

IAC-19, E6,1,4

A Swedish Perspective on Innovation and Growth for Space

Johanna Bergström-Roos^{*ad}, Jonas Ekman^a, Marta-Lena Antti^b, Anna Öhrwall Rönnbäck^c, Olle Norberg^a

^a Department of Computer Science, Electrical and Space Engineering, Luleå University of Technology, Space Campus, 98192 Kiruna, Sweden

^b Department of Engineering Sciences and Mathematics, Luleå University of Technology, 97187 Luleå, Sweden.

^c Department of Business Administration, Technology and Social Sciences, Luleå University of Technology, 97187 Luleå, Sweden.

^d LTU Business, Space Campus, 98192 Kiruna, Sweden

* Corresponding Author johanna.b.roos@ltubusiness.se

Abstract

Luleå University of Technology (LTU), located in the leading space region of Sweden has since 2014 been conducting a regional space programme for innovation and growth. This programme consists of two consecutive EU-funded regional projects, with several co-funding partners. The foundation of the programme is based on a realization that the full potential for research and business opportunities involving a space base (Esrange Space Centre) seemed far from utilized, especially for small and medium-sized enterprises (SMEs). Therefore, the University stepped in to take a leading role in encouraging regional space industry innovation and growth, through the already strong position of the university within space technology research and education. With reinforced investment in research and education, the goal was to further strengthen its position as the leading space technology university in Sweden, as well as its role as an important catalyst for regional growth within the space sector.

The co-funding project partners ¹ are a research institute, major Swedish space industry companies, innovation support actors, regional investors and financiers, such as the municipalities of Kiruna and Luleå, the County of Norrbotten, and a regional bank. The programme is conducted by LTU in collaboration with these partners, led by the university's business development company, LTU Business.

The objective of the space innovation and growth programme is to strengthen the regional space ecosystem by encouraging collaboration between industry, academia, regional SME's and actors within the innovation support system. In addition, to create a strong innovation system for growth in the space industry based on collaboration, research, test-driven development and clustering.

The purpose of this paper is (1) to report mid-term results, and (2) to encourage external collaboration with the regional space programme. Four years after the initiation, there are now mechanisms in place to stimulate not only collaboration between the project partners, but also additional activities that are the result of the activities of the first three years in the programme.

Keywords: (maximum 6 keywords)

Innovation, New Space economy, Regional growth, Academia, Space industry and SME.

¹ LTU, LTU Business, ABI, IRF, SSC, OHB Sweden, GKN Aerospace, Kiruna and Luleå municipality, Region Norrbotten and Sparbanken Nord (a regional bank).

1. Background

The objectives of the regional space programme (also referred to as the programme) with its two RIT² projects emerged through an EU project³ that was carried out in 2014, referred to as *the initiating project*. The first RIT project is referred to as *the first phase* (2015-2018) of the programme [1]. RIT 2021 is the further development of the first phase and referred to as *the second phase* (2018-2021) of the programme [2].

During the initiating project in 2014, several joint meetings were conducted by actors within Space Kiruna [3], the local space council in Kiruna, consisting of actors involved in space activities or related to it. The purpose of these meetings was to establish a common roadmap and to increase the attractiveness and competitiveness of Kiruna as a space city on the global arena. Several actors within the regional innovation system also participated in the meetings with the ambition to include the whole region, when possible.

Space activities in the region started in the late 1950s when Dr Bengt Hultqvist was sent to establish a scientific institute in Kiruna, today known as the Institute of Space Physics (IRF) with world-leading research in space physics. Esrange Space Centre was established in 1966, initially in order to launch sounding rockets for science, and has today developed into a strategic asset for the European space community with a broad range of services, such as sounding-rocket and balloon-launch facilities, a huge ground station for satellite operations and a wide range of ground-based instruments with data series since the mid-1960s. EISCAT (the European Incoherent Scatter Facility) was established in 1975 and the university space education programmes started in the 1990s, with space-related courses and programmes up to PhD level and two research groups in atmospheric science and onboard space systems. The activities developed and the number of space actors⁴ in the region increased during the following decades and are today firmly established on the global space arena. By 2014, the space activities were widely successful in both industry and academia, excelling in areas spanning from natural sciences to advanced technology development. Collaboration between the actors were often based on a classic contractor/client set-up, but few collaborations had been carried out as joint R&D projects. Prior to the regional space programme (i.e. before 2015), a local strategy for space had been established in Kiruna for decades, but a regional plan for the space industry were non-existent. Efforts were lacking to strengthen the

regional innovation system and to integrate it into the ongoing international space collaborations in the region. The actors within the space sector needed to increase their capability to collaborate in research and development between academia, industry and the innovation support system.

Results from the initiating project indicated that despite ongoing space activities, the collaboration between the space sector, regional SMEs and actors from other business areas was weak. The regional innovation climate for space-related activities was also deemed to be inadequate, but that there was a great deal of interest in increasing the level of collaboration in the local business community.

In a global economy with increased competition, innovative development is expected to lead to increased sustainable growth, with new products and services, more viable companies and more job opportunities. In the EU funded programmes for regional growth, the goal is to support such activities for Europe as a whole, broken down to countries, and regions, such as Sweden, and the northernmost region of Sweden. SMEs in particular are expected to provide the largest number of new jobs in the European economy, something that has already been observed during the last 15 years. Therefore, the business climate for SMEs is paid special attention. There is potential within the space industry to broaden regional entrepreneurship and connect it to existing space activities, as well as to national and international partners and customers. The fact that this had not already been done to a greater extent at the time (according to the report from the initiating project, 2014), despite space-related activities being conducted in the region since the 1950s, indicated that something was missing. For this reason, LTU decided to broaden its role within the space sector by reinforcing its education and research initiatives, including a closer collaboration with the business sector.

