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What is value in the New Space Economy? The end-users' perspective on satellite data and solutions

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ABSTRACT

New industrial dynamics are disrupting the space sector. New stakeholders bringing in capital, technologies, and knowledge from other industries are developing next-generation space infrastructures and services. Both commercial and institutional space projects have to be valuable for a wider set of end-users, asking not only for economic returns but also social and environmental benefits. Space organizations urge understanding and fostering value in the New Space Economy ecosystem. Indeed, end-users are still struggling to enact the expected value of satellite data and solutions for their business. This paper aims to investigate the expected value and the level of adoption (enacted value) of satellite data and satellite-based solutions in the New Space Economy ecosystem from end-users' perspective. We interviewed 21 managers from end-user organizations in different sectors (i.e., Insurance & Finance, Energy & Utility, Transportation & Logistics). Value is deeply discussed in general management literature, and we identify Value Theory as the theoretical lens with the most explanatory power for the phenomenon under examination. From the end-users' perspective, we frame the expected value and the enacted value in taking strategic and tactical decisions regarding their activities, services and products, laying the foundations for further studies of value mechanisms in the New Space ecosystem. Our research set a theoretical and conceptual foundation on value in the New Space ecosystem. It also delineates the blurred boundaries of the New Space ecosystem, the main stakeholders involved, and their perception of value. Insights and implications for strategic and innovation management are also provided. Practitioners may exploit our research results and leverage the end-users-oriented framework to develop next-generation space projects in the New Space ecosystem. We also discuss the limitations and further developments of this research.

1. Introduction

New industrial dynamics are disrupting the space sector. New stakeholders bringing in capital, technologies, and knowledge from other industries are now involved in developing next-generation space infrastructures and services. Space projects have to be valuable for a wider set of end-users, asking not only for economic returns but also social and environmental benefits in the long term.

In a traditional space economy, space organizations (i.e., upstream and downstream) build a satellite constellation and develop a satellite-based solution commissioned and paid upfront by the client, usually a space agency. Thus, the scope, the end-users and the expected value of a satellite infrastructure are clearly identified since the beginning of the project/programme.

In the New Space Economy, the liberalization of the market and the ever-easier and cheaper access to satellite data have changed the value proposition of space organizations toward end-users. For example, free access to space infrastructure, such as GNSS, has stimulated the emergence of new products, services, businesses and industries. Without satellite navigation data, end-users such as Uber, Ofo and Deliveroo would not be the worldwide giants we all know that have revolutionized mobility and consumers' lives. End-users can capture the value of satellite data and generate new businesses. However, the complexity and deep uncertainties affecting the medium-long-term development of this business may limit the expected value enactment. Indeed, the heterogeneity of the applications complicates the identification of end-users, their needs and engagement strategies. End-users may enact the expected value from satellite data but have to be engaged by space organizations in different ways and with different purposes. Different end-users can access data in different countries, and the same satellite data can be valuable for different industries and purposes. Understanding what value end-users expect from satellite data is thus the most urgent

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issue to be addressed, and taking the users' perspective is fundamental to understanding the value of satellite data and satellite-based solutions.

End-users can collect quasi-real-time and precise data from many sources, including satellite data. Although data per se are worthless, they should become useful information to stakeholders and thus respond to their needs. On the one hand, space organizations (i.e., upstream and downstream) building satellite infrastructures and sensors, and producing the data, cannot envisage all the possible applications of their data as they are not end-user experts. On the other end, end-users (including organizations from other sectors such as Insurance & Finance, Energy & Utility, and Transportation & Logistics) are unaware of the kind of data satellites might generate and how to enact the expected value they are not space experts. This lack of awareness and alignment of respective value propositions between space organizations and end-users leads to missed opportunities for exchange value.

We identified a relevant knowledge gap. Despite the relevance of considering the users' needs in developing new satellite and satellite-based solutions, the existing body of knowledge disregard their perspective. Addressing this knowledge gap (i.e., a limited investigation of the users' value perception regarding satellite data and satellite-based solutions) enables a much more comprehensive and nuanced understanding of the value created by satellite data and satellite-based solutions. The users' perspective could support satellite developers in understanding the difference between the expected value and the current level of adoption of satellite data (enacted value) in users' decision-making and the reasons behind this difference. Considering the expected and enacted value of satellite data from the users' perspective is particularly relevant in the New Space Economy, where private organizations, policymakers, and space agencies are fostering new satellite technologies and business development [1,2].

Our article aims to investigate the expected value and the level of adoption (enacted value) of satellite data and satellite-based solutions in the New Space Economy ecosystem from the end-users' perspective. To this end, we will answer the following research questions:

RQ1. What value do end-users expect from satellite data in the New Space Economy ecosystem? Why?

RQ2. What is the level of adoption of satellite data in end-users' decision-making? Why?

As the first research to take end-users' perspective in examining the expected and enacted value of satellite data and satellite-based solutions in the New Space Economy ecosystem, this research is exploratory in nature, and qualitative research is the most appropriate approach for this purpose [3,4]. There are four limitations to the generalization of our results. 1) We analyze three sectors (i.e., Insurance & Finance, Energy & Utility, Transportation & Logistics). We clearly justify why these sectors were selected in section 3.3, yet would not be appropriate to generalize to other sectors.. 2) We interviewed managers from European organizations. Research conducted in different contexts may lead to different results. 3) We selected private commercial organizations that use satellite data only for commercial purposes, which might not be representative for the defence sector, and 4) this paper leverages the perspective of end-users' managers. Further research can leverage this research as starting point to gain the data-provides managers' value perspective. Overall, this study is a foundation for future research to provide a more complete and accurate understanding of the value mechanisms in the European New Space Economy ecosystem.

2. Background

2.1. The New Space Economy value chain

We subscribe to the OECD definition of the New Space Economy: "*the full range of activities and the use of resources that create value and benefits to human beings in the course of exploring, researching, understanding, managing, and utilizing space*" [5]. This definition hinges on the concept of value, which is the main purpose of space data and infrastructures [6].

