




# An Emerging Innovation Ecosystem for New Space—Kvarken Space Center in Finland

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## 1 INTRODUCTION

Space, a source of inspiration for humanity, has been integral to our lives since the historic moment in 1969 when Neil Armstrong took mankind's first steps on the Moon. However, the pervasive influence of space on our daily lives may not be immediately apparent. From smartphone navigation to air travel, weather forecasting, and financial transactions, we are constantly utilizing space systems. In fact, the absence of these systems would render modern life, particularly in developed nations, virtually

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impossible (Jakhu et al., 2020). Space harbors immense untapped potential to address future crises, stimulate job creation, and foster innovation within the space industry (European Commission, 2016). In the coming years, space entrepreneurs, who provide cost-effective and affordable space solutions, will play a pivotal role in the evolution of the space economy (Peeters, 2021).

In developed economies, the intricacy of the space economy is on the rise, and distinguishing between space-related and unrelated activities is becoming progressively challenging. As the OECD Handbook on Measurement of the Space Economy (OECD, 2022) predicts, measuring the space economy will remain an evolving field as commercial space activities are changing rapidly. There is no explicit definition of space economy, nor is there a clear separation between different sub-areas.

The OECD Handbook on Measurement of the Space Economy defines the space economy as ‘the full range of activities and the use of resources that create and provide value and benefits to human beings during exploring, understanding, managing and utilising space.’ This includes all public and private actors involved in developing, providing, and using space-related products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles, and satellites) to space-enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities (OECD, 2022). For comparison, the US Bureau of Economic Analysis (BEA) described the following definition when compiling their Space Economy Satellite Account: ‘The space economy consists of space-related goods and services, both public and private. This includes goods and services that are used in space, or directly support those used in space, require direct input from space to function, or directly support those that do, and are associated with studying space’ (OECD, 2022).

As Peeters (2021) and Weinzierl (2018) point out, the term New Space lacks a single, specific definition, reflecting its multidimensional nature that goes beyond mere commercial aspects. Various interpretations exist, ranging from the Space Frontier Foundation’s view of New Space as a pathway to human settlement through economic development to Martin Sweeting’s (Sweeting, 2018) emphasis on a fresh ethos that challenges traditional aerospace methods with entrepreneurial and agile approaches (Denis et al., 2020). Alternative terms such as Alt.space, entrepreneurial space, and commercial space have also been employed

(Pomeroy et al., 2019). These designations not only encapsulate technological innovations but also underscore new business models and organizational structures that focus on collaboration, agility, incremental deployment, and customer-centric design (Denis et al., 2020).

In essence, ‘New Space’ represents a paradigm shift, characterized by the inclusion of non-traditional actors such as private investors and hybrid public–private organizations, as well as a new approach to space utilization exploration, and commercialization (Peeters, 2021; Weinzierl, 2018). In the past decade, the space sector has seen a rise in initiatives providing open access to a wealth of space-derived data, enabling diverse entities in the field to utilize the rapidly increasing data volume (Aloini et al., 2022).

This chapter aims to provide an in-depth analysis of the emerging innovation ecosystem in the New Space sector, with a specific focus on the Kvarken Space Center. Recognizing the persistent challenges and opportunities in this rapidly evolving field, our purpose is to explore and articulate the key factors driving innovation and growth at the Kvarken Space Center. Through this exploration, we address critical questions such as: ‘What are the specific challenges facing the New Space ecosystem?’ and ‘How is the Kvarken Space Center contributing to overcoming these challenges and fostering innovation?’ This approach allows us to delve deeper into the role of the Kvarken Space Center as a pivotal player in shaping the future of the New Space Economy.

## 2 NEW SPACE ECONOMY ECOSYSTEM

### 2.1 *Early-Stage Ecosystems Establishment*

An innovation ecosystem can be defined as a network of interconnected actors, formed around a focal firm or a platform (a shared focal point or asset), incorporating production and use side participants, creating and appropriating new value through innovation (Thomas & Autio, 2020). Currently, there is only a limited body of literature and understanding around early-stage ecosystems in the New Space industry. Work more closely linking the nascent organizational processes of ecosystems to the different institutional and inter-organizational environments found in unsettled industry spaces, where the initial circumstances for ecosystem formation are asymmetric, distributed, and dynamic, is still missing (Salenius et al., 2023).

Business ecosystems develop through four life cycle phases: birth, expansion, leadership, and self-renewal (Moore, 1993). In the first stage, entrepreneurs focus on defining what customers want i.e., the value proposition of a new product or service. It is also often beneficial to cooperate during the first stage (Moore, 1993). As early-stage ecosystem collaboration lacks external trust and legitimacy, emerging ecosystems must engage legitimacy building, with agency and coordination to support interaction with the ecosystem participants and those looking to support or join it. Partner alignment, formation of a joint vision, core value proposition, and ecosystem identity are also critical. To pursue the ecosystem's intended value proposition, securing material and intellectual resources is required (Salenius et al., 2023).