Kiruna is known as “Sweden's Space City” where Esrange Space Centre (operated by SSC), the Institute of Space Physics, EISCAT (an international cooperation between research groups and research councils), and LTU are the largest actors. Despite world-leading activities, there are relatively few other established space actors in the northernmost region of Sweden, where it should be natural to have more local and regional companies, e.g. suppliers to Esrange. This lack is linked to several facts, e.g.; (1) historically a relatively small number of R&D projects conducted in the region and/or

² RIT is an abbreviation of space for innovation and growth in Swedish.

³ The initiating project “Innovation in a space and mining town” (2014).

⁴ <http://spacekiruna.com/om-oss/> (all actors, in Swedish)

in collaboration between the different space actors, (2) the habit of doing everything in-house or together with ESA members due to the regulation of industrial return, (3) an industrial culture that has not stimulated innovative efforts in the region (company head-quarters located further south), and (4) an inadequate business and innovation climate related to space in the region, just to mention a few.

- Innovation and incubator for the space industry in Kiruna [7]
- Kiruna - Closer to Space, a study on market development [8]

According to the leader of the initiating project (Kiruna Space), no earlier measures had been taken within the space sector to strengthen the region's capacity for collaboration within research and innovation between academia, industry and actors within the innovation support system. Attempts had been made to build networks or perform inventory of different abilities in the region, but not with enough force and focus to create any lasting results in respect to innovations or support systems. Other types of measures had indeed been taken within the space industry in later years (2005-2013), such as an EU project to stimulate the development of space tourism and commercial space travel (Spaceport Sweden). However, this initiative was not directly linked to the already established space industry and is for the moment on hold while awaiting the availability of manned space tourism.

No other similar national projects have been encountered during the preliminary study phase. However, there were several interesting activities worth looking at regarding monitoring, exchange of information and, in some cases, collaboration, such as the Enterprise Europe Network⁶, LTU's Graduate School of Space Technology as well as the incubator ESA-BIC⁷. The Swedish space industry was, and still is, not large from a global perspective, so the RIT project was also counting on inviting both regional and national actors to participate and enrich the upcoming RIT project in various ways. The regional space programme was also planned to be open for collaboration with other interested parties that would emerge over the course of the programme activities.

2. The space business environment

The expansion of the space business in Kiruna has been successful throughout the years. Space Kiruna, the local space council in Kiruna, has pinpointed seven development areas⁸ for the future. The RIT projects can address all of them by conducting applied research, technological development and innovation focusing on Triple Helix collaboration between the business, public and academic sectors.



Figure 1. Spin-offs in the space business in Sweden before the two RIT projects (2014)⁵

Another reason is the limited number of residents with suitable expertise in Kiruna (approximately 23.000 inhabitants) as well as in the scarcely populated region (approximately 250.000 inhabitants), which may both explain and be a circumstance that could make innovation efforts less prosperous. One important key to success is collaboration focusing on cross-pollination through knowledge and technology dissemination between different parties as well as increased expertise to strengthen the attractiveness and competitiveness of the region.

The situation analysis that was conducted in 2014, prior to the RIT projects, gathered information to harmonise the aim of the upcoming projects with the development strategy of Space Kiruna, the regional development and innovation strategies [4] on a general level (not specifically space), the national innovation strategy and the EU innovation programme Europa 2020. In addition to the initiating project, four studies were conducted:

- An inventory of Swedish space research, space education and space industry and how they cooperate [5]
- Synergies through collaboration between the Esrange Space Centre and Space Campus [6]

⁵ This figure was published by the Swedish National Space Agency and only consists of the 30 largest SMEs in Sweden at the time.

⁶ EEN, an EU project with the aim of assisting SMEs with internationalisation

⁷ The Swedish ESA-BIC was not established until November 2015.

⁸ 1. Research & Education, 2. Innovation & Entrepreneurship, 3. Science & Infrastructure,

4. Satellite communication & control, 5. Space & Aerospace vehicles, 6. Launch of Rockets, Balloons & Satellites, 7. Space Adventures/Experiences & Commercial Spaceflights

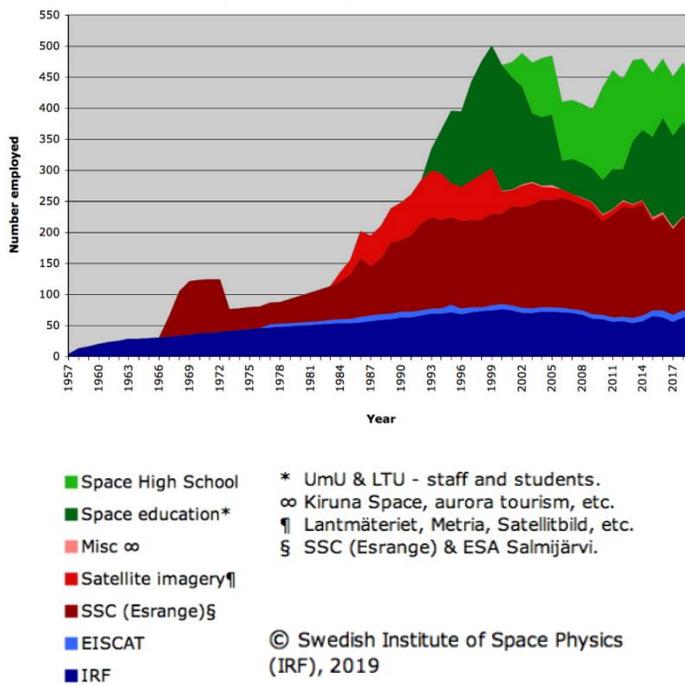


Figure 2. The development of the space business within Space Kiruna 1957-2019.

