STUDY ON

LATVIA'S PARTICIPATION IN EUROPEAN SPACE AGENCY SINCE 2015

Public procurement No. IZM 2019/13

Authors: Tõnis Eerme, Oliver Lillestik

Contents

1. Introduction

The European Space Agency (ESA, www.esa.int) is an international organisation with 22 Member States. Its mission is to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world. The Member States of ESA are: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, and the United Kingdom.

ESA's headquarters are in Paris which is where policies and programmes are decided. ESA also has sites in a number of European countries, each of which has different responsibilities:

- EAC, the European Astronauts Centre in Cologne, Germany;
- ESAC, the European Space Astronomy Centre, in Villanueva de la Canada, Madrid, Spain;
- ESOC, the European Space Operations Centre in Darmstadt, Germany;
- ESRIN, the ESA centre for Earth Observation, in Frascati, near Rome, Italy;
- ESTEC, the European Space Research and Technology Centre, Noordwijk, the Netherlands.
- ECSAT, the European Centre for Space Applications and Telecommunications, Harwell, Oxfordshire, United Kingdom.
- ESEC, the European space Security and Education Centre, Redu, Belgium.

ESA employs around 2200 scientists, engineers, information technology specialists and administrative personnel from all the Member States. ESA's budget for 2019 is 5.72 billion Euros (**Figure 1**). ESA's mandatory activities (space science programmes and the general budget) are funded by a financial contribution from all ESA's Member States, calculated in accordance with each country's gross national product. In addition, ESA conducts a number of optional programmes. Each Member State decides in which optional programme they wish to participate and the amount they wish to contribute.

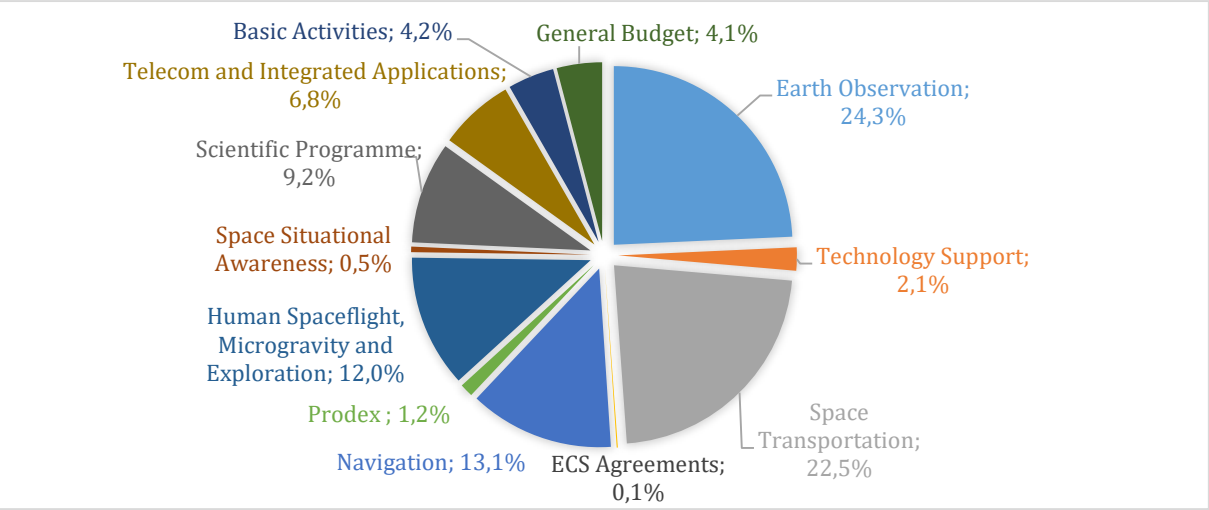

Figure 1 ESA budget by domain for 2019[1]

Since 2004, thirteen European countries (EU-13) have joined the European Union. As of August 2019, all these countries have established formalized ties with the European Space Agency (ESA). There are five Full Members and one Associate Member among the EU-13. The cooperation between the remaining seven EU-13 countries is governed by the international agreements that ESA concludes with its external partners: five countries have signed the European Cooperating

[1] http://www.esa.int/spaceinimages/Images/2019/01/ESA_Budget_by_domain_2019

State agreement, while two countries have concluded Cooperation Agreements. The summary of ESA and EU-13 cooperation is provided in **Table *1***.

Table 1 ESA cooperation with the new European Union member states (EU13)[2]

Country	Cooperation Agreement	Extended CA	European Cooperating State	Extended ECS	Associate Member	Full Member
The Czech Republic	1996		2003			**2008**
Hungary	1991		2003	2008		**2015**
Romania	1992		2006			**2011**
Poland	1994		2007			**2012**
Estonia	2007		2009			**2015**
Slovenia	2008		2010	2015	**2016**	
Latvia	2009		2013			
Lithuania	2010		2014			
Slovakia	2010		2016			
Bulgaria			2015[3]			
Cyprus	2009	2015	2016			
Malta	2012	2017				
Croatia	2018					

By the decision of the European Space Agency (ESA) Council of 21/22 March 2001, ESA created a new European Cooperating State (ECS) status which opened up opportunities for East European countries to participate more closely in ESA programmes. Latvia is one of the five ECS countries as of September 2019. ESA Council at its meeting of 13-14 June 2012 unanimously approved the draft ECS Agreement between the Government of Latvia and the ESA (ESA/C(2012)61). Parties signed the latter on 15 March 2013. The purpose of the PECS Charter is to define the terms and conditions of the financial contribution of Latvia to the PECS pursuant the terms of the ESA/Latvia ECS Agreement. Pursuant to Article 14 of the ECS Agreement, the ESA/Latvia ECS Agreement will remain in force for a period of 5 years, i.e. until 29 January 2020. In the second half of 2019, Latvia has to make decisions about the next steps in ESA-Latvia cooperation.

The purpose of the report is to provide a comprehensive look at the Latvian participation in ESA activities since 2015 and thoroughly analyse available options for ESA-Latvia cooperation beyond 2020.

[2] Sources:
- ESA website
- Sagath, D., Adriaensen, M., Giannopapa, C., 2018. Past and present engagement in space activities in Central and Eastern Europe. Acta Astronautica 148, 132–140. https://doi.org/10.1016/j.actaastro.2018.04.048
- Klock, E., Aliberti, M., 2014. ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession – With a Special Focus on the CEE Region (No. ESPI Report 47). European Space Policy Institute, ESPI, Vienna.

[3] Bulgaria signed an ECS Agreement directly without a prior Cooperation Agreement.

2. Data collection methodology

2.1. Study samples

The data about the impacts of the PECS funding to the main beneficiaries of the PECS calls in Latvia between 2015 and 2019 were gathered through face-to-face interviews with managers of space companies and representatives of research groups at universities (see companies 1-9 in **Table 2**). The list of companies without ESA contracts but with space heritage and strategic focus on aerospace business as of August 2019 included SIA Fiber Optical Solution, SIA Axon Cable, SIA Allatherm, and SIA HEE Photonic Labs. Institute of Solid State Physics of the University of Latvia, Sidrabe, and Hansamatrix were added to the study sample after the discussions with the Ministry of Education and Science of Latvia. Axon Cable, Sidrabe, and Hansamatrix are not yet registered ESA-STAR database[4] despite participating in the briefings of different Latvian PECS calls.

Table 2 Latvian entities interviewed for the 'Study on Latvia's participation in ESA since 2015'

No	Entity	PECS contracts	PECS proposals	Space heritage
1	**Riga Technical University**	YES	YES	YES
2	**Eventech, SIA**	YES	YES	YES
3	**RD Alfa Mikroelektronikas Departaments, AS**	YES	YES	YES
4	**Institute of Electronics and Computer Science (IECS)**	YES	YES	YES
5	**Latvian State Institute of Wood Chemistry**	YES	YES	YES
6	**Baltic Scientific Instruments, SIA**	YES	YES	YES
7	**Foundation Institute for Environmental Solutions**	YES	YES	YES
8	**Baltic Satellite Service, SIA**	YES	YES	YES
9	**Meža ipasnieku konsultativais centrs, SIA**	YES	YES	YES
10	**Institute of Solid State Physics of the University of Latvia**			
11	**Allatherm, SIA**	To be signed	YES	
12	**Fibre Optical Solutions, SIA**			YES
13	**HEE Photonic Labs, SIA**		YES	
14	**Axon Cable, SIA**			YES
15	**Sidrabe, SIA**			YES
16	**Hansamatrix, AS**			

The short descriptions of the interviewed entities:

RD ALFA Mikroelektronikas Departaments (http://www.rdalfa.eu) was established in 1962 and accumulates almost 60 years of experience in the design and production of HiRel, RadHard & ITAR free analogue integrated circuits for aerospace, defence and other high-performance applications. The company has significant expertise in the field of Analog and Analog to Digital

[4] The ESA Member States have made it mandatory for the ESA to register economic operators wishing to do business with the ESA. Therefore, being registered in the ESA e-tendering system ESA-STAR (https://esastar-emr.sso.esa.int/) is a good indicator of an entity's intent to do business with ESA.

technology (Bi-polar (Bi), Bi-FET, complementary Bi, CMOS, and Bi-CMOS), and the design and testing of microcircuits.

Baltic Scientific Instruments (http://bsi.lv/en/) was established in 1994 on the basis of Riga Research and Development Institute for Radio-Isotope Apparatus (RNIIRP), which belonged to the Ministry for Atomic Energy of the former Soviet Union. RNIIRP was an important contributor to the Soviet space programmes, such as Buran. All semiconductor detectors of the Soviet space programmes were fabricated in Riga. Due to its unique competences, Baltic Scientific Instruments cooperated with ESA under the ESA's Science Programme long before the first Latvian PECS call.

Eventech (http://eventechsite.com/) was established in 2011 as a spin-off company of the Institute of Electronics and Computer Science. The company is the technology leader in terrestrial timing application for Satellite Laser Ranging. The core technology of the company is licensed in from the Institute of Electronics and Computer Science which has worked on the design of event timer systems since 1970s.

Foundation Institute for Environmental Solutions (http://www.videsinstituts.lv/) is a privately established research and development institution focused on the management of natural resources. The institute is a multi-disciplinary team of specialists in ecology, limnology, forestry, agriculture, chemistry, physics, technologies, and innovation management who apply Earth Observation and environmental remote sensing to develop data-based solutions in their particular fields of expertise.

Latvian State Institute of Wood Chemistry (http://www.kki.lv/) was established in 1946. It is a state R&D Institute providing research and testing in the field of wood and wood component chemistry and technology, polymer chemistry and biotechnology. The Polymer Department of the Institute develops polyurethane foam materials for cryogenic insulation. In Soviet time, the foams developed by the Institute were used in the space shuttle Buran. Currently, the institute has active collaboration with ArianeGroup GmbH that has resulted in one joint patent application.

The Institute of Materials and Structures of **Riga Technical University** (http://www.rtu.com/) has three main competence areas: (i) investigation of composite structures; (ii) composite material testing and mechanical behaviour characterization; (iii) composite material concept design, analytical and numerical analysis. The two research themes of the group that have potential applications in space domain are: (i) the design of launcher and satellite structures and; (ii) non-destructive testing of space structures based on vibration correlation technique.

Institute of Electronics and Computer Science (http://www.edi.lv/) has about 60 years of experience in developing hardware and software for different application domains. Its main competences in the space field cover: (i) extremely precise event timing, development of units for earth and space domains; (ii) unsupervised and automatic satellite image land cover classification, creation of dedicated algorithms and software tools to cluster, classify and detect changes in the optical satellite imagery, and (iii) compact electronically steerable antenna array systems for networking and data transfer.

Meža ipasnieku konsultativais centrs SIA (http://www.mikc.lv/) is one of the largest forest management companies in Latvia. It offers a wide range of advisory services to actors in the forestry value chain. The company has long experience with collecting and processing airborne remote sensing data. It is the technology commercialization partner of the Foundation Institute for Environmental Solutions.

Baltic Satellite Service SIA (http://www.baltsat.lv/) is a company developing solutions for processing satellite imagery established in 2016. It has developed fully automated technology for processing Sentinel-1 and Sentinel-2 images to provide immediate access to each image for

further analysis, implementation in any software application and use in machine learning platforms.

Institute of Solid State Physics of the University of Latvia (https://www.cfi.lu.lv/) was formed in 1978. Since 2005, the institute has been a coordinator of several National Research Programs in Materials Science and Information Technologies: "*Development of advanced functional materials for microelectronics, nanoelectronics, photonics, biomedicine and constructional composites, as well as related technologies*" (2005-2009), "*Development of novel multifunctional materials, signal processing and information technologies for competitive knowledge-based products*" (2010-2013), "*Multifunctional materials and composites, photonics and nanotechnology*" (2014-2017). In 2016, the institute was awarded a prestigious grant from Horizon 2020 programme's TEAMING call (https://www.camart2.com/). This grant amounts to 15 million Euros and focuses on the efficient transfer of new materials and technologies into commercial products.

Allatherm (http://www.allatherm.com) was established in 2015. The founders of the company have more than 25 years of experience in developing innovative, customer-oriented thermal products, systems and solutions. At his previous employers, the founder and CTO has worked together with the leading European space organisations, such as ESA, Thales Alenia Space, OHB, and Airbus Defence and Space, on challenging thermal management solutions.

Fiber Optical Solutions (http://opticalsolution.lv/) is a vertically-integrated company specializing in the production Fiber Optic Gyroscopes (FOG). It was established in Riga in 2013 as a sister company of Optolinks (http://www.optolink.ru/), a Russian entity developing and manufacturing FOGs. The company is currently working on a new site for the manufacturing of optical components, including ISO4 clean rooms. Upon completion, the new facilities would allow the manufacturing of gyroscopes and Inertial Measurement Units on-site in Latvia. Fiber Optical Solution has supplied high precision FOGs and other Inertial Navigation Systems to more than 20 companies worldwide, including NASA, Applanix Corporation and Lockheed Martin.

Axon Cable is the Latvian subsidiary of the French group Axon Cable (http://www.axon-cable.com). The company was established in Latvia in 2000. The company manufactures high-tech cable assemblies for different industries, with aerospace and defence representing 60% of the total turnover. The assembly of cables and connectors is performed in Latvia, from which more than 90% of all the manufactured products are exported. The company sells ESCC (European Space Components Coordination) qualified wires and connectors. Commercial space contracts include wire harness cabling for Airbus-OneWeb satellite constellation.

HEE Photonic Labs (http://www.heephotonic.eu/) was established in 2007 as a spin-off of the University of Latvia. The company aims at developing innovative satellite laser ranging systems and other specific optical systems for space applications. The team originates from the University of Latvia's research group that has experience in designing and producing optical systems for space tracking since 1970s. Totally, the team has designed, built and sold world-wide about 50 various space-related optical instruments and devices.

Sidrabe (https://www.sidrabe.com/) is designing and manufacturing vacuum deposition equipment, and developing technological processes related to novel materials. Its predecessor, Vacuum Metallization Design Bureau, was established in 1962. The design bureau actively contributed to the Soviet space programs, including the Buran program. The company's main shareholder is an investment fund based in the United States. The company performs R&D in the domain of functional coatings. Sidrabe is an expert in effective cooling of metallic foils, polymeric films and foam materials, and deposition onto powder materials.

Hansamatrix (http://www.hansamatrix.com/) is a leading Baltic electronic system product developer and manufacturer, listed on the Nasdaq Baltic Main List. It operates in industrial

systems, data network infrastructure, IOT, medical and several other business-to-business market sectors. The company is transitioning from offering contract manufacturing services towards offering a full range of services, including value added design, engineering and aftermarket services.

Table 3 Key financial data for the interviewed Latvian companies

Company	Annual turnover (2018, in Euros)	Annual profits (2018, in Euros)
Baltic Scientific Instruments, SIA	4 816 796	399 737
RD Alfa Mikroelektronikas Departaments, AS	1 247 994	382 985
Eventech, SIA	155 208	17 150
Meža ipasnieku konsultativais centrs, SIA	2 951 529	78 707
Baltic Satellite Service, SIA	80 129	18 628
Axon Cable, SIA	29 821 373	1 028 400
Allatherm, SIA	70 608	3 874
Fiber Optical Solution, SIA	3 522 646	-1 735 706
HansaMatrix, AS	21 153 730	781 018
HEE Photonic Labs, SIA	3 790[5]	3 363
Sidrabe, AS	432 930	-216 570

The second sub-sample of the study of Latvia's participation in ESA as a European Cooperating State included the entities that have completed or almost completed **only small ESA contracts** (**Table 4**): feasibility studies of research and development activities or awareness and education activities. Several activities were implemented by a consortium of partners. In such cases, only prime contractors were added to the study sample. **Ventspils University of Applied Sciences** (formerly Ventspils University College) executed both one feasibility study and one education activity.

Table 4 Prime contractors of small projects funded under the Latvian PECS calls

Contractor	Type	Feasibility study	Awareness and education activity
Aspired, SIA	Company		**X**
Foundation Ventspils High Technology Park	NGO		**X**
Ventspils University of Applied Sciences	Academia	**X**	**X**
Institute of Physics of the University of Latvia	Academia	**X**	
Riga Technical University	Academia	**X**	
The University of Latvia	Academia	**X**	
Meža ipasnieku konsultativais centrs, SIA	Company	**X**	
Baltic Satellite Service, SIA	Company	**X**	

[5] Data from the 2017 annual report.

2.2. Data collection methods

The data about the impacts of the PECS funding to the main beneficiaries of the PECS calls in Latvia were gathered through **face-to-face interviews** with managers of space companies and representatives of research groups at universities. A **semi-structured questionnaire form** was developed on the basis of the questionnaire applied in the study '*Ex ante assessment of multiplier effects induced by space investments from very small ESA candidate countries' perspective'* that was executed by Invent Baltics OÜ in 2015 in the Czech Republic and Estonia[6]. The latter questionnaire is fully compliant with the reference studies performed in Norway[7] and Denmark[8].

The questionnaire followed the so-called BETA (*Bureau d'Économie Théorique et Appliquée*) methodology that focuses on the **indirect industrial (economic) impacts** of space activities. The indirect industrial effects stem from the contractual relationships between the space agencies and the contracting bodies (companies and academia) that carry out a project. The indirect industrial effects include all the benefits in terms of technology, know-how, corporate image or business contracts, which the firms derive from their participation in ESA programmes and can use elsewhere, resulting in increased (additional) sales and value added.

Four types of indirect economic effects are distinguished in the **BETA methodology** (see Cohendet 1997[9]):

- **Technological effects** corresponding to the transfer of technology developed during an R&D programme by the participants to it like derivatives from ESA products, new products, and product improvements.
- **Commercial effects**: i) network effects (the impact of the programme on the research and business connections of the participants involved); ii) reputation effects (ESA contracts can be used as a marketing tool or reference).
- **Organisation and method effects** like changes to the organisational structure, adoption of novel quality control, experimental procedures, tests and measurement, management methods.
- **Work factor effects** like heightened qualifications and skills acquired by the personnel employed in public R&D programmes, which enable them to feed expertise into the company departments not directly concerned with the same activities, also building up a critical mass of specialists, scientists, engineers and technicians.

The study questionnaire contained sections for collecting retrospective data about the respondents' position in the space value chain and benefits from the completed Latvian PECS projects. Also, the questionnaire sought to map the entities' expectations about their future progress in the institutional and commercial space markets as well as potential economic effects from the PECS funding.

The Latvian Ministry of Education and Research sent a letter to the main beneficiaries with the study questionnaire attached to it allowing respondents to prepare themselves for the interviews and pool together relevant data. The introductory letter was sent on May 21st 2019 and the interviews were conducted between June 10th and July 10th 2019 (see **Table 5**). The interviews

[6] Invent Baltics OÜ (2015). Ex ante assessment of multiplier effects induced by space investments from very small ESA candidate countries' perspective, Contract No. 4000109692/13/NL/KML (unpublished).
[7] Evaluation of Norwegian Space Programs. PricewaterhouseCoopers AS, 2012
[8] Danish Agency for Science (2008). Evaluation of Danish Industrial Activities in the European Space Agency (ESA). Assessment of the economic impacts of the Danish ESA-membership. March 2008.
[9] Cohendet, P.; Evaluating the industrial indirect effects of technology programmes: the case of the European Space Agency (ESA) Programmes. In: Proceedings of the OECD Conference on Policy Evaluation in Innovation and Technology, 1997. [www.oecd.org/sti/innovationinsciencetechnologyandindustry/1907989.pdf].

were conducted at the premises of the respondents. The interviews lasted usually 1-2 hours depending on how thoroughly a respondent had prepared for the meeting.

