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Best practices in downstream space technology transfer

From ESA Space Solutions and EU Astropreneurs, to Flanders' Space

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Abstract

The challenging environment of outer space (weightlessness, vacuum, temperature extremes) demands for systems that are failure-proof, reliable, and durable. The resulting technologies are in a class of their own. These high standards offer valuable attributes to terrestrial industries as well. Therefore, technology transfer is especially effective in the space field. The transfer of space technology towards terrestrial applications provides tremendous returns as it stimulates innovation and spurs economic growth. Innovation is thus not always the invention of a brand-new or revolutionary technology. In fact, the most efficient innovations stem from using existing technologies for purposes unrelated to their original use in order to create something new (technology as an enabler) or to improve something that already exists (technology as a differentiator). This process, referred to as technology transfer also brings valorisation as ideas and concepts are moved from the laboratory to the marketplace. The intention is to get the maximum value out of technology development in order to boost the economical and industrial competitiveness. Contrary to what some consider a waste of money, investments in space offer a lot of utility with a high potential of spillovers. Nevertheless, in an ESA survey earlier this year only half of the participants was convinced that space activities make daily life easier. This outcome implies that the topic needs more attention.

The process of technology transfer with regard to space consists of three segments. The first includes upstream transfers, spinning in ground based technology to support space programmes. The second segment is not a direct form of technology transfer but is about using space-enabled data. The third segment contains downstream transfers. This is the process of turning space technology (hardware or software, products, processes including: know-how, procedures, methodologies, and systems) into an application down on Earth. The research scope of this master's thesis will be limited to this downstream segment, and will only cover the European space sector.

The research can be divided into three levels: ESA, EU, and Belgium. Furthermore, a case study for a potential terrestrial application on the basis of space technology will serve as a connection to practice throughout the different chapters and will showcase the ingredients one needs in order to set the downstream space technology transfer process in motion. In the first chapter, an explanation will be given on the different actors involved in this process. The research will then be split up into different levels. First, both the ESA and EU space technology transfer programmes will be discussed consecutively in two separate chapters. For both programmes the key actors and characteristics will be described, while the case study will provide practice-oriented insights. The next chapter will contain a comparison between these ESA and EU programmes. In the last chapter the focus is on their national implementation, as well as on other space technology transfer initiatives in Belgium.

Finally, this master's thesis concludes with a list of best practices. This list will contain two parts. The first set, consisting of microscale best practices, will map the landscape of the downstream space sector in order to guide entrepreneurs through the different initiatives. The second part of best practices will recommend the course of action from a policy perspective. These guiding principles for governing bodies, or macroscale best practices, will serve to further stimulate the process of downstream space technology transfer throughout Europe (ESA and EU), but also on a national (Belgium) and regional (Flanders) level.

Over the past decades, space technology has given us laptops, wireless devices, miniaturised equipment, and even artificial limbs and organs. During the new era of space exploration we have not only captured mind-boggling images of ultimate distant objects and a black hole. The advances in robotics for planetary exploration, with automated guided vehicles in factories developed on the basis of the ExoMars rover have also reached our own planet. In the future, more manned space missions should lead to exciting spin-off opportunities. Meanwhile, entrepreneurial activities need to be promoted in order to generate the return that keeps investments flowing. Therefore, the actors responsible for the valorisation of space technology may even be regarded as the driving force behind the space industry.

List of abbreviations

ARTES: Advanced Research in Telecommunications Systems

BIC: Business Incubation Centre

CSL: Centre Spatial Liège

EBAN: European Business Angel Network

EBN: European BIC Network

EEN: the Enterprise Europe Network

EIC: European Innovation Council

ESA-STAR: ESA's online System for Tendering And Registration

ESA: European Space Agency

H2020: Horizon 2020

IBN: Innovative Business Networks

imec: Interuniversitair Micro-Elektronica Centrum

IRL: Innovation Readiness Level

ISS: International Space Station

MELiSSA: Micro-Ecological Life Support System Alternative

NASA: National Aeronautics and Space Administration

NTTI: National Technology Transfer Initiative

OECD: Organisation for Economic Co-operation and Development (OECD

R&D: Research and development

SME: Small Medium Enterprise

TRL: Technology Readiness Level

TT: Technology transfer

TTN: Technology Transfer Network

TTPO: Technology Transfer Programme Office

VLAIO: Flanders Innovation & Entrepreneurship

VARIO: The Flemish Advisory Council for Innovation and Enterprise

VRI: Flemish Space Industry

VRWB: Flemish Council for Science Policy

VRWI: Flemish Council for Science and Innovation

WSL: Wallonia Space Logistics

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1. Introduction

The origin of the transfer of space technology on a significant scale can be traced back to NASA's Apollo era. Everyone can relate to the digital photography technology to capture images from long range telescopes which led to the miniaturised cameras on today's smartphones, or to space blankets used on the exterior surfaces of a spacecraft for thermal control that are now also standardly included in first aid kits. Both technologies were developed by NASA during the 1960's and are still used today, yet few people will be able to bring up such space connections when asked to. In fact some people even bring up technologies that are wrongly attributed to space. Teflon, known for non-stick cookware in ordinary households is such an example. Although it has been used by NASA for heat shields, space suits and cargo, Teflon was actually invented two decades before NASA even existed. Another example is Velcro, even though used frequently on board crewed spacecraft, it is actually a Swiss invention from the 1940's.

This poor public awareness of space technology and its impact for life on Earth was reaffirmed earlier this year when ESA released a survey in the five most populous ESA member states.[1] Although the results showed that 90% had a positive perception of space activities, only 53% was convinced that daily life was made easier by space activities. A meagre 40% felt that they were well informed about European space activities. Moreover, the majority estimated that a common citizen contributes €245 to space programmes, while only 33% was able to select the correct which was "less than €20". These numbers seem to confirm that there is a need to pay more attention to the topic of space technology transfer towards terrestrial applications. Especially with regard to space technology in Europe.

1.1 Research scope and objective

The process of technology transfer with regard to the space sector, can be categorised into three different segments.

The first segment includes upstream transfers. This means spinning in ground based technology towards the space sector such as to develop or improve satellite components, construction of launchers, life support, etc.

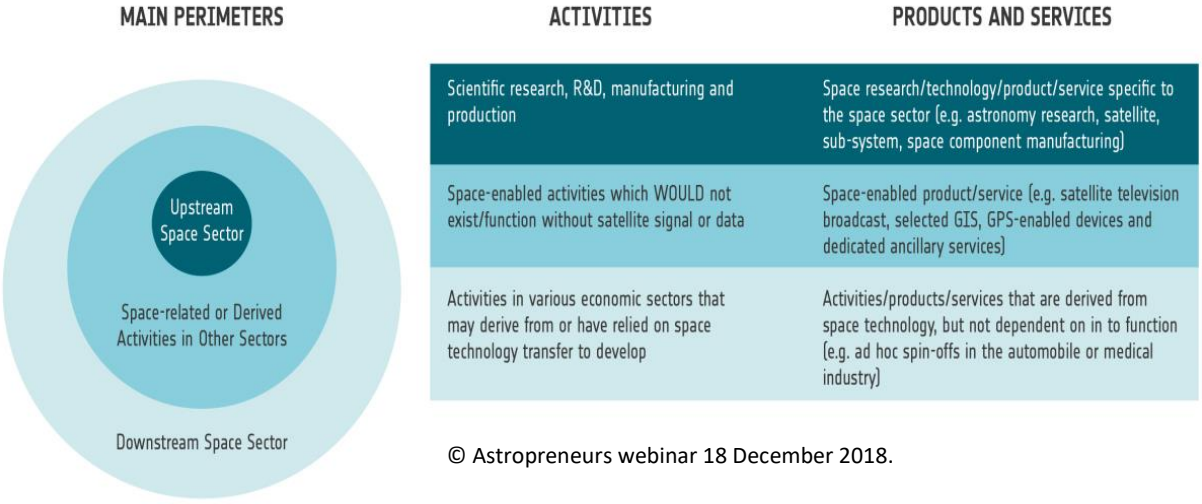
The second segment is about space-enabled data or services. This is not really a direct form of technology transfer but is about the processing and use of space-enabled data, giving rise to innovative applications relying on satellite data.

Finally, the third segment is about downstream transfers where technologies, developed for space programmes, are used in non-space applications. This means spinning out space technologies to terrestrial sectors where they function without further dependency on space-enabled data or operations. Downstream transfers can include the transfer of products such as software and hardware to terrestrial applications. A few examples are: a sensor designed for analysing the atmosphere of Mars

[1] ESA, "The Harris Interactive survey - Europeans and space activities", http://esamultimedia.esa.int/docs/corporate/European_and_space_activities_Harris_results.pdf, retrieved: 6 June 2019.

is now used on Earth to measure air quality or to detect gas leaks[2]; a space radiation detector was transformed to a terrestrial application to analyse historic artworks and detect forgeries[3]; software for processing satellite data is now used to detect Alzheimer's disease[4], or to improve efficiency for oil and gas industries[5]. Downstream transfers also include the transfer of processes such as expertise and certain methodologies used in the space sector, for instance: the use of electrical wiring techniques developed for ESA satellites in Formula One cars[6]. Furthermore, transfers combining both products and processes developed for ESA space programmes are also possible. For example: in order to produce artificial hearts for transplantations, miniature satellite equipment was used, but also the reliability and design methodologies, testing strategies and know-how for the electronics on satellites were necessary[7]. Another possibility in the downstream segment is that the transferred technology was developed in space, typically with experiments on board the International Space Station (e.g. based upon plasma experiments on the ISS plasma technology is now used for medical applications to treat wounds or skin diseases, as well as for non-medical applications such as to neutralise odours in ordinary kitchens[8]).

The figure below gives an overview of the 3 mentioned segments.



© Astropreneurs webinar 18 December 2018.

[2] ESA, "From Red Mars to Green Earth", www.esa-tec.eu/success-stories/from-space/from-red-mars-to-green-earth/, retrieved: 24 May 2019.
[3] ESA, "Space radiation detector can help to spot fakemasterpieces", 2019, www.esa.int/Our_Activities/Space_Engineering_Technology/Space_radiation_detector_can_help_to_spot_fake_masterpieces, retrieved 24 May 2019.
[4] ESA, "Identifying Alzheimer's Using Space Software", www.esa-tec.eu/success-stories/from-space/identifying-alzheimers-using-space-software/, retrieved: 24 May 2019; ESA, "Space brings savings to offshore oil and gas", www.esa-tec.eu/success-stories/from-space/space-brings-savings-to-offshore-oil-and-gas/, retrieved: 24 May 2019.
[5] ESA, "Space brings savings to offshore oil and gas", www.esa-tec.eu/success-stories/from-space/space-brings-savings-to-offshore-oil-and-gas/, retrieved: 24 May 2019.
[6] ESA, "Drive me to the Moon", www.esa-tec.eu/success-stories/from-space/drive-me-to-the-moon/, retrieved 24 May 2019.
[7] ESA, "Space in your heart", www.esa-tec.eu/success-stories/from-space/space-in-your-heart/, retrieved: 24 May 2019.
[8] ESA, "Plasma medicine – How space science improves patient care", www.esa.int/Our_Activities/Space_Engineering_Technology/TTP2/Plasma_medicine_how_space_science_improves_patient_care; ESA, "Cold plasme freshes up French Fries", 2016, www.esa.int/Our_Activities/Space_Engineering_Technology/TTP2/Cold_plasma_freshens_up_French_fries, retrieved: 24 May 2019.

The transfer of technology (processes, products, and services) from the European space sector to a non-space sector (spin-out), forms the scope of this master's thesis research. This means that only the outer segment in the figure above, about the downstream transfers, will be discussed further. The use of satellite data and technology transfer from non-space sectors to strengthen the space industry (upstream or spin-in) are not covered.

Downstream space technology transfer is thus understood as the process of turning space technology (hardware or software, products, and processes including: know-how, procedures, methodologies, and systems) into a terrestrial application. This downstream segment is particularly interesting because it gives added value to space technology by creating innovations with it down on Earth. The space industry has all the ingredients to become the main driver of economic and social growth. Space will serve as the enabler for the smart economy of the future. The downstream segment will thereby play an increasingly important role. However, there is not a very widespread awareness about the advantages that this downstream segment has to offer, which makes it all the more important as a topic to talk about. Moreover, there is an astronomical amount of initiatives, and lots of these also promote upstream transfers or space-enabled data, so limiting the scope to the downstream segment helps to focus only a few specific programmes within the endless stream of space related initiatives.

The rest of this thesis will thus proceed on the downstream space sector. A personal concept for a potential terrestrial application on the basis of space technology will be the starting point for this research. This will showcase the ingredients that one needs in order to set this downstream space technology transfer process in motion. The concept will further serve as a case study throughout the different chapters.

The research will then be split up into different levels. First, the European programmes of the EU and ESA will be discussed in two separate chapters. For both programmes the key actors and characteristics will be described. At the end of each of the two chapters the case study will serve as a connection to practice. A following chapter will then compare these ESA and EU downstream space technology transfer programmes.

After the comparison of these European programmes, their implementation and other space technology transfer initiatives in Belgium will be studied. The research can therefore be divided into three levels: ESA, EU, and Belgium.

Finally, this master's thesis will be concluded with a list of best practices. This list will be split up into two parts. The first set, consisting of microscale best practices, will map the landscape of the downstream space sector in order to guide entrepreneurs through the different initiatives. The second part of best practices will recommend the course of action from a policy perspective. These guiding principles for governing bodies, or macroscale best practices will serve to further stimulate the process of downstream space technology transfer throughout Europe (ESA and EU), but also on a national (Belgium) and regional (Flanders) level.

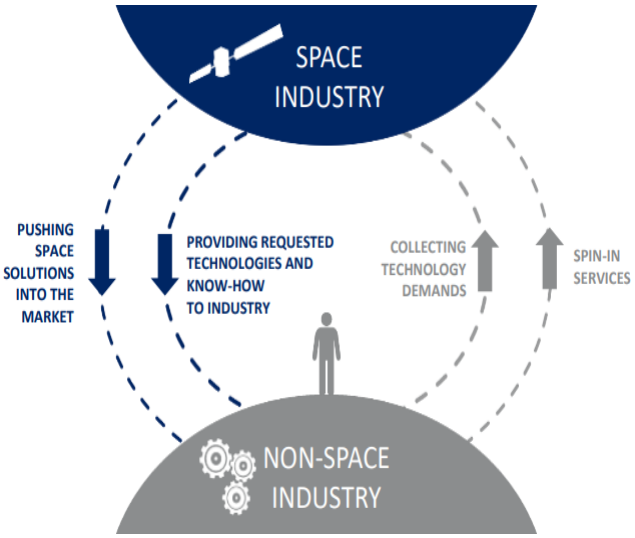
Before jumping into the different levels of technology transfer initiatives, the remainder of this introductory chapter will give an overview of the assets that the downstream space sector has to offer. Furthermore, an explanation will be given on the different actors involved in the space technology transfer process.

1.2 Innovation and technology transfer

Innovation is the practical implementation of an idea into a new device or process, typically resulting in solutions that better meet existing or new market needs. It can originate with many different actors, such as individuals, universities, research institutions, or companies. Especially companies are well suited to innovation activities because of the available amount of resources in combination with management systems. Furthermore, two models can be observed to explain the driving forces behind innovation. In the push model, a new technology is regarded as primary source of innovation and is translated into a commercial application. In this model, the technology transfer process starts from the technology itself, by scanning the space market for technologies and services. These are then matched with the technological needs of non-space markets, to improve non-space applications and services (technology as differentiator) or even to create a whole new product for the identified industries (technology as enabler). It also possible that this process takes place in the reverse way (matching non-space technologies with the needs of the space market), but as already explained this falls outside the thesis scope. It will become clear that a pure push approach is rather outdated. The pull, model on the other hand, is based on the perceived market demand. Following this model, innovation is driven by the requirements of potential customers.

Innovation is not always the invention of a brand-new or revolutionary technology. Rather than inventing something new, the most efficient innovations can actually stem from using existing technologies for purposes unrelated to their original use. This process is referred to as technology transfer (TT). TT is an intentional procedure governed by a contractual relationship process. It takes technologies, innovative methods, knowledge or facilities that were developed for a specific market, and adapts these in order to create something new or to improve existing processes or products in completely different market sectors. The TT process includes valorisation, as ideas and concepts are moved from the laboratory to the marketplace.[9] Its purpose is to get maximum value out of technology (valorisation) and to boost the economy.

The challenging environment of outer space (weightlessness, vacuum, temperature extremes) demands for systems that operate for years on end. With no chance of repair, they have to be failure-proof, reliable and durable. The resulting technologies are in a class of their own. As a consequence, TT is especially effective in the space field. These high standards offer valuable attributes to terrestrial industries as well. Contrary to what some consider to be a waste of money, investments in space technology thus offer a lot of utility with a high potential of spillovers. By encouraging the commercial use of advanced technologies with TTs, the returns



© ESA Space Solutions

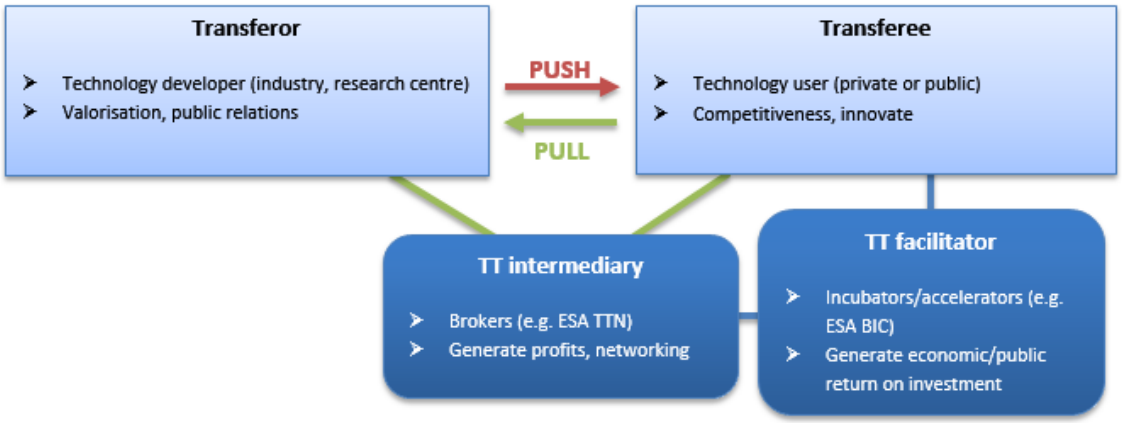
[9] ESA, "Down to Earth, How space technology improves our lives", Technology Transfer Programme, 2009, 4.

on investments in space missions are increased. The development of a TT process from space to Earth does not only benefit the aerospace industry but also the network of national companies. TT has been shown to stimulate innovation in business and commerce, support economic growth and provide a return on public investment in research and development (R&D).[10]

The space TT process is carried out by different entities, such as business incubators and accelerators, national TT initiatives, and the Technology Transfer Network, involving technology brokers and networking fora.[11] Typically the TT process involves four different categories of actors.

First of all a transferor is required. This can be any kind of industry actor, research centre, or laboratory where space technology is developed. The second category are the technology brokers. These are the TT offices and private companies operating as intermediaries by bridging the space sector with terrestrial market segments. On the other side of the process is the transferee. This is the public or private entity that ends up using the technology, implementing the transferred technology to create or improve products and/or processes, in order to increase competitiveness. Finally, TT organisations can come into play to facilitate the transfer process. These are the incubators, accelerators, or science and technology parks supporting the transferee.

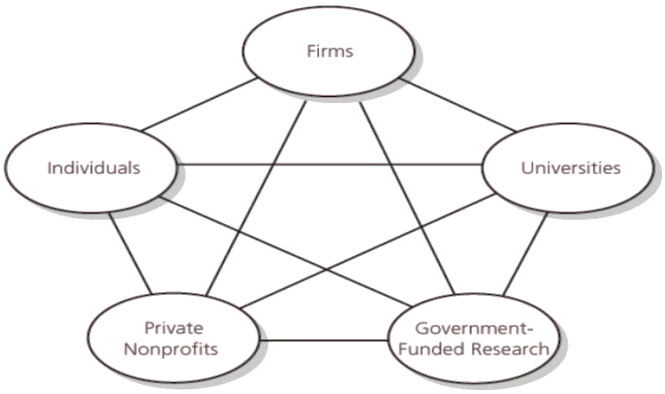
The motives, leading the actors to participate in the process, vary between the categories. The reason to engage in the TT process for the transferor of technology (e.g. industrial partners or research centres developing technology for ESA programmes) may be of economic self-interest (valorisation of R&D by pursuing new commercial markets, reducing dependency on public funding, maintaining public relations, sharing costs, and reducing the development time for a new technology), or it may be of a publicly imposed interests (increasing the return on investment with regard to scientific knowledge and technology acquired during space programmes, developing a strong aerospace and industrial space capability, helping SMEs[12], encourage companies, universities and research institutions to collaborate, or to accelerate innovation in general). Second, the interests of intermediaries (brokers) and facilitators (TT organisations) to stimulate the TT process typically reflect the same public incentives as mentioned above in order to create new businesses and boost innovation. However, private entities may also have an economic interest of their own to be profitable as specialised agents within the TT process.



[10] K. VENTURINI, C. VERBANO, "A systematic review of the Space technology transfer literature: Research synthesis and emerging gaps", *Elsevier*, 2014, 102.
[11] ESA, "Down to Earth, How space technology improves our lives", Technology Transfer Programme, 2009, 4.
[12] European Commission, "What is an SME?", https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en, retrieved 24 May 2019.