This paper deals with the value captured by end-users in the New Space Economy ecosystem. In our research, we will investigate the value captured by end-users by adopting satellite data generated by space projects developed by upstream and downstream stakeholders (for simplicity, we will refer to them as "space organizations"). We subscribe to the three macro segments of stakeholders usually considered in this context, according to the Space Economy Observatory [7].

- Upstream stakeholders; space Industry companies and institutions engaged in research, development, construction and management of enabling space infrastructures and technologies.
- Downstream stakeholders; companies offering digital innovation solutions and services (e.g., IT provider, system integrator, consulting firm) and specialized research centres that deal with research, development and implementation of the most advanced digital technologies leveraging space technologies and data.
- End-users; companies, and institutions in demand, interested in new applications and services deriving from the combined use of space and digital technologies.

Four main value streams conventionally represent the New Space Economy realm and create value for end-users [8]. They are:

- Space Access; enabling the exploration of outer space (e.g., rockets, telescopes, unmanned and manned space vehicles, such as the International Space Station, Virgin Galactic for space tourism, or Mars rovers) [9].
- Earth Observation; monitors the Earth and its land, water, and atmosphere through satellite imagery [10].
- Satellite Navigation; allows users (equipped with compatible devices) to determine their position, velocity, and time by processing signals from satellites [10].
- Satellite Communication; data transmission in telecommunications, TV broadcasting, telephone, radio, and recently, the internet [11].

In our research, we investigate the value captured by end-users in adopting Earth Observation (EO) and Satellite Navigation (GNSS) data and satellite-based solutions because of 1) the increasing empirical relevance of users' perspective in these two domains in the European context [10], 2) direct access to company managers, and a vast public secondary data useful for the purpose of our research, and 3) because the users' perspective in these domains has been largely underinvestigated. Fig. 1 summarises the value streams and segments in the New Space Economy ecosystem in a comprehensive value chain. In grey is depicted our level of analysis.

2.2. Key industrial dynamics underpinning the emergence of the New Space Economy

Several industrial dynamics underpin the emergence of the New Space Economy and transform the value mechanisms in the space ecosystem, including how end-users enact expected value. We briefly present the most relevant ones in the context of our research.

- Macro-economic and socio-political changes; recent years have seen the emergence of a considerable number of new space-faring nations (i.e., countries that have developed access to space capabilities) and the establishment of several new Space Agencies [12].
- New regulations and policies encourage cross-fertilization between the space and non-space industries (e.g., ICT, energy, healthcare) [13,14]. This is happening because governments and public institutions are fostering the commercialization of space, opening the sector to non-space sectors. For example, most data generated by the Copernicus programme are publicly available based on a Full, Free,

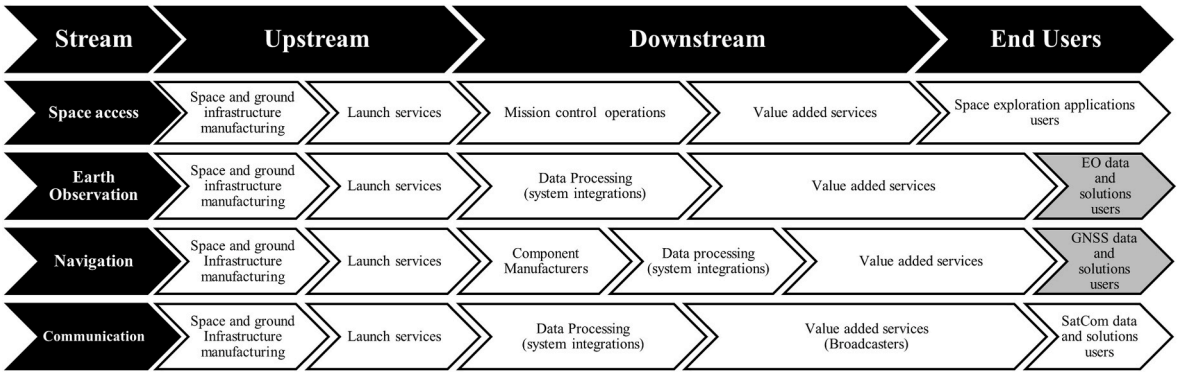

Fig. 1. The New Space Economy value chain [7].

and Open data policy since 2013, attracting more than 570,000 registered individual users to the Copernicus data hub [10].

- New funding and financing dynamics; Outsourcing is increasingly used by space agencies, and new kinds of collaboration are being accelerated (e.g., Public-Private-Partnership). The public sector has diversified and transformed its processes to invest money and encourage the growth of new private players [15]. The expanding market and lower entry barriers (e.g., program development costs) are attracting an increasing number of end-users and private investors, fostering private-to-private funding mechanisms, and shifting funding away from traditional public sources and toward angel investors, venture capital firms, and private equity [16,17].
- New technologies; Non-space sector innovations are adopted by the space sector, which necessitates the transfer and integration of human resources and know-how from other fields (e.g., 3D printing) [18]. Technological downsizing and cost reduction decrease the risks of participation in space missions. The introduction of new digital technologies (e.g., the Internet of Things, data analytics, machine learning algorithms, artificial intelligence, cloud, and edge computing) and their inexpensive availability are transforming the space sector into a cross-technological realm [6,19], attracting a growing number of end-users.

These industrial dynamics attract new end-users who capture value from space data and solutions. They are new space organizations that use public and private funds to run their business, address existing and growing space industries with innovative ideas, or strive to establish unique footholds in emerging space markets (e.g., SpaceX). Non-space organizations, mainly in information and communication technology (ICT), integrate space and digital technologies to bring innovative products and services to a wide range of sectors and end-users (e.g., Google). New end-users, the focus of our research, governmental or private organizations, and people utilizing space technology for commercial purposes (e.g., Red Cross, Uber, society).