The region has few SMEs in the space industry and there is no natural connection between existing SMEs and the space industry. Furthermore, the understanding of the needs in the space industry is not always clear to the SMEs. However, there is an interest in changing this and a desire among the established space companies to help SMEs enter the space industry. Important is that the larger companies contribute to the development of the smaller, and that the latter can grow on a global market, where the competitors of the larger companies might be present.

The space industry in the region consists of only one larger space company, SSC, which therefore has a prominent role in the regional space programme, as a major part in both RIT projects. SSC has representatives in several working groups and became the first member of the Centre of Excellence in Space Technology within LTU. SSC participates through activities such as master thesis projects with graduate students, PhD students and postdocs, as well as activities to reinforce the innovation support system.

Two larger space companies outside the region are involved in the RIT projects; GKN Aerospace and OHB Sweden. All in all, there will be a total of twelve PhD students and five postdocs employed by LTU. They are expected to contribute to the development of space

expertise in the region, creating natural links between the university and the larger companies, and to reinforcing the critical mass of space operators in the programme. The companies outside the region participate in the project in similar ways to SSC. GKN has a history (under the name Volvo Aero Corporation) of collaborating with LTU both in aeronautics and astronautics since the early 1990s. OHB was formerly a part of SSC.

The PhD students focus on knowledge and technology development based on challenges within the space industry. This is expected to reinforce the region's competence within areas that may enrich more companies, not least regional SMEs. There is also a plan to share this knowledge with other industries. Three of the PhD projects relate to new manufacturing methods for space components and could be applied in other industries. The fourth PhD project deals with assuring the region's excellence in terms of qualified balloon launch services. The remaining three PhD projects are all related to the increased market demand for small satellites. Still, we have four additional PhD students to engage in the project and five postdocs. The technical challenges that will be in focus here are still to be decided.

3. A brief description of RIT and RIT 2021

The projects described below are two regional projects funded by the EU. They were initiated by LTU in order to strengthen the space sector in the northernmost region in Sweden. The first project, RIT, was carried out 2015 - 2018. The second project, RIT 2021, is ongoing 2018-2021. The projects are planned and performed one after the other, towards the same long-term goal in the overall regional space programme.

The overall long-term goal for the programme is to contribute to the region enhancing its role as Sweden's leading space region, offering a productive and attractive innovation environment. An environment creating sustainable growth that attracts people, investments and companies to the region. The project-specific objective was initially to increase the capacity in research and innovation by collaboration between academia, the industry and actors within the innovation support system. Later, in phase two, the focus moved towards establishing the achieved results performed in the first phase based on collaboration, research, test-driven development and clustering.

Altogether, there are five Work Packages (WP) within the projects:

- WP 1: to establish a Centre of Excellence in Space Technology at LTU in Kiruna.
- WP 2: to carry out collaborative PhD and postdoc projects between the space industry and the academic sector.
- WP 3: to initiate, establish and further develop an innovation support system relating to the space industry, in order to utilise new knowledge, such as technological developments from WP 2.
- WP 4: to plan, prospect and realise a testbed for testing and qualification of components and systems intended for space deployment.
- WP 5: to establish a cluster for SMEs within the aerospace business in order to increase the number of regional suppliers.

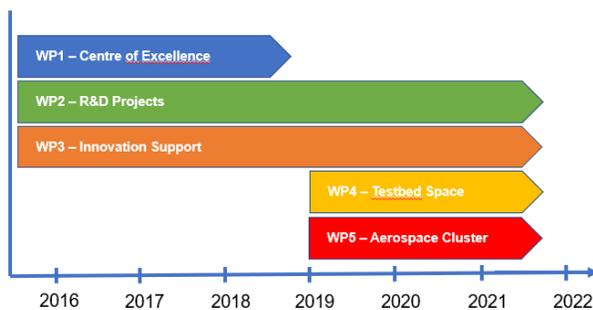


Figure 3. An illustration of the duration of the five work packages within the two RIT projects.

4. Organisation and implementation

4.1 Project organisation

LTU is the programme owner, who initiated the two RIT projects together with LTU Business, a subsidiary to the university supporting commercialization of research results (amongst others). In the second phase of the programme, two more actors entered as so-called core partners⁹, the Institute of Space Physics (IRF) and the Arctic Business Incubator (ABI), also in charge of ESA-BIC Sweden, the Swedish space incubator connected to the ESA incubator programme.

The two RIT projects are managed by the corresponding author of this paper, who has a project group consisting of the WP leaders and a steering group including the core partners. In the first phase of the programme, there were three WPs, of which two had separate working groups

and/or steering groups. In the second phase, there are four WPs, of which two have separate working groups and/or steering groups.

All three space companies (*SSC, GKN Aerospace and OHB Sweden*) are so-called partners¹⁰ and they are strongly linked to the WP that is focusing on R&D collaboration between industry and academia (WP1). There have been eight PhD students involved since the start, all working with technical challenges within the Swedish space industry. Four new PhDs and five postdocs are planned to be employed within the coming year (2020). There are five prime financiers¹¹ and they are not involved in the activities besides the steering group of the project.

4.2 Working method Project organisation

The two RIT projects are collaborative projects with many partners, which requires coordination between the various participants to be able to benefit from one another.

The joint meetings within the regional space programme are called *Space Innovation Forum* and gather the partners to clarify the progress of the activities as well as identify the expertise and skill requirements of each actor. These meetings contribute to the utilisation of the project results and to match the participants for additional collaboration.

The project management and the steering group work proactively in close dialogue with the project manager (PM). Reports on the progress are delivered to TVV¹² and the steering group three times a year. The PM is responsible for ensuring that the project adheres to the funding decision as well as the laws and regulations that apply to an EU funded project. The PM shall also continuously ensure that the goals are being met, that plans regarding who is to utilise the results of the project are followed, that the results are disseminated and established internally and externally, and the PM shall continuously monitor and actively participate in and learn from the external evaluation conducted in regard to the project.

