LARGE EO CONSTELLATIONS OF SMALL SATELLITES TO DELIVER FAST AND RELIABLE INFORMATION FROM SPACE FOR SECURITY APPLICATIONS

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ABSTRACT

The European Union Satellite Centre (SatCen) is a key institution in the space and security domain, being a reference provider of products and services resulting from the exploitation of relevant space assets and collateral data in support of the decision-making and actions of the European Union in the field of Common Foreign and Security Policy (CFSP).

The benefits coming from the use of smallsat constellations technologies are tangible in several sectors and the security domain is not excluded from the list of fields positively affected by this disruptive technology. The increased amount of data coming from smallsat constellations requires also new paradigms in the processing of data: the creation of information in space through on-board processing allows to reduce the latency from the raw data acquisition to the advanced product generation. This shift is fundamental in a sector like security where the fast delivery of information is crucial.

The present work aims to present the added value and challenges in the Space and Security domain related to the advancement of technologies that allow building large Earth Observation (EO) constellations of small satellites and implementing new processing capabilities on board, with a particular focus on the possibility to create information directly from space.

1 INTRODUCTION

Large EO constellations of small satellites provide enhanced monitoring capabilities on a worldwide scale. In fact, while traditional satellites have limited revisiting times and acquisition windows, constellations can offer a shorter revisit time using acquisitions taken by several satellites during the day. This is potentially a game changer in the security domain for observing areas at diverse local times [1].

The benefits of small satellites in terms of manufacturing and deployment are clear: small satellites typically focus on one relatively narrow payload technology or application, unlike large satellites that may carry many complex sensors or payloads. Their decreased size and complexity make it possible to develop the satellites faster, reducing costs thanks to the use of simpler technologies and shorter development time. Thus, small satellites enable the deployment of large constellations, and although individual satellites have relatively short lifespans requiring fast replacement rates, this requirement is satisfied through the implementation of lean production chains, putting in place efficient assemblyline processes [2]. The satellites are put in orbit in batches, each of them including a large number of units maximizing the use of each launcher's capacity and establishing an operational service faster than traditional constellations. In addition, having a large number of satellites in orbit enable more responsive architectures in front of critical requests than a single satellite. It is also worthwhile to observe that using sensor planning standards it is possible to have a certain interoperability with different space and ground segments between constellations belonging to different providers. From the user point of view, this represents an added value, having the possibility to require the needed data regardless of the provider.

When referring to applications for security scenarios, smallsat constellations present new risks. Technical risks might be related to their tracking (and related cybersecurity risks) or, their limited orbit and attitude control (during their operational life and at the end of a mission). Moreover, the entrance of new satellite owners and operators commercially complement the systems offered from national entities. The entrance of these new actors in the market in a short period requires the assessment of the trustworthiness of their infrastructures and capacities. In the case of security applications, these are critical points.

SatCen considers all these aspects and work to make the maximum benefits of smallsat constellations, ensuring that the data and services provided satisfy the security requirements associated to its services. As a result of a number of SatCen Research, Technology Development and Innovation (RTDI) initiatives, large EO constellations of small satellites have been identified as a potential asset to support SatCen operations (e.g., critical infrastructure / coast / port monitoring, contingency planning, border surveillance, humanitarian aid, situational awareness). The increased amount of data and the faster availability of relevant information could indeed lead to the generation of new Geospatial Intelligence (GEOINT) products enabling, for instance, continuous situational awareness reporting. This innovation would boost the number of user requests for GEOINT products to be performed. On the other hand, this growth of data requires new methodologies to ingest and process all the information provided from space.

2 INFORMATION MADE IN SPACE

Several policies [3] highlight the need for exploiting the potential of large EO datasets captured by future constellations with semi-automated or autonomous capabilities for hazard detection and monitoring, hazard mapping and hazard forecasting. Up to now, this exploitation is mainly made on-ground, processing the raw images and generating Level-1 (L1) or Level-2 (L2) products, which require some significant time before the products are available at the final user side [4].

Today, the evolution of on-board hardware and software technologies (e.g. edge computing) make possible to carry out some of this processing, or even the application of new algorithms already in the satellite, reducing considerably the time to have information available.

The benefits derived from the integration of advanced on-board processing capabilities to extract relevant information in space are evident for sectors like security, safety, or emergency. Machine Learning (ML) and Artificial Intelligence (AI) are one the most used techniques for onboard processing [5]. The creation of GEOINT products mostly relies on already calibrated images; the processing from raw data to L1-L2 products directly on board would shorten the amount of work of ground processing facilities, resulting in a lower latency to get decision ready information. On-board processing could also reduce the size of data to be delivered for specific GEOINT tasks (e.g., for early-detection, feature extraction or change detection, target detection, where less ancillary data for atmospheric correction would be needed in space). It is also important to highlight that the reduced size of the information to be delivered allows a faster transmission, which combined with the transmission capacity enabled by telecom smallsat constellations, could drive to quasi real-time detections for timely decision-making.

However, it is also extremely important to consider reliability and security aspects when exploiting the data and capacity of these smallsat constellations. Algorithms shall be scrutinized to create advanced and trustful on-board intelligence, and secured access to the satellite hardware for onboard software updates must be properly considered to avoid any non-desired modification or malfunctioning. In addition, trustworthiness of the information should also be guaranteed in the whole EO data chain, from the image provider to the final users passing through the intermediate layer of GEOINT provider. All the resulting information (including the ancillary data as geolocation and calibration) should be transmitted in compliance with the security levels required for each case (e.g., data privacy, cybersecurity and information classification in case of need). In the global context, it is therefore important to ensure secure communications, including synergies with satellite communications solutions (e.g., GOVSATCOM), for secure data transfer.

3 ACTIVITIES AT SATCEN ON SMALLSAT CONSTELLATIONS

SatCen is constantly evaluating the use of data and capacities from current and upcoming constellations to identify the ones that provide added value in its daily work. Sensors like VHR SAR and optical, videos, HR and thermal, flying in constellations, have been identified as possible source of information. In particular, the use of constellations allows to increase the available images during a single day thanks to the overpass of multiple satellites.

SatCen supports the test and use of smallsats through activities like:

- providing technical and functional requirements to industry in the preparation of future missions;
- providing requirements on onboard processing capabilities (e.g., based on AI) from the user perspective;
- ingesting of sample products in SatCen infrastructure (e.g. GEO-DAMP) to verify interoperability of data;
- testing of smallsats data in operational scenarios.

Possible future activities could consider the demonstrations of onboard detections, the demonstrations of EO/Telecom smallsats joint operations and a deeper integration of smallsats data with other traditional EO sources, the validation of processing chains in SatCen workflow.

4 CONCLUSIONS

The present article shows the advantages and risks of the use of smallsat constellations in the security domain, with a particular focus on the creation of information made in space.

Both EO and telecommunication constellations have wide potential to enhance current operations, enabling new GEOINT services in terms of new use of data as well as new service provision capacity, proving an improvement in terms of quantity (e.g., new GEOINT products) and quality (e.g., better interoperability).

However, the involvement of final users since the very early definition stage is key to ensure that the onboard algorithms are designed in line with real operational needs. The involvement of final users in the early phases will, in addition, serve to specify the necessary security and reliability requirements to be guaranteed in the end-to-end services, from data request to final information access.

5 REFERENCES

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