Towards a future-oriented accountability

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Towards a future-oriented accountability: Accounting for the future through Earth Observation data

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Abstract

Purpose: This paper follows the call for more future-oriented practices within organisations, particularly in relation to how they respond to growing concerns about Earth's sustainability and life on the Planet. This study aims to explore how the data produced by major scientific projects in the Space sector can support future-oriented accountability practices by enabling both a projection and an imagination of a more or less distant future, thereby feeding into accountability practices.

Design/methodology/approach: We rely upon a multiple interpretative case study analysis and interview-based data from three main organisations in the Earth Observation (EO) value chain: an International Space Company, a Research Centre of Energy Transition, and a European Private Equity Firm.

Findings: We find that future-oriented accountability practices can be fed by a creative assemblage of scientific data provided by Space sector's programmes with different sources of knowledge and information. These data are embedded into a broader accountability system, connecting different actors through a 'value chain': from the data providers, gathering data from Space, to the primary users, working on data modelling and analysis, to the end users, such as local authorities, public and private organisations. The predictive data and expertise exchanged throughout the value chain feed into future-oriented accountability efforts across different time-space contexts, as a projected and imagined, more or less distant, future informs the actions and accounts in the present.

Originality: This research extends the literature on the time dimension of accountability. We show how a creative assemblage of scientific data with different sources of knowledge and information - such as those provided by Space sector's programmes and EO data - enable organisations to both project the present into (a more or less distant) future *and* imagine this future differently while taking responsibility, and accounting for, what could be done and desired in response to it. We also contribute to the limited literature on accountability in the Space sector by examining the intricate accountability dynamics underpinning the relationships among the different actors in the EO data value chain.

Keywords: Accountability, Space Sector, Earth Observation Data, Future, Imagination.

1. Introduction

Over the past few years, the state of the natural environment on Earth and its potential consequences for the future of the Planet have been of growing concern for institutions, organisations, and society at large. All components of society are required to take responsibility for action by embedding a critical reflection about the future in their programmes, initiatives, and practices (Gümüsay & Reinecke, 2022). Accounting and accountability practices are no exception.

Accountability involves explaining and taking responsibility for one's actions towards 'others' (Sinclair, 1995). This concept has evolved over the past few decades to encompass a broader range of factors and 'others', across different time-space contexts (Frey-Heger & Barret, 2021; Quattrone, 2022; Tregidga & Laine, 2022). This expanded notion of accountability emphasises the need for organisations to move beyond current contingencies and situated circumstances and consider the demands of others in the future to make responsible decisions in the present (Chakhovic & Virtanen, 2023; Favotto et al., 2022; Mashaw, 2014). This future-oriented approach is not only about projecting the present into the future – i.e., trying to prefigure the future from the present – but also about imagining the future, what could be desired and longed for, while taking responsibility for it, with decisions and actions that follow such imagination (Gümüsay & Reinecke, 2024).

Accounting for these decisions and actions requires increasingly complex data and forecasts about Earth's sustainability, with complex time-space patterns concerning a future that can be partly prefigured from the present but can also be imagined differently. This complexity makes it relevant for organisations to rely upon sophisticated data, enabling both a projection *and* an imagination into how problems and challenges could be addressed. For example, data coming from major scientific projects, including ambitious programmes in the Space sector (see, e.g., Alewine, 2020; Di Tullio et al., 2023; Tucker & Alewine, 2021; 2022), enable predictions but also creativity, desire, and aspiration for possible solutions, feeding into decisions and actions that need to be accounted for.

Recent research has highlighted the limitations of current accountability practices in embedding the needs of 'others', as these others are spread across different time-space contexts, are not directly demanding accountability (Chakhovic & Virtanen, 2022; Chakhovich, 2019), and often do not have a voice (Quattrone, 2022; Agyemang, 2024). "In a context of uncertainty where we face futures and others about which our understandings are always incomplete and provisional", scholars need to embrace a forward-looking approach to accountability, recognising accountability needs to be "speculative" (Favotto et al., 2022, p. 2). A future-oriented approach to accountability needs to be grounded in imagination and speculation, based on the creative assemblage of different sources of knowledge, measurement, observation, description, and quantification. It is an accountability that needs to go beyond prescriptive and rigid calculative practices and embrace what is yet to come (Chakhovic, 2022; Favotto et al., 2022). This calls for a future-oriented accountability approach that is not merely grounded on a projection of the past-present into the future, accounting for these projections, but also speculates creatively about the future while taking moral responsibility for it, embedding such speculation in future-oriented accountability.

Prior studies have pointed to the need to re-embed the demands of future others into the responses and accounts of the present (see, e.g., Chakhovic & Virtanen, 2023; Dillard & Vinnari, 2019; Favotto et al., 2022). However, less is known about how these demands can be imagined and embedded in responsible decisions and actions, particularly in relation to Earth's sustainability problems. Here, we argue that scientific data gathered from Space can play a significant role in projecting and imagining, thereby informing the responses and accounts of the present. It is these data and how they sustain future-oriented practices of accountability that this paper seeks to explore, in particular, their ability to inform current decisions and actions to protect 'the one world we all inhabit' (Favotto et al., 2022, p. 2).

The Space sector offers a relevant setting for exploring the collection and production of data on Earth sustainability and their link to complex patterns of accountability for present and future accountees (see, e.g., Alewine, 2020; Di Tullio et al., 2023; Tucker & Alewine, 2021; 2022). In particular, Earth observation (EO), i.e., the use of remote sensing technologies to collect data on land, marine (seas, rivers, lakes) and atmosphere, has been recognised as one of the most critical activities of the Space sector (e.g., Autry, 2018; Denis et al., 2020; Sweeting, 2018), providing data that are capable of improving human understanding of many natural processes, supporting decision-making at different levels (Tassa, 2020). By providing information about the condition of the Planet and its changes, EO data can support the creative design and implementation of innovative solutions and environmental policies, inform efforts towards the preservation of natural resources, enhance human capacity to efficiently check progress towards international agreements and the achievement of the United Nations Sustainable Development Goals (see, Andries et al., 2019; Anderson et al., 2017; GEO, 2017). It follows that EO data can facilitate the creation of solutions for beneficiaries who were previously not targeted (UNCTAD, 2021; OECD, 2020).

While data from Space, and specifically EO data, have been recognised for their crucial role in our society today, how these data are used to project and imagine the future, including the needs and demands of future accountees, while accounting for responsible decisions in the present, has been overlooked by the accounting literature. By building upon a multiple interpretative case study methodology, we analyse how EO data can support future-oriented accounts and practices of accountability. The analysis of how EO data are used by multiple users in the EO data value chain provides an ideal setting for the purpose of our study. In particular, we explore how three distinct users in the EO data value chain use EO data generated by Copernicus, the European Union (EU) flagship programme of EO, to prefigure the future while imagining it, following the creative solutions fed by EO data. The three case studies analysed are an International Space Company (ISC) acting as a data provider and data aggregator, a Research Centre for Energy Transition (RCET) serving as a primary user of EO data, and a European Private Equity Firm (EPEF)[1] functioning as an end user.

Our paper offers several contributions. Firstly, we contribute to the limited literature on the time dimension of accountability that has called for future-oriented approaches (Chakhovic & Virtanen, 2023; Favotto et al., 2022; Mashaw, 2014). Here, we highlight that future-oriented accountability practices can be fed by a creative assemblage of the scientific data provided by Space sector's programmes (EO data in our paper) with different sources of knowledge and information. This assemblage enables organisations to project the present into a (more or less distant) future *and* imagine it differently while accounting and taking responsibility for such projection and imagination (i.e., what could be done and longed for to address Earth's sustainability problems). In so doing, we also extend prior studies that have related "account-ability" (i.e., the ability to offer an account for action) to "response-ability" (i.e., the ability to embed responses to others' reactions into accountability practices, see Favotto et al., 2022), by showing how these relations can be informed by the scientific data coming from Space, enabling a projection into the future that can also be imagined differently through actions and decisions fed by those data. We show that these data are capable of offering a form of "imaginatory data", "focusing on deliberative instantiations of how real-world problems could be solved" (Gümüsay & Reinecke, 2024, p. 11) while also accounting for these instantiations.