The starting point of innovation ecosystems in literature can be defined as an empirically observed trend of non-hierarchical organization of the innovation process among actors that complement each other with non-generic collaboration (Salenius et al., 2023). The actor assuming the ecosystem leader role first engages in governance related actions such as designing the role of other actors and coordinating interactions and initiates, maintains, and develops ecosystem (Dedehayir et al., 2018). Ecosystems are composed of heterogeneous participants in various roles and facilitate an output that is more encompassing than any single participant can deliver alone. There is a great interdependence among its participants which is managed primarily by non-contractual mechanisms of system governance (Thomas & Autio, 2020). One of the most critical features in industry platforms is the potential of network effects (Gawer & Cusumano, 2014).

Innovation management in innovation ecosystems focuses mainly on two perspectives: analysis of innovation management strategies, and value creation and capture in innovation ecosystems (Li, 2019). Leveraging collaboration is the key to value creation through innovation. The innovation ecosystem approach examines the very nature of successful innovation systems and stresses that the system is greater than the sum of its parts. On the surface, many innovation systems contain all the right elements, but still fall short of expected outcome. Innovation ecology is dependent on the presence of several factors, such as talent, companies, institutions, and capital elements and to a great extent on identities, meaning, networking capabilities, culture of trust, and pragmatic cooperation. Smart development of a complex dynamic non-hierarchical system is of key importance. In addition to finding the right compositions of

elements, it is important to stimulate their relations and interactions in non-linear and non-hierarchical ways. For the development of innovation ecosystems, the definition of the system and its boundaries is not important but aiding the self-organization of its actors and facilitating the system's emergence from the multiple interactions are (Jucevičius & Grumadaitė, 2014).

## 2.2 *Unveiling the Future: The Ascendance of the New Space Economy*

The New Space Economy heralds a significant paradigm shift in the global space sector, increasingly characterized by the burgeoning role of private enterprises alongside groundbreaking technological innovations. This shift represents a departure from the era historically dominated by government agencies, marking the dawn of a new age where private companies are not only democratizing access to space but also pioneering novel business models and services. The term 'New Space' aptly encapsulates this evolution, denoting the emerging trend of innovative private space ventures that autonomously seek business opportunities, liberated from the confines traditionally imposed by governmental space missions (Profitiliotis & Loizidou, 2019).

Moreover, the sustainable growth and economic viability of the space economy are increasingly underpinned by 'New Space' initiatives. Such initiatives, propelled by technological advancements and innovative business models, aim to make space more accessible and beneficial for a wider array of applications. As the space economy continues to evolve, the distinction between governmental and commercial space activities becomes more nuanced, highlighting the critical role of public-private partnerships in advancing space technology and infrastructure (Peeters, 2021).

The current era is marked by a notable surge in commercial satellite launches, space tourism ventures, and private lunar exploration missions, fundamentally transforming the economic landscape of space activities. The comprehensive analysis provided by Greg Sadlier et al. (2019) further illuminates the economic impact of these activities, underscoring the strategic importance of nurturing this burgeoning field.

The narrative of the New Space Economy is one of profound transformation, characterized by the melding of entrepreneurial innovation with strategic economic growth. It is an era defined by the quest for sustainability, the expansion of access to space, and the enhancement of

global connectivity, all supported by a collaborative spirit among stakeholders. This narrative offers a multifaceted perspective on the ongoing evolution within the global space sector, showcasing its potential to drive future technological, economic, and societal advancements, enriched by the insights (Gonzalez, 2023; Paravano et al., 2023; Peeters, 2021; Profitiliotis & Loizidou, 2019; Sadlier et al., 2019).

The advent of reusable launch vehicles, SmallSats, and CubeSats has revolutionized space access, making it more cost-effective and inclusive. These innovations have precipitated a significant uptick in spacecraft launches, with SmallSats representing a substantial majority in recent years. Furthermore, the deployment of satellite constellations promises to extend global coverage, facilitating a range of applications from climate monitoring to broadband internet, marking a critical driver for the space market's future trajectory (Aloini et al., 2022; Deloitte Insights, 2023; Denis et al., 2020).

Venture capital and private equity firms have significantly increased their investment in space-related start-ups and technologies, fostering an environment ripe for innovation and competition. This influx of capital has enabled the emergence of new business models, such as mega constellations, and supported ambitious projects by leading companies like SpaceX and Blue Origin, thereby contributing to the sector's expansion and commercialization. The global space economy's growth trajectory underscores the sector's burgeoning strategic importance, with start-up equity investments reaching notable figures and a policy shift catalyzing the establishment of space start-ups, reflecting the entrepreneurial dynamism propelling the industry's growth (Deloitte Insights, 2023; Emen, 2020; McKinsey & Company, 2023).

An increasing reliance on space-based data by government agencies, private companies, and research institutions is driving the demand for space data and related services. This has led to the development of the space data-as-a-service market, where companies offer customized data sets for diverse applications, highlighting the critical role of space data in various industries (Deloitte Insights, 2023).

Projections indicate substantial growth in the sector's value and the number of active satellites, emphasizing the necessity for continued innovation, investment, and collaboration between public and private entities. Addressing emerging challenges, such as supply chain disruptions, regulatory hurdles, and environmental concerns, will be pivotal for the sector's sustained growth and long-term viability (Space Foundation, 2023).