Table 5 Basic information about the face-to-face interviews

No	Entity	Contact person	Position in the entity	Date of interview
1	**Riga Technical University**	Dr. Kaspars Kalninš	Leading researcher	10.06.2019
2	**Eventech, SIA**	Pavels Razmajevs	COO	10.06.2019
3	**RD Alfa Mikroelektronikas Departaments, AS**	Lev Lapkis	Development Manager	10.06.2019, 11.09.2019[10]
4	**Institute of Electronics and Computer Science (IECS)**	Dr. Ints Mednieks	Senior researcher	11.06.2019
5	**Latvian State Institute of Wood Chemistry**	Dr. Ugis Cabulis	Director	11.06.2019
6	**Baltic Scientific Instruments, SIA**	Dr. Vladimir Gostilo	CEO	11.06.2019, 9.09.2019
7	**Baltic Satellite Service, SIA**	Ilze Barga	CEO	13.06.2019
8	**Foundation Institute for Environmental Solutions**	Inese Suija-Markova	Managing director	20.06.2019, 10.09.2019
9	**Meža ipasnieku konsultativais centrs, SIA**	Gundars Skudrins	CEO	10.07.2019
10	**Institute of Solid State Physics of the University of Latvia**	Dr Andris Anspoks	Deputy director for Innovation	21.08.2019
11	**Allatherm, SIA**	Dr Donatas Mishkinis, Igor Ushakov	CTO, CEO	21.08.2019
12	**Fibre Optical Solutions, SIA**	Alexander Blumental	Executive director	21.08.2019
13	**HEE Photonic Labs, SIA**	Dr Andris Treijs	CEO	21.08.2019
14	**Axon Cable, SIA**	Yann Sinquin, Ineta Pechonka	Deputy General Manager, Sales and Marketing Coordinator	09.09.2019
15	**Sidrabe, SIA**	Nils Veidemanis, Andrejs Balabkins	CEO, Head Of Marketing Department	10.09.2019
16	**Hansamatrix, AS**	Krišs Osmanis	Senior Product Development Manager	10.09.2019

The semi-structured interviews with the main beneficiaries of the PECS calls in Latvia showed that awareness about ESA optional programmes and the ESA procurement system varies considerably among the interviewees. Some of the current ESA contractors have limited knowledge about ESA's programmatic needs and functioning of ESA procurement system. On the other hand, there are companies that invest their time and resources in ESA-related business development. For example, Eventech SIA has participated in ESA Technology Harmonisation process by attending mapping meetings pertaining to their field of expertise. Considering rather low awareness levels of the interviewed entities, the principal investigator of the study compiled

[10] There were follow-up phone interviews with a number of entities.

a tailored feedback letter to the respondents to inform them about business opportunities in the most relevant ESA optional programmes.

It was expected that the awareness about ESA optional programmes is even lower among the entities without ESA contracts (entities number 10 to 16 in **Table 5***)*. Therefore, the data gathering among such respondents was organised differently than in case of the ESA main beneficiaries in Latvia. After the consultations with the Latvian Ministry of Education and Research, it was decided to compile an interactive presentation covering the key features and results of the PECS programme and alternative future options on the basis of the discussions during the ESA–Latvia High Level Bilateral Meeting that took place on 7 August 2019 in Riga. The interactive presentation consisted of 45 slides and it included 10 open-ended questions:

- Do you think that the Latvian PECS programme has been successful? Did it achieve its goals? Please explain your viewpoint.
- Is the extension of PECS suitable for Latvia? Why?
- Why the scores [*of Latvian proposals to the PECS programme*] have been low?
- Why the industry has not been more active [*in the PECS progra*mme]?
- Should there be certain focus (e.g. Earth Observation or material sciences) in the PECS programme?
- How much should Latvia contribute to the PECS programme [*if extended*]? The minimal contribution is 7.4 million Euros in 5 years.
- Do you have an opinion about the optimal level of Latvian contribution to ESA?
- Would you see your organisation bidding in the open call of the Third Party Programme?
- How much should Latvia contribute to the Third Party Programme? The minimal contribution is 3.5 million Euros in 7 years.

The Latvian Ministry of Education and Research sent an introductory letter to the entities without ESA contracts yet on 13 August 2019 and the interviews were carried out between 21 August 20109 and 10 September 2019 (see ***Table 5***). The interviews were conducted by the principal investigator at the premises of the respondents, except for Axon Cable SIA. All meetings took place in Riga. The interviews lasted between 60-120 minutes.

The data about the impacts of PECS funding to the entities implementing the small projects were gathered through phone interviews (**Table *6***). The interviews were based on three open-ended questions:

- What were the main direct results of the small project?
- What are the ongoing and prospective activities of the entity in the space domain?
- Possible future collaboration with the European Space Agency in the future?

Table 6 The phone interviews with the managers of PECS small projects

No	Entity	Contact person	Position in the entity	Date of interview
1	**Foundation Ventspils High Technology Park**	Dr. Dita Lašinska	Head of science and technology museum	10.07.2019
2	**Ventspils University of Applied Sciences**	Romass Pauliks	Electronics and Satellite Technology Department Manager	3.07.2019
3		Maris Elerts	Dean, IT faculty	3.07.2019
4	**Institute of Physics (the University of Latvia)**	Dr. Kalvis Kravalis	Senior researcher	26.06.2019
5	**The University of Latvia**	Dr. Janis Balodis	Director	17.06.2019

The phone interviews were conducted between June 17th and July 10th 2019 (see **Table *6***) and lasted between 20 to 30 minutes. The managers of two small projects implemented by Aspired SIA (education activity) and Riga Technical University (feasibility study) did not respond to the repeated requests for a phone interview. The principal investigator filled in questionnaire forms for both face-to-face and phone interviews and distributed the filled-in forms to the respective respondents for approval. Only duly approved questionnaires were used for further analysis.

3. Economic impacts of the ESA contracts in Latvia

3.1. Latvian ESA contractors

As of September 2019, Latvian entities[11] have had an opportunity to submit their ideas to **six calls** for Outline Proposals under the PECS in Latvia, further on jointly labelled as the PECS calls:

- **AO7516** – the 1st call (PECS-1); deadline – 1 July 2013;
- **AO8437** – the 2nd call (PECS-2); deadline – 30 November 2015;
- **AO8855** – the 3rd call (PECS-3); deadline – 31 March 2017;
- **AO9562** – the 4th call (PECS-4); deadline – 3 December 2018;
- **AO9791 –** the 5th call (PECS-5); deadline – 1 May 2019;
- **AO9953 –** the 6th call (PECS-6); deadline – 18 September 2019.

Table 7 The largest Latvian beneficiaries of the Latvian PECS calls (in terms of total price of recommended activities)

Contractor	Type	Total sum of recommended activities (€)
RD Alfa Mikroelektronikas Departaments, AS	Company	806 695
Eventech, SIA	Company	695 232
Foundation Institute for Environmental Solutions	NGO / company	678 933
Meža ipasnieku konsultativais centrs, SIA	Company	498 684
Latvian State Institute of Wood Chemistry	Academia	446 072
Allatherm SIA		386 000
Institute of Electronics and Computer Science	Academia	346 781
Riga Technical University	Academia	279 104
Baltic Scientific Instruments, SIA	Company	249 977
Baltic Satellite Service, SIA	Company	249 408

Altogether 39 activities have been recommended for funding under the first five PECS calls. The total price of the recommended Latvian activities was **5.08 million Euros.** Successful bidders of the first three PECS calls have concluded 27 contracts with ESA. Six more activities were recommended for funding by ESA under both PECS-4 call and PECS-5 call but the contracts to implement the recommended activities are still to be signed (under negotiation). The activities of 16 Latvian entities were recommended under the first five PECS calls. There were 7 companies, 7 academic establishments, and 2 non-governmental organisations among the successful Latvian bidders. For comparison, 13 Estonian private sector entities were awarded contracts with ESA under three calls for Outline Proposals of the Estonian PECS programme between 2011 and 2014.

Two aspects regarding the distribution of the contracts between ESA and Latvian entities are important to note. Firstly, the high concentration level of the contracts. From the pool of the signed contracts, just 7 entities have concluded 19 contracts (70 % of the total number of the awarded

[11] Legal Entity is any natural or legal person or public entity or group of persons and/or bodies which offers on the market, respectively, the delivery of supplies, products or services and which satisfies the eligibility criteria specified in Article 18 of the ESA Procurement Regulations (ESA/REG/001, rev. 5) and therefore is eligible to submit proposals to ESA. In case of universities, faculties can be considered as separate entities.

contracts) amounting up to 88% of the total commitments to the Latvian entities. Foundation Institute for Environmental Solutions (IES) and RD Alfa Mikroelektronikas Departaments are the ESA contractors with the largest number of the recommended PECS activities; both have 5 successful proposals.

Secondly, a substantial share of small PECS activities in Latvia (14 activities, 36% of the total number of the recommended activities). The price of small contracts is below 50 000 Euros. These small ESA contracts can be classified into two sub-types:

- **Feasibility studies** of research and development activities – as a rule of thumb, such projects' role is to demonstrate the viability of a proposed technology and capabilities of the project team to ESA;

- **Awareness and education** activities, such as the Satellite Technology Education Programme implemented by Ventspils University College.

3.2. Completed research and development projects funded from Latvian PECS programme

As of July 2019, the seven main beneficiaries of the Latvian PECS calls have completed ten activities aimed at research and development work (**The majority** of the completed projects reached to the technology readiness levels TRL3 (corresponding to 'Analytical and experimental critical function and/or characteristic proof-of-concept') and TRL4 (respectively, 'Component and/or breadboard validation in laboratory environment'), while marketable products and services are at least TRL8. The Eventech's projects were the only projects that reached product development phase (above TRL6). Otherwise, the completed activities were early stage applied research projects. Consequently, indirect industrial effects of the projects will emerge over a longer period of time. As a similar survey of ESA contractors in the Czech Republic revealed, there is an average time lag of 4-5 years between ESA commitments and the indirect industrial effects resulting from the implementation of ESA contracts. For early stage applied research projects, this period is even longer.

Table *8*). The total sum of the completed research and development contracts was 2 003 578 Euros, which equals to 62% of the total commitments allocated to the Latvian entities under the first three PECS calls.

The completed projects fall under three different categories:

- **Hardware activities** (e.g. flight hardware) related to ESA's missions, in the form of payloads or its sub-systems, or satellite-platform technologies and sensors, or to generic technologies with the potential for re-use;
- **Research and Development activities** (including technology demonstrations, industrial processes and their qualification/certification) leading to products (hardware or software) or to generic technologies with the potential for re-use;
- **Space applications**, products and services, such as Earth Observation applications, making use of space infrastructure that is already existing or scheduled for operation in the near term.

The majority of the completed projects reached to the technology readiness levels TRL3 (corresponding to 'Analytical and experimental critical function and/or characteristic proof-of-concept') and TRL4 (respectively, 'Component and/or breadboard validation in laboratory

environment'), while marketable products and services are at least TRL8. The Eventech's projects were the only projects that reached product development phase (above TRL6). Otherwise, the completed activities were early stage applied research projects. Consequently, indirect industrial effects of the projects will emerge over a longer period of time. As a similar survey of ESA contractors in the Czech Republic revealed, there is an average time lag of 4-5 years between ESA commitments and the indirect industrial effects resulting from the implementation of ESA contracts[12]. For early stage applied research projects, this period is even longer.

Table 8 The completed research and development projects funded from the first three Latvian PECS calls

Contractor	Title of activity	Contract amount (€)	Target TRL	Contract type
Foundation Institute for Environmental Solutions	*Simulating performance of ESA future satellites for water quality monitoring of the Baltic Sea*	159 979	3	Research and development activities
	Simulation of Sentinel-2 images for Land Cover / Land Use monitoring using hyperspectral airborne remote sensing	150 019	3	Space (downstream) Applications
	Assessment of grassland quality-quantity parameters management activities using Sentinel-1-2 data (SENTIGRASS)	149 509	3	Space (downstream) Applications
Latvian State Institute of Wood Chemistry	*Rigid polyurethane foams for internal tank insultation for launcher upper stages (CRYOFOAMS)*	201 977	5	Research and development activities
Riga Technical University	*Methodology for assessment of damage resistance properties of sandwich structures for European space sector*	200 000	4	Research and development activities
Eventech, SIA	*Onboard implementation of the Multi-Purpose Event Timer*	396 038	6	Hardware activities
	Laser Ranging Station (LRS) for cooperative targets	199 281	7	Research and development activities
Institute of Electronics and Computer Science	*Dynamic land use monitoring by fusion of satellite data (DYNLAND)*	146 781	3	Space (downstream) Applications
RD Alfa Mikroelektronikas Departaments, AS	*Research and development of microchip αRD124*	199 999	3	Research and development activities
Baltic Scientific Instruments, SIA	*Development performance of a miniature gamma spectrometer for remote sensing planetary applications*	199 995	4	Research and development activities

3.3. Indirect industrial effects from the completed Latvian PECS activities

Despite generally rather low target TRLs of the completed PECS projects, the main beneficiaries of the first three Latvian PECS calls already reported substantial positive effects from the PECS contracts. The patterns of the indirect industrial effects are different for industry and academia and dependent on the field of activity.

[12] Invent Baltics OÜ (2015). Ex ante assessment of multiplier effects induced by space investments from very small ESA candidate countries' perspective, Contract No. 4000109692/13/NL/KML (unpublished).

Two companies that aim at developing **flight hardware or space qualified components** – Eventech SIA and RD Alfa Mikroelektronikas Departaments AS – reported technological effects and commercial effects (**Table 9**) which is usual for entities close to the market.

Eventech was involved in the consortium implementing the activity '*Laser Ranging Station for Cooperative Targets*' (GSTP programme's Work Plan ref. G618-050GS). The prime contractor of the activity was DiGOS Potsdam GmbH (Germany) and other sub-contractors were ASA Astrosysteme GmbH and ÖAW-IWF Graz (both from Austria), all well-known actors in satellite laser ranging market. Eventech was invited to the consortium because it is the sole European commercial supplier of event timers with the necessary performance.

RD Alfa Mikroelektronikas Departaments has demonstrated its capabilities to develop working prototypes of integrated circuits demanded by the European space industry. If RD Alfa Mikroelektronikas Departaments successfully passes the evaluation and qualification of processes and this leads to potential future inclusion into the European Preferred Parts List, then the company's product range will help to reduce the dependence of Europe's space sector on non-European component suppliers, such as Texas Instruments.

Table 9 Technological and commercial effects reported by Latvian space hardware developers

Entity	Technological effects	Commercial effects
Eventech, SIA	The company has already sold several licenses of its upgraded space event timer developed under ESA contracts.	New valuable business contacts were obtained while working with ESA.
RD Alfa Mikroelektronikas Departaments, AS	New integrated circuits with very high commercial potential were developed under the PECS program.	The ESA staff members facilitated contacts with the European Large System Integrators[13] with whom the company now negotiates the supply of rad-hard electronic components.

The unique market positions of both companies, potentially being the single European suppliers of products continuously required by the European space sector, enable to exploit new technologies outside the PECS framework. **It follows that almost one third of the total commitments allocated to Latvian entities under the first three PECS calls have been placed to the companies with a high potential of generating indirect industrial effects both inside and outside ESA procurement system.** However, the real effects of the PECS projects start to accrue within the next 3-4 years.

The third company among the main beneficiaries, **Baltic Scientific Instruments**, reported mainly **technological effects** from the completed PECS activity. Within the ESA project, the company:

- Developed a new concept for cooling high purity germanium to liquid nitrogen temperature – Baltic Scientific Instruments mastered how to fill detectors with dry nitrogen. Now this technology is routinely used in the detectors fabricated by the company.
- Prototyped and tested a new semiconductor material.

There were four activities aimed at developing **new Earth Observation applications** or components of the applications by two entities – Foundation Institute for Environmental

[13] Large System Integrators (LSIs) in the space industry specialise in bringing together component subsystems into a whole and ensure that those subsystems function together. The list of space-related LSIs includes: Airbus Defence and Space SAS, Airbus Defence and Space GmbH, Airbus Defence and Space Ltd, Arianegroup FR, Arianegroup GmbH, Thales Alenia Space France SAS, Thales Alenia Space Italia Spa, and OHB System AG.

Solutions and Institute of Electronics and Computer Science. These two beneficiaries reported mainly **technological effects** and **work factor effects** (**Table 10**). The work factor effects are related to building up a critical mass of technology experts in the entities together with deepening the specialisation of labour. Larger teams are more sustainable and capable of delivering more complex, commercially viable applications in the future.

Foundation Institute for Environmental Solutions considers remote sensing based on satellite data as a tool facilitating its core business: the provision of knowledge-based services enabling better management of natural resources. It means that some of the outputs of the completed and ongoing PECS projects could be turned into elements of bespoke services. EO skills are already instrumental for implementing a string of research and development projects funded from European Union LIFE+ Nature and Biodiversity Programme[14], Interreg Baltic Sea Region 2014-2020[15], or the Latvian Environmental Protection Fund[16].

Table 10 Technological and work factor effects reported by Latvian developers of EO applications

Entity	Technological effects	Work factor effects
Foundation Institute for Environmental Solutions	Various contracts placed by private sector customers that are implemented using EO service components. The annual revenue in the region of 20 000 Euros (2018). SentiSIMULAT is a precursor activity to any ongoing internal project that deploys EO data.	Thanks to the PECS projects, IES currently employs 3 EO experts and is hiring 2 EO experts. The PECS projects have enabled intrafirm specialisation.
Institute of Electronics and Computer Science	The DYNLAND project is a precursor of three follow-up research and development projects.	New staff was hired for implementing the DYNLAND project to bring in novel competences to the team. The follow-up projects enable to add also business development experts to the team.

Institute of Electronics and Computer Science has been able to win two follow-up projects funded at national level to further valorise the algorithms for unsupervised and automatic satellite image land cover classification generated in the DYNLAND project. The projects funded by the Investment and Development Agency of Latvia (LIAA)[17] and from the European Regional Development Fund (ERDF)[18] together with another PECS project expected to commence later in 2019 provide the Institute with a revenue stream of 0.3 million Euros annually between 2019 and 2021. Such funding level enables to maintain a dedicated EO team of 6 to 8 people.

These follow-up projects funded at national level have clearly defined commercial objectives on top of the technological objectives. The LIAA-funded project aims at preparing the commercialization strategy for the technology with the creation of **a spin-off company** as the

[14] The following projects to study grasslands are partly based on SentiGRASS outputs:
Viva Grass (https://www.videsinstituts.lv/en/projects/land/grassland-mapping) and
Grass Service (https://www.videsinstituts.lv/en/projects/land/grassland-assessmen).

[15] The project „*Rural RDI milieus in transition towards smart Bioeconomy Clusters and Innovation Ecosystems* (RDI2CluB)" (09.2017 – 09.2020, http://rdi2club.eu/)

[16] The results of SentiSimuLat are feeding in the project „*Remote sensing methodology for monitoring greenhouse gas emissions in wetlands*" (04.2018.–09.2019, https://www.videsinstituts.lv/en/projects/land/ghg-monitoring-in-wetlands.html).

[17] "*Dynamic Land Use Monitoring*" (NevKlas, 1.10.2018-31.03.2021). The project's budget is 305 th. Euros and the grant is 275 th. Euros.

[18] The project WoodStock (*Satellite remote sensing-based forest stock estimation technology*) project is focused on the development of the prototype technology for estimation of forest stock volume from high-resolution satellite data. The duration of the project is 3 years (03.2019-02.2022) and the planned cost is 498 th. Euros.

expected end-point of the project. The ERDF-funded project entails effective collaboration with the industry. The project is implemented jointly with Baltic Satellite Service SIA.