In so doing, we also extend the scant literature on accounting and accountability in the Space sector (Di Tullio et al., 2023; Tucker & Alewine, 2021; 2022) by showing how EO data are embedded into a broader accountability system, connecting different actors through a 'value chain', from the data provider gathering data from Space to the primary users working on data modelling and analysis, to those actors making decisions, - the end users -, i.e. local authorities, public and private organisations, citizens. We show that the information and expertise exchanged throughout the value chain feed into actors' future-oriented accountability efforts across different times-spaces, as the imagined reactions from a more or less distant future and 'others' accountees inform the accounts of the present.

This paper is structured as follows. In section 2, we draw on prior studies that have emphasised the time dimension of accountability. Further, we introduce the EO data value chain, highlighting the relationships among the different actors involved in using EO data. Section 3 presents the research methods and the specific setting of our analysis. Insights from this setting are analysed and discussed in sections 4 and 5. Finally, section 6 outlines our conclusions and suggests opportunities for further research.

[1] International Space Company, Research Centre of Energy Transition and European Private Equity Firm are pseudonyms used for privacy and confidentiality.

2. Literature review

2.1 Future-oriented accountability

Accountability has been defined as "a relationship in which individuals are required to explain and take responsibility for their actions" (Sinclair, 1995, pp. 220–221). It entails mutual understanding between those accountable and 'others' regarding desirable behaviour and performance (Day & Klein, 1987), involving practices and procedures for justifying action and decisions and taking responsibility (Ahrens & Chapman, 2002; Roberts & Scapens, 1985).

Over the past decades, the concept of accountability has evolved from a narrower focus on accounting-based accountability to a more inclusive view, also encompassing a growing emphasis on sustainability (see, Dillard & Vinnari, 2019; Frey-Heger & Barret, 2021; Tregidga & Laine, 2022). Indeed, 'sustainable development', defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43), implies an accountability relationship with present and future accountees. Therefore, sustainability requires organisations to broaden the span of accountability to take into account the needs and demands of other accountees (i.e., those demanding accounts), also beyond a finite or defined time-space, including those others that are yet to come (Favotto et al., 2022) and/or lack voice (Quattrone, 2022).

Recent research has acknowledged the challenges of accountability towards 'future' accountees, that do not directly demand accounts for action (Tregidga & Laine, 2022; Chakhovich, 2019). As effectively discussed by Chakhovic and Virtanen (2023), the definition of sustainability entails a paradox: it requires a dialogue with present and future stakeholders, while future stakeholders cannot directly participate in it. Along these lines, Favotto et al. (2022) link the relational aspect of accountability to the concept of "response-ability", conceived as the capacity to provide responses taking others into account while giving an account. This suggests that being accountable implies the capacity of actors to be morally responsible for a broader scope of 'good' than their private interests (Shearer, 2002), giving an account for action towards a 'community' of others (McKernan, 2012), that might be unknown and invisible (Quattrone, 2022; 2004), spanning beyond present or past time-space contexts (Achilli et al., 2022; Chakhovich, 2019).

Along these lines, Favotto et al. (2022) point to a future-oriented and speculative accountability grounded in responsiveness to "futures and others about which our understandings are always incomplete and provisional" (p. 2). This form of accountability needs to be grounded in experimentation, imagination, and care and be open to a more or less distant future and others. This also requires working on speculations by creatively assembling different sources of knowledge, including accounts and predictions moving beyond pure calculations, and continuously reflecting and revising these speculative accounts, searching "for better accounts, better calculations, better solutions" to respond to future (Favotto et al., 2022, p. 6). Chakhovic and Virtanen (2023) highlight that "the issues here come down to whose future prediction is the most accurate" (p. 15, see also Jordan & Messner, 2020), as the expertise on the needs of future stakeholders can be found in "unexpected places". They call for more research "to locate further ways to predict the interests of future stakeholders" (Chakhovic & Virtanen, 2023, p. 16; see also Grisard et al., 2020).

These calls for future-oriented accounts and accountability are in line with recent calls for broader future-oriented practices in management, organising, and organisation research (see, e.g., Gümüsay & Reinecke, 2022; 2024), pointing to the need for all components of society to embed a critical reflection about the future into their initiatives, programmes and practices (see, e.g., Augustine et al., 2019). This reflection does not simply mean projecting the present into the future through prediction and prefiguration but also involves a more creative and imaginative leap into the future, driven by aspirations and values about what could count, be aspired and be done for the future and future others (Gümüsay & Reinecke, 2024; Busco et al., 2018). Here, "imaginatory forms of data", "focusing on deliberative instantiations of how real-world problems could be solved", are necessary to feed and explain "a process of envisioning and elaborating possible futures collaboratively" (Gümüsay & Reinecke, 2024, p. 11).

In this context, we argue, science data gathered from major scientific projects, such as those in the Space sector and related to EO programmes, can provide relevant predictive and projective data on Earth's sustainability, offering information on a future that is already visible from Space but not yet on Earth, while also feeding processes of envisioning and imagination of possible or different futures. These data, we argue, can also feed future-oriented accountability practices, embedding the organisations' responses to a future that is both projected *and* imagined. Next, we discuss this potential further, delving into the critical features of EO data systems and accountability in the Space sector.

2.2 Accountability and Earth Observation Data

Accounting studies in the Space sector have highlighted the relevance of this setting as a research site for exploring sustainability, accounting, and accountability practices (Tucker & Alewine, 2021; 2022). Recent studies have discussed the risk that the New Space Economy may itself endanger Earth's sustainability (Durrieu & Nelson, 2013; Palmorth et al., 2021), also given the growing number of actors working in this industry, especially those from the private sector, seeking for commercial opportunities and profits (Paikowsky, 2017), often hiding unsustainable practices. In response to the above challenges, Di Tullio et al. (2023) point to the need for a pluralistic accountability framework for Space businesses, both public and private (Martin & Beaudry, 2015), calling for greater collaboration, transparency, and regulation.

While improving the accountability frameworks in the Space sector is undoubtedly relevant, Space projects and programmes also offer a unique source of data to inform actions and decisions in this sector and beyond (Di Ciaccio et al., 2018; Hiriart & Saleh, 2010). In recent years, the widespread availability of EO satellite data has enabled many organisations to innovate their business models, has enhanced managerial decision-making, and enabled the detection of environmental challenges that were previously unnoticed, or has facilitated the creation of solutions from user groups that were previously not targeted (UNCTAD, 2021; OECD, 2020). EO satellites provide data on lands, seas, rivers, lakes, and the atmosphere (Tassa, 2020). They feed complex processing models, including weather and natural disaster forecasting models, climate monitoring systems and policies (IPCC, 2021; Finer et al., 2018), as well as the management of agrifood systems (Denis et al., 2020). Space-based images from EO activities also support location-based services and improve large safety systems by helping with accident prevention and informing actions to counter natural disasters. Additionally, these data support emergency management and disaster risk reduction planning, the monitoring of floods and droughts, soil moisture, vegetation, and deforestation, while helping governments and organisations track progress in aligning with international agreements and the United Nations Sustainable Development Goals (Anderson et al., 2017; Andries et al., 2019; GEO, 2017).

To fully exploit the potential of EO data, the scientific community draws on multiple ‘value chain’ methodologies (Tassa, 2020), connecting the different actors using these data. Figure 1 shows the multiple ‘actors’ engaged in the EO value chain, including data providers that generate, collect, manage, analyse, integrate, aggregate, and transform Earth Science data into information; intermediaries or “primary users” that synthesise, translate, communicate, and develop decision-support products; “end users” that make decisions based on the information received; and “citizens” that can be impacted by the decisions (Virapongse et al., 2020).