The disruption of the space sector and the growth of huge end-user markets lies in the availability, reusability and analytical reproducibility [20] of satellite data. The same data can be processed, with relatively small costs, to create valuable products and services for many end-users. The applications domains of satellite data span from, e.g., land use and cover mapping [14], carbon biomass assessment [21], disaster and risk management [22], air and water quality monitoring, and resources: Earth Observation imageries are used to monitor ecosystems and biodiversity [23]. Yet, as explained in section 1, the users' perspective of the value of satellite data and satellite-based solutions is under-investigated.

2.3. Value mechanisms

In general management literature, value is vastly discussed. Researchers often simultaneously discuss both contents (what is value?) and process (how is value created?) as these two aspects are strictly intertwined [24]. We will take both perspectives in our paper. In line with Gil and Fu (2019) [25], we define value as *"the sum of the economic benefits and wider social gains to be accrued from a new large-scale technology development minus the capital costs to be incurred"*. Scholars distinguish between the expected value and enacted value [24,26]. Expected value is the value a stakeholder expects to receive. The enacted value is the value a stakeholder receives [27]. In our paper, we will leverage these two key concepts, further explained in section 3.2.

Value mechanisms are the processes that explain how value is created, distributed and captured at several levels, including the micro (person, group), meso (organization), and macro (networks, industries, society) [24,28,29]. In our research, we will investigate the meso-level. Management scholars distinguish between value creation, distribution and capture mechanisms [24,26,29,30]. Value creation is the process of co-producing offerings (i.e. products and services and information relationships) in a mutually beneficial seller/buyer relationship [31]. Value distribution refers to the process of transferring the value from the seller to the user [32]. Value capture is the process of securing profits from value creation and the distribution of those profits among participating actors such as providers, end-users, and partners [24]. Value capture necessitates proper governance structure design to ensure that the value created exceeds the cost of achieving that [33]. Value capture extends beyond monetary value and legal agreements. Value capture involves actions that allow providers and end-users to decide how the additional value created should be allocated between them [24].

We subscribe to the existing body of knowledge regarding the transformation of decision-making processes to enact the expected value by adopting data and digital technologies [46,47] regarding the organizations' activities, services and products.

Different methodologies and standards have been developed to assess the expected and enacted value, considering its multidimensionality, subjectivity and dynamicity. For example, triple-bottom-line accounting [34] is a popular paradigm to describe sustainability that integrates economic, social, and environmental (ecological) considerations and is extensively used for public planning and decision-making [35,36]. Environment, Social and Governance (ESG) reporting is a growing method to capture the enacted value. For example, the energy company ENEL reported in its sustainability report how it is "*continuing to pursue partnerships in the 'Space Economy' sector*" and "*together with the European Space Agency (ESA), is promoting the development of applications in the space sector to* support *the safety of distribution networks, economic and environmental sustainability and circular cities"* (ENEL, 2022, p. 23) [37]. For clarity, Table 1 summarises the main methodologies and standards organizations adopt to capture the enacted value.

Table 1
Main methodologies and standards to capture the enacted value. Adapted from OECD (2022) [1].

Methodology	Description	Indicators
Environment, Social and Governance (ESG) reporting	ESG reporting consists in disclosing information covering an organization's operations and risks in three areas: environmental stewardship, social responsibility, and corporate governance. End-users may look at ESG reports to understand if the company enacts their expected value.	General ESG indicators (e.g., environmental impact) are assessed through qualitative and quantitative KPIs (e.g., tons of CO2 gas emission). Sector-specific ESG (e.g., promoting STEM research and studies) assessed through qualitative and quantitative KPIs (e.g., number of educational programs enabled by the company).
Triple-bottom-line accounting	Triple-bottom accounting incorporates three dimensions of value: social, environmental, and financial. These three dimensions can be summarized as "people, planet, and profit.	Money, Environmental measures (e.g., electricity consumption, gas emissions), Social measures (e.g., employment, charitable contributions)
Grand challenges reporting	Grand challenges are challenges for humanity. They may include climate change, loss of biodiversity, income inequality, housing shortages, and loss of social mobility. They are context-specific, and each country/sector has its own.	Social and environmental value. For example, the company report the discovery of new technologies to improve global health, reduce water consumption, mitigate the digital divide, or tackle climate change.
Cost-benefit analysis	Cost-benefit analyses quantify benefits and costs reconducting the enacted value in monetary terms. The outcomes are compared with a "do-nothing scenario".	Monetized benefits and costs, including intended and unintended economic, social and environmental value.
Input-output modelling	Input-output models trace the value generated by a project or technology in other domains of the economy.	GDP, social value (e.g., employment), and environmental value (e.g., pollution) multipliers, comprising direct, indirect and induced value created in both the private and public sectors.
General equilibrium modelling	Dynamic and complex Input-output models to assess the value of different project or policy options on the economy over time.	GDP, social value (e.g., employment), and environmental value (e.g., pollution) multipliers, comprising direct, indirect and induced value created in both the private and public sectors.
Multi-criteria analysis	Multi-criteria analysis allows systematic decisions to be made in cases where value quantification is difficult due to its multidimensionality and intangibility.	Value is weighted and ranked to predetermined qualitative and quantitative criteria usually provided by sector experts.

3. Methodology

3.1. Research design

We investigate our research questions using a qualitative and abductive research approach. The unit of analysis of this study is the value captured by end-user organizations by exploiting satellite-based applications. The level of analysis is the end-user organization adopting satellite data or satellite-based solutions in its business. The empirical context of our research is the European New Space Economy ecosystem.

3.2. Theoretical lens

We identified Value Theory [38] as the theory with the most explanatory power for the phenomenon under examination. In our paper, we leverage two key elements of Value Theory: i) "expected value" and ii) "enacted value" [26].