1.3 TT intermediaries

In the introduction, it was explained that innovation originates with different actors. The linkages between these actors are of key importance in the innovation process. Networks of innovators can leverage knowledge and other resources in order to create technological advances. Such networks can enable firms to achieve more than they could individually. A technology cluster can be established to stimulate research collaboration by connecting industries that are linked through relations between suppliers and buyers.



MULYANINGRUM, "Sources of Innovation in the Industry Dynamics of Technological Innovation Case of Procter & Gamble's"

A TT network typically involves firms that operate as brokers, transferring existing information or technology from one domain to another in which it can be used in a new and profitable way. Brokers are in a position to find unique combinations between the assets possessed by two parties. A broker may be the one that connects clusters, individual firms, or other actors such as governmental entities and research institutions, that would otherwise share no connection. Instead of creating breakthroughs in technology, brokers exploit the potential synergies of existing technologies. Their expertise lies in the ability to recognise and capture potential solutions that may be matched to problems in unexpected ways.[13] Alternatively, such a broker network may also be the result of public support in order to stimulate collaboration and accelerate innovation.

After this introductory chapter, different kinds of TT intermediaries will be discussed for each level. First, the ESA Technology Transfer Network, with a highly engaged Belgian company will come across. Thereafter, due to the lack of specific TT intermediaries with regard to space on the level of the EU, some more general intermediaries within the EU framework will be mentioned. However, it will become clear that the EU space TT facilitators take over some of these intermediary functions. Finally, within the national level of Belgium, a new regional initiative called Innovative Business Network can also be regarded as part of the TT intermediary category.

1.4 TT facilitators

Another important role in the innovation process is played by TT facilitators. TT facilitators exist in different forms, ranging from incubators and accelerators to science parks. The precise characteristics depend on the specific institution, however before taking a look at the most prominent facilitators for the transfer of space technology in the following chapters, more detail on TT facilitators in general will be provided first.

[13] M. SCHILLING, "Strategic Management of Technological Innovation", McGraw-Hill Education, 2017, chapter 2.

Science parks, incubators and accelerators are considered to be important policy tools for supporting innovation and technology-oriented entrepreneurial growth. Their existence is essential for the creation and development of innovative technology-based firms. TT facilitators help to overcome the market failure that occurs when a new technology has the potential for important social benefits, but its potential for direct returns is highly uncertain.[14] TT facilitators support start-ups in different ways to overcome barriers during the early stages of development. Policymakers have recognised the importance of seeding and accelerating entrepreneurship and technological innovation through incubation mechanisms that offer economic sustainability. TT facilitators are therefore generally established through public-private collaborations among universities, industry, and all levels of government. As already mentioned, the purpose behind this public support is to promote the transfer of technology in order to support start-ups by providing enabling linkages to help new businesses survive, scale up, and grow, thereby developing local innovative firms.[15]

One form of TT facilitators are accelerator programmes. These mainly focus on educating and mentoring start-up founders, thereby preparing founders for public pitch events to present their businesses to large groups of potential investors. In practice, accelerators combine distinct services and functions that are difficult and costly for an entrepreneur to find and obtain.[16]

Another possibility are science parks. These are regional initiatives, typically set up by the government to foster R&D collaboration between government, universities, and private firms. Sufficient public funding is important, otherwise science parks are more likely to fill up units with any rent-paying activity rather than exclusively supporting novel entrepreneurship. Their initial mission is to generate high technology growth, but limited subsidised office space for innovative start-ups can force science parks to turn to more mature companies that are able to afford the high rental fees. With less subsidies, generating sufficient rental income is required to cover the operational expenses, and when office space for free or at a fee significantly below market prices can no longer be provided, this results in a selection of more mature firms. This is bad for start-ups and entrepreneurs in early development stages since they typically do not have fully developed business models, and have very limited or no revenues.[17]

Lastly, TT facilitators can also take the form of business incubation centres (BICs). The support provided by BICs can be brought under three dimensions: infrastructure, business support, and access to networks. Infrastructure is the core of a BIC's value proposition. It consists of office space, small scale production facilities, and shared resources such as a reception, conference rooms or car parking. These are resources and services that an incubatee probably would not otherwise have access to during early development stages. More specialised resources, such as laboratories and research equipment, can also be regarded as part of the infrastructure proposition. Moreover, incubatees enjoy office space together with a shared resources bundle including energy, water, telecommunications and cleaning.

[14] M. COLOMBO, and M. DELMASTRO, "How Effective are Technology Incubators? Evidence from Italy" Research policy 31, 2001, 1103-22.
[15] S. MIAN, W. LAMINE, and A. FAYOLLE, "Technology Business Incubation: An overview of the state of knowledge", *Elsevier*, 2016, 1.
[16] S. MIAN, W. LAMINE, and A. FAYOLLE, "Technology Business Incubation: An overview of the state of knowledge", *Elsevier*, 2016, 2.
[17] J. BRUNEEL, T. RATINHO, B. CLARYSSE, and, A. GROEN, "The Evolution of Business Incubators: Comparing demand and supply of business incubation services across different incubator generations", *Elsevier*, 2012, 119.

This support also eliminates the burden of planning, setting up and paying individual providers, allowing incubatees to concentrate on their core activities.[18] The second aspect of a BIC's value proposition is to provide business support through mentoring services. This can include in-house or outsourced coaching, and training sessions such as seminars or workshops. Finally, the third aspect of a BIC's value proposition is network access. An incubated start-up can get access to financial support and professional business services through the BIC's network of different partners such as university technology transfer offices, consulting firms or experts, insurance companies and project management firms. Professional business services are specialised support services, including accounting, legal or administrative support, and strategy consulting.[19]

A TT facilitator thus covers different forms of business support. Furthermore, much of the literature in this domain is fragmented and anecdotal with a focus on success stories and outcomes. As a consequence, a unified theory is hard to come by. This is amplified due to the differences between science parks, incubators, and accelerators in relation to geographic, political, social, and economic systems.[20] A lot also depends on the policy of a particular TT facilitator. Selection criteria are for example not standardised. Selection can depend on performance criteria or on a prior presentation of a business plan to a committee. Similarly, exit policies vary and can be completely absent or rather strict, with companies having to graduate after reaching a certain level of maturity or after a certain period of time.[21]

Just like the TT intermediaries, the following chapters will discuss the main TT facilitators on each level. With regard to ESA, these are the ESA BICS. For the EU, these are the Astropreneurs Accelerator and the SpaceUp programme. Finally the implementation in Belgium will be addressed as well.

[18] J. BRUNEEL, T. RATINHO, B. CLARYSSE, and A. GROEN, "The Evolution of Business Incubators: Comparing demand and supply of business incubation services across different incubator generations", *Elsevier*, 2012, 111-112.
[19] R. PHILLIPS, "Technology business incubators: how effective as technology Transfer mechanism?" *Technol Soc,* 2002, 304-305.
[20] P. PHAN, D. SIEGEL, and M. WRIGHT, "Science parks and incubators: observations, synthesis and future research", 2005.
[21] J. BRUNEEL, T. RATINHO, B., CLARYSSE, and A. GROEN, "The Evolution of Business Incubators: Comparing demand and supply of business incubation services across different incubator generations", *Elsevier*, 2012, 113.

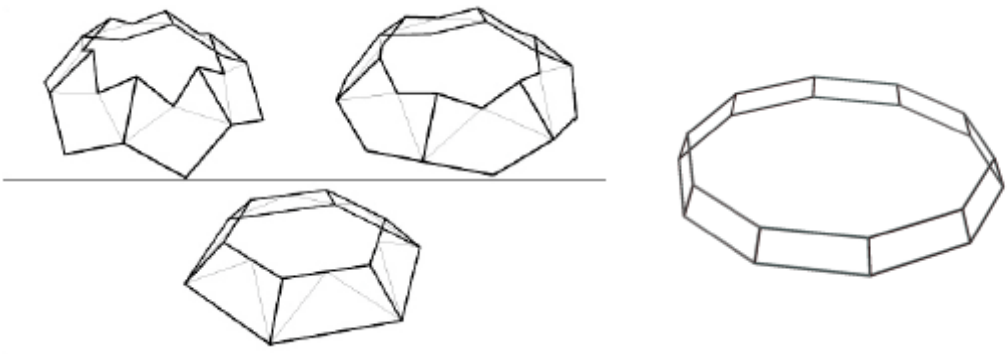
2. A technology transfer case

From 13 to 16 November 2018, the Technology Transfer & Innovation Workshop was held by ESA Academy's Training & Learning Facility in ESEC-Galaxia Belgium. During this 4-day workshop, 30 participating students were given various lectures about different disciplines within the field of TT and innovation, including patenting, entrepreneurship, and business incubation. Furthermore, hands-on experience was also provided through a group assignment. The students had to work around a real ESA patent to brainstorm potential application ideas, and to develop a business model around it. At the end of the week, the students followed in the footsteps of real entrepreneurs and had to pitch their ideas.

By following a similar pattern as for the group assignment, and inspired by the same patent, this workshop formed the basis of a business model developed for this thesis project. This business model will be explained in this chapter and will be used throughout the rest of the thesis as a practice-oriented reference and case study for the different TT initiatives. The case study provides the opportunity to illustrate barriers in practice and will contribute to the conclusion on best practices for entrepreneurs and policymakers, which is the main objective of this thesis.

2.1 ESA patent

As already mentioned, the workshop was built around a specific patent. ESA PAT 568, is an ESA invention of a large, low weight, compactly deployable antenna structure. It is used for telecommunications and scientific missions, since these require large deployable apertures to fulfil their increasingly challenging requirements. ESA lacked large aperture deployable antennas in the range from 4 meters and above. The main difficulty is that the large structures have to be stowed in a small fairing, typically with a diameter of around 2 meters. Therefore, ESA developed technology related to large deployable structures to cover the need for large space antennas for radio frequency applications. These structures had to be very reliable, light weighted and stable after deployment. The technology presented provides a low weight, compactly deployable support structure suitable for large deployable apertures. It is based on a bar-linkage structure and allows the construction of unit cells of scalable and modular deployable structures with double curvature.



Design possibilities based on ESA PAT 568

The simple construction provides efficient stowage to a small packed volume, with guaranteed deployment. It is characterised by a high reliability, reduced mass, transportation and installation ease, and a high stability. Due to the module prismatic shape, the resulting surface will lay on an spherical section.

Based on this patent and the exercise during the 4-day ESA Technology Transfer & Innovation Workshop, an individual concept was created. The business idea of this concept will be explained below.

2.2 Astrolympia

During the workshop, the students were placed in different groups. Each group had to come up with an original business model based on the patent which was just described. The first step was to brainstorm on potential applications. An excellent tool used for idea generation was PatentInspiration.[22] The generated ideas were then evaluated according to their market potential and technical fit. The market potential is about the existing need in practice, or the market opportunity from a commercial viewpoint. The technical fit is about the problem in practice, and how the technology in the proposed application can solve this problem. By ranking the ideas according to their market opportunity and technological fit, each group selected their best application. These were then further developed according to a business analysis roadmap. In what follows, this approach is illustrated, but on an individual basis. It is an idea for the establishment of a start-up named *Astrolympia*, and it will be used as a case study in this master's thesis.[23] The business analysis roadmap will be further explained, however it will not be fully applied in detail since the business model for Astrolympia is currently still under development and has been accepted under one of the TT initiatives that will be described later in this thesis.

The idea behind Astrolympia, is to combine sport and space. The slogan of this business concept is: Fit with space. The aim is to fit sports infrastructure literally with space by saving weight, storage room and offering installation ease. Space technology can also be used in order to stay fit in the physical meaning of the word. With the right nutrition, sports performances can be improved, and with the right materials and technology "sportables" can be developed. In a highly urbanised world, efficient use of space and time is becoming increasingly important. Astrolympia aims to use the benefits of space technology to develop products that fit those needs and to enable sport on the go, anywhere and anytime. For this purpose, ESA technology will be used for terrestrial application in sports infrastructure (small arenas, trampolines, fitness devices,...), aiming for mobility and practical use, easy instalment, and lightweight portability for better transportation (efficient storing) to different locations. In addition, other interesting links between space and sport exist. Branding the space connection can make a real difference. For example, food supplements or medicines developed on the basis of ESA research for astronaut training programmes, with guaranteed quality requirements. Since

[22] www.patentinspiration.com/?fbclid=IwAR2dEo8qztTrD6EXpPkT52eCoaoxazSBzWQt29ncZNxoxCJR-m5LlEclKxM, retrieved: 29 May 2019.
[23] www.f6s.com/astrolympia.

space is very hyped (think of all the NASA branding on t-shirts and sweaters these days) this might be an opportunity to successfully apply ESA research for terrestrial use.

Following a similar process as during the workshop, the initial idea was drafted on the basis of the market opportunity and the technical fit. The market aimed for is sport and entertainment, specifically for mobile actors. A market study can be performed to know more about the commercial opportunities and customer expectations. The next step is to evaluate the technical fit in a use case scenario of the technology as a potential solution to a specific problem in practice, for example transportation and installation issues of existing devices.

The business analysis roadmap helps to make the business model commercially viable. For Astrolympia, this is still in progress but some illustrations will be given with the applied business analysis roadmap below.

1) Statement of opportunity

(Explain the significance of the problem and provide elements of context, additionally explain why this problem matters to you as an individual)

> E.g. The sport sector is an attractive market: lots of events, public support and teambuilding events for private sector, but events at different locations require mobility which can sometimes be very hard to combine with the required material. Applying ESA technology for such a purpose could solve transportation and installation issues. Additionally there are other opportunities with regard to sport, for example making use of nutrition developed for astronauts exercise programmes could be very attractive for sportspersons.

2) Problem of practise

(Explain the use case scenario and the problem being faced by users, in practical terms)

> E.g. To transport current infrastructure, a lot of storage room is needed. Moreover, taking into account heavy weight structures and complicated installation of different components, practical use of existing models is low. For sports nutrition, a lot of variety already exists. However, the use of food supplements developed for human space travel and nutrition complementing the astronauts exercise programme is unique (long conservation, compact and rich in essential nutrients).

3) Target customer segments

(Identify potential customers)

> E.g. Sporting goods retailers, companies/organisations with sport or teambuilding activities, governmental partners (sport events), sports enthusiasts.

4) The product, what is it?

(Defining the product in factual statements)

> E.g. The enclosure shall cover a space of 6m in diameter, size of the package stowed, stiffness when deployed, method of deployment, integration or not of goals and nets, etc.

5) How does it solve the problem?

(Explain in particular the role of the patented technology in solving the problem)

E.g. Lightweight, deployable structure could make it possible to get rid of different components, making a product in one whole which could be deployed automatically.

6) Key benefits

(Present here the key benefits and the most compelling reasons to buy the product)

Sports devices:
- Compact storage
- Easy to deploy and transport
- Stable and durable
- Lightweight

Sports nutrition:
- Rich in essential nutrients
- Long conservation
- Compact high energy source
- ESA brand

7) Competition

(Present substitute & competitive products. Explain how they compare and how your product is better)

- Inflatable infrastructure, require energy source, noisy
- Existing arenas are heavy and hard to install
- (Permanent infrastructure) = more complementary than competitive since the aim is on mobility
- Sports nutrition including spirulina is already on the market, however quality is often disputable. Bringing space food under one brand connected to space technology while adjusting it specifically for sports use delivers guaranteed quality

8) Business Canvas Model

(Outline the business model of the start-up in the following template)

<table>
<tr>
<td rowspan="2">Key Partners

• ESA
• Retailers
• Government</td>
<td>Key Activities

• Marketing
• Product demonstration
• Customer relations</td>
<td rowspan="2">Value Propositions

• Mobile infrastructure
• Easy to install
• Efficient storing
• Multifunctional</td>
<td>Customer Relationships

• Personalised website?
• Events (demonstration?)</td>
<td rowspan="2">Customer Segments

• Sporting goods retailers
• Companies/organisations with sport or teambuilding activities
• Government (sport events)</td>
</tr>
<tr>
<td>Key Resources

• ESA technology
• ESA BIC
• Experience</td>
<td>Channels

• Online
• ESA BIC
• Retailer store</td>
</tr>
<tr>
<td colspan="3">Cost Structure

• Production (materials, infrastructure)
• Staff
• Advertising</td>
<td colspan="2">Revenue Streams

• Product sale
• Promoting company</td>
</tr>
</table>

9) Implementation strategy

(How to develop and bring the product to the market, e.g. start-up, unit in an incumbent organisation, etc…)
Roll out plan: the steps & milestones from inception to commercial operations

> Once access to funding (with interested investor, partner, or ESA demonstrator/BIC): create start-up and aim for direct sales to customers (especially for sports nutrition), as well as cooperation with retailers or other entities.

Finally a strengths, weaknesses, opportunities, and threats (SWOT) analysis can be performed to reinforce the strategic plan. In short, with regard to Astrolympia the main strengths are: a growing network, multidisciplinary, and the space connection. Main weaknesses are: lack of technical experience in product development, an incomplete team, and no financial resources. Opportunities include: an emerging need for mobility on the market, a space connection that allows for differentiation, and access to the Astropreneurs Accelerator. Finally, identified threats are: financial risk and technical issues. An early identification of weaknesses and threats is vital. It allows for a timely search for solutions. For example, since the concept of Astrolympia is lacking technical capacity, it would be very advantageous if an engineer joined the team, or if a cooperation with a technical partner could be established. It appeared that both options were achievable. With regard to the first, a close friend just graduated as an engineer and showed keen interest to join the project. The option of finding a technical partner will be discussed in the following paragraph.

2.3 Polar Developments

Polar Developments is a start-up that was founded in 2018.[24] It has experience in structural design and product development. They extract technologies from within the specialised space sector and transfer them to sectors that can benefit from these. Polar Developments is currently developing various R&D projects with public and private funding in order to test new materials and typologies. They verify the results obtained through the construction of prototypes and specific test campaigns.

Important for this thesis study and for the connection with Astrolympia is their development of deployable structures based on ESA PAT 568 (low weight, compactly deployable support structure), which was described earlier. The company is currently developing a product to support solar panels based on this patent. A business analysis to make the product commercially viable is however still in progress, and the company has shown interest for potential alternative business ideas based on this patent. Since it is incubated in ESA BIC Madrid, the connection with Polar Development will also be used to perform a small practical review at the end of the chapter on ESA Space Solutions.

[24] Polar Developments, www.polardv.es/.

3. ESA Space Solutions

ESA Space Solutions is the overarching trademark created by ESA to give special recognition to products and services that make use of space technology. This initiative also provides opportunities for space-provided services and data, or for technologies from Earth for an application related to space. However, the focus on ESA Space Solutions in this thesis follows the research scope as explained in the first chapter on the spin-off (from space to non-space), or downstream side of TT. The Space Solutions trademark label has been set up as a marketing opportunity for companies producing systems, products, and services that are using space technologies and or services made available through space programmes.[25]

As already indicated in the introductory chapter, space research focuses on developing and perfecting technologies and processes to unprecedented levels to provide reliable service during year-long space missions, with little possibility for maintenance and corrective intervention. Often this results in leading-edge technologies for which ESA takes out patents. Although a new technology is most often developed in response to a single specific need, once created it may have multiple divergent uses. The transfers from space have helped companies and other actors to improve in a wide variety of domains, such as in industrial production, instrumentation for medical fields, efficient transportation, water recovery, waste management, artificial intelligence, safety and security, and many more.

Apart from its mission to oversee and direct the development of Europe's space capability, ESA has an inherent responsibility to arrange and facilitate space spin-offs, which contribute to the non-space economy and technological infrastructure in ESA member states. As new technologies, systems and processes are continuously being developed for ESA space programmes, many of these have potential non-space applications. ESA's Technology Transfer Programme works on making space technologies available for such non-space applications to the benefits of European citizens and to strengthen the competitiveness of the European industry. At the heart of this system is an agile and specialist transfer and incubation network, connecting and enabling businesses and entrepreneurs across Europe.

3.1 ESA Technology Transfer Programme Office

The ESA Technology Transfer Programme Office (TTPO) provides space solutions from space, down to Earth. Since the early 1990s, TTPO has promoted space technology spin-offs for terrestrial uses across a wide range of activities. The TTPO has the overall responsibility for the TT process at ESA.[26] The main mission of the ESA TTPO is to facilitate the use of space technology and space systems for non-space applications and to further demonstrate the benefit of the European space programme to European citizens. The TTPO is responsible for defining the overall approach and strategy for the transfer of space

[25] ESA, "Space solutions", www.esa.int/Our_Activities/Space_Engineering_Technology/Space_solutions/Space_solutions2, retrieved: 25 April 2019.
[26] ESA, "Our future in the space age", www.esa.int/Our_Activities/Space_Engineering_Technology/TTP2/Our_Future_in_the_Space_Age, retrieved: 24 April 2019.

technologies including both the broker network (TT intermediaries) and the incubation of start-up companies (TT facilitators).[27] It is part of the Systems, Software and Technology Synthesis Department in the Agency's Directorate of Technical and Quality Management. ESA's Technology Transfer Program Office (TTPO) has established initiatives for space technologies to be identified and adapted for non-space use that result in commercially viable products and high potential companies. As shown throughout the previous chapter, new products can be developed by brainstorming potential application ideas based on ESA patents and by building a business model around it. Apart from intellectual property right protection, this process involves networking, business incubation and entrepreneurship. These will be illustrated through the description of ESA TT intermediaries and facilitators, accompanied by a case study of Polar Developments at ESA BIC Madrid, and by the business concept of Astrolympia.

The TTPO has established multiple initiatives for space technologies to be identified and adapted for non-space use that result in commercially viable products and high potential companies. Two major initiatives will be discussed, one can be categorised as a TT intermediary, the other as a TT facilitator.