The external communication is led by the PM along with a communications officer. The WP leaders, the core partners and the partners participate in this work within the steering group, the project working group and/or within the WPs working groups. The WP leaders have an individual responsibility to spread information about the

⁹ Core partner are those leading the project and they administrate their own part of the budget.

¹⁰ Partners do not have their own budget linked to the project.

¹¹ TVV, the County of Norrbotten, the Municipalities of Kiruna and Luleå and Sparbanken Nord.

¹² TVV is the authority that manages EU projects in Sweden

results within each WP, both internally and externally, and this process naturally involves the core partners, as they are part of the various working groups involved in the WPs. The biannual Space Innovation Forum always begins with a situation report regarding the progress. The project's external evaluators¹³ actively participate in these meetings in order to evaluate planning, implementation and results. After each meeting, an internal learning process is completed with relevant partners. The operational organisation is led by the PM and revolves around the WPs, in order to ensure that they get the resources they need. The WPs are linked by a joint working group for the project, the PM group, which is led by the PM. This group meets twice a month to work on internal adjustment and follow-up of the activities in the different WPs. Continuous follow-up, evaluation and internal learning is ensured through current evaluation that was activated already at the start of the programme.

4.3 Target groups

There are three primary target groups:

- The business community in existing space companies.
- SMEs in other industries that do not deliver to the space industry today but who could and would like to do so.
- Academia that aims to build excellence in specific areas that are needed in the space industry.

The space companies that have chosen to participate in the project with PhD students have an interest in cooperating with academia and gaining access to skills that they themselves lack. The PhD students will focus on areas where the industry itself is very successful or has come a long way in its development work, but where they find it difficult to move further. The competence they seek is not available on the market and carrying out the research themselves is usually too expensive. A collaborative project with the university is therefore a good solution, both for larger companies and even better for the smaller ones. The collaborative project should strive to maximize the leverage that the presence of larger space companies can provide in the ecosystem. It should also stimulate SMEs who are not connected to the space industry today but who could be involved in the project to broaden their market. At present, they are often interested in this, but need help to find their way into the space industry. Both collaborative projects and meeting places can create valuable contacts that in turn lead to a natural access to the space industry. SMEs can also in many cases benefit from cooperating with academia. Traditionally, this is not very well-developed in the northernmost region in Sweden and does not occur to any significant extent.

¹³ Oxford Research is the external evaluator
<https://oxfordresearch.se/en/>

Here, as in many other cases, it is often about finding the right paths, in this case into the university.

Secondary target groups:

Kiruna Municipality, the northernmost region in Sweden and the space industry of Sweden and Europe are examples of secondary target groups.

5. Goals and Activities

The overall goal of the regional space programme and its two RIT projects is to contribute to strengthening the northernmost region in Sweden as Sweden's leading space region and offer a productive and attractive innovation environment. Long-term sustainable growth is created, which attracts people, investments and companies to the region.

The short-term goal of the first phase of the programme was to increase the regional ability in research and innovation collaboration between academia, industry and actors within the innovation support system. The short-term goal of the second phase is to establish and further develop a strong innovation system for growth in the regional space sector based on collaboration, research, test-driven development and clustering.

Altogether, there are five WPs within the RIT projects, each of them representing intermediate goals. These are presented below, together with corresponding activities.

5.1 WPI: Establish a Centre of Excellence in Space Technology at Space Campus in Kiruna.

This WP was led by LTU and the goal was reached within the first phase and therefore ended in 2018. It was about establishing a collaborative platform for academia, industry and the innovation support system. Interaction between academic expertise and industry needs create synergies, and in the Centre, larger companies and SMEs form clusters with academia and participate in relevant development projects. As these projects are conducted on an early TRL-level¹⁴, open innovation can disseminate knowledge to more parties without creating competition between the companies. The ambition is to continuously conduct pilot projects to create a flow of new knowledge, which can be developed into innovations in the next step. The Centre is a meeting place where technology transfer and skills flow freely between young talents and more senior ones; where technology is at the Centre and new ideas and collaboration formats are born. This also creates a flow of ideas with other industries. A special focus is placed on including SMEs that have not previously been suppliers to the space industry.

¹⁴ TRL – Technical Readiness Level (1-9)

Some activities performed:

- Knowledge gathering through situation analyses of the needs within the space industry and the competence within the regional SMEs.
- PR and strategic information efforts.
- Ensuring a learning process and implementation of the results.
- Maintaining and developing networks between the business, academic and public sectors.
- Increase the dissemination of knowledge within/to the business and public sectors.
- Transferring results and knowledge between academia and industry.
- Networking with external parties.
- Collaborating with interdisciplinary research.

5.2 WP2: Carry out R&D projects in collaboration between industry and academia.

This WP is led by LTU and the goal in the first phase was to enrol eight PhD students led by supervisors from LTU and co-supervisors from the industry. For the second phase, a supplement of four new PhDs and five postdocs are planned to be enrolled. The work is based on the companies' needs and is expected to yield new processes, methods, instruments, software, design or databases of information etc. that can be suitable for commercialisation or for other research projects. Sometimes, these results can be difficult to identify, and a continuous result inventory is therefore needed within the projects so that knowledge can be identified, developed and commercialised, or be of public benefit otherwise. Specialists within WP3 (see section 5.3) constitute important resources in this context.

Some activities:

- Knowledge gathering through situation analyses of relevant technologies and gathering of relevant references for the work.
- Testing activities.
- Experimental evaluation.
- Validation work.
- Systematic documentation.
- Result inventory.

The eight initial PhD projects within the first phase were as follows:

1. SMARTi – Links between an additive metal deposition process and the mechanical properties of Ti-6Al-4V

Participants: LTU Division of Materials Science and GKN Aerospace Engine Systems.

