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EXECUTIVE SUMMARY OF THE THESIS

Tackling grand challenges through space projects: an investigation of the ESA Business Application project programme

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1. Introduction

Since the first launch of a satellite into orbit in 1957, the space sector has seen a high technological improvement pushing their application towards the edge of human imagination. During the initial stages, the economy was mainly driven by public organizations with military and defence purposes. As time goes by, the high cost of missions becomes increasingly unsustainable for organisations, highlighting the necessity to find new revenue streams for these applications, pushing towards a commercialization of space. Governmental bodies began establishing regulations that allow private actors to participate in the space economy in order to fulfil the requirement for the financial sustainability of space.

With the advent of the new century, the privatization of the sector and the higher accessibility to space data, attract an increasing number of stakeholders resulting in a growing number of satellite applications adopted by non-space users such as farmers, logistics companies, and energy providers. Nowadays, many services built on space data are commonly used in our everyday life. Space agencies are adapting to this sector transition, and the European Space Agency (ESA) makes no exception. In their vision they declare "boost commercialization for a green and digital Europe" (ESA, 2021). In order to actively achieve this purpose, the Business Application Programme is established. It is a European initiative to support both financially and managerially commercialization of space-based applications, products and services exploiting space data and technologies in non-space domains (e.g., insurance, energy, and healthcare).

Furthermore, space-based projects with terrestrial applications can contribute to achieve social challenges of planetary significance. These are also

called "grand challenges" such as climate change, zero hunger, etc., and are defined as such if they produce outcomes potentially affecting millions of people through the implementation and commitment of different scientific disciplines by capturing public attention and political support (Gould, M., 2010). For example, earth observation satellites with dedicated payloads installed provide monitoring of air quality by detecting the quantity of pollutants in the environment, enabling authorities to deploy targeted actions. However, there's still a lack of understanding about the relevant features which characterize projects into the Business Application Programme portfolio and in assessing their impact on society (Morretta et al., 2022).

Likewise, since recent years have seen a lot of macroeconomic events affecting the world's economy, is interesting to evaluate how projects of the programme reacted to them and what actions have been put in place by ESA to enhance the recovery. Moreover, their contribution to grand challenges needs to be further investigated. Is still not clear what are the determining factors within a project providing positive impact on these challenges.

This research aims to provide an overview of the projects within the Business Application by detecting main trends regarding space technologies used, sectors these services will serve, customers being targeted and member state participation. I address these research questions: how much is ESA Business Application contributing to adopting space technologies into downstream applications? What are the most relevant and recurring features in the projects applied? How can they contribute to grand challenges?

2. Literature review

After a brief historical introduction on space economy, I've investigated the market perspective of earth observation, satellite navigation and satellite communication technologies.

The National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), and Agenzia Spaziale Italiana (ASI) are three of the major stakeholders in the space industry and their structure, history and intended purposes are thoroughly examined.

Furthermore, ESA most important programmes are investigated. The first one is Galileo, the European satellite navigation system, which provide five high-performance service to users worldwide. Galileo grants Europe and its people autonomy and independence in the provision of navigation, positioning, and timing information (PNT) services. The European Copernicus Earth Observation Program is then developed further. The vast array of services offered by it are reviewed, with a special emphasis being placed on the Free, Full, and Open data policy adopted by it in 2013. Finally, the programme object of the research, Business Applications, is studied, by providing insights on how the programme works, how the application iter is arranged and how the financial scheme for funding projects is established.

I also researched at the literature on project management-related subjects. Techniques for managing project portfolios are essential for overseeing several projects, with the Multiple Project Management (MPM) approach receiving particular attention. Satellites are extremely complicated technologically and contextually, necessitating an alternative project management strategy. Building a comprehensive perspective of the project that transcends the iron triangle scheme's conventional wisdom and becomes more connected to the project's environment is essential in complex project management. Many stakeholders are involved in space economy, including operators, regulators, citizens, interest groups, and suppliers. Maintaining relationships with each of them is essential to the success of the project. In addition, I investigated how the subject of project performance related to completing grand challenges. Project success and project management success are outlined. Since intangible contributions made by projects are also taken into consideration, the first method is the most suitable approach for assessing how projects contribute to the completion of grand challenges.

3. Methodology

I built and analysed an original database of 998 projects developed between 2014 and 2022. The research focused on extracting information from the Business Application web page, where the various projects are registered. Each of these is characterized by a description of what needs it aims to meet, the intended users, and what space technologies are exploited. After that, data were formatted and recorded in a dataset, providing the basis for future analysis. As a result, 34 variables were created, some of which were directly published on ESA's website, while others required processing and assumptions to be properly recorded. In addition, ESA provided their internal classification of the economic sectors in which the projects operate, different from that published on the site, and therefore the various projects are reassigned according to the new guidelines.

First, a descriptive analysis of the dataset is conducted to identify the key patterns in both technological and non-technological features. In addition, time series of projects submitted to the program are examined and compared with macroeconomic events, technological milestones, and tenders released by ESA. Then, a more analytical method is employed to determine which aspects of project profiles are most important for addressing grand challenges. Logistic regression is used in order to build three models for Climate Change, Net Zero & Carbon Neutrality and Biodiversity Loss grand challenges.