Expected value is the value a subject expects to gain from an object and is interested in exchanging money. Value cannot be treated as a mere quality of an object nor as the mere mental quality of a subject [39] but emerges in a relation between the object (e.g., satellite data) and the expected value-taking subject (e.g., expected value regarding the adoption of satellite data in taking tactical and strategic decisions) [38]. End-users interested in adopting satellite data in their decision-making manifest expected value.

Enacted value is the value a subject may (or may not) capture in using the object [26]. Value is multi-dimensional, subjective and changes over time [40,41]. End-users who, for example, improve their services by adopting satellite data in their decision-making exploit the enacted value provided by satellite data.

In investigating the expected and enacted value, it is important to consider the three main characteristics of value that we report here for completeness. 1) Value is multi-dimensional. It includes tangible (e.g., revenues) and intangible (e.g., knowledge, inspiration, motivation, such as the "Apollo effect" [42]) dimensions. 2) Value changes over time. A project generates short-term and long-term value. An infrastructure may generate benefits even decades after its completion [43]. Thus considering the long-term value created in the project design is fundamental to grasping the enacted value of its outcome [44]. 3) Value is subjective. Different stakeholders have different value perceptions and expectations. Value is conceptualized in terms of the recipient stakeholder [45]. Individuals (or organizations) will evaluate something as valuable if it fulfils their implicit or explicit needs [46].

3.3. Data collection

Our research is based on two sets of data. First, we conducted open interviews. Second, we gathered internal documents, publicly available data and ongoing involvement for triangulation. These two data collection methods are conventional and appropriate for qualitative research and ensure the richness of the results and the purpose of triangulation [47]. Interviews were chosen as a suitable method to explore end-users' value mechanisms in the exploratory part of our research. Interviews can bring essential experts' ideas closer to practice while identifying various problem-solving methods [48], and the interviewer is given the opportunity to ask clarifying questions [49].

We use three sequential sampling strategies: one for the end-users sector sampling, i.e., Insurance & Finance, Energy & Utility, Transportation & Logistics), one for organization sampling (i.e., the organization) and one for managers sampling (i.e., those who work in such organizations). As proper of qualitative research standards, we select the sectors, organizations and managers to reach the theoretical saturation [4]. Which is the point at which new information or data no longer adds any new insights or perspectives to the existing body of knowledge [3].

Following Eisenhardt (1989) [50], we select three end-users sectors of the European Space Economy ecosystem, i.e., Insurance & Finance, Energy & Utility, and Transportation & Logistics, based on three main criteria. 1) Diversity, the three sectors have different maturity levels regarding satellite data and satellite-based solutions. In detail, Transportation & Logistics sector has high maturity (e.g., all end-users companies use satellite data to improve the logistics operation), the Energy & Utility sector has medium maturity (e.g., a growing number of companies are using satellite data to monitor their infrastructure but still not all of them), the Insurance & Finance sector has low maturity (few companies are using satellite data in their business). Considering these different level of maturity may support the generalizability of our results for sectors with similar characteristics. 2) Importance, as shown in

Table 2
Revenues generated by EO and GNSS in the Insurance & Finance, Energy & Utility, and Transportation & logistics sectors. Adapted from EUSPA (2022) [10].

	Revenues in 2021 (Million €)			Expected Revenues in 2031 (Million €)		
	EO	GNSS	Total	EO	GNSS	Total
Insurance & Finance	145	251	396	994	472	1466
Energy & Utility	522	21,840	22,362	742	35,223	35,965
Transportation & Logistics	107	71,705	71,812	226	133,892	134,118

Table 2, the adoption of EO and GNSS satellite data and satellite-based solutions in these sectors generated €94 billion in revenues worldwide in 2021 and is expected to grow dramatically to €171 billion by 2031 [10]. 3) Data accessibility, we had direct access to company managers, and these organizations published many secondary data useful for the purpose of our research. Overall, these three sectors are expected to be the most prominent and promising in adopting satellite data and satellite-based solutions in their business, with huge contributions to the European Space Economy Ecosystem growth [1].

Organizations were chosen using a theoretical sampling method to assure theoretical saturation [3,4]. We included commercial end-users organizations across Europe adopting satellite data and satellite-based solutions for commercial purposes.

Interviewing end-user stakeholders offers the opportunity to investigate their perception of value and how they capture it. Managers were selected with a purposive sampling based on job content and the direct connection of managers with space organizations [51,52]. We interviewed 21 managers with an average of 16 years of experience. The interviews lasted, on average, 44 min. All the discussions were conducted online, and all interviewees and organizations were given anonymity [53]. The sampling stopped when we reached theoretical saturation [49]. Table 3 summarises the profiles of the managers interviewed.

We leveraged the deep knowledge of two of the three authors with the empirical context, conducting open interviews initiated by the question, "*How do you capture value from the adoption of satellite-based data and/or solutions in your business? Why?*". The discussion was an open interview to access the respondent's point of view [54]. Thanks to the permission for recording (from 20 out of 21 interviews), the lead author transcribed the interviews. We also took extensive notes during the interviews.

We sought additional secondary data to triangulate the primary data [47]. For example, if an interviewee referenced a specific project, we gathered pertinent information about the such project. Secondary data consists of information from public and non-public organizations (e.g., project reports, presentations, website news, company reports, detailed plans, and newspaper articles) that deal with completed or ongoing projects based on the adoption of satellite-based solutions in the end-users business. A combination of quantitative and qualitative data was gathered [55]. The triangulation of primary data with secondary data was extremely relevant to mitigate possible bias deriving from asking directly to managers the initial value associated with satellite data. We used secondary data to identify the initial value expected by the end-users associated with space data [56]. For example, we search for newspaper articles or managers' declarations on the organization's website regarding the expected value from satellite data, and triangulate it with their responses.