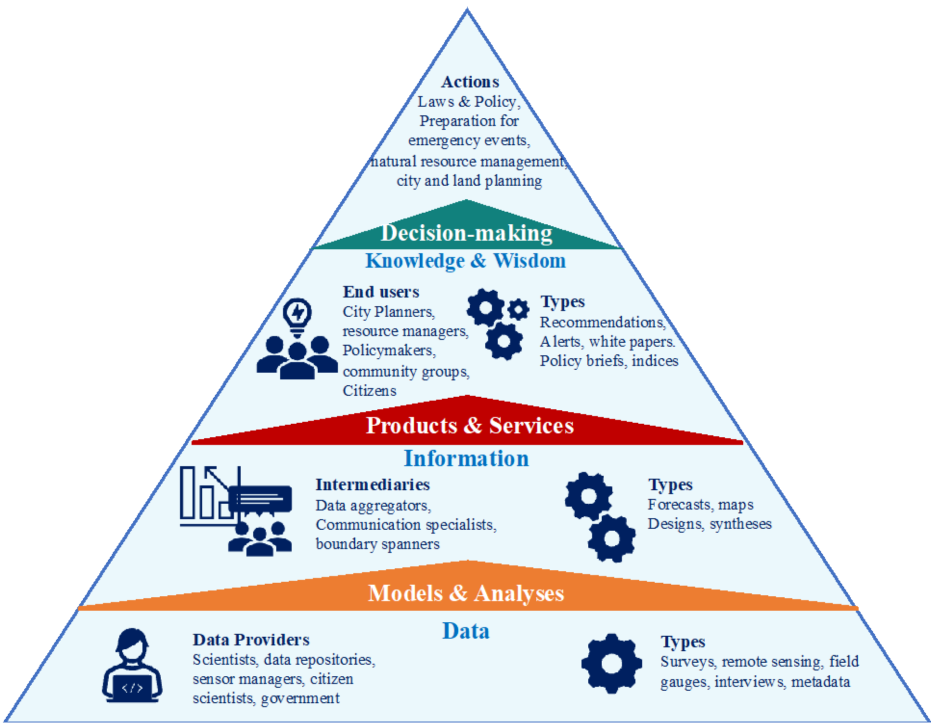

Figure 1 – EO data value chain – (Source: Figure adapted from Virapongse et al., 2020; p. 235)

Actors' involvement in the value chain is supposed to facilitate the use of EO data in decision-making, informing actual responses for current and future societal benefit (Tassa et al., 2022). One of the main challenges of using EO data comes from assessing the present-future benefits and impacts derived from using these data. This depends on several parameters, such as the cost of the solutions derived from these data, the timeliness of data availability, the existence of viable alternatives, the expected benefits, the risks, and the potential consequences of a wrong decision today for the future (Virapongse et al., 2020). This is likely to feed into the accountability system of actors along the value chain, informing actors' accountability efforts to meet current and more practical demands from the present, as well as the needs of future generations.

According to PwC (2019), increasing organisations' awareness about the economic, social and environmental benefits derived from the use of EO satellite data is essential to improve the use of these data for decision-making processes. However, as we move down the value chain, the visibility, perception and benefits generated by satellite data become smaller even if the value of the economic activity, for which it is relevant, increases. Therefore, decision-makers may fall victim to planning fallacy due to inadequate methodological approaches and measurement systems that analyse Space projects' outputs, time lags, and long-term impacts (OECD, 2020). Improvements in predictive analytics are essential in this context (PwC, 2019).

The above considerations suggest complex accountability patterns pertaining to the actors along the EO data value chain and spanning across space-time boundaries. By providing information about the state of the environment and its changes, EO data allow users to make predictions about global environmental and social challenges, thus informing better planning and highly advanced innovations in response to those challenges (Tassa et al., 2022). This also enables imagining the future differently based on such responses, addressing critical challenges for the benefit of future generations. Here, we argue that investigating how EO data are embedded into the accountability system of the actors across the EO value chain is relevant to understanding the possibility for future-oriented accountability practices, accounting for actors' responses to a projected and imagined future. Next, we explain our research methods that draw on the Space sector as our research site.

3. Research Methods

3.1 Research background: The EO data value chain and the Copernicus programme

Previously known as Global Monitoring for Environment and Security (GMES), Copernicus is the EU flagship EO programme, established in 2014 from a joint initiative between the EU, its member states, and the European Space Agency (ESA). By relying on a set of dedicated satellites (the Sentinel family[2]), Copernicus provides

[2] The so-called Copernicus Sentinel family consists of: Sentinel-1 specialized in land and ocean services (Sentinel-1A launched in 2014, Sentinel-1B in 2016), Sentinel-2 – land monitoring (Sentinel-2A launched in 2015, Sentinel-2B in 2017), Sentinel-3 – ocean forecasting, environmental and climate monitoring (Sentinel-3A launched in 2016, Sentinel-3B in 2018), Sentinel-4 – atmospheric monitoring payload (launched in 2019), Sentinel-5 – atmospheric monitoring

accurate, reliable, timely and openly available data to users in support of environmental monitoring and civil security (see Tassa, 2020)[3]. In the last decade, Copernicus unlocked unprecedented opportunities for data exploitation, contributing to the creation and growth of organisations within and beyond the Space sector, improving the knowledge and understanding of different natural and social phenomena from Space, and ultimately benefiting citizens within and beyond Europe (Denis et al., 2020; Tassa, 2020)[4]. By providing a wealth of data related to the environment, including information on climate change, air quality, natural disasters, and land, the Copernicus programme supports organisations and governments in achieving sustainable development goals by predicting potential future impacts of their decisions, thus allowing proactive actions to address emerging challenges for the benefit of current and future generations (Tassa et al., 2022; United Nations Office for Outer Space Affairs, 2018). Additionally, international organisations, such as UNESCO, use data from the programme to assess actual and potential damages to natural and historical sites to prevent or mitigate their destruction (PwC, 2019).

In 2020, the European Association of Remote Sensing Companies (EARSC) published the Copernicus' Sentinels Benefits Study (SeBS) to demonstrate the benefits of using EO data from Copernicus satellites. Applying a tier-based data value chain framework (see Figure 2) to more than 23 case sites (See Appendix 2), the SeBS methodology shows "how a specific EO-derived service is being used by an organisation which is, in turn, benefiting others and ultimately society and citizens at large" (EARSC, 2020, p. 6). The tier-based EO data value chain is structured along four "tiers" representing providers and users of EO data (see Figure 2): Tier 1 represents the "supplier" of the EO service, the data provider; Tier 2 is the "primary user", which exploit the data available and integrates them through their business process; Tier 3 are the "secondary users" i.e. all the specific users of the service provided by the primary user; and Tier 4 represents the broader "citizens and society".

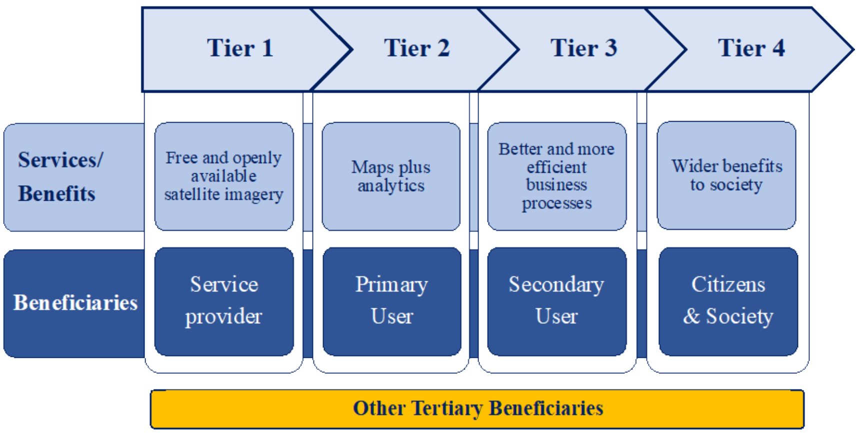

Figure 2 – Illustration of the Tier-based data value chain (Source: Figure adapted from EARSC, 2020; p. 19)

payload (launched in 2021) with Sentinel-5 Precursor (P) – atmospheric monitoring launched in 2017, and Sentinel-6 – oceanography and climate studies (launched in 2020).