3.1.1 ESA Technology Transfer Network (TT intermediary)

In the introductory chapter, the importance of TT intermediaries was already described by highlighting the role of networks of innovators to stimulate innovation. With regard to the TT process of ESA, the role of the TT intermediary is fulfilled by the ESA Technology Transfer Network (ESA TTN). It consists of brokers across Europe who are working to identify innovative uses for technology developed as part of the ESA space programme. The ESA TTN thus functions as a matchmaking service to help non-space businesses to find cutting-edge space technology they might never have thought of using. The TTPO works to share the benefits of ESA R&D, and with this TTN it is able to stimulate the TT process by promoting the endless supply of opportunities present in ESA's space programmes.

The ESA TTN is managed by Verhaert, a Belgian company. In 2016, based on an international tender procedure, ESA awarded a contract to this company to become prime broker in its TTN.[28] The implementation of the TT initiatives throughout the ESA member states, such as the network of technology brokers and incubation centres, was thereby placed under supervision of Verhaert. This contract emphasised the increasing importance of professionalising TT and ensured extra efficiency of the investments in aerospace. With this contract, Verhaert gained a leading role in Europe with respect to space TT, and has become a major partner for the management and operation of incubation and acceleration programmes in that regard. The company now finds itself in a unique position to stimulate product innovation on a European level, by forming a bridge between the space and non-space industry, or between large corporations and the start-up community based on technology incubation and acceleration services. In total, the ESA TTN consists of 15 individual brokers. In order to initiate a TT, these brokers identify local opportunities and assist local industries and start-ups to apply ESA technology.

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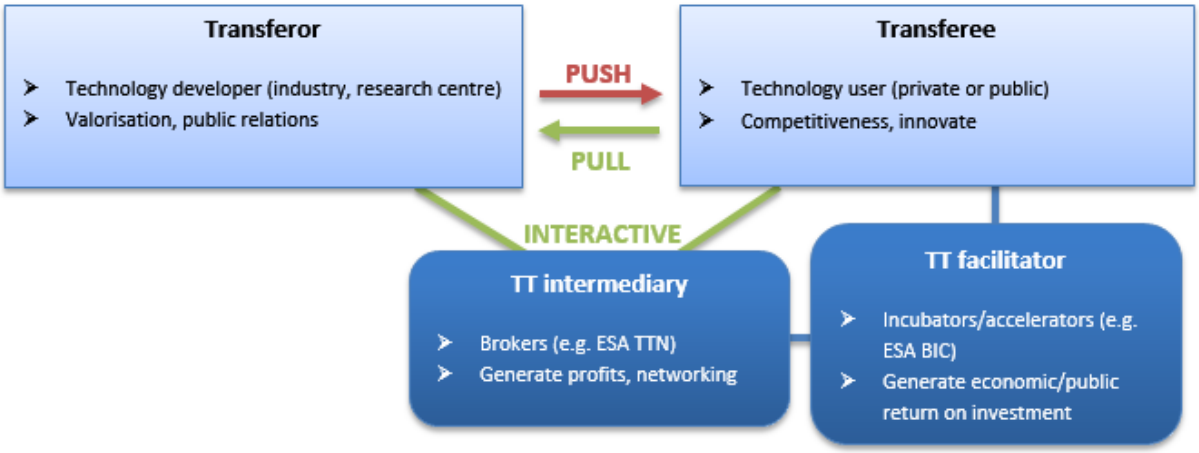
[27] Anonymous, "iOpener Online Gaming Company Financed Through ESA Anonymous European Science and Technology Review", ProQuest Central, *ESTR*, 2008, 10.

[28] S. WAES, "Minister Sleurs witnesses contract award by ESA to Verhaert", 2016, https://verhaert.com/press-conference-esa-prime/, retrieved: 15 May 2019.

The main purpose of technology brokers is to initiate or stimulate the transfer process. They hunt for technological needs of non-space markets and scan the space market for technologies and services to match those needs. The space technologies are then marketed to the identified market sectors to improve non-space applications and services or even to create a whole new product.

Verhaert has developed a specific approach and programme for this purpose: TechXfer. This programme differentiates from the classical approach for technology valorisation by diverging from a technology push model to a user-focused pull model or interactive model. As already mentioned in the introduction, a technology push model starts from a newly developed technology, which is then offered for new applications. However, instead of starting from a certain technology, a user-driven approach is much more efficient. By identifying industrial needs, new applications and business opportunities are enabled, and suitable space technologies are made available to the rest of the European industry. In order to identify such user needs, events are regularly organised. This way, a potential user with a certain need can meet and connect with the space business community, where a fitting solution may be present. This proactive approach to search for requests and specific needs, while matching them with space technologies that could offer a solution to those terrestrial needs, creates a complete chain of technology valorisation ranging from opportunity creation (scouting, workshops and events), feasibility research (consultancy), and ESA funding for demonstrators to develop prototypes (open calls). Yet, this Techxfer approach is not purely based on the pull model. More accurate would be to describe it as a hybrid model since it is mixing up the push and pull models and is based on proactive and interactive elements. With this TechXfer approach, innovative applications of space technology are enabled in different market segments on Earth. Aside from their networking service, it is thus possible that brokers also provide support similar to that of a TT facilitator. This will be illustrated further in the chapter on ESA Space Solutions Belgium.



As part of the ESA TTN activity, a Technology Forum is also maintained.[29] This is an online database where requests for technologies are matched with available space technologies. The forum works in both ways, as requests for technologies can be launched, and solutions can be offered by promoting technologies, services or know-how. The forum still serves as a source for inspiration but is now less frequently used. Other platforms, such as the ESA Open Innovation Space Platform are more commonly used these days.

[29] ESA, Technology Forum, www.esa-tec.eu/, retrieved: 25 April 2019.

3.1.2 ESA Business Incubation Centres (TT facilitator)

It is a tough challenge to make the leap from an initial idea to a fully-fledged, financially viable company. Therefore, next to intermediary actors, facilitators provide necessary business and technical support. To boost the development of newly-founded enterprises, the ESA TTPO has established TT facilitators to assists young companies in acquiring early stage and seed funding by training them for investment readiness and putting them in touch with venture capitalists.[30]

In 2003 the ESA Business Incubation Centres (ESA BICs) were initiated. As a TT facilitator, ESA BICs broaden the market for space technology by supporting the creation of start-ups whose business idea derives from space technologies or systems. During the early stages of the incubated companies, ESA BICs provide critical resources such as access to engineering and support from ESA experts. Moreover, ESA's pre-seed funding enables start-ups to develop proof of concepts in order to get investors on board. The ESA BICs are located in 17 member states. The only member states without BICS (for now) are Luxembourg, Romania, Greece, Denmark and Poland. However, in total there are 20 different BICs. This is because some member states (Germany, France, and Spain) have established two ESA BICs on their territory.[31] These 20 ESA BICs are forming the largest ecosystem in the world for space-related entrepreneurship, with an impressive number of 700 start-ups fostered throughout Europe. Spread over more than 60 cities in 17 countries, more than 300 start-ups are currently under the two-years BIC programme, with another 180 taking in yearly.[32] Moreover, with the plans for ESA BIC Africa the ESA BIC network is about to expand outside Europe. The aim of introducing ESA BICs in Africa is to support regional technology development, spin-offs, and access to European-based satellite infrastructure. Space technologies are already being used across the African continent for infrastructure development and satellite data for extensive socio-economic benefits, spanning from disaster monitoring to military surveillance, telecommunications services, education, weather studies and scientific experiments.[33]

ESA BICs have open calls for proposals, which means that applications can be submitted at any time. Application procedures always include similar documentation, such as the Business and Activity Proposal accompanied by several templates. In the following paragraphs, a general overview on the benefits, requirements, application procedure, and evaluation criteria, will be given. The purpose of this overview is to come to a comparison between the space TT initiatives of ESA and the EU (which will be discussed in the next chapter). The overview for ESA BIC will be drawn from the documentation that applicants need to fill in, as well as from information gathered from ESA TTPO experts. However, it is important to keep in mind that the extent and modalities of the support provided in practice is negotiated on a case-by-case basis. Moreover, small differences can occur between different ESA BICs,

[30] ESA, "Down to Earth, How space technology improves our lives", Technology Transfer Programme, 2009, 5.
[31] ESA, ESA Business Incubation Centres, www.esa.int/Our_Activities/Space_Engineering_Technology/Business_Incubation/ESA_Business_Incubation_Centres12, retrieved: 13 May 2019.
[32] ESA, "Thirteen innovations from succesful ESA BIC Madrid start-ups", 2019, www.esa.int/Our_Activities/Space_Engineering_Technology/TTP2/Thirteen_innovations_from_successful_ESA_BIC_Madrid_start-ups, retrieved: 15 May 2019.
[33] Space in Africa, "How ESA Business Incubation Centre could help boost commercial space innovations in Africa", 2019, https://africanews.space/how-esa-business-incubation-centre-could-help-boost-commercial-space-innovations-in-africa/, 28 May 2019.

depending on specific national and site conditions. Therefore, some of the existing variations will also be illustrated during this description.

a) Formal requirements

There are several general application requirements in order to be eligible for an ESA BIC application. First of all, it is required that the applicant's product, service, or process, is based on a transfer of space technology to, and/or utilisation of a space system in a non-space environment (spin-off), or exploitation of non-space technology in the space market (spin-in).

ESA BICs clearly aim for local, early stage start-ups since a company must not be older than five years. Furthermore, the total amount of de minimis aid (state aid such as subsidies, holdings, loans, and bonds) may not exceed €200 000 over a period of three years. Moreover, the start-up has to be located in an ESA membership member state (or Canada, which has a Cooperation Agreement with ESA), and managed from the offices of the preferred ESA BIC. Although the overall aim is to support start-ups, some ESA BICS allow a natural person to apply, but it is only possible for a citizen (above the age of 18 and able to enter into a binding agreement) to apply, if that person is going to start a new company. For instance, in Belgium, if the applicant has not established a start-up at the time the application is submitted, the applicant shall consent to register as a company within three months following the acceptance of the proposal. While in Sweden, one has to set up and register a company prior to the start of the business incubation, and the authorized representative of the applicant must become a resident of Sweden before signing an incubation contract. Another slightly different rule applies in ESA BIC Madrid, where it is required that the applicant's company is registered in the Community of Madrid, in one of the four locations of the ESA BIC Madrid Region, no later than 6 months after its incorporation into the programme.[34]

A common rule among all ESA BICs is that it is not allowed for the applicant to be hosted in another business incubator, entity or organisation providing similar support, for the duration of the incubation contract. The Applicant must also be able to communicate in English, and is liable for any misrepresentation during the application procedure. Finally, the incubation period is always limited to a maximum of 24 months.

b) Benefits & support

Every ESA BIC offers to support projects and ideas by providing funding, business support, technical assistance, office accommodation, and services. First with regard to funding, as a general rule the financial support granted by an ESA BIC (partly governmental, partly ESA funding) to one project is around €50 000. Typically this financial support is sliced in two, with the €25 000 from ESA to be spent on technical development or on intellectual property protection related costs, while the other half, coming from the particular government has to be spent on rent and on marketing, consulting, intellectual properties and external services. Next to this funding, an extra loan up to €50 000 from local banks is also common. The ESA BIC funding is meant to cover expenses with third parties

[34] ESA BIC Madrid, www.madrimasd.org/emprendedores/esa-bic-comunidad-madrid/documentacion, retrieved 13 May 2019.

regarding product development and intellectual property protection. Incubatees are not allowed to use it for reimbursement of their own hours spent in the project. Again, the details can be somewhat different according to each specific ESA BIC. For instance, in ESA BIC UK the incentive is set to a maximum of £41 500, covering costs incurred for the development of products, prototypes, software and intellectual property rights. Within this overall amount, a maximum of £5 000 may be allocated to market research activities. [35]

Second, the business support usually includes advice and coaching for business development with regard to marketing, implementation strategies, market studies, search for investors, etc. Networking opportunities through access to the ESA Space Solutions community, such as workshops and events, are also an important asset.

Next, the technical support includes software and product development and typically goes up to 80 hours. However, this can also be capped lower, such as the maximum of 40 expert hours for prototyping and technical development in ESA BIC Bavaria, Germany. ESA resources and expertise can be very valuable, since they know the space technology best. Furthermore, ESA BICs are strategically located near prospering science and innovation campuses. Office space, and test facilities are also important assets for the development of start-ups.

Finally, specific advice and services are given with regard to various aspects, especially intellectual property rights. This does not only include access to intellectual property, such as ESA patents for commercialisation, but also enables the use of the prestigious ESA Space Solutions brand, which is highly valued by investors.

c) Application procedure

Applicants need to fill in a Business & Activity Proposal. This proposal should contain around 30 pages (with the proposed incubation activities to maximum 10 pages, the business plan to maximum 25 pages, and additional annexes to maximum 15 pages), with an Executive Summary limited to 1 page. This document always consists the following information. The first and second part contain a cover letter to introduce the applicant and to officially agree to the terms and conditions of the contract. The third part contains the executive summary, which describes the business idea and its implementation, explains the ESA BIC investment opportunity (motivation and requested support), and states the goals on short-term and long-term. The fourth and core part covers the same aspects in more detail. Most important are the following elements: business model (supply chain, production, and distribution), strategy (market approach, and strategies with regard to marketing and sales), a risk analysis (barriers, competition), finance (assets, liabilities, profits and losses), and activity proposal (all kinds of scheduling, requested amount of hours of technical support, requested business support).

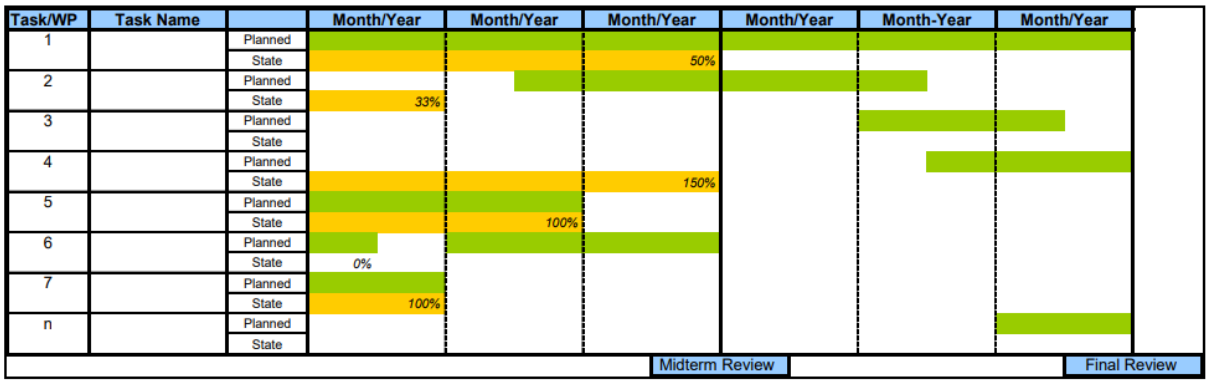
[35] ESA BIC UK, https://stfc.ukri.org/innovation/our-facilities-and-services/european-space-agency-business-incubation-centre-uk/, retrieved: 9 May 2019.

d) Evaluation criteria & follow up

ESA and its local partner first assess the admissibility of the applicant's proposal. Evaluation procedures are carried out jointly by ESA and its local partner, and is thus again slightly dependent on the ESA BIC at hand. In case the proposal is compliant with the formal requirements, applicants will be invited to hold a presentation of the proposal in front of the specific ESA BIC evaluation board. This joint evaluation board between ESA and its local partner, meets quarterly or tertiary to evaluate the proposals received in the preceding three or four months. The maximum period between receipt of a proposal and contract placement is in principle no longer than 6 months (e.g. ESA BIC Austria, Belgium, UK), but can also be set shorter (e.g. 4 months in ESA BIC Noordwijk and Sweden).[36]

In general, beside compliance with ESA general and ESA BIC specific formal requirements, the evaluation of an application, both the written proposal and the presentation, shall be based on the way the following criteria. First, weighing for 25%, background and experience (consisting of different elements such as team composition, support entities, and vision). Next, technology for 20% (which includes space connection, technical feasibility of the product/service to be developed, product development strategy, and intellectual property strategy). Then, value proposition and market for 20% (value proposition, market, competition). Business modelling and risk for 15% (revenue model, finance, and risk). Finally, the activity proposal for 20% (quality of the business application, scheduling of milestones, cost planning, work break down, management, and ESA BIC investment opportunity).

When an applicant is accepted, a midterm and final review will take place. Again, templates are provided by the ESA BIC in order to gather the required information. During the midterm review, the incubatee documents in detail the status of its technical and commercial progress in relation to the activity and delivers a pitch to introduce the business concept to a potential new audience. Furthermore, an overview is given of the expert hours used and needed, as well as of the major challenges ahead. A progress status is also given with regard to costs, tasks and objectives. During the final review, at the end of the incubation period, the incubatee will render a complete statement of all the work undertaken during the incubation period, and shall detail the progress and full results such as lessons learned, details of the received support, established contacts, technical and financial developments, and intellectual property rights.



Template of an incubation planning overview in the ESA BIC Belgium Proposal Template.

[36] ESA BIC Austria, www.esa-bic.at/bic-open-call/, retrieved: 9 May 2019; ESA BIC Noordwijk, www.sbicnoordwijk.nl/esa-bic/, retrieved: 9 May 2019; ESA BIC Sweden, www.esa-bic.se/howtoapply, retrieved: 9 May 2019.

3.1.3 Case study

a) Polar Developments

First of all, the connection with Polar Developments illustrates the opportunities of networking. At the end of the ESA Technology Transfer & Innovation Workshop week, I explained my own business concept (see Astrolympia) to several ESA TTPO experts. They were very supportive and brought me into contact with Polar Developments, since they knew that the company was working on the basis of the same patent at ESA BIC Madrid. This connection was, from an entrepreneurial perspective, very interesting because of the complementarity of interests with Polar Developments. They appeared to have excellent technical capacities, but still required new applications to strengthen their business concept, while I had a business idea but no real resources or technical capabilities.

Furthermore, some insights and thoughts on the incubation process were gathered during several teleconferences with the Chief Technology Innovation Officer (CTO) of Polar Developments. Overall, he appeared to be satisfied with the ESA BIC's approach. The procedure was perceived as systematic and complete, not only evaluating technical, but also financial and business aspects. Apart from technical optimisation of their product, the core added value of ESA BIC Madrid, in his opinion, was in the business support. This can be explained by the fact that the start-up already had a strong technical background, with relevant experience from other ventures such as from Comet Ingeneria, while more market oriented directions were somewhat lacking. Although the business support of ESA BIC does not guarantee success, according to the CTO it should in any case be enough to evaluate whether a business concept is credible enough for a company to survive. Furthermore, the importance of networking was highlighted. Especially the experience of ESA, the access to facilities and local agents, and the support given by the government were said to be very helpful. It was also examined whether some barriers, complicating the procedure, occurred. This seemed not really the case since the support and partners make things easier. However, the CTO assured that a lot of work is required in order to be successful during the ESA BIC process. The documentation load in particular can be very demanding and time consuming. With regard to ESA's intellectual property, Polar Development gained a free license until the product would be fully developed and sales could take off. The CTO was also enthusiastic about the region-specific features of ESA BIC Madrid, because there are four different sites located at four universities in Madrid. The different universities obtain diverse support and this provides the opportunity to interconnect with more actors instead of a single concentrated, but maybe also more isolated centre.

Finally, the question was raised what the most important benefits were that an ESA BIC has to offer. In his answer, he mentioned: access to facilities, networking advantages, and business advice. The latter was specified as showing ways to boost one's business, rather than doing it for the incubatee as a service. Of course the funding is also very useful, Polar Developments is mainly spending this on dedicated manpower, engineering subcontracting, and demonstrators manufacturing. Connected to this question, if there had to be made suggestions to improve the ESA BIC process, the only thing that the CTO put forward would be to minimise the documentation load as much as possible. Administration, formalisation, and gathering all the information for midterm and final reviews can be an extensive work package asking valuable time.

b) Astrolympia

As already mentioned, the networking with some ESA TTPO experts opened up contacts with Polar Developments. A fruitful connection, since this Spanish start-up showed interest and already made some designs for a product based on the business idea for Astrolympia. Rather than immediately trying to go through the incubation process and registering a company, cooperating with this already incubated Spanish start-up was a logical and less costly move. Aside from network opportunities, this also shows that applying for ESA BIC already requires some level of development. For an individual in idea phase, directly applying for an ESA BIC is not evident. Instead, one needs to develop a strong business proposal first, with a competent team, and sufficient planning and studies.

A good tool to measure the state of development is the Innovation Readiness Level (IRL). It is a similar concept to the Technology Readiness Level (TRL) but instead of describing the state of technology, the IRL gives an indication, on a scale from 1 to 9, of the business development stage. IRL 1 means idea phase, where there is only the intention to translate an idea into a business. It then goes gradually up as a business concept is formulated when more studies and analyses are performed (IRL 2), to experimental evidence (IRL 3), development of components and business planning (IRL 4), component integration and credible business plan (IRL 5), prototyping with full business plan (IRL 6), limited production and revenues (IRL 7), towards transition to full production and distribution (IRL 8), until full scale operations become possible (IRL 9). If this is applied to Astrolympia, where the initial idea has been transformed into a modest business concept, it becomes clear that the IRL is not higher than 2. This means that the value of innovation is still very low, probably too low for acceptance to an ESA BIC.

Lastly, during the hunt for opportunities in the development of my own business concept for Astrolympia, ESA Business Applications came across. This initiative helps companies to integrate space data and technology into commercial services.[37] Although interesting as a TT facilitator, ESA Business Applications mainly focusses on the use of space-enabled data, which falls outside the scope of this thesis research. Nevertheless, this initiative was explored because of a tender, "Space4Sport Kick-Start", which seemed to be particularly interesting for the business concept of Astrolympia.[38] Therefore, in the following paragraphs the ESA Business Applications initiative will be explained briefly, and its relevance for Astrolympia will be discussed.