3.4. Data analysis

We abductively coded our data. We performed a content analysis using Atlas.ti software, and following the guidelines provided by Hsieh et al. [56]. We built a framework (Fig. 2) derived from the existing body of knowledge and populated with data regarding the i) expected value and ii) enacted value regarding the adoption of satellite data in decision-making reported by the interviewees. Discussion among authors supported the finalization of the coding. As a result, the transcribed information was thoroughly examined based on its content and summarized in a framework (Figs. 3 and 4) [57–59]. Finally, we leverage the Value Theory [38].

In our framework, we distinguish between strategic and tactical

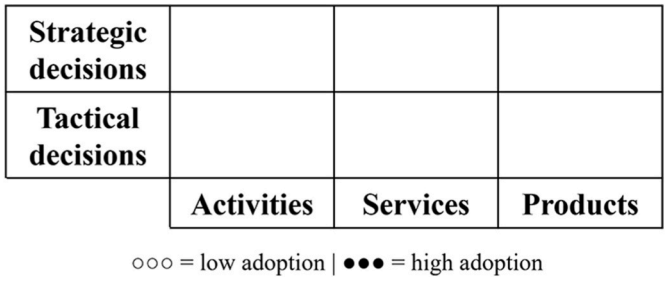

Fig. 2. Framework of analysis.

Table 3
Profiles of the interviewees.

#	Industry	Job Role	Experience
Int 1	Insurance & Finance	Data Scientist	12 years
Int 2	Insurance & Finance	Head of Portfolio Management	14 years
Int 3	Energy & Utilities	Head of Assets Coordination	18 years
Int 4	Energy & Utilities	Innovation and Partnerships Manager	22 years
Int 5	Transportation & Logistics	Head of Technical Dept.	10 years
Int 6	Insurance & Finance	Head of Space	25 years
Int 7	Energy & Utilities	Head of Venture Building and Scouting	12 years
Int 8	Transportation & Logistics	Head of Marketing, Communication and Strategic Business	28 years
Int 9	Energy & Utilities	Geodynamics dept. Engineer	11 years
Int 10	Insurance & Finance	Leading Expert Space Insurance Underwriting	24 years
Int 11	Energy & Utilities	Head of Innovation	18 years
Int 12	Energy & Utilities	Head of Open Innovation	14 years
Int 13	Insurance & Finance	Head of Innovation	13 years
Int 14	Energy & Utilities	Head of Innovation	14 years
Int 15	Insurance & Finance	Head of business development	13 years
Int 16	Insurance & Finance	President	31 years
Int 17	Insurance & Finance	Senior Project Manager	11 years
Int 18	Transportation & Logistics	Account Manager	12 years
Int 19	Energy & Utilities	Senior Manager	14 years
Int 20	Energy & Utilities	Head of Digital Services	19 years
Int 21	Insurance & Finance	Data Scientist	13 years

	Activities	Services	Products
Strategic decisions	Energy & Utilities ●●● Transport & Logistics ●○○ Insurance & Finance ●●○	Energy & Utilities ●●○ Transport & Logistics ●○○ Insurance & Finance ●●●	Energy & Utilities ●●○ Transport & Logistics ●○○ Insurance & Finance ●●●
Tactical decisions	Energy & Utilities ●●○ Transport & Logistics ●●● Insurance & Finance ●●○	Energy & Utilities ●●○ Transport & Logistics ●○○ Insurance & Finance ●●○	Energy & Utilities ●●● Transport & Logistics ●○○ Insurance & Finance ●●●

○○○ = low expected value | ●●● = high expected value

Fig. 3. Expected value from the adoption of satellite data in decision-making from the end-users' perspective.

	Activities	Services	Products
Strategic decisions	**Energy & Utilities** ●●○ *Transport & Logistics* ●●○ **Insurance & Finance** ●○○	**Energy & Utilities** ●○○ *Transport & Logistics* ●●○ **Insurance & Finance** ●○○	**Energy & Utilities** ○○○ *Transport & Logistics* ●○○ **Insurance & Finance** ○○○
Tactical decisions	*Energy & Utilities* ●●● *Transport & Logistics* ●●● *Insurance & Finance* ●●○	*Energy & Utilities* ●●○ *Transport & Logistics* ●●○ **Insurance & Finance** ●○○	**Energy & Utilities** ●○○ *Transport & Logistics* ●●○ **Insurance & Finance** ●○○

○○○ = low adoption | ●●● = high adoption
Italic if Enacted value ≥ Expected value
Bold if Enacted value < Expected value

Fig. 4. Level of adoption of satellite data in decision-making from the end-users' perspective.

decisions. 1) Strategic decisions have a medium-long time horizon (i.e., 3+ years), imply a huge investment of resources (both monetary and non-monetary), have a cross-functional impact on the organization and the business, and are often non-reversible. They usually bring a radical transformation of the organization and business. For example, acquiring a firm to gain new internal competencies is a strategic decision to improve the organization's value proposition in the long term; it requires a huge investment of resources and impacts the entire organization (e.g., organization structure redesign). This decision is difficult to reverse, especially in short to medium term. 2)Tactical decisions, on the other hand, have a short time horizon (i.e., less than 3 years), require a limited investment of resources, have a vertical impact on the organization or business, and are often reversible. For example, launching a new product is a tactical decision with a relatively short-term horizon (depending on the product, with a short return of investment time), requires limited resources and impacts the organization's single business line. It is often reversible, withdrawing the product from the market.