[3] https://www.copernicus.eu/en/access-data (Last access on May 10th 2024)

[4] https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_benefitting_society_and_the_environment (Last access on May 10th 2024)

Along the EO data value chain, the benefits of using satellite data are not always evident (EARSC, 2020). For example, as the primary user, a road agency may use EO data to identify the risk of ground movement. However, the engineers or construction workers are only concerned with the defined works, not how the route was chosen (see the EARSC case study on "Ground Motion Monitoring in Norway", EARSC, 2020). In particular, the benefits of using satellite data for decision-making become widespread at the bottom of the EO data value chain, as end-users are unaware of the links between the products/services offered by the market and satellite data exploited to develop them. For instance, citizens may witness fewer roads being damaged or fewer road delays and closures. However, they are unaware of the process to achieve this, nor are they informed about what kind of EO satellite data was used to determine a route that will hopefully avoid works and damages in the future (see the case study on "Ground Motion Monitoring in Norway", EARSC, 2020).

While much work is needed to increase awareness among citizens of the benefits generated by using EO data, it is of utmost importance that these data inform decisions, innovation, and operations within public and private organisations (Tassa, 2020). As this paper aims to explore how EO data can support future-oriented practices of accountability, the analysis of the EO data value chain across the different tiers offers an ideal setting for our study, as it enables exploring how distinct users in the EO data value chain use EO open data (e.g., Copernicus) to predict and imagine more or less distant future benefits coming from their decisions, innovations, and actions, while accounting for those. We take three sites for examining the EO data value chain: an International Space Company (ISC) acting as a data provider and data aggregator, a Research Centre for Energy Transition (RCET) serving as a primary user of EO data, and a European Private Equity Firm (EPEF) functioning as an end user. The following section delves into the methodological approach used in this study.

3.2 Data collection and analysis

In this paper, we draw on semi-structured interviews with key informants in our three selected sites (Blazejewski, 2011; Baxter & Jack, 2008; Yin, 2009). We collected our primary data from 21 interviews with 11 informants (see Appendix 1). From February 2021 to May 2023, 14 interviews were carried out with managers from the ISC, including the Strategy and Communication Officer; Head of the Earth Observation Department; Head of Corporate Knowledge; Senior Advisor of Earth Observation, Earth Observation Planning and Control Manager 1; and Earth Observation Planning and Control Manager 2. Furthermore, we conducted four interviews with the Director and a Researcher of the RCET focused on the benefits of investing in energy transition projects and three interviews with Partners of the EPEF. The three actors use and benefit from other companies' uses of EO data in different ways. While the ISC represents a data provider that collects data from Copernicus satellites, RCET is a primary user in the EO data value chain, granting access to other users, such as public and private organisations, to the data generated by the Copernicus datasets. EPEF, instead, represents an end user aiming to accelerate the "Grey to Green" transformation of European small and medium-sized companies by leveraging sustainable investments.

Interviews were semi-structured and open-ended. Most of the interviews lasted between one and two hours and, when allowed, were recorded and transcribed into electronic files. During this process, we asked different interviewees similar questions, sometimes meeting with them more than once, to learn different points of view and clarify their understanding of the critical issues being researched. In particular, interviewees were asked about the integration of EO data into their activities, actions and decisions and how these data were used for accountability purposes. The primary data collected from interviews have been triangulated with other secondary information sources that helped us to reconstruct the background for the study (see Appendix 2 for the list of documents analysed). The case material gathered through the interviews and the analysis of the additional documents were then converged and triangulated to strengthen the findings and promote a deeper understanding of how different organisations use EO data for future-oriented accountability purposes.

Although, at the early stage of this study, qualitative data analysis software was considered suitable for the automation and management of the large amount of data collected (Richards, 1999), it did not help in identifying and understanding the contextual situations in which actors commented and referred to when talking about the use of EO data and their beneficial use for future-oriented accountability. As mentioned by Phillips and Hardy (2002), although computer software is a convenient tool for managing and automating the analysis of large amounts of data, it does "not improve" the analysis in terms of the way in which the researcher explores multiple meanings and traces their implications — as a part of a subjective process — and it certainly does not make the analysis more "rigorous" or "valid" (Phillips & Hardy, 2002, p. 78). The structure imposed by this software may "constrain the analysis of data, precluding the interplay among creative insights, memoing, and continuing organising and connections of information that results from continuous interfaces with data and notes" (van den Hoonard & van den Hoonard, 2008, p. 188). Consequently, manual coding and mapping were considered more suitable for data analysis (Berry & Otley, 2004; Miles & Huberman, 1994; Ryan et al., 2002).

Data analysis started as soon as some of the primary data were collected. The key actors and activities were mapped based on the collected information to explore how the different informants were involved in the EO data value chain. After transcribing the interviews and the notes, we added a commentary section to each interview file to enable triangulation with secondary data. We initially coded primary data from interviews according to ISC, RCET, and EPEF interviewees' job positions' initials letters (e.g., Head of Corporate Knowledge - HCK). The data analysis proceeded with a second coding process to develop a sharper narrative focus on organisations' roles in the EO data value chain and explain how these use EO data for accountability purposes. We used descriptive labels from concepts and notes gathered during the transcriptions of the interviews to identify the key narrative facts that explain how EO data are used for accountability purposes. These were organised according to the "who", "to whom", "how/by which means", and "for what" categories of accountability described by the accounting literature (Joannides, 2012). We also added the temporal dimension "when", as we are interested in future-oriented accountability practices.

To facilitate the analysis of the findings, we organised the narrative facts according to the following categories of analysis: 1) the different actors involved and that use EO data for current and future decision-making, coded as Users "U"; 2) the type of accountability towards other users, coded as Accountability Level "AL"; 3) the type of data, satellite image or information shared, coded as Inputs "I"; 4) the type of relations, methods or action taken, coded as Processes "P"; 5) the temporal dimension of the decision/action taken, coded as Time "T"; 6) present benefits, coded as "PB"; 7) future benefits, coded as "FB" (see Table 1).

Categories of analysis	**Code**	**Sequential narrative of facts**		
WHO?	User - "U"	Service provider	Primary user	End users, including future generations
TO WHOM?	Accountability Level - "AL"	Accountable to users in Tier 2 and Tier 3	Accountable to users in Tier 1 and Tier 3	Accountable to users in Tier 1, 2 and 3
FOR WHAT?	Type of data, satellite image or information - Inputs "I"	Quality of data	Data modelling and visualisation	Use of data for decision-making
HOW/ THROUGH WHICH PROCESSES?	Type of relations, methods or actions taken - Processes "P"	Collect data from satellite and create databases	Design tailored dashboards including current data and future forecasts	Take decisions based on the data dashboards and implement measures for business, society
WHEN?	Temporal dimensions - "T"	Short term, regular and on-time update	Short, medium term and future forecasting	Ongoing decisions with short-, medium- and long-term impacts
PRESENT BENEFITS	Present benefits - "PB"	Free access to satellite data to deliver services and target new markets	Enhanced data delivered	Use of data to inform decision-making and policy; Increased awareness and possible savings from innovation
FUTURE BENEFITS	Future benefits - "FB"	Increased growth; more availability and simultaneity of data	Innovative products and services to forecast social and environmental outcomes	Awareness of sustainable issues to inform decisions and be responsible to current and future generations

Table 1 - Narrative facts and sequential ordering (Source: Authors' own creation)

Our analysis proceeded with constructing a visual/thematic map (Braun & Clarke, 2021; 2012). Initially, data were clustered around similar narrative themes coherent with the research question and the theoretical gap identified in the literature. We listened to audio records and read textual data collected from interviews, reports and case studies to describe both informants' implicit and explicit ideas that made references to the use of EO satellite data for decision-making and future implications for the environment and society as a whole (Braun & Clarke, 2019). Then, we identified five First-order Narrative Themes (FNT) that emerged from the sequential narrative of facts: "Users' involvement and accountability exchanges in the EO data value chain"; "Type of EO data used according to organisations' needs"; "Type of EO data generated and shared"; "Measurement and modelling methods used to enhance the adoption EO data for decision making"; and "Projection of the possible future benefits generated through the aid of EO data" (see Figure 3).

