Fachhochschule Nordwestschweiz
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Evaluation of the existing Swiss institutional R&D funding instruments for the implementation of the space-related measures

On behalf of the Swiss Space Office,
State Secretariat for Education, Research, and Innovation SERI

D3 Final Report

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Management Summary

This document is the final report on the project "Evaluation of the existing Swiss institutional R&D funding instruments for the implementation of the space-related measures" conducted by the School of Business, University of Applied Sciences and Arts Northwestern Switzerland, on behalf of the Swiss Space Office (SSO), State Secretariat for Education, Research and Innovation. It analyses the coherence, relevance, effectiveness, impact and sustainability of space-related funding provided to Swiss companies and research institutes through the European Space Agency (ESA) and SSO within the framework of the National Complementary Measures (Activités Nationales Complémentaires, ANC).

The report draws on 79 interviews, of which 40% were conducted with academic institutes and 60% with companies. The gross sample of the Swiss space sector consisted of 142 organisations, 47 academic institutes and 95 companies (overall response rate of 55.6%). In addition, we collected 135 responses to questionnaires on ESA-funded contracts and 19 responses to questionnaires on ANC projects out of a total of 428 selected contracts (response rate of 36%).

The results show that the Swiss space community has gained many more members, in particular companies, in the more recent past. The space business is mainly a European business. It is for many organisations a side business, with a small but growing contribution to the total sales or budget and a small share of employees. The space industry is one of the most research-intensive and innovative industries in Switzerland.

The evaluation of the Swiss/ESA space-related funding focused on three key aspects: 1) Relevance and consistency, 2) effectiveness, and 3) effects of the funding.

Ad 1) Relevance and consistency. The overall positive response on the influence of public funding on space activities and the positive results of the supported projects confirm the relevance of the funding approach. In addition, ESA funding programmes and the ANC were generally assessed as well organised and transparent, though, in particular with regard to ESA programmes, the respondents also pointed to some implementation problems and suggested improvements. Dedicated workshops and training on different aspects (e.g. how to write successful proposals, how to read the ESA General Terms and Conditions) would also be useful.

The Swiss space community expressed the desire of steering and governing space activities more according to national priorities and independently of the European competitors. This could be done through a Swiss space science and technology plan or programme which complements the Swiss ESA engagement. Coherence and coordination of the space funding with other science and innovation funding should also be guaranteed, e.g. through regular talks with SNF and CTI.

Ad 2) Effectiveness. According to Swiss space policy documents, the space related funding should contribute to improving the quality of life in Switzerland, creating innovations and a knowledge society, and positioning the country as a competitive, reliable and irreplaceable partner with an image of top quality, reliability, unique competency and internationally highly competitive technology. This study provides evidence that the scientific and technological expertise in the Swiss space community is considerable. The specific set-up and partnering requirements of the space funding bring together players from science and industry. However, as the Swiss space community is overall rather small, it is not always easy to find an appropriate Swiss partner and some flexibility of the funding is recommendable to ensure that it can support space-related innovation and knowledge production effectively.

Furthermore, a public awareness initiative should communicate the successes of the Swiss space sector and convey its positive national and international image to the benefit of the entire country.

Ad 3) Effects. The space projects have several short-term and direct results (*outputs*), such as new knowledge, new or substantially changed products (goods or services), or technical progress (advances of the Technology Readiness Level). Seven out of ten projects would not have been realised without the public funding. Taking a mid- to long-term perspective, the results of funded projects lead to further academic, technological and economic *outcomes*: for instance growing academic reputation and networks, higher competitiveness, increasing competencies of the personnel, increasing the number of jobs requiring high qualifications, product and process innovations, or more sales on space markets.

The present study could not address the wider *impacts* of space-related activities on other societal systems (e.g. health, education, internal security, monitoring of climate or natural hazards) and the quality of life in the country. This should be addressed by future studies and monitoring and reporting activities.

Access to qualified space engineers and personnel and to the international space community, including ESA, public funding of space activities and the positive long-term demand development were described as key contributors to success in the space sector. The Swiss Confederation should take further complementary measures to ensure that these factors continue to exert their positive role in the future.

We suggest 15 recommendations which can contribute to the success of the funding and improve the general conditions for being successful in space science and industry in the future.

Recommendations oriented towards space-related funding

Recommendation 1: Continue investing in space activities.

Recommendation 2: Work towards a Swiss Space Programme for space science, technology development, and space data use.

Recommendation 3: Provide support – directly or indirectly through involving topic experts, trainers and coaches – on all non-technical (administrative, legal, economic) matters related to the acquisition and management of institutional space projects.

Recommendation 4: Enhance the communication of business-related information to the Swiss space community.

Recommendation 5: Discuss the needs of the Swiss space community on a regular basis with SNF and CTI and offer joint information events and information material for academic institutes and enterprises.

Recommendation 6: Ensure a flexible approach in the implementation of funding measures (including ratio between academia and industry, and direct funding to industry) to ensure that the overall goal of creating innovations and a knowledge society can be reached, along the whole value chain.

Recommendation 7: Analyse – in discussion with key players from the Swiss space sector – whether further support to innovation, technology development in TRLs 7-9 and product development is needed, including support to industrialization and cost reduction programmes.

Recommendation 8: Analyse possible contributions for stabilising the cash flow of SMEs, such as bridge funding for ESA contracts or reimbursements of costs for preparing offers.

Recommendation 9: Communicate clearly the responsibilities of SSO and SSC.

Recommendations on additional measures

Recommendation 10: Design a public awareness campaign on the successes of the Swiss space community.

Recommendation 11: Find – in discussion with key players from the Swiss space sector – ways to support the global business development of the Swiss space industry.

Recommendation 12: Explore and support business and public use cases for space-data.

Recommendation 13: Discuss with ETH/Universities/UAS representatives possible ways to strengthen the role of "Aerospace Engineering" in the STEM fields (and in particular in postgraduate engineering education).

Recommendation 14: Pilot and test the acceptance of support to cross-organisational mobility schemes between academia, industry and ESA for graduate students as well as senior engineers and scientists.

Recommendation 15: Regular (annual or biannual) monitoring of and reporting on the Swiss space community involving industry associations at national level (SSIG) and at European level (Eurospace), as well as ESA and other relevant actors

1. Introduction

This document is the final report on the project "Evaluation of the existing Swiss institutional R&D funding instruments for the implementation of the space-related measures" conducted by the School of Business, University of Applied Sciences and Arts Northwestern Switzerland, on behalf of the Swiss Space Office (SSO), State Secretariat for Education, Research and Innovation (SERI). It analyses the coherence, relevance, effectiveness, impact and sustainability of space-related funding provided to Swiss companies and research institutes through the European Space Agency (ESA) and SSO within the framework of the National Complementary Measures (Activités Nationales Complémentaires, ANC).

Such an evaluation is important and timely for different reasons. First, the Federal Dispatch on Education, Research & Innovation foresees a total of mCHF 528.2 of space-related funding for the time period 2013-2016 (Schweizerischer Bundesrat, 2012). This funding aims at fulfilling important political goals, like contributing to Switzerland's reputation as a scientifically powerful and technologically innovative country; and economic, political and social goals, like transferring the space-related scientific and technological achievements whenever possible to applications and translating them into higher economic growth and social welfare. It is a duty to Swiss tax payers to document how space-related funding is being used and how it benefits society in the form of a summative evaluation of previous funding periods. Second, science, technology and the economy are dynamic. Regular assessments, whether funding arrangements still meet the needs of potential beneficiaries, i.e. firms and research institutes, are consistent with other policies and funding, reach the desired goals and generate positive effects are highly recommendable in guiding ongoing funding instruments (formative evaluation).

We first develop a theoretical framework for the impact analysis drawing on the academic and evaluation literature in the field. Section 3 summarises the empirical approach and the outcomes of interviews with selected experts of the Swiss space community. In section 4 we present the results, distinguishing between the results of interviews with corporate and academic members of the space community and a survey on space projects conducted with ESA/Swiss (co-)funding. The last section recapitulates the main results and makes recommendations for Swiss space policy.

2. Tentative theoretical framework for analysing the impacts of institutional space-related funding

A number of studies have attempted to measure and analyse space-related activities and the consequences of funding provided by ESA or national agencies. However, the overall approaches, terminology, concepts and definitions vary and, before any data is used and compared, it is of utmost importance to understand properly what it shows and how it was generated.

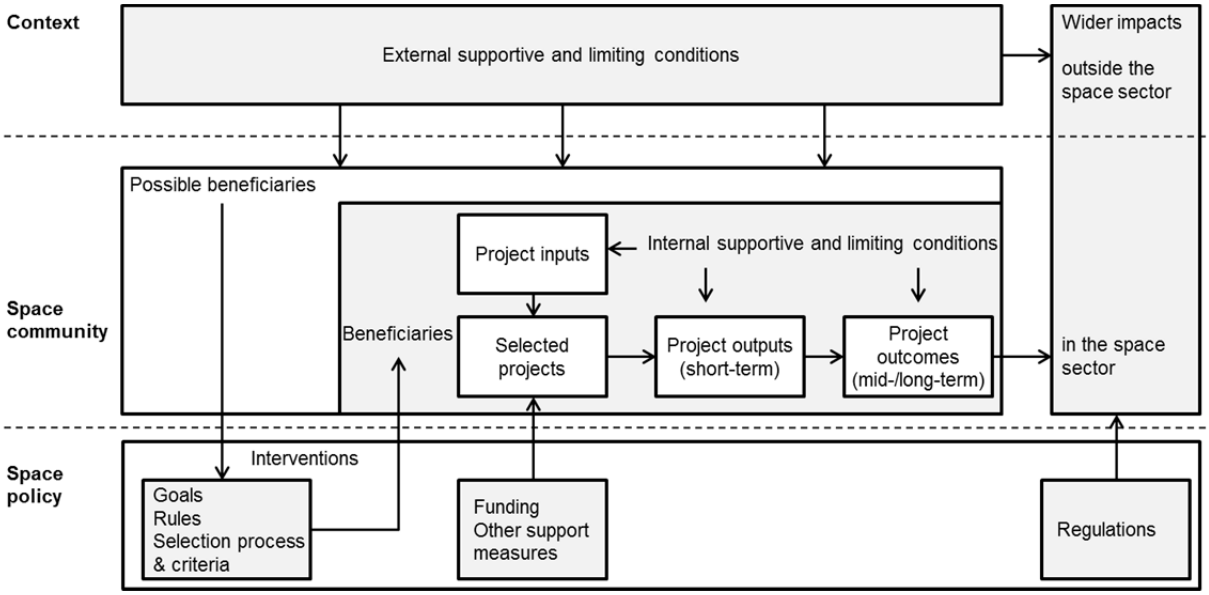
The following figure sketches a logic model of space-related support measures. It distinguishes between the space community, the context (upper part), and space policy (lower part). The space community according to this definition consists of the possible beneficiaries of space-related funding, which are business enterprises or companies and research institutes engaged in space-related activities (OECD, 2012).[1] Recipients for space funding are selected from these possible beneficiaries, through applications and contracts and according to defined processes, rules, and

[1] Governmental actors are excluded as they are usually not entitled to receiving space-related funding from ESA or Swiss national sources.

criteria. These beneficiaries receive the public funding for a specified activity and purpose, for which the requirements are usually defined in the underlying programme and in the project itself. However, whether project goals can be achieved depends not only on the funding, but also on other internal inputs and conditions as well as external inputs and conditions. These contextual conditions plus the success of the project itself also determine any further outcomes which the beneficiaries might obtain plus wider impacts on the society.

The following sections elaborate more on this model and the key concepts of this evaluation. They present some results and influences according to the national and international literature.

Figure 1: Logic model for the Swiss space-related support measures



Source: FHNW.

External supportive and limiting conditions

International sources generally point out that the space economy is challenging to measure as it does not map well on common industrial classifications. However, it has been perceived as a dynamically growing and innovative sector both at global level (OECD, 2011, 2014; Space Foundation, 2014) as well as in individual countries (see Oxford Economics, 2009, on the UK). However, some observers also noted that the fit between space technology and societal needs has varied over the past decades; whereas up to the mid-1980s this fit was generally given and space-related R&D coincided with society and industry needs, e.g. miniaturization, energy savings, resistance to hostile environment, information processing, knowledge of materials at microscopic and atomic level, this fit was lost in later decades. Sectors other than space gained a head start in meeting the new societal needs; the space sector was not cutting edge in all fields and lost out to other industries (e.g. automotive, consumer electronics) with regard to organizational innovations (Bach, Cohendet, & Schenk, 2002).

In addition to these more structural developments on space markets and related markets where dual-use (civil/military use) or multi-purpose technologies might be sold, there are also cyclical influences on the space business. Though they have been perceived as generally favourable for

the space sector in the last period of economic crisis after 2008 (OECD, 2011) this differs to some degree by industry and country.

When measuring the impacts of space funding it is therefore necessary to take into account the structural and cyclical developments which affected funded companies as they influenced the realisation of funded projects and any follow-up activities. Further external influences on funded companies can stem from labour markets, capital markets, and last but not least laws and policies, for instance on tax, labour, or trade issues. For application and service companies, for instance in the field of navigation, the access to data generated by satellites/space technologies is more important than the use of such technologies themselves; hence, they depend on reliable data access.