For a limited period of 6 months, ESA Business Applications initiative offers 4 major benefits: funding (ranging from €60 000 to more than €2 million per activity), a personalised ESA consultant with tailored technical and commercial guidance, access to an extensive network of partners, and credibility of the ESA brand. However, in order to be eligible, there some general requirements. First, residence is required in an ESA member state that subscribed to the ESA Advanced Research in Telecommunications Systems (ARTES) programme dedicated to downstream applications, and namely the Integrated Applications Promotion and the Competitiveness and Growth Application Segment. (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Portugal, Romania, Sweden, Switzerland and the

[37] ESA Business Applications, https://business.esa.int/, retrieved 14 May 2019.
[38] ESA Business Applications, Space4Sport Kick-Start, https://business.esa.int/funding/invitation-to-tender/space4sport-kick-start, retrieved 14 May 2019.

United Kingdom). Furthermore, in order to obtain funding from ESA, the applicant company needs to be registered in the ESA's online System for Tendering And Registration (ESA-STAR) system.

Applications to ESA Business Applications are open all year and can be done in two different ways. First, it is possible to directly apply, with a project from any industry, through the open call for proposals. Projects accepted through this process are funded by ESA for 50%. Another option is to apply to the competitive tenders listed on the official website. Every few weeks, new themes for competitive tenders, or Kick-start Activities, are opened, and proposals can be submitted in response to one of such regular open competitions.[39] These are directed at a specific problem or opportunity. Each application received is assessed in competition with other proposal applications. Accepted projects are funded by ESA for 75%, up to €60 000. The remaining budget may come from different sources (own funding, profits, investors, bank loan, etc.), in order to show cash flow within company and to prove availability of sufficient resources. For the Kick-start Activities, the application process has also been streamlined, and paperwork has been minimised to a single document of maximum 20 pages, combined with a rapid evaluation process, with approved activities starting within six weeks from evaluation.

With regard to the "Space4Sport Kick-Start", a clear link and interest was observed for Astrolympia. Through a webinar, more information was then gathered to explore whether the business concept of Astrolympia was compatible with ESA Business Applications.[40] However, several issues were identified. For instance, it appeared that Spain did not subscribe to the ARTES programme, which would complicate the cooperation with Polar Developments, since it is based in Madrid. A solution would be to establish a legal entity on the territory of one of the participating states (most probably Belgium), but this already requires some investment. Even in the event that Spain would be a participating state, it would still be difficult to team up with Polar Developments, because overlaps between different ESA funding programmes (for example with ESA BIC) should be avoided. Moreover, a large part of the business concept seemed not compatible with the focus of ESA Business Applications on satellite data, since services should use one (or more) of the following space assets: satellite navigation, satellite communication, Earth observation, and spaceflight technologies. The use of the structural technology behind satellite infrastructures does not cover such assets. Only with regard to spaceflight technologies a link could be obtained. For human spaceflight, the Space4Sport Kick-Start Activity proposal mentions the development of space telemedicine capabilities with applicable elements such as technologies, health sensors, procedures and best practices developed for astronauts. In this regard, a potential link could be drawn with the aspect of Astrolympia that focusses on sports health and medicine. However, it is unsure whether this would suffice, since the Kick-Start Activity illustrates the application of sports medicine as data collection, transmission and analysis allowing medical personnel to provide tailored advice regarding the sport programme to be followed. Furthermore, the barrier to establish a legal entity in a participating state remains, and with only 75% funding by ESA, finding additional resources poses an extra challenge. Overall, after exploring the ESA Business Applications initiative in more detail this TT facilitator turned out less suitable, at least on a short term, for Astrolympia than appeared at first sight.

[39] ESA Business Applications, Kick-Start Activities, https://business.esa.int/news/kick-start-activities-new-funding-opportunity-for-innovative-applications-ideas, retrieved: 14 May 2019.
[40] Space4Sport Webinar, 7 & 14 May 2019.

4. EU Horizon 2020

In contrast with its global leading position in science, Europe lags behind in bringing innovative ideas to the market. Many European start-ups have difficulties to make it beyond the critical first few years, and many of them leave Europe. With Horizon 2020 (H2020), the European Commission wants to give innovative companies better opportunities to become world leading enterprises. H2020 is implemented by the European Commission as the eighth framework programme, funding research, technological development, and innovation. It is an instrument for investments in research and innovation that is implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. In addition to the private investment that this money will attract, it promises more breakthroughs, discoveries and world-firsts by taking great ideas from the lab to the market. Seen as a means to drive economic growth and create jobs, the goal of H2020 is to ensure Europe produces world-class science, remove barriers to innovation and make it easier for the public and private sectors to work together in delivering innovation. H2020 is the biggest EU research and innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020).[41] The programme will be succeeded by Horizon Europe, which will continue the research and innovation programme with a budget of €100 billion for the period between 2021 to 2027.[42]

The European Commission opened up H2020 to the rest of the world, as participants regardless of their place of establishment or residence can join in most of the calls of Horizon 2020.[43] Furthermore, associated countries participate in H2020 under the same conditions as EU Member States. There are 16 countries associated to H2020 (Iceland, Norway, Albania, Bosnia and Herzegovina, North Macedonia, Montenegro, Serbia, Turkey, Israel, Moldova, Switzerland, Faroe Islands, Ukraine, Tunisia, Georgia, and Armenia).[44]

H2020 contains different sections.[45] One of these sections is Industrial Leadership, whereby space research is directly targeted. The commission's purpose is to prepare for the increasing role of space in the future and to reap the benefits of space now. The overarching objective is to contribute at the European level, in conjunction with member states and ESA, to the safeguarding and further development of a competitive and entrepreneurial space industry. This implies enabling advances in space technologies from idea to demonstration in representative terrestrial environments and in space.

[41] European Commission, "What is Horizon 2020?", https://ec.europa.eu/programmes/horizon2020/en/what-horizon-2020, retrieved: 3 April 2019.
[42] European Commission, "Horizon Europe - the next research and innovation framework programme", https://ec.europa.eu/info/designing-next-research-and-innovation-framework-programme/what-shapes-next-framework-programme_en, retrieved: 26 May 2019.
[43] European Commission, "Participant Portal H2020 Online Manuel, http://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/international-cooperation_en.htm, retrieved: 16 May 2019.
[44] European Commission Directorate-General for Research & Innovation, "Associated Countries to Horizon 2020", http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/3cpart/h2020-hi-list-ac_en.pdf, retrieved: 16 May 2019.
[45] European Commission, "Horizon 2020 Sections", https://ec.europa.eu/programmes/horizon2020/h2020-sections, retrieved: 16 May 2019.

4.1 Networks (TT intermediary)

A network of the EU specifically for space TT does not exist. However, more general networks such as the European BIC Network (EBN) and the Enterprise Europe Network (EEN) bring together all kinds of organisations that support the development and growth of innovative entrepreneurs, start-ups and SMEs. These networks provide a certification system for incubators and accelerators, networking opportunities through events and online platforms, and can lead to funding sources.

4.2 COMPET 7: Technology transfer and business generators (TT facilitator)

Funded by the EU under the call "H2020 COMPET 7: Technology transfer and business generator", several TT initiatives have been established.[46] The reason behind the call is to safeguard and further develop a competitive, sustainable and entrepreneurial space industry in combination with a world-class space research community to maintain and strengthen European leadership and non-dependence in space systems. Of key importance for the achievement of these goals are, fostering innovation in the space sector, and enabling space-based terrestrial innovation.

The call was only launched in 2017, when ESA TT initiatives, offering similar space-specific support already existed. The number of space initiatives supporting businesses is only growing in Europe. Most importantly, the ESA and national TT initiatives. However, the EU still recognised a need to continue to inspire entrepreneurs by turning space-related business ideas into commercial endeavours and to further promote opportunities for new and existing start-ups coming from space and non-space sectors.[47]

As a consequence, the objective of this EU initiative is not to support the establishment of more BICs, but rather to provide additional assistance to entrepreneurs and other innovation agents in overcoming financial, administrative and networking barriers. In particular, it should contribute to access public funding opportunities of the EU, as well as other funding opportunities from member states, ESA, and regional authorities. Therefore, these EU initiatives are aimed to be complementary with existing TT initiatives such as ESA BICs.

[46] European Commission, "COMPET-7-2017 - Technology transfer and business generators", https://cordis.europa.eu/programme/rcn/701814/en, retrieved: 17 May 2019.
[47] European Commission, "Technology transfer and business generators", 2017, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/compet-7-2017, retrieved: 16 May 2019; European Commission, "COMPET-7-2017 - Technology transfer and business generators", 2017, https://cordis.europa.eu/programme/rcn/701814/en, retrieved: 16 May 2019.

4.2.1 Astropreneurs

The Astropreneurs Accelerator is an ongoing project, funded under the above mentioned TT and business generator. It only started in January 2018, and will end in June 2020, which means that it is currently over halfway through in its two and half year lifetime. It is a mentoring programme that turns space-related ideas into viable businesses, and promotes opportunities for entrepreneurs coming from the space and non-space sectors.[48] The goal is to select start-ups within space and non-space sectors, to receive support in order to create viable business cases and adopt a faster market approach by mentoring them on business and technical needs, helping them to access private and public funding and overcome financial, administrative and networking barriers standing in the way of success in the commercial phases.

The Astropreneurs consortium consists of 8 partner organisations, most of which are also part of the ESA brokers network, such as Verhaert. Despite this limited consortium, the Astropreneurs Accelerator addresses most of the European countries (20 EU countries), and the contributions of the partners amount up to nearly €2 million. Currently, the Astropreneurs Accelerator includes 80 mentors (limited to 100).

In short, the programme provides networking opportunities, as well as business, technical and indirect funding support. The programme also supports the use of space data, and TT from non-space sectors to the space sector, but these will not be covered, as the research of this thesis is limited to the transfer of technology from the space sector to non-space sectors.

a) Formal requirements

The Astropreneurs project is targeted at start-ups, either individuals (academia, entrepreneurs) in idea phase or already more advanced entities such ESA BIC alumni, and registered SMEs. However, applicants have to fulfil several requirements in order to be eligible to project evaluation. First, the idea should be space-related. Second, applicants have to be located in a EU member state or a country participating in H2020 programme. Non-EU Astropreneurs, if selected, will have to establish a company in an EU country to be eligible before being accepted to the programme. Applicants must also be above legal age and be able to communicate in English. Only one application per individual or company will be accepted.

b) Benefits & support

If the application appears to be successful, a project manager will be assigned to each Astropreneur. The project managers guides the Astropreneurs through the mentoring programme. The first step is the signature of an agreement between the selected start-up and a partner organisation. Then, the project manager performs a needs assessment with regard to the market and funding needs of the start-up, and defines an action plan in order to assign a single or group of mentors to match the

[48] European Commission, "Turning space-related ideas into viable businesses and promoting opportunities for entrepreneurs coming from space and non-space sectors", https://cordis.europa.eu/project/rcn/212903/factsheet/en, retrieved: 16 May 2019.

objectives of each start-up. After that, the successful applicants will be entitled to the 50 hours of mentoring from Astropreneurs mentors and experts, over a period of roughly 6 months. Originally this term was 3 months, but the Astropreneurs team asked the European Commission to extend that term because of practical reason (mentor availability, external connections, time schedules, etc.). The support includes business and technical mentorship. It also provides access to the space economy Astropreneurs network of investors, industry and supporting agencies, with workshops and initiatives aimed at a wider audience to address private and public funding opportunities, but also to overcome the financial, administrative and networking barriers to the market.

The Astropreneurs project is especially beneficial for networking opportunities. It holds a database over 20 EU countries covering 1194 organisations; 849 Entrepreneurs, start-ups, SMEs, investors, and other relevant innovation stakeholders; 199 Incubators and other relevant infrastructures; and 146 Acceleration programmes and other initiatives fostering innovation and entrepreneurship.

c) Application procedure

All mentoring will be completed in June 2020. Meanwhile, applications can be submitted through open calls at any time, but evaluations of applications only take place after 6 closing dates.

To start the procedure, applicants have to create a start-up profile on F6S. This online platform is home to over 800 000 start-ups and more than 10 000 start-up programmes globally, and provides founders the opportunity to apply to accelerators, pitch for investment, and post or apply for jobs. On this forum, all the necessary information for the Astropreneurs application can be submitted. First, a description of the current state of business is required. Next, the mentoring needs have to be identified and described. The remaining part is about the business application information. First of all, this includes an explanation of the business idea itself, a clarification of the space connection of the business idea, followed by a motivation of why the applicant wants to become an Astropreneur. Finally, the applicant has to describe how the Astropreneurs support would help to achieve the objectives with regard to the business idea. Additionally, the applicant may also upload an annex file to illustrate the business concept, prototypes, etc.

d) Evaluation criteria & follow up

Once an application has been reviewed against the eligibility criteria, each application will be assessed based on the information supplied in the application. Results and any feedback are communicated with 4 weeks of the closing date.

The evaluation is made by the Astropreneurs team and independent experts. Applicants have to score a total of 60 out of 100 points to be eligible to join the Astropreneurs Space Accelerator. If in any criteria the score is zero points, the application will be immediately rejected, and fewer projects may be selected if there are not enough quality proposals.

The following scores and set of criteria and sub-criteria are used by the Tender Evaluation Board to award a score for each application:

With regard to the business idea, 30 points: a) Value proposition: the clear added-value to the costumer; b) Market: market credibility and prospective customers identified; c) Competition: competitors and substitutes on the market and proposed business positioning, marketing and sales strategy.

For the space connection of the business idea, 30 points: a) Space connection: clearly identified, well described and credible; b) Technical feasibility of the product/service to be developed c) Product development strategy: if the IRL is low, clearness of the R&D strategy; d) Intellectual property strategy: actions/plans to protect the idea and/or to secure the use of a third party technology.

The motivation to be an Astropreneur is counting for 20 points: a) Vision: clear and feasible long-term and short-term vision; b) Experience and team composition: evidence of appropriate experience and (prospective) entrepreneurial skill set. In case of an existing team: roles complementarity. In case of an incomplete team, clearness of the composition plan; c) Expected results: expected achievements with the participation in Astropreneurs Space Start-up Accelerator; d) Commitment: applicant capacity and resources to undertake the mentoring programme.

The last criteria is about expectations and the way the applicant will use the Astropreneurs support to achieve business objectives, and counts for the remaining 20 points: a) Adequacy: the mentoring programme delivers the support highlighted and required by the applicant; b) Added value: identify the added value to the business concept/idea; c) Sustainability: capability to take the mentoring results forward after completing the programme.[49]

If the application appears to be successful, a memorandum of understanding between the start-up and the Astropreneurs project will clarify the rights and obligations of both parties. The programme aims for an acceleration period of 3 months, but this can be longer depending on the selected Astropreneurs' needs, to scale up the initial business idea of the applicant and in order to capitalise target markets and global opportunities. Finally, every 6 months until 30 June 2020, selected Astropreneurs should give updates on the number of received mentoring hours, number of applications for funding, as well as deliverables and results from the mentoring programme.

4.2.2 SpaceUp

The SpaceUp project started in June 2018 and will last until May 2021. It is actually a sister programme of the Astropreneurs project.[50] On the basis of a memorandum of understanding, both projects cooperate by exchanging strategies, invitations to each other's event, trainer workshops, and students taking part in the Space Academies after having been through the Astropreneurs mentoring programme.[51] Compared to the Astropreneurs project, it is running half a year later, but with a lifespan of 3 years, it is also lasting longer. Just like the Astropreneurs project it is funded under the TT and

[49] Astropreneurs, "Call for Startups: Notes and Guidance for Applicant Startups", https://astropreneurs.eu/wp-content/uploads/2018/06/Astropreneurs_Call_Startups_Guidance_ver1.0_FINAL_20180604.pdf, retrieved: 17 May 2019.
[50] SpaceUp, "SpaceUp Newsletter #1", 2018, https://mailchi.mp/e35b9768c97e/spaceup-newsletter-90671?e=2ce8e87117, retrieved: 19 May 2019.
[51] Astropreneurs, "Astropreneurs & SpaceUp signed a MOU to collaborate2019", https://astropreneurs.eu/astropreneurs-spaceup-signed-a-mou/.

business generator call of H2020. SpaceUp can be seen as a follow-up programme providing additional training to enlarge and scale up start-ups that successfully completed other TT initiatives such as ESA BIC or the Astropreneurs project. The overall objective of SpaceUp is to contribute at a European level to the safeguarding and further development of a competitive and entrepreneurial space industry.[52]

The SpaceUp consortium consists of 9 partner organisations, with 2 coming from Belgium (European Business Angel Network and SME4Space VZW). Just like the Astropreneurs Accelerator, the contributions of the partners amount up to nearly €2 million.[53]

With 6 European Space Academies, SpaceUp promotes TT through networking, outreach and matchmaking with investors. Its experts offer advice on how to best profit from the opportunities of other initiatives of the EU and ESA. As already mentioned SpaceUp builds on activities carried out by Astropreneurs, but also by ESA BICs, aiming for further commercialisation of ESA BIC alumni. At the same time it reinforces the spin-off (and spin-in) efforts of ESA through enhancing connections and networking with non-space technology experts, e.g. in marine, logistics, land-use and security.

a) Formal requirements

SpaceUp is specifically targeting European companies with a strong team and established business, that already received seed investment from accredited investors, but still need scaling. Entrepreneurs in earlier stages are not suited for the programme. However, it is also clear that the aim is to support start-ups, since participating companies must not be older than 5 years. Finally, there has to be a space connection. Companies have to adopt at least one space technology and/or work with Copernicus, Galileo, or EGNOS data.

b) Benefits & support

Throughout the project lifetime, 6 Space Academies will take place in 6 different European countries. These are mainly networking events for the participating entrepreneurs to look for potential partners. However, customised business services will also be provided to selected companies, as for each Space Academy, the 10 most advanced start-ups will be selected. In total, 60 start-ups will be selected as most advanced start-ups and will benefit from high-level support.[54]

The Space Academy is a two-day event for European space-tech entrepreneurs to accelerate their business. The first day, which is only open to start-ups and coaches, consists of workshops and group sessions where entrepreneurs can improve their skills and get insights from experts on various topics. During this day, all accepted entrepreneurs are welcome to join the Space Academy workshops on different topics (e.g.: Investment readiness, crowdfunding, artificial intelligence, business models, European Space ecosystem), however, only the selected 10 most advanced get additional individual

[52] www.space-academy.eu/.
[53] European Commission, "Assisting European SPACE Start-ups in scaling UP", https://cordis.europa.eu/project/rcn/216072/factsheet/en, retrieved: 28 May 2019.
[54] EBAN, "Participate in the Space Academy, Accelerate Your Start-up on the Road to Maturity!", www.eban.org/participate-in-the-space-academy, retrieved: 28 May 2019.

support and training.[55] The second day of the conference involves panels and keynote sessions with 60 to 100 participants such as space actors, investors, entrepreneurs, and regional industry.

The 10 selected start-ups are then given the opportunity to pitch during 3 minutes to this audience for high-level feedback. Moreover, the 10 selected companies are offered high-level services, starting several months before each Space Academy based on their business plan and needs. Then, during the second day of a Space Academy, these advanced start-ups take part in up to 6 individually selected one-to-one mentoring and coaching meetings. Other benefits are: matchmaking with investors and experts, credit passport (international creditworthiness certificate), feasibility studies on EU public funding, business model analysis, consultancy on human resource matters, intellectual property right analyses, up to €400 reimbursement for eligible travel and hotel costs, access to EBAN Networking App, access to all other workshops and sessions of the EBAN Congress, a chance to compete for special recognition awards and prizes, profile listed in EBAN congress booklets and website, and pre-event visibility in promotional campaigns.

c) Application procedure

The first Space Academy took place in Helsinki, Finland 3-4 June 2019. The registration form was divided into 2 sections. Section 1 was for all applicants who wanted to participate in the Space Academy at their own expenses. Section 2 was for advanced applicants to take part in a competitive selection process to benefit of SpaceUp's high-level support. The last Space Academy is planned for 2021 and will take place in Brussels.

d) Evaluation criteria & follow up

For each Space Academy, only the 10 most viable cases are selected by the SpaceUp Evaluation Committee. This makes SpaceUp an excellent programme for high IRL start-ups that still need scaling to be fully commercially operational.