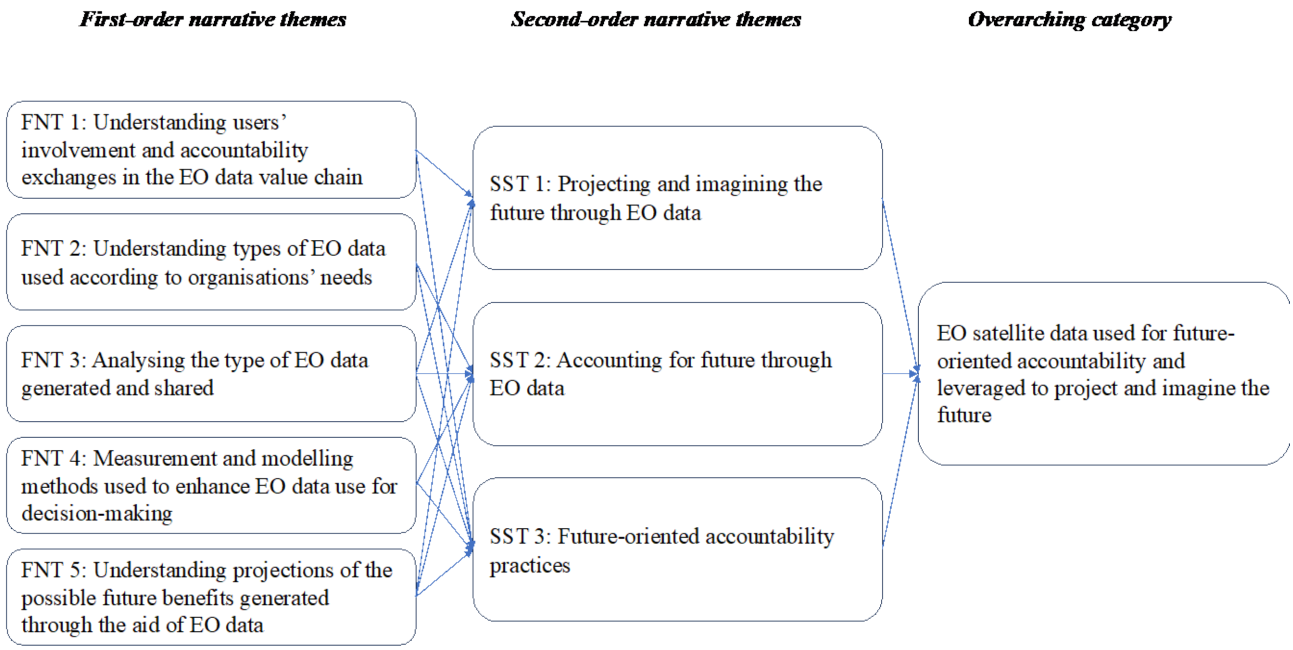

Figure 3 – Visual map analysis (Source: Authors' own creation)

Finally, based on their thematic denotations, the emerging FNTs were aggregated into three main Second-order Sub-Themes (SST), which were helpful to structure the discussion section of this paper: "Projecting and imagining the future through EO data", "Accounting for future through EO data", and "Future-oriented accountability practices" (see Figure 3). As a conclusive step of our analysis, we clustered the narrative facts classified in Table 1 with the FNTs and SSTs shown in Figure 3 to develop our plot. In the following section, we present the key insights from our analysis.

4. EO data value chain and users' accountability relations

4.1 EO data provision - the role of the data provider

EO data providers play a crucial role in collecting satellite data for analysis and forecasts related to climate, Earth's crust, sea, and land phenomena. Among these providers, ISC is a European public organisation dedicated to the observation of Space and one of the partners contributing to the Copernicus Programme. In particular, ISC coordinates the delivery of data from the Copernicus satellites. In one of our interviews, the Senior Advisor for EO Programmes of ISC explained the ubiquitous role of EO activities in today's world:

> *Data from Space have become an integral part of our daily lives. From smartphones to agricultural monitoring, the value generated by Space [observation] activities goes beyond the borders of the Space sector itself [...] with substantial environmental and socio-economic impacts on countries, industries, firms, and individuals.* (SAEO)

Accounting for the value generated by activities and innovations fed by EO data is crucial for the data provider to attract further investments from public and private entities:

> *This value [of EO data][…] is fundamental [to us] and needs to be made explicitly clear to justify to private and public administrations the future returns – not only economic return but also social and environmental – for every euro invested in EO programmes and satellites.* (SAEO)

The value generated by EO data is linked to several (economic, social, and environmental) benefits in the short, medium, and long term (EARSC, 2020). These benefits need to be measured and reported to convince public and private financiers to invest in the research and development of current and future EO space programmes and to account for these programmes.

> *Investors' consensus is achievable only if we can clearly explain how we have used their funding in the past, our past achievements, and what future benefits they will have from investing today in EO satellites and complementary missions.* (SCO)

> *We need to justify the value added by the Space programmes we launch. We need to gather as much data as possible to justify our promises, particularly the socioeconomic benefits we will generate for current and future generations of citizens through our Earth Observation and exploration activities.* (EOPC1)

The quotes above point to the importance of EO data for feeding the accounting and accountability systems of Space programmes, specifically in relation to EO investments. At the same time, the EO data generated by data providers like ISC can provide valuable information that might support the decisions of organisations outside the Space sector (see, e.g., PwC; 2019; 2016). As suggested by the Head of the Earth Observation Projects and the Head of Corporate Knowledge of ISC:

> *EO data from satellites are crucial in our time, not only for companies operating in the Space sector! These data have a strong socio-economic impact on companies and governments worldwide. Nowadays, every economic branch worldwide relies, to a certain extent, on good EO data and images […] Here you have some examples. By monitoring EO data, companies can estimate the time delivery of any air/sea shipments and adapt or change any agricultural practices used […] Many companies, entrepreneurs, or even individual activities already depend on accurate EO forecasts. What would the world look like without EO data, forecasts, and images?* (HEOP)

> *Think about the short-, medium- and long-term benefits in terms of saved lives, improved social conditions, reduced CO2 emissions and eventually, organisational costs we could generate if*

managers, researchers, and ministers could gather Space-driven and real-time data and images to make better future decisions. Also, think about the increasing number of stakeholders that, consciously or not, might benefit from these decisions and data […] These benefits will also affect future generations! Our role is to make sure we make available data from the satellites for as many uses and applications as possible. (HCK)

However, outside the Space sector, the relevance of EO data is almost unknown to users:

Hundreds of thousands of primary and end users benefit from EO satellite data. Some [of them] are unaware of the benefits generated by or the implications of not using [data from] EO satellites. Let us think about the pharmaceutical companies that have to deal with vector diseases connected to weather forecasts. These forecasts are made possible thanks to satellite data! [Therefore] they use satellite data on weather forecasts because these are critical and strategic, as these companies spend billions for the production of vaccines or any other kind of products that heavily rely upon certain geographical and atmospheric conditions […] Deciding to stop or start the production of a pharmaceutical product in one country or another […] is the result of analysis of the return of investments and socio-economic benefits that these products have on specific communities. This analysis would not be possible without the support of EO data. (SAEO)

In spite of the lack of awareness, satellite data provided by ISC feed creative solutions from actors within the EO data value chain, "for as many uses and applications as possible" (as quoted above), and in relation to social and environmental challenges. For example, ISC collaborated on the launch of a web platform powered by Copernicus data, to monitor the environmental and topological parameters of the Earth (such as global radiation, air temperature, wind speed, altitude, surface typology, land cover, presence of desertic areas and population, terrain roughness). By using these data to feed projections about the future, European companies and governmental institutions are able to work on innovative solutions for climate change, zero carbon emissions, or water-energy-food consumption. As mentioned by the Head of the Earth Observation Projects:

We aim to expand the use of future EO-based information in society and increase the % of technology and knowledge transfer between our company and the different European suppliers, other companies and communities of users. For instance, these users could subsequently deploy and benefit from using EO's future research, output, and innovation in operational monitoring programmes to provide timely, reliable, quality data to vital public information services that yield high socio-economic benefits. (HEOP)

As we show next, information collected by data providers not only enables to project the present into the future, but they are also 'imaginatory' data (Gümüsay & Reinecke, 2024), as they trigger imagination and aspirations about the future.