The third pair of the PECS beneficiaries that reported similar effects were academic entities: the Latvian State Institute of Wood Chemistry and Riga Technical University. The respective PECS activities were based on prototyping of **novel materials and structures** with new properties and comprehensive testing of the prototypes.

As a result of the PECS activities, the institutes gained new technological knowledge about the materials and structures (**technological effects**), and pertinent testing protocols (**organisation and method effects**). This new knowledge has been partially disclosed to the public domain in the form of scientific publications:

- Franzoni, F., Odermann, F., Wilckens, D., Skuķis, E., Kalniņš, K., Arbelo, M.A., Degenhardt, R., 2019. Assessing the axial buckling load of a pressurized orthotropic cylindrical shell through vibration correlation technique. *Thin-Walled Structures* 137, 353–366.
- Cabulis, U., Yakushin, V., Fischer, W.P.P., Rundans, M., Sevastyanova, I., Deme, L., 2019. Rigid Polyurethane Foams as External Tank Cryogenic Insulation for Space Launchers. *IOP Conference Series: Materials Science and Engineering*, Volume 500, conference 1.

Some of the new skills and knowledge could be also commercialised. Riga Technical University has already established one spin-off company (IC3 SIA), potentially producing cylindrical and conical sandwich panels with interesting niche applications for which manufacturing and testing methods were developed in the PECS project. The Latvian State Institute of Wood Chemistry considers the total addressable market for its cryogenic polyurethane foam too small to transfer the technology to a spin-off company.

As of July 2019, the interviewed main beneficiaries altogether reported three scientific publications to inform the research community about the outcomes of the PECS projects. In addition to the two publications above, also the Institute of Electronics and Computer Science had one publication:

- Dinuls, R., Mednieks I., 2018. Nonparametric Classification of Satellite Images. *Proceedings of the 2018 International Conference on Mathematics and Statistics*. ACM, New York, NY, USA, pp. 64-68.

3.4. Latvian entities in ESA projects outside the PECS programme

Several Latvian companies and research institutes have a rich and illustrious history in the space domain. During Soviet time, **Latvian State Institute of Wood Chemistry** developed the polyurethane foam *Ripor 2 N* that was used as a cryogenic insulation material in the space shuttle Buran equipped with the carrier rocket Energy.

For using polyurethane foams as cryogenic insulation materials, many technological challenges must be overcome. Latvian State Institute of Wood Chemistry has very unique and specific knowledge in this field. This competence has attracted strong interest from the European Large System Integrators even without Latvia's participation in ESA programmes. The institute has active collaboration with the ArianeGroup's unit in Bremen (ArianeGroup GmbH, formerly Astrium GmbH) since 2006. The Polymer Laboratory of the institute has even filed in one joint patent application with Astrium GmbH "*Polyurethane foam for thermal insulation at extremely low temperatures*" (no DE102010007713; priority date: April 2009).

On the basis of the close relationship with ArianeGroup, the project "*Rigid Polyurethane Foams for Internal Tank Insulation for Launcher Upper Stages* (CRYOFOAMS)" was successfully proposed for funding under PECS. According to the interview with the Director of the institute, bidding for the PECS project was a natural extension for the collaboration with ArianeGroup. The Institute's participation in Soviet space programmes has translated into the long-term collaboration with the European prime contractor. The latter in turn into the first ESA research and development contracts without too much emphasis on business development activities.

Similarly, **Baltic Scientific Instruments** has been doing business with ESA since the mid-2000s, participating in the development of gamma-ray detection systems. This was largely possible because the company was a part of Bruker group (https://www.bruker.com/) at the time. The first PECS project of Baltic Scientific Instruments can be viewed as a continuation of a work performed for ESA in 2008. Back then, the company designed the first prototype of a miniature HPGe gamma-ray spectrometer, comprised of a large high purity germanium detector cooled by a Stirling electrical cooler. This promising technology had a few flaws that were addressed in the company's first PECS project. Once again, the company's long track record enabled to become the partner of ESA with a rather low business development effort.

However, for the next ESA contracts, the company needs to establish partnerships with major actors on the European space market and to study the nuances of the ESA programmatic needs. Undeniably one of the most advanced Latvian high-technology companies needs to dedicate more managerial resources to space domain to increase its long-term competitiveness in the field.

The examples of Eventech SIA and RD Alfa Mikroelektronikas Departaments AS demonstrate that dedicated business development effort along with unique value proposition pays off. For example, **Eventech** participates in many major space trade shows, such as Toulouse Space Show, Paris Space Week, London Space Week, and Satellite 2019, and also in ESA-sponsored events, such as Industry Space Days. The company has also participated in relevant ESA Technology Harmonisation Advisory Group's meetings. The international space shows and ESA events offer excellent networking opportunities not only for marketing purposes but also for gathering technological information and business intelligence.

As a result of these efforts, Eventech is well known actor in the space community. The first chances to contribute to ESA activities outside the PECS framework have emerged. For example, the company has been offered an opportunity to contribute to the activity "*Engineering Model of a laser altimeter for the AIM mission* (G61M-002EC)" implemented by Portuguese and Romanian entities and funded from GSTP Element 1 programme.

RD Alfa Mikroelektronikas Departaments also has become a part of the European space community. The company regularly participates in the networking events and information days organized by ESA, such as Industry Space Days (https://www.industryspacedays.com/) and the European Space Components Conference. The company attends the major European industry events, such as Toulouse Space Show and Paris Space Show.

Thanks to its unique product line, the company is already involved in ESA proposals outside the Latvian PECS calls. For example, a Spanish prime contractor included RD Alfa as an external provider to a bid to the tender AO9852 "*Manufacture and reliability testing of non-hermetic (plastic) encapsulated devices*". The statement of work of the tender specifically asked for performing tests with the integrated circuit LM139A. The company's product αRD139A is fully compatible with the circuit and therefore was approached by the prime contractor. The tender closed in July 2019 and is currently under evaluation.

3.5. Impacts of feasibility studies funded from Latvian PECS programme

ESA has funded nine feasibility studies under the Latvian PECS calls (**Table 11**). All these activities are completed or nearly completed (e.g. in the stage where just a final report is still to be submitted). As of July 2019, the total funding to execute the feasibility studies in Latvia is 430 824 Euros which amounts to 13% of the total funding to the Latvian entities under the first three PECS calls. For a comparison, just three feasibility studies were funded under the Estonian PECS calls between 2011 and 2014.

Three of the feasibility studies have been successful in leading to follow-up activities by the Latvian contractors in the PECS programme. In addition to **RD Alfa Mikroelektronikas Departaments**, two EO companies demonstrated their technological capabilities to ESA and have been able to spot a niche for their solutions in the European market for EO applications.

Table 11 Feasibility studies funded from the Latvian PECS calls

Contractor	Title of activity	Contract amount (€)	Follow-up
Meža ipasnieku konsultatīvais centrs, SIA	*Human settlement pattern modelling -support tool for rural development planning (Human Habitat)*	**50 000**	**Yes**
Baltic Satellite Service, SIA	*Fully-automated software system for monitoring gas pipeline protection areas using multi-spectral satellite imagery*	**49 994**	**Yes**
RD Alfa Mikroelektronikas Departaments, AS	*Development of microcircuit RD117 (analogue of LM117) for applications in ESA missions – initial study*	**54 792**	**Yes**
Baltic Scientific Instruments, SIA	*High resolution X- and Gamma-ray spectroscopy systems for space applications*	**49 982**	
Ventspils University of Applied Sciences	*Establishing nanosatellite ground station by adapting RT-16 radio telescope infrastructure – feasibility study*	**49 907**	
Riga Technical University	*Development and validation of methodology for assessment of damage resistance properties of sandwich structures for European space sector - feasibility study*	**49 104**	
The University of Latvia	*Ground Station for Optical Observations of near-Earth objects –Preparatory Study*	**47 102**	
Institute of Physics of the University of Latvia	*Evaluation and development of linear electricity converters with hydraulic or acoustic coupling*	**49 943**	
Riga Technical University	*Development of the prototype of autonomous aerospace vehicle for comprehensive monitoring (DREAM)*	**30 000**	

The feasibility study provided significant value to **Baltic Satellite Service.** The company identified new promising service ideas and established contacts with potential customers. From the company's perspective, ESA also functions as a validator of the company's ideas. If a project gets funded, it signals to the bidder that there may be a less congested market niche in the highly competitive European space downstream applications market. Similarly, **Meža ipasnieku konsultatīvais centrs** – the technology commercialization partner of the Foundation Institute for Environmental Solutions – obtained new knowledge about the socio-economic value of using satellite data in rural development planning.

Two feasibility studies of academia – Ventspils University of Applied Sciences and the Institute of Geodesy and Geoinformatics of the University of Latvia – have also been successful. **Ventspils**

University of Applied Sciences found out the bandwidths of satellite links that are mostly deployed in Europe. It identified missing capabilities that its ground station (in particular, the RT-16 antenna in Irbene) has to add to the current infrastructure to become integrated to ESTRACK network of ground stations operated by ESA[19]. As a result, the university drafted an investment plan for the next few years. The investment plan needs to find support from national funding sources. The university is now confident that its ground station could become an attractive service provider on the international scene if the Latvian government would commit funding for upgrading the station. Likewise, **the University of Latvia** prepared plans how to develop an optical tracking device for optical observations of near-Earth objects, capable of high accuracy satellite laser ranging and contributing to the International Laser Ranging Service (ILRS).

In contrast to the examples in Chapter 3.3, not all prior collaborations with the European Large System Integrators have been successfully transformed into research and development projects funded by ESA. The **Institute of Physics of the University of Latvia** got its project idea from the participation in the consortium of the European Union 7th Framework Programme research project "*Space Thermoacoustic Radio-Isotopic Power System*" (SPACE TRIPS, 2013-2015) where the institute collaborated with Thales Alenia Space and CNRS (French National Research Center). However, the institute's technological concept turned out to be unachievable.

3.6. Impacts of education and awareness activities funded from Latvian PECS programme

ESA has funded four education and awareness activities under the Latvian PECS calls (**Table 12**). As of July 2019, the total budget allocated to the education and awareness activities in Latvia is 221,222 Euros which equals to 7% of the total commitments to the Latvian entities under the first three PECS calls. In contrast, none of the activities funded under the Estonian PECS calls was an education and awareness activity between 2011 and 2014.

Table 12 Education and awareness activities funded from the Latvian PECS calls

Contractor	Title of activity	Contract amount (€)	Completed (Y/N)
Aspired SIA	*Raising the motivation and awareness of children and youngsters about space and space technologies*	**50 000**	**Y**
Ventspils University of Applied Sciences	*Ventspils University College satellite technology education programme*	**49 067**	**Y**
Foundation Ventspils High Technology Park	*Space Challenge: Interactive Teaching Tool*	**50 000**	**N**
Foundation Institute for Environmental Solutions	*Expanding Earth Observation awareness among key decision-makers (EXPANDEO)*	**72 155**	**N**

Just two education and awareness activities have been completed by July 2019. One of the prime contractors of the completed activities, Aspired SIA was not available for a phone interview. Therefore, only the outcomes of the "*Ventspils University College satellite technology education programme*" are discussed in the following paragraphs.

Ventspils University of Applied Sciences has a special role in the Latvian space ecosystem. The Ventspils International Radio Astronomy Centre of the Ventspils University of Applied Sciences (VIRAC, http://virac.eu/en/home/) carries the task to keep Latvia's unique infrastructure – RT-16 and RT-32 telescopes located in Irbene – in good working condition to support the research of

[19] http://www.esa.int/Our_Activities/Operations/Estrack/Estrack_ground_stations

the community of radio astronomers. VIRAC is also an important employer of the graduates of Computer Science and Electronics' study programmes of the university.

The education project had impressive results considering the small size of the project:

1) Between 2015 and 2018 space technologies became integral parts of teaching at the university. Dedicated course content in satellite technologies was created. The content is introduced into the curriculum of several study courses since 2017. Every year 4-5 students select themes connected to satellite technologies for bachelor or master theses.
2) Research work was conducted to develop a high-speed downlink communication channel for cubesats (using RT-16 antenna). The work was started under the PECS project using FPGAs to design a reconfigurable (change speed, modulation) information transmission system. The high-speed downlink communication channel is now further developed using own funds. The system is selected by the Estonian Student Satellite Foundation (https://www.estcube.eu/en/foundation) to be used as a payload of EstCube-2 mission.

The project may have a long-lasting impact on the development of the Latvian space ecosystem by supplying qualified labour to the nascent industry.

The project "*Expanding Earth Observation awareness among key decision-makers (ExpandEO)*" executed by the Foundation Institute for Environmental Solutions also has a potential to have a strong impact on the development of the market for EO applications in Latvia. The project seeks to address the bottlenecks holding back the demand side of the market. The project will develop custom-made training materials that vigorously demonstrate EO's political, operational, economic, and environmental benefits to public and private decision-makers.

4. Comparison with other national level studies

4.1. Overview of national level studies

The prominent publication by OECD about space economy[20] outlined six national assessments of spin-off multipliers from space programmes. Five ESA member states in Europe had performed country-wide *ex post* analyses of the indirect industrial effects. Four of the country-wide studies followed methodologically the BETA approach. The Norwegian[21], Danish[22], Portuguese[23], and Irish[24] studies relied on narrow definitions of the indirect industrial effects similar to the BETA methodology and constructed simple output metrics (spin-off multipliers) built on the general logic of basic financial analysis (economic returns). The input data was collected directly from ESA contractors (primary data) through online surveys and face-to-face or telephone interviews.

In general, these national-level studies aimed at measuring the technology transfers from the space sector to other sectors of the economy as a result of public space investments, or more specifically, institutional investments to ESA programmes. Such studies are usually been commissioned by governmental bodies responsible for co-ordinating industrial and research participation in the programmes of ESA. In 2015, ESA funded the execution of comparable national-level studies in the Czech Republic and Estonia[25].

The impact assessment studies have been either regular and repeated over a certain interval of time for active monitoring and management of public investment in space – up to date Norway is the only example here– or one-off exercises in order to justify the increased contribution to ESA (Denmark) and/or for purposes of strategic planning (Ireland, Portugal, and Estonia).

Table 13 Comparison of the metrics reported in the reference studies

	Norway (2012)	Denmark (2008)	Ireland (2012)	Portugal (2010)
Reported multiplier	Spin-off multiplier with accumulated delay (3 years)	Spin-off multiplier without delay, time series of 8 years, direct effects included	Non-accumulative spin-off multiplier with delay (5 years)[26]	Spin-off multiplier without delay, time series of 10 years, direct effects included
Value of the reported multiplier	4.8 (1985-2012)	4.5	1.25 (2008) 2.81 (2011) 5.35 (2014)	2
Value of the multiplier (indirect effects only)		3.7		1

[20] OECD (2014). The Space Economy at a Glance. Paris: OECD Publishing.
[21] Norwegian Space Centre, Annual Report 2012, NSC-Report 2013/7; 24 pages
[22] Danish Agency for Science (2008). Evaluation of Danish Industrial Activities in the European Space Agency (ESA). Assessment of the economic impacts of the Danish ESA-membership. March 2008.
[23] Survey of the Impact of Portugal's Participation in ESA: Assessment of Economic Benefits for Companies and Academia. Research Report by Clama Consulting for Fundação para a Ciência e a Tecnologia, April 2011, 87 p. (unpublished).
[24] Evaluation of the Economic Impact of Ireland's Membership of the European Space Agency on Irish Industry; Research Report by Delve Research for Enterprise Ireland, August 2012, 33 p. (unpublished).
[25] Invent Baltics OÜ (2015). Ex ante assessment of multiplier effects induced by space investments from very small ESA candidate countries' perspective, Contract No. 4000109692/13/NL/KML (unpublished).
[26] The Irish study reported a non-accumulative spin-off multiplier based on an analytical finding that the correlation between the Irish public spending on ESA programmes and turnover derived directly from ESA related products or services suggests an average 5-year timeframe between investment and impact on turnover.

Different studies reported slightly different indicators under the common label of 'spin-off multiplier' (**Table 13**). For example, the Danish multiplier can be expressed by the following formula:

$$Spin-off\ multiplier\ = 0.83 \times \frac{\sum_{2000}^{2007}\left(indirect\ turnover\right)}{\sum_{2000}^{2007}\left(\begin{matrix}net\ value\ of\\ ESA\ contracts\end{matrix}\right)}$$

The indicator shows that within the study period, each Euro committed to Danish ESA contractors induced 3.7 Euros of additional turnover outside the ESA procurement system. Each country study had its unique background to be taken into account. For example, the Danish multiplier included a constant for allocative inefficiency, i.e. deadweight loss caused by taxation.

4.2. Samples of the reference studies

The main characteristics of the samples of the reference studies are provided in **Table 14**. Similarly to Latvia, these studies demonstrate that high levels of concentration of ESA contracts are common in smaller ESA member states. The largest 10 Danish private (space) companies were awarded 98% of the total value of ESA contracts during the period from 2000 to 2007[27]. As of the end of 2014, the companies in the Czech study sample accounted for around 74% of the total value of ESA commitments to the Czech entities and 91% of the total value of ESA commitments to the Czech industry, while ESA commitments to the companies in the sample of the Estonian study constituted 88% of the total ESA commitments to the Estonian companies under PECS calls.

Table 14 Main characteristics of the samples of the reference studies

	Norway (2012)	Denmark (2008)	Ireland (2012)	Portugal (2010)	The Czech Republic (2015)	Estonia (2015)
Country's status at the time of the study	Full member since 1986	Full member since 1977	Full member since 1980	Full member since 2000	Full member since 2008	ECS since 2010
Total number of ESA contractors in an economy at the time of the study	57	~30 (2000-2007)	>80 (2000-2012)	78 (57 companies, 21 academia) (2000-2009)	44 (28 industry, 16 academia), (2008-2014)	18 (13 industry, 5 academia) (2010-2014)
Number of entities invited to participate in the study	28	12 interviews	42 companies	23 companies and 19 academia	15 companies interviewed	10 companies interviewed
Number of replies	28		30	19 companies and 8 academia		
Response rate	100%		71 %	64 %		

4.3. Methodologies of the reference studies

The main data sources for the reference studies were surveys and interviews to estimate the indirect effects (additional turnover, but also additional employment). While the Norwegian and

[27] Danish Agency for Science (2008). Evaluation of Danish Industrial Activities in the European Space Agency (ESA). Assessment of the economic impacts of the Danish ESA-membership. March 2008.

Portuguese studies used both surveys (questionnaires) and interviews, the Danish, Estonian, and the Czech studies were based on interviews, and the Irish study was based on a survey only.

Interviewing ESA contractors is a viable data collection technique for the space offices of smaller ESA Member States. In general, interviews (or more broadly case studies) have high costs per respondent (case/project), consequently, they tend to be quite selective and suffer from the objection that they may not be representative. The latter argument might be more pertinent to assessments of larger R&D programmes with multiple thematic areas/verticals, but given the total number of ESA contractors and the concentration levels of the contract values in smaller Member States of ESA, interviews with up to 20 stakeholders could easily give a representative overview of the indirect industrial effects of investments in space.

