliminary services and assess the potential capabilities of the mission, the system will be deployed in several stages starting from a precursor mission that will precede the full constellation and will provide initial SSA/SST services.

The constellation will be able to collect data and information from the on-board optical sensor, by sounding the RSO rbiting the circum-terrestrial space.

Currently the use of this large volume of data aims at the creation of a precise and detailed catalogue of objects orbiting Earth. This massive database, along with several other physical observations and measurements, will contribute to the realization of further services that will be able, not only to predict the location of specific object in space, but to characterise the object itself, in terms of attitude, shape, behaviour and surrounding environment.

These data can be integrated with the ones generated by ground infrastructures, already deployed, which are dedicated to the monitoring of RSO. Thanks to these two complementary approaches, i.e. ground-based and space-based monitoring and tracking, Data Fusion could become a fruitful solution to better describe and model the orbital behaviour of satellites and debris.

5 THE ROLE OF ITALIAN SST OPERATION CENTER

The Italian Air Force has been involved in SST operations since 2014; personnel of the Italian Flight Test Wing managed the Italian SST Operations Center (ISOC) and operated telescopes and radar sensors.

Over time, ISOC improved its operational tools and developed a platform to manage analyses and services.

The following picture (Fig. 6) depicts the system architecture highlighting systems, services and interfaces:

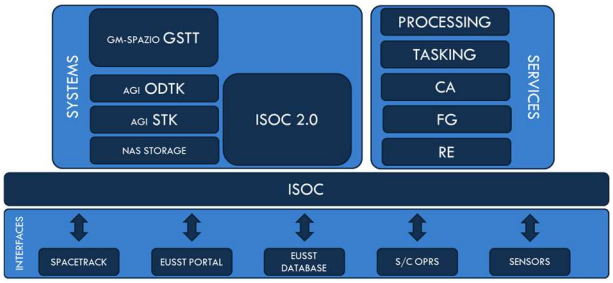

Figure 6

The main SST services are:

- Re-entry (RE): analysis of uncontrolled re-entry in Earth atmosphere for large objects and rocket bodies;
- Conjunction Analysis (CA): analysis of the collision probability and geometry for conjunction events;
- Fragmentation (FG): analysis of in-orbit fragmentation as consequence of satellite break-ups or collisions.

Figure 7

The New Space Era, with its new sectors, is facing an increasing congestion and risks of collisions and interferences: space environment is congested, contested and competitive. These aspects require a faster and continuous upgrading of analysis tools and services.

5.1 ISOC HERITAGE & DEVELOPMENTS

ISOC has a deep experience in RE, FG and CA; along several years, some main events can be reported:

- Tiangong-1 station re-entry campaign;
- Long March CZ-5B R/B re-entry campaign;
- Microsat-R ASAT event analysis;

The Aerospace System Engineering Group is working on future developments about the following areas:

- Services automation;
- New algorithms for CA-RE-FG events characterization;
- From SST services to Space Domain Awareness.

Furthermore, working on identification, characterization and understanding of any factor, passive or active, associated with the space domain that could affect space operations is very important because they are strictly related with space security, safety and economy but also with keeping space environment available for next generations.

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