4.2 Projecting and imagining the future - the role of the primary user

RCET is a public research centre specialising in energy transition. As a primary user in the EO data value chain, RCET uses the data from the above web platform launched by ISC and other partners to develop interactive cartographic dashboards. The interactive dashboards developed by the RCET are designed to support end-user categories, such as entrepreneurs, ministers, and local authorities. These dashboards make it possible to analyse, in an integrated way and from an energy planning perspective, the multi-dimensional impacts of the exploitation of renewable energy sources, with particular reference to wind and photovoltaic instalments.

For example, the dashboards offer interactive cartographic maps that allow users to identify areas for plant installation based on physical, environmental, and topological parameters, using inclusion/exclusion criteria and thresholds set by the dashboards' users. Each dashboard is based on a proprietary database powered by different publicly available datasets (among others, Copernicus and Sentinels Hub), from which quantitative information relating to the different parameters is extracted. In this way, the end user can create and imagine multidimensional simulation cases of various technological solutions and obtain assessments relating to the investment's financial impact (based on different metrics, like the internal rate of return, the payback time, and the net present value) and environmental effects (in terms of avoided CO2 emissions). As stated by the scientific Director of RCET while presenting the interactive dashboards:

> *EO data observations are fundamental for our research on the renewable energy transition of public/private companies and governments worldwide. In addition to the development of a dashboard that shows real-time environmental indicators (with one hour of buffer) and future financial returns in terms of Discounted Cash Flow and ROI in renewable energy plants, we also built a room – that we call "the decision theatre" – with a touch monitor the size of a rounded wall, where ministers, CEOs, CFOs, anyone interested in renewable energy transition has the chance to navigate autonomously every social, environmental and economic indicator available in our platform most of which are informed by EO data*. (DET)

The dashboards are displayed on a rounded wall of a room, called the Energy Transition lab room, with a theatre effect, where users can move and interact with the data. The decision 'theatre' combines data from satellites with other economic and statistical sources to set the conditions for forecasting but also imagining creatively, depending on the parameters set by the users, future economic, social, and environmental benefits of any current decision taken or future major projects launched by private and public institutions.[5] The dashboards offer an example of how EO data can be used to speculate about future performance and address future accountees' needs, both projecting and imagining the future:

> *Understanding the relationship between topographical and topological conditions, a specific geographic region's economic growth, energy consumption, and pollution is critical for forecasting future energy demand and environmental impacts. In general, different choices and, consequently, different long-term pathways related to the energy transition produce multi-dimensional effects for the benefit of many other categories of stakeholders (i.e., the impact on the energy systems, the environment, the economy, and society). For this reason, it is important to develop science-based methodologies and planning tools that can provide a holistic assessment of these impacts.* (DET)

The Director of the research centre continued mentioning that:

> *Through the use of EO data observations, our ability to track the Earth's geographical and topographical opportunities and changes, define the most adequate areas to exploit renewable resources and possibly begin an energy transition process unfolds across a spectrum of multiple timeframes spanning from mere tens of minutes to decades and potentially even longer frames in the future. This happens especially when we try to forecast geospatial changes in some regions of the globe or, if we look at the economic point of view, when we attempt to forecast the future economic return on investments and discounted cash flows of building green infrastructures in specific locations worldwide. Thanks to our analysis, simulations, and tools, we can foresee the future.* (DET)

Another example is offered by the EO data-driven simulations in relation to the renewable energy leapfrogging of countries in sub-Saharan Africa by 2040. Energy leapfrogging refers to switching new or up-to-date energy technologies, such as solar electricity generation technologies in rural areas, and adopting energy-efficient policies (IEA, 2023) that can be implemented where an older technology has not previously been deployed. The simulations conducted by the RCET through the dashboard show that, by 2040, sub-Saharan countries in Africa could leapfrog from a situation of low or no availability of energy to a sustainable and universally accessible supply, skipping the intermediate steps characterised by unsustainable use of energy commodities and standing up as one of the active players in the global energy transition. This imagined scenario is not a mere projection, as it will require shaping actions and decisions creatively in order to be achieved, such as ad

[5] Please refer to other research based on similar simulations and analysis such as building a highway in a certain geographical location (See for instance the EARSC's case study on "Highways Management in Italy", EARSC, 2022) or financing projects based on a specific type of renewable resources (See for instance the EARSC' case study on "Renewable Minigrid Deployment in Ethiopia", EARSC, 2023)

hoc incentive schemes, appropriate regulatory frameworks, and greater participation from private actors and local businesses. Therefore, the insights generated by simulating the instalment of renewable resources exploitation plants in different regions of the globe, such as sub-Saharan Africa, through the satellite data, trigger creative solutions for imagining the future differently: a desired future, that is not a phantasy or a projection, but a 'real option' (Gümüsay & Reinecke, 2024) following from the innovations fed by those data. As we see next, this also enables offering an account of such an imagined future.

4.3 Responses to a more or less distant, projected and imagined, future - the role of the end-user

End users are organisations along the value chain that rely on a particular set of information and projections provided by the primary users, making decisions and creating innovative solutions accordingly (see EARSC, 2020). EPEF is a European private equity firm committed to energy transition and is an end user of the EO data value chain. In particular, EPEF works towards integrating EO data and analysis from the dashboards developed by RCET with more traditional financial indicators to support the energy transition of its portfolio investments within companies.

For example, consulting partners within EPEF have worked on the design of an integrated management system that combines EO data dashboards with financial information to assess the ESG performance of green investments in energy transition. As a private equity fund, EPEF is accountable to the investors for achieving financial and non-financial ESG targets (quantified through ad hoc KPIs), which are met by implementing strategic interventions (in small and medium enterprises). A consulting partner of EPEF highlighted the high pressure s/he is exposed to when making investment decisions:

> *The advent of the SDGs, the publication of the Climate Change and Energy Transition Law and the EU Taxonomy set the stage for a comprehensive and ambitious framework to reshape Nations' energy landscape in Europe. There are high expectations and pressures on us to decarbonise our portfolios of clients. Since 2022, these regulatory pressures have affected our business model and brought us to develop a new strategy called "Equity for Climate Action". Contrarily to our competitors, we did not target the green sector investing in the energy transition of large companies through green tech and green infrastructures. Our buyout strategy focused on the core of the EU economy, which is small and medium enterprises operating in multiple sectors.* (PPEF1)

The pressures described above have led EPEF to take responsibility and commit to the energy transition of its portfolio clients, focusing on small and medium companies:

> *To give you some numbers, small and medium companies represent 63% of all European companies' CO2 emissions, and 72% of them have no decarbonisation plan. We select and transform these companies through a Grey-to-Green transition and are responsible for their*

capacity to create value. The higher the value we help them create through green processes, services and products, the better our exit strategy and the buyout value will be. It is a win-win strategy for our client, the financiers of the buyout strategy, and all our indirect stakeholders. (PPEF2)

To implement its strategy, EPEF consulting partners recently relied upon the use of EO data and multidimensional dashboards developed by the RCET to account for current and future financial, social and environmental impacts of their investment decisions in energy transition:

We must choose the right KPIs to measure companies' energy transitions without exposing our buyout fund to a downgrading. This requires considering not only the present financial inputs and knowledge capital but also the future social and environmental outcomes and impacts of our investment decisions, primarily when referring to the energy transition of the companies we invest in. By observing the on-time variation of EO data coming from Space and by practising simulations that combine environmental, economic, and social dimensions, we can provide valuable information to our financiers also on what kind of renewable resources (e.g. photovoltaic or wind-powered resources) can be exploited in certain recommended areas of the globe; and eventually forecast the economic returns from using different energy resources, such as sea waves or wind, to power a manufacturing plant or offer products and services. (PPEF3)