End-users take strategic and tactical decisions in three main domains: activities, services and products. 1) Activities consist of internal processes and actions the end-users take to develop, deliver and improve their services and products. Activities are necessary conditions for the exploitation of their value proposition. For example, energy companies have the main value proposition to deliver electricity on time to their clients (both companies and citizens). To do so, they need to monitor and maintain their electricity distribution lines. Monitoring and maintaining the energy distribution infrastructure are two necessary activities for energy companies to realize their value proposition. 2) Services are the application of one party's competencies (such as knowledge and skills) to benefit another [60]. Services do not necessarily depend on a tangible good. Services are strictly connected with value, as experience and perception are essential to determining the value of the service [61]. For example, remote sensing companies offer satellite-based monitoring services to their energy clients, providing them with knowledge and expertise. 3) Products consist of tangible goods (or bundles of tangible and intangible goods) sold to end-users to satisfy their needs [62]. In our research, products necessarily depend on tangible goods. Products are the result of industrial processes. For example, a GPS sensor is a product sold by space firms to mobility end-users. It results from the generation, distribution and storage processes.

To interpret our data, we qualitatively assess the expected value (Fig. 3) and level of adoption (Fig. 4) by populating the framework of analysis with a three dimensions scale [63] ranging from "low expected value/adoption" (i.e., three white dots) to "high expected value/adoption" (i.e., three black dots). Besides, in Fig. 4, we qualitatively compare the expected value and the enacted value deriving from the adoption of satellite data. We represent in italics those sectors in which the enacted value is more or equal to the expected one, and vice-versa in bold.

4. Results

Regarding the expected value of adopting satellite data in decision-making, our data shows that Energy & Utilities, Insurance & Finance, and Transportation & Logistics end-users have different value expectations, as summarized in Fig. 3. Overall, end-users declare high expected value from satellite data for improving their activities, services and products. Energy & Utilities end-users have great value expectations regarding adopting satellite data in strategic decisions regarding their activities. Insurance & Finance strongly expect value for decision-making, both strategic and tactical, regarding their services and products. Transportation and Logistics declare high expected value in tactical decisions regarding their activities.

As for the enacted value of satellite data in decision-making, our data shows that end-users take strategic and tactical decisions thanks to adopting satellite data in their business to improve activities, services and products. However, our data highlight different levels of adoption of satellite data for Energy & Utilities, Insurance & Finance and Transportation & Logistics end-users. We summarise our results in Fig. 4. End-users mostly adopt satellite data to take tactical decisions rather than strategic ones. Furthermore, end-users leverage satellite data to improve their activities rather than their products or services. The enacted value of satellite data in taking tactical decisions regarding the activities is more or equal to the expected value for all the end-users (in *italics*). Energy & Utilities and Insurance & Finance have received less value than they expected (in **bold**), especially in taking strategic decisions regarding services and products.

In the next pages, we further present our results comparing the expected value (Fig. 3) and the enacted value (Fig. 4) regarding adopting satellite data in decision-making.

4.1. Adoption of satellite data in taking tactical decisions

Overall, end-users prefer to adopt satellite data in tactical decisions, and the enacted value is more than the expected value. End-users adopt satellite data to decide on low-risk and short-term investments. They know how to properly assess the expected value and exploit the enacted value in decision-making. Managers favour adopting satellite data to improve the efficiency of business activities rather than the quality of services and products delivered.

> *"Space is very far from our daily base. We start to explore the value of satellite data for our activities, looking for efficiency improvement that requires small and low-risk investments"* [Int19 - Energy]

4.1.1. Activities

End-users adopt satellite data to take tactical decisions to improve their activities. It is the more frequent and consolidated adoption because the value of satellite data is easily assessable in the short term.

> *"We use Earth Observation imagery to monitor our infrastructure. You can monitor vast territories more frequently than helicopter flights with the same amount of money. The cost-saving is easy to calculate"* [Int11 - Energy]

Managers appreciate the relatively frequent and continuous update of satellite data (both positioning and imagery) that meet their expectations in tactical decisions.

"Satellite positioning data offer you quasi-real-time information about your fleet; this information is fundamental in managing and programming the logistics on a minute basis. Satellite data improve efficiency" [Int5 - Transportation]

The satellite data and applications' novelty foster end-users' managers to explore their adoption in a "safe environment" that does not directly impact their end-users.

"We prefer first to experience and learn the benefits of satellites internally. The easy way is to experiment with the adoption of satellite imagery to efficient our internal processes before selling a new satellite-based service or product" [Int1 - Insurance]

4.1.2. Services

End-users adopt satellite data to make tactical decisions regarding their services. Indeed, satellite data are appropriate to guarantee a relatively high return on investment in the short term as they add value to existing services. Satellite imagery provides new insights about the market (e.g., urbanization, climate) that are fundamental for managers to take tactical decisions regarding their services, and for Energy & Utilities and Transportation & Logistics end-users, the enacted value is more than the expected value.

"We use satellite data to assess the market's status and evolution. It really improves the quality of our services and previsions regarding our insurance services" [Int7 - Energy].

Besides, our data shows that end-user managers use satellite data as a marketing tool to bundle the existing services with attractive value-added content to attract new end-users and justify a higher price for the existing service.

"Space is fascinating. Going to clients saying you are providing this service by leveraging satellite data makes you very innovative and smart" [Int8 - Transportation].

Still, our data show limitations in exploiting satellite data to take tactical decisions, mainly because technology does not meet the expected value, and because of a low-risk appetite of managers when it comes to enriching services with satellite data.

"You can use data to provide a new service. However, if you are not a satellite expert, you can't totally trust them. We use very simple imagery in our decision-making, but we don't want to risk so much in selling a satellite-based service" [Int13 - Insurance]

4.1.3. Products

Despite a huge value expectation regarding adopting satellite data to make tactical decisions regarding products, Energy & Utilities, and Insurance & Finance end-users do not see the enacted value. Satellite data are marginally adopted as add-ons for their products to make a bundle product whose value is increased by the "space technology".

"We offer our clients the possibility to include satellite-based information in our infrastructure monitoring dashboard. It adds the value of our product but does not disrupt it" [Int4 - Energy]

Nevertheless, satellite data are rarely used to take tactical decisions in product development and delivery. Indeed, interpreting satellite data for product development requires strong competencies to interpret the information deriving from data and integrate them with the product.