Table 15 Data collection methodologies of the spin-off multiplier studies

	Norway (2012)	Denmark (2008)	Ireland (2012)	Portugal (2010)	The Czech Republic (2015)	Estonia (2015)
Methodology	Survey, regular status meetings	Interviews	Survey (online)	Survey (e-mail), interviews	Interviews	Interviews
Questionnaire design	Dedicated questionnaire: quantitative data	Dedicated questionnaire: quantitative and qualitative data	A section in the questionnaire for quantitative data	Panel for quantitative data with a few questions for qualitative data	Dedicated questionnaire: quantitative and qualitative data	Dedicated questionnaire: quantitative and qualitative data
Data validation	*By industry experts *Comparison with primary data (regular interviews) *Comparison with available secondary data	*By industry expert (outsourced) * Comparison with available secondary data	*Comparison with available secondary data	*Comparison with available secondary data *Comparison with primary data (regular interviews)	*Comparison with available secondary data	*Comparison with available secondary data

4.4. Comparison with the Estonian study (2015)

The Estonian study[28] was the only study performed in a country in the directly comparable phase in the ESA accession process. At the time of the study, only the projects funded under the first Estonian PECS call were successfully implemented. Even though only one company provided a quantitative estimate for the resulting indirect industrial effects at the time of the study, it was evident that the completed PECS projects had strong positive impacts on the commercial activities of the involved companies. The quantified indirect industrial effects were achieved in the space downstream segment, while the non-space indirect industrial effects were non-quantified but still substantial. According to the results of the study, each Euro committed by ESA to the Estonian companies for implementing the PECS projects had already induced almost 0.2 Euros of additional sales outside ESA tendering system in both the space domain and other fields of activity.

[28] Invent Baltics OÜ (2015). Ex ante assessment of multiplier effects induced by space investments from very small ESA candidate countries' perspective, Contract No. 4000109692/13/NL/KML (unpublished).

The profile of the ESA contractors in Estonia was rather different from the Latvian case. In Latvia, the only private sector entities with completed research and development projects funded from PECS programme have long traditions in the space domain. Some of the employees of the companies have more than 30 years of experience with space projects. In Estonia, among the beneficiaries of PECS calls were private sector entities without any space heritage. For such entities, ESA projects enabled to spin-in to the PECS framework with a terrestrial technology and adopt it for a space application (see **Figure 2**). Subsequently, the upgraded technologies were spun off to the original field of activity to generate commercial benefits. Some reference studies (e.g. in Canada[29]) have shown that when a new space application is developed in relation to a terrestrial market where demand already exists, high multipliers of indirect economic impacts are common.

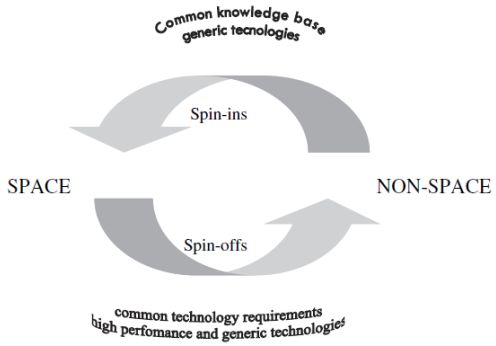

Figure 2 The conceptual model of technology transfer between space and non-space domains[30]

The main difference between Estonia and Latvia is related to this 'spin-in and spin-off again' effect. The Estonian PECS beneficiaries were able to deploy the technologies upgraded in the PECS programme in their main business domain. A fair share of the Estonian PECS beneficiaries operated in the fields of economic activity characterised with a low need for physical capital (e.g. software business). Therefore, the development cycles were shorter and indirect economic effects emerged relatively quickly. In Latvia, such industries have hardly been involved in the PECS calls. For comparison, the product development cycle of Baltic Scientific Instruments is around 10 years and, consequently, indirect economic effects accumulate over a longer period of time.

Also, the Estonian PECS beneficiaries were able to build upon strong reputation effects. As a result, a new indicator of the indirect industrial effects was witnessed in Estonia – seed and early stage equity funding to start-ups with PECS contracts. Two companies were able to attract equity funding from either international institutional investors or local business angels thanks to strong reputation effects of ESA contracts. The total amount of equity investments directly attributable to the ESA projects was 12.1 million Euros at the time of the Estonian study in 2015.

[29] W. Ricard, D. Grandadam, F. Prado-Saldanha, P. Cohendet, L. Stojak (2015). A new perspective on innovation in space and its implications on the tools and measures used to assess the indirect impacts of public investment in the space sector, New Space, 3, 87-91.
[30] International Space University. (1997). Bridging space and society with technology transfer. Space Policy, 49-60

5. Legal background of future scenarios of ESA-Latvia cooperation

5.1. Provisions of the ESA Convention

Since its establishment in 1975, ESA has gradually expanded. In Article XIV, the ESA Convention[31] defines different mechanisms for establishing co-operating links between the Agency and third states or international organisations.

According to the Article XIV of the ESA Convention:

- Cooperation may take the form of **specific agreements**: '*The Agency may, upon decisions of the Council taken by unanimous votes of all Member States, cooperate with other international organisations and institutions and with Governments, organisations and institutions of non-member States, and conclude agreements with them to this effect.'*
- Cooperation may take the form of **participation in one or more ESA programmes**: '*Such cooperation may take the form of participation by non-member States or international organisations in one or more of the programmes under Article V[32], 1 a (ii)[33] and V, 1 b[34]. Subject to the decisions to be taken under paragraph 1* [=by the Council]*, the detailed arrangements for such cooperation shall be defined in each case by the Council by a two-thirds majority of the States participating in the programme in question. These arrangements may provide that a non-member State shall have a vote in the Council when the latter examines matters pertaining exclusively to the programme in which that State participates*.' - For several former ESA non-member states, such as Finland, Austria and Norway, the possibility of participating in ESA optional programmes was beneficial in preparing their accessions to the ESA Convention. Also, Hungary participated in PRODEX programme from 1997 to 2002[35].
- Cooperation may translate into granting **Associate Membership** to non-member states: '*Such cooperation may also take the form of according associate membership to non-member States which undertake to contribute at least to the studies of future projects under Article V, 1 a (i)[36]. The detailed arrangements for each such associate membership shall be defined by the Council by a two-thirds majority of all Member States*.'

The provisions of Article XXII define the arrangements for accession to the ESA Convention:

- *After the entry into force of this Convention, any State may accede thereto following a decision of the Council taken by **a unanimous vote of all Member States**.*
- *A State that wishes to accede to this Convention shall notify the Director General, who shall inform the Member States of this request at least three months before it is submitted to the Council for decision.*

In the 21st century, eight countries have acceded the European Space Agency:

- Portugal (November 2000),

[31] https://esamultimedia.esa.int/docs/LEX-L/ESA-Convention/SP-1317_EN.pdf
[32] Article V is about the activities and programmes of ESA.
[33] This stipulation obliges ESA with respect to the mandatory activities to ensure the elaboration and execution of a scientific programme including satellites and other space systems.
[34] This stipulation concerns the execution of the optional activities.
[35] Klock, E., Aliberti, M., 2014. ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession – With a Special Focus on the CEE Region (No. ESPI Report 47). European Space Policy Institute, ESPI, Vienna.
[36] This stipulation obliges ESA with respect to the mandatory activities to ensure the execution of basic activities, such as education, documentation, studies of future projects and technological research work.

- Greece (March 2005),
- Luxembourg (June 2005),
- The Czech Republic (August 2008),
- Romania (December 2011),
- Poland (November 2012),
- Estonia (September 2015),
- Hungary (November 2015).

Two different accession pathways have been followed[37]:

- **Pathway 1**: the full membership has been preceded by a Cooperation Agreement; this was the accession route for Portugal, Greece, and Luxembourg.
- **Pathway 2**: the candidate countries had to sign a Cooperation Agreement, to be followed by an ECS Agreement and a related PECS Charter, and an Accession Agreement to join the ESA Convention that was the end-point of this route; this pathway was followed by the five Central and Eastern European countries that acceded ESA from 2008 to 2015.

The ECS status was specifically designed to meet the needs of the Central and Eastern European countries. The Pathway 2 has extra steps compared to the Pathway 1. Nevertheless, Estonia became an ESA Member State in 2015, i.e. within 8 years since a Cooperation Agreement with ESA was signed (2007).

5.2. European Cooperating State

In October 1999, ESA organized a two-day Workshop in Budapest with a view to analysing relations between ESA and its partners in Central and Eastern Europe (CEE). ESA introduced the different mechanisms defined in the ESA Convention (Article XIV) in order to establish co-operating links with non-member States. One important conclusion of the event was that the path of cooperation proposed by ESA to the CEE countries in order to become an ESA Member State did not suit their needs or financial capacities. In particular, the conclusion of an Associate Membership Agreement was not considered reasonable because it required financial participation by the countries in the ESA's General Budget (at a rate of 50% of what they would pay as a full Member State), which implied too steep a budgetary increase with respect to the former Soviet bloc countries' financial and industrial capabilities[38].

Hungary, Romania, Poland and the Czech Republic expressed interest towards an intermediate step that would enhance the potential for cooperation and would facilitate the development of cooperation projects with ESA, with a view to facilitating their progressive integration into ESA's programmes and activities. As a response, ESA Council, during its December meeting in 1999, decided to set up an ad-hoc Council Working Group that would look into the ESA's enlargement. The Working Group produced a report that was adopted by Council in June 2000. This report contained several recommendations, the most important being that '*the Agency establishes a specific framework for facilitating the participation of European non-Member States in ESA programmes*'. This led to the creation of the new concept of a 'European Co-operating State'. Based on this report, a model Agreement for ECSs was proposed, allowing for the indirect participation by an ECS in all ESA programmes and activities. This ECS model Agreement was discussed in the

[37] Klock, E., Aliberti, M., 2014. ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession – With a Special Focus on the CEE Region (No. ESPI Report 47). European Space Policy Institute, ESPI, Vienna.
[38] Baudin, Catherine, Karl Bergquist. "Towards an Enlarged Partnership – ESA's Relations with the Czech Republic, Hungary, Poland and Romania." ESA Bulletin 107 (August 2011): 84-86.
http://www.esa.int/esapub/bulletin/bullet107/bul107_10.pdf

relevant Council subordinate bodies before being adopted by Council itself on 21/22 March 2001. **So, the integration model based on ECS was tailored as a mechanism for integrating the CEE region into ESA[39].**

The ECS status has a number of objectives[40]:

- It should create and strengthen the industrial expertise and capacity of non-member states in order to have fair industrial participation in future ESA programmes and an equitable geographical return after accession to the Convention.
- It offers ECS states indirect access to programmes and activities while also improves their understanding of ESA's organisation and functioning as well as European space products and procedures.
- It should ensure coherence between the space activities of ECS and ESA member states, for example by avoiding unreasonable duplication of activities.

ECS countries subscribe to the PECS Charter, describing the projects to be undertaken and their funding, normally around one year after the signature of the ECS Agreement. Each PECS member agrees to spend a minimum of 1 million (at 2001 rates) per year on the agreed space activities.

5.3. ESA Associate Member State

Associate Member state status is defined in Article XIV.3 of the ESA Convention. After participating in some optional programmes of ESA, Austria, Norway, and Finland were the first countries to get Associate Member status, in 1979, 1981 and 1987 respectively. The Associate Membership was a precursor to their subsequent accession to the ESA Convention, in 1984, 1985, and 1994 respectively[41]. The participating state may renew or end the Associate Membership Agreement after 3-5 years. The Associate Member may also apply for the accession to ESA under article XXII of the ESA Convention.

The acquisition of the Associate Membership status has not been mandatory for states to become full members. While Austria, Norway and Finland became associate members before they joined ESA as full members, Portugal, Luxembourg and Greece skipped this step and leaped from Cooperation Agreements directly to full ESA membership. Also the guidelines concerning Associate Membership Agreement adopted by the ESA Council in October 1985 affirmed that Associate Membership and accession had to be treated separately and that the former was not a preliminary for accession and would not lead automatically to accession[42].

Associate Membership implies a more active involvement of non-ESA member states in ESA programmes and activities in a flexible way. It provides opportunities for participation in optional programmes but requires only a minimum level of participation in ESA mandatory programmes and a contribution to the ESA general budget on the basis of average national income. Programmatically, the Associate Member must participate in some of ESA's mandatory activities

[39] Sagath, D., Adriaensen, M., Giannopapa, C., 2018. Past and present engagement in space activities in Central and Eastern Europe. Acta Astronautica 148, 132–140. https://doi.org/10.1016/j.actaastro.2018.04.048

[40] Klock, E., Aliberti, M., 2014. ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession – With a Special Focus on the CEE Region (No. ESPI Report 47). European Space Policy Institute, ESPI, Vienna.

[41] https://en.wikipedia.org/wiki/Enlargement_of_the_European_Space_Agency

[42] Klock, E., Aliberti, M., 2014. ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession – With a Special Focus on the CEE Region (No. ESPI Report 47). European Space Policy Institute, ESPI, Vienna.

and can participate in optional programmes with a guaranteed minimum industrial return as well as in scientific and technical research studies, receiving the results of such studies.[43]

The minimum level of participation in ESA mandatory programmes is particularly beneficial to smaller countries as they tend to be less competitive in the ESA Science Programme. For example, the peer-review of the Danish Contributions to Space Research from 2008[44] brought out that:

- Although the overall Danish return from ESA between 2000 and 2007 was 0.99, it masked **significant under-return** in the mandatory (science) programmes. – Similarly, the implementation of supportive transitional measures, such as Industry Incentive Schemes, with its positive impact on the overall geographical return indicators in the new ESA Member States may mask limited competitiveness in the ESA Science Programme of the countries.
- That Danish space research would benefit from national-level earmarked funding for ESA related science projects. This funding should allow participation in ESA projects. – The same applies for any other smaller ESA member state. Due to the ESA Science Programme's long and often uncertain development cycles, complementary national level funding schemes to the ESA Science Programme are needed to maintain and nurture the capabilities of an ESA member state in space science domain.

5.4. ESA Member State

On 13 December 2018, the ESA Council adopted *Resolution on industrial policy measures to achieve a successful integration of European States in the frame of ESA* (ESA/C/R/CCLXXVII/Res. 1(final)). The resolution revised the conditions to a European state requesting to become a candidate ESA Member State. A candidate country is required to be an Associate Member for at least 7 years. Furthermore, a candidate country is required to satisfy a set of industrial policy requirements:

- A geographical return coefficient equal to or exceeding 0.85 in optional programmes at the end of the Associate Membership period;
- An industry-academia-ratio in optional programmes better than 75% at the end of the Associate Membership period;
- A published national space strategy detailing both ESA and non-ESA funding scheme contributions.

The regulation effectively creates a new pathway of the accession process:

- **Pathway 3**: the candidate countries have to sign a Cooperation Agreement, to be followed by an ECS Agreement and a related PECS Charter, and an Associate Membership period must be successfully completed before an Accession Agreement to join the ESA Convention can be signed.

The new pathway would extend the period from a Cooperation Agreement to the full membership to at least 15 years which is around twice the duration of the whole Estonian accession process.

[43] Hoerber, T.C., Lieberman, S. (Eds.), 2019. A European space policy: past consolidation, present challenges and future perspectives, Space power and politics. Routledge, Abingdon, Oxon ; New York, NY.
[44] Danish Agency for Science Technology and Innovation; Evaluation of the Danish Contributions to Space Research: A Peer Review of Danish Space Research; August 2008

6. Comparison of alternative ESA-Latvia cooperation models

6.1. Available ESA-Latvia cooperation models

Since the introduction of the ECS status until the changes in ESA accession policy in late 2018, the ECS had three routes to pursue after the conclusion of a five-year PECS programme[45]:

- To continue to cooperate with ESA by signing an extension to the PECS Agreement for another 5 years, as was the case for Hungary in 2008 when Hungary and ESA extended the ECS Agreement for another five-year-period[46],
- To apply for Associate Membership, or
- To apply directly to become a member state.

The adoption of the *Resolution on industrial policy measures to achieve a successful integration of European States in the frame of ESA* means that Latvian choices have effectively been reduced to two alternatives regarding the next steps in Latvia-ESA cooperation:

- To become an Associate Member State of ESA or
- To extend PECS programme.

If Latvia would opt for the extension of the PECS programme, then it would be a subject of changes compared to the running PECS period. The *Latvia PECS end of Period Report* prepared by ESA in July 2019 has pointed at a number of issues that could be addressed by revising Latvian priorities regarding the cooperation with ESA and modifying rules of future PECS calls:

- The proposal evaluation procedure will be streamlined by ESA and time to contract will be shorter.
- The Latvian Delegation and ESA should jointly contemplate at least the following changes in the rules:
    - increasing the minimum score for a proposal to get recommended for implementation – for example, Tender Evaluation Board should give a proposal at least 60 points corresponding to at least 'Good' in ESA scoring system.[47] Currently, even 'Barely acceptable' projects have been funded, even though after re-scoping the activity.
    - Setting additional requirements to technical maturity of proposals to target higher Technology Readiness Levels.
    - Setting additional requirements to more active involvement of Latvian industry in ESA calls.

The comparison of the two available options is based on the respective model agreements tailored for Latvia by ESA. These model agreements were added to the minutes of the ESA – Latvia High Level Bilateral Meeting that took place on 7 August 2019 in Riga. The comparison is based on the content analysis of the agreements. Both model agreements incorporated Articles with coinciding or similar content, even though the numbering of the Articles was different.

[45] Klock, E., Aliberti, M., 2014. ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession – With a Special Focus on the CEE Region (No. ESPI Report 47). European Space Policy Institute, ESPI, Vienna

[46] https://www.esa.int/About_Us/Plan_for_European_Cooperating_States/Hungary_and_ESA_sign_PECS_Agreement_for_another_five_years

[47] Fiorilli, S., 2015. The ESA Procurement Process: at the crossroad of political mandates and industrial realities. Tijdschrift Aanbestedingsrecht.

6.2. Differences between alternative ESA-Latvia cooperation models

The main differences between the two cooperation models are related to:

- The participation in ESA optional programmes enabled by the Associate Member state status.
- Representation in the meetings of the ESA delegate bodies.
- Voting rights on issues relating to those activities and programmes that Latvia participates.

These topics are covered in the Articles 4 and 5 of the model agreement. Due to access to ESA optional programmes, the Associate Member state agreement included also special provisions about industrial policy considerations. With respect to the fair geographical distribution of contracts relating to the activities and the optional programmes in which Latvia participates, ESA shall apply for Latvia the rules developed for the various activities and programmes, to the same extent as for the other participating states of the optional programmes.

Regarding representation, the model agreement specifies that Latvia shall have a vote in the ESA Council when the latter examines matters pertaining exclusively to the programme in which Latvia participates or when its financial interests are involved. In addition, Latvia shall have observer status in the Council for matters of common interest. This does not hold for the Council meetings that are held on a restricted basis in accordance with the relevant rules of procedure. In the Council meetings, Latvia shall have the right to be represented by up to two delegates who may be accompanied by advisors.

Increased involvement in the Council meetings constitutes a major step forward for Latvia compared to the ECS status. Latvia had a right to attend the meetings of the Council and its subordinate bodies only as an observer through one representative and just for matters relating to the PECS.

As an Associate Member, Latvia shall have the right to be represented at meetings of the subordinate and advisory bodies of ESA, competent in any capacity to deal with the activities and programmes in which Latvia participates. Latvia shall also have the right to be similarly represented on the Programme Boards of ESA concerned with those optional programmes in which Latvia participates. Latvia shall have the right to be heard at the above meetings and to vote, in its capacity of Participating State, on issues relating to those activities and programmes.

Following to the discussions during the ESA-Latvia High Level Bilateral Meeting, the ESA optional programmes in which Latvia seriously considers participation are:

- The General Support Technology Programme (GSTP)[48],
- The Earth Observation Envelope Programme (EOEP)[49].

GSTP has five major objectives, including: (i) to foster innovation by creating new products; (ii) to facilitate spin-in from outside the space sector. These two objectives are highly relevant for any emerging space nation. Every single one of ESA's 22 member states, also Slovenia as an Associate Member and Canada as a Cooperating State, contributes to GSTP programme. It covers all

48 https://www.esa.int/Our_Activities/Space_Engineering_Technology/Shaping_the_Future/About_the_General_Support_Technology_Programme_GSTP

49 https://www.esa.int/Our_Activities/Space_Engineering_Technology/About_the_Earth_Observation_Envelope_Programme_EOEP

technology disciplines and applications, except telecommunications. GSTP covers activities with the technical maturity levels from TRL3 to TRL9[50]. The goals and flexibility of GSTP make it attractive to very small countries comparable to Latvia, such as Estonia and Slovenia.