Internal supportive and limiting conditions

Company strategy also may play a decisive role with regard to reaping the success of space-related activities. Bach et al. (2002) distinguish between a) a space-only, b) a dual use and c) a traditional transfer strategy. Applying a "space-only strategy" firms couple ESA and other space markets to obtain a profitable (space) business. The second strategy of dual use, defined by Bach et al. (2002) to include military and other civil, non-space applications, implies that firms from the very beginning develop dual knowledge which can be exploited in space and non-space activities. The last strategy of transferring space technologies to other industries and terrestrial applications is the least likely to succeed, not only because of the challenges of building up a common knowledge base (which is also required in b), but in particular because of lacking knowledge on non-space markets (Bach et al., 2002).

Implementing a consistent strategy can have important consequences for the outcomes and wider impacts of space projects. The use on the ground of technologies flown into space will be limited, whenever they are too expensive to be used on the ground. The transfer of technologies used for ground activities is easier to implement, as the cost differences tend to be lower. As components for satellites in Low-Earth Orbit are not anymore at the forefront of technology in all areas (see above), spinning-in COTS (commercial off-the-shelf) technologies from other industries can be a very attractive option from a company-perspective, as the lower costs of ground technologies can open up considerable space markets.

Policy interventions and funding

The Swiss Space Policy as developed in 2008 describes as the main goals of Swiss endeavours in the space sector:

- "Development and use of space applications to improve the quality of life for citizens.
- Long-term commitment to space exploration for the progress of innovation and of the knowledge society.
- Significant scientific, technological and industrial contributions to make Switzerland a competitive, reliable and vital partner." (http://www.sbfi.admin.ch/themen/01371/01417/index.html?lang=en)

The Swiss Space Implementation Plan (SSIP) from 2013 develops this further and highlights the importance of access to space and the development and utilisation of space infrastructures:

"Emphasis will be placed on promoting existing and new focal areas of Swiss excellence, consolidating national activities and securing access to procurements and data on a European and worldwide level, in particular with the aim of

- securing access to space;
- allowing entry to the critical technological path in the development of space infrastructure (mainly satellites);
- fostering the utilisation of space infrastructure through secured data access, build-up of know-how across the whole process and promoting incentives for downstream industry." (Swiss Confederation, Federal Department of Economic Affairs, Education, and Research, 2013).

Switzerland pursues these goals through funding channelled through mainly two instruments:

1) Contributions to the European Space Agency (ESA) allowing participation to a large number of its programmes,
2) Funding of the complementary national activities (Activités Nationales Complémentaires ANC) implemented through the Swiss Space Office (SSO).

Ad 1) ESA-Programmes. In the absence of its own space agency, Switzerland pursues its space-related goals mainly through participation in selected ESA programmes. The European Space Technology Masterplan 2014 distinguishes for Switzerland 8 funding areas: 1) General Budget, 2) Scientific Programme, 3) Microgravity, Human Spaceflight & Exploration, 4) Earth Observation, 5) Technology, Telecommunications & SSA, 6) Navigation, 7) Launchers & Guiana Space Centre, and 8) PRODEX (European Space Agency, 2014, pp. 141-143). The SERI website (cf. http://www.sbfi.admin.ch/themen/ 01371/01510/index.html?lang=en) and various ESA sources provide details on the different programme families.

After further discussions with the SSO it was decided to distinguish five types of projects which partly run across these programmes and vary by the position of agency (ESA) and contractor:

1) Co-financed technology development (Industry initiated)
2) Technological development (Agency initiated)
3) Development for a mission (built to order)
4) PRODEX
5) Other

Ad 2) Complementary national activities. The ANC are implemented in order to improve the Swiss scientific and technological position mainly in European space programmes. The ANC funds are used for funding of selected infrastructures and key projects in specific domains, in particular favouring technology transfer from academia to industry. They serve the following purposes (cf. http://www.sbfi.admin.ch/themen/ 01371/01417/index.html?lang=en):

- to ensure that the competences of the Swiss-based research structures involved in ESA-related activities are sustainable,
- to create optimal conditions that enable Swiss industry to take part in calls for tender for European institutional programmes, and
- to help strengthen technical competences in established scientific and technological fields, foster technology transfer and create new competences.

The ANC are being managed by the SSO which is the main competence centre of the Federal government for space matters. SSO prepares and implements the Swiss Space Policy, repre-

sents Switzerland in the governing bodies of the European Space Agency ESA, implements the complementary national activities, and coordinates space activities at Federal level. SSO also funds a substantial part of the Swiss Space Center (SSC), a national platform within the Federal Institutes of Technology in Lausanne and Zurich. The SSC supports the SSO in implementing the Swiss Space Policy on specific tasks by networking Swiss actors at national and international level, facilitating access to space projects for established actors and for newcomers, providing education and training, and promoting public awareness of space.

Project outputs

Project outputs refer to the products generated by space-related projects, e.g. the knowledge, technologies, processes, instruments, infrastructure, services etc. directly invented, developed or built by project participants with the funding. Outputs will often reflect projects' goals or objectives, but not only in theory might unintended outputs, coincidental insights, or serendipitous discoveries appear as well. Outputs are heterogeneous and usually lack a price tag or common measure that permits for easy aggregation. Evaluations therefore tend to follow one of two approaches for measuring outputs:

- Equating output values with input values, i.e. measuring total project budgets including public funding and funding from other sources (Danish Agency for Science Technology and Innovation, 2008); this approach, however, essentially fails to capture the value that is generated within the projects.
- The other approach is qualitative: it presents and (eventually) counts the different outputs generated or advanced through the funding, e. g. scientific publications, new technologies, patents and licences etc. (Academy of Finland, 2004; Amesse, Cohendet, Poirier, & Chouinard, 2002; Centre for Strategy & Evaluation Services (CSES), 2011). This approach lacks a uniform measure for the different outputs, complicates or even prevents comparisons across programmes and projects, and does not provide monetary values. Still, it is currently the best approach to capture the diversity and richness of outputs.

Project outcomes

As project outcomes we define all those effects that result with the participants of funded space-related projects due to the project realisation. French scholars distinguished four types of such project outcomes (Bach et al., 2002; Cohendet, 1997):

- *Technological* outcomes are new or improved technologies which are introduced into a market and become product innovations. The target markets can be related to space programmes, but they can also be totally different markets in which the developed technologies are being used.
- *Commercial* effects refer to increased sales of goods or services which do *not* incorporate technological innovation, but result, for instance, from a grown international co-operation network, new sales contacts, or reputational gains from the involvement in space projects which translate into sales.
- Effects on *organisation and methods* cover process and organisational innovations which result from the high standards imposed by space performance and reliability specifications. Examples are new production techniques, techniques of quality control or project management.

- *Work-related* effects refer to the acquisition of skills and qualifications within space programmes. It also includes the creation, maintenance or growth of teams of specialists, scientists, engineers, and technicians which can constitute the "critical mass" of human capital that the company needs in order to be able to enter this market.

These outcomes can translate into an increase in sales, cost reductions and/or the existence of a critical mass of space-related specialists. Different studies tried to assess the industrial and economic returns from public space investments (see Table 1). The results depend, of course, on the structure and focus of a country's space sector and the estimates rely on different methodologies and are therefore difficult to compare and interpret.

Table 1: Multiplier effects of public space investments

Country (underlying years)	Estimated multipliers (annualised)	Sources
Belgium (2010)	1.4	OECD (2011)
Canada (2000-11 for investments realised 2000-08)	1.94 1.78 (without imports)	FHNW calculation according to Goss Gilroy Inc. (2010)
Denmark (2000-2007)	4.5 3.7 (without spin-offs)	Danish Agency for Science Technology and Innovation (2008)
Ireland (2012)	3.6	OECD (2014)
Norway (1997-2013)	3.5 (1997) 4.8 (2013)	Norsk Romsenter (Norwegian Space Centre) (2014)
Portugal (2012)	2	OECD (2014)
UK (2012)	1.9	OECD (2014)

Source: FHNW compilation.

Wider impacts

Wider impacts of space-related funding cover in our understanding those which go beyond the participants in funded projects and reach industry, academic organisations, or society as a whole. This does **not** reflect the distinction between upstream and downstream activities which is frequently found in space-related reports (see e.g. Bullock et al., 2009; OECD, 2012; Oxford Economics, 2009).[2]

In a recent paper Clark et al. (2014) distinguish between economic, social, strategic and environmental impacts of space investments. They do not distinguish outcomes and impacts and some of their impacts which accrue to beneficiaries of space funding have already been considered above.

Economic impacts can apply to suppliers to organisations benefitting from space funding, e.g. in the form of direct revenues from space-related contracts or indirect effects resulting from technical progress due to sophisticated requirements with regard to the provided technologies. Wider economic effects would also result if other companies (not those directly funded in space programmes) commercialize or use the developed technologies and generate additional revenues or cost savings. Knowledge spill-overs from the space sector would be an obvious (positive) external economic effect of space activities for which the originating space-related companies or organisations do not receive any compensation. Market spill-overs might occur as well, to consum-

[2] The OECD (2012, p. 43) defines the upstream sector as "manufacturers of space hardware and providers of services that enable the launch of systems into space", whereas downstream includes "operators of satellites and providers of space-enabled products and services".

ers or producers. Take the use of a meteorological satellite as an example which improves – or not – weather forecasts and reduces the costs resulting from meteorological disturbances (e.g. in agriculture) as organisations and individuals can better prepare for such conditions. ESA publications and brochures list several examples for such technologies and spill-overs into other economic sectors (see the ESA brochure "Technology Success Stories"). A nice example is the Temprakon quilt sold by the Danish company Quilts of Denmark QOD. It was developed in 2001/2 by QOD together with Outlast technologies based in Colorado, USA. Outlast had in 1991 licenced a temperature phase change material (PCM) from the Triangle Research & Development Corp. which the latter had developed for NASA space missions to protect astronauts against extreme temperature fluctuations (Vanhaverbeke, Vermeersch, & Zutter, 2012). PCM, developed with NASA funding, became an essential part of a new product (and company) more than 20 years later and on a different continent.

The previous example illustrates the challenges with measuring the wider impacts of space efforts, which, however, still has been attempted. A report from Oxford Economics (2009) estimates that the indirect economic effects constitute another £1.735 billion of value added in 2006/07 (in addition to the £2.760 billion of direct value added by the space sector). The report also suggests significant spill-overs from space investments in communications, broadcasting, earth observation, navigation, and education. It estimates that they add up to a social return rate of 70%; i.e. for every 100 £ invested in space activities another 70 £ worth of spill-overs result in these key application domains (in total £892 million in 2006/07). Canadian studies measured ratios of 3.5:1 and 4.2:1 for indirect : direct economic effects of the Canadian ESA participation (Amesse et al., 2002).

Strategic effects refer to political effects in defence or international politics, but also reputation gains to companies, scientific organisations and even society as a whole resulting from the realisation of space missions (Clark et al., 2014). *Social* impacts in the understanding of Clark et al. (2014) cover impacts on the quality of life, e.g. through improvements of health, education or general pride in space achievements. *Environmental* impacts include positive effects resulting from a better monitoring of the environment and global processes, as well as negative effects, e.g. fuel and CO_2 emissions or debris resulting from spaceflights. In addition, the impact on environmental policy-making through problem identification and environmental status monitoring is also mentioned.

The measurement of wider impacts is for many reasons challenging (Clark et al., 2014; Cohendet, 1997; OECD, 2012): identifying all impacts and recipients, attributing causality to the space-related funding, putting a price tag or even quantifying impacts require insights and data which are not readily available. In addition, effects will not only be direct, but also indirect – taking the meteorological example above, raised agricultural productivity thanks to more precise weather forecasts might have wider economic effects on crops, prices, exports, dietary habits etc. General impact evaluations therefore have at most listed the social and environmental effects which could be identified by program participants and beneficiaries of the funding. This can only be considered as anecdotal evidence of limited value. Anything more sophisticated, however, is only possible in the framework of dedicated studies and considerable investment of time and resources to compile the necessary data (see the suggestions in Clark et al., 2014, table 4).

Due to the lack of well-established measures, the impossibility to realise a dedicated data collection and reach out to beneficiaries and users in the corporate sector, administration, the health sector, or society in general, wider impacts lie beyond the scope of this study.

3. Empirical approach

3.1 Approach and methods of data collection

The required data refers to three units of observation: a) Policy interventions, i.e. the funding programmes for space-related activities, b) funded space projects, and c) the organisations conducting these space projects. While some data may be collected with comparable quality at any of these three levels, other data is level-specific; e.g. funding regulations and procedures are programme-specific, whereas the goals or outputs are project-specific. We included all three levels in the data collection and combined projects and programmes. The data collection relies on three methods:

1) Semi-structured face-to-face interviews with organisations have been used in evaluations all around the world to collect data on the impact of space-related funding (Bach et al., 2002; Cohendet, 1997; Danish Agency for Science Technology and Innovation, 2008; Hertzfeld, 2002; Prognos AG, 2008). Face-to-face interviews were held in this evaluation with twenty key players of Swiss space industry and space research.
2) *Structured telephone interviews* targeted Swiss companies and institutes with minor and potential future involvement in the space sector.
3) A *written survey* on selected projects of the interviewed organisations collected data on the corresponding programmes, as well as project inputs, goals, outputs, and outcomes.