"I think we lack the competencies to leverage satellite data to develop our product and meet the expected value. If we build new infrastructure, I will ask experts for information about the territory, no more. We are not able to design the infrastructure based on satellite data" [Int12 - Energy]

End-user managers also underlined the lack of solutions able to answer their expectations and needs regarding product development properly.

"Earth Observation offers many smart solutions for whom we are unwilling to pay. Why do I have to invest in satellite information when they do not answer my needs, or can I use other sources that provide less expensive solutions?" [Int10 - Insurance]

4.2. Adoption of satellite data in taking strategic decisions

Despite the expected huge value, few managers adopt satellite data in strategic decisions. End-users mostly adopt satellite data in strategic decisions for their activities rather than their services or products. Overall, managers feel uncomfortable with the reliability of satellite data, they understand and expect high value in the long term, but they do not experience enacted value right now. They consider investing in satellite data too risky for strategic decisions, especially since the benefit/cost ratio appears unclear.

"Satellite will revolutionize our decision-making, but nowadays, I can't build my business on information that I don't understand where they come from. Besides, satellite data requires huge resources and competencies. Do the benefits really repay the cost?" [Int11 - Energy]

4.2.1. Activities

End-users adopt satellite data in taking strategic decisions about their activities. In detail, managers highlight the strategic role and the expected value of satellite data for planning infrastructure development and mitigating climate change risks.

"Satellite imageries are very effective in improving our planning process. They offer useful information to understand if and where to build the energy power infrastructure. Modelling and predicting climate evolution are very important, especially for renewable energy plants. Here, satellite data are good allies" [Int 9 - Energy]

Satellite data are considered a unique source of information with low costs compared to in-situ inspections. End-users use satellite imageries to predict the environment and climate's evolution and have started to invest hugely in this information. However, the expected value is still far from being enacted, especially in the insurance sector.

"We are investing in new competencies and technologies because we understand satellite data may disrupt the insurance sector, and we have to be ready. Right now, we are not" [Int 2 - Insurance]

Managers integrate satellite data and complement it with other sources of data. Satellite data plays a marginal role in taking strategic decisions regarding the activities of their firms as they are complex decisions that require a huge amount of different data that need to be integrated, and end-users now lack these capabilities.

"Satellite data play a marginal role in our strategic decision processes. They are often used as a complementary data source to other more consolidated information" [Int5 - Transportation]

4.2.2. Services

End-users leverage satellite data to take strategic decisions regarding their services. According to our data, the expected value is very high, especially in the insurance sector, where intangible goods are the core of their value proposition. Insurers are starting to use satellite data to improve their services and decide whether to invest or not in specific markets.

"We increasingly leverage satellite data to understand if and how to provide insurance services in given markets (e.g., ensuring the agriculture sector in developing countries). Insights about the evolution of the environment are, in this case, very strategic for us" [Int17 - Insurance]

Still, the long-term value of satellite data appears unclear to end-

users who cannot enact the value of satellite data. They regret huge investments in satellite data to take strategic decisions as they lack an understanding of the potential value of satellite data in their business.

> *"Satellite data, and space in general, are fascinating. However, we don't really grasp the value of their adoption that justify huge investments to take strategic decisions regarding our services"* [Int14 - Energy]

4.2.3. Products

The managers interviewed greatly expect the value of satellite data adoption. However, managers stated they are not using satellite data in strategic decisions regarding their products as they do not meet their expectations. They declare the main reason is that satellite data do not offer the proper solution for their needs. Indeed, satellite data providers offer useful services that managers can exploit poorly to make thoughtful strategic decisions regarding their products.

> *"Providers offer very interesting tools that lack in answering our real needs. We look for precise and reliable information regarding our asset, that nowadays appears fragmented"* [Int3 - Energy]

Relying on new sources of information for strategic decisions requires long approval processes within the end-users organization. It slows down adoption or often does not start because the effort required does not seem to repay the value that can be drawn.

> *"Before using satellite data, you must trust them, and its reliability must be approved internally. Very often, we don't start this process because we don't understand the value in it"* [Int8 - Transportation]

Strategic decisions are risky, and their implementation generally requires huge resources. The managers interviewed declare themselves as risk averse. They are waiting for a higher maturity of the satellite data and their applications that justify the adoption of satellite data in strategic decisions regarding their products.

> *"We can't bet in our business, we see the potential value of satellite data in our business, but nowadays it is still too risky and not mature enough"* [Int 15 - Insurance]

5. Discussion

Our results show a relevant difference between the expected value and the enacted one (i.e., level of adoption) resulting from adopting satellite data in taking tactical and strategic decisions. Satellite data meets end-users' expected value in making tactical decisions. Transportation & Logistics manifest an enacted value that is in line with expectations. However, the expected value is still not enacted for strategic decisions about services and products, especially for Insurance & Finance and Energy & Utilities end-users. The emerging industrial dynamics underpinning the rise of the New Space Economy play a key role in enacting the end-users' expected value.

Value Theory [38] (Section 3.2) offers several insights to sense-make our results. In light of the theoretical lens, in the following sections, we discuss what the value expected and enacted by the end-users are (section 5.1), and why (section 5.2).

5.1. The expected and enacted value from the end-users' perspective

End-users adopt satellite data for tactical decisions rather than strategic ones, requiring fewer resources and risks. It implicates a better assessment of the expected value before the adoption of satellite data, and, requiring fewer resources, the enacted value in tactical decision-making is relatively easy to be achieved.

End-users tend not to adopt satellite data in strategic decisions for three main reasons.