2 and 3. Facilitation of innovation within space manufacturing

Participants: LTU Division of Product Innovation and GKN Aerospace Engine Systems.

4. New measuring method for balloon-borne stratospheric wind profiling

Participants: LTU Division of Space Technology and Swedish Space Corporation (SSC).

5. Formation flying in space – on-board systems to calculate trajectories etc.

Participants: LTU Division of Space Technology and OHB Sweden.

6. Development of high-performance avionics for the satellites of the future

Participants: LTU Division of Space Technology and initially AAC Microtec (half the project).

7. Software-defined radio for ground-based satellite communication

Participants: LTU Division of Space Technology and SSC.

8. MicroPILS – Micro Propulsion In the Loop Simulations

Participants: LTU Division of Space Technology and initially NanoSpace (half the project).

These projects are part of RIT 2021 as well, where they are about to finish, and most of the new PhD students and postdocs for the second phase are not yet selected. One first PhD-student has been enrolled in a project regarding additive manufacturing method selective laser melting (SLM) in industrial space applications. The new PhD students and postdocs will also be working on challenges within the Swedish space industry.

5.3 WP3: Initiate an innovation support system around the space industry

Initially this WP was led by LTU Business and a working group consisting of actors within the existing local/regional innovation support systems connected to all kinds of businesses. At the time, no specific activities connected to the space industry were in place, so the work with adjustments for space business started from scratch. One of the first goals was to get ESA-BIC Sweden¹⁵ in place and to identify actors within the regional support system that were relevant for the space business. In the second phase, the number of actors within the WP has decreased to two, LTU Business and ESA-BIC Sweden, who collaborate with other partners when required. The work is focused on establishing and further developing the innovation support system that was initiated in the first phase and tailor it for space business as well as identifying and involving the already existing regional, national and international ecosystems.

¹⁵ ESA BIC Sweden, the Swedish incubator for space related start-ups, which was inaugurated in November 2015.

Some activities in the first phase:

- Develop cooperation within the existing local, regional, national and European ecosystems.
- Create innovative venues for stakeholders in the space sector.
- Develop methods and processes for innovation and commercialization.
- Conduct inventory of results.
- Capture potential business ideas.
- Verify and develop potential business ideas.

Some activities in the second phase:

- Develop a methodology for further processing of business ideas from the PhD student projects (a commercialization programme).
- Implement the *Commercialization programme step 1* with the PhD student projects.
- Implement the *Commercialization Step 2* programme for four of the most promising innovations.
- Develop a methodology and processes for identifying and developing business ideas within up- and downstream, for example linked to satellite data.
- Conduct five events to stimulate the development of business ideas in the space industry.
- Develop an innovation management methodology for SMEs who want to enter the space industry.
- Implement two development programmes for SMEs who want to enter the space industry.
- Implement three summer student programmes at LTU (2019-2021) where at least three SMEs with connections to the space industry co-operate as outsourcers.
- Package and market a cohesive offer of innovation support, incubation and business development for the industry.
- Establish business advisory tools and methods, as a complement to the corporate financing available through ESA-BIC, for innovative startups in the space industry.
- Increase competence around business models linked to new up and downstream services and products from business developers and share with SMEs and startups.
- Increase the ability to attract capital to invest in the innovation phase through various activities such as; match investors with innovations, share information with different stakeholders and support them in evaluation and support for innovation etc.

5.4 WP4: Establish a commercial Testbed for Space

This WP was implemented in the second phase in order to commercialise the test infrastructure that has been built up while designing and constructing scientific

instruments for space missions over the years. The WP is led by LTU in collaboration with the Institute of Space Physics (IRF).

The *Testbed for Space* is planned to be available for education, research and development throughout the whole TRL scale and to be an arena for test-driven development for the region's SME. The testbed serves as a catalyst for new services and products and offers an arena for collaboration, where researchers, students and regional SMEs are involved.

Some activities planned:

- Planning: A sustainable business model prepared for how the main players' aggregate infrastructure can be offered to external stakeholders (inventory, agreements, packaging of Testbed Space 1.0).
- Project planning: Investment plan compiled for complementary infrastructure (roadmap).
- Realisation: Marketing of Testbed Space 1.0.
- Identify and develop new services and products that can generate business for regional companies or start-ups connecting to Testbed Space.
- Initiate the Testbed with a business plan and preliminary planning
- Workshop with stakeholders to identify common needs and goals.

5.5 WP5: Initiating an SME cluster for aerospace companies

During the first phase, the ambition was to involve SMEs in the different collaborative R&D projects between industry and academia as much as possible. It turned out to be more difficult than anticipated to reach this goal. Therefore, this WP was implemented in the second phase. The cluster will work on strengthening the ecosystem and invite SMEs/suppliers that are interested in entering the space business.

Some activities planned:

- Develop the initial version of the northern node of Aerospace Cluster Sweden (ACS).
- Arrange meeting places between large/small companies, industries/areas of expertise as well as networking, matchmaking, seminars, workshops, exposures etc.
- Outreach activities and visits to regional SMEs.
- Matchmaking between the SMEs and the established space companies.
- Participation in the S3¹⁶ pilot for clusters.
- Develop a database for the members of the cluster.

¹⁶ S3 – a national project to strengthen the strategic capabilities within a cluster and thereby to strengthen the companies' competitiveness.

6. Results from RIT and RIT 2021 so far

The overall goal of the regional space programme and its two RIT projects is of a diffuse character and does not have a specific and measurable ending point. Contributing to the enforcement of the northernmost region in Sweden as Sweden's leading space region is a never-ending project. Nevertheless, the activities performed so far are already showing results. In addition, the region offers a more structured, productive and attractive innovation environment where long-term sustainable growth is created. In short, an interesting region that attracts people, investments and companies. The goal of the first phase¹⁷ has been well achieved. The goal of the second phase¹⁸ cannot yet be defined since only one third of the project has been completed to date.