3.2 Samples and responses

The samples consisted of Swiss organisations in the space sector and their space projects.

Organisations. We identified 153 separate organisations in the Swiss space sector of which 52 (34%) are academic and 101 (66%) are corporate. 119 organisations conducted ESA or ANC projects (39 academic, 80 corporate). The 153 organisations in the gross sample were then invited to participate in the survey. Out of the 52 academic institutes 2 did not exist anymore or could not be located after continued searching and 3 answered that they had stopped their space activities since receiving the funding. The same happened to 6 companies (3 inexistent or unreachable and 3 stopped space activities). This reduced the gross sample to a total of 142 organisations, 47 academic institutes and 95 companies. In total 79 interviews were conducted, of which 40% with academic institutes and 60% with companies. The overall response rate was 55.6%, nearly 70% among academic institutes and approximately 50% among companies (see Table 2). 20 interviews were conducted face-to-face (average interview duration of 70 minutes) and 59 by phone (average duration 34 minutes). Interviews were usually recorded and transcribed as summaries.

Table 2: Realised sample by sector and funding status

	Academic institutes		Companies		Total	
	N	in %	N	in %	N	in %
Cleaned gross sample	47	100.0%	95	100.00%	142	100.00%
Respondents	32	68.1%	47	49.5%	79	55.6%
with space-related public funding (ESA/ANC) 2010-14	26	55.3%	42	44.2%	68	47.9%
without space-related public funding 2010-14	6	12.8%	5	5.3%	11	7.7%
Rejections	7	14.9%	5	5.3%	12	8.5%
Non-responses	8	17.0%	43	45.3%	51	35.9%

Source: FHNW

Projects. The organisations in the sample had more than 1'000 different ESA contracts and 31 ANC projects. We included all 31 ANC projects and made a systematic selection of 397 ESA-funded contracts for the project-related survey. Overall we received 154 filled in questionnaires answered by 18 academic institutions and 31 companies. 98 questionnaires were filled in by companies, 56 by academic institutions. The overall response rate was 36% (see Table 3).

Table 3: ESA and national space-related contracts to Swiss organisations

	All contracts per organisations		Gross sample		Responses		
	N	in %	N	in %	N	in %	Response rate
ESA-funded*	1526	98.0%	397	92.8%	135	87.7%	34.0%
Mesures de positionnement	31	2.0%	31	7.2%	19	12.3%	61.3%
Total	1557	100.0%	428	100.0%	154	100.0%	36.0%%

* "Contract" refers to the participation of a Swiss organisation in an ESA project.

Source: FHNW Swiss space sector survey 2014/2015.

Several respondents were unable to recognise projects in the sample conducted by their organisations or the correct projects could not be identified (e.g. in the case of universities with one organisational ID for several institutes). Hence, the original aim of putting together a random sample of funded projects for the data collection could not be realised and several respondents had to be asked to select projects on which they wanted to respond. This probably introduced a bias towards more productive and more successful projects. As we do not have any information on 90% of all funded projects we recommend that the project-related results are interpreted with some care.

3.3 Expert interviews

Seven expert interviews were conducted during the development of the questionnaires to get a better understanding of the structure of the Swiss space sector (corporate and academic), the goals and measures of Swiss space policy, the role and function of ESA and, last but not least, the general perceptions of Swiss and ESA space-related activities.

4. Results

4.1 Academic institutes in the space sector

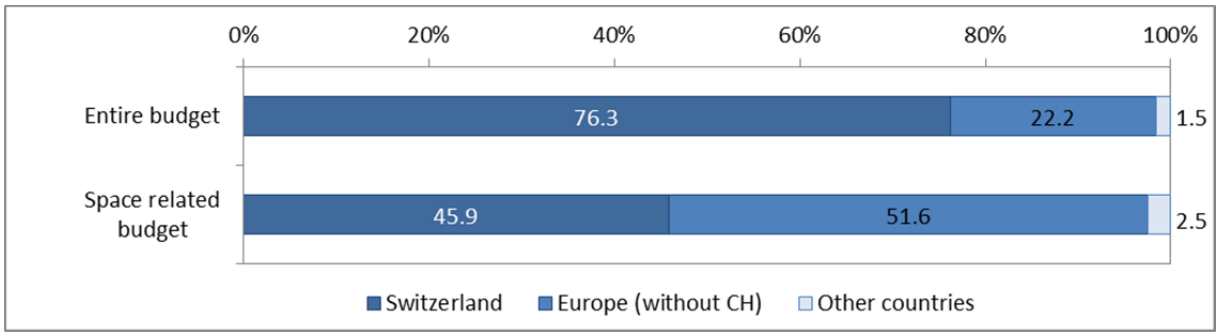
Structure. A total of 32 academic institutes participated in the analysis. 30 out of these 32 institutes are engaged in space activities, more than three quarters (78.1%) had ESA-contracts between 2010 and 2014, and 28% obtained funding from the National Accompanying Measures (ANC).

The median founding year of the academic institutes responding to our survey was 1978 and the median start year of their space activities was 1997; in other words, most of the institutes have considerable experience in their fields and shorter, but still notable, experience in the space sector. Only 3 out of 29 research institutes who provided this information started to work in the space sector within the last 5 years.

Eleven or approximately one third belongs to the ETH sector, another eleven belong to universities, five (15.6%) to universities of applied sciences (UAS) and another five to non-university research or other institutions (including one federal office).

Funding. Among the surveyed academic institutes the share of the space-related activities within the budget was on average 30% in 2013. The ESA-funding itself contributed on average only 3.4% to the total budget (median). Even if only those institutes which carried out ESA-funded activities are included, the average share is very low with approximately 5%.[3] Approximately 77% of the research institutes' total budgets come from Swiss sources and 23% from other European countries, including above all ESA and the EU framework programmes for research (see Figure 2). The figures are quite different, when it comes to the space-related part of the budget only; the majority is now from outside the country, above all Europe. However, as the institutional funding of university institutes, space-related teaching and administration from cantonal and federal budgets are included as well, almost half the budget (46%) is contributed from national sources (see Figure 2).[4]

Figure 2: Share of geographic areas in entire budget and space budget of academic institutes in 2013 in % (arithmetic means)



Entire budget n=20. Space-related budget n=19.

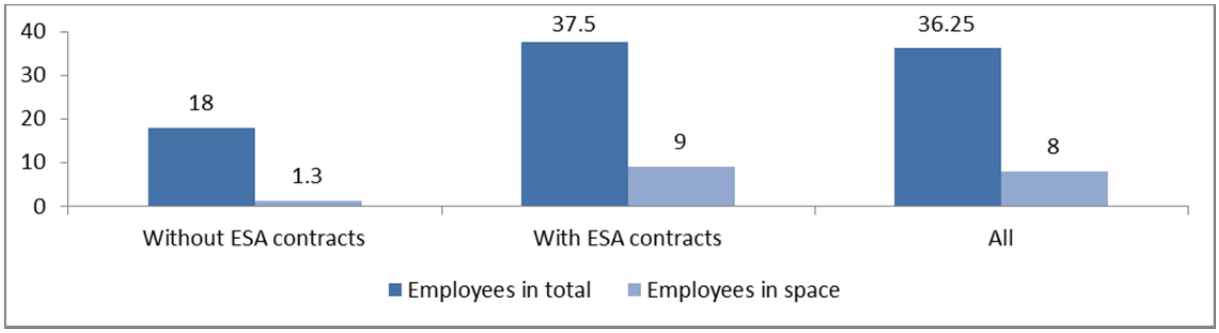
Source: FHNW Swiss space sector survey 2014/2015.

Employment. The 30 academic institutes active in the space sector had on average 36.25 employees of which 8 (22%) actually worked on space activities. Institutes involved in ESA contracts had very similar figures: 37.5 employees of which 9 (24%) worked in space activities. Those not engaged in ESA contracts are only half as big in size and less orientated towards the space sector, with only 1.3 full-time equivalents (7.2%) engaged in space activities (see Figure 3, note that for the latter group n=5 only).

[3] However, by no means this should be taken as an indication that ESA-funding is of little relevance for research. First, respondents might not have been fully aware of where funding for a particular contract came from, in particular if it was not a direct ESA contract (but indirect for sub-system providers). This probably leads to an underestimation of total resources obtained from ESA. Second, the overall budget is not limited to third-party funds, but it includes the institutional funding for teaching provided by the university as well. Third, it should be noted that the arithmetic mean is with 12.5% considerably larger than the median, as there are many institutes where ESA only contributed little and six institutes where ESA-contracts contributed more than 25% to the budget.

[4] It needs to be noted that all funding provided through ESA or the EU was considered in this analysis as European, even if it might stem from Swiss contributions to these multinational organisations.

Figure 3: Employees of academic institutes in total and in space activities in 2013 (median)



Without ESA contracts n=5. With ESA contracts n=24.

Source: FHNW Swiss space sector survey 2014/2015.

4.2 Companies in the space sector

Structure. Forty-seven companies answered our questions. Sixty percent (28 companies) are independent and 19 (40%) belong to a group; the groups are predominantly Swiss-based – 13 out of 19. The headquarters of the six companies belonging to foreign groups are based in France (3), Germany, UK, and the US (each 1). 38 of the 47 companies (80.9%) had received ESA contracts between 2010 and 2014 and 16 (34%) had received funding through the ANC. Only one company stated that it is currently not involved in space activities. The Swiss space industry consists mainly of so-called "Tiers 3 and 4" actors (OECD, 2014), i.e. material and components providers for space and ground systems and scientific and engineering consultancies, with one Tier 1, namely RUAG Space.

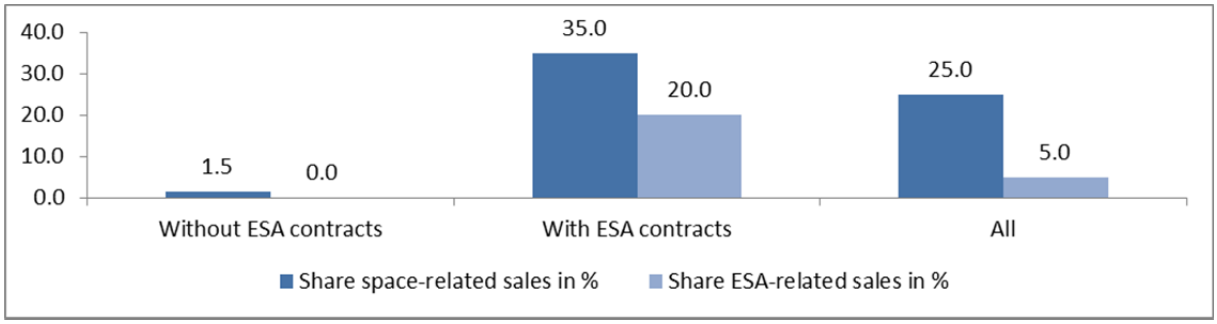
The companies are on average considerably younger than the academic institutes: the median founding year is 1998/1999 and space activities were started on average in 2004. One third of all companies providing this information had only up to 5 years of working experience in the space business, i.e. they started to work in it in 2009 or later. The industry is dynamic and growing.

Sales. The share of space-related sales added up to only 25% of all sales for the surveyed companies (see Figure 4). This is slightly lower than in the academic institutes (see above). Sales to ESA were slightly more important for companies (5%) than for academic institutes (3.4%).[5] Limiting this analysis to the companies which received ESA contracts between 2010 and 2014, the numbers change somewhat and in particular the average (median) contribution from ESA to companies' sales in 2013 rises to 20% (see Figure 4). 17 out of 45 companies (37.8%) worked primarily for space markets (i.e. had sales in these markets of more than 50%). 13 companies (28.9%) realised more than 50% of their sales to ESA, and another 5 made between 25 and 50% of their sales to ESA; this indicates that 40% of the interviewed firms heavily depend on ESA as a client. This confirms the importance and even necessity of an institutional market in the space sector.

The Swiss space business is predominantly orientated towards European clients (see Figure 5): for space-related sales Europe is by far the most important market with a market share of nearly 73%. Swiss markets contribute 30% when all sales are considered, but only 11% in space-related sales. The importance of clients in the USA is slightly bigger overall than in the space sector only; with regard to Asia shares are similar.

[5] Again, we do not deduce from this that ESA-funding is of little importance for companies (see footnote 3 above).