The New Space Economy heralds a novel approach to space exploration and utilization, marked by the increasing role of non-traditional actors, the integration of space activities with ICT, and significant economic expansion. The sector's evolution presents exciting opportunities for interdisciplinary research, technological advancements, and economic development, underpinned by a collaborative spirit among all stakeholders (Aloini et al., 2022; Chavy-Macdonald et al., 2021; Deloitte Insights, 2023; Denis et al., 2020; Emen, 2020; McKinsey & Company, 2023; Pomeroy et al., 2019; Space Foundation, 2023; Weinzierl, 2018).

The European space sector is undergoing a transformative phase, shaped by global trends such as technological innovations, increased private sector investments, and a growing demand for space-based data and services. These trends are not only reshaping the space sector globally but are also manifesting uniquely in Europe, underpinned by strategic EU initiatives, investments, and the burgeoning role of commercial space activities.

Europe has embraced the technological advancements that are driving the New Space Economy forward. Innovations in reusable launch vehicles, SmallSats, and CubeSats, similar to global trends, are making space more accessible and cost-effective. This has led to an increase in spacecraft launches and the development of satellite constellations offering global coverage. European space endeavors are supported by strategic investments aimed at fostering technological advancements and commercial activities within the space sector. The European Union, recognizing the strategic importance of space, has allocated significant funds to its space programs, aiming to strengthen Europe's position in the global space economy and enhance its autonomy in space (Council of the European Union, 2020a, 2020b).

The European space sector is increasingly driven by commercial activities, aligning with the global shift toward a New Space Economy characterized by the involvement of private companies and entrepreneurs. This shift is facilitated by EU policies that encourage the commercialization of space and the success of European space companies in the global market. Initiatives to promote space and provide access to finance for start-ups, expanding businesses, and SMEs are crucial in developing a competitive European space industry (Council of the European Union, 2020a).

The EU's substantial space investments, particularly the €14.4 billion, earmarked for the European Space Programme for 2020–2022(24),

underscore its commitment to advancing satellite systems like Galileo, EGNOS, and Copernicus. These investments also aim to nurture space entrepreneurship and innovation, furthering the development of the European space sector. The EU's space policy is designed to meet increasing societal demands for space-based solutions and strengthen Europe's standing in the global space arena (Työ- ja elinkeinoministeriö, 2020).

While the European space sector benefits from the EU's strategic focus and investments, challenges remain in fully tapping into the potential of the New Space Economy. The integration of emerging space companies into significant space projects and the global market poses a formidable challenge. Nonetheless, the European space sector, with its rich history of technological innovation and strategic investments, is well-positioned to navigate these challenges and capitalize on the opportunities presented by the New Space Economy (Council of the European Union, 2020b).

The European Space Economy is at a pivotal juncture, with the EU's strategic initiatives and investments playing a critical role in shaping its future. The transition toward a more commercial and innovative space sector reflects Europe's response to global trends and its ambition to remain a key player in the New Space Economy.

In the evolving landscape of the New Space Economy, Finland's strategic approach and the initiatives at the Kvarken Space Center exemplify the nation's commitment to harnessing the potential of space for economic development, technological innovation, and societal benefits. Positioned within the broader European context, Finland's endeavors in space reflect a concerted effort to align with EU strategies, leverage investments, and capitalize on the burgeoning role of commercial space activities.

Finland has proactively embraced the shift toward a more commercial and private sector-driven space industry. This transition is marked by technological breakthroughs and a significant decrease in the costs associated with space exploration, enabling Finland to explore new business models and state-of-the-art technologies across various sectors (Harri et al., 2020; Piirainen et al., 2022). The Finnish government's reports and policy programs underscore the nation's vision to integrate space activities across sectors, translating space strategies into actionable goals and fostering government-led actions and investment programs to amplify space activities (Harri et al., 2020; Piirainen et al., 2022).

The New Space Economy program, spearheaded by the Finnish Ministry of Employment and the Economy, targets economic growth and employment through innovative business models. Coupled with Business Finland's New Space Economy program (2018–2022), these initiatives position Finland as a key player in the global space economy, emphasizing sustainable space utilization, climate change objectives, and security (Ranne, 2021).

At the heart of Finland's space endeavors lies the Kvarken Space Center, serving as an innovation hub and a beacon for Nordic cooperation in space. The center facilitates stakeholders in the Nordic region to explore new opportunities, enhance the use of satellite technology, data, and applications in various domains, thereby reinforcing Finland's pivotal role in space-related Nordic collaboration. The inception of the Kvarken Space Center, through the KvarkenSpaceEco project supported by the EU Interreg Botnia-Atlantica program, showcases a successful collaboration among universities and research institutions from Finland and Sweden (Kvarken Space Center, 2024).

Despite the promising trajectory, Finland faces regulatory challenges and hurdles related to the decentralized nature of its space sector. Overcoming these obstacles is paramount for Finland to fully leverage the opportunities presented by the New Space Economy (Harri et al., 2020). The Finnish space sector, characterized by a diverse array of companies and a highly educated workforce, stands testament to Finland's capabilities and ambitions in space (Pirainen et al., 2022).