Therefore, integrating EO data into decision-making processes for investment decisions is considered crucial by EPEF to meet the accountability expectations of current financiers, portfolio companies and the broader society calling for actions to support the energy transition. At the same time, EO data can support meeting the needs and expectations of future accountees, thereby expanding the span of accountability over time:

We need to improve our understanding of future environmental changes produced by current efforts towards energy transition. Such endeavour requires us to find data that explains in detail the Earth's social and environmental crisis to foster processes of technological change (to fight climate change). In this way, we will be able to anticipate and address the needs and requests of future stakeholders. We think these data need to come from EO information, and we believe this information will help us improve the effectiveness of our investment decisions, possibly sooner rather than later. (PPEF3)

As mentioned by EPEF's consulting partners, the focus of the "Equity for Climate Action" strategy goes beyond green technology start-ups and companies that produce clean technologies and renewable infrastructures, where most capital has been allocated until now. PPEF1 mentioned the idea of making existing companies (small and medium enterprises in Europe) greener and emphasised how the use of EO data in conjunction with other kinds of KPIs can help improve companies' energy transition and reporting transparency:

> *Using more tailored and detailed KPIs based on the geographic and topographic characteristics of some regions of the globe, we can understand the risk of future extreme weather-related events for companies and, therefore, make better company asset evaluations. This will have positive implications for our client's market presence and talent attractiveness, as by shifting towards green energy, we support companies' performance from diverting current negative economic trends, such as the increase in energy costs. Regarding decarbonisation, we will support our clients in continuously investing in R&D and, therefore, improving the environmental performance of their products and services in terms of fine particulate matter and greenhouse gas emissions. EO data from Space will be highly valuable for renewable energy generation forecasting, providing insights into the benefits generated by renewable energy investments and, therefore, improving our clients' reporting transparency and ultimately shaping the future of our Planet.* (PPEF1)

The narrative above illustrates the benefits of adopting EO data across multiple users of the EO data value chain, by providing projections about the future, as well as triggering innovative solutions for a different (imagined) future while feeding into accounting and accountability systems (such as the integrated management system of EPEF). This suggests possibilities for future-oriented accountability, which we will discuss further in the next session.

5. Discussion – towards a future-oriented accountability

5.1 Projecting and imagining the future through EO data

The analysis above shows how multiple users can draw upon EO complex data to project the present into the future. These projections enable managers within organisations to prefigure the future and imagine it *differently*, triggering creative responses to such predictions. Here, imagination is fed by a projection of the present into the future and by users' creativity and aspiration towards a different future. The dashboards developed by RCET, for instance, allow users to 'play' with the data and run multi-dimensional analyses and simulations of the use of renewable sources across different territorial scales and times, measuring financial and environmental impacts, thereby imagining different possibilities fulfilling users' innovative aspirations. These tools rely on modelling EO data through, e.g., geophysical and ecological observations and models across various scales: spatially, from local to global phenomena, and temporally, from seconds to hours to decades and longer, with different configurations of possible, desired, future, related to users' innovative activities.

For example, within RCET, the use of EO data observations to analyse the impacts of the exploitation of renewable energy sources enables final users to track Earth's geographical and topographical changes, define the most adequate areas to exploit renewable resources and possibly begin an energy transition process across a spectrum of multiple timeframes spanning from mere tens of minutes to decades and potentially even longer frames in the future (as quoted above). Through the multispatial and multitemporal analysis and simulations run in the 'decision theatre' developed by RCET, end users can creatively assemble different sources of information (measurement, observations, and quantifications) to 'plausibly speculate' (Gümüsay & Reinecke, 2024) about the future, following their innovations. For example, users can analyse variables that could influence the renewable energy leapfrogging of countries in sub-Saharan Africa by 2040 (as quoted above). This triggers an imagination about the future, following the possible creative solutions of actors fed by EO data and aspiring towards what could be done to fulfil such imagination.

Therefore, EO data offer a form of 'imaginatory' data, feeding not only a prefigured future but a desired future, longed for through imagination. Although imagined, this desired future is not fictional, as it is configured throughout a value chain of actors, providing and using EO scientific data to make projections *and* imagine the future creatively through the innovation triggered by those predictions. Here, projection and imagination need to work together to offer 'real options' towards an imagined desired future with 'speculative rigour' and through a collective effort (Gümüsay & Reinecke, 2024). Our findings show that this is possible through EO scientific data as they flow across the value chain between providers and users, within and beyond the Space sector.

5.2 Accounting for an imagined future

The creative responses triggered by EO data and the desired imagined future associated with those responses are accounted for within the accounting and accountability systems of users in the EO data value chain. The findings from the three selected sites operating in the EO data value chain show how complex scientific Space data are integrated into accounting practices and tools (such as dashboards and performance measurements), feeding the decision-making processes of multiple users and enabling them to account for these decisions. For example, ISC, as a data provider working in the Space sector, needs to give an account of its activities, with their financial, social and environmental impacts, to investors interested in the future benefits of current investments (quoted above).

These findings also confirm the relevance of EO data to support the evaluation of the possible benefit of projects and investments for future generations (Diffenbaugh et al., 2020; Dubovik et al., 2021; Florio & Morretta, 2021), as these data are integrated within users' accounting and accountability systems. Here, our findings show that end users like EPEF draw on the integration of EO data into investment decision-making processes to meet the accountability expectations of investors, clients, and broader society calling for actions to support the energy transition. As mentioned by a Partner of EPEF, using more tailored and detailed KPIs, combining geographic and topographic EO data and with other indicators, help measure the benefits generated by renewable energy investments and, therefore, improving portfolio companies' reporting transparency while ultimately shaping the future of our Planet (as quoted above).

These considerations also reveal how integrating EO data within accounting tools and measures enables scientific expertise to be transformed into practical, tailored information, supporting managers and other users within public and private organisations in decision-making (such as for the Energy Transition decision theatre based on Copernicus EO data developed by RCET). This also triggers a future-oriented accountability, as we discuss next.

5.3 Towards a future-oriented accountability

Our study responds to recent calls for more future-oriented accountability practices (Chakhovic & Virtanen, 2023; Favotto et al., 2022; Mashaw, 2014). Accounting for an imagined future does not only imply a projection of the present into the future through complex data (such as EO data), but it also requires imagining the future, triggering creative responses towards what could be done and aspired to through these data and accounting for these responses. Therefore, future-oriented accountability needs to embed creative responses towards a projected future that can also be imagined differently precisely through such responses. In so doing, accountability and response-ability (Favotto et al., 2022) are linked through future-oriented patterns of envisioning and imagination that are fed by complex scientific data and provide for possible instantiations of creative solutions to present-future challenges.

The resulting future-oriented accountability responds to the broader call for more future-oriented practices, informed not only by predictions but also by imaginatory forms of data and imagined desired futures (Gümüsay & Reinecke, 2024). The imaginative work enabled by the creative assemblage of scientific data from Space with other sources of knowledge opens up possibilities for developing a "future-forming" orientation to accountability practices (Gümüsay & Reinecke, 2024, p. 3) by replacing a static and only re-active approach based on mere projections of the present into the future, with imaginative explorations into what the future could be (as with the renewable energy leapfrogging of countries in sub-Saharan Africa by 2040 quoted above). By offering an account of those imaginations, future-oriented accountability practices can enable the construction of possible future realities, as when alternatives are imagined and accounted for, realities are altered.

A future-oriented accountability approach also needs to imaginatively search for the 'expertise' required to predict the needs of more or less distant future accountees, considering that this expertise can be found in 'unexpected places' (Chakhovic & Virtanen; 2023, see also, Grisard et al., 2022). Here, the needs of future-oriented accountees cannot be projected only from the needs of current generations (Chakhovic & Virtanen; 2023) but need to be imagined. Our findings show that this imaginative work can be informed and sustained by scientific data from Space (as mentioned by PPF3 above), providing for future-oriented data-driven account-ability and response-ability. These considerations also point to the integration of EO data in accounting and accountability practices as a way to "go beyond calculation", to be open to the 'other' and be prepared to revise accounts and calculations as spatial and temporal conditions and impacts evolve over time (Favotto et al., 2022, p. 12; see also Quattrone, 2022), thereby sustaining evolving future-oriented accountability efforts.