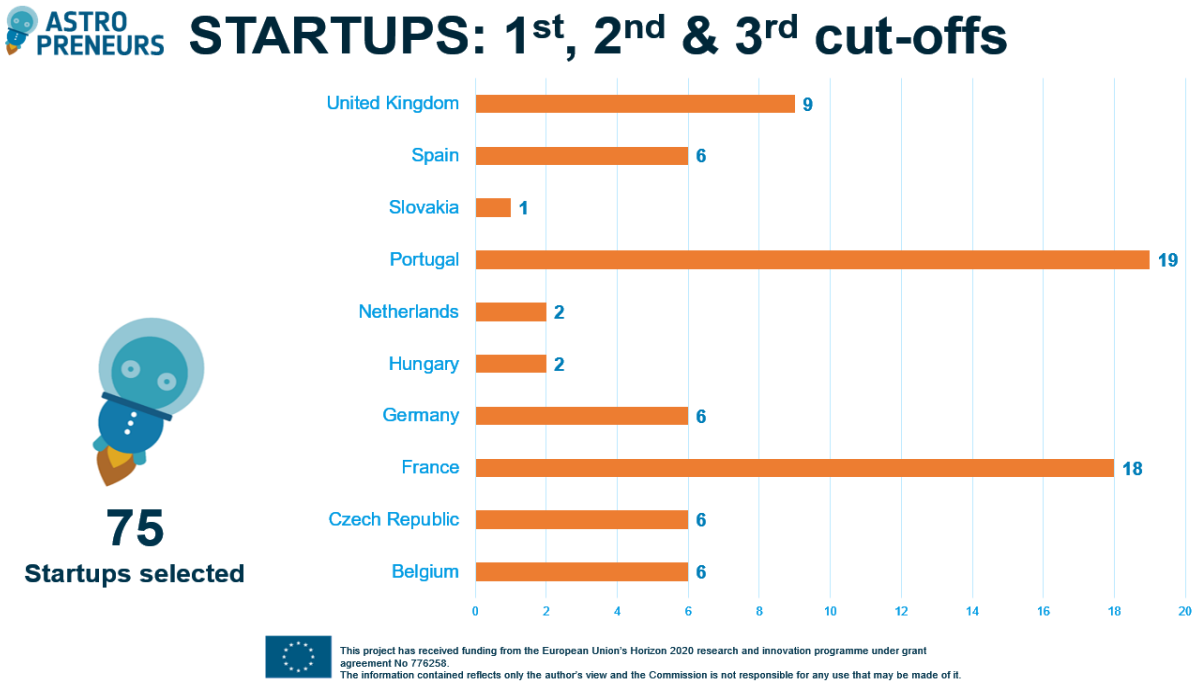
Advanced applicants have to submit a business plan to enable an in-depth analysis and evaluation by SpaceUp experts. The Evaluation Committee evaluates all advanced applicants, with particular emphasis on the company's status, stage of the product or service, and the market strategy. Before each Space Academy, 10 start-ups will be selected.

4.3 Case study

With the business concept of Astrolympia I applied to the Astropreneurs Accelerator before the third cut-off date (11 April 2019). One month later it was announced that my application was successful. So far, 75 Astropreneurs have been selected, and 75 more should be selected over the next 3 cut-offs. Most of the selected Astropreneurs come from a country where one of the partners is located (with the exception of Austria). Aside from Astrolympia, 5 other Astropreneurs are located in Belgium (2 are based in Flanders: one works with artificial intelligence technology on Earth, the other focusses on

[55] EBAN, "Participate in the Space Academy, Accelerate Your Start-up on the Road to Maturity!", 2018, www.eban.org/participate-in-the-space-academy, retrieved: 22 May 2019.

refuelling satellites in space. The remaining 3 are based in Brussels: 2 are working in the Earth observation sector, the other one is specialised in innovative manufacturing technologies).



As already mentioned, the application procedure went via the F6S online platform. Making a profile and going through the application form was not too extensive. The text boxes below each question were restricted in order to keep the answers brief, which kept the process short and clear. The questions were aimed to define the business concept, to explore the state of it, and to explain objectives in order to identify mentoring needs. Furthermore, a big chunk of the questions was about the space connection, the motivation to become an Astropreneur and how the support would be used to achieve the stated objectives. Lastly, the opportunity was given to upload an annex file with extra information. Everything that had not been covered throughout the application was collected in this file. It contained some illustrations, further explanations, and relevant information collected during the ESA Technology Transfer & Innovation Workshop through which a direct link with the engineer behind the patent was shown.

Being a lawyer with no previous experience in entrepreneurship did not stand in the way of convincing the evaluation board to accept me as an Astropreneur with the business concept of Astrolympia. This illustrates the accessibility of the Astropreneurs initiative. Nevertheless, a good business idea is required and acceptance is not guaranteed, since applicants have to score a total of 60 out of 100 points to be eligible to join the Astropreneurs Space Accelerator, and fewer projects may be selected if there are not enough quality proposals.

The F6S forum also allows for the creation of a start-up profile based on the business concept, even when such an entity has not been registered in reality. This gives beginning entrepreneurs a real sense of their initial business idea and opens up opportunities to start looking for partners.

After the Astropreneurs team informed me that Astrolympia was accepted, a project manager was assigned to perform a need assessment in order to define a tailored action plan and to select mentors according to the defined business, technical and/or funding areas. The assigned project manager is

coming from one of the eight partner organisations. In the case of Astrolympia, this is someone from Verhaert, which is very practical since we are both located in Belgium. Thus far, an exploratory action plan has been drafted. This documents includes the term of mentorship (11 June until 11 December 2019), the aims and objectives and summarises the state of activities and requirements. For example, the project manager suggested to do some additional patent scouting in order to capture the most appropriate technology.

Since the mentoring programme starts after the deadline of this thesis, more detailed information regarding this case study is not yet available. However, being part of the Astropreneurs network already proved to be valuable as numerous invitations reached me through the profile of Astrolympia on the online platform of F6S.

Finally, the table below gives a general overview of what the complete process will look like. This process is split in two parts. The first part is of an undefined duration whereby the project manager works out a plan with the Astropreneur according to the need assessment. Once the project manager has selected the suitable mentors, the actual support of around 50 hours can take off. The mentoring programme is scheduled to last 12 weeks. Between week 6 and 8, there will be an assessment of the progress to ensure that the requirements of the Astropreneur are being met. By the end of the programme the objectives, activities and deliverables will be reviewed by the project manager with the Astropreneur and assigned mentors.

Who?	What?	How?	Duration (hours)
Project Manager	Introducing to the startup	Online meetings (or in person if possible)	As needed
	Sign the agreement	Agreement between the partner and the Astropreneur	
	Perform the need assessment	Online meetings (or in person if possible)	
	Define the action plan (including objectives, actions and KPIs)	Action plan	
	Select the mentors	Action plan	
	Monitor the process and KPIs	Online meetings (or in person if possible)	
	Assess the mentoring and report the work done	Report	
	Record time, activities and outputs	Timesheet	
Mentors	Introducing to the startup	Online meetings (or in person if possible)	50
	Revisit the action plan	Online meetings (or in person if possible)	
	Support, guidance, facilitation, feedback and review of the defined action(s)	Online meetings (or in person if possible)	
	Collaborate on the monitoring and validation of the process and KPIs	Online meetings (or in person if possible)	
	Report the work done and KPIs achieved	Report	
	Record time, activities and outputs	Timesheet	

5. Comparison between the ESA and EU space TT programmes

In this chapter, the space TT programme of ESA and the EU are compared. The comparison follows the same structure as in the chapters above, which means that the intermediaries are compared first and facilitators second.

At the end of the chapter, this comparison will be visualised with a table containing an overview of the ESA and EU space TT programmes. Lastly, the *IRL maturity spectrum* at the bottom of that table will give an indication about which programme is best suited for each IRL. For instance, if an individual is only in idea phase of a business venture based on TT, the best option is to apply for the Astropreneurs project. In case this initial idea has already been developed further into an advanced start-up, it becomes possible to compete for the high-level support in the SpaceUp Academies. However, this start-up maturity spectrum is not a strictly fixed chronological order. For example, some start-ups become Astropreneurs after successfully completing the ESA BIC in order to improve pitching or other skills, and it is also possible for early-stage start-ups to join the SpaceUp academies (although they will not be eligible for high-level support). The spectrum thus merely gives an indication for the most suitable space TT initiative relative to the readiness for innovation.

5.1 TT intermediaries

Within the European space sector, both ESA and the EU established space TT initiatives. ESA's intermediary (ESA TTN) and facilitator (ESA BIC) are naturally specifically designed for the space sector. The ESA TTN operates as a user-driven (pull model) matchmaker between space and non-space industries. It consists of brokers who identify opportunities, initiate and stimulate the transfer process with opportunity creation (scouting, workshops and events). Next to networking services, these brokers also assist local industries, on a national level, with feasibility research (consultancy) and ESA funding for demonstrators to develop prototypes (open calls), services that are usually provided by a TT facilitator. This will be discussed further in the chapter on ESA Space Solutions Belgium.

On the other hand, the EU has not a real TT intermediary dedicated to space. However, there are a lot of EU initiatives bringing together all kinds of organisations that support the development and growth of innovative entrepreneurs, start-ups and SMEs.

It is thus interesting to observe that the TT intermediary of ESA (the ESA TTN) has been developed to the extent that it now also provides support similar to that of a facilitator (with open calls for demonstrators, mainly on a national level), while the EU space TT facilitators provide services similar to those of intermediaries. This clearly illustrates that the EU is relatively new to this domain. Taking into account the absence of a dedicated EU space TT intermediary, the EU space TT facilitators can even be considered as hybrid actors, somewhere between the role of intermediaries and facilitators. For now, this setting on the EU level is sufficient. Both Astropreneurs and SpaceUp are new initiatives and introduce the involvement of the EU in the field of space TT. Furthermore, this hybrid structure with strong networking elements makes sense with regard to the positioning on the maturity spectrum, since networking opportunities are of key importance in the beginning of business development, as well as in the final phase of scale-up. For example, during the early phases it is

important to collect info and advice or to assemble a team, while it is important to have publicity and access to investments during the latest stages.

5.2 TT facilitators

The life of a start-up begins with an idea and lots of enthusiasm, coming from an entrepreneur or a team. Entrepreneurs and start-ups have the possibility to find support and mentoring through different space TT facilitators. Incubators and accelerators of ESA and the EU provide space-specific commercial and technical assistance and help start-ups to apply space technology to non-space industrial, scientific and commercial fields (and vice-versa).

For beginning entrepreneurs, founders, and start-ups the Astropreneurs Accelerator provides a mentoring programme. This initiative can be regarded as the most accessible during the early stages of a business concept, since the registration of a start-up is not required to be eligible for the programme and even when selected, Astropreneurs are not obliged to create one. Therefore it is especially suitable for academia in idea phase, or entrepreneurs that want to build a strong business case before applying to ESA BIC or other programmes. The downside is that it does not provide direct funding. Instead, the focus is on spotting funding opportunities, as mentors look for the most adequate EU, national, and private funding opportunities.

The evaluation with regard to ESA BIC is already more demanding, reflected by a heavier application procedure with more documentation. In order to stand a real chance of acceptance, one needs more than a good business idea. A clear execution plan, precise goals and an adequate management team are very valuable. Moreover, the requirement not to be hosted in another support programme illustrates that ESA BIC is a dedicated and complete programme on its own.

For the high-level support of SpaceUp, a high IRL is recommended. It typically builds on activities carried out by ESA BICs, aiming for further commercialisation of ESA BIC alumni.

A final remark is that both ESA BICs and the EU accelerators provide networking opportunities. This is especially true for the latter, since there is no network of the EU dedicated to space TT. The Astropreneurs space economy network is actually functioning as an intermediary. However, instead of screening for user needs, it is more focussed on matching funding sources with its Astropreneurs. With an extensive database over 20 EU countries covering a wide range of relevant innovation stakeholders, the Astropreneurs space economy network is particularly beneficial for networking opportunities. The SpaceUp network on the other hand is mainly targeted towards investors.

<table>
<tr><th></th><th>TT intermediary</th><th colspan="2">TT facilitator</th></tr>
<tr><td>ESA</td><td><u>ESA TTN</u>

➢ User-driven matchmaking between space and non-space industries
➢ Promoting TT:
▪ Opportunity creation (scouting, workshops & events)
▪ Feasibility research (consultancy)
▪ ESA funding for demonstrators (open calls)
➢ Online platforms</td><td colspan="2"><u>ESA BIC</u>

➢ Numbers:
▪ 20 ESA BICs in 17 member states
▪ Over 700 start-ups fostered
▪ Over 300 currently incubated
➢ Benefits & support:
▪ Technical: 80 hours, product development
▪ Business: advice, coaching, studies
▪ Direct funding: €50 000
▪ Networking: ESA Space Solutions community
▪ ESA brand
➢ Requirements:
▪ ESA member state
▪ SME (or establish one within certain period), not older than 5 years
▪ Not hosted in another support programme
▪ De minimis limit
▪ Space connection
➢ Application:
▪ Open call for proposals
▪ In depth 30 page proposal with templates
➢ Evaluation & follow up:
▪ ESA BIC evaluation board
▪ Quarterly or tertiary and decision within 6 months
▪ Written proposal and presentation
▪ Background and experience (25%); Technology (20%); Value proposition and market (20%); Business modelling and risk (15%); activity proposal (20%)
▪ Midterm and final review
➢ Term:
▪ 2 years</td></tr>
<tr><td>EU</td><td>No specific space TT network
But more general: EBN, EEN,…</td><td><u>Astropreneurs</u> (January 2018 - June 2020)

➢ Numbers:
▪ 20 EU countries
▪ Limited to 150 Astropreneurs
➢ Benefits & support:
▪ Business
▪ Technical
▪ 50 hours of mentoring
▪ Networking: Astropreneurs space economy network
➢ Requirements:
▪ Participating country H2020
▪ Individual or start-up not older than 5 y
▪ Space connection
➢ Application:
▪ Open call for proposals
▪ 6 cut-off dates
▪ Profile on F6S with a brief amount of information
➢ Evaluation & follow up:
▪ Decision within 4 weeks of cut-off date
▪ Business idea (30 points); Space connection (30 points); Motivation (20 points); Expectations and objectives (20 points)
▪ Updates every 6 months until June 2020
➢ Term:
▪ Max. 6 months mentorship</td><td><u>SpaceUp</u> (June 2018 - May 2021)

➢ Numbers:
▪ High-level support limited to 60 advanced start-ups
➢ Benefits & support:
High-level support:
▪ 6 space academies
▪ 3-minute pitching slot
▪ One-to-one mentoring
▪ €400 reimbursement
▪ Credit passport
▪ Feasibility studies on EU funding
▪ Networking
▪ Compete for awards
▪ Promotional campaigns
➢ Requirements:
▪ EU SME, not older than 5 y
▪ Established business (high IRL)
▪ Space connection
➢ Application:
▪ Online registration form
➢ Evaluation & follow up:
▪ SpaceUp Evaluation Committee
▪ IRL stage and marketing
➢ Term:
▪ 2-day Space Academy
▪ Several months individual support for preparation</td></tr>
</table>

6. ESA Space Solutions Belgium & Flanders's Space

The ESA Space Solutions Belgium is a national programme launched in November 2018.[56] Beside managing the ESA TTN, Verhaert is also managing this programme, in close cooperation with Galaxia Space Innovation and imec. The programme brings together a large partner network throughout Belgium. ESA Space Solutions Belgium implements the entire space TT programme (including upstream, space-enabled data and service, and downstream) on a national level. However, taking into account the scope of this thesis, activities with regard to space data will not be discussed. The initiatives within the scope of this thesis and within the network of Space Solutions Belgium are the following: Astropreneurs (with Verhaert as partner organisation as already discussed), ESA BIC Belgium (some site specific elements will be explained), and technology valorisation ranging from opportunity creation (scouting, workshops and events), feasibility research (consultancy), and ESA funding for demonstrators to develop prototypes (open calls). This chapter will therefore zoom in on ESA BIC Belgium and the technology valorisation initiatives. Once these aspects of ESA Space Solutions Belgium have been covered, a final stop will be made at the Region of Flanders.

However, before going over to ESA BIC Belgium a brief explanation of the Belgian state structure is required. This is because the initiatives within ESA Space Solutions Belgium combine aspects of an international and economic nature which cause for some complications. This is due to the fact that Belgium is a federal state, with communities and regions who independently exercise their authority within their domains. The powers of the federal state are limited to public interest, for example foreign affairs. Furthermore, the federal state retains a considerable amount of common heritage such as the federal scientific and cultural institutions. Lastly, the federal government's powers also cover everything that does not expressly come under the domains of the Communities or Regions. The Communities relate to language and culture. Since Belgium has three official languages (Dutch, French and German), there are 3 communities: the Flemish Community, the French Community and the German-speaking Community. On the other hand, the Regions aspired to more economic autonomy and relate to economic interests, which resulted in the establishment of three regions: the Flemish Region, the Brussels Capital Region and the Walloon Region. Up to a certain level they can be compared with the American states or the German 'Länder'.[57] In total, there are six governments (and parliaments) in Belgium: one Federal Government, two Communal Governments (for French and German speaking parts), two Regional governments (for the Brussels and Walloon Regions), and finally one Flemish Government (combining both the Flemish Community and Region).

With regard to ESA Space Solutions Belgium, both the federal and Regional powers come into play. Whereas space in the international context is a responsibility (foreign affairs) of the federal government of Belgium (e.g. subscribing onto ESA programmes goes through the federal Belgian Science Policy Office, Belspo), space in the economical context is a responsibility of the Regional

[56] Verhaert, "Launch ESA Space Solutions Belgium", https://verhaert.com/esa-space-solutions-belgium-brings-entrepreneurs-closer-to-space-technology-and-know-how/, retrieved: 30 May 2019.
[57] Federal Portal Belgium, "Belgium, a federal state", www.belgium.be/en/about_belgium/government/federale_staat, retrieved: 26 May 2019.

governments.[58] The initiatives within ESA Space Solutions Belgium thus require federal support (given by Belspo), as well as Regional support (by Regional governments and Regional economic partners). This structure will have a visible impact on the different initiatives throughout the rest of this chapter.

6.1 ESA BIC Belgium

The organisational structure of ESA BICs has already been outlined in chapter 3. The organisation of ESA BIC in Belgium will be shortly mentioned here.

In 2012 ESA BIC Wallonie Redu and ESA BIC Flanders were created. Related to the Belgian federal state structure, the ESA BIC was split up in two when it opened in Belgium. However, with the introduction of Space Solutions Belgium in 2018 these were merged into one ESA BIC Belgium, which is managed by Verhaert. Nevertheless, in practice the BIC programme in Belgium is still organised separately between Flanders and Wallonia.

In Flanders this programme is in the hands of imec.istart, which is the incubation programme of imec, a world-leading R&D and innovation hub in nano electronics and digital technologies. The imec.istart team has been in operations since mid-2011 and has supported over 160 incubatees (mostly non-space related) so far. The programme was the first in its kind in Belgium and has received international recognition by different organisations.

In Wallonia the incubation programme is implemented by Galaxia Space Innovation (the regional consortium of Skywin, Idelux, CSL and WSL), offering a 2 000 m² business park dedicated to space applications. Because it is connected to the Redu facilities, it enables satellite applications development. The Redu BIC site is located in the futuristic Galaxia business park in Transinne. In close proximity to ESA's European space Security and Education Centre (ESEC) and sited next to the Euro Space Center, Galaxia also aims to offer opportunities to students and researchers. As a consequence of the variety of satellites operated by ESA from Redu, ESA BIC in Redu is aimed at companies specialised in telecommunications, Earth observation, navigation systems as well as integrated applications, all where the use of satellite data is an integral part of the solution. This unique link provides fresh data, collected from satellites for immediate processing and analysis, as well as exclusive direct and quick access available to start-ups hosted at the Redu site.

The benefits of ESA BIC were already largely covered in chapter 3. For ESA BIC Belgium it is the typical funding up to €50 000 (50% from ESA and 50% from governmental fund).This funding can be used for the development of products, prototypes software and IPR. Support goes up to 80 hours and includes technical, business development (workshops, trainings, coaches), IP Consulting, and financial administration. Finally access is provided to ESA facilities, the incubator's facilities and networks (coaches, experts, suppliers), and the ESA BIC community. The evaluation procedure is managed locally by ESA Space Solutions Belgium with the participation of ESA, Belspo, imec.istart and Galaxia Space Innovation.

[58] Artikel 6bis, § 2 van de bijzondere wet tot hervorming der instellingen van 1980, www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=nl&la=N&cn=1980080802&table_name=wet.

During the launch event of ESA Solutions Belgium, the first three start-ups of the incubation programme were announced. Veoware Space uses high resolution images of satellites for geographical information projects (GEOINT); Heart Kinetics developed an instrument to accurately monitor heart functions in a non-invasive way; and AirShaper offers an online platform to assess aerodynamics through a simulation performed on a cloud-based wind tunnel software.

6.2 Technology valorisation

Over the past few years, the Belgian aerospace policy has increasingly supported the importance of a broader valorisation of space technology. Belgium was one of the pioneers in elaborating an ESA National Technology Transfer Initiative (NTTI). NTTIs are part of the ESA TT programme and facilitate transfers on a national level by matching requests for specialised technologies from the national non-space sector with technology descriptions provided by their national space industry. A NTTI also addresses the need for funding and other support and may involve local companies to provide this. The technology brokers are the contact point between the ESA TTPO and the national initiatives.[59] In 2014, Verhaert was selected by Belspo and ESA to develop its Techxfer approach in the context of the NTTI Belgium. This appointment has enabled Verhaert to demonstrate its successful approach to ESA, which has resulted in today's selection of Verhaert as ESA's prime broker to implement this approach on a European scale. It has become one of the leading actors in Europe with respect to TT and incubation of technological starters.

Next to ESA BIC Belgium, the NTTI also provides technology valorisation in three different ways. Through technology scouting, feasibility studies, and calls for demonstrators co-financed by ESA and Belspo. The Belgian NTTI programme is managed by Verhaert. While this company operates as an intermediary within the ESA TTN, on a national level it provides both services of a TT intermediary and facilitator.

First of all, Verhaert provides technology scouting as a service. This is about discovering new ways to tackle challenges by scanning through the ESA network and space industry.