In conclusion, Finland's strategic approach within the European context, bolstered by initiatives like the Kvarken Space Center, illustrates the nation's resolve to be at the forefront of the space revolution. As Finland navigates the complexities of the New Space Economy, its contributions to the global space industry and the Finnish economy's overall development are poised to make significant strides, contributing to the sustainable growth of the space sector.

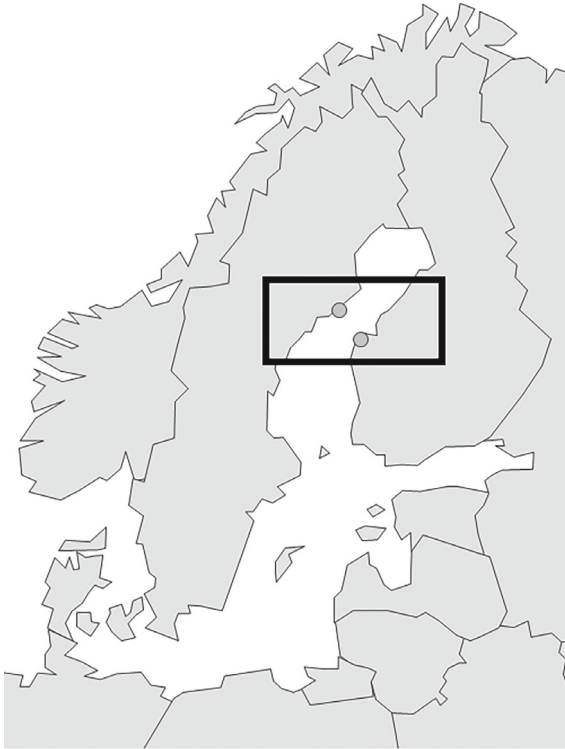
### 3 METHODOLOGY

#### 3.1 *Emergence of a Sustainable Commercial Space Economy*

The research was conducted within the framework of the EU Interreg Botnia-Atlantica Kvarken Space Economy project, spanning from 2019 to 2022, with the objective of establishing the Kvarken Space Center.

Situated in the Kvarken region (Fig. 1), which encompasses both Finland and Sweden, the center aims to serve as a catalyst for innovation in regional New Space activities. Its primary mission is to create a sustainable structure for regional economic development, focusing on space-based business and innovation. Additionally, the center seeks to bolster regional businesses by facilitating the development of new opportunities within the New Space Economy and aiding in the commercialization of existing space-based data through the establishment of a regional innovation ecosystem (Kvarken Space Center, 2019).

The concept of open innovation posits that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they advance their technology (Chesbrough, 2006).



**Fig. 1** The Kvarken region between Sweden and Finland

The current body of literature suggests that open innovation thrives under conditions of technological complexity and market uncertainty (Herskovits et al., 2013). This paper delves into the potential of New Space in the Kvarken region in Finland, by scrutinizing the critical aspects and demands for the regional innovation ecosystem landscape. It does so by leveraging insights from industry representatives and examining the manifestation of open innovation within these innovation ecosystems. Our objective is to elucidate the management of the open innovation process within an ecosystem involving multiple participants.

The study of an emerging ecosystem is inherently exploratory, necessitating the use of qualitative case study methods and in-depth interviews. The analysis of how ecosystems emerge is primarily anchored in empirical observation (Salenius et al., 2023). Semi-structured interviews with representatives from diverse sectors within the industry landscape were conducted, both in-person and via video conference calls. These sectors spanned energy, IT, maritime, logistics, land surveying, construction, security, forestry, and waste management. Additionally, subject matter experts involved in the KvarkenSpaceEco project were consulted. The research and establishment activities for the Kvarken Space Center ecosystem were conducted from January 2020 to September 2022, involved 30 interviews, 3 workshops, and several separate consultations and discussions. The aim was to map the landscape of the New Space Economy in the Kvarken region and identify potential opportunities for the innovation ecosystem. The current and potential utilization of space-based data for new product and service development and application for the development of internal business processes were also discussed. The authors of this chapter played a dual role as actor/observer, with the active goal of initiating and supporting the new space innovation ecosystem establishment in the Kvarken region. The research was designed to capture a snapshot of perspectives within a specific time-frame, focusing on the qualitative insights that inform the current state and potential future directions of the sector as related to the Kvarken Space Center in Finland.

The interviewees comprised entrepreneurs, technology and strategy managers, facilitators, coordinators from the business world, as well as experts from universities and research institutes. These individuals were either participating or aspiring to participate in the Kvarken region's space ecosystem. The interviews, which lasted from one to two hours, were

documented. An organized approach was employed to analyze the qualitative data gathered from interviews and reports to uncover underlying themes (Appendix: Thematic Culmination Points from the Interviews). Subsequently, we performed a detailed manual analysis to delve deeper into these themes. Additionally, to validate our findings and ensure robustness, we cross-referenced these themes with relevant literature in the field.