6.1 Results within WP1; to establish a Centre of Excellence in Space

WP 1 had three milestones. The first, *to establish an attractive test and development platform for academia, industry and the innovation support system*, is achieved. The Centre of Excellence in Space is taking shape and the project partners are interested in long-term collaboration. In addition, the WP has broadened the content to include a wider circle of activities within LTU to include space-related subjects besides onboard space systems and atmospheric science. This has increased the interest of external actors to get involved.

The second milestone within WP1, *the regional actors have started to collaborate in a more structured and result-orientated way*, is achieved. Regular meetings between the different actors are in place in order to inform each other on a regular basis as well as to include each other as extra resources when needed. An established working method for inquiries from SSC for personnel supply from the university and matching of regional suppliers for various tasks is in place. This information is shared with the entire Swedish space community via the Centre of Excellence and Aerospace Cluster Sweden when needed. Several workshops with participants from both SME and major space industries have been carried out, with the aim of finding common denominators for future collaboration. IRF has requested contacts from the Centre to find suppliers in the region and several companies have sought opportunities for cooperation. Several SMEs have also begun to cooperate with both industry and academia.

¹⁷ The goal in the first phase was to increase the regional ability in research and innovation collaboration between the academia, the business sector and actors within the innovation support system)

The third milestone within WP1, *collaboration between different actors creates synergies that strengthen the attractiveness of the region and its ability to grow*, is achieved. The RIT project and the Centre of Excellence are now well-established partners that the industry counts on when they need help with matchmaking. Space Innovation Forum has proven to be highly appreciated for networking and at least one new company and several joint projects or business ideas have been initiated during these events. The collaboration with the national cluster Aerospace Cluster Sweden is formally established and the inauguration of a northern node was carried out on May 2018. Contacts have subsequently been made with the two southern nodes, with focus on finding subcontractors in our region. New partners, suppliers and customers have found each other and started to create a common value.

6.2 Results within WP2; to implement knowledge-building and joint development projects between the space industry and academia

WP 2 had three milestones in the first phase. The first one, *the actors in the space sector have increased their expertise in research and innovation collaboration between academia, industry and actors in the innovation support system*, is achieved. Through close collaboration with PhD students, the space industry has increased their expertise in collaboration with academia, and vice versa. During the Space Innovations Forum, ideas for new in-depth collaborations have arisen. Through the PhD student projects, the companies have taken part in the innovation support system that has been developed during the project and PhD students have also collaborated with each other so that the companies have greater access to a broader competence. Business representatives have often been co-authors in scientific publications and thereby knowledge transfer has taken place naturally. The companies have also had access to the PhD students' broadened network with other researchers at LTU and other universities. Some of the PhD students have spent several months at foreign universities. Through this, the companies have received additional research results that are relevant to their own area.

The second milestone within WP2, *several new PhD students linked to solve challenges within the space industry creates a strategic increase in competence in space business*, is achieved. The goal is well-fulfilled, except for one PhD student who chose to end his employment already after two years. The companies are

¹⁸ The goal in the second phase was to establish and further develop a strong ecosystem for growth in the regional space sector based on collaboration, research, test driven development and clustering.

very satisfied with their respective PhD students and in some cases they have started talking about employment as soon as the student has graduated. This is very promising and will give long-term effects for the companies and their business.

The third milestone within WP 2, *at least eight new products/services have been identified for further development towards commercialization*, is achieved. Some examples are; an analysis method for studying texture in microstructure through the use of neutron radiation, a new method for qualifying additive manufacturing of components for rocket engines, a new way to get nanosatellites to communicate with each other during formation flying, an innovative way of measuring wind speeds at different heights during balloon flights as well as an improvement of the onboard computers when launching satellites.

6.3 Results within WP3; Initiating an innovation support system around the space sector.

WP 3 had three milestones in the first phase. The first one, *to secure financing for verification of new business ideas and incorporate an IP process in the innovation system*, is achieved. Regarding the IP rights, the foundation has been laid within the project agreement signed for the PhD students between participating companies and LTU. Clearly, this goal is dependent on factors that are beyond the scope of the project as there is a special legislation in the Swedish higher educational institutions that gives teachers, researchers and students at the universities the right to own the IP that their work creates.

When it comes to access to verification means, the goal is more than well met. There are now at least three different funding for verification available for space related ideas. The type of support varies partly with the origin of the idea and its maturity. For ideas that do not have a link to the university, verification means are available at very early stages through a regional offer given by LTU Business in collaboration with ALMI¹⁹. These funds amount to a maximum of 50,000 Euro per idea. For ideas in the very early stages originating from LTU, there is the possibility, again via LTU Business, to utilize support available in two steps. The first step is a maximum of 30,000 Euro per idea, while the second step can provide an additional up to 40,000 Euro. For ideas, irrespective of origin, which have come further and are being handled in limited liability companies, there is the possibility of taking part in an offer at ESA-BIC Sweden with up to 50,000 Euro per company.

¹⁹ ALMI is a Swedish state-owned company founded in 1994 with the task of creating growth and renewal in the business sector through financing in combination with coaching. The

The second milestone within WP3, *the innovation support system is an integrated part within the Centre of Excellence*, is achieved. As the leaders of WP1 (the Centre of Excellence) and WP3 (the innovation support system) have both been part of the project management team, the integration has been smoothly developed and consolidated during the programme. The Centre's stated ambition is to make use of the established innovation support actors and the tools and processes that they possess. Building something new for the Centre was never an option. Both representatives from the space industry and researchers/students at the university have been trained in the innovation system's basic tools, which means that the innovation support system was gradually integrated even before the Centre's formal start.