A second way of technology valorisation is to provide feasibility research to find out whether an idea is achievable. This consists of consultancy work aiming at facilitating technology transfer. It can be

[59] ESA Technology Transfer Programme Office, www.esa.int/Our_Activities/Space_Engineering_Technology/TTP2/National_Technology_Transfer_Initiatives, retrieved: 26 May 2019.

requested from both sides of a downstream transfer: a terrestrial company willing to use technology from the space industry or a space company willing to apply its knowledge to a terrestrial application.[60]

Finally, the NTTI facilitates the transfer process through a call for TT demonstrator. Through this call, supported by ESA and Belspo, Verhaert invites applicants to submit proposals for the development of demonstrators regarding the transfer of a space technology into a non-space application. The call is open to both space and non-space entities registered and established in Belgium, but the intended transfer must be based on space technology for the use in a non-space environment only (spin-off). Together with ESA, Verhaert can select indicatively two projects per year to be funded with a maximum amount of € 38 000 each to build a demonstrator. This budget can be used to cover technical costs for the implementation of demonstrators, such as workforce, materials, and equipment. Furthermore, the call offers advice on product development, access to Europe's largest technology network, access to feasibility studies and research, and identification of market opportunities. The projects should be executed in maximum 6 months.[61] The aim is to fund promising projects that make use of space technology or knowledge for a commercial product or application on Earth. The projects are to support the advancement of technologies that have a high space TRL, but a lower TRL for ground based commercial applications. Demonstrator projects help to determine and eliminate the technical risk particular to a new terrestrial application, where there is a strong commercial or societal benefit. A TT demonstrator project will result in the measurement of one or more technical features that are specific to the terrestrial application of a space technology. ESA Technology Transfer Demonstrator projects aim to fund developments at an earlier and higher stage of technical risk. The application, evaluation, and follow-up are similar to the ESA BIC. Application is done through submission of documentation (a proposal template of maximum 10 pages). Proposals are then evaluated by the Tender Evaluation Board, which consists of ESA and Verhaert experts and stakeholders. A midterm and final review are also organised to give an overview of the technical progress that has been made.[62]

6.2.1 Case study

The national call for demonstrators seems like a potential interesting option for Astrolympia in the future. Once the strategy and business plan are developed further through the Astropreneurs Accelerator, Astrolympia could be registered as a company. If this can be realised, applying to the call for demonstrators would become possible. This would provide an excellent opportunity, since it is a short-term programme that is specifically aiming to eliminate technical barriers. As shown by the SWOT analysis of Astrolympia in the second chapter, the main weakness of the business case was the lack of technical capacities. The call for demonstrators is a very suitable tool in that regard.

Strengthening the business case first is also necessary in order to have a real chance of acceptance for the demonstrator call. In the selection of projects, the evaluation board gives priority to projects with

[60] ESA Space Solutions Belgium, "Feasibility Studies", https://spacesolutions.be/feasibility-studies/, retrieved: 27 May 2019.
[61] ESA Space Solutions Belgium, "Belgian Technology Transfer Demonstrators", https://spacesolutions.be/demonstrator/, retrieved: 27 May 2019.
[62] ESA, "Technology Transfer Demonstrators", 2018, www.esa.int/Our_Activities/Space_Engineering_Technology/TTP_Business_Opportunities/Technology_Transfer_Demonstrators, retrieved: 15 May 2019.

a clear ground based commercial application focused on a customer group with defined needs, and it is an advantage if specific customers already expressed a clear interest in the technology. The evaluation also takes into account work previously performed for the proposed TT such as funding, technology development, market and feasibility studies, customer relations, etc.

By adding the call for demonstrators to the IRL maturity spectrum, it becomes clear that at least some level of maturity is needed in order to have a real chance to be accepted. For example, the evaluation of the call for demonstrators takes into account market opportunities and proven customer interest. Completing the Astropreneurs mentoring programme first could lead to a sufficient level of maturity in that regard. The position of the call for demonstrators and ESA BIC on the spectrum below are interchangeable. The demonstrator call can be placed before ESA BIC because of its lighter application procedure. Moreover, its short-term characteristics of 6 months may allow technical assistance, but an incubation programme such as ESA BIC could still be useful to reach a successful operational phase afterwards. The call for demonstrators could also be placed after ESA BIC, as it is possible that an ESA BIC alumnae applies for such a call to develop a new application. It is even possible that an already fully established and mature company (that has to deal with a certain technical problem) competes for the demonstrator call, since there is no restriction on how old an applicant company may be. If that is the case, the spectrum below could still be representative by regarding the specific department of the company as a separate entity that is experimenting and developing a new application. In any event, the spectrum is not an absolute chronological order, but merely gives an indication for the most suitable space TT initiative in relation to the readiness for innovation.

6.3 Flanders' Space strategy: Technology transfer

This final part takes a look at the outermost local space TT initiatives, more specifically with regard to the Region of Flanders. With a dedicated strategy towards the space industry, the importance of this sector was recognised. Within the Flanders' Space strategy, a good amount of attention is being payed to the importance of technology valorisation and the opportunities of space TT. It is that part of the strategy that will be the main subject in this chapter. Lastly, an interesting debate that will be touched upon is the question of Regional participation in the Belgian space policy. Because of the federal state structure, explained in the beginning of this chapter, there are those who argue that there is too little Regional participation in space policy concerning international matters with regard to the subscription to ESA programmes. Therefore, the effective start-up of an Interfederal Space Agency of Belgium (ISAB) or Spacebureau in which the Communities and Regions will be represented was suggested in the Flanders' Space strategy. There has been some determination to establish such an agency, however this reform is not entirely in the interest of the other Regions (Wallonia and Brussels). The future of this potential agency is still highly uncertain but cannot be excluded either. The question thus raises what the impact of such a reform would be on local space TT initiatives.

The Flemish Advisory Council for Innovation and Enterprise (VARIO) was established by the Flemish Government in 2016. The VARIO is the successor of the Flemish Council for Science and Innovation (VRWI), which was the strategic advisory body for the Flemish Government for science and innovation between 2010 and 2016. In turn, the VRWI was the successor of the Flemish Council for Science Policy (VRWB), which was active from 1985 to 2009. The VARIO consists of ten members who work independently from the Flemish Government and the Flemish stakeholders in the field of science, innovation, industry and enterprise. The council advises, on its own initiative or on request, the Flemish Government and the Flemish Parliament on its science, technology, innovation, industry and entrepreneurship policy.[63] As already explained, space in the international context, primarily ESA is a responsibility of the federal government of Belgium, but space economy is a responsibility of the Regions (e.g. the Flemish government). With this in mind, VARIO proposed several recommendations and a number of concrete actions in its most recent advisory report of February 2018, Flanders' Space.

Flanders' Space was produced upon a request for advice from the Flemish minister responsible for Innovation and Economy, to develop a long-term (not limited to the legislature) strategy for space in Flanders. The advice is intended as to support the minister in shaping the policy on the Flemish space economy within the Flemish Government. In this advisory report, VARIO puts forward several recommendations in order to strengthen the Flemish space industry, as well as to benefit more from this sector.

The starting point of Flanders' Space is that the space economy goes well beyond the space sector itself and comprises all the possible impacts of space-derived products, services and knowledge, on the global economy and society. Flanders' Space considers the space economy as the enabler for economic and social growth. This viewpoint was inspired by the Organisation for Economic Co-operation and Development (OECD) that 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 in the course of exploring, understanding, managing and utilising space. Hence, it 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, meteorological services, etc.) and the scientific knowledge generated by such activities.[64]

Rather than covering the whole strategy, the rest of this chapter will elaborate on the relevant aspects of the strategy with regard to the downstream space sector. The relevant recommendations will be updated in view of the developments that have been achieved since the advice was published. For example, the initiative of ESA Space Solutions Belgium (November 2018) did not yet exist when the advice (February 2018) was published. Connecting what has been achieved since the recommendations for the downstream space sector, as originally envisioned by the strategy of Flanders' Space, will potentially bring new insights.

[63] VARIO, www.vario.be/en/about-us, retrieved: 30 May 2019.
[64] OECD, "Handbook on Measuring the Space Economy", 2012, 20, www.oecd-ilibrary.org/economics/oecd-handbook-on-measuring-the-space-economy_9789264169166-en;jsessionid=KaCwjm-0MIE0hitu2iuP4REv.ip-10-240-5-103, retrieved: 31 May 2019.

6.3.1 Space clusters

VARIO sees cooperation both between space actors as well as between space and terrestrial industry, as an opportunity that needs to be promoted. Therefore, in its advice it recommended a Flemish cooperative model in which both industry and knowledge institutes (such as academia and research centres) are present.

a) IBN Space 4.0

On a Regional level in Flanders, a cluster policy was introduced in March 2016 by the Flemish Government.[65] The goal of innovation clusters is to unlock unused economic potential among Flemish companies through active and sustainable collaboration between different actors. This cluster policy concentrates on collaboration agreements of Flemish companies with growth ambitions, innovation awareness, an international attitude and a willingness to collaborate with other companies and knowledge centres, both for the realisation of their individual company targets as well as to contribute to competitiveness growth among a large group of Flemish companies. This offers the actors the possibility of clustering.[66] To achieve growth in the space economy VARIO recommended to focus more on the application of space technology and knowledge on Earth. Therefore, the space economy is to be put forward as one of the priorities throughout inter-cluster cooperation. This means establishing cross-fertilisation, complementarity, maximum synergy and cooperation in technological developments with terrestrial industries. From the point of view of the accompanying policy, Flanders must ensure and enable that knowledge and technologies developed within the space context are actually valorised and anchored in Flanders.

One type of clusters are Innovative Business Networks (IBNs). These are aimed to construct a dynamic within a group of companies and other organisations with a bottom-up approach. These innovation networks are expected to implement concrete action plans, with visible economic added values for the participating actors through collaboration.[67] In May 2018, only a few months after the publication of Flanders' Space, an IBN specifically devoted to space, entitled Space 4.0, was recognised by the Flemish government. The IBN has an allocated budget of € 300 000 for a period of 3 years. Half of this budget is coming from the industry itself, the other half is coming from Flanders Innovation & Entrepreneurship (VLAIO). The IBN Space 4.0 aims to create a sustainable network leading to an ecosystem in Flanders in which space technology plays a crucial role for the realisation of today's challenges. By bringing together the Flemish companies and research institutes around the development of new products and services based on space technology, the cluster organisation can bring added value to the use of space technology for the economy. Actors ready to use space as an asset can benefit from the cluster support. As a forum for collaboration, exchange and technology transfer, Space 4.0 aims at increasing the technological innovation by its members. Cross-fertilisation with other economic sectors is crucial to ensure the competitiveness of the cluster members.

[65] "Besluit van de Vlaamse Regering tot regeling van de steun voor innovatieclusters in Vlaanderen", 4 March 2016, www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=nl&la=N&table_name=wet&cn=2016030413.
[66] VLAIO, "Innovation clusters in Flanders", www.vlaio.be/nl/andere-doelgroepen/flanders-innovation-entrepreneurship/innovation-clusters-flanders/innovation, retrieved: 31 May 2019.
[67] VLAIO, "Innovative Business Networks", www.vlaio.be/nl/andere-doelgroepen/flanders-innovation-entrepreneurship/innovation-clusters-flanders/innovative, retrieved: 31 May 2019.

Although the IBN Space 4.0 was only established in 2018, it is actually based upon an organisation that already exists since 1995, the Flemish Space Industry (VRI). The VRI is a non-profit organisation that contains 33 members related to the space sector, connecting 18 SMEs, 8 larger companies, as well as 6 research and educational institutions (e.g. imec, VITO, SCK, Von Karman Institute), and 1 other ecosystem actor (the Flemish Aerospace Group).[68] Its purpose is to develop cooperation and to strengthen the technological basis between these different actors, as well as to be internationally competitive as a region.

One of the first activities within the Space 4.0 cluster was the creation of a competence matrix of the VRI members. This exercise allowed to map the main activities of the VRI members, at the same time emerging interests in new applications were explored. Especially artificial intelligence was brought up as a growing domain of interest. In September 2018, a seminar was organised with the intention to take the initial steps towards implementing the Flanders' Space strategy.[69] Because the space sector is of an international nature, and in order to eventually reach a unified national strategy where each region would be in the position to fine-tune the national space policy according to its preferences, informal cooperation was also established with the federal government, Belspo and the other Regions such as with Wallonie Espace (the Walloon and Brussels space cluster counterpart). Furthermore a technological workshop took place in February 2019 with the VRI members whereby the Flanders' Space strategy was analysed. Potential partnerships and applications, both within the space and non-space sector, were explored. This resulted in several working groups.

With ESA's prime broker on board, one of the assets that the IBN Space 4.0 has to offer is the transfer of technology to other sectors. Flanders is known for several highly specialised sectors, these could be further improved on the basis of space technology. Therefore, VRI currently calls upon all entities to submit proposals on technology transfer projects. Since Flanders' Space highlights the importance of downstream applications, the number of cooperation projects with non-space sectors is growing. One of the working groups is called Space for Pharma and brings the enterprises within the Flemish space industry, as well as the academic and science institutes, together with pharmaceutical and biotech companies. Over the past few years, different space actors have developed different systems, instruments and research facilities, enabling innovative scientific research and product development in space. With several pharmaceutical partners, it is now investigated whether this technology in space can result in added value for the development of new medicines. Another working group is targeting the increasing demand for robotics and intelligent systems in hazardous or inaccessible environments. Robotic arms, remote controlled rovers or landers, autonomic and unmanned spacecraft, as well as other systems equipped with artificial intelligence have been used for years in the hostile space environment. Flanders holds a lot of scientific and technical capacities in this domain. The knowledge and available technology with regard to radiation resistant electronics and avionics, robotic joints, and sensors can be used for applications on Earth. The maintenance of nuclear reactors and the inspection of underground or undersea installations, but also the use of robots for minesweeping and evacuations are some of the applications proposed and discussed within this working group. The IBN is currently looking for more ideas to create additional working groups. A possible theme for an upcoming working

[68] European Cluster Collaboration Platform, "Space 4.0 (Flemish Space Industry)", www.clustercollaboration.eu/cluster-organisations/space-40-flemish-space-industry, 31 May 2019.
[69] VRI, "Invitation seminar: 'Space 4.0 in Flanders'", 2018, https://vri.vlaanderen/en/invitation-seminar-space-4-0-in-flanders/, retrieved: 30 May 2019.

group is about closed loop systems. For example, such a working group could consist of technologies such as water purification systems developed by QinetiQ and the "Bake in Space" project of Puratos.[70]

Participation in international events and networking are also managed by the cluster. Furthermore, it stimulates inter-cluster cooperation. As already mentioned, the VRI contains one other ecosystem actor. With the Flemish Aerospace Group there is a project about additive manufacturing for aerospace applications. Synergies with other clusters (e.g. Flanders Food, Flanders.Bio) are also being explored.

Case study

Since the VRI is looking for new members to join the Space 4.0 cluster and start cooperating, there are opportunities to open up new working groups. With regard to Astrolympia, there might be a possibility to establish a working group on space for sport, something which was reaffirmed by the IBN coordinator. The same is true for other start-ups. For example it was mentioned that one of the other Flemish start-ups within the Astropreneurs Accelerator works with artificial intelligence, and since a clear interest for cooperation in this domain was expressed within the VRI, this Astropreneur could be integrated to such a cooperation.

Moreover, this concept of clustering inspired me to reach out to the other Belgian Astropreneurs. Together with the other Belgian start-ups and Verhaert, it is currently explored whether a *Belgian Astropreneurs Club* can be established.

b) Triple helix Taskforce 'Space Economy'

First of all, the triple helix model is an innovation format based on interactions between government, industry, and university. The involvement of the university sphere accompanies the shift to a knowledge economy (with a high dependency on knowledge, information, skills and access to these by business and public sectors).[71] Nowadays, organisations do not just rely on their own internal knowledge, sources and resources (such as their own staff or R&D) for innovation, but also use multiple external sources (building upon research, technical support, consultancy, customer feedback, published patents, competitors, external agencies, etc.) to drive innovation. This triple helix model is something which is already ingrained in research and knowledge centres (e.g. imec, VITO, SCK), and Flemish clusters (e.g. IBN Space 4.0).[72] This has given Flanders a worldwide reputation for innovation, topping the charts in R&D, innovation and collaboration between industry, academic and governmental institutions.[73]

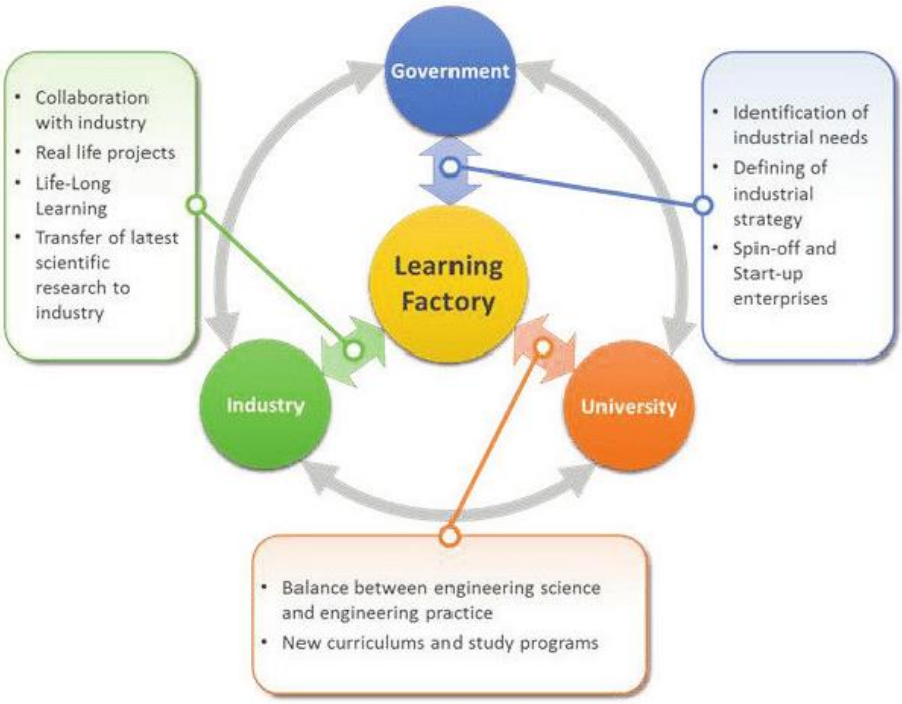
[70] J. LUYPAERT, "Belgian Bakery Bold About Baking Bread On Mars", 2019, https://onestagetospace.com/2019/04/17/belgian-bakery-bold-about-baking-bread-on-mars/, retrieved: 5 June 2019.

[71] OECD, "The Measurement of Scientific and Technological Activities: Guidelines for Collecting and Interpreting Innovation Data: Oslo Manual, Third Edition", 2005, para. 71.

[72] Vlaams Parlement, Voorstel van resolutie betreffende de uitbouw en valorisatie van de Vlaamse ruimtevaarteconomie, 1952 Nr. 2, 24 April 2019, http://docs.vlaamsparlement.be/pfile?id=1479603.

[73] Center for European Economic Research Manheim, Innovation Indicator, 2014; Bloomberg Innovation Index 2017; The World Economic Forum, "The Global Competitiveness Report", 2017.

However, according to some studies, the triple helix module still lacks an institution or organisation that really establishes a direct relationship between government, industry, and academia. Therefore, the concept of a Learning Factory was introduced.[74] Through such a Learning Factory, a link between university and industry can be established using practice-based engineering and real life projects. A link between university and government can also be established in order to identify needs of industrial enterprises and to define an industrial strategy. As a consequence, this also results in a link between government and industry. A Learning Factory is a place where these three spheres (university, industry and government) meet each other, share needs and expectations, and work on collaborative projects. It is a place where the real-world is brought into the classroom by providing practical experience for engineering students, to help transfer the latest scientific research to industry through collaborative projects, and to help the government identify needs of industrial enterprises.



VARIO recommended, in the context of a Flemish cooperative model, to establish a triple helix Taskforce 'Space Economy'. This Taskforce would have the mandate and the necessary authority to develop an integrated and coordinated strategy for the Flemish space economy. Such a Taskforce would ensure that the Flanders' Space strategy draft is translated into a concrete action plan, and that the recommendations from this VARIO advisory report are effectively implemented. In order to function optimally, the Taskforce should have a balanced composition, a workable size and receive the necessary support (administrative, logistical and financial) within the Flemish economy, science and innovation policy. VARIO recommended a maximum of 12 members, 6 coming from industry and the other half from other segments such as research and government. It was also recommended that the body would be placed under the authority of the Flemish minister responsible for Economy, Innovation

[74] I. VEZA, N. GJELDUM, and M. MLADINEO, "Lean Learning Factory at FESB – University of Split", Procedia CIRP 32, 2015, 132-137.

and Scientific research, and that its term would not be limited to the legislature, just like the strategy and action plan.[75]

Currently, a triple helix Taskforce 'Space Economy' does not yet exist. However, a proposal of a resolution (which is a formal recommendation to the Flemish government) has been accepted recently by the Flemish parliament. In this resolution, the Flemish government is asked to install a long-term vision and roadmap for the space economy, the return to terrestrial industries, and to establish a triple helix Taskforce.[76]

It is remarkable that the Flemish minister of Work, Economy, Innovation and Sport, was of the opinion that such a Taskforce had become superfluous after the creation of the IBN Space 4.0 in May 2018. One month later he argued that the establishment of the Taskforce was not recommended anymore since the IBN was already fulfilling its tasks.[77] In the minister's opinion, the IBN was the ideal instrument handed over to the space industry to ensure the implementation of Flanders' Space, with a shared responsibility between the sector and the government. Nevertheless, with the recent resolution asking for the creation of the Taskforce it appears that the IBN Space 4.0 is not sufficient on its own to guarantee a long-term action plan to implement the envisioned strategy. The IBN provides opportunities on an operational level in the field to join forces between companies and other actors, but the triple helix Taskforce asked for in the Flemish resolution would better support the Flemish space policy in general. It would serve as a point of contact for the Flanders' Space ecosystem, while also guarding the economic and social returns, and represent the Regional interests of Flanders in order to get a higher return from ESA programmes. Lastly, VARIO recommended that this Taskforce should identify specific entry barriers and needs of the Flemish space actors within the existing portfolio of policy instruments and examine how these gaps can be overcome by taking into account the specificity of the space sector for funding channels. For this reason, it was mentioned in the strategy that in order to optimise the existing support mechanisms, the Flemish policy for economy, science, and innovation could provide sufficient support through feasibility studies (both economic and technical), the development and construction of demonstrators and prototypes, and a pallet of other measures (e. g. interest-free loans, financing start-ups, export support, etc.) so that the Flemish space SMEs could prosper. That kind of support is now collectively provided under the newly established initiative, ESA Space Solutions Belgium.