Five main questions were developed for the analysis:

1. What type of infrastructure would be needed to support innovation in the Kvarken region?
2. What type of competence, skills, products, or services would companies offer to the ecosystem either as individual offerings or connecting into a part of a value chain?
3. How can the decentralized nature of the space sector in the Kvarken region be effectively managed to enhance efficiency and foster a more coordinated approach?
4. Considering the global space economy, what are the potential areas for scalable business for companies in the Kvarken region, and how can these opportunities be maximized to support the growth of the local space economy ecosystem?
5. What strategies can be employed to improve the understanding and utilization of space-based data in the region?

Furthermore, the material concerning Finland's space economy has been primarily sourced from reports commissioned by the Prime Minister's Office. These reports, which scrutinize and aim to develop Finland's space strategy and space economy, serve as foundational references for the development of the national space economy, including in the Kvarken region. Based on this material, efforts have been made to utilize the nationally approved space strategy measures to ascertain and develop the state of the space economy in the Kvarken region.

## 4 FINDINGS

In the establishment phase of the KvarkenSpaceEco project's ecosystem, we observe a harmonious alignment with foundational principles delineated in Sect. 2.1 of our literature review. This phase embodies the

essence of collaboration, value generation, ecosystem identity, and the strategic amalgamation of essential elements for ongoing development. These facets collectively mirror the theoretical underpinnings and practical examples cited in the scholarly discourse, thereby validating our research findings within the broader context of ecosystem evolution.

During the research and development of the Kvarken Space Center, observations of the New Space innovation ecosystem revealed that open development activities at the ecosystem level really mean finding new ideas together with innovation projects. The findings provide additional evidence that the formation of an innovation ecosystem for New Space is important and for companies that make people meet others and share a common interest in innovation cooperation. The actors emphasized interaction between members, as one company representative formulated: *'The goal of this New Space Economy ecosystem is to get people to talk, meet and know others, and find requirements of common interest.'*

A common platform must provide opportunities for brainstorming, advancing ideas into innovation projects, and creating a sustainable New Space Economy ecosystem. Creation of joint projects, from the bottom up by starting with brainstorming sessions, meetings, and workshops between organizations facilitate emergence of new ideas and incorporate the various views of different parties.

A broad level of interest can also be observed from the industry interviews for new technology, space-based data applications and opportunities utilizing new data layers to support day-to-day business and innovation. Business needs and interest areas of application range extensively. Only a few companies are already integrating space-based data into their processes. Proper understanding of data access, application, and possibilities for data utilization is still on a low level.

A major unanswered question is the viability of satellite remote sensing for local applications as the level of local infrastructure, easy utilization of drones and access to good quality aerial images and ready-made materials provided by public sector actors is commonly and often freely available for diverse applications. For many applications, openly available remote sensing data was considered to have insufficient spatial resolution for many industrial use cases and the cost of commercial imagery product remains expensive (especially for small companies). As a mitigating action cost sharing between several users of commercial imagery products acquisition was identified (e.g., via the Kvarken Space Center, shared project consortiums or actors in the value chains). The value of remote sensing

was especially observed for business activities, products, and services delivered to more remote geographical areas. The most utilized space data applications on the local level are connected to Positioning, Navigation, and Timing (PNT); in activities requiring PNT data, and were observed especially in the energy, maritime, security, logistics, and construction planning and engineering related discussions. Also, the value of PNT was identified in many new opportunities for product and service development, for example in combination of geographical information systems and supporting location-specific decision making in e.g., built and urban environments.

From the Business Development workshop (application to Waste Management) key identified issues included how to enhance traceability, developing pre-sorting, resource, and route optimization and how to make the waste value chain more transparent, identify origin and target actions on specific geolocations. In addition, special interest in applying space-based data to developing countries' needs was acknowledged. Current ESA funding calls were also reviewed as an opportunity to pursue further support for potential business applications.

During the Ecosystem Workshop 2022, several representatives of different companies pointed out that remote sensing, PNT data, and telecommunications support applications in the energy industry, logistics, shipping, improving the situational picture and awareness, agriculture, and forestry for change detection, connectivity, and forecasting. Often space-based data offers only a single part in a diverse value chain.

Several university and business representatives drew strong attention to the fact that education and know-how related to the utilization of space must be developed in Finland. The informants agreed that Finnish education is mostly insufficient to meet the challenges of the New Space Economy. One key requirement for the development of the space industry is to invest in the development of competence and know-how comprehensively in accordance with the needs of different sectors. Companies develop the ability to take advantage of emerging opportunities and participate in the New Space Economy as they create and acquire new skills and abilities.

In an interview with a manager of a start-up space data company, a comprehensive view on developing competencies from a business point of view was discussed. He emphasizes the critical need for understanding and effectively utilizing space-based satellite data, such as remote sensing

images, across various applications. The manager points out a significant gap in the general awareness and technical know-how among users, particularly in accessing, interpreting, and using raw image data and its associated metadata. This lack of understanding hinders the ability to extract valuable information from these images.