1. They still see very promising satellite data or general space technologies but are far from their business. Despite the New Space Economy attracting a growing number of users, they still lack a comprehensive understanding of the space ecosystem. Therefore, end-users focus on existing key resources and competencies for their decision-making processes [33,64]. The expected value is high, but the resources to fill the gap between the expected value and the enacted value appear too high [65].
2. Managers see the opportunity to adopt satellite data in their decision-making; yet they still believe it requires radical organizational transformation rather than incremental. Moving from the Old Space to the New Space requires radical transformation also for non-space companies. End-users are already dependent on existing resources and data, making difficult the transition toward the adoption of satellite data in their decision-making [66].
3. To assess the expected value of satellite data and satellite-based solutions, end-users need specialized knowledge of the satellite solution and what alternatives exist [67]. The lack of competencies in assessing the expected value makes end-users overoptimistic [41]. Transportation & Logistics, which traditionally have more experience regarding satellite data, especially in navigation satellites, have acquired the competencies to properly assess the expected value over time. They may leverage the experience in adopting satellite data in the Old Space to foster their business in the New Space Economy.

Summarising, in the New Space Economy, end-users lack the competencies and instruments to assess the expected value in the long-term and prefer to adopt satellite data in tactical decision-making as they generally require fewer resources and reversible choices.

5.2. Why is there a gap between the value expected and enacted

End-users expect value from satellite data because they recognize the novelty and appropriateness [68] of satellite data in taking tactical and strategic decisions about their activities, services and products. The New Space economy trends of new technologies, new funding opportunities, and new policies foster the end-users' value expectations. However, achieving the expected value (or experiencing the value enacted) seems difficult for three main reasons.

1. Adopting satellite data in decision-making processes depends on organizational formation [69] and transaction costs between the data providers and the end-users [70]. Our results show that end-users see high transaction costs in adopting satellite data and, therefore, a huge gap between the expected value and the enacted value [71]. The decreasing costs of satellite data management infrastructures and management, proper of the New Space Economy, could support further satellite data and satellite-based solutions for end-users. Therefore, data providers may engage end-users and negotiate solutions to reduce transaction costs and foster the adoption of satellite data in strategic decisions regarding services and products.
2. Second, our data show that end-users regret spreading the adoption of satellite data due to a lack of resources and competencies. Data providers should focus on building and providing these resources and competencies to end-users [72] rather than offering only the solution to their problem. It may foster the enactment of the expected value. Policymakers and space agencies should continue to foster the New Space Economy ecosystem through actions to promote satellite data adoption.
3. End-users recognize the expected value of satellite data in decision-making but have a vague understanding of how to achieve the enacted value in the long term. Satellite data and solutions providers do not properly answer their needs, reducing end-users willingness to adopt satellite data in decision-making [73,74]. By directly engaging with stakeholders, satellite data and solutions providers

should become more aware of the value for the end-users and offer them data and solutions to answer their needs and enact the expected value properly.

6. Conclusions

Our work explains, from the end-users' perspective, the expected value and the enacted value [36] regarding the adoption of satellite data in decision-making in the New Space Economy ecosystem, and why there is a gap between the expected value and the enacted value occurs. End-users have great expectations of the value of adopting satellite data in decision-making. However, the enacted value is less than the expected value for Insurance & Finance and Energy & Utilities end-users, who are sectors that are not mature yet in terms of satellite data and satellite-based adoption.

Our research demonstrates that satellite data are mostly adopted to take tactical decisions rather than strategic ones. End-users mostly adopt satellite data in making decisions about their activities. They slightly adopt satellite data to make decisions about their services, but they poorly adopt satellite data in taking decisions regarding their products, especially since they do not adopt satellite data in taking strategic decisions about their products.

End-users see satellite data as a complementary resource for decision-making that requires new competencies and still appears far from their business and too risky compared to existing solutions [69,75]. End-users understand and appreciate the expected value of satellite data in the short term but are still not able to fully enact the expected value in the long term [71] due to a lack of literacy [68]. Satellite data do not fully answer the end-users' needs and need to be engaged since the satellite-based solution development began.

For the first time in Space Economy studies, we take the end-users' perspective to investigate and explain the value mechanisms in the New Space Economy ecosystem. We extend the Value Theory by testing it in the new space economy ecosystem. Space scholars may benefit from this management fresh perspective in building new research. We show how Value Theory [38] has the explanatory power of the phenomenon and offers useful insights to academics and practitioners to foster the transition in the adoption of satellite data in the decision-making processes of end-users.

Our research has three main contributions to practice. First, policymakers in the European space ecosystem (e.g., European Commission) and space agencies (e.g., ESA, EUSPA) may leverage our results to orient their initiatives in fostering the satellite data and satellite-based solutions in the end-users sectors analyzed. We showed strong value expectations not yet enacted in the Energy & Utilities and Insurance & Finance sectors due to a lack of end-users' literacy and capabilities. Policymakers may promote new initiatives, or reinforce the existing ones (e.g., intermediaries such as Copernicus Relays, Copernicus Academy, ESA BICs), focusing on end-users' literacy and capabilities building. Second, satellite data providers may leverage the suggestions discussed in sections 5.1 and 5.2 to support users in adopting satellite data in taking strategic decisions, increasing their value creation. Third, end-users in the selected sectors may leverage our framework (Fig. 4) to self-assess the current level of adoption of satellite data in their activities, services and products.

As explained in section 1, this research is exploratory in nature and should be considered as a foundation for future qualitative and quantitative research to provide a more complete and accurate understanding of the value mechanisms in the New Space Economy ecosystem. There are four limitations to the generalization of our results. 1) We analyze three sectors (i.e., Insurance & Finance, Energy & Utility, Transportation & Logistics). Further research may adopt our research protocol and framework to investigate other sectors. 2) We interviewed managers belonging to European organizations. Further research could explore and compare the results in other contexts. 3) We selected private commercial organizations that use satellite data only for commercial purposes. Further research may complement our results with defence, public institutions or private companies adopting satellites not for commercial purposes. 4) This paper leverages the perspective of end-users' managers. Further research can use this research as starting point to interview data-provides managers to present a complementary perspective.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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