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Towards a Greek Earth Observation Small Sat Programme: First steps

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Abstract

The Hellenic Space Center (HSC), the National Space Agency of Greece supervised by the Ministry of Digital Governance, is designing Greece's first space-based Small Sat National Earth Observation Programme. The project, intended for civil applications, aims to provide all public sector authorities with high quality imagery of the Greek territory captured from space. HSC has conducted a detailed investigation, consulted by key Greek ecosystem stakeholders, to specify their user needs and requirements in terms of resolution, revisit time, desired optical or infrared channel and other technical characteristics. The results of this study are being distilled into a unique design that will make optimal use of new space solutions, commercial-off-the-self (COTS) products and cutting-edge technologies for the space segment, in addition to the use of the ground segment and downstream applications. Once operational, the system will substantially reduce annually recuring operational expenditure of the Greek state by defragmenting or completely substituting the current modus operandi of procuring commercial imagery products. At the same time, it will build a much-needed technical capacity in the country and enhance the public sector's capability to respond effectively to a wide range of challenges with a particular focus on disaster management, agriculture, maritime/marine, and climate change applications. Currently, our team has conducted a collection of the national user needs/requirements, defined a set of critical applications, and proceeded to the initial mission overview. The findings of this present paper are not considered conclusive as the detailed mission objectives and requirements are going to be refined through an Agile approach involving the users and the involved Ministries.
Keywords: Earth Observation, Small Sat, New Space, Space Strategy, Low Earth Orbit

Acronyms/Abbreviations

Commercial off-the-shelf (COTS)
Earth Observation (EO)
Hellenic Space Center (HSC)
Low Earth Orbit (LEO)
Short-wave infrared (SWIR)
Sun-synchronous Orbit (SSO)
Technology Readiness Level (TRL)
Visible and near-infrared (VNIR)

1. Introduction

The National EO Small Sat Programme is a project commissioned by the Ministry of Digital Governance of Greece and implemented by the Hellenic Space Center (HSC) to create the first National Space Earth Observation system. Currently, HSC has been conducting a feasibility study which aims to consolidate all available market information and create a list of proposals to the Ministry with specific technical, cost and schedule characteristics to address national EO needs. HSC has precisely and thoroughly identified the national end-users, the different critical applications, captured the user needs/requirements and defined the initial mission objectives for an Earth Observation mission. The application needs were translated into high level payload engineering parameters (spatial, temporal, spectral resolution, etc), mission requirements (availability, rough orbital profile, etc.) and the inputs were used to identify the various payload/optical imaging systems.

More specifically, the end-user needs, and mission objectives/requirements were translated to target performance specifications related to the payload/optical imaging system. To minimize potential risks, high Technology Readiness Level (TRL) payload candidate solutions were evaluated. A thorough market research and analysis, including COTS and custom payload solutions took place to identify the most suitable set of candidate camera systems. For each payload detailed specs, time plan, application examples, previous integration usage, flight heritage

and costs were analysed. Imaging solutions from different providers were considered and multiple technical discussions either online or face-to-face were performed.

2. Definition of applications, user needs and mission objectives

2.1 Identification of Users

Earth Observation data and services benefit a large base of users, including:

- **Core users**: International institutions and bodies as well as national, regional or local authorities entrusted with the definition, implementation, enforcement and monitoring of a public service or policy. EO informs the decision making of national governments tasked with, for example, setting up plans for disaster response, improving resilience against high-risk hazards, or adapting policy to the effects of extreme weather and climate change.
- **Commercial and private users**: Geospatial data and analysis tools help businesses address sustainability and climate risks and optimize their use of resources (e.g. farmers, shipping companies, airlines, etc.). The use of EO by these communities is abundant – use cases and examples of applications can be found throughout this report, both in general and in each market segment.
- Importantly, the availability of EO data in combination with technological developments (e.g. artificial intelligence, cloud computing, machine learning) will enable **research communities** to generate a vast amount of insights – these include tracking and visualizing forest and coral-reef loss or predicting disease outbreaks and glacier melts.

Within the scope of the project, HSC reached a multidisciplinary list of national users ranging from Ministries (e.g., Civil Protection, Environment), Public Agencies (e.g., Cadastre offices, regional offices) as well as clusters of municipalities and private companies.

2.2 Definition of Applications, User Needs & Requirements

It is accepted and proven that EO information gathered from spacecraft provides substantial benefits supporting economic development and supports informed policy and decision making. Geospatial technologies, remote sensing, satellite communication and navigation systems are providing many new ways for effective management of natural resources. This has resulted in enabling a variety of data and information products for societal benefits and also helping planners and decision-makers to embark upon unique people-centric services.

Earth observation data can be exploited for several new opportunities, such as the sustainable management of natural resources. Some specific applications (Fig. 1), relevant to Greece's needs, include:

- ✓ Forecasting weather
- ✓ Tracking biodiversity and wildlife trends
- ✓ Measuring land-use change (such as deforestation)
- ✓ Monitoring and responding to disasters, including fires, floods, earthquakes, and tsunamis
- ✓ Managing energy sources, freshwater supplies, and agriculture
- ✓ Addressing emerging diseases and other health risks
- ✓ Predicting, adapting to, and mitigating climate change

Various key national stakeholders and end users were reached, and their input was used to formulate precisely their application needs accompanied with specific objectives, requirements and needs. User consultations through co-design, structured group interviews, dissemination of questionnaires and one-to-one meetings were realized to extract the needed information. In parallel, a desk study and analysis of published reports and market research [1][2][3], in European Level was performed to complement the identified applications and needs by the end-users and ensure the complementarity and added value capabilities and services/products to existing European (COPERNICUS) and International missions.