Furthermore, the manager stresses the importance of enhancing machine learning skills. He argues that analyzing satellite data without machine learning tools is too labor-intensive, highlighting the need for teaching the creation of machine learning models. Alongside this, there is a call for increasing data science education to enable structured big data analysis, requiring specialized data processing skills in programming languages like R or Python.

The discussion also extends to the teaching of artificial intelligence (AI) algorithms. The use of various AI models in the processing of space data is deemed crucial for analyzing the material effectively and preparing forecasts. This technical competence is complemented by a need for general business skills in start-ups within the New Space Economy. The manager enumerates roles such as front-end and back-end developers, designers, mobile application developers, and professionals in sales, marketing, partnerships, and fundraising. These roles are essential for a comprehensive understanding of the possibilities within the New Space Economy ecosystem and the interconnections between different actors.

A working model was also created that brings the relevant actors together to create solutions and consider possible project piloting and funding for Business Development Workshops. The proposed format was found to be an excellent approach from the point of view of developing a sustainable New Space Economy ecosystem in the Kvarken region. According to the model, existing funding tools or opportunities are combined with a real business challenge and a group of relevant industry players is ideal to strengthen the development of a New Space Economy ecosystem. The model can also serve as a blueprint for the development of future ecosystem networking opportunities.

Many aspects and needs of the innovation ecosystem were collected with the help of industry feedback:

1. Recognizing the value of the company/organization in the innovation ecosystem and creating added value to develop one's own

operations. As observed in the ecosystem literature, the key question was also, how can the developing innovation ecosystem create value for participating companies and organizations?

2. What kind of activity will the innovation ecosystem have for participating companies and organizations. Ease of use of business incubator services, regular ecosystem member meetings, organizing/providing various events (such as hackathons, webinars, learning opportunities, online courses, training, and short courses on space technology, data, and business), provision of a common online platform or group to share information, facilitating establishment of consortia and project groups for EU space searches were identified as the main needs, as well as the creation of a center for start-up activities to connect the designs of the different sectors interested in the area.
3. Infrastructure, business incubator services, open access to information resources, availability of laboratories also for research and training activities, the creation of collaboration platforms for information exchange, the acquisition of data and equipment required for training activities, the utilization of infrastructure funding and the combination of industry/business know-how, products and services in the region are also needed to support innovations, as well as the current manufacturing possibilities for New Space Economy applications are of paramount importance for the development of a sustainable space economy ecosystem in the Kvarken region.
4. Those who participated in the workshop were asked what kind of expertise, skills, products, or services they would offer to the ecosystem either as individual offers or as part of the value chain. The following components were identified; participation in system design, knowledge, and training of the latest technology, information science for environmental and climate applications, climate solutions utilizing satellite data to measure, monitor, and reduce the carbon footprint of companies, applications of real-time satellite data packages, satellite data application related to climate change, GNSS-controlled automation, application and management of ESA projects, implementation of mapping services, access to international contacts, access to industrial and agricultural information and possible end users of applications, knowledge of battery chemistry and mobile networks and the provision of satellite testing facilities

(vibration and RF) and opportunities to organize joint events with ESA BIC Finland.

5. Based on the discussions and presentations, the Kvarken Space Center should act as an umbrella that connects actors through events and activities as a form of Finnish-Swedish cross-border cooperation. Cooperation opportunities were seen as joint EU funding efforts, project consortia, matchmaking, customer and partner search, offering start-up events and organizing company and group visits, as well as direct promotion across the region.

Several development initiatives were identified across ecosystem actors, structures, activities, and support. The development of the space economy ecosystem will require increasing the awareness and commitment of stakeholders related to the New Space Economy. The establishment and support of a continuous innovation pipeline, the initiation of new space projects, participation in, supporting and promoting the establishment of new project consortiums were seen as important. Supporting industry in the introduction of New Space Economy applications, providing business incubation and mentoring for start-up and spin-off companies, identifying business and funding opportunities, establishing and developing local/regional innovation infrastructure for joint efforts in the New Space innovation ecosystem were identified. Organizing special events on business opportunities, new technology and networking, developing and promoting education in key subject areas (e.g., remote sensing, PNT, satellite communication, and New Space Business), and disseminating information to stakeholders were also recognized as important aspects of development. In Table 1, the key findings are presented categorized by their main themes.

The New Space Center plays a pivotal role in the evolution of the space ecosystem, serving as a linchpin across various key areas outlined in Table 1. Within the realms of education and skills development, the Center spearheads innovative programs and partnerships that bridge the gap between theoretical knowledge and practical application in space sciences. By collaborating with academic institutions and industry leaders, the Center engages in various activities to equip ecosystem members with the necessary expertise and insights. Through the ecosystem members, the Center's contribution extends beyond networking to