The **Industrial Policy Committee** (IPC) acts as the Programme Board of GSTP. The IPC's role is to define, implement and monitor ESA's industrial policy. It also approves the procurement and contract proposals submitted to it for the conduct of ESA's activities. IPC has to increase fairness in the access to ESA procurement by all firms, including SMEs. IPC defines suitable approach for programmes supporting worldwide competitiveness of European industry[51].

EOEP is the backbone for implementing the ESA Earth Observation Strategy 2040 whose prime objectives are to help society to: (i) develop and provide the observations to better understand the complexity of the Earth and monitor its health; (ii) enable improved predictions of the physical interaction of society with the Earth system; (iii) inform decision makers and citizens on scenarios and consequences of political and economic decisions regarding the Earth. EO science for society is one of the EOEP-5 (2017-2021) core activities that is the most relevant regarding the Latvian capabilities in this domain. EO science for society pioneers new EO services and scientific discoveries, stimulating downstream industry growth, and supporting international responses to global societal challenges[52].

Programme Board for Earth Observation (PB-EO) coordinates the European and national Earth observation activities and makes recommendations to the Council with regard to future programme and decisions that remain within the competence of the Council[53].

Table 16 Estonian delegates to the Programme Boards of the optional programmes subscribed by Estonia

ESA Delegate Body	Number of meetings annually	Estonian representative (affiliation)	Need for more representatives
PB-EO	4-5, usually at ESRIN (Frascati, IT)	Mr Ants Vain (Estonian Land Board)[54]	-
IPC	5, usually at ESTEC (Noordwijk, NL)	Mr Madis Võõras (Estonian Space Office)[55]	The workload requires the second representative.

The subscription to GSTP and EOEP by the Latvian government would replicate the Estonian selection back in 2015. The Estonian delegates to the Programme Boards of the two optional programmes are given in **Table 16.** The Estonian experience demonstrates that ESA full member states should nominate at least 2 delegates to attend IPC meetings regularly to cover the whole spectrum of relevant issues with sufficient diligence.

The direct costs related to the representatives in various ESA delegate bodies were equal to around 1.5% of the Estonian total contribution to ESA[56]. The costs do not include the labour costs of the Estonian Space Office. Nevertheless, this is a very cost-effective level that has been achieved by consciously fostering very active dialogue between the Estonian Space Office and all major

[50] https://mzo.gov.hr/UserDocsImages/dokumenti/Medunarodna/ESA-prezentacije/ESA%20Visit%20to%20Croatia%2011%20March%202019%20Technology.pdf
[51] https://www.esa.int/About_Us/Law_at_ESA/ESA_s_organs_and_functioning
[52] https://eo4society.esa.int/about/
[53] https://www.esa.int/About_Us/Law_at_ESA/ESA_s_organs_and_functioning
[54] The PB-EO delegate is supported by a representative at DOSTAG (the technical advisory board of the ESA's PB-EO), Dr Rivo Uiboupin (TalTech)
[55] The IPC delegate has an advisor, Tõnis Eerme (Invent Baltics OÜ), responsible for industrial liaison activities of the Estonian Space Office.
[56] Invent Baltics OÜ (2018). Final Report: Public tender no. HNR180297 "Assessment of economic impacts from the full membership of Estonia to the European Space Agency".

stakeholder groups. Knowledgeable persons outside the government agencies were contractually engaged in the ESA delegate bodies.

In addition to the Programme Boards and their advisory boards (e.g. PB-EO/DOSTAG), an ESA Associate Member should pay attention to the European space technology harmonisation process. The aim of the harmonisation process is to provide strategic guidance, in the form of detailed technology development roadmaps, for space technology in Europe. Technology Harmonisation Advisory Group (THAG) is the focal point of this process. The THAG is formed by the Member States' representatives in the harmonization process. The Member States are involved in the harmonization process to support the technological landscape mapping (national input) and to approve the Technology Roadmaps[57]. One of the Key Performance Indicators of ESA is the share of harmonised roadmap activities implemented versus all activities in the roadmap[58].

Link to the harmonisation process would provide Latvian space companies an opportunity to get first-hand information about the medium-term ESA procurement plans. Eventech as a technology leader in Europe in its market nice has already participated in pertinent ESA Technology Harmonisation Advisory Group's open mapping meetings. The company was involved thanks to the communication from SME4SPACE (www.sme4space.org), a non-profit organisation aiming at facilitating the access of SMEs to space activities, particularly to ESA and EU programmes. However, according to Eventech, a Latvian representative should actively participate in the harmonisation process and disseminate relevant information to the Latvian stakeholders.

In case of GSTP, it is crucial to note that each Participating State decides upon the amount of its participation and the technological activities to support[59]. In practice it means that any commitment from GSTP to a Latvian entity requires an approval letter from the Latvian delegation. Procedural aspects related to the approval should be agreed at national level as soon as possible, e.g.:

- Is the delegate to IPC authorized to issue such approval letters?
- If national-level inter-institutional consultations are needed, then what ministries and organisations are involved in the process? What ministry or organisation has the casting vote? Should there be established a dedicated body? Etc.

If GSTP funds are overbooked, i.e. the potential commitments to Latvian entities surpass the Latvian contribution adjusted with the ESA non-industrial costs, then a thoroughly elaborated procedure would be one of the instruments for implementing the priorities of a National Space Plan.

6.3. Similarities between alternative ESA-Latvia cooperation models

The most important similarity between the two alternatives relates to the provisions about dedicated instruments for building the industrial expertise and capacity in Latvia to prepare for participation in ESA programmes. The Associate Member agreement foresees an incentive scheme in the form of Requesting Party Activities which shall be based on full cost reimbursement and national funding. Latvia's expenditures to Requesting Party Activities shall amount to a minimum of 500.000 Euros per year (2018 economic conditions) and shall not exceed its contributions to the optional programmes in which it participates. According to the ECS Agreement, Latvia shall

[57] https://eurospace.org/wp-content/uploads/2019/02/the-european-space-technology-harmonisation-info-note-2018.pdf
[58] https://eurospace.org/wp-content/uploads/2019/02/harmonisation-brochure-2016-finale.pdf
[59] https://mzo.gov.hr/UserDocsImages/dokumenti/Medunarodna/ESA-prezentacije/ESA%20Visit%20to%20Croatia%2011%20March%202019%20Technology.pdf

participate in and contribute financially to the PECS, in particular through its subscription of the "PECS Charter".

The model agreements establish identical regulations (e.g. 'Privileges and immunities of ESA' and 'Dispute resolution') or almost identical regulations for several themes. The main themes are summarised in **Table *17***.

Table 17 Commonalities of the two ESA-Latvia cooperation models

Theme in model agreement	The main regulations	Associate Member vs ECS country
Use of facilities	The contracts contain dispositions on preferential use, where the parties commit to giving preference to products or services available from the other, e.g. Latvia to European space transportation systems, facilities and products. Latvia shall have access on a cost-reimbursable basis to the facilities and services of ESA for Latvia national space projects. The methods of calculating costs shall be those applied to the ESA Member States when utilising the ESA facilities and services for their own space projects. In return, Latvia shall make available its facilities and services to the Agency and its Member States on favourable terms.	In addition, the AM agreement declares: If ESA or its Member States do not have certain facilities required for its missions, then ESA shall, subject to arrangements existing at the relevant time with other entities and on terms of parity in this matter with other Associate Members of ESA, give detailed consideration to the appropriate Latvian facilities with a view to their potential use.[60]
Exchange of information	With a view to identifying possible areas of cooperation, ESA and Latvia shall exchange information in the following spheres: (i) the content of, and plan for, their current and future space programmes; (ii) matters of scientific and technical interest resulting from their space activities. ESA and Latvia may establish a scheme to permit the exchange of experts concerned with work within the competence of ESA. ESA and Latvia will also consult with each other when they are represented at international organisations or events relating to space activities. ESA and Latvia will seek to harmonise their positions on matters which are likely to have a bearing on the implementation of their common space programmes and activities.	In addition, the ECS agreement declares that: Latvia shall have access to ESA's young graduate and fellowship programmes, subject to conditions to be mutually agreed.

[60] As an example of such facilities, Tartu Observatory of the University of Tartu has furnished the laboratory of space technology: https://www.to.ee/download/m5a25b0dbaadc4#laborid_eng_297x210_2_netti_22_11_pdf. The core processes and procedures of the laboratory have been inspected by the experts from ESA Quality Assurance and Management Section.

Theme in model agreement	The main regulations	Associate Member vs ECS country
Intellectual property	ESA and Latvia shall ensure adequate and effective protection of Intellectual Property and of any pre-existing rights that may come into play in the course of cooperation. The specific provisions concerning the rights of access, dissemination and use of intellectual property as well as of technical information and data developed, shall follow ESA's rules and procedures.	

7. The experience of the Central and Eastern European countries in ESA

Chapter 7 covers the main aspects of the transitional process of the recently joined ESA Full Members and the Associate Member. The chapter provides basic facts about the accession process of the ESA member states and related space governance issues. We focus on six Central and Eastern European countries: the Czech Republic, Hungary, Romania, Poland, Estonia, and Slovenia. **Table 18** summarizes the countries' contributions to the ESA budget in 2019.

There are considerable country-by-country differences in contribution patterns. Larger countries contribute to all major optional programmes and technology domains, while smaller countries focus their efforts[61]. For smaller countries, such as Estonia and Slovenia, General Support Technology Programme (GSTP) is rather obvious and safe choice as it covers all technology disciplines and applications except for telecommunications. Also, one of the objectives of GSTP is to facilitate technology spin-in from outside the space sector[62]. For example, Estonia contributed to GSTP in a bid to activate the so-called 'Earth-Space-Earth' technology transfer pathway[63], i.e. ESA contractors adopt terrestrial innovations for space purposes and the upgraded technologies are later commercialized on the main target markets of the contractors.

Table 18 The distribution of contributions of Central and Eastern European to ESA in 2019 (in million Euros) [64]

	Poland	Romania	The Czech Republic	Hungary	Estonia	Slovenia
Mandatory Programme	23.3	8.1	7.8	5.2	1.1	0.4
Optional Programmes	11.3	37.3	25.3	0	1.6	2.0
TOTAL	**34.6**	**45.4**	**33.1**	**5.2**	**2.7**	**2.4**

Poland is the largest of the countries in terms of population and the absolute size of its GDP. However, Romania's contribution to ESA surpasses the Polish contribution. The contribution level per capita is a useful indicator of a country's commitment to become integrated to the European space community. The Czech Republic stands out with that respect while Hungary is lagging behind (**Figure 3**), despite being the first to sign the Cooperation Agreement with ESA. The stark contrast between the Czech Republic and Hungary which are of comparable size can be attributed to differences in industrial base and research capacity but more likely in space governance. More effective space governance manifests itself in the overall geographical return coefficient[65].

Poland, Romania, Estonia and Hungary as new Member States are undergoing their transitional arrangements. These entail specific objectives, measures and conditions for geographical return statistics, such as the implementation of Industry Incentive Schemes. Therefore, the overall

[61] Source: websites of the CEE countries' ministries supervising for the ESA membership. National space strategies.

[62] https://www.esa.int/Our_Activities/Space_Engineering_Technology/Shaping_the_Future/About_the_General_Support_Technology_Programme_GSTP

[63] See: Petroni, G., Venturini, K., Santini, S., 2010. Space technology transfer policies: Learning from scientific satellite case studies. Space Policy 26, 39–52.

[64] Sources: https://en.wikipedia.org/wiki/European_Space_Agency
Websites of the CEE countries' ministries supervising for the ESA membership, e.g. https://www.gov.pl/documents/910151/911704/Space19%2BESA_MGS_PDF.pdf/32781378-1c4d-cd37-e508-dcd1ca3f16f2

[65] The coefficient is one of the main key performance indicators (KPIs) of ESA. KPIs are tools for monitoring the achievement of the ESA's objectives and the progress of activities and programmes.

geographical return coefficients for these new Member States do not fully reflect the true competitiveness of the countries in the ESA procurement system. At the same time, the Czech Republic has successfully completed the transitional period and its entities are competitive even in the ESA Science Programme.

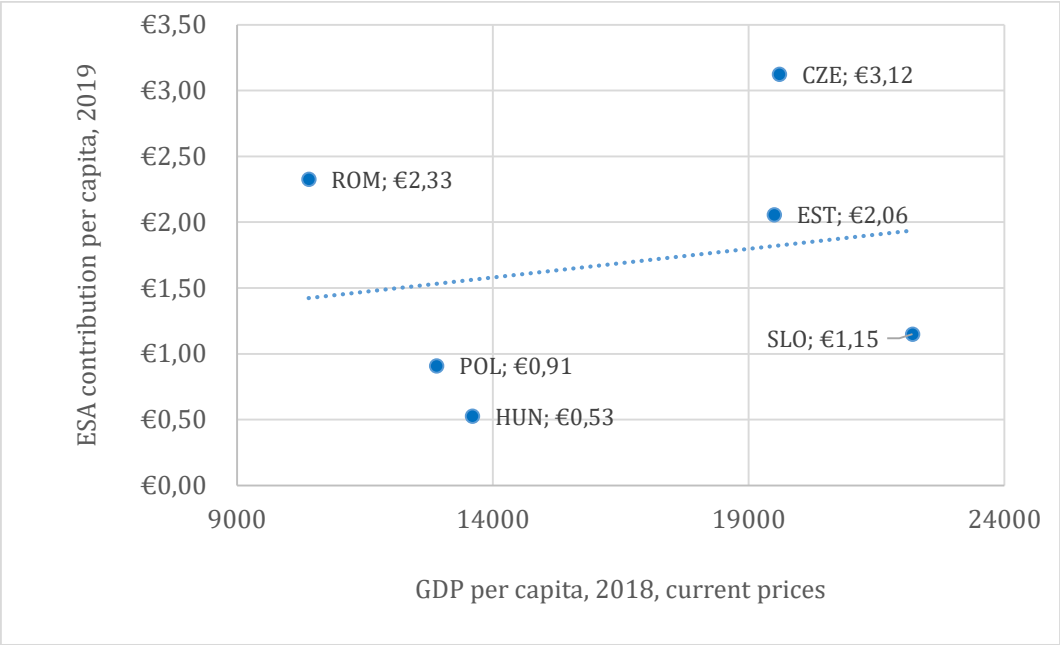

Figure 3 The CEE countries' relative contributions to ESA, in Euros per capita[66]

7.1. The Czech Republic

The Czech Republic signed the Cooperation Agreement with ESA in 1996 after considering the Czech potential for space activities and completing the legislative process. Successful cooperation and satisfactory results led to the establishment of the Czech Space Office (CSO), a non-governmental and non-profit organization, in 2003[67]. The main objective of the CSO (http://www.czechspace.cz/) was creating and maintaining the space information infrastructure fostering a representative and efficient participation of Czech research, development and industrial organizations in the international space projects. The CSO contributed to the development of space activities in the Czech Republic.

The Plan for European Cooperating States (PECS) was signed in 2004. The Czech Republic contributed €9.7 million to the PECS in the course of about four years. The Czech PECS programme was completed with the accession of the Czech Republic to the ESA Convention in November 2008[68].

The Czech Space Alliance (CSA, http://www.czechspace.eu/) was established in 2006 under the auspices of CzechTrade, the export promotion agency of the Ministry of Industry and Trade. The CSA is an industrial association of, and for, the Czech space industry, with proven skills and track record in aerospace business and with broad international client base.

[66] Source: https://en.wikipedia.org/wiki/European_Space_Agency
[67] Machay, M., 2011. Contemporary Czech space policy and its future prospects. Space Policy 27, 170–173. https://doi.org/10.1016/j.spacepol.2011.05.001
[68] Klock, E., Aliberti, M., 2014. ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession – With a Special Focus on the CEE Region (No. ESPI Report 47). European Space Policy Institute, ESPI, Vienna.

Based on Government Resolution No. 282 of 20 April 2011, the Ministry of Transport is the main coordinator of space activities of the Czech Republic. For effective coordination, the Ministry of Transport of the Czech Republic established a Coordination Council for Space Activities under its leadership. The Coordination Council consists of high level representatives of the Ministry of Transport, the Ministry of Industry and Trade, the Ministry of Education, Youth and Sport, the Ministry of the Environment, the Ministry of Foreign Affairs, the Ministry of Defence, the Office of the Czech Government, and Government Commissioner for cooperation with European GNSS Agency. The daily management of space issues lies within the Space Technologies and Satellite Systems Department at the responsible Ministry.

The Czech Republic joined the European-wide ESA Business Incubation Centres (BIC) network in 2016 by establishing ESA BIC Prague (http://www.esa-bic.cz/). In 2018, ESA BIC Prague branch in Brno was open.

Since 2017, an ESA Third Party Programme, the "*Framework project implementing ESA's support of space-related activities in the Czech Republic*" (so called Czech Third Party Framework Project, C3PFP) is being implemented using ESA's expertise and competences. The C3PFP is a substitute to a national space programme. The C3PFP was initially foreseen to be in force until June 2020. However, in March 2019, the Minister of Transport of the Czech Republic requested for an increase of funding and a two years extension of the framework.

The Czech Republic's contribution to ESA mandatory and optional programmes has been rigorously increased over the past 10 years, from around 14 million Euros in 2009 to 33 million Euros in 2019. The budget allocated to the C3PFP comes on top of this amount. The witnessed surge is well in line with the recommendations of the Czech National Space Plan 2014-2019 to increase participation in ESA optional programmes[69]. Currently, a new National Space Plan 2020-2025 is prepared by the responsible Ministry.

7.2. Romania

The national authority for space activities is the Romanian Space Agency (ROSA, http://rosa.ro/index.php/). Established in 1991, ROSA became an independent public institution under the authority of the Ministry of Education and Research (MER) in 1995. ROSA was the appointed as the national representative for ESA by Laws 40/1993 and 01/2007. The Romanian Parliament established in 2007 the Sub-committee for Space, having ROSA as the rapporteur[70].

ESA and Romania signed two Cooperation Agreements – in 1992 and 1999. In February 2006 Romania strengthened its relations with ESA by signing the European Cooperating State Agreement. The PECS Charter between ESA and Romania was signed in February 2007. According to the model PECS contract, Romania was under the obligation to pay a contribution of at least 1 million Euros per year. However, Romania committed to contribute 10 million Euros over the five year period[71].

In December 2011, Romania became the 19th ESA Member State as a result of Law no. 262/2011 (17.12.2011) ratifying the Agreement between Romania and ESA on Romania's accession to the

69 https://www.mdcr.cz/getattachment/Dokumenty/Strategie/Narodni-kosmicky-plan/Narodni-kosmicky-plan-2014-2019/NSP_2014_2019_ENG.pdf.aspx

70 Piso, M.-I., Racheru, A.-L., Simion, I., 2008. Space programme in Romania - Sharing between national and international activities. 59th International Astronautical Congress 2008, 14, 8987-8992

71 Klock, E., Aliberti, M., 2014. ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession – With a Special Focus on the CEE Region (No. ESPI Report 47). European Space Policy Institute, ESPI, Vienna.

ESA Convention[72]. Romania as a New Member State still benefits from the transitional period that is currently foreseen to be completed in 2022, after a three-year extension was approved by ESA Council in December 2018.

The national programme Research, Development and Innovation Program STAR (Space Technology and Advanced Research, http://star.rosa.ro/) complementing the ESA full membership was set up for 2012-2019, approved by Law no. 262/2011. The main objective of STAR program is to increase the competitiveness of Romanian research, industrial and academic entities for participating in the activities of ESA[73]. The total budget of the calls under the STAR program for the period 2016-2019 was 88.5 million Romanian lei (slightly above 19 million Euros[74]).

Romanian overall geographical return coefficient was well below 1 by the end of the first half of 2019. The return coefficient is brought down by low values of the return coefficient in technology domains that account nearly half of the Romanian contribution to ESA in 2019. It means that Romania is contributing to these domains proportionately several times more than Romanian entities have been able to win contracts. The Romanian overall geographical return coefficient is low despite the ongoing Industry Incentive Scheme and the existence of substantial national support programme. It implies that Romania is currently over-investing to the ESA programmes. Therefore, it would be rational to lower its contribution to ESA from the current level (2.33 Euros per capita). Lowering the contribution would also alleviate lingering problems to actually pay the sums to ESA[75].