6.3.2 A Belgian space agency, the monster of Loch Ness of science policy

As already mentioned, space in the international context is a responsibility of the federal government of Belgium, while space in the economical context is a regional responsibility. Belspo is the federal governmental body responsible for science policy in Belgium. It designs and implements federal

[75] VARIO, "Flanders' Space: Een strategie voor de Vlaamse ruimtevaarteconomie", 2018, 5, www.vario.be/nl/publicaties/advies-2-flanders-space, retrieved: 25 October 2018.
[76] Vlaams Parlement, Voorstel van resolutie betreffende de uitbouw en valorisatie van de Vlaamse ruimtevaarteconomie, 1952 Nr. 2, 24 April 2019, 4-5, http://docs.vlaamsparlement.be/pfile?id=1479603.
[77] Vlaams Parlement, Vraag om uitleg over de opvolging van een Vlaamse ruimtevaartstrategie van Lieve Maes aan minister Philippe Muyters, 14 June 2018, https://www.vlaamsparlement.be/commissies/commissievergaderingen/1261608/verslag/1263989, retrieved: 1 June 2019.

research programmes, and manages the participation of Belgium in European and international organisations. With regard to space, Belspo includes three institutes: the Royal Belgian Institute for Space Aeronomy, the Royal Meteorological Institute of Belgium, and the Royal Observatory of Belgium and Planetarium. Belgium is an important player in European space initiatives. However, in contrast to a lot of its neighbouring countries, Belgium never created a national space agency, nor did it establish a national space programme. Instead, Belgian space activities are highly dependent on ESA and EU programmes. With regard to ESA, Belgium is an important investor. By contributing 4,6% of the total budget for ESA's mandatory programmes, Belgium is one of the biggest spenders among the member states (surpassed only by France, Germany, the UK, Italy and Spain). Calculated per capita, after Luxembourg, Belgium is even the biggest contributor. During the ESA Ministerial Council of 2016, Belgium signed for about 200 million on ESA programmes. As Jean-Marie Luton, former ESA Director General, once described: "Belgium is the smallest of the large and largest of the small ESA member countries". The Belgian space strategy is thus to rely on the industrial and science return from ESA programmes. However, over the last few years, in addition to this ESA return the EU space programmes have also become increasingly important.

Since space in the international context is a federal responsibility, Belspo manages foreign relations, most importantly with ESA. Nevertheless, Flanders has a Regional space competence for science, research, innovation and economy, and Flemish stakeholders have often expressed their dissatisfaction because of a relative lower ESA return rate to Flanders. The lion's share has long been for the space industry in Wallonia and Brussels. Traditionally, these regions covered a more advanced space industry. However, over the years, absorption capacity in the Flemish region increased. Allegedly, Belspo does not sufficiently take into account Flemish expertise when signing onto ESA optional programmes. From the Flemish side, the argument is made that this is caused by Belspo opting for ESA programmes relating to bigger infrastructure programmes such as for Ariane, while more niche programmes such as for communications or sensors are being neglected. This would be advantageous for the Brussels and Walloon Region where there is more knowhow on programmes related to Ariane or the International Space Station, while Flanders is strong in Earth observation, navigation, and life sciences. Although this situation has been mediated over the last few years by singing onto a wider variety of programmes (the return rate to Flanders went from 20% in 1993 to 35% in 2006), it is still being argued that the situation did not improve enough.[78]

The Flanders' Space strategy aims to increase the ESA return rate to Flanders by solving the problem of too little Flemish participation in the national space policy concerning international matters. This can be done by persuading the Federal government (through Belspo) to subscribe sufficiently to those optional ESA programmes for which Flanders has a strong technological potential, so that the Flemish presence therein increases. Therefore, the Flanders' Space strategy suggested the effective start-up of an interfederal space agency, a formal structure in which the Regions would get active participation to spend the federal budget, which has remained stable around €200 million for ESA programmes. The initial steps towards the foundation of such an agency, thereby replacing Belspo, had already been taken by a ministerial council on 25 November 2016. However, this decision was never implemented

[78] Vlaams Parlement, Schriftelijke vraag nr. 505 van Matthias Diependeale aan Philippe Muyters, 12 April 2017, http://docs.vlaamsparlement.be/pfile?id=1269027, retrieved: 2 June 2019; VARIO, "Flanders' Space: Een strategie voor de Vlaamse ruimtevaarteconomie", 2018, 41, www.vario.be/nl/publicaties/advies-2-flanders-space, retrieved: 25 October 2018.

and discussions on the creation of such an agency have been dragging on ever since. In order to capture the ongoing discussions and to suggest a way forward, an overview will be given on the actual efforts made during the past legislature with regard to the stated goals in the Federal Coalition Agreement regarding the reform of the Belgian space policy.

6.3.2.1 The Federal Coalition Agreement (2014-2019)

In 2014, the creation of an Interfederal Space Bureau with legal personality, a setup in which the regions would be involved, was announced in the Federal Coalition Agreement.[79] This year is the final phase of that agreement, however, so far the creation of an Interfederal Space Bureau has not been realised. Nevertheless, important steps in this process have been taken.

In general, the Belgian space policy, as written down in the present Federal Coalition Agreement, primarily focusses on the return-on-investment of space activities for the Belgian economy and society. The federal government of Belgium reaffirmed to continue to support the European space programmes of both ESA and the EU. These programmes generate an industrial return, as well as services beneficial to the government and its citizens. As already explained, space in the international context is a federal responsibility, while space in the economical context is a Regional responsibility. There has been no intention to alter this policy, however, there is a clear expression from the Flemish side for structural reforms on the federal level with regard to space. Most importantly, the creation of an Interfederal Space Bureau would be realised in order to include active participation of the Regions, as well as to assemble the entire personnel and all financial resources of the federal departments. The objective of this would be to improve the coordination on the federal level with regard to space activities. Of particular importance is the fair distribution of return-on-investment between the different Regions. An institution such as an Interfederal Space Bureau would thus represent Belgium on the international stage in a coordinated way, thereby replacing Belspo, while taking into account the specific interests and needs of the different Regions. The creation of an Interfederal Space Bureau would also be achieved within the state budget and it was even assumed that it would result in saving more money, although it will become clear that others claim that the opposite is true.[80]

<u>2014</u>

By the end of 2014, the VRWI advised the Flemish government to establish to strive for a higher return-on-investment, thereby referring to the numbers agreed in the ESA Ministerial Council of 2014.[81] The target to reach was fixed on 56% for Flanders, 34% for Wallonia and 10% for Brussels. The VRWI also advised to have more presence in space research and science in Belgium through an active role in the creation of an Interfederal Space Bureau. Flemish policymakers were advised to take initiative in this regard in order to get equal participation of the Regions on the federal space policy, and to reach the target for return.

[79] Federaal Regeerakkoord 2014, 74.
[80] Federaal Regeerakkoord 2014, 104.
[81] VRWI, Federaal wetenschapsbeleid vraagt proactieve houding Vlaanderen, Advies 200, 2014.

In a policy note of former secretary of state for science policy, Elke Sleurs, the federal government was given the task to create an Interfederal Space Bureau with legal personality by 2015.[82] The document refers to this bureau for the first time as a Belgian space agency.

2015

In August 2015, a question was raised within the Flemish Government about the progress that had been made for the establishment of this entity.[83] It appeared that no formal initiatives had been taken by that time. By the end of 2015 the VRWI repeated its statements in a second advice, reminding the Flemish government of the importance to have equal representation with a future Interfederal Space Bureau in order to increase the return-on-investment for Flanders.[84]

2016

According to a report from the Chamber of Representatives of Belgium of May 2016, the treaty text with regard to the creation of an Interfederal Space Bureau was being discussed in an intercabinet working group. The Interfederal Space Bureau should have been operational by January 2016, however discussions with regard to the preparation of the 2016 ESA Ministerial Council prevailed as they were more urgent at that period in time. The secretary of state communicated that the creation of the Interfederal Space Bureau would be delayed until early-2017.[85] Finally, progression was made in November 2016, when the Ministerial Council decided to set up an Interfederal Space Agency of Belgium (ISAB). For the first time the idea of an interfederal space institution began to take real proportions. It was announced that ISAB would be operational in 2017. Moreover, the Federal Coalition Agreement was further implemented by planning the integration of science policy in the Federal Department (FOD) for Economy, ISAB and the Federal Scientific Institutions.[86]

2017

In 2017, Zuhal Demir became the successor of Elke Sleurs as secretary of state for science policy. Her policy statement of mid-2017 firstly refers to the controversial reforms regarding the science policy. The petition “Save Belspo” collected thousands of signatures, illustrating a strong opposition against the integration of science policy into the FOD for Economy which would lead to the termination of Belspo.[87] Moreover, the Regions of Brussels and Wallonia opposed to the creation of ISAB. The Union Wallonne des Entrepises also asked the Federal Government to review its space policy. With regard to the decision of the Ministerial Council for the creation of ISAB, the policy statement mentions that the financial aspects of ISAB were being examined. This would include an overview of the return-on-

[82] Belgische Kamer van Volksvertegenwoordigers, Algemene Beleidsnota Wetenschapsbeleid, 2014, Doc. 54 0588/036, 10.
[83] Vlaams Parlement, Schriftelijke vraag van Peter Van Rompuy aan Philippe Muyters, Nr. 750, 31 augustus 2015.
[84] VRWI, “Beleidsbrief Werk, Economie, Wetenschap en Innovatie, Advies 211, 2015.
[85] Belgische Kamer van Volksvertegenwoordigers, “Beknopt Verslag Commissie voor het bedrijfsleven, het wetenschapsbeleid, het onderwijs, de nationale wetenschappelijke en culturele instellingen, de middenstand en de landbouw”, 2016, CRABV 54 COM 420, 7 & 11.
[86] Belgische Kamer van Volksvertegenwoordigers, Schriftelijke vraag en antwoord, Nr. 0454, Zittingsperiode 54, 24 januari 2017.
[87] Belgische Kamer van Volksvertegenwoordigers, “Beleidsverklaring van de staatssecretaris voor wetenschapsbeleid, namens de Commissie voor het bedrijfsleven, het wetenschapsbeleid, het onderwijs, de nationale wetenschappelijke en culturele instellingen, de middenstand en de landbouw uitgebracht door Johan Klaps”, 2017, Doc. 54 0020/070, 3-4

investment, a planning of budgetary savings, and would also take into account current developments under the space programmes of the EU which are advantageous for bigger conglomerations as they are based upon open competitive tendering instead of ESA's geo-return.[88] In an advice of December 2017 on the draft budget for 2018 regarding the science policy, the Interfederal Space Bureau was even referred to as "the monster of Loch Ness of science policy".[89] The expression was used to describe the ongoing uncertainty about the actual realisation of the interfederal entity, since its foundation had already been delayed several times. Additionally, because the Interfederal Space Bureau (the original term used in the Federal Coalition Agreement) was referred to as an agency throughout different policy documents, and because the Ministerial Council of 25 November 2016 reached an agreement on the draft treaty text giving it the official name of Interfederal Space Agency of Belgium, there had been some confusion on what this difference in terminology implied. However, in her policy note Zuhal Demir emphasised that this terminology had no real impacts and did not change the original objective of an Interfederal Space Bureau as envisioned in the Federal Coalition Agreement, which was to obtain better coordination by integrating all personal and financial resources into one organ with direct participation of the Regions.[90] Furthermore, the creation of an advisory council for space consisting of academia, scientists, employers within the space industry, and users of space infrastructure and applications was envisioned. This advisory council would ensure a successful Belgian space strategy on a long term, with full transparency and open dialogue with the different stakeholders. Moreover, it would provide continuity during the transition from the current space administration toward the Interfederal Space Bureau.[91]

2018

In her policy statement of 2018, the secretary of state for science policy repeated the need for a strong and flexible space administration, aiming for the creation of an advisory council for space and ultimately for an Interfederal Space Bureau.[92] In the Flemish parliament, the Flemish minister for Economy and Innovation Philippe Muyters, communicated that it was the ambition to realise the Interfederal Space Bureau by the first of January 2019.[93]

[88] Belgische Kamer van Volksvertegenwoordigers, "Beleidsverklaring van de staatssecretaris voor wetenschapsbeleid, namens de Commissie voor het bedrijfsleven, het wetenschapsbeleid, het onderwijs, de nationale wetenschappelijke en culturele instellingen, de middenstand en de landbouw uitgebracht door Johan Klaps", 2017, Doc. 54 0020/070, 25.

[89] Belgische Kamer van Volksvertegenwoordigers, "Ontwerp van uitgavenbegroting voor het begrotingsjaar 2018 over sectie 46 – POD Wetenschapsbeleid", 2017, Doc. 54 2690/035, 6.

[90] Belgische Kamer van Volksvertegenwoordigers, "Ontwerp van uitgavenbegroting voor het begrotingsjaar 2018 over sectie 46 – POD Wetenschapsbeleid", 2017, Doc. 54 2690/035, 17.

[91] Belgische Kamer van Volksvertegenwoordigers, "Ontwerp van uitgavenbegroting voor het begrotingsjaar 2018 over sectie 46 – POD Wetenschapsbeleid", 2017, Doc. 54 2690/035, 15-16.

[92] Algemene beleidsnota 2018, 34.

[93] Vraag om uitleg over het advies Flanders' Space: een strategie voor de Vlaamse Ruimtevaarteconomie, van de Vlaamse Adviesraad voor Innoveren en Ondernemen (VARIO), van Lieve Maes aan minister Philippe Muyters, 1332 (2017-2018), 22 maart 2018, www.vlaamsparlement.be/commissies/commissievergaderingen/1229784/verslag/1243259, retrieved: 23 April 2019.

2019

By the first of January it became clear that this ambition was not fulfilled. ISAB had not been created, still showing more resemblance to the mysteries of Loch Ness than showing any sign of life of a Belgian space agency. Moreover, the department for science policy and Belspo are still standing.

By the end of this year there will be another ESA Ministerial Council. Only a few months earlier, national elections take place, and a new Federal Coalition Agreement will be formed. Finally, a question was raised within the Belgian senate about the future of the entity. In her answer, the Belgian minister for Science Policy, Sophie Wilmès, referred to the decision from the Ministerial Council in 2016 to set up ISAB. She stated that the matter required further steps, but concluded that these were never taken.[94]

6.3.2.2 Arguments in favour of ISAB

First of all, the creation of ISAB was recommended because an overarching formal structure with active participation of the different Regions is lacking. Up till now, conversations on science policy between the federal government and the Regions are taking place via the Interministerial Committee for Science Policy and more specific consultancy organs where the position of Belgian delegations for international relations is prepared. Such a consultancy organ between the Regions and the federal government does not exist with regard to space.[95] The only contact between the Regional space industries and the federal level is of a limited and informal nature. However, the space sector has transformed from a technological and science sector towards a user-sector since space applications are becoming increasingly important for the economy. Most of these applications relate to Regional competences, but since a formal structure for Regional participation on the federal level is lacking, this results in the perception that the federal policy cannot be streamlined with the Region-specific needs. ISAB would become a formal structure for such participation. Moreover, ISAB would allow Flanders to push for the improvement of its return.

Finally, the policy documents between 2014 and 2019 that were discussed above made notice of another reason in favour of ISAB, namely with regard to European space programmes of the European Commission. This is because the modalities of the calls for EU space programmes are very different from ESA programmes. ESA works with the principle of geo-return (returning the corresponding contribution of each member in the form of industrial contracts), while the EU procurement does not allow for such a return and works according to the strict principle of best value. This results in a highly competitive environment, and in that regard a national agency can help to build a stronger national position to win these European calls.[96] Furthermore, since ESA works with the principle of geo-return

[94] Belgische Senaat, van Christie Morreale, aan de minister van Begroting en van Ambtenarenzaken, belast met de Nationale Loterij en Wetenschapsbeleid Zitting 2018-2019, Schriftelijke vraag nr. 6-2250, 4 maart 2019.
[95] Vlaams Parlement, Vraag om uitleg over het gebrek aan vooruitgang bij de ontwikkeling van een interfederaal ruimtevaartbureau en het lage aandeel aan Vlaamse 'return on investment' van Koen Van den Heuvel aan minister Philippe Muyters, 2016, www.vlaamsparlement.be/commissies/commissievergaderingen/1088215/verslag/1091015, retrieved: 3 June 2019.
[96] Belgische Kamer van Volksvertegenwoordigers, Algemene beleidsnota Wetenschapsbeleid, DOC 54 0588/036, 2014, 8-9.

to each member state as a whole, it does not distinguish regional returns. ISAB would give Belgium more flexibility to arrange a fair return to each of its Regions.

6.3.2.3 Arguments against ISAB

The idea of ISAB received a lot of criticism and was even described as a monstrous creature that would be very complicated and costly to make. On both the Brussels and Walloon Region, as well as on the federal level the idea was not well received. It seems that ISAB is really only in the interest of the Flemish Region. The Regions of Brussels and Wallonia even tried to start a procedure against the creation of ISAB. There has been also a lot of opposition on the federal level as well because the federal government wants to safeguard its remaining competences.[97]

One of the arguments countering the idea of ISAB was about the financial implications. Even VARIO mentioned in its Flanders' Space strategy that it was not in favour of setting up specific new structures or instruments and rather recommends to seek for opportunities within the existing structures and instruments. Although it was originally argued that the creation of ISAB would result in budgetary savings, other estimates showed that it would bring a cost of €5 million.[98]

Lastly, the idea of ISAB also faced strong opposition because it would replace Belspo. The petition "Save Belspo" was already mentioned. The fear is eminent that with the replacement of this renowned federal institute a lot of knowhow would be lost.

From the discussions above it has been shown that the idea of ISAB is not being supported outside of Flanders. Nevertheless, ISAB keeps up appearing in Flemish documents (e.g. the recent resolution which was also asking for the creation of the triple helix Taskforce, and in response to a survey by the VRI before the elections at least two political parties in Flanders expressed their ongoing support to create ISAB).[99] Although the idea is not entirely abandoned, it looks like a Belgian space agency, envisioned by the Federal Coalition Agreement 2014-2019, will not be realised anywhere soon. On the other hand, the idea of an advisory council that was suggested as an addition to ISAB is showing a more promising future. Instead of a space agency, something as a permanent advisory council for space could be installed with economic, science and institutional actors representing industry, research and governments. This would close the gap where a formal structure between the Regional and federal level is missing.[100]

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[97] Belgische Kamer van Volksvertegenwoordigers, "Beleidsverklaring van de staatssecretaris voor wetenschapsbeleid, namens de Commissie voor het bedrijfsleven, het wetenschapsbeleid, het onderwijs, de nationale wetenschappelijke en culturele instellingen, de middenstand en de landbouw uitgebracht door Johan Klaps", 2017, Doc. 54 0020/070, 18

[98] Belgische Kamer van Voksvertegenwoordigers, "Ontwerp van Algemene Uitgavenbegroting voor het begrotingsjaar 2018", 2017, Doc. 54 2690/035, 6.

[99] VRI, "Partij standpunten aangaande hun toekomstig "Beleid voor de ruimtevaart sector in Vlaanderen" 16 mei 2019", 2019, https://vri.vlaanderen/wp-content/uploads/2019/05/Partij-standpunten-ruimtevaartbeleid-v1-volledige-tekst.pdf, retrieved: 1 June 2019.

[100] Belgische Kamer van Voksvertegenwoordigers, "Ontwerp van algemene uitgavenbegroting voor het begrotingsjaar 2019", 2018, Doc. 54 3294/010, 15-16.

7. Conclusion

What are now the key takeaway practices and lessons learned from the findings throughout this thesis? The following list of 12 guidelines will capture the core elements of this research. The purpose behind this list of best practices is to boost the downstream transfer of space technology, both on an entrepreneurial (micro) level and policy (macro) level. Finally, some closing remarks on the importance of downstream space TT for the past and future will conclude this thesis.

7.1 Microscale best practices for entrepreneurs

The microscale best practices were gathered through the case study of Astrolympia. These guidelines will mainly serve beginning entrepreneurs that want to establish a downstream space TT. As was the case for Astrolympia, the starting point was a simple idea coming from an ordinary student. Nevertheless, some elements may be valuable for more mature ventures as well.

1. Space connection & vision

One of the first selection criteria for space TT programmes is the link with space. As shown throughout this thesis, space may serve as an enabler offering unique technology on which an entire new business can be built. Space can as well be a differentiator for established firms that want to differentiate their products and services from their competitors. Whether Space is an enabler for a new business or a differentiator for an existing one, the key is to show why space offers added value. This does not only mean pointing out throughout the application why the specific space technology makes a difference, but also why the space technology is a value creating component fulfilling an essential role for the innovation.

Space has disruptive technologies and requires disruptive thinking. As such, space attracts new talents, people who want to do new stuff. This results in the creation of non-conventional human capital.[101] The population of space entrepreneurs, from the Astropreneurs Accelerator to the ESA BICs, have an extreme range of backgrounds. From engineering to law-practice, from design to marketing and sales. This proves that about any individual with a simple idea, the right motivation, and a clear vision is able to disrupt, differentiate, or enable a new business on the basis of a space relationship. Although start-ups often struggle to raise revenues early on, a clear vision can attract invaluable human resources. As a consequence, human capital can overcome this early lack of resources.