**Table 1** Enhancing the New Space Economy: the role of the Kvarken Space Center in developing the space ecosystem

<i>Category</i>	<i>Key findings/insights</i>
Open development activities	<ul style="list-style-type: none"> <li>– Open development signifies collaboratively finding new ideas within innovation projects</li> <li>– The significance of establishing an innovation ecosystem for new space</li> <li>– Emphasis on fostering dialogue, meetings, and shared interests</li> </ul>
Industry interviews	<ul style="list-style-type: none"> <li>– Widespread interest in new technology and space-based data applications</li> <li>– Few companies currently integrate space-based data</li> <li>– Limited comprehension of data access and its potential uses</li> </ul>
Satellite remote sensing	<ul style="list-style-type: none"> <li>– The feasibility of satellite remote sensing for local applications remains uncertain</li> <li>– Publicly available data often lacks the necessary resolution</li> <li>– Notable value in remote geographical areas and activities requiring PNT data</li> </ul>
Business Development Workshop	<ul style="list-style-type: none"> <li>– Focus on enhancing traceability in waste management</li> <li>– Interest in applying space-based data to developing nations</li> <li>– Exploration of current ESA funding opportunities</li> </ul>
Ecosystem Workshop 2022	<ul style="list-style-type: none"> <li>– Space-based data often plays a role in a multifaceted value chain</li> <li>– The importance of education and expertise in space utilization in Finland</li> </ul>
Skill and competence development	<ul style="list-style-type: none"> <li>– The need for understanding and utilizing space-based satellite data</li> <li>– The importance of advancing machine learning and data science education</li> <li>– Emphasis on mastering AI algorithms and general business acumen</li> </ul>
Working model	<ul style="list-style-type: none"> <li>– A model that amalgamates relevant stakeholders to devise solutions</li> <li>– Merging funding mechanisms with tangible business challenges</li> </ul>

(continued)

**Table 1** (continued)

<i>Category</i>	<i>Key findings/insights</i>
Industry feedback	<ul style="list-style-type: none"> <li>– Recognizing a company’s value within the ecosystem</li> <li>– The necessity for infrastructure and business incubator services</li> <li>– The expertise, skills, and services offered to the ecosystem</li> </ul>
Kvarken Space Center role	<ul style="list-style-type: none"> <li>– Serving as a nexus that connects various stakeholders</li> <li>– Promoting Finnish-Swedish cross-border collaboration</li> </ul>
Development initiatives	<ul style="list-style-type: none"> <li>– The need to heighten awareness and stakeholder commitment</li> <li>– Advocacy for the New Space Economy</li> <li>– Organizing events centered on business opportunities and novel technology</li> </ul>

community engagement, fostering advancements in technology and business opportunities, thereby reinforcing its integral position within the space ecosystem’s fabric.

## 5 CONCLUSION AND FURTHER RESEARCH DIRECTIONS

Several significant empirical findings and implications for the development of a sustainable space innovation ecosystem in the Kvarken region have been identified and several key elements can be underscored. As discussed, coordination efforts to support early-stage ecosystem emergence and development are required, therefore the following should be considered:

1. **Continuous Innovation Pipeline:** Essential for generating new ideas and solutions, the establishment and nurturing of an innovation pipeline is a primary consideration.
2. **New Space Projects and Industry Support:** Crucial for applying theoretical concepts and realizing economic benefits, the introduction and industry support of New Space Economy applications is vital.

3. **Business Incubation and Mentoring:** Providing incubation and mentoring to start-ups and spin-offs is necessary to foster new business growth and entrepreneurial activities in the space economy.
4. **Identification of Business and Funding Opportunities:** This is vital for the financial sustainability of the space innovation ecosystem.
5. **Local/Regional Innovation Infrastructure:** Building and enhancing infrastructure is important for collaboration and resource sharing among different ecosystem actors.
6. **Event Organization:** Focusing events on business opportunities, new technology, and networking is important for knowledge sharing and value creation (e.g., Business Development Workshops).
7. **Stakeholder Awareness and Engagement:** Enhancing awareness, engagement, and commitment toward the New Space Economy is critical for fostering an innovation-supportive environment.

In addition to these elements, the collaborative Business Development Workshop model developed for encouraging involvement of relevant actors in solution creation, potential project piloting, and funding should be further explored. The model represents a practical approach to fostering collaboration and promoting collective efforts in the innovation ecosystem as seen in Fig. 2.

Some significant challenges were also uncovered around capabilities. There is a notable gap in the region regarding the necessary skills and educational opportunities for utilizing space data. Despite the presence of suitable capabilities across almost all areas of the space economy, these resources are not being optimally utilized. Furthermore, sustainable development regarding the new space innovation ecosystem has not been fully realized based on individual actors.

To address these challenges, the Kvarken Space Center has initiated several research, development, and innovation projects in collaboration with local universities and industry representatives. These projects aim to foster a sustainable New Space Economy ecosystem in the region. They have already enhanced awareness, understanding, and utilization of space-based information, leading to the creation of new innovations in the field.