7.3. Poland

Informal cooperation between Poland and ESA began in the 1980s and grew in the 1990s. The first formal Cooperation Agreement between ESA and Poland was signed in January 1994. In January 2002, a new Cooperation Agreement was signed. It enabled Poland to participate in ESA research, scientific and development programmes[76]. In April 2007, Poland and ESA signed the European Cooperating State Agreement and the PECS Charter was signed in April 2008. The PECS Charter enabled Poland to participate in almost all ESA programmes and activities. Altogether 47 projects with a total budget of 11 million Euros were funded.

In September 2012, the Accession Agreement between Poland and ESA was signed, and on 19 November 2012 Poland officially became the 20th ESA full Member. In addition to the mandatory programme of ESA, Poland joined ten optional programmes in 2012, declaring the total annual contribution for this purpose in the amount of about half of the mandatory contribution. The transitional period is currently foreseen to be completed for Poland in 2019[77].

Polish Space Agency (POLSA, https://polsa.gov.pl/en/) was established by the Act of 26 September 2014. The new institution pooled together responsibilities related to coordinating and executing the space policy of Poland in a single organization. Before that move, the Polish space strategy was implemented by various institutions such as: the Polish Office for Space (established

[72] http://rosa.ro/index.php/en/rosa-home/history-menu
[73] http://www.research.gov.ro/ro/articol/3893/despre-ancsi-anunturi-p5-cercetare-in-domenii-de-interes-strategic https://star.rosa.ro/downloads/C3_2016/ProgSTAR_PACHET_INFORMATII_C3-2016_A1-A5.pdf
[74] Converted using the average exchange rate of year 2016.
[75] https://www.romania-insider.com/romania-loses-voting-right-european-space-agency
[76] Manikowski, P., 2013. Developments in space activities in Poland. Space Policy 29, 35–39. https://doi.org/10.1016/j.spacepol.2012.11.002
[77] Klock, E., Aliberti, M., 2014. ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession – With a Special Focus on the CEE Region (No. ESPI Report 47). European Space Policy Institute, ESPI, Vienna.

in 2001), the Space Research Center of the Polish Academy of Sciences, the Center for Radio and Satellite Engineering, and Space and Satellite Research Committee of the Polish Academy of Sciences. One of the main tasks of POLSA is to support the Polish space industry in obtaining funds from ESA.

In connection to the accession process, the Polish government adopted the document "*Action program for the development of space technologies and the use of satellite systems in Poland*" in June 2012. In February 2017, the current Polish Space Strategy[78] was approved. The Strategy is being implemented under coordination of the Minister of Entrepreneurship and Technology. The Strategy has a number of specific objectives. The first of the objectives is to take steps to increase the competitiveness of the Polish space sector and its market share in the European space sector. For that purposes, various instruments of governmental intervention are foreseen, including:

- Considerably larger contributions to the optional programmes of ESA, ultimately to the level of 150% -200% of the contribution to the mandatory programme, which would effectively mean more than doubling the current contribution level;
- Development and implementation of the National Space Program – the draft program was ready by December 2017. The National Space Programme 2019-2021 envisages the implementation of 54 complementary projects, supporting the development of the Polish space sector. The estimated budget of the programme amounts to 248.5 million Polish zloty (56 million Euros).

According to the Polish Space Strategy, the accession to ESA had a major impact on the entrepreneurial sector. While in September 2012 there were less than 50 Polish entities registered in EMITS, by 2017 the number had increased to more than 300. Over 70 entities are members of the Polish Space Industry Association (SPACE PL, http://space.biz.pl/association/) that was founded in October 2012. The mission of SPACE PL is to create a strong Polish space industry that will successfully compete on the European space market.

7.4. Estonia

A Cooperation Framework Agreement between Estonia and ESA concerning space cooperation for peaceful purposes was signed in June 2007. Estonia adopted its first Green Paper on national space policy in 2008. The Green Paper suggested that the Estonian government should actively pursue ESA membership[79]. The European Cooperating State Agreement between Estonia and ESA entered into force in November 2009. Estonia signed the PECS Charter in September 2010. The total contribution of Estonia to the PECS programme was nearly 6.4 million Euros and 27 projects were successfully completed.

The positive outcomes of the Estonian PECS programme pushed Estonia rapidly towards the full membership. The Agreement between ESA and Estonia regarding the accession to the ESA Convention was signed in February 2015 and Estonia became the 21st ESA Member State as from 1 September 2015. The period between the Cooperation Framework Agreement and the membership was the shortest among the CEE countries.

The Estonian Space Office is a unit created within Enterprise Estonia (https://www.eas.ee/), a public business development and support agency established by the Ministry of Economic Affairs and Communication, to coordinate daily issues related to the full membership in ESA. The head

[78] https://miir.bip.gov.pl/fobjects/download/295879/zal-_nr_5_do_opz_polska-strategia-kosmiczna-pdf.html
[79] Kolk, A., Võõras, M., 2009. Estonian space policy and governance in the international space community. Space Policy 25, 218–223. https://doi.org/10.1016/j.spacepol.2009.08.001

the Estonian Space Office, Mr Madis Võõras, is the Head of the Estonian delegation to ESA. The Ministry of Economic Affairs and Communication is responsible for strategic coordination of space affairs in Estonia. Currently, a new National Space Programme 2021-2027 is under preparation by the ministry. The ESA membership is the backbone of the Programme. Several future funding scenarios are considered at the moment. The most ambitious scenario foresees almost threefold increase in the contribution to ESA budget from 2.06 Euros per capita to 5.77 Euros per capita.

Estonia as a New Member State greatly benefits from the Industry Incentive Scheme (IIS). High quality of the proposals by Estonian entities to the IIS is the main reason why the spend rate under the IIS has been high. Consequently, the overall geographical return coefficient of the country is above 1.0. The Estonia's transitional period is currently envisaged to be completed in 2024, after a three-year extension was approved by ESA Council in December 2018. However, as of September 2019, the Estonian Parliament has not ratified the extension.

The Estonian Space Office initiated the INNOSPACE project in April 2017 to support the full membership to ESA. This 3-year project has three lines of activity:

- Comprehensive support to Estonian entities related to the ESA procurement system, including scouting of suitable tenders, assistance in proposal formulation and writing, advisory function regarding ESA regulations, and facilitation of international collaboration.
- Support to the operations of ESA BIC Estonia (https://www.esabic.ee/) that was officially launched in November 2017. The consortium behind BIC Estonia Foundation consists of eight partners: Tartu Science Park (www.teaduspark.ee), Tallinn Science Park Tehnopol (www.tehnopol.ee), the City of Tartu, City of Tallinn, the University of Tartu (www.ut.ee), Tallinn University of Technology (www.taltech.ee), Tartu Observatory (nowadays a part of the University of Tartu), and Kredex (www.kredex.ee).
- Comprehensive support to potential beneficiaries of various ESA traineeship schemes.

The Estonian Space Office allocated 430 000 Euros to the procurement from its budget. Tartu Science Park as the operator of ESA BIC Estonia is the coordinator of the consortium implementing the INNOSPACE project. The consortium includes Tallinn Science Park Tehnopol, Invent Baltics OÜ (www.invent.ee), and Maakuma OÜ as other partners.

ESA BIC Estonia has got off to a good start. Altogether, eight start-ups have joined the incubation program of the BIC[80] from various fields of activity. The first company, Space IT (www.spaceit.eu), has graduated the program and has been accepted to the Starburst accelerator (http://starburst.aero/), the global program solely focused on the aerospace business. Space IT develops Mission Control System (MCS) for small satellite missions applying Mission Control-as-a-Service business model. With 17 employees, Hepta Group Airborne (http://airborne.hepta.ee/) has shown the fastest growth among the companies in the program. This growth is fueled by pre-seed investment round of 650 000 Euros closed in June 2019.

The package of services offered through ESA BIC Incubation to the Estonian startups during the two-year programme is the following[81]:

- Incentive Funding up to 50 000 Euros for product development and IPR
- Business Development loan of 50 000 Euros
- Technical support up to 80 hours of expert advice which is the role of the research and development partners of the BIC (the universities)

[80] https://www.esabic.ee/start-ups/
[81] https://www.esabic.ee/incubation-program/

- Business development support and mentoring by experts up to 100 hours which is the role of the two science parks in the consortium
- Financial and Administrative support (office space)
- Intellectual Property consulting
- The right of use of ESA BIC brand
- Access to the international network of ESA BICs community.

7.5. Hungary

Hungarian relations with ESA started as early as 1991, when the country signed a Cooperation Framework Agreement. Hungary was the first non-ESA member state to join PRODEX. The total contribution of Hungary to PRODEX from 1997 to 2002 was 3.45 million Euros[82]. In April 2003, Hungary became an ECS country and some months later the country left the PRODEX programme to benefit from the PECS programme. The PECS Charter was signed in November 2003 and 37 projects in the field of Space Science, Life and Material Science, Space Technology and Earth Observation were undertaken.

In 2007, the accession negotiations between Hungary and ESA started, but in November 2008 Hungary decided to go ahead with an extension of its participation in PECS for another 5 years. In February 2015 Hungary signed the Accession Agreement to ESA and became a full Member State of ESA in November 2015. Hungary has subscribed to GSTP. From this programme:

- The establishment of ESA Business Incubation Centre Hungary at Wigner Research Centre for Physics[83] was funded. The ESA BIC opened in July 2018.
- RADCUBE Mission[84] has been developed. Hungary has funded GSTP Element 3 "Fly" aimed at creating flight opportunities for new technologies.

The Hungarian transitional period in ESA is currently foreseen to be completed in 2021.

The Hungarian Space Office (HSO, http://www.hso.hu/) manages and co-ordinates space activities in Hungary, representing members of both the scientific community and industry. It was established as government office in 1992. In 2010, HSO became a department of the newly created Ministry of National Development.

Hungarian Space Cluster (http://en.hunspace.org/) was established in May 2007. The Cluster's main goal is to facilitate success of its members in the ESA procurement system exploiting the business opportunities emerging thanks to the ESA full member status. For Hungarian space community, participation in European and ESA programmes is one of the main priorities, since the Hungarian government has almost completely cut off expenditure for space R&D at national level[85] [86].

[82] Klock, E., Aliberti, M., 2014. ESA Enlargement: What Interested Countries Can Do to Prepare Themselves for Ultimate Accession – With a Special Focus on the CEE Region (No. ESPI Report 47). European Space Policy Institute, ESPI, Vienna.
[83] https://wigner.mta.hu/esa_bic/en/esa-business-incubation-centre-hungary
[84] https://www.radcube.hu/en/the-mission/
[85] Ferencz, C., 2010. Overview of Hungarian space activity: Plenty of potential, not enough support. Space Policy 26, 105–108. https://doi.org/10.1016/j.spacepol.2010.02.006
[86] European Space Agency, 2018. European Space Technology Master Plan (ESTMP).

7.6. Slovenia

Slovenia signed a Cooperation Agreement with ESA in May 2008. Already in January 2010, ESA concluded the European Cooperating State agreement with Slovenia which was followed by the endorsement of the PECS Charter a few months later (November 2010). The Slovenian contribution to the PECS programme amounted to 6.25 million Euros for five years. Altogether 26 projects were funded for a total of 5.2 million Euros[87].

Slovenia signed an Association Agreement with ESA in July 2016, allowing direct participation in ESA optional programmes. Slovenia contributes to three optional programmes – GSTP, EOEP-5, and PRODEX. The selection is well in line with the country's industrial capabilities. Nevertheless, the country's overall geographical return coefficient is below 1 as of 2019. This may be a sign of governance problems but also evidential of long business development cycles in the ESA procurement. Suitable Invitation to Tenders emerge sporadically, competition is heavy, particularly in Earth Observation domain, and time-to-contract can be over a year. Therefore, the accumulated geographical return coefficient indicators reach to the acceptable level with a time lag of several years.

The Slovenian Centre of Excellence for Space Sciences and Technologies SPACE-SI (http://www.space.si/en/) was established in 2010 by a consortium of academic institutions, high-tech SMEs and large industrial companies in order to benefit from the advantages of small satellite technologies and applications in Earth observation, meteorology and astrophysics. SPACE-SI was created with the assistance of the EU's European Regional Development Fund. The initial investment for 2010-2013 was 9.3 million Euros. One of the main purposes of the establishment of SPACE-SI was to enable Slovenia to join ESA.

The authority for space research and programs related to ESA is with the Ministry of Economic Development and Technology (MEDT). MEDT is national coordinator of space related matters. It was also the administrative unit in charge of implementing the ECS agreement.

[87] http://www.mgrt.gov.si/si/delovna_podrocja/sodelovanje_z_esa/kaj_je_esa/

8. ESA programmes for Latvia

8.1. Third Party Programme

ESA considers a programme as a Third Party Programme if the programme is fully financed by the respective state, without the use of ESA Member State funds. The respective state retains overall programmatic and financial responsibility over the programme and takes decisions on programmatic and financial issues relating it. ESA manages the technical and contractual aspects of the programme following its internal practices in force. Since 2019, a Third Party Programme with a minimum annual contribution of 500 000 Euros (at 2018 economic conditions) is embedded to an Association Agreement between ESA and an Associate Member. The duration of a Third Party Programme is initially seven years and it is renewable after that[88].

A Third Party Programme is intended to prepare the respective country's industry to be successful in the ESA optional programmes. In that sense, the Latvian Third Party Programme programme could be seen as a seamless continuation of the ongoing PECS programme which has the following objectives:

- To build the industrial expertise and capacity to prepare for participation in ESA programmes.
- To ensure coherence of developments with ESA programmes and avoid duplication with the Member States.
- To improve understanding of ESA's organisation, functioning, standards and procedures.
- To promote cooperation of entities with those in the ESA Member States (and national industry and academia).

The interim assessment of the PECS programme provided in the *Latvia PECS end of Period Report* and also the direct feedback collected through the face-to-face interviews with 16 Latvian entities confirm that all these objectives are still fully relevant for Latvia.

A Third Party Programme is an Associate Member's equivalent of an Industry Incentive Scheme even though the latter has more challenging goals. An Industry Incentive Scheme is not only aiming at supporting the participation of a new ESA Member State in ESA optional programmes that the Member State subscribes to but also the participation in ESA mandatory activities (especially the Scientific Programme)[89].

A Third Party Programme can act also as a national programme, e.g. by[90]:

- Funding Latvian possible contributions to ESA space science missions (scientific instruments);
- Supporting education and awareness with a focus on university courses related to space – four entities cited poor access to qualified workforce as the main factor limiting their long-term competitiveness in space domain; one of the respondents even was preparing a joint proposal with a university to be submitted under the sixth Latvian PECS call (PECS-6) [91] to introduce a new course into the curricula of the university to address this bottleneck.
- Supporting activities that are relevant of efficient coordination of Latvia-ESA cooperation and daily operations of the Latvian delegation. The *Latvia PECS end of Period Report*

[88] Eric Morel, Nathalie Tinjod, Stephen Airey; Latvia: Evolution of ESA progress for ECS and AM; Presentation delivered at the ESA–Latvia High Level Bilateral Meeting; 7 August 2019; Riga.
[89] https://www.esa.int/About_Us/Business_with_ESA/If_you_are_from_an_ESA_New_Member_State
[90] Eric Morel, Nathalie Tinjod, Stephen Airey; Latvia: Evolution of ESA progress for ECS and AM; Presentation delivered at the ESA–Latvia High Level Bilateral Meeting; 7 August 2019; Riga.
[91] AO9953 – the 6th call (PECS-6); deadline – 18 September 2019.
http://emits.sso.esa.int/emits/owa/emits_online.showao?typ1=8154&user=Anonymous

recommended setting up an industrial coordination and support team along the lines of the Estonian INNOSPACE project to help industry maximise the return on any ESA investments.

The following activity types could be considered for a Third Party Programme[92]:

- **Hardware activities** (e.g. flight hardware) related to ESA's missions with a specific focus on technologies and products either at very low or very high TRLs, i.e. such activities that are usually not covered by ESA optional programmes.
- **Research and Development activities** including also industrial process development with process qualification and certification which could lead to competitive advantage in European space market; for example, Axon Cable could be interested in space qualification of its manual soldering processes in Latvian production unit.
- **Space applications**, products and services, such as Earth Observation applications, with a particular focus on applications between TRL5 and TRL8 where there is a lack of instruments enabling entities to share technological and business risks related to the first customer pilots and service scale-up.
- **Preparatory Activities,** such as market surveys, requirement definitions and demonstrators.

While these four activity types were supported in the PECS calls, ESA would suggest also adding **National Trainee funding** as an option to a Third Party Programme.

The respondents warmly welcomed an idea to have a Third Party Programme for Latvia. For several interviewees, it was a decisive factor making the associate membership a more attractive option than the extension of ECS. Only a few respondents had an opinion about suitable level of funding to the Latvian Third Party Programme. Three respondents wanted it to be on par with the current PECS funding, i.e. around 1.5 million Euros a year. Once again, access to high-quality support services was highlighted as a necessary pre-condition for implementing the Third Party Programme effectively and efficiently.

Out of the seven interviewed entities without ESA contracts as of August 2019, five expressed strong willingness to participate in the Latvian Third Party Programme if it will be opened for proposals. One company linked its participation to the outcomes of the evaluation of the PECS-6 call: if the company's proposal will be successful in the PECS call, it would develop the technology further under the Third Party Programme. One company still needs to figure out, if their value proposition could be accommodated in the ESA programmes. The main beneficiaries of the PECS calls in Latvia between 2015 and 2019 confirmed their readiness to propose activities to the Third Party Programme. The interviews confirmed that there is a well-articulated demand for the Third Party Programme in Latvia.

8.2. GSTP programme

8.2.1. Overview of the programme

Every single one of ESA's 22 member states, also Slovenia as an Associate Member and Canada as a Cooperating State, contributes to the General Support Technology Programme (GSTP). For smaller countries, such as Estonia and Slovenia, participating in GSTP is rather obvious and safe

[92] Eric Morel, Nathalie Tinjod, Stephen Airey; Latvia: Evolution of ESA progress for ECS and AM; Presentation delivered at the ESA–Latvia High Level Bilateral Meeting; 7 August 2019; Riga.

choice as the programme covers all technology disciplines and applications except for telecommunications.

GSTP has five major objectives[93]:

- Enable missions of ESA and national programmes by developing technology;
- Foster innovation by creating new products;
- Strengthen the competitiveness of European industry;
- Improve European technological non-dependence and the availability of European sources for critical technologies – this objective is one of the reasons why Eventech and RD Alfa Mikroelektronikas Departaments have good chances to be competitive in GSTP programme;
- Facilitate spin-in from outside the space sector – this objective makes GSTP an interesting option for countries without existing space industry or space heritage.

The programme is divided into three programme elements (*Develop*, *Make* and *Fly*). High level information about the elements is provided in **Table 19**. Activities funded under GSTP Element 1 are procured according to the respective Work Plans that are constantly revised and updated by the Industrial Policy Committee (IPC) of ESA. The IPC acts as the Programme Board of GSTP. Activity proposals and selection of activities are made by representatives of the technical and application domains and internally coordinated at ESA. Selected activities are often continuations of previous activities funded under other ESA programmes, including Industry Incentive Schemes in the new ESA Member States in the transitional phase. Roughly 10-25 activities are approved and added to GSTP Element 1 Work Plan at the IPC meetings (5 times a year), including *ad-hoc* proposals. The latter can be submitted to so-called GSTP Element 1 frameworks, such as *G617-241TA, Assessments to prepare and de-risk technology developments*.[94]

Table 19 Overview of GSTP Elements

	GSTP Element 1	GSTP Element 2	GSTP Element 3
Title	*"Develop": Technology developments for future missions, ground applications and tool*	*"Make": Development of technology and products for commercial sustainability*	*"Fly": In-orbit demonstration of new technologies, pre-paration of future missions and small missions*
Focus	Development of technologies and products from low TRL to qualification Platform, Payload, Ground Segment and Engineering tools	Market driven, industry initiated, co-funded direct negotiation activities for technology maturation leading to products	Envelope which hosts projects such as satellites (for technology demonstration), ISS payloads, technology flight opportunities

Activities funded from *G617-241TA* framework must contain at least one of the following tasks:

- Analysis of specifications, development actions, schedule and cost.
- Assessment of the benefits and disadvantages of the solution with respect to the state-of-the-art.