4. Results and discussions

The results show interesting outcomes. First of all, satellite communication (SatCom) services, which were for many years the sole commercial driver for space assets (J. N. Pelton & S. Camacho-Lara, 2017), now seem instead to be losing share to satellite navigation services and earth observation. These new technologies, have found interesting applications in various areas, increasingly gaining a foothold in the running of terrestrial businesses. In particular, is observed a gradual absorption of satellite navigation (SatNav) technologies, which until 2018 were the most adopted by projects within the Business Application. Since then, the exponential growth of Earth observation (EO) data has taken hold, becoming the most leveraged. EO data-driven services in particular have found fertile ground in areas such as Agriculture, Forestry & Fishing, Energy & Utilities, Construction & Infrastructure, Finance, Insurance & Legal, and Environment & Wild Life (Figure 1). This technology has enabled operators in these fields to rely on data for weather forecasting, solar irradiance prediction, ground deviation analysis, vegetation monitoring, damage assessment following severe events, pollution monitoring, and site assessment for construction purposes. Satellite navigation technologies find useful applications in sectors such as Transport & Logistics and Health & Social Care, where real-time geolocation and positioning are of paramount importance for running operations. Lastly, Satellite communications find easy implementation in the Education Information & Communication sectors. Indeed, their main added value concerns precisely the possibility of providing a stable and fast internet connection in remote places on earth that terrestrial telecommunications technologies could not reach.

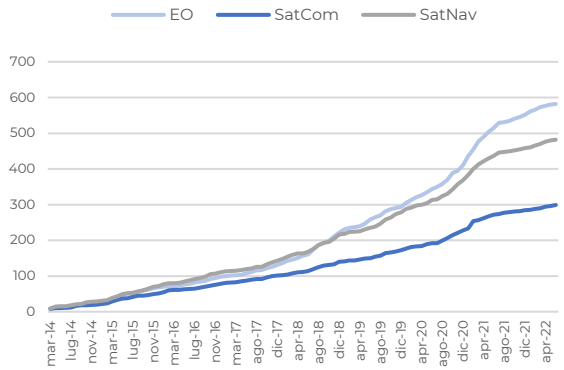

Figure 1: cumulated time-series of space technologies employed

On the level of the most participatory countries in the application of such projects to the programme, the most involved ones turned out to be the United Kingdom, Italy and Germany, which count for approximately 50% of the total number of projects in the Business Application. Interestingly, participation by France and Spain, two countries among the largest contributors to the budget

allocated to ESA by the various member states, is much more limited. The reason is sought in the lack of budget allocation for the Business Application program, and the higher focus on developing national space economies toward the upstream sector rather than the downstream one.

Macroeconomic events impacted the whole society and world economy, especially the advent of COVID-19, and Business Application projects make no exception. In most areas, coronavirus was an obvious blocking factor, especially in the early periods of lockdown and general uncertainty, in which registered applications dropped dramatically. However, the recovery put in place was rapid and exponential, and, in many areas, applications have even doubled since that time, driven especially by the Health & Social Care sector. Especially in this field, space technologies were of paramount importance during the crisis, empowering operations to be run remotely reducing the probability of being infected. Satellite navigation enabled the prompt identification of covid cases, allowing the authorities to activate all isolation procedures and limit the virus's spread. Another very impactful event is found in Brexit, especially for projects proposed by British prime contractors. Britain's exit from the EU has created obstacles in business relations with Europe, bringing uncertainty and causing a slowdown in investment in UK. In Business Application projects, this was especially observed in the Transport & Logistic sector, where England was the leading country for proposed services until 2021 and has seen a sharp decline in submissions since then.

To incentivize applications in a particular area or theme, ESA opens calls in order to find companies with proposals for services using space technologies. The use of these tools has proven to be very effective. Spikes in applications have been noted during the opening periods of these tenders in almost all areas. This tool was found to be critically important during the stages of great impact mentioned above, effectively incentivizing a quicker recovery.

Furthermore, the analysis of the Business Application projects concerning their impact on grand challenges shows that 32% of them succeed in contributing positively to at least one of the challenges select by this research. Especially projects using earth observation greatly impact challenges such as Climate Change, Net Zero & Carbon Neutrality, and Biodiversity Loss. The ability to obtain spatial data regarding air quality, greenhouse gasses emissions (GHG), solar irradiation prediction, and habitat health monitoring are key in assessing these challenges. Then again, satellite navigation applications have greatly impacted the protection of older population segments and biodiversity prevention. The ability to remotely monitor people's health status through these technologies combined with in situ accessories and the ability to geolocate animals are surely two key functionalities in providing a positive contribution to these challenges. Satellite communications also greatly impacting humanitarian and social disparity challenges. The ability to provide a stable and fast connection in remote places or areas with poor telecommunications infrastructure allows the most marginalized population to access all the services provided by Internet and to their educational content.

5. Conclusions

In conclusion, this research highlighted how the Business Application Programme is an effective initiative for boosting the commercialization of services provided by space assets. Key technology and business-related trends that have characterized the past, present and will emerge in the future of this industry have been highlighted. In addition, it was shown how services enrolled in the program can have a central role to contribute positively to “Grand Challenges” achievement. Notably, their impact varies according to the characteristics of the technologies used and the domain in which they operate.

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