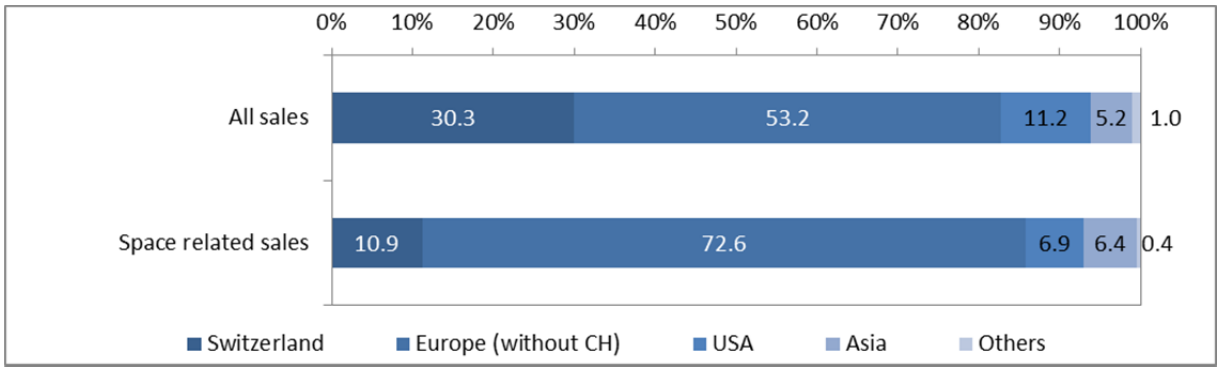
Figure 4: Shares of sales by ESA-funded/not ESA-funded companies in 2013 (median values)



Without ESA contracts n=9. With ESA contracts n=38.

Source: FHNW Swiss space sector survey 2014/2015.

Figure 5: Share of geographic areas in companies' sales in 2013 in %



All sales n=39. Space-related sales n=36.

Source: FHNW Swiss space sector survey 2014/2015.

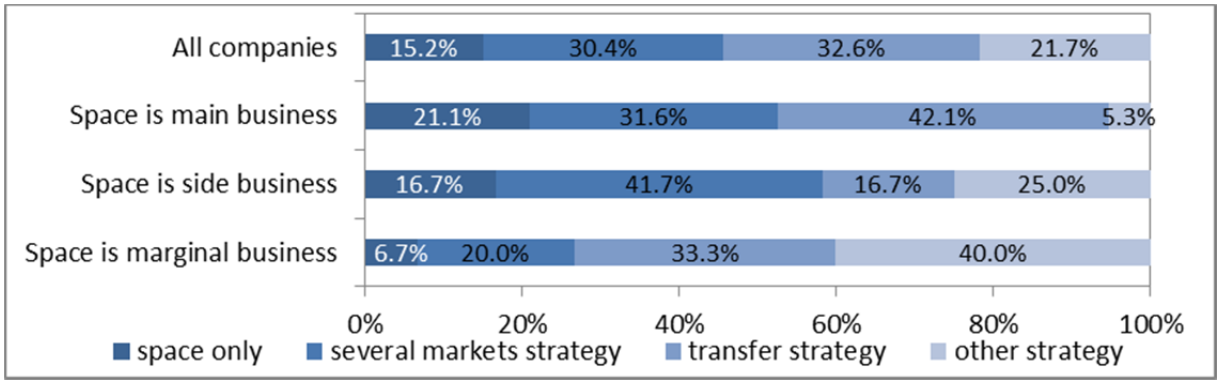
Space market strategies. We asked companies what strategy they follow with regard to the space market, distinguishing between four possible strategies:

- We develop or sell only for/in this market and **not** for/in other markets (space-only).
- What we develop or sell in this market needs to have other market(s) as well (several markets).
- We first develop for the space market and then analyse wider sales possibilities (transfer)
- Other

Most common are the transfer and the several markets strategies (see Figure 6). We generated a variable for segmenting the results on the importance of the space business for the organisation and distinguish three groups: 1) Space is the main business (more than 50% of sales or employees); 2) Space is a side business (more than 5 but less than 50% of sales or employees); 3) Space is a marginal business (less than 5% of sales or employees in space). Out of the 46 companies involved in space, for 19 (41%) it is the main business, for 12 (26%) it is a side business, and for 15 (33%) it is a marginal contribution to their sales.

Companies which realise more than 50% of their sales on space markets more often pursue a transfer strategy. If the space business is a side business, companies try to be successful with their products or services with space and non-space clients at the same time. Those companies which generate their main business in other markets outside space follow a different strategy than the three pre-defined strategies, usually the transfer of technology and competencies from other markets into the space market.

Figure 6: Space-market strategy by degree of involvement in the space sector



All: n=46, space is main business n=19, space is side business n=12, space is marginal business n=15.

Source: FHNW Swiss space sector survey 2014/2015.

Employment. The surveyed companies with space activities are predominantly small and medium-sized enterprises. They have on average 18 employees (full-time equivalents). There are several micro companies with fewer than 10 employees and many small firms with up to 50 employees in Switzerland, but a few larger players with 250 or more employees in Switzerland as well (see Table 4).

Table 4: Company sizes in 2013 by ESA-funding

	Not ESA funded		ESA funded		Total	
Employee groups	**Count**	**%**	**Count**	**%**	**Count**	**%**
Micro (1-9)	3	33.3%	17	44.7%	20	42.6%
Small (10-49)	4	44.4%	9	23.7%	13	27.7%
Medium-sized (50-249)	1	11.1%	6	15.8%	7	14.9%
Large (250 or more)	1	11.1%	6	15.8%	7	14.9%
Total	9	100.0%	38	100.0%	47	100.0%

Source: FHNW Swiss space sector survey 2014/2015.

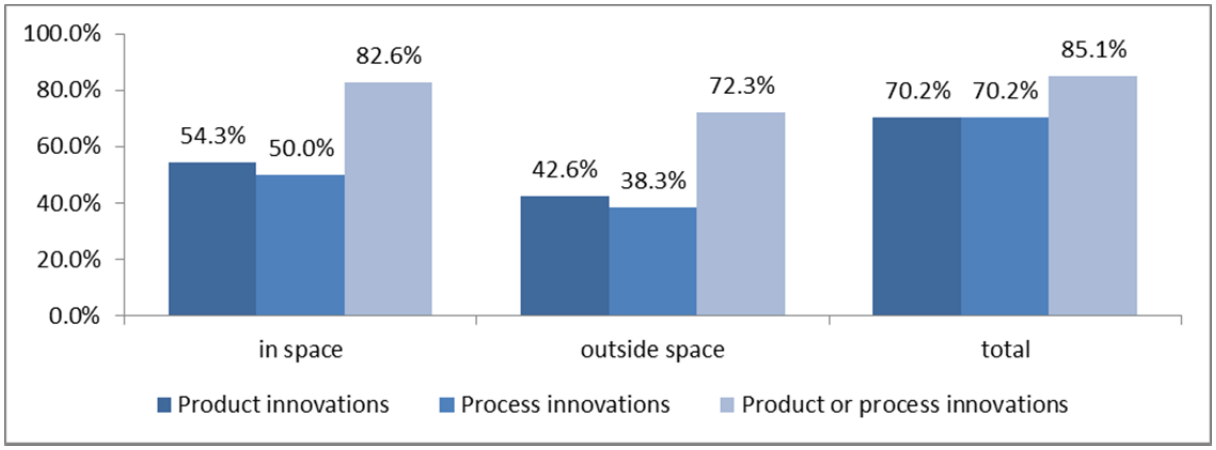
R&D and innovation. The space sector is a very innovative part of the Swiss economy by different indicators:

- More than 90% of the interviewed companies conducted research and development (R&D) activities in Switzerland and, most notably, 84% percent of them continuously and 16% occasionally. Hence, conducting R&D seems to be mandatory for being active in the space sector. In order to compare this to other industries, we use the Swiss innovation survey 2013. This survey referred to the calendar years 2010-2012 and used the same definitions as our survey (see box 1). The most research-driven Swiss industry is the chemical industry where 70% of the Swiss companies answered the question on whether they conducted R&D between 2010 and 2012 with "yes". Hence, the companies active in the space industry more often conduct R&D than the latter industry.
- A good measure for the importance of R&D in a company is its research intensity. Either R&D expenditures or R&D personnel are usually chosen as R&D input indicators, and total sales to market or total employment are used to quantify company size. Taking R&D employees divided by total employees in the space sector, we get an overall R&D intensity of 25% (median value) – i.e. on average 25% of the companies' employees worked in R&D. Limiting this to the companies' space activities only (R&D employees in space activities/employees in space activities) the value grows to 50%; i.e. 50% of the employees working for space worked on R&D tasks. We lack comparable data from the Swiss innovation survey, where only the data

based on R&D expenditure was published. However, according to the most recent waves of this survey the share of R&D expenditures to sales is in the range of 7-10% in the most R&D-intensive industries (Arvanitis, Ley, Seliger, Stucki, & Wörter, 2013; Arvanitis et al., 2014), and considerably lower than in the space sector. Though it certainly influences the results that the indicators draw on different approaches, the finding that the space sector belongs to the most innovative part of the Swiss economy can be confirmed with this innovation input indicator as well.[6]

- More than 50% of the surveyed companies introduced product innovations and almost the same share introduced process innovations (defined as below in box 1) related to their space activities (see Figure 7). Including non-space activities as well, more than 70% of all surveyed companies were product innovators and the same percentage were process innovators between 2012 and 2014. Only seven companies indicated that they had not innovated in this period whereas 85.1% innovated. The indicator confirms again that space sector companies belong to the most innovative Swiss companies: they are on a par with or even more innovative than companies in the vehicle and chemical industries (approximately 80% of all firms introduced innovations according to Arvanitis et al., 2014).

Figure 7: Innovating companies between 2012 and 2014 by type of innovation in % (arithmetic means)



Total: n=47, in space: n=46, outside space: n=47.

Source: FHNW Swiss space sector survey 2014/2015.

Box 1: Definitions of research and innovation indicators (translated from the Swiss innovation survey, Arvanitis et al., 2013)

Research *refers to basic research and research activities with direct relationship to specific applications (applied research).*

Development *refers to the utilisation of established scientific knowledge for producing new or improving existing products and processes.*

[6] International case studies also confirm that the space industry is considerably more R&D intensive than manufacturing as a whole (see OECD, 2014): in Canadian space manufacturing R&D expenditures constituted in 2012 approximately 28% of its GDP (6 times the value for manufacturing) and in Italy approximately 11.5% (8 times the value for manufacturing).

Product innovations *are technically new or significantly improved products from the perspective of your enterprise, i.e. products which are new or significantly improved or changed with regard to their capability of use, quality, or the physical or interactive components employed in their production.*

No product innovations are simple esthetical modifications of products (e.g. colouring, style) and product variations, e.g. because of client specifications which do not change at large the product (good or service) with regard to its technical basics and use characteristics.

Process innovations *refer to the first use of technically new or significantly improved manufacturing or process technologies for producing goods respectively services for persons or objects. Though the product may change as well, raising efficiency is in forefront. New manufacturing technologies developed by you and sold to other enterprises are product innovations. Simple organisational or management changes are not subsumed among process innovations.*

4.3 Institutional space contracts of Swiss organisations

Data on the activities conducted by the Swiss space community was gleaned from 154 filled in questionnaires answered by 18 academic institutions and 31 companies. A total of 98 questionnaires were filled in by companies and 56 by academic institutions. This represents only a small share of approximately 10% of all ESA- or ANC-funded contracts to Swiss organisations (see Table 3 above) and we must assume that the responses are rather a positive selection of all contracts. Note that part of the questions does not cover entire activities, but only the part for which the responding Swiss participant was responsible. Concerning ESA activities, it has to be recalled that most of them are not stand-alone activities, but are (or are aiming at being) integrated in big ESA programmes with many other actors.

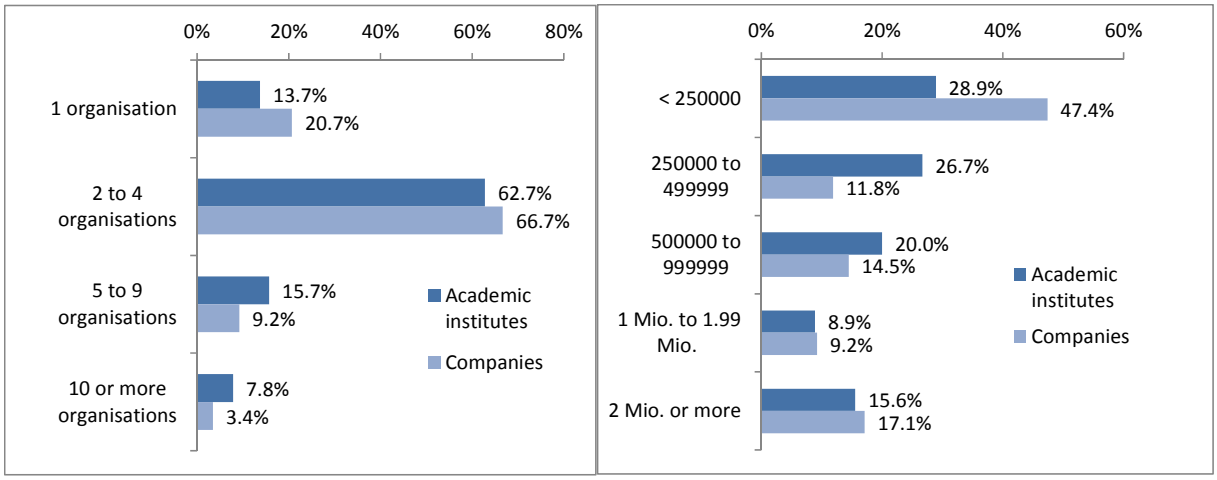
Academic institutes are more often project leaders or partners than enterprises (see Figure 23 the annex). In contrast, a higher share of enterprises than academic institutes served as suppliers/sub-contractors. Not surprisingly players whose main business is space most often act as project leaders and entities who earn less than 5% of their budget through space activities most often participate as sub-contractors in funded projects (see Figure 23 the annex).