2. Find a suitable TT facilitator

It can be challenging to navigate through the numerous space TT initiatives, both within the EU and ESA. The IRL maturity spectrum can be a useful tool to explore and identify the most suitable facilitator according to the current IRL of one's business development state. An entrepreneur in idea phase will have different priorities and needs than a start-up with a higher IRL. Moreover some TT facilitators have higher requirements and will not be accessible for a beginning entrepreneur.

[101] ELDERLING, C., "We need more Space!", 2019, www.linkedin.com/pulse/we-need-more-space-cornelis-niels-eldering/, retrieved: 30 May 2019.

It is however important to underline that the spectrum does not give an indication of an absolute chronological order. For instance, an ESA BIC alumnae may still want to become an Astropreneur to get additional coaching, or a start-up may opt for only one of the initiatives, and it may as well be that an already established company applies for a demonstrator call. The spectrum merely gives an indication for the most suitable and accessible space TT initiative in relation to the readiness for innovation.

3. Strategy

The second chapter went through the different steps to generate a business model based on space technology. The business analysis roadmap provides the basic elements to map out a strategy to make the business model commercially viable. Additionally, in order to strengthen this strategy and to highlight the critical aspects of the business model, a SWOT analysis can be made. This should also help to identify the unknowns during the early phase of the project. Lastly, a good strategy also means flexibility. Having a backup plan allows to have enough alternatives to rely on when a failure or problem occurs.

Yet, no matter how strong a strategy may be, innovation involves taking risks and goes with learning and failing. Fortunately, a lot of funding opportunities can ease these risks and costs. However, in order to seize those opportunities a successful application is required. The above mentioned practices are important, but some additional elements should be included for the particular applications to funding. First and foremost it is important to understand why the funding is necessary (for scaling, to tackle technical barriers, for competitive advantage, etc.). The same exercise should be made from the perspective of the respective investor. This can be done by asking questions such as why the funding should be granted, or what the return on investment would be. A successful application shows how the project contributes to the valorisation of technology and how it contributes to the development of an ecosystem as a whole, potentially through collaboration with other companies or research institutes. Furthermore, it can be useful to benchmark the selected technology against other technological options for the same added value. This allows to examine whether the most appropriate technology was captured. In that regard, it is also important to distinguish a technology swap (estimate price decrease that the technology allows relative to the existing product), from new value creation (take into account the new features and hence new values to the end users when comparing with the price level of the existing product). Finally, it is a good idea to sketch an overview of the current scientific and commercial state-of-the-art based on scientific papers, review articles, patents, latest products available on the market, etc.[102]

[102] B. BRAECKMAN, "Guidance and advice for innovation subsidies", https://verhaert.com/guidance-advice-innovation-subsidies/, retrieved: 4 June 2019.

4. Network

Maybe the most important element of all, a growing network. Setting up a basic network is the key in order to obtain a space connection in the first place. Getting in touch with experts from within the space industry will make a good start. From thereon, an idea can grow along with the network that surrounds it.

Networking is not only of key importance in the beginning of business development, but also during the different development stages, as well as in the final phase of scale-up. For example, during the early phases it is important to collect info and advice or to assemble a team, while it is important to have publicity and access to investments during the latest stages. Moreover, putting effort in an ever expanding network should be a core activity from start to finish because it has self-reinforcing effects. It helps to get accepted for space TT programmes, which in turn will greatly enhance one's network. Continuously being on the lookout for potential partners, investors, customers will create opportunities, whatever the state of business.

7.2 Macroscale best practices for policymakers

a) ESA Space Solutions

5. Open innovation and diverse ESA BIC locations

Start-ups or companies in an open innovation context continuously seek inspiration from other sectors. Nowadays, organisations do not just rely on their own internal knowledge, sources and resources for innovation, but also use multiple external sources to drive innovation. Therefore, instead of a single concentrated and more isolated centre, it may be advantageous to establish several sites or to provide a variety in the knowledge centres surrounding an ESA BIC facility. This offers the opportunity to interconnect with a larger variety of different actors. For instance, the case study showed that ESA BIC Madrid includes four locations with region-specific features near four different universities. This diversity of different innovation campuses was perceived to be very effective.

b) Horizon Europe

Horizon Europe will be the successor of H2020. What lessons can be learned with regard to space TT?[103]

6. Complementarity with ESA TT programme

With its business incubators, ESA has developed the strongest and most extensive space TT facilitator. The EU facilitators, on the other hand, are accelerators that fit in very well, either before (Astropreneurs) or after (SpaceUp) the ESA BIC programme. While the ESA facilitator is more focussed on business and technical support in combination with direct funding, the EU space TT facilitators aim to provide mentoring and indirect funding opportunities through networking and advice. By 2021 both the Astropreneurs Accelerator and the SpaceUp programme will be completed. It is recommended

[103] European Commission, "Horizon 2020 interim evaluation: maximising the impact of EU research and innovation", 2018, https://ec.europa.eu/transparency/regdoc/rep/1/2018/EN/COM-2018-2-F1-EN-MAIN-PART-1.PDF, retrieved: 1 June 2019.

that the successor programmes maintain a similar complementarity. Horizon Europe will also introduce the European Innovation Council (currently under the form of EIC pilot), which will focus on scaling up highly technological start-ups in general. Additional or successor space TT programmes are not yet announced but should be launched in order to preserve and further expand the network and knowhow gathered by the Astropreneurs Accelerator and SpaceUp Academies.

As a consequence, the objective of the EU is not to establish incubators similar to ESA BIC, but rather to provide additional assistance to entrepreneurs and other innovation agents in overcoming financial, administrative and networking barriers. In particular, it contributes to access public funding opportunities of the EU, as well as other funding opportunities from member states, ESA, regional authorities, and private investments. Therefore, these EU initiatives are aimed to be complementary with existing space TT initiatives such as ESA BICs.

7. Increase synergies between space TT programmes

The use of space technology is able to push the boundaries of innovation forward, and this is what the European industry and economy needs. In contrast to its global leading position in science, Europe lags behind in bringing innovative ideas to the market. Many European start-ups have difficulties to make it beyond the critical first few years. Therefore it is important to promote entrepreneurial activity, innovative start-ups, or disruptive thinking on the basis of space technology. The growing awareness of the TT process to valorise space technology should result in the further expansion of support for innovative starters within the European space ecosystem, so that innovative commercial off-the-shelf technologies and economic growth follow.

In order to deepen Europe's innovation and risk-taking capability to compete on an intensified global competitive market that is increasingly defined by new technologies, a European Innovation Council will be put in place by 2021 under Horizon Europe. With regard to space, this entity may be a suitable partner for ESA in order to formally align the TT programmes. It may also increase synergies between ESA and EU space TT programmes. Exchanging knowhow, networks, or infrastructure could enrich both ESA and EU space TT programmes. For example, industry days could be organised with new and graduated start-ups, where the entrepreneurs can meet each other to share their experiences and ideas. For the moment, the requirement not to be hosted in another support programme illustrates that ESA BIC is a dedicated and complete programme on its own and does not have to rely on other initiatives simultaneously. However, this requirement should not be applied too strictly with regard to the EU facilitators in order to allow a stronger collaboration between ESA BIC and EU facilitators.

8. A space TT facilitator with direct funding

With Astropreneurs and SpaceUp, H2020 introduced two facilitators specifically for the support of start-ups relying on space. Both programmes fit in very well with existing space TT programmes. However, both the EU facilitators mainly focus on advice and networking, but in contrast with ESA BIC they do not offer direct funding. Instead, current EU space TT facilitators render guidance and assistance in the application for other funding opportunities within the EU framework (but also outside

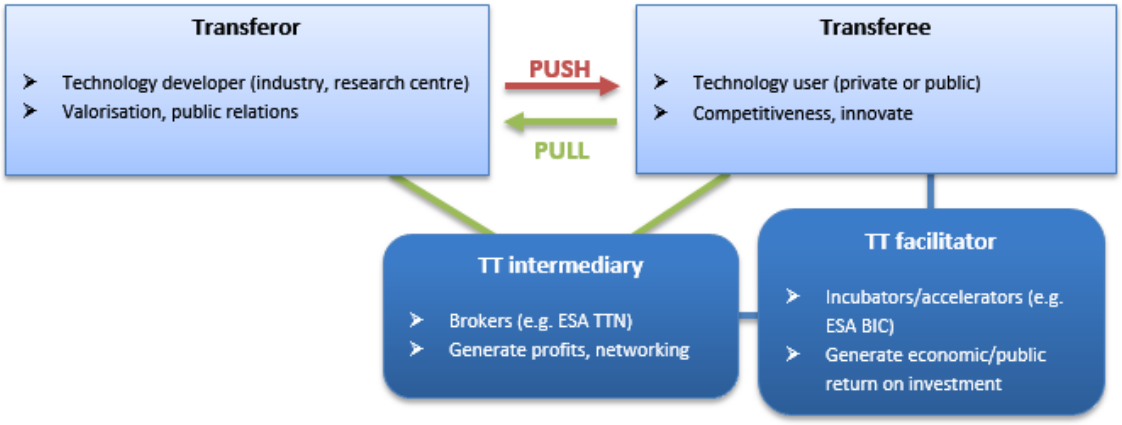
of it). It would be convenient if at least one space TT facilitator of the EU could offer direct funding to selected start-ups. Preferably in the early IRL stages, since the mature start-ups attract investments and funding more easily. However it should be realised that direct funding comes with more documentation and a heavier application procedure. The impact of such a trade-off should be minimised in order to keep accessibility high enough to respect the current complementarity with ESA BIC.

c) ESA Space Solutions Belgium & Flanders' Space

9. Technology interaction model

Originally the TT process was based upon the technology push model, starting with a technology in search of an application. Over the years this model evolved to a user-focussed pull model, based on the market demand. Verhaert refined this pull model further with its Techxfer approach with proactive and interactive elements. In order to identify user needs, events are regularly organised. This way, a potential user with a certain need can meet and connect with the space business community, where a fitting solution may be present. This proactive approach to search for requests and specific needs, while matching them with space technologies that could offer a solution to those terrestrial needs, creates a complete chain of technology valorisation ranging from opportunity creation (scouting, workshops and events), feasibility research (consultancy), and ESA funding to tackle technical barriers (open calls for demonstrators). With this TechXfer approach, innovative applications of space technology are enabled in different market segments on Earth.

Alongside this proactive search for user needs and fitting space technologies, increasing TT activities have also led to new strategies on the level of the transferor. Technology valorisation now even directs the research agenda and determines the technology route map. Such a proactive stance during technology development with regard to valorisation opportunities, should be encouraged during the set-up and selection of space programmes. The valorisation potential can already be taken into account from the start, where each mission's budget also includes activities to enable this technology valorisation.



10. Clustering

The goal of innovation clusters is to unlock unused economic potential among companies through active and sustainable collaboration between different actors. The Flemish cooperative model in which both industry and knowledge institutes are present, stimulates growth ambitions, innovation awareness, an international attitude and contributes to competitiveness growth among a large group

of Flemish companies. However, clustering can and should be done on all different levels. From an overarching European (ESA Space Solutions) and national (ESA Space Solutions Belgium) cluster, to the collaboration on a more regional level (IBN Space 4.0). This could be even taken further to create local mini-clusters, such as a Belgian Astropreneurs Club. In turn, clustering produces self-reinforcing effects because it results in inter-cluster synergy, cross-fertilisation, complementarity, and technological advances.

11. Triple helix Taskforce 'Space Economy'

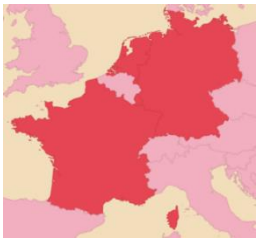
The IBN Space 4.0 does not equal the role of a triple helix Taskforce. The IBN works on the level of industry but does not involve sufficient other stakeholders to implement a more general Flemish space policy, such as to manage inter-clustering. A permanent triple helix Taskforce would thus still provide a useful unit in addition to the IBN. If such a Taksforce could also be established for the Regions of Brussels and Wallonia, these could become representative space committees for the Regions on a federal level.

VARIO recommended to establish a triple helix Taskforce 'Space Economy'. This Taskforce would have the mandate and the necessary authority to develop an integrated and coordinated strategy for the Flemish space economy. Such a Taskforce would ensure that the Flanders' Space strategy is translated into a concrete action plan, and that the recommendations from this VARIO advisory report are effectively implemented. In order to function optimally, the Taskforce should have a balanced composition, a workable size and receive the necessary support (administrative, logistical and financial) within the Flemish economy, science and innovation policy.

Additionally, VARIO recommended that a triple helix Taskforce should identify specific entry barriers and needs of the Flemish space actors in order to optimise the existing support mechanisms within the Flemish policy for economy, science, and innovation. The newly established initiative, ESA Space Solutions Belgium, now provides that kind of support for technology (scouting, feasibility studies and demonstrators), but also for business (incubators and accelerators). A triple helix Taskforce could monitor this programme further on a Regional level and assess the economic and social returns.

Finally, within the triple helix model a Learning Factory should be added. With regard to the Belgian space sector, ESEC has all the ingredients to fulfil that role. The case study of Astrolympia showed that this ESA facility in Belgium can serve as a potential Learning Factory, offering opportunities to students, researchers and industry. The Technology Transfer & Innovation Workshop was held by ESA Academy's Training & Learning Facility in ESEC-Galaxia Belgium and was based upon a real case, bringing the real-world into the classroom which results in the creation of new projects.

Taking into account the positive effects of a Learning Factory, Belgian policymakers should be on the lookout for similar initiatives. One example would be ActInSpace.[104] This event, taking place in France, has only been around for three years but already went global. It is an event where students and entrepreneurs have to tackle challenges with space technology or data.



© ActInSpace

[104] https://actinspace.org/.

Over thirty countries participated in last year's edition. Belgium is not one of them, although all its neighbouring countries are.

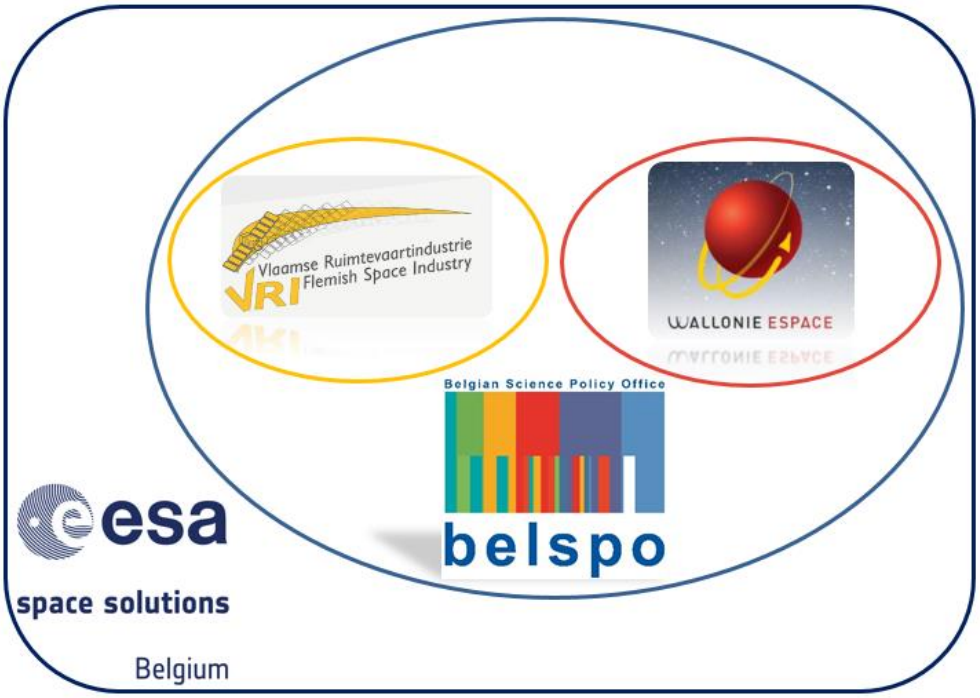
12. ISAB alternative

Because of the clash of interests between Flanders (strive towards a higher return and representation), Brussels and Wallonia (a higher return to Flanders implies a lower return to the other Regions), and the federal level (preserve its remaining competences and institutes), ISAB gained a bad connotation outside of Flanders. Although all the neighbouring countries of Belgium have created a national space agency, the past five years of legislature have shown that an Interfederal Space Agency of Belgium will not be established anywhere soon.

Nevertheless, there are strong arguments favouring at least some kind of formal overarching structure in which both federal and Regional stakeholders are represented. Precisely because of the Belgian federal state structure, a formal representation of the Regions on the federal level seems justified in light of the Regional competences concerning the space economy. This would allow the Belgian delegation to take more Region-specific needs into account when signing onto ESA programmes, which would also contribute to the legitimacy of its decisions. Moreover, the integration of all personal and financial resources into one organ would be advantageous. Finally, with regard to the space programmes of the European Commission, where procurement works according to the strict principle of best value, a stronger national organisation can also bring competitive advantages to win these European calls. However this should not be overstated. The main actors in the Belgian space industry are SMEs operating on a Regional level, and the EU procurement may not work with the principle of geo-return but still ensures a balanced industrial base, supporting SME participation.

Rather than the costly creation of a new institute such as ISAB and in order to avoid the replacement of Belspo, a permanent committee for space could be installed instead with economic, science and institutional actors representing industry, research and governments. This would close the gap where a formal structure between the Regional and federal level is missing. This national committee would also enable a stronger national organisation of the industry (which is already happening through Regional clustering). Compared to other fields of economic activity, the Belgian space sector is relatively modest in size, therefore it is imperative for Belgian companies to bundle their forces in space business, creating stronger ties between all Belgian space actors. With ESA space solutions Belgium, the basis for such a formal overarching structure is already there. ESA Space Solutions Belgium is based upon a partnership between actors of the different levels. A permanent committee within this setting could be established and would make more sense than creating a whole new agency that would disrupt the entire system. Such a committee could for example consist of the representative of the triple helix Taskforce from each Region, together with Belspo. This structure, with stakeholders from the Regions and the federal level, would resemble a small scale ESA specifically tailored for Belgium. Moreover, strengthening this overarching structure would further facilitate space TT since it would contribute to a better alignment between the different actors, especially those operating on different levels (between the Regions or between a Regional and federal level). Finally, dedicating the role of ESEC to that of a Learning Factory, as described with the triple helix model, would also make more sense if it can operate on a national level within the structure of ESA Space Solutions Belgium.

It can be concluded that the Flanders' Space strategy includes several interesting recommendations. Some of these could be transplanted to a national level. This would be more efficient since it would enable more connections between relevant actors, and unlock the full potential of resources and opportunities available in Belgium. With regard to space TT, such a national initiative is already there. The structure of ESA Space Solutions Belgium connects several partners that are managing the space ecosystem within their Region. Building upon this initiative will be effective and efficient. Instead of setting up new structures or instruments, a committee can be embedded into this existing structure. In the figure below the suggested setup is illustrated. The Regions are represented by their respective triple helix Taskforce or space cluster (e.g.: VRI for Flanders, and Wallonie Espace for Wallonia and Brussels); Belspo remains the federal representative; and finally an ESA Space Solutions Belgium committee, consisting of a representative of each Region and the usual Belspo delegation, forms the overarching formal structure and represents Belgium on the international field.



7.3 Closing remarks on downstream space technology transfer

From the introduction it appeared that in the five biggest ESA member states, public awareness about the impact of space technology on everyday life was relatively low. Nevertheless, the European space industry has found many innovative ways to apply its technology on Earth. ESA and the EU are running successful initiatives to promote the transfer of space technology. In addition to the enormous knowledge that space exploration has already delivered, space technologies have become integrated into everyday life so deeply that modern society could not function without them. The European space programmes bring a tremendous return in terms of jobs, technological knowhow, scientific knowledge and space spin-offs.

Over the past decades, space technology has given us laptops, wireless devices, exotic materials, and even artificial limbs and organs. So far, the ESA and EU space programmes have mainly concentrated on Earth observation, communications, global positioning, and space science missions. During the current era of space exploration we even managed to capture mind-boggling images of ultimate distant objects and a black hole. Moreover, the advances in robotics for planetary exploration, with automated guided vehicles in factories developed on the basis of the ExoMars rover reached our own planet.[105] The advances in space technology over the last few years with regard to miniaturised satellite systems with likewise power supplies and equipment such as sensors, communications, or electronics continuously improve our lives.

In the future, spin-offs are likely to reflect the increase of prolonged manned space missions. ESA's involvement in human spaceflight, and the planned Moon and Mars missions should lead to new and exciting spin-off opportunities. New spacelabs will also allow more experiments in microgravity, where a weightlessness environment allows for a more straightforward analysis of biological processes, contributing to medical breakthroughs. As human space travel progresses and life-support in space becomes more of an issue for European astronauts, it is likely that we will get further benefits from this on Earth in the coming years. Over the past three decades ESA has already been working on the Micro-Ecological Life Support System Alternative (MELiSSA) project to develop closed loop systems, using biological filters and other techniques to convert human waste into drinking water, food and oxygen. Through SEMiLLA IPStar, its technology transfer member, the project delivers Earth based circular systems in treating biological and other waste in a highly eco-friendly manner. We might even get unlimited, clean, space based solar power.

The transfer of space technology is a source of innovation and improves life on Earth on a daily basis. In order to overcome market failures, entrepreneurs and companies need all the support they can get to put this process into practice. Their risk taking ventures generate a visible return that keeps investments in space flowing. Therefore, the actors responsible for the valorisation of space technology may even be regarded as the driving force behind the space industry.

[105] ESA, "Space tech modernizes Portuguese factory", 2018, www.esa.int/Our_Activities/Space_Engineering_Technology/TTP2/Space_tech_modernizes_Portuguese_factory, retrieved: 4 June 2019.

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