In conclusion, the KvarkenSpaceEco project has established both an invaluable and robust foundation for the sustainable development and evolution of a space innovation ecosystem in the Kvarken region. The project's findings and initiatives serve as a strategic guide for future

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**Fig. 2** Innovation ecosystem potential overview in the Kvarken region in Finland. The Kvarken Space Center functions as the hub for local and regional activities and gives a single interface to Swedish and international collaboration

advancements in the New Space Economy, while also emphasizing the urgent need for further research. This is particularly salient in the context of early-stage ecosystems in the new space industry, an area currently characterized by a limited body of literature and empirical studies. The challenges and key elements identified by the project offer a fertile ground for future scholarly work in this underexplored domain. Moreover, the project’s collaborative model, along with the research, development, and innovation projects it has initiated, represent promising approaches to addressing these challenges. As there is currently limited research available on early-stage ecosystems and their establishment, this paper offers a single case perspective for future research efforts into uncovering rationale and mechanisms for early-stage ecosystem development, especially in the new space industry. Therefore, there is a prevailing need for further

studies that delve into the complexities and nuances of early-stage space innovation ecosystems, thereby fostering a more sustainable and robust space innovation ecosystem in the Kvarken region and beyond.

To promote the development of space technology and harness the commercial potential of the emerging space industry, the following policy recommendations are presented:

1. **Facilitating Regional Networking and Collaboration:** Foster and deepen networking among regional stakeholders in the space industry. Encourage collaboration and knowledge exchange among local space-related organizations, universities, and businesses. This recommendation is based on points 1, 2, 3, 4, 5, 6, and 7 in the Conclusions.
2. **Enhancing Public–Private Partnerships:** Foster collaboration between government bodies and private enterprises in the space sector. Encourage joint ventures and public funding in private space initiatives to accelerate technological advancements and commercial viability. This recommendation is based on points 1, 2, 3, 4, and 5 in the Conclusions.
3. **Supporting Education and Workforce Development:** Invest in educational programs and training facilities focused on space technology and research. Promote STEM education to build a skilled workforce equipped to meet the demands of the growing space industry. This recommendation is based on points 1, 2, and 4 in the Conclusions.
4. **Encouraging International Collaboration:** Promote cross-border cooperation, particularly with Sweden, to jointly participate in the New Space Economy, proceed with economic steps toward a new space product and service industry, and to meet the capacity requirements of infrastructure, education, and innovation in the field of commercialization and utilization of space. This recommendation is based on points 2, 4, 5, 6, and 7 in the Conclusions.

## APPENDIX

Thematic culmination points from the interviews:

<i>Interviewee</i>	<i>Theme</i>	<i>Related point to consider</i>	<i>Applicability to ecosystem elements</i>
Informant A: ICT Manager	Smart transport and data integration	Exploring IoT and location data for fleet management and asset tracking	1, 5
Informant B: Business Development Director	Integration of business in development projects	Need for engineers with natural sciences background and business understanding	2, 3
Informant C: Leading Specialist	Digital solutions for data management	Increasing importance of data science and GIS in product and service offerings	1, 2, 4
Informant D: CEO	Collaboration in the ecosystem	Learning about new data opportunities and integrating them into workflows	2, 6, 7
Informant E: Program Manager	The need for multi-talented individuals in future skills	Understanding the interplay between systems and the concept of time	1, 2, 7
Informant F: Area Manager	Solving customer challenges with technology	N/A	2, 3
Informant G: CEO	Interest in measuring technology and analytics in space	Potential in hardware and analytics for upstream and satellites	1, 2, 4
Informant H: Energy and Maritime Director	Material management and seafare optimization	Utilizing container tracking and positioning, voyage optimization challenges	2, 5
Informant I: Program Manager, Energy Distribution	Network monitoring and maritime data utilization	Time synchronization, utilization of wireless and satellite for backup, navigation, and vessel use optimization	1, 4

(continued)

(continued)

<i>Interviewee</i>	<i>Theme</i>	<i>Related point to consider</i>	<i>Applicability to ecosystem elements</i>
Informant J: Vice President	Data analytics and ecosystem engagement	Advise on active ecosystem establishment and engagement with companies and students	2, 6, 7
Informant K: Research and Development	Real-time information and infrastructure understanding	Application of satellite imagery in infrastructure and maintenance	2, 4
Informant L: ICT Director	Usability of open-source remote sensing data	Challenges in spatial resolution and data frequency	1, 5
Informant M: Project Manager	Utilization of GIS data and software	Contribution of development activities to commercial products	2, 4
Informant N: Vice President	Introduction to space-based data	Interest in ecosystem providing relevant application information	2, 7
Informant O: CCO	Openness to ecosystem cooperation	Interest in more available information and collaborative activities	1, 2, 7
Informant P: Associate Professor	Importance of start-ups and new ideas	Need for critical mass and collaboration among various stakeholders	1, 3, 4, 7
Informant Q: CEO	Facilitating concrete ecosystem activities	Strategies for creating sustainable business flows within the ecosystem	3, 4, 5
Informant R: Lecturer and Researcher	Trends, capabilities, and collaborative projects	Understanding technology trends, mapping capabilities, and analyzing opportunities for collaboration	1, 3, 5
Informant S: CEO	High-resolution imagery and skill development	Need for high-resolution data, machine learning, and data science skills	3, 4, 5

(continued)

(continued)

<i>Interviewee</i>	<i>Theme</i>	<i>Related point to consider</i>	<i>Applicability to ecosystem elements</i>
Informant T: Project Controller	Utilization of space-based data and blockchain	Systems development utilizing space-based data, drone inspections, and interest in hackathons	1, 6

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