The majority of space projects were rather small with up to 4 participating organisations (75% of the projects on which academic respondents reported and 87% of the projects of companies, see Figure 8a) and almost 60% having a volume of less than 500'000 EUR (see Figure 8b). Very small projects are more common among companies which reported that every second project was smaller than 250'000 EUR. Still, there is also a non-negligible share of very large projects with a volume of more than 2 million Euros.

Most of the projects in the sample have been started in the last four years (see Table 16 in the annex). 30% of the projects are still ongoing, most of the completed projects lasted one year. Companies realised more long-lasting projects than academic institutes.

Figure 8a and b: Project sizes by sector of project participants

a) Number of participating organisations b) Total budget (in EUR)

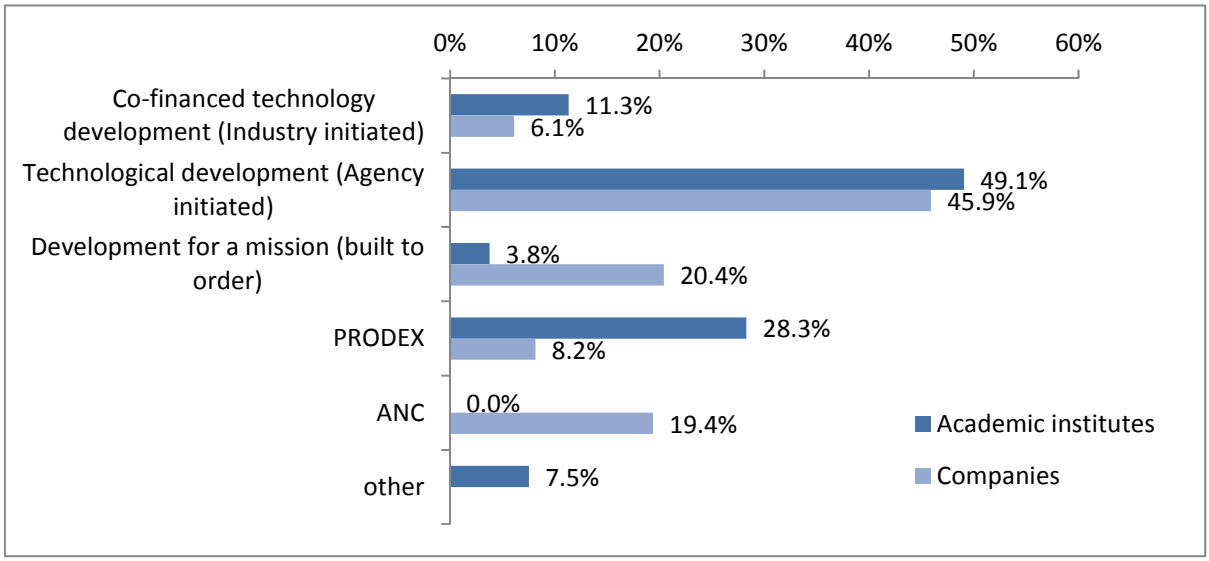


a) Academic institutes n=51, Companies n=87. b) Academic institutes n=45, Companies n=76.

Source: FHNW Swiss space sector survey 2014/2015.

Nearly half the projects were agency-initiated. These technological development projects were equally important for both sectors. Academic institutes additionally were highly involved in PRODEX projects, which were less common for enterprises. Only companies reported on developments for missions and ANC projects (for the latter academic respondents were not surveyed).

Figure 9: Main type of project by sector of respondent



Academic institutes n=53, Companies n=98. Only companies were surveyed on ANC projects.

Source: FHNW Swiss space sector survey 2014/2015.

4.4 Influences on space sector activities

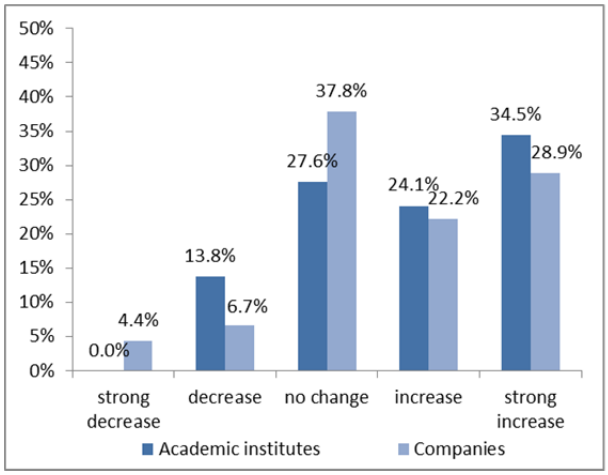
We also included a number of influences on space sector activities in the survey and asked respondents to what extent these influences had a positive or negative impact on their space activities.

4.4.1 Mid-term demand development

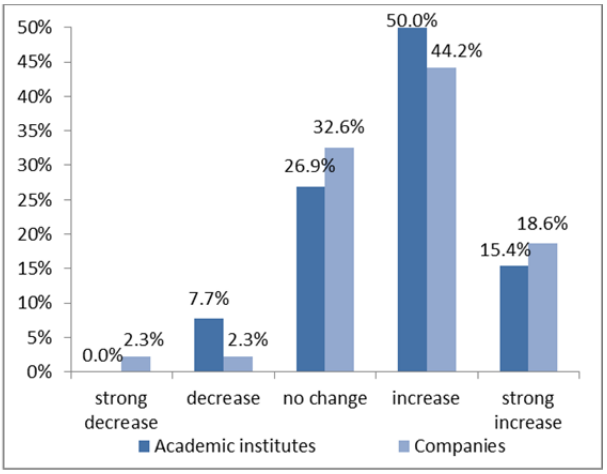
In a first question we assessed the demand in the period 2012-14 and the (expected) future demand development in 2015-17. For both periods, the demand developments are evaluated as rather positive with little difference between corporate and academic respondents. Notably, expectations for 2015-17 are slightly more positive than past developments 2012-14. It should be noted, however, that the majority of interviews was conducted before the Swiss National Bank abolished the minimum exchange rate, and the expectations of export-oriented companies are probably less positive today than they were end of 2014.

Figures 10a and b: Mid-term demand development for space activities

a) Experienced in 2012-14



b) Expectations for 2015-17



2012-14: Academic institutes: n=29, companies: n=45; 2015-17: Academic institutes: n=26, companies: n=43.

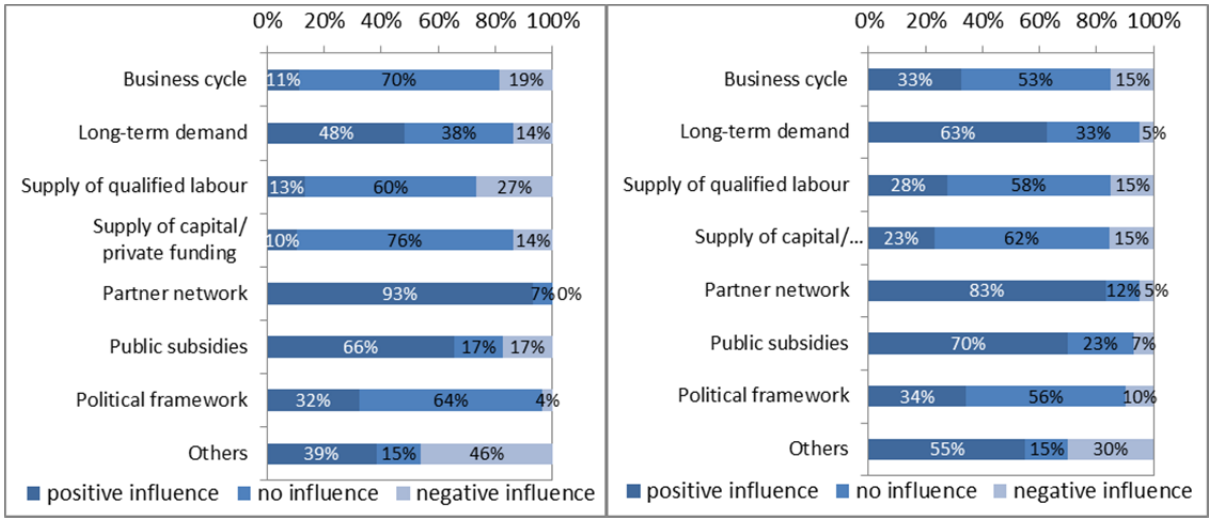
Source: FHNW Swiss space sector survey 2014/2015.

4.4.2 Influences on space activities

Next, we asked companies and academic institutes about eight different influences. We asked them whether these influences had a positive, negative or no influence on their space activities and whether any influence was strong or weak. The central values which split the response distribution in two halves (medians) are shown in the annex (Table 11 and Table 12). The partner networks and public subsidies, not differentiating between funding from cantonal, national or international sources, had a positive influence for both types of institutions (see also Figures 11a & b). Corporate respondents also pointed to a positive influence of long-term demand growth. Having highly qualified employees is a key influence on being successful in space research or industry and in particular academic institutes pointed to problems with filling open positions for qualified staff. Both academic institutes and companies frequently recruit foreign engineers in order to maintain their level of space activities and benefit from their international networks. Raising the share of Swiss employees requires increased efforts in Switzerland to educate and train a sufficient number of qualified personnel. Other issues that were mentioned as influential are: aspects of ESA governance (e.g. decision-making, lobbying of larger countries), the strong Swiss Franc, the reputational benefits of working in the space sector, infrastructure (either positively as an enabler and precondition for doing certain projects, or as restriction, limiting the space activities because of missing lab and office space), relations with EU.

Figures 11a and b: Influences on space activities 2012-14 by sector of the respondent

a) Academic institutes b) Companies



See Table 11 and Table 12 in the annex on the data.
Academic institutes: n≥ 28 (other influences n=13), companies: n≥ 39 (other influences n=20).
Source: FHNW Swiss space sector survey 2014/2015.

4.5 Assessment of funding programmes

Importance of funding programmes. To assess the level of awareness of the different programs at European and national level participants were asked an open question on which programs they found particularly important for their organisation. ESA and EU programmes were mentioned by most respondents. For ESA programmes, the ESTMP 2014 provides an overview of the importance of different programme families for Swiss organisations (European Space Agency, 2014, p. 142): in 2014, Earth Observation received the biggest share of the Swiss contribution to ESA, followed by Science (including PRODEX), Technology/Telecommunication, Launchers, Human Spaceflight/Exploration, and Navigation.

Among the national funding sources academic institutes listed most often SNF followed by the SSO programmes (MdP/ANC), and the CTI. Companies pointed most often to SSO, CTI and SNF, as well, but with a lower priority for SNF. Every fourth enterprise was not aware of any national program.

Application procedure and programme management. We asked respondents how strongly they agree or disagree with statements on the programmes to which the projects on which they reported belonged. This serves to assess the perception of the application procedure and programme management during project execution. For sake of better legibility we reduced the original five-point scales to three-point scales in this report (e.g. "strongly agree" and "agree" were combined to "agree").

For most aspects of the application procedure and programme management the median values are neutral and do not differ between academic and corporate respondents. Respondents do not have a strong positive or negative opinion on the application procedure (see Table 5). Academic institutes slightly more often found that the application resulted in a lot of paper work (see Table 17 and Table 18 in the annex).

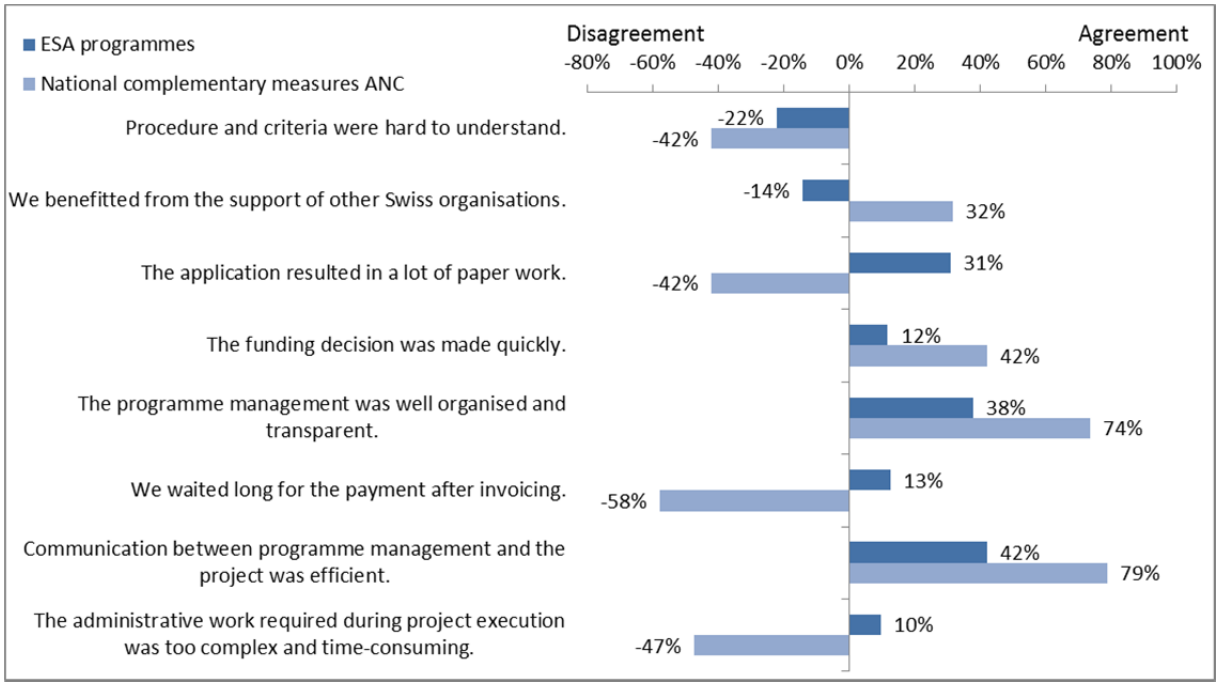
During project execution the majority of respondents experienced an efficient communication with the programme management which itself was mostly judged as being well organised and transparent (see Table 5).