6. Conclusion

This paper has shown how the predictions and imagination enabled by EO data can sustain organisations (in the Space sector and beyond) in decisions and innovations, providing for a future-oriented accountability.

Firstly, we extend the literature on accountability by delving into its time dimension (e.g., Chakhovic & Virtanen, 2023; Mashaw, 2014). We show that the EO data collected from Space, integrated with other information data, enable organisations to both project the present into the future through predictions *and* imagine the future differently by responding to these predictions through creative solutions fed by those data while also embedding such responses into their accounts. In so doing, we extend prior accounting studies on "response-ability" (Favotto et al., 2022; see also, Giovannoni et al., 2023), by showing how its relations with the ability to give an account for action can be informed by the scientific data coming from Space, enabling a projection into the future that can be also longed for, and imagined differently, through actions and decisions fed by those data.

Further, we show the elusive and temporally fluid nature of accountability as part of the way organisations account for actions and thereby construct themselves as 'accountable'. This confirms the dynamic, fluid, and chameleonic nature of accountability (Sinclair, 1995) not only across space but also across time, as accountors and accountees are dispersed across time-space contexts. Therefore, the future is not a black box, ultimately affecting accountability. Instead, by integrating data from Space and managing multiple spatial-temporal dimensions, accountability practices can embed a wide range of information (spatially, from local to global phenomena; and temporally, from seconds to hours to decades and longer), focused on 'how real problems could be solved' while accounting for these possible solutions. Here, complex scientific data provide a form of 'imaginatory data' (Gümüsay & Reinecke, 2024) as they feed decision-making and creative responses towards a more or less distant and desired future while accounting for these responses.

Secondly, we extend the scant literature on accountability in the Space sector (Di Tullio et al., 2023; Tucker & Alewine, 2021; 2022) by showing the complex accountability systems at work among the actors of the EO value chain. Complex scientific data, such as EO data collected by Copernicus satellites, feed the decision-making processes of a number of actors (within the Space sector and beyond) by enabling these actors to project and imagine the implications of their decisions. We found that these forecasts become an integral part of the accountability systems of the actors along the value chain, as organisations strive to account for actions based on a projected and imagined future.

Our study has practical implications for organisations within and outside the Space sector. We show that projecting the present into the future and imagining the future require the joint effort and commitment of all actors involved in the EO data value chain. Here, we suggest that EO data and the data value chain from the Space sector can feed nuanced accountability practices, embedding an imagination and envisioning, fed by complex scientific data. The continuous development and enhancement of applications, tools and modelling systems are necessary to improve predictions and the imaginatory potential of the data. This potential needs to be value-led (Gümüsay & Reinecke, 2024) and is responsible for triggering actions and decisions towards a desired future.

In this paper, we have focused on the use of EO data. Further research can be undertaken to investigate how other scientific data from Space or Space activities and programmes can support speculative accountability practices within public and private organisations (within and outside the Space sector). Here, we call for more research investigating the role of accounting and accountability in addressing global challenges coming from an 'emergency' future, such as climate change, social disruption, and health emergencies. Furthermore, future research could unpack the ethical and regulatory dimensions underpinning the use of scientific data from Space, delving into the auditing, governance, privacy and assurance processes related to predictive data and models and their use for accounting and accountability purposes.

Appendix 1

Interviews	**Code**	**Number**	**Hours**
Head of Corporate Knowledge	HCK	5	10
Senior Advisor Earth Observation	SAEO	2	3
Head of Earth Observation Projects Department	HEOPD	3	3
Strategy and Communication Officer	SCO	2	3
Earth Observation Planning and Control Manager 1	EOPC 1	1	2
Earth Observation Planning and Control Manager 2	EOPC 2	1	2
Director of the Research Centre for Energy Transition	DET	2	3
Researcher the Research Centre for Energy Transition	RET	2	3
Partner 1 at European Private Equity Firm	PPEF1	1	2
Partner 2 at European Private Equity Firm	PPEF2	1	1
Partner 3 at European Private Equity Firm	PPEF3	1	1
Total		**21**	**33**

Source: Authors' own creation

Appendix 2

Author	Title	Year of publication
Caribou Space	Understanding the impact of Earth Observation for sustainable urban development	2020
EARSC	Sentinels Benefits Study Methodology: A Practical Guide for Practioners to evaluating the benefits derived from the use of Earth Observation data	2020
EARSC	Sentinels Benefits Study (SeBS) - Renewable Mini-Grid Deployment in Ethiopia	2023
EARSC	Sentinels Benefits Study (SeBS) - Air Quality Forecasting in Latvia	2023
EARSC	Sentinels Benefits Study (SeBS) - Oil Spill in the Mediterranean	2022
EARSC	Sentinels Benefits Study (SeBS) - Water Quality in Finland	2022
EARSC	Sentinels Benefits Study (SeBS) - Deforestation Monitoring for Sustainable Palm Oil Production	2022
EARSC	Sentinels Benefits Study (SeBS) - Highways Management in Italy	2022
EARSC	Sentinels Benefits Study (SeBS) - Grassland Monitoring in Estonia	2021
EARSC	Sentinels Benefits Study (SeBS) - Making Wine in France	2021
EARSC	Sentinels Benefits Study (SeBS) - Insurance & Risk Monitoring in Slovenia	2021
EARSC	Sentinels Benefits Study (SeBS) - Forest Monitoring in Portugal	2021
EARSC	Sentinels Benefits Study (SeBS) - Lake Water Quality Management in Germany	2021
EARSC	Sentinels Benefits Study (SeBS) - Global Oil Industry Activity Monitoring	2021
EARSC	Sentinels Benefits Study (SeBS) - Ground Motion Monitoring in Norway	2020
EARSC	Sentinels Benefits Study (SeBS) - Aquifer Management in Spain	2020
EARSC	Sentinels Benefits Study (SeBS) - Golf Course Monitoring in Italy	2020
EARSC	Sentinels Benefits Study (SeBS) - Growing Potatoes in Belgium	2019
EARSC	Sentinels Benefits Study (SeBS) - Farm Management Support in Poland	2019
EARSC	Sentinels Benefits Study (SeBS) - Navigation through Sea-ice off Greenland	2019
EARSC	Sentinels Benefits Study (SeBS) - Flood Management in Ireland	2018
EARSC	Sentinels Benefits Study (SeBS) - Farm Management in Denmark	2018
EARSC	Sentinels Benefits Study (SeBS) - Forestry Management in Sweden	2016
EARSC	Sentinels Benefits Study (SeBS) - Pipeline Infrastructure Monitoring in the Netherlands	2016
EARSC	Sentinels Benefits Study (SeBS) - Winter Navigation in the Baltic	2015
ESA	Copernicus4Regions Info Session - The Copernicus Space Component: Today's Status and the Future	2020
ESA	Contract signed for new Copernicus ROSE-L mission	2020
ESA	Climate Change from Space - Climate kit	2021
Leonardo	Accelerating technology evolution	2020
PwC for European Commission	Copernicus Market Report	2019

PwC for European Commission	Report on the Copernicus downstream sector and user benefits	2016
PwC for European Commission	Report on The socio-economic impact of the Copernicus programme	2016
PwC for European Commission	Copernicus services in support to Cultural Heritage	2018
PwC	Copernicus ex- ante benefits assessment	2017
PwC	The role of emerging space nations in supporting sustainable development and economic growth	2020
PwC	Socio-economic impact assessments and accompanying foresight study of selected ESA Earth Observation activities_Executive Summary	2019
Thales Group	Press release - Thales Alenia Space signs contract from ESA to build Copernicus Rose-L Satellite	2020

Source: Authors' own creation

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