The third milestone within WP3, *several creative meeting points have been initiated in order to stimulate opportunities for collaboration between academia, industry and the innovation support system*, is achieved. Several meeting points have been arranged where two events have been established; Space Innovation Forum (SIF) and *Lift Off*. Nine completed SIF events have been carried out and were all well-attended and appreciated by the different target groups. Throughout the SIF events, there has been a mixture of information, inspiration, matchmaking and innovation-oriented workshops. The other established event called *Lift Off* is a labour market fair that the students at LTU have developed in order to annually gather the space industry and match them with students for suitable degree projects, summer employment, master theses and finally employment after graduation. The event has been carried out three times so far and the plan is to continue annually in October.

6.4 Results within WP4 (the Testbed) and WP5 (the Cluster)

These two WPs were implemented in the second phase (January 2019) and need more time before any results are clear.

In short, so far, the testbed WP has first done a thorough inventory of the currently available test equipment in Kiruna. In order to examine the potential for complementary infrastructure, the WP then surveyed the need in Europe for test, verification and validation of space equipment and components. This will now lead to a prioritized investment plan. The WP has also examined the legal and commercial implications involved in setting up the testbed.

Furthermore, regarding the establishment of a northern node of the Aerospace Cluster Sweden, the initiation is

goal is more successfully commercialised innovative ideas, more viable companies to be started/developed, and more companies to increase their competitiveness and growth.

under way. A first inventory of suitable regional suppliers has been performed with a reasonable number of SMEs identified. A series of local workshops together with interested SMEs has been launched during 2019 where information of the possibilities to become a supplier is presented and discussed. A dedicated training course for SMEs to approach the space industry is taking shape and will be executed during 2020.



Figure 4. Eight new space-related companies have established in the region since the start of the RIT projects and some 15 regional SMEs interested to enter the space industry are identified.

6.5 Additional bonus results

In addition to all the anticipated goals there are several additional bonus results occurring in the wake of the regional space programme. Some of them are presented below:

- LTU has strengthened its position as Sweden's Space University and representatives from the university are more often invited as speakers at space conferences and round tables etc.
- Initially we spoke about "a space city" (Kiruna) but now it is all about a "space region". A much broader commitment has been developed throughout the region and we believe this is a strength for the future.
- During the time frame of the programme, a Swedish space strategy has been worked out and adopted by the Swedish government. Most of the project partners have been involved in the process and ensured that it has a focus on space operations in the region. This is important for the region's development into Sweden's leading space region. Four space-related start-ups have started with support from ESA-BIC Sweden and LTU Business. Another two companies were entering the ESA-BIC as the first phase closed.
- Two new space companies have been launched, one dealing with satellite communication and one with space component testing. Both are still under development.
- LTU has developed a laboratory for testing and development of space systems and components to be

sent out into space (NanoSatLab). This is an important cornerstone for the development and attraction of the test environment at the space campus.

- The national cluster *Aerospace Cluster Sweden* became aware of the programme and invited us to become their node in northern Sweden. This is expected to strengthen the conditions for future development and growth within the space industry both regionally and nationally
- Our achievements within the programme also caught the eye of the national cluster, *Big Science Sweden*, and offered us to become their northern node and, LTU Business was commissioned to staff a full-time job for 3 + 3 + 3 years.
- It is interesting that more subjects than just the traditional space topics are interested in participating in the Centre of Excellence for Space. This probably leads to a greater potential for interdisciplinary projects that can deliver results of an unexpected kind and stimulate further growth.
- SSC and LTU have initiated a new project called *Global Watch Centre* together with a new player, the company ÅF, who has not been particularly involved in the space business before. This project is recently initiated and has just completed a preliminary study. The *Global Watch Centre*, with the aim of strengthening the region's ability to receive, store, process, analyse and finally distribute large (huge) amounts of data from satellites, can be one of the biggest regional investments ever in the space area. The view is set to a global Centre where environmental data collected by satellites shall be made available to all countries interested, via the UN.
- Collaboration between industry and academia has proved to be interesting also for the Institute of Space Physics (IRF) in Kiruna who traditionally works with basic research with previously no connection to commercialization or entrepreneurship. Thanks to the RIT project there is a joint effort where IRF, LTU and SSC will work on developing the region into an attractive place for testing and qualification of components and systems intended for space deployment.

7. Discussion

There is no doubt that the two RIT projects have created better conditions for regional development in the space sector. Instead of talking of a single space city (Kiruna), actors within Norrbotten are talking about space as a strategic business area for the whole region since LTU stepped in and initiated the regional space programme. Recently, the university management was reinforced by a vice rector with a focus on space. As a direct result of these events LTU has strengthened its role as a catalyst in regional growth. It has strengthened the attractiveness

of the university itself but also the attractiveness of the entire space region.

The substantial interest from the space industry has also been an important success factor and today, technology and knowledge transfer between academia and industry is becoming business as usual. It can still be developed, but there is no longer a doubt that there is a good return on these investments.

An interesting discussion is why there have been so few spin-offs start-ups or regional SMEs involved in the expansion of the regional space sector. As it opened up and started to talk about external regional suppliers, the SMEs have identified space as a potential market. Previously there was a built-in respect for "rocket science" and that the space sector is too advanced for ordinary high-tech companies. SMEs are today more prepared to step into the space industry and many more entrepreneurs are interesting in applying for a slot in the Swedish incubator ESA BIC Sweden

Also, the fact that there is a regional innovation support system in place and that the expression "space ecosystem in our region" is naturally used, shows that the space actors are aware of the need of collaboration amongst a further circuit than previously included. This would probably not have been so clear without a common regional space programme.