Table 5: Opinions on application procedures and criteria and programme management

	Disagree	Neutral	Agree	Total count	Median
Procedure and criteria were hard to understand.	45%	34%	21%	154	Neutral
We benefitted from the support of other Swiss organisations.	36%	37%	27%	154	Neutral
The application resulted in a lot of paper work.	21%	36%	43%	154	Neutral
The funding decision was made quickly.	23%	38%	39%	154	Neutral
The programme management was well organised and transparent.	15%	28%	57%	154	Agree
We waited long for the payment after invoicing.	29%	38%	33%	154	Neutral
Communication between programme management and the project was efficient.	13%	27%	60%	154	Agree
The administrative work required during project execution was too complex and time-consuming.	31%	36%	33%	154	Neutral

Source: FHNW Swiss space sector survey 2014/2015.

Figure 12: Opinion on application procedure and programme management by programme type (difference between the share which agreed and disagreed in percentage points)



Bars show the range between the share of respondents which agreed and the share of respondents which disagreed to the statement. Negative values stand for a higher share of disagreement than agreement.
ESA programmes: n=135; National complementary measures ANC n=19.

Source: FHNW Swiss space sector survey 2014/2015.

Comparing ESA programmes with the national complementary measures ANC which are administrated by SSO with support from SSC, we get a more positive assessment for the ANC for all questions (see Figure 12). In particular, the application procedure and realisation are less bureaucratic, communication is judged as more efficient and payment terms are more reliable. However, these results have to be understood in the specific context of the funding: ANC projects are stand-alone, aiming to push small pilot activities between industry and academia, while ESA projects are quite often elements of big, multinational and multiannual development programmes

which per se are more complex to implement (but eventually also with considerably larger impacts).

4.6 Challenges in obtaining institutional space contracts and approaches and measures to resolve them

4.6.1 Challenges

One set of questions in the interviews asked respondents about the challenges they encountered in applying for ESA-funding and how they overcame these challenges. In addition, they were asked to suggest measures that could help the Swiss space community to become more successful with ESA applications.

Table 6: Challenges in obtaining ESA contracts

Rank	Academic institutes	Companies
1	Timing	Finances
2	Communication	Administration
3	Finances	Timing
4	Administration	Communication
5	Politics	Politics
6	Finding partners	Authorisation
7	Authorisation	Further challenges
8	PhD students	-
9	Further challenges	-

Note: Academic institutes n=30. Companies n=38.

Source: FHNW Swiss space sector survey 2014/2015.

In terms of *timing* academic institutes most often criticized project cycles. The time available for writing and submitting bids is being considered as too short and it is often followed by an unpredictable waiting period for the funding decision. This causes multiple problems: it prevents bidding for other projects due to eventual resource limitations (in case several bids are won); if the decision time is overtly long, academic staff is without funding which raises job insecurity and eventually even causes job changes or work on other projects out of necessity. This results in staff shortages if the funding decision is positive. It also implies financial losses. Additionally, the project start usually has to follow immediately after the funding decision has been made. All in all, an efficient task and resource planning and management are made nearly impossible. Schedules and the achievement of milestones have often been described as overambitious during project realisation. For companies timing also posed a challenge though it was mentioned slightly less often than in the academic sector. The difficulty of being available on short notice was often mentioned. The short-term availability of resources for writing bids and starting projects also pose challenges for the surveyed companies. Also frequent and short-term changes, e.g. in the form of additional requirements, are being considered as very challenging. The projects are generally subject to significant time pressure, while at the same time proposal plans are hardly followed. Resource planning and management poses a challenge for enterprises as well.

Financial issues. Probably the most challenging problem for companies is delays of payments. Several companies complained of advance work to ESA which can put severe cash flow constraints on the company. Additionally, due to project milestones the partial payments are a planning risk as well. The devaluation of the Euro and delayed payments generated financial problems for the funded academic institutes and companies as well. ESA projects and budgets for

certain programmes and topic areas fluctuate which makes planning for academic and corporate entities more difficult. Some SMEs struggle with the high costs of writing ESA proposals. Very specialized companies also mentioned difficulties in the pricing of tailor-made products. Some enterprises regret that they have no access to science funding from SNF.

Above all academic institutes described settings with *indirect communication* as challenging; this can refer to communication with ESA via project partners, but also with project partners or clients outside of Europe via ESA – the higher the number of players involved in projects the more complex the communication gets and the higher the overhead that it generates. It comes with little surprise that finding the right information and the person in charge of certain topics also raised the challenges of obtaining ESA contracts for enterprises as well as for academic institutes. Additionally, changing priorities over time as well as decision making processes at ESA which are sometimes perceived as being tedious are considered as troublesome. Moreover, presenting the technology in an understandable language to ESA experts and convincing them of industrial standards is being described as not easy. Several respondents praised the ESA personnel for its technological knowledge and competences; however they wish that economic aspects of the development and provision of technology would be given higher attention. Different respondents also pointed out that they perceived a more open and comprehensive information policy on ESA matters in other ESA member countries than in Switzerland; however, it was also stated that this has improved in recent years.

The writing of bids was described by academic institutions as a highly *administrative* task which is more complicated than for SNF or CTI proposals, e.g. with regard to demonstrating the necessary knowledge and capability to deliver the promised results. The amount of paperwork was mentioned often as a cause for a large overhead (see above). Companies often pointed to the long and intense procurement procedure. The complexity and workload of project administration compared to project size and output were criticized as well as a perceived growth of ESA rules and requirements.

For academic institutes, *politics* plays an important role. Some actors' perception is that other countries apply more pressure on ESA compared to Switzerland. Several enterprises feel that the political dimension plays a more important role than the commercial one in ESA decisions and that in international competitions political power of the country seems to play an important role in the funding decisions. In terms of partnerships some seem to have difficulties of finding partners or feel disadvantaged compared to the prime contractors which enter proposals as standing consortia.

Authorisation questions such as liability or Intellectual Property ownership are usually dealt with by applying the General Terms and Conditions of ESA. This was considered as considerable administrative "overkill" and raised many questions and insecurity in academic institutions and companies. Following the compliance rules of ESA contracts was also perceived as challenging. One academic respondent commented: "We sign the contracts blindly." Additionally, distinct export and customs regulations in Switzerland and the EU cause delays and raise costs.

Academic institutes face further challenges such as the employment of PhD students. ESA projects are seen as an opportunity for PhD students; however, due to the uncertainty of time and budget, it is a risk for the students as well as the academic institute to depend on ESA funding. For small enterprises the dependency on ESA projects is very large and thus a weakness among others due to the project cycles. Several respondents mentioned "that you already need to be an expert" before you stand a chance of winning a bid.

Six academic institutes and three companies reported that they never had any challenges in obtaining an ESA and/or Swiss contract.

4.6.2 Dealing with challenges

Respondents were also asked about their *approach to overcome* the above mentioned challenges. Networking and maintaining contacts to ESA were described as essential in order to overcome these challenges and gain access to an ESA contract by academic institutes (n=19). Building collaborations and partnerships refers to the mobilisation of external resources which is also necessary for being successful. Being well informed and knowing the rules and guidelines of ESA is essential. Previous experiences with ESA projects considerably raise chances to win a bid which underlines the importance of "space heritage" and the difficulties encountered above all by new players when trying to enter the space community. Trial and error is seen as another solution to overcome challenges. Respondents also describe having a specialized team ready with the necessary competencies as a plus. In terms of finances, academic institutes cross-fund and complement ESA projects with co-funding from other sources.

Enterprises (n=32) – just like academic institutes – pointed to networking and lobbying as the main measures to overcome challenges. At some point being pushy and persistent also contributes to success. Another tactic is described in creating a stand-by situation in order to be ready as soon as the bid is tendered. Gradually gaining experience with ESA contracts and proving one's competencies with small contributions was described as an approach to incrementally build up reputation within ESA. Forming collaborations with other, more experienced partners, being highly innovative and at the same time specialized also contributed to success. In terms of finances, enterprises are also focusing on internal process optimization (salaries, production costs, location). Four enterprises stated that they had found insurmountable problems in the application process and had abandoned projects.

4.6.3 Changes of ESA or national funding policies since 2010

We asked in the interviews for changes of ESA or national funding policies since 2010 which had an impact on the organisation.

Half of the academic institutes (n=25) perceived an increase of administration and also in competition with regard to ESA funding. However, an increase of transparency was also mentioned. Others describe the funding policies as stable. The availability of the national complementary measures and Calls for Ideas were mentioned positively. Five respondents reported no changes.

Compared to the academic institutes the enterprises (n=31) answered with a stronger focus on national funding policies. The work of SSO and of the Swiss Space Center (SSC) has improved from the enterprises' perspectives. The access to SSO and to information in general is described as more open. The interviewees also made comments in favour of the national complementary funding and the perceived focus on niches (Swiss Space Implementation Plan) and smaller players. At ESA level, an increase of administration and higher influence of the EU is described as a challenge. Respondents reported increasing delays in financial payments and a higher risk aversion which also contributes to more administration.. Twelve respondents reported no changes.

4.7 Goal attainment and outputs of space projects

Another section of the project questionnaires asked questions on

(1) Goal attainment or effectiveness of the projects,

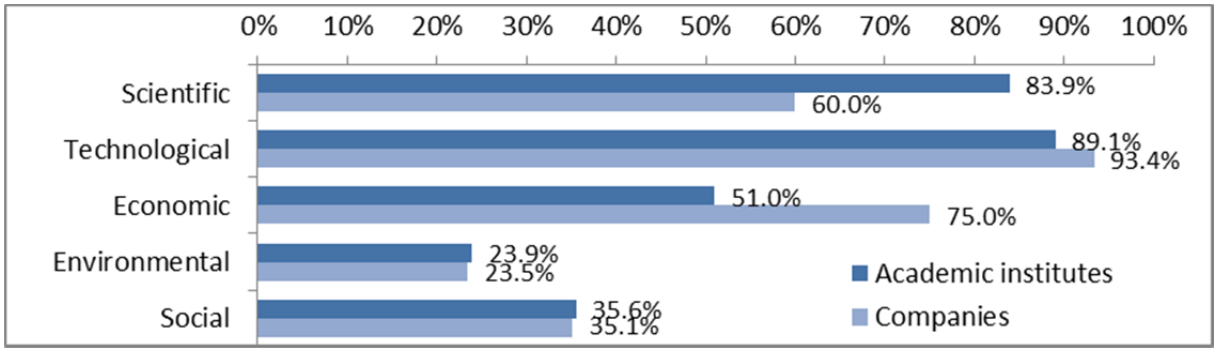
(2) outputs generated by the projects,

(3) and project additionality.

4.7.1 Goal attainment or effectiveness of the projects

Almost all academic and corporate respondents saw technological goals in the ESA projects on which they reported; more than 80% of the academics also perceived scientific goals and three quarter of the surveyed firms perceived economic goals in "their" ESA projects (see Figure 24). Environmental and social goals were mostly irrelevant.