93 https://www.esa.int/Our_Activities/Space_Engineering_Technology/Shaping_the_Future/About_the_General_Support_Technology_Programme_GSTP

94 https://mzo.gov.hr/UserDocsImages/dokumenti/Medunarodna/ESA-prezentacije/ESA%20Visit%20to%20Croatia%2011%20March%202019%20Technology.pdf

- Assessment of critical issues related to using a given technology for a specific application, using analysis, simulation and/or breadboarding.

However, it must be noted that in the presence of the Latvian Third Party Programme, it would be more convenient for potential bidders from Latvia to propose any *ad-hoc* activities for funding to the Third Party Programme instead of the GSTP Element 1 frameworks.

The main objective of GSTP Element 2 is to offer industry a mechanism for submitting at any time unsolicited proposals for market-oriented technology activities. Activities submitted in the frame of GSTP Element 2 may be related to the improvement or development of satellite subsystems or equipment (including EGSE), space transportation subsystems or equipment up to engineering model or qualification model, and the improvement or development of ground and user system and equipment up to prototypes and commercialized products. Activities should address any the following technology themes: Earth Observation, science, exploration, human spaceflight, space transportation, satellite navigation, or generic technologies. The proposals submitted to the Open Call[95] of the Element 2 must include a realistic business plan. Industry has to foresee other customers on top of ESA.

Table 20 The funding schemes of GSTP Element 2: ESA's share in total price of an activity

	SME	Non SME	Research Institutes and Universities
TRL ≤ 5	Up to 75%	Up to 75%	Up to 100% (<30% total)
TRL > 5	Up to 75%	Up to 50%	Up to 75%

ESA has established GSTP Element 3 in order to give companies access to the relevant flight environment in the shortest time possible, by embarking flight demonstrators as hosted payloads on a variety of carriers – including suborbital rockets, launchers, satellites and the International Space Station (ISS) – with all the onboard resources they need to operate[96]. In-Orbit Demonstration (IOD) helps de-risk innovative payloads and accelerate their development to market ready products. GSTP Element 3 offers SMEs and research institutes an opportunity to acquire flight heritage.

8.2.2. Potential of Latvian entities in GSTP

8.2.2.1. The assessment of Latvia's potential by ESA

The *Latvia PECS end of Period Report* prepared by ESA in July 2019 included a thorough analysis of all PECS contracts that have been awarded to Latvian entities under the first three PECS calls. Among other aspects, the report assessed the programmatic fit between the proposed technologies and ESA optional programmes paying special attention to the maturity levels of the technologies.

GSTP Element 1 was considered a suitable optional programme for the PECS contracts:

[95] AO 9834 GSTP ELEMENT 2: Call for Proposals - FOR MARKET ORIENTED ACTIVITIES http://emits.sso.esa.int/emits/owa/emits_online.showao?typ1=8073&user=Anonymous

[96] https://www.esa.int/Our_Activities/Space_Engineering_Technology/Shaping_the_Future/GSTP_Element_3_Fly_Technology_Flight_Opportunities_Permanently_Open_Call_for_Flight_Demonstrators_and_Carrier_Flight_Opportunities

- Targeting generic technology and techniques (40% of the total commitments under the Latvian PECS), particularly for activities in microelectronics (**RD Alfa Mikroelektronikas Departaments**), event-timing devices (**Eventech**), and structural damage assessment domains (**Riga Technical University**). The average target TRL of the activities falling under the category of generic technology and techniques was 3.57, which sits between laboratory experiments and breadboards. The focus was on the development of Electrical, Electronic and Electromechanical (EEE) components that are currently only available from US suppliers and the products could be very interesting to the European space market if they can be successfully qualified and supplied at a competitive price. At ESA, the developments in the field of EEE components have been carried out in recent years through the European Components Initiative[97] funded through the Mandatory Programme, ARTES Advanced Technology[98], the Technology Development programme[99], and the GSTP. RD Alfa Mikroelektronikas Departaments has the potential to secure work under these programmes. The event timers being developed by Eventech are considered to be world class and have a promising market both for Space Situational Awareness[100] (SSA) and in-orbit applications. They could potentially be considered for developing further SSA programme but also under GSTP programme.
- In the domain of Space Transportation and Re-entry Technology (15% of the total commitments under the Latvian PECS). Research conducted by the **Latvian State Institute of Wood Chemistry** is expected to contribute to a related activity within the Future Launchers Preparatory Programme (FLPP)[101]. Certain launcher-related developments have also been carried out under GSTP, which could be considered as a more flexible alternative to FLPP from the Latvian government's viewpoint.

The *Latvia PECS end of Period Report* also pointed at Latvian capabilities in the field of satellite laser ranging. The Institute of Astronomy of the University of Latvia operates the station RIGL 1884, part of the International Laser Ranging Service[102] managed by NASA. This expertise, together the leading Latvian technology in event timing devices, could certainly be exploited within the relevant ESA programmes. According to ESA's expert opinion, the most relevant programme would be the Space Surveillance and Tracking (SST) segment[103] of the (SSA), although certain related developments at ESA have been carried out through GSTP.

In the fourth PECS call, Allatherm's activity was recommended for funding. The company is working with OHB System AG, a European Large System Integrator, in the breadboard development of a Xenon Refueling Compressor for the "*European System Providing Refueling, Infrastructure and Telecommunications*" of the Gateway programme[104]. This collaboration can be advanced and strengthened in the European Exploration Envelope Programme (E3P)[105], although the company has a potential to implement follow-up activities under GSTP as well.

The development of space products is split into numerous phases. RD Alfa Mikroelektronikas Departaments, Eventech, and Allatherm have passed or will pass soon the engineering

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97 https://www.esa.int/Our_Activities/Space_Engineering_Technology/European_Component_Initiative_ECI
98 https://artes.esa.int/advanced-technology
99 https://www.esa.int/Our_Activities/Space_Engineering_Technology/Shaping_the_Future/About_the_Technology_Development_Element_programme_TDE
100 https://www.esa.int/About_Us/ESAC/Space_Situational_Awareness_-_SSA
101 https://www.esa.int/Our_Activities/Space_Transportation/New_Technologies/FLPP_preparing_for_Europe_s_next-generation_launcher
102 https://ilrs.cddis.eosdis.nasa.gov/
103 https://www.esa.int/Our_Activities/Space_Safety/Space_Surveillance_and_Tracking_-_SST_Segment
104 https://www.esa.int/Our_Activities/Human_and_Robotic_Exploration/Exploration/Gateway
105 https://www.esa.int/About_Us/Ministerial_Council_2016/Human_Spaceflight_and_Robotic_Exploration_Programmes

breadboard phase and are ready to enter Engineering Model and Flight Model phases soon. These phases mean that only space-grade components are to be used and more stringent product assurance and testing procedures must be followed. As a consequence, the related cost levels hike. The activities targeted at Flight Model development are in the region of 500 000 Euros, while activities for space qualification of an EEE component could exceed 1 million Euros.

Each Participating State of GSTP decides upon the amount of its participation and the technological activities to support[106]. Any commitment from GSTP to a Latvian entity requires an approval letter from the Latvian delegation. If Latvian annual contribution to GSTP will be around 1 million Euros, then commitments to Flight Model and Space Qualification activities could consume almost entire yearly budget allocated to GSTP[107].

There should be established a transparent procedure of the Latvian delegation for giving approvals to activities proposed by industry. The priorities to be set by a National Space Plan would serve as the backbone of the procedure. The principles of this decision-making procedure must be unambiguously clear to the interested parties as business development cycles are very long on institutional space market. For companies, changing the rules often or having a procedure which is open to alternative interpretations would mean an additional risk of bearing sunk cost related to the business development activities.

Also, a possibility of a high or very high concentration level of contracts placed to Latvian entities under GSTP must be fully acknowledged by all stakeholders. Nevertheless, support to activities aimed at qualifying space products is strongly recommended as these products can be offered in volume to many different institutional (i.e. ESA) and commercial missions.

8.2.2.2. Self-assessment of companies

The interviews with the main beneficiaries of the PECS calls in Latvia between 2015 and 2019 showed that overall awareness about GSTP is low. The respondents did not have a clear idea:

- What type of technology developments are procured under this programme,
- How the programme is structured, or
- How the work plans and procurement plans are compiled.

Opinions about the fit between an entity's research and development roadmap and the programmatic boundary conditions of GSTP (e.g. the programme's objectives, and covered technology domains and technology maturity levels) were formed on the basis of communication with ESA staff, both representatives of the ESA's New Member State section and technical officers. Also, in a few cases, a respondent had been invited to join an activity funded under GSTP programme.

Four entities among the main beneficiaries of the PECS calls identified GSTP as one of the most relevant ESA optional programmes for them:

- Eventech
- RD Alfa Mikroelektronikas Departaments
- Latvian State Institute of Wood Chemistry
- Riga Technical University.

[106] https://mzo.gov.hr/UserDocsImages/dokumenti/Medunarodna/ESA-prezentacije/ESA%20Visit%20to%20Croatia%2011%20March%202019%20Technology.pdf
[107] The non-industrial costs of the GSTP programme are around 20%.

Also, Allatherm sees GSTP as the suitable optional programme for funding its follow-up activities. In case of Allatherm, awareness level about the ESA optional programmes was very good as the company's CTO has had a long career in various space companies and research organisations that had been involved in many ESA projects.

Among entities without an ESA contract as of August 2019, Fiber Optical Solution, HEE Photonic Labs, Axon Cable, and Sidrabe have in-house projects that could have a potential to be developed under GSTP Element 1 de-risk framework.

8.3. EOEP-5

8.3.1. Overview of the programme

The Earth Observation Envelope Programme (EOEP-5) is a key programme of the Earth Observation Directorate with a budget of around 1.2 billion Euros in the 2017-2025 period. The essential features of EOEP-5 are[108]:

- **Block 1** - Future Missions with the following activity lines:
  - Prepare the future of Earth Observation, including
    - Earth Explorer 10 (EE-10) – in September 2018, the Harmony, Daedalus and Hydroterra candidate missions were chosen to enter pre-feasibility study and compete to be the EE-10 mission[109], and
    - Call for Early Mission Concepts
  - Prepare the future of Copernicus Space Component
  - Investigate possible candidates for the new class of "Missions of Opportunity"
  - Investigate new EO models.
- **Block 2** - Mission Development (definition, development, launch, commissioning), focusing on the following tasks:
  - Complete EE-7 (Biomass)[110] and EE-8 (FLEX)[111],
  - Implement and complete EE-9 - the candidate missions are *„Sea surface KInematics Multiscale monitoring*" (SKIM) [112] and *„Far-infrared Outgoing Radiation Understanding and Monitoring*" (FORUM)[113],
- **Block 3** - Mission Management:
  - Operate and manage SMOS, Cryosat, Swarm, ADM-Aeolus and EarthCARE missions
  - Develop Level-2 products for Earth Explorers
  - Reshape the ESA Ground Segment architecture and procurement in line with the "EO Innovation Europe" approach, by bringing the users to the data.
- **Block 4** - EO Science for Society[114] with the following objectives:
  - foster scientific excellence and maintain a structured dialogue with international EO science communities
  - maximise scientific impact of ESA, European missions and National missions
  - engage the users and pioneer new EO applications, including via the use of EO exploitation platforms

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[108] http://space.biz.pl/wp-content/uploads/2018/05/ESA-Stephane-Combes.pdf
[109] https://www.esa.int/Our_Activities/Observing_the_Earth/Three_Earth_Explorer_ideas_selected
[110] https://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme/Earth_Explorers/Future_missions/Biomass
[111] https://earth.esa.int/web/guest/missions/esa-future-missions/flex
[112] https://www.skim-ee9.org/
[113] https://www.forum-ee9.eu/
[114] Information about tenders announced under the Block 4 are visible to the professional community via dedicated website: https://eo4society.esa.int/category/opportunities/invitations-to-tender/.

- stimulate downstream industry growth,
- support international responses to global societal challenges and Sustainable Development Goals
- implement 10% of Block 4 on the basis of an open call to ensure that both industry and scientific institutions can take advantage of new opportunities that occur for the exploitation of EO missions in today's rapidly evolving ICT conditions.

The Block 4 has the lowest entry barriers for countries with emerging EO community. This idea was also highlighted in the *Latvia PECS end of Period Report*. The report concludes that: "*The Latvian entities currently involved in EO activities are more prepared for the Development and Exploitation component. Entities like the Institute for Environmental Solutions would be prepared to participate in invitations to tender such as the EO Science for Society permanently open Call, which is currently available. /…/ the entities are mainly focused* ***on algorithm and service development***."

According to the ESA's assessment, EOEP would be suitable for Latvia, in particular the Baltic Regional Initiative could be of interest. For many regions in Europe, a dedicated strategy has been developed and agreed in cooperation with the European Commission. These strategies address environmental issues, socio-economic issues and sustainable development in the Alps, the Black Sea, the Danube, the Baltic and the Atlantic region. At present, the use of EO within these regional level activities is quite low. This is due to a number of factors including a requirement for customized processing of the EO data in each region, a requirement for fusion of a range of diverse datasets, modelling capabilities, and a lack of familiarity by many of the regional actors with satellite EO. To address these issues and expand the uptake of EO, ESA started a number of Regional Initiatives.[115] Several Invitation to Tenders have already been closed under the Baltic Regional Initiative[116].

8.3.2. Potential of Latvian entities in EOEP-5 Science for Society

Activities in EO domain constituted 28% of the commitments to Latvian entities under the first three PECS calls. These projects were thoroughly analysed in the ESA's *Latvia PECS end of Period Report.* Three additional activities in this service domain have been recommended for implementation in the fourth PECS call and another three activities in the fifth PECS call in Latvia. As a result, the share of activities in the EO domain from the commitments increases to 35%.

The average target Technology Readiness Level of the EO activities funded in the first three PECS calls was 3.43, which is between prototype and alpha version with respect to software maturity and between concept analysis and non-operational service verification from the perspective of applications and services. The projects are still quite far away from market. Additional research and development work to reach market must funded either by entities itself or in combination with public funding instruments. EOEP-5 programme would be suitable for the Latvian entities to finance follow-up activities and new developments.

For comparison, 31% of the total commitments under the Estonian PECS programme were allocated to the EO domain. Based on ESA's feedback that there were good capabilities in this area, Estonia decided to subscribe to EOEP-5 programme. The contribution to the programme is

[115] https://eo4society.esa.int/regional-initiatives/overview/

[116] Most recently AO9680 BALTIC REGIONAL INITIATIVE – APPLICATIONS covering the following topics:

- Integrated Maritime and Coastal Zone Monitoring
- Land and Agriculture Management
- Climate Impacts
- Emerging HELCOM Monitoring and Assessment Priorities

The state-of-the-art of the topics was partly defined by the results of the successfully completed Latvian PECS projects.

roughly 24% of the total Estonian contribution to ESA. It was expected that the experience acquired by the relevant Estonian entities by the end of PECS should enable them to participate successfully in competitive tenders under EOEP-5, particularly in the Baltic Regional Initiative. In Estonian case, the entities that are successful in EOEP-5 competitive tenders come mostly from academia. For example, Tartu Observatory (since 2018, a part of the University of Tartu) is the coordinator of a consortium that won the tender *Fiducial Reference Measurements for Satellite Ocean Colour* (FRM4SOC) in 2016[117]. From industry's perspective, EOEP-5 calls are highly competitive (especially AO9101 Open Call for Proposals[118]) and tenders that have a good fit with the EO companies' business strategies in terms of technology development are scarce.

Among the Latvian entities, the Foundation Institute for Environmental Solutions (IES) has the best opportunities in EOEP-5 tenders because:

- It has successfully completed a number of ESA contracts in diverse areas (land use monitoring, inland water monitoring, awareness raising, simulation, and calibration and validation).
- It is the focal point of a wide network of potential end-users and has a very good understanding of real-life challenges in the respective fields, e.g. in forestry, the problems related to forest inventory, illegal logging, and spread of diseases and pests.
- It owns an aircraft carrying custom-made hyperspectral sensors enabling to collect data from ultraviolet to far-infrared wavelength for in-situ reference data.

IES itself sees the organisation contributing to the development of new advanced EO methods and techniques, particularly in the fields of land use and monitoring of inland water. Also, IES has collected long time series of high-quality in-situ reference data that are of interest for several topics to be funded under the Baltic Regional Initiative.

Emerging EO service providers, such as Meža ipasnieku konsultativais centrs and Baltic Satellite Service, focus on the development of EO-based downstream services, e.g. for monitoring forests. The services under development will add value to both forestry management companies in private sector but also to publicly owned companies. It is highly commendable to introduce national-level public procurement of innovative services to help the services to market, streamline core business processes in publicly owned companies, and offer vital data about the natural resources in Latvia in near real-time. The first such cases are emerging in Latvia, for example, a tender by JSC Latvian State Forests to develop a solution for evaluating tree stands from remote sensing data[119].

Also, ESA recommends to increase cooperation with other entities active in Earth Observation domain in the Baltic Sea region. ESA has already funded projects with similar technical objectives in Estonia, Lithuania and Latvia. Without collaboration between the beneficiaries, it may lead to excessive supply of services and through this pose a threat to the viability of the nascent EO industry in the region.

8.4. Other ESA optional programmes

GSTP and EOEP are the ESA optional programmes with at least four interested entities among the Latvian respondents as of September 2019. Both GSTP Element-1 and EOEP-5 Block 4 - EO Science for Society are good options for the Latvian government to keep successfully completed activities of the Latvian PECS contractors progressing along the TRL ladder. Harsh competition in EOEP-5

[117] https://frm4soc.org/
[118] https://eo4society.esa.int/2018/04/26/open-call-for-proposals/
[119] https://www.lvm.lv/biznesa-partneriem/iepirkumi/inovaciju-projekts

tenders and launch of the Latvian Third Party Programme may constrain the interest of potential bidders towards EOEP-5. Therefore, achieving the threshold value for the geographical return coefficient in EOEP-5 could become challenging.

The *Latvia PECS end of Period Report* identified four ESA optional programmes that could be considered as a part of the bundle that Latvia will subscribe to. The number of Latvian entities interested in these ESA optional programmes is one or two per programme. If the number of interested parties per optional programme is one or two, then subscribing to such programme entails considerable risks for Latvia. For example, the Latvian State Institute of Wood Chemistry has established collaboration with Ariane Group in the development of light insulation material technology for application in launchers, a development that could be continued under the Future Launchers Preparatory Programme (FLPP). This partnership could lead to a small but secure georeturn for Latvia under FLPP. However, if the collaboration breaks down or top management of the Latvian State Institute of Wood Chemistry would decide to withdraw from the space domain due to the revision of strategic and scientific goals, then it becomes almost impossible for Latvia to win contracts and to achieve prescribed georeturn level under FLPP.

A limited number of interested parties would also mean that the national contribution to the optional programme should be modest. The lowest feasible contribution to an ESA optional programme is around 300 000 Euros. Despite the modest contribution, Latvia should be represented on the Programme Boards of ESA concerned with those optional programmes in which the country participates. Therefore, participating in a number of ESA optional programmes but with a limited contribution in each results in relatively higher administration and governance costs.

Therefore, it is premature for Latvia to join the ESA optional programmes that are listed in **Table 21**. The Third Party Programme and GSTP Element 1 offer good funding prospects for the all interested entities mentioned in **Table 21**.

Countries that are of similar size to Latvia – Estonia and Slovenia – both subscribe to GSTP and EOEP-5. Slovenia also participates in PRODEX[120].