An interesting challenge has been the wide target group consisting of primarily existing space companies, SMEs, researchers and students within space academia as well as secondary the Kiruna and Luleå Municipalities, the northernmost region in Sweden and the space industry of Sweden and Europe. It was initially necessary with this wideness in order for all the actors to get to know of each other and there is a wide common opinion that this was good. At the same time, there are voices that want to focus more on the hope of finding common denominators that are more specific to their area of interest.

Effects on the short term (2021) are all connected to the results that the programme has set up for the two RIT projects. It is all about going from initiating activities in the first phase and establishing the results in the second phase. Effects on the long term are more of general character and they need to be pronounced in a wider scope like regional and national visions for the space sector. This in combination with decisiveness. One very important step would be for the Swedish government to take the decision to invest in a launch facility for small satellites at Esrange Space Centre. There is a common will to express this will happen, but so far there is no decision on the financing. Such a decision would give the region a boost in many ways, not only for the industry

itself but for the whole sector with R&D collaborations between industry and academia involving both researchers and students. In addition, the space education programme could increase with several new directions. This would also give Europe access to space from European ground and open up for further international collaboration and synergies.

8. Conclusions

In general, according to the external evaluators, the two RIT projects have been a catalyst that was necessary for the results of the regional space programme to arise. Several concrete results, e.g. the Space Innovation Forum, the PhD projects and the Centre of Excellence, probably would not have come into being, but remained as unmet needs.

The projects have been successful and reached most goals according to plan so far. This due to that the project plan was structured and followed as planned and that there was a fruitful dialogue with the external evaluator. The projects have also worked focused on internal communication so that the activities in the five work packages could benefit from each other and together reach longer than possible on their own.

An important point is that the space industry is global in nature and that regionally, nationally as well as internationally, activities must be allowed within the framework of a regional EU project, to be successful.

It has been shown that the university, together with LTU Business, can take a leading role in promoting innovation and growth in small, medium and large industrial enterprises. LTU has stepped forward and clearly demonstrated that it intends to invest more in space and to do so together with other regional space actors. Having a university with the ambition of being Sweden's leading space university is a strength that no other region in Sweden can be proud of. It is also clear that established national space companies, whether they were parties to the projects or not, are interested in collaborating with the university.

Another key to success is collaboration focusing on cross-pollination through knowledge and technology dissemination between different parties, e.g. industry and academia. This takes time and leads to increased expertise which strengthens the attractiveness and competitiveness of the region. It is easier for larger companies to collaborate with academia in research projects than it is for SMEs who normally lack a relevant R&D budget. Some kind of innovation (monetary) checks for SMEs would have helped. We also learned that innovation within processes and methods are more

common than within development of new products and services.

The development of an innovation support system specifically formulated for the space business is a key to success for stimulation of new innovations, spin-offs and start-ups in the region. Just the fact that there are speaking partners within the different steps in business development and a Swedish space incubator in place helps and naturally in parallel an ability to rise funding for the business cases to develop.

The regional space programme has the ambition to involve the different partners at all levels in each organization. In the work packages, specialists in each area were active and, in parallel, the parties' management worked together to pave the way for a joint strategic work. The latter has probably been the main reason why we today are talking about a space region, and not just about Kiruna as the regional space city. It has also been crucial that the space actors now understand each other's driving forces better and that they regularly tune in on how things are going and therefore strengthening each other's operations when possible. Today, the image of the space region is clearer, both internally and externally, with a message that is common and clear.

The results are in this case heavily linked to a dedicated project management and a team that worked focused and goal oriented. It was of great importance that the initiator and owner of the project was strong in supporting the project management as well as financially strong. The team was also supported by the regional space actors on a national level as several space seminars have been arranged outside the region were important regional spokespersons announced a clear joint message. Finally, there are still many challenges to work on. Even though the new space economy includes start-ups and new space companies in a much broader way today than ever before, the space business is still demanding and a challenging path to navigate for SMEs or start-ups who are trying to establish a new company.

Acknowledgements

Thanks to the prime financiers of the project: EU, TVV (The Swedish Agency for Economic and Regional Growth) and the County of Norrbotten as well as the co-financiers: IRF, ABI, LTU Business, SSC, GKN Aerospace, OHB Sweden, Kiruna and Luleå municipality and Sparbanken Nord.

References

- [1] The RIT webpage (first phase 2015-2018), <http://old.ritspace.se/> (accessed 15.07.19).
- [2] The RIT 2021 webpage (second phase 2019-2021), <https://www.ritspace.se/> (accessed 15.07.19).
- [3] The Space Kiruna webpage <http://spacekiruna.com/>
- [4] RIS (Regional Innovation Strategy 2014) and RUS (Regional Development Strategy 2014) <http://norbotten.se/sv/Utveckling-och-tillvaxt/Regional-utveckling-och-framtid/Regionalt-utvecklingsuppdrag/Regional-utvecklingsstrategi/>
- [5] Johanna Bergström Roos, "An inventory of Swedish space research, space education and space industry and how they cooperate amongst themselves" (2015). Only in Swedish. <https://www.ritspace.se/contact/media/>
- [6] Johanna Bergström Roos, "Synergies through collaboration between the Esrange Space Centre and Space Campus" (2015). Only in Swedish. <https://www.ritspace.se/contact/media/>
- [7] Pär Johansson, "Innovation and incubator for the space industry in Kiruna" (2015). Only in Swedish. <https://www.ritspace.se/contact/media/>
- [8] Patrik Kjellman, "Kiruna – Closer to Space, a study on market development" (2015). (in Swedish). <https://www.ritspace.se/contact/media/>
- [9] Oxford Research, Final report of the project RIT, "Lärande utvärdering av projektet RIT – Rymd för innovation och tillväxt" (in Swedish) <https://www.ritspace.se/contact/media/>