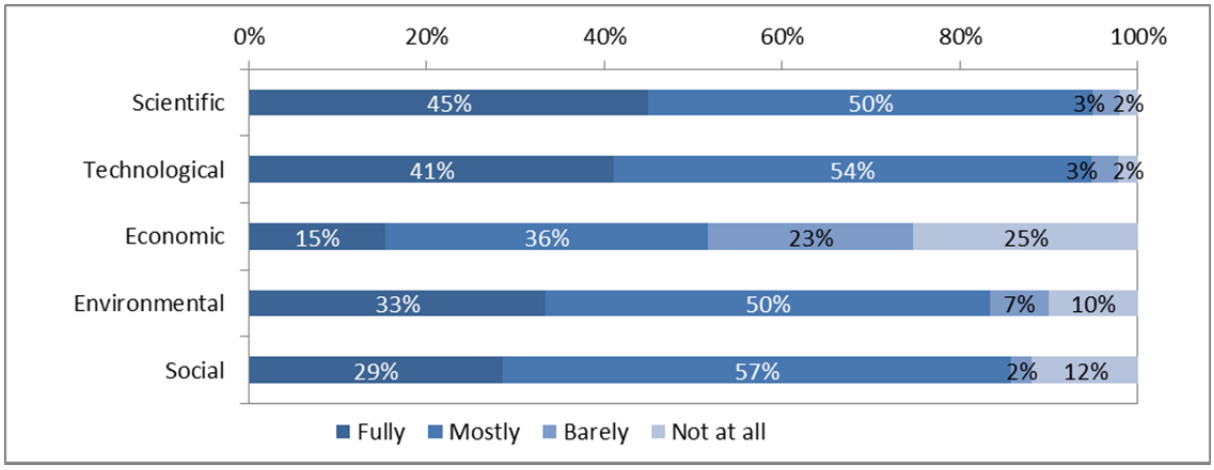
Figure 13: Percentage of projects for which the specific goal was applicable by sector



Academic institutes: n≥ 45, companies: n≥ 74.

Source: FHNW Swiss space sector survey 2014/2015.

Figure 14: Projects by type of goals and level of goal attainment (in %)



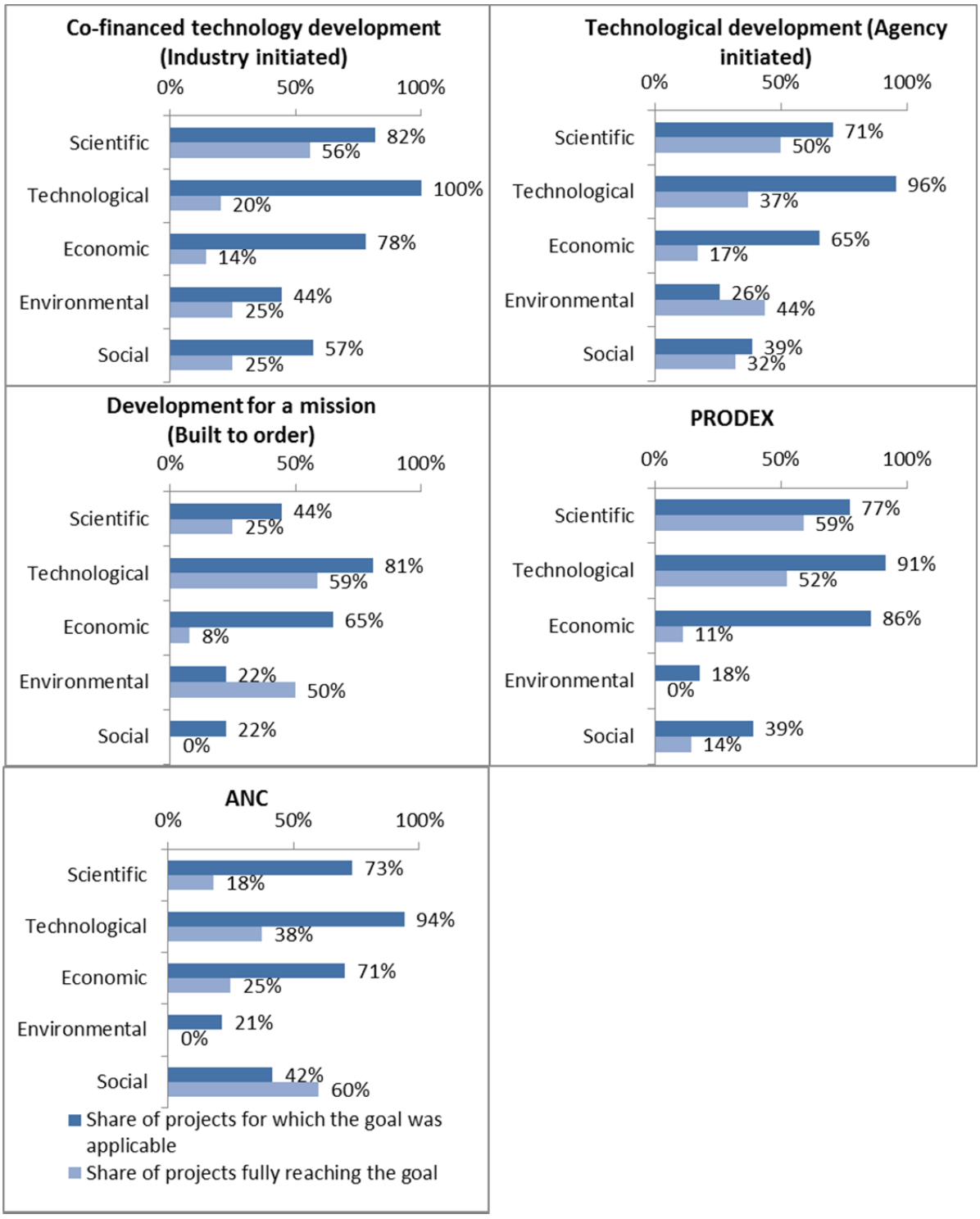
Scientific n=98, technological n=134, economic n=91, environmental n=30, social n=42.

Source: FHNW Swiss space sector survey 2014/2015.

In addition to their mere existence, we requested information on the attainment of certain goals. Overall, goal attainment was rather high and quite similar from the perspective of academic and corporate respondents (see Figure 14 below and Figure 24 in the annex). Economic goals were the exception, as almost 50% of the projects (for academic institutes even the majority) reached the economic goals only barely or not at all. We do not know which economic goals were pursued

by the projects (and project participants) and why they were not reached in the view of the respondents, but overall this suggests a more critical opinion towards short-term economic results; economic results rather materialized mid- to long-term and after the funded projects had ended (see Table 10, p. 38).

Figure 15: Percentage of projects for which a goal type was applicable and which fully reached the goals by project type



Source: FHNW Swiss space sector survey 2014/2015.

One might suspect different *project types* to have different goals, e.g. *technological development* projects might not have to fulfil economic goals. Figure 15 shows that *industry initiated* projects in general aim for a higher number of goals than the other project types. However, they do not fare so well with regard to fully reaching these goals, in particular the technological and economic goals are often not fully reached. Technological development projects are less ambitious (fewer goals), but they fully reach their goals slightly more often. Respondents found that 86% of the *PRODEX*-projects pursued also economic goals, however only 11% of these projects also fully attained the economic goals. PRODEX-projects fare considerably better with regard to the attainment of scientific and technological goals. *Built to order* projects mainly pursue technological goals and they also reach these more often than the other project types. All other goals are less common among this type of projects. In *ANC* projects, goal achievement was above average for social and economic goals but below average for scientific goals. Environmental goals were not fully reached by any *PRODEX* or *ANC* project, however, n are fairly low for this type of goals and results should be considered with caution.

Multiple goals are very common in the space sector. Over 60% of the projects wanted to reach at least three of the specified goals. The more goals a project seeks to achieve the lower is the level of complete goal achievement. For instance, projects with only one goal reach this goal in 100% of cases, whereas merely 40% of the projects with four goals also reach these goals. Still, projects reach more goals when they have set more goals. There might also be a critical mass of goals; 13% of the projects with five goals did not achieve any of the goals (see Table 7).

Table 7: Multiple goals and goal achievement

		% of all projects	Number of achieved goals (fully or mostly)					
		Total	0	1	2	3	4	5
Number of applicable goals	1	14%	0%	100%	-	-	-	-
	2	26%	6%	19%	75%	-	-	-
	3	36%	2%	4%	29%	65%	-	-
	4	14%	0%	0%	26%	32%	42%	-
	5	11%	13%	0%	0%	7%	40%	40%
	Total	100%	4%	20%	34%	29%	10%	4%

Source: FHNW Swiss space sector survey 2014/2015.

Table 8: Simultaneous goal achievement (fully or mostly)

	Scientific	Technological	Economic	Environmental	Social
Scientific (n=93)	100%	92%	39%	18%	27%
Technological (n=127)	68%	100%	36%	20%	26%
Economic (n=47)	77%	98%	100%	19%	34%
Environmental (n=25)	68%	100%	36%	100%	72%
Social (n=36)	69%	92%	44%	50%	100%

Percentages refer to the total number of projects which achieved the goal in the rows; e.g. 92% of the projects which achieved their scientific goal also achieved their technological goal.

Source: FHNW Swiss space sector survey 2014/2015.

It is also of interest to see which type of goals is likely to be attained jointly. Table 8 shows the percentage of jointly achieved goals as a share of the total number of projects which achieved the other goal (row wise). For instance, 92% of the projects which had a scientific goal and reached this goal also reached their technological goal. Whatever goal a project attains, it is also very likely that it reaches its technological goals; for instance, if a project reached its economic goals it is virtually given that it also reached its technological goals (98%) (and less probable that scien-

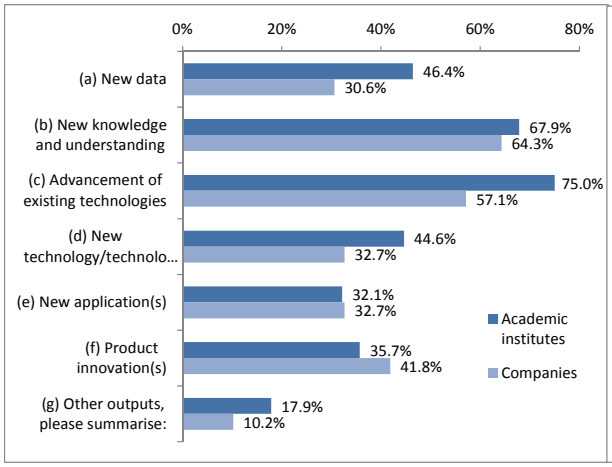
tific goals were reached as well). But no matter which other goals are achieved, only in 4 out of 10 projects the economic goal is simultaneously achieved (see Table 8).

4.7.2 Outputs generated by the projects

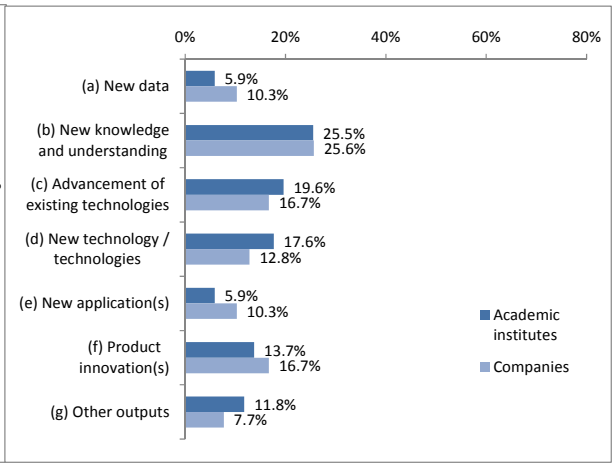
We asked for seven possible project outputs which could of course appear in combination (multiple responses): New data, new knowledge and understanding, advancement of existing technologies, new technologies, new applications, product innovations, and other output. For both, academic and corporate respondents, the most common project outputs were new knowledge and the advancement of existing technologies. Most other output categories were more or less equally likely generated except for new data, which more often resulted from the projects on which academic institutes reported (see Figure 16a). Additionally the questionnaire asked for the main output of a project. In both sectors, new knowledge was most often the main output followed by the advancement of existing technologies (see Figure 16b).

Figure 16a and b: Resulting project outputs

a) Resulting outputs (multiple responses)



b) Main output (single response, all outputs=100%)



Academic institutes n=56, companies n=98.

Source: FHNW Swiss space sector survey 2014/2015.

Box 2: Technology Readiness Levels (TRLs)

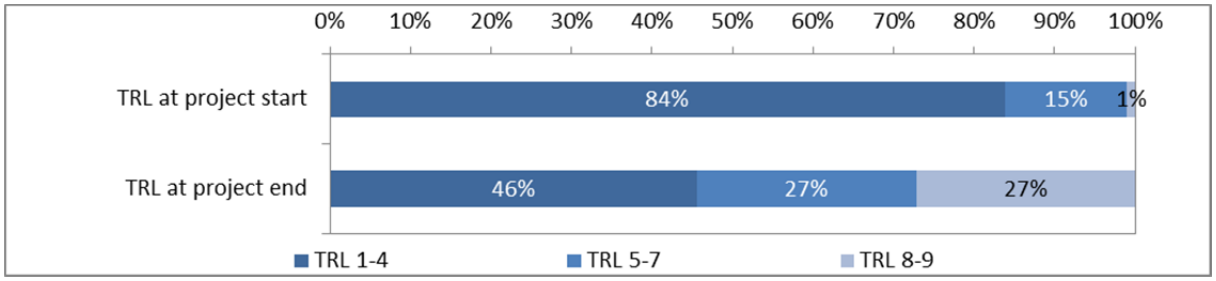
TRLs are a set of management metrics that enable the assessment of the maturity of a particular technology and the consistent comparison of maturity between different types of technology - all in the context of a specific system, application and operational environment.