Table 21 Overview of the ESA optional programmes suggested for Latvia

ESA optional programme	Short description of the programme	Interested entities
Space Situational Awareness Programme (SSA) – Space Surveillance and Tracking (SST) Segment[121]	SST currently focuses on: • Developing SST networking technologies and conducting qualifications of national assets, including radars, optical telescopes and laser-ranging systems; • SST data processing and application development, following a 'community approach' to the SST core software, which helps avoid duplication and ensure interoperability; • SST sensor development, primarily on the ground, but also addressing further conceptualising of a space-based optical; • Simulate the performance of SST architectures and develop data exchange standards.	Eventech The Institute of Astronomy of the University of Latvia (HEE Photonics Lab)

[120] Slovenia joined PRODEX in 2016.
[121] https://www.esa.int/Our_Activities/Space_Safety/Space_Surveillance_and_Tracking_-_SST_Segment

ESA optional programme	Short description of the programme	Interested entities
Future Launchers Preparatory Programme (FLPP) [122]	FLPP aims at: • Preparing competitive technologies for future launchers with low development and production costs; • Shortening launcher development duration and lowering development risks; • Promoting industry and new Member States participation in launcher development.	The Latvian State Institute of Wood Chemistry
European Space Exploration Envelope Programme (E3P) [123]	E3P integrates all ESA's existing space exploration efforts into single programme. Its goal is to secure Europe's central role in global space exploration and deliver new results in both basic and applied science.	Allatherm Baltic Scientific Instruments
PRODEX[124]	PRODEX is devoted to the development of science experiments. Its activities broadly address space science instrumentation and science ground exploitation, and are implemented through dedicated contracts with scientific institutes and industrial companies in the funding country. The largest set of activities is related to the science programme, but PRODEX also supports scientific experiments in areas such as Earth Observation, Robotic Exploration, and the ISS, as well as national contributions to missions led by international partners.	Baltic Scientific Instruments

122 https://www.esa.int/Our_Activities/Space_Transportation/New_Technologies/FLPP_preparing_for_Europe_s_next-generation_launcher

123 https://www.esa.int/About_Us/Ministerial_Council_2016/Human_Spaceflight_and_Robotic_Exploration_Programmes

124 https://sci.esa.int/web/prodex

9. Policy recommendations

The 16 face-to-face interviews and 5 phone interviews with managers of space companies and representatives of research groups at universities provided valuable information about how to promote Latvia-ESA cooperation for the benefit of Latvian companies, universities, and research institutes. The information was generalized into five space policy themes discussed in the following chapters.

9.1. Latvia-ESA collaboration

On 13 December 2018, the ESA Council adopted *Resolution on industrial policy measures to achieve a successful integration of European States in the frame of ESA* (ESA/C/R/CCLXXVII/Res. 1(final)). The resolution revised the conditions to a European state requesting to become a candidate ESA Member State. A candidate country is required to be an Associate Member for at least 7 years and satisfy a set of industrial policy requirements. The adoption of the resolution means that Latvia has basically two major options regarding the next steps in Latvia-ESA cooperation:

- To become an Associate Member State of ESA or
- To extend PECS programme.

The Associate Member State status offers more opportunities to integrate to the European space industry while the continuation of the PECS programme provides a protected environment to widen the pool of potential bidders in Latvia, especially from industry, and master project development, project management and business development skills. The Associate Member state agreement enables Latvia to subscribe to any ESA optional programme which gives Latvian entities an access to open tenders of ESA and widens the opportunities to join industrial consortia to compete for contracts. The analysis of the completed Latvian PECS projects showed that a number of Latvian entities, such as Eventech and RD Alfa Mikroelektronikas Departaments, have developed capabilities in specific niches that are of high interest to ESA and other players within the European space sector. According to the managers of the companies, they would have better chances to join the value chains of the European Large System Integrators if Latvian decision-makers would prefer the associate membership over the alternative, the extension of the ECS agreement.

The associate membership has garnered very strong support from the Latvian space community. Out of the 16 interviewees, only one company thought that the extension of ECS agreement would be in the best interests of the Latvian entities. Two companies did not have any opinion on this matter. Other respondents clearly preferred the associate membership to the ECS extension. For several interviewees, ESA plans to introduce a Third Party Programme[125] for Latvia as a part of the Associate Member agreement, was a decisive factor for supporting the associate membership.

The reasons for picking the associate membership over the alternative varied but one of the repeatedly mentioned argument was that in the PECS programme there was a perceived funding ceiling for the Latvian manufacturers of (space qualified) components and developers of instruments for future space missions. Some of the companies are entering into the phase where they will be developing flight models of their space products. The costs of such projects are

[125] While the recently joined New Member States (Poland, Estonia, and Hungary) benefit from Industry Incentive Scheme, a special transition measure similar to the PECS funding, an Associate Member may launch a Third-Party Programme that could be used as an instrument to help to better position Latvian industry to achieve geo-return in ESA Optional Programmes.

expectedly higher than in the PECS programme, where the price of an activity was not allowed to exceed 400 000 Euros (see **Table 22**).

Table 22 Funded activity types and technology readiness level ranges in the Latvian PECS calls

Activity type	Max contract size (€)	PECS-1 AO7516	PECS-2 AO8437	PECS-3 AO8855	PECS-4 AO9562	PECS-5 AO9791
Flight Hardware activities	400 000	Start-TRL ≥ 3 End-TRL ≥ 6	Start-TRL ≥ 3 End-TRL ≥ 5	Start-TRL ≥ 3 End-TRL ≥ 5	Start-TRL ≥ 4 End-TRL ≥ 6	Start-TRL ≥ 3 End-TRL ≥ 5
Research and development activities	200 000 or 225 000	Start-TRL ≥ 2	Start-TRL ≥ 2 End-TRL ≤ 5	Start-TRL ≥ 3 End-TRL ≤ 5	Start-TRL = 3-4 End-TRL = 5-6	Start-TRL = 3-4 End-TRL = 5-6
Space (downstream) Applications	100 000 or 150 000	Start-TRL ≥ 2 End-TRL ≥ 6	Start-TRL ≥ 4	Start-TRL ≥ 4	Start-TRL ≥ 4 End-TRL ≥ 6	Start-TRL ≥ 4 End-TRL ≥ 6
Preparatory activities	50 000 or 100 000		Yes	Yes	Start-TRL =2	Start-TRL =2
Awareness and education activities	50 000 or 75 000	Yes	Yes	Yes	Yes	Yes

Conclusion: The emerging Latvian space community considers deepening Latvia-ESA cooperation and signing an Agreement to become an Associate Member State inevitable for further progress of the space business in Latvia.

9.2. Latvian contribution to ESA

Subscriptions to ESA optional programmes reflect a country's strategic choices but also enable to build up industrial capabilities for long-term competitiveness in the institutional space market. Countries that contribute at least three times more to the optional programmes than to the mandatory programmes tend to have higher overall geographical return coefficients. The Polish and Czech space strategies have pointed at this link and set funding objectives to increase the contributions to ESA optional programmes. The approach that Hungary recently adopted, i.e. bringing the investments to the optional programmes down to a minimum, is not supportive to the country's performance in the ESA procurement and shall not lead to noticeable socio-economic effects.

The respondents were asked to indicate their expectations to the Latvia's total contribution to ESA. Three different contribution levels were defined – 1.8 million Euros, 2.8 million Euros, and 3.9 million Euros. The respondents who had an opinion on this issue preferred **2.8 million Euros**, i.e. 1.47 Euros per capita. The preference was motivated mostly by a need to increase funding from the current PECS: the level would mean doubling the contribution to ESA as the funding to the PECS programme stands currently at 1.42 million Euros a year. This preferred level would put Latvia ahead of Slovenia, also an Associate Member, in terms of the total contribution to ESA (see Figure 4).

At the same time, the respondents conceded that the Latvian contribution above this funding level would be '*unreasonable*' as '*Latvia is not a well-known space centre*'. Some of the CEE countries

that have recently joined the ESA Convention struggle to achieve an **acceptable overall geographical return coefficient** even in the presence of specific support instruments, such as national Industry Incentive Schemes. The problem with georeturn indicator is a possible signal of overinvestment to the ESA programmes, which basically means the funding level is not in line with existing national capabilities.

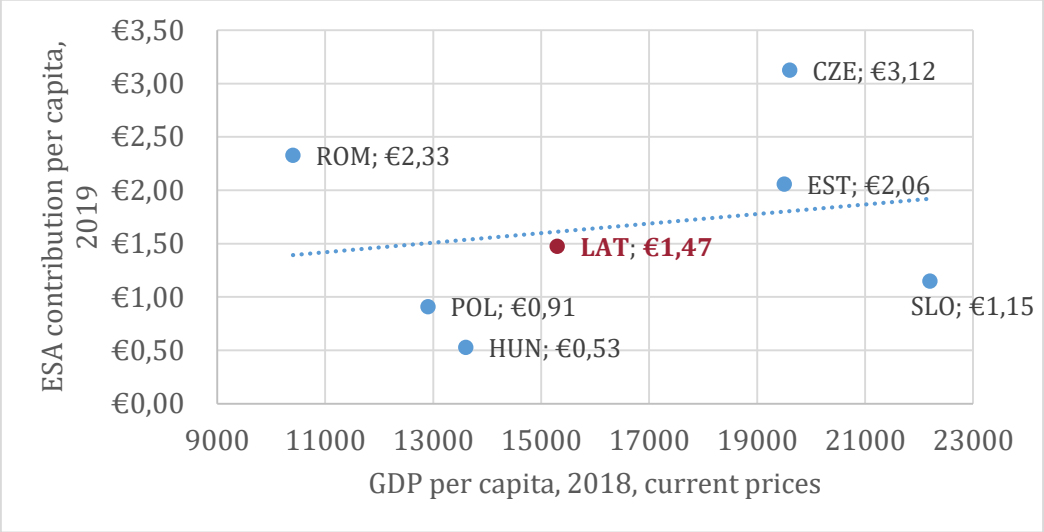

Figure 4 Latvian 'ideal' contribution and the CEE countries' relative contributions to ESA, in Euros per capita[126]

Recommendation: The total Latvian contribution to ESA programmes should be close to 1.5 Euros per capita. Such contribution level would enable to launch a Third Party Programme comparable to the Latvian PECS programme in terms of funding level.

9.3. Participation in ESA optional programmes

The associate membership agreement enables to participate in ESA optional programmes. Latvia has to subscribe to such optional programmes that match with its industrial capabilities. **General Support Technology Programme** (GSTP) and **Earth Observation Envelope Programme** (EOEP-5) appear to be rather safe choices with a sufficient number of potentially interested Latvian bidders. Subscribing to other ESA optional programmes is considered too suboptimal for Latvia because of low number of interested entities (see **Table 23**). If the number of interested parties per optional programme is 1 or 2 then subscribing to such programme entails considerable risks for Latvia. For example, if new management of an entity decides to withdraw from the space domain, then it becomes almost impossible to achieve the desired georeturn on the optional programme level.

All ESA member states contribute to the GSTP. For smaller countries, such as Estonia and Slovenia, participating in GSTP is an attractive choice as the programme covers all technology disciplines and applications except for telecommunications. GSTP has five major objectives[127]:

- Enable missions of ESA and national programmes by developing technology;

[126] Sources: https://ec.europa.eu/eurostat/databrowser/view/tec00001/default/table?lang=en https://en.wikipedia.org/wiki/European_Space_Agency

[127] https://www.esa.int/Our_Activities/Space_Engineering_Technology/Shaping_the_Future/About_the_General_Support_Technology_Programme_GSTP

- Foster innovation by creating new products;
- Strengthen the competitiveness of European industry;
- Improve European technological non-dependence and the availability of European sources for critical technologies;
- Facilitate spin-in from outside the space sector, to activate the so-called 'Earth-Space-Earth' technology transfer pathway[128], i.e. ESA contractors adopt terrestrial innovations for space purposes and the upgraded technologies are later commercialized on the main target markets of the contractors.

Table 23 Short assessment of the relevance of ESA optional programmes for Latvia

ESA optional programme	Arguments for subscribing	Interested entities	Recommendation
GSTP Element 1	**Flexible, wide coverage in terms of technologies, potential to follow up activities funded under the PECS calls**	**Between 5 and 10**	**Strong YES**
GSTP Element 2	Open call for develop marketable products	Latvian entities operate at lower TRLs	NO
GSTP Element 3	-	-	NO
EOEP-5	**Integration to the European EO community, funding for EO applications**	**Up to 4**	**Maybe**
SSA/SST	To support a competitive entity	1 or 2	NO
FLPP	To support a competitive entity	1	NO
E3P	To support a competitive entity	1 or 2	NO
PRODEX	To support a competitive entity	1	NO

Recommendation: The Latvian capabilities in space domain justify participation in two ESA optional programmes. Subscription to the General Support Technology Programme (GSTP Element 1) is strongly recommended. The Earth Observation Envelope Programme (EOEP-5) should be seriously considered.

9.4. Space governance in Latvia

A **formal national structure** is essential for a smooth participation in ESA. The liaison with industry is a crucial task that requires a formal structure with resources that need to be proportional to the contributions to the different ESA programmes and the possible existence of a National Programme. An effectively run national space agency that manages a dedicated national space programme is an ideal case of the strong formal national structure. At the same time, even 'mid-sized' countries, such as Austria, Belgium and Switzerland, *de facto* identify the national

[128] See: Petroni, G., Venturini, K., Santini, S., 2010. Space technology transfer policies: Learning from scientific satellite case studies. Space Policy 26, 39–52.

space programs with the ESA programs[129]. Also, the Czech Republic, the most advanced space national among the CEE countries, still does not rush to establish a national agency: the draft of the National Space Plan 2020-2025 phrases that "*possibility to establish a national space agency should be further analysed*". By implementing the Third Party Programme through the ESA, the Czech Republic signals that ESA is the space agency of the Czech space community.

Estonia offers an example how to manage the ESA membership in a very lean way. Cost-effective governance is achieved by the active dialogue with all major stakeholder. Parties outside the government sector are trusted to represent Estonia in various delegate bodies but the Estonian Space Office still firmly steers the execution of the Estonian space policies. Also, the INNOSPACE project enables to offer services to the space community that are provided by industry/SME/space associations and clusters in the other Central and Eastern European countries, such as technical support to potential bidders, networking at international scale, or distributing information related to the technology harmonization process run by ESA.

In Latvia, the space sector is represented by the Ministry of Education and Science, which is in charge of space policy and facilitating multi-disciplinary research. An official from the Ministry, Mr Kaspars Karolis, represents Latvia in the PECS Committee, a dedicated committee established for monitoring the ECS agreement between Latvia and ESA as well as the coordination with other ECS. The Associate Member state agreement implies more active participation in ESA governing bodies in contrast to the ECS.

As an Associate Member, Latvia shall have:

- a vote in the ESA Council when the latter examines matters pertaining exclusively to the programme in which Latvia participates or when its financial interests are involved;
- the right to be represented at meetings of the subordinate and advisory bodies of ESA, competent in any capacity to deal with the activities and programmes in which Latvia participates.

If Latvia subscribes to just two optional programmes – GSTP and EOEP – then the country should have:

- At least **one representative in the Council**, even though having two representatives would correspond to the actual work load. Given the low level of industry involvement, one of the delegates should be a representative of the Ministry of Economics or agencies under its supervision.
- At least **one representative in the Industrial Policy Committee**, even though having two representatives is highly commendable. Again, a representative of the Ministry of Economics should be involved to embed ESA affiliation seamlessly in the overall innovation policy mix of Latvia.
- At least **one representative in the Programme Board for Earth Observation**. As markets for Earth Observation applications are still dependent on (both supranational and national level) public procurement, then an official responsible for public procurement of innovation (PPI) in the country could be a good candidate. PPI is gaining prominence in the agenda of the Ministry of Economics.
- Having **one representative in the Technology Harmonisation Advisory Group** is highly commendable. The delegate could be a representative of space industry association.

[129] Petroni, G., Bigliardi, B., Galati, F., Petroni, A., 2018. Which benefits and limits derive from ESA membership for European Countries owning "medium-sized" space agencies? Acta Astronautica 142, 130–137. https://doi.org/10.1016/j.actaastro.2017.10.032

In Estonia, members of the delegation to ESA often have multiple roles. For example, the head of the delegation is also the country representative in the Council and IPC. These roles enable to consolidate vital information about ESA plans and programmes for effective coordination and communication with stakeholders at national level. The report suggests that the members of the Latvian delegation would not be replaced too frequently to gain experience enabling to navigate in the complex and nuanced ESA industrial policy and procurement system.

A few respondents pointed at the silo effect in space governance. The Ministry of Economics appears to be less informed about Latvian activities at ESA than expected by Latvian industry. Several respondents suggested that the overall responsibility Latvian space policy should be shifted to the Ministry of Economics instead of the Ministry of Education and Science. This move could address the problem of currently low industry ratio for Latvia by paying more attention to entities with technology spin-in potential. ESA activities should be seamlessly integrated with other public innovation policy instruments, such as the support measure for the commercialization of research results[130] managed by the Investment and Development Agency of Latvia (LIAA) under the supervision the Ministry of Economics.

Recommendation: Effective inter-ministerial collaboration between the Ministry of Economics and the Ministry of Education and Science is necessary for extracting maximum socio-economic benefits from the on Latvia-ESA cooperation in the coming years. Also, the Investment and Development Agency of Latvia and non-governmental organisations representing Latvian space community should be actively involved in the coordination of Latvia-ESA collaboration.

9.5. Support services to Latvian entities

Several respondents voiced a concern that doubling the Latvian contribution to ESA programmes would require heavy investment in various **support services**, such as assistance in benchmarking a development idea against the programmatic needs of ESA, assistance in the preparation of a tender offer, and helpdesk function related to the ESA rules and regulations.

Recommendation: Latvia should consider setting up an **industrial coordination and support team** that advises potential bidders in ESA affairs.

The support services would enable to address several problems, such as:

- Rather low evaluation scores of proposals to ESA. According to the *Latvia PECS end of Period Report*, in the third and fourth PECS calls, some of the lowest scores were given to Latvian entities under the management criterion. Improvement under this sub-criterion is easy to achieve by offering high quality advisory services to Latvian bidders.
- Low number of successful bidders – commitments to top seven entities constituted 88% of the total commitments to the Latvian entities in the first three PECS calls. Access to advisory services would enable to address concerns of prospective bidders about IPR issues, financing, or long-term business opportunities in ESA tendering system that have ruled out the entities' participation in the PECS calls until now.

There are several available options to offer high quality advisory services to Latvian entities. One option could be signing a multi-annual procurement contract with a consultancy firm to assist newcomers to ESA tenders in all aspects of related business development. This is an approach applied in the Estonian INNOSPACE project. Another option could be pooling together a number of specialised European consultancy bureaus capable of writing proposals conforming to ESA

[130] http://www.liaa.gov.lv/lv/fondi/2014-2020/atbalsts-petniecibas-rezultatu-komercializacijai

regulations and best practices. Latvia could offer subsidies to Latvian entities to purchase services from such qualified service providers.

The *Latvia PECS end of Period Report* prepared by ESA in July 2019 suggests to set up an industrial coordination and support team along the lines of the Estonian INNOSPACE project to help industry maximise the return on any ESA investments. The Estonian Space Office initiated the INNOSPACE project in April 2017 to support the full membership to ESA. This 3-year project has three lines of activity:

- Comprehensive support to Estonian entities related to the ESA procurement system, including scouting of suitable tenders, assistance in proposal formulation and writing, advisory function regarding ESA regulations, and facilitation of international collaboration.
- Support to the operations of ESA BIC Estonia (https://www.esabic.ee/) that was officially launched in November 2017.
- Comprehensive support to potential beneficiaries of various ESA traineeship schemes.

The Estonian Space Office allocated 430 000 Euros to the procurement from its budget. Tartu Science Park (www.teaduspark.ee) as the operator of ESA BIC Estonia is the coordinator of the consortium implementing the INNOSPACE project. The consortium includes Tallinn Science Park Tehnopol (www.tehnopol.ee), Invent Baltics OÜ (www.invent.ee), and Maakuma OÜ as other partners.

Replicating similar approach in Latvia would require active involvement of the Investment and Development Agency of Latvia and the Ministry of Economics, in addition to the Ministry of Education and Science.