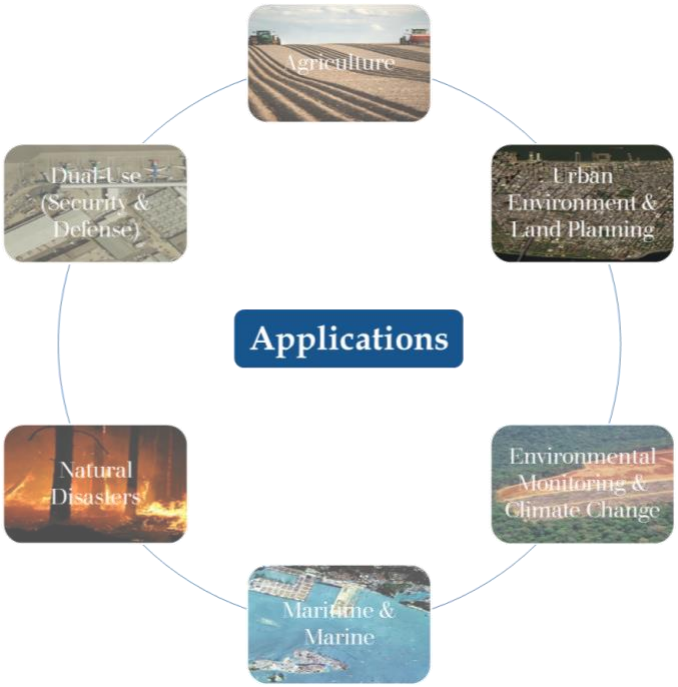

Fig. 1. Critical applications related to the identified user needs/requirements.

2.3 Mission Objectives, Assumptions & Constraints

The application needs, objectives and user specifications were grouped and the captured needs and resulting objectives and requirements are now documented. More specifically, the mission requirements were formulated by analysing the mission objectives and constraints, and cover areas such as performance (spatial, spectral and temporal resolution), coverage (orbit, number of satellites, scheduling), responsiveness (processing delays, operations, data timeliness). On the other hand, operational requirements such as duration, availability, survivability, data distribution and data format (i.e. level of processing) were considered. It should be noted that these are living areas of analysis and engineering and will continue evolving iteratively with additions and adaptations according to the project and user needs.

- ✓ The mission will be designed to provide enhanced revisit frequency, coverage, timeliness and reliability for operational services and applications according to the documented user needs and requirements for the Greek territory.
- ✓ The mission will provide an operational Earth Observation sensor capable to produce imaging products related to various application domains such as: disaster monitoring, agriculture, environmental monitoring, urban environment, maritime, marine and dual use.
- ✓ The mission will focus on the Greek territory on a bi-weekly basis and will be inline with mayor European and International missions.
- ✓ The mission will complement current European and International missions such as the COPERNICUS and Landsat missions.

The top-level mission objectives/capabilities and requirements can be summarized in the following table:

Table 1. Small Sat National Earth Observation Mission objectives and requirements inline with the identified user needs/requirements

Capability	Performance
Earth Observation applications	• Disaster monitoring: floods. fires, etc. • Agriculture: crop monitoring, vegetation coverage, mapping of soil types, moisture. • Environmental monitoring: land use mapping, changes, biodiversity, climate change. • Urban environment: urban green, urban planning, cadastre. • Maritime and Marine: monitoring, surveillance, water quality • Dual use: law enforcement, security and defense.
Orbit Characteristics	SSO (Sun-synchronous Orbit) LEO, Altitude = 450-700 km (~500Km)
Spacecraft type options	CubeSat Constellation (6U, 12U, 16U), Shared satellite platform (hosted payload) or MicroSat
Spacecraft design life	> 3 years (ideally >5)
Coverage	Greek territory (priority)
Swath size	> 20 Km
Capabilities	Tasking & Spacecraft agility
Spatial Resolution	< 10 m (Hyperspectral), < 5 m (Multispectral)
Spectral Range	VNIR (Hyperspectral), SWIR, Coastal blue, Red Edge
Temporal Resolution	To be able to fully cover Greece in 2 weeks
TRL	> 7 (ideally 9)

3. Conclusions

The current paper presents a work-in-progress report and an overview of the definition of the user needs, requirements, and mission objectives for the Greek National Earth Observation Programme. Most of the applications and requirements are related to natural disasters, agriculture, and environmental monitoring. While Greek entities have access and exploit major European and International initiatives such as COPERNICUS and Landsat missions, it is evident that the current space capabilities cannot thoroughly and successfully fulfil some crucial user requirements, especially those related to timeliness and temporal resolution (i.e., for natural disasters, multitemporal crop monitoring, water quality). Furthermore, free, and open EO satellite missions offer a medium to low spatial resolution (~ 10-250 m), however considering Greece's size and geomorphology, it is evident that imaging products with higher spatial resolution (~ 5 m) are needed. Finally, most of the users expressed their interest in more sophisticated spectral bands like Coastal Blue, Red Edge and SWIR in high spatial resolution, which are either not available in the free missions (>10 m pixel size) or are sold in high prices in the case of VHR commercial satellite providers.

It is evident that mission objectives are strongly influenced by the user needs/requirements and many different solutions can fulfil the various needs in a certain extend. Mission objectives are living areas of analysis and engineering and will continue evolving iteratively with additions and adaptations according to the project needs.

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