Level	***Definition***	***Engineering/R&D Terms***
TRL 1	*Basic principles observed and reported*	*Scientific research*
TRL 2	*Technology concept and/ or application formulated*	*Systems analyses, Pre-phase A studies*
TRL 3	*Analytical and experimental critical function and/or characteristic proof-of-concept*	*Laboratory experiments*
TRL 4	*Component and/or breadboard validation in laboratory environment*	*Component, breadboard*
TRL 5	*Component and/or breadboard validation in relevant environment*	*High-fidelity breadboard, brassboard, engineering breadboard, function-oriented model*

TRL 6	*System/subsystem model or prototype demonstration in a relevant environment (ground or space)*	*High-fidelity lab prototype, engineering qualification model, subsystem model, development model, system model*
TRL 7	*System prototype demonstration in a space environment*	*System demonstration*
TRL 8	*System completed and "flight qualified" through test and demonstration (ground or space)*	*Theoretical first unit, flight unit, flight spare*
TRL 9	*Actual system "flight proven" through successful mission operations*	*Mission operations, flight qualified hardware*

We also asked the respondents about the technology readiness levels (TRLs) of the technologies at project start and at project end (see Box 2 on the definitions of TRLs). Figure 17 shows that the distribution of TRL levels in funded space projects significantly differs between project start and end. Funding contributed to reaching TRL levels 8-9 which were literally inexistent at project start.

Figure 17: TRL-levels of projects at start and end (in % of all projects)



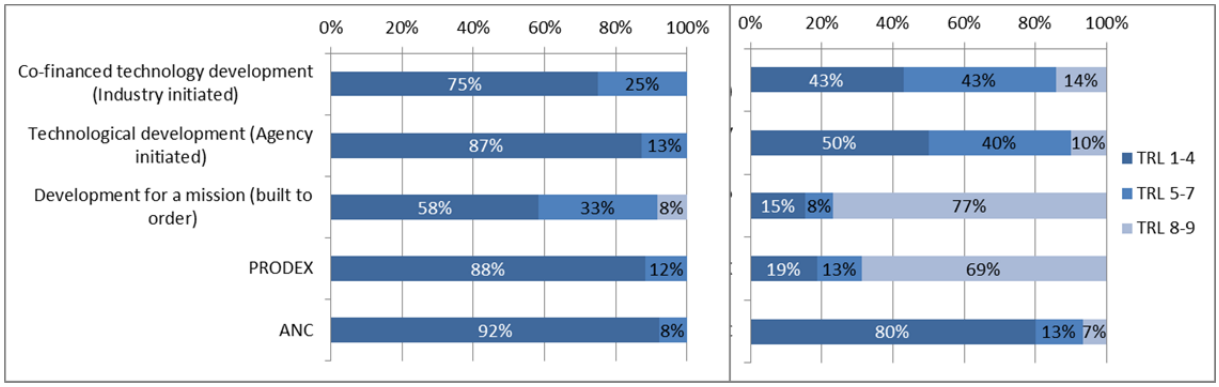
Project start n=99, project end n=103.

Source: FHNW Swiss space sector survey 2014/2015.

No real difference between the TRLs in projects of academic institutes and enterprises at project start and end appears (see Table 19 in the annex). Given their different missions and responsibilities this might come as a surprise, as we might essentially expect that research institutes focus on the lower TRLs and companies on the higher TRLs. However, this result might also be due to the specific focus of the funding and the resulting rules and requirements of project selection (which resonates with one of the criticisms to ESA funding mentioned in the expert interviews, see section 3.3, p. 15ff.). Partly this can be unveiled through differentiating the development of TRL levels by project type (see Figure 18). Built to Order and PRODEX projects most advance technologies, but also for industry-initiated and agency-initiated projects we see some technological progress. ANC projects, which in our sample were only reported by companies, mostly remained at TRL levels 1-4; however, it should be noted that the aim of this programme is to build up scientific and technological competences related to space activities and reaching TRLs 3-4 starting at lower TRLs.

Figure 18: Percentage of projects with TRL-level at...

a) … project start b) … project end



Industry initiated: n=7, agency initiated n=47, built to order: n=12, PRODEX: n=16, ANC: n=13.

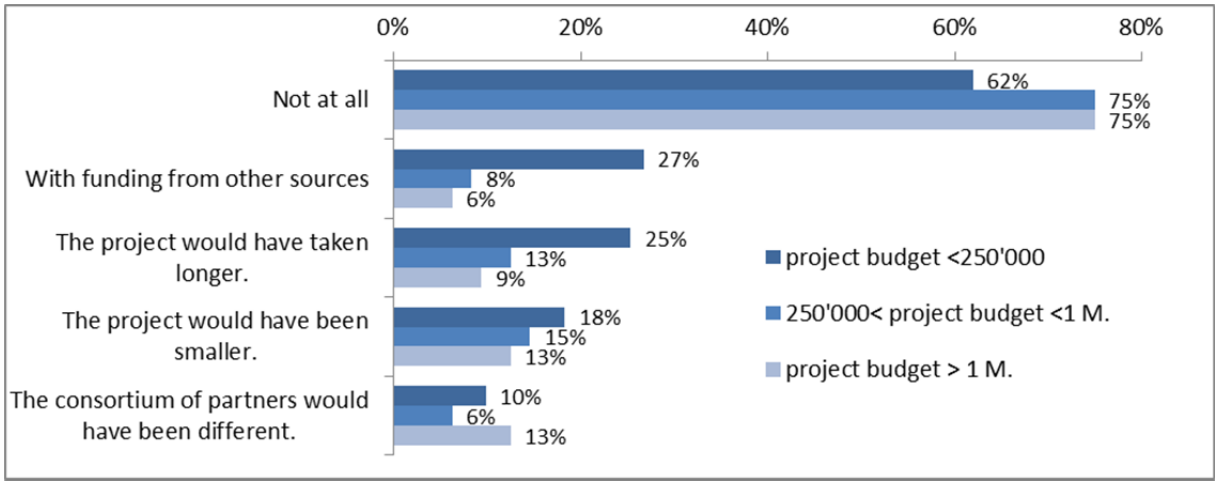
Source: FHNW Swiss space sector survey 2014/2015.

4.7.3 Project additionality

In order to get a better understanding of whether the projects mobilised additional inputs and produced additional outputs, which would not have been obtained without the funding, we asked hypothetical questions on whether and how the respondents would have realised the projects without public funding.

Most of the projects relied strongly on public funding from ESA and the Swiss Space Office: 70% would not have been realised without it. Only one out of six projects either would have possibly been realised with funding from other sources, would have taken longer to carry out, or would have been smaller. In one out of ten the respondents think that the consortium of partners would have been different without the funding. The differences between projects on which academic institutes reported and projects on which companies reported are negligible (see Figure 25 in the annex) and they are not clear-cut if we differentiate organisations by the importance of the space business (see annex Figure 26).

Figure 19: Realisation of project without public funding by project volume in Euro



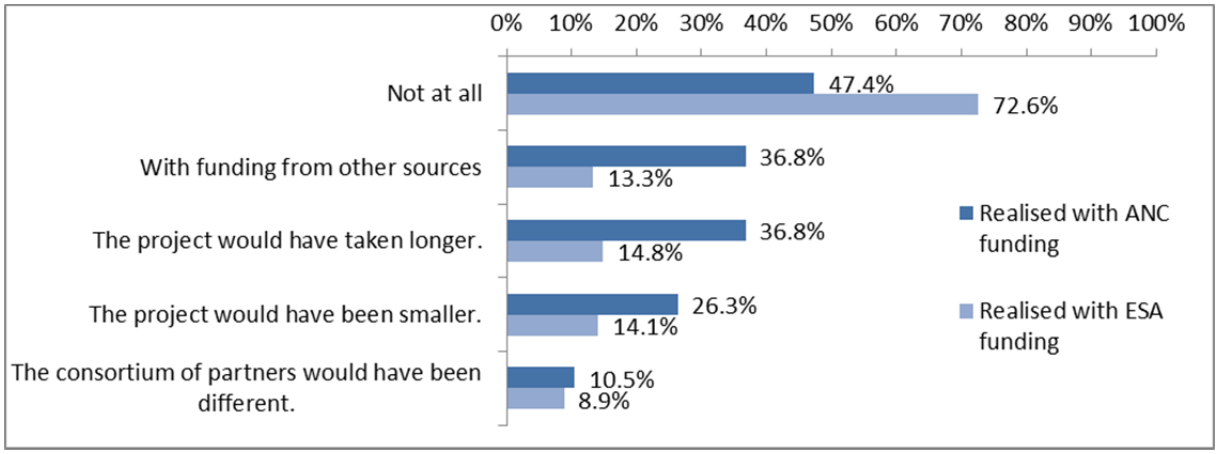
Note: <250'000: n=71; 250'000 - 1 M.: n=48; > 1 M.: n=32.

Source: FHNW Swiss space sector survey 2014/2015.

Additionality by project size. Differentiating by project size we find that three quarter of all projects with a budget larger than 250'000 Euros would not have been realised without ESA funding – in small projects (with a budget of less than 250'000 Euros) this would have been only two third of the projects. Additionally, one quarter of the small projects would have been funded by other sources. The larger projects are, the lower respondents perceive the chances of realising it without the public funding and a different size, duration and funding configuration (see Figure 19).

Additionality by project type. For ANC projects we note considerably more often than for ESA-funded projects that other funding alternatives or project set-ups would have been possible (see Figure 20).

Figure 20: Realisation of project without public funding by type of project



Realised with ESA funding n=135; realised with ANC funding n=19.

Source: FHNW Swiss space sector survey 2014/2015.

All in all, additionality is slightly higher and windfall effects are **less** likely for ESA projects than for ANC projects and the larger projects get.

4.8 Outcomes of space-related activities

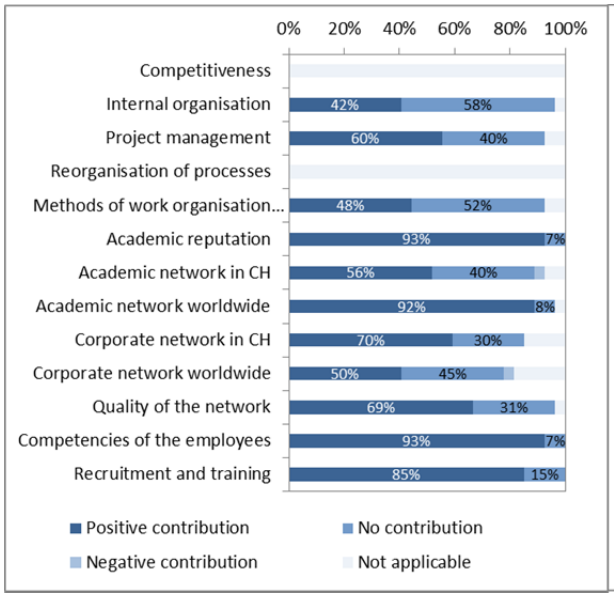
4.8.1 Organisation-related outcomes of space-funding

In the organisation-related interviews companies and research institutes were asked whether the space funding contributed to different outcomes: describing the internal organisation of the funded organisations, their competitiveness, reputation, networks and competencies. The contribution could be positive or negative (or non-existent) and strong or weak. Most items were put to both, research institutes and companies, except for competitiveness and introduction of new organisational procedures which were only asked to companies and academic reputation which was only assessed for academic institutions.

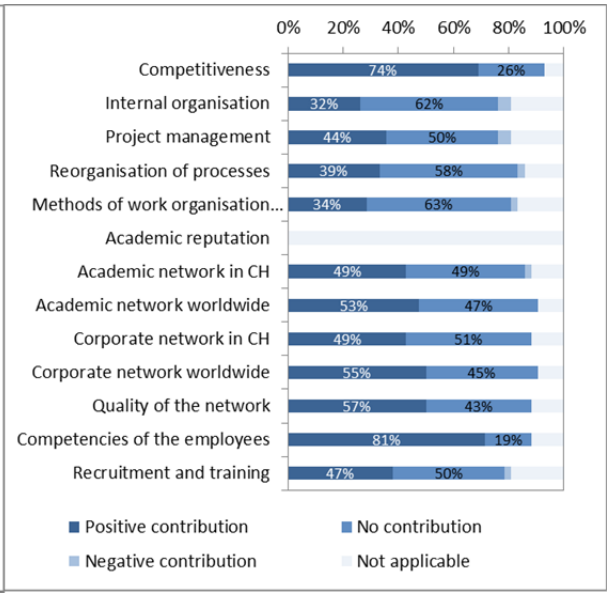
Looking only at the share of respondents in each sector that made a positive assessment (see Table 13 and Table 14 in the annex and Figures 21a and b), we find generally a more positive assessment of the funding among research institutes: more than 80% of the academic respondents assessed the contribution to academic reputation, the size of the global academic network, employees' competencies, and the recruitment and training of staff as positive. The ESA/ANC projects had among academic institutes rather little impact on the internal organisation, organisation of work, and size of the global corporate network.

Figures 21a and b: Organisation-related outcomes of ESA/ANC projects by sector

a) Academic institutes



b) Companies



See Table 13 and Table 14 in the annex on the data.
Academic institutes: n≥ 22, companies: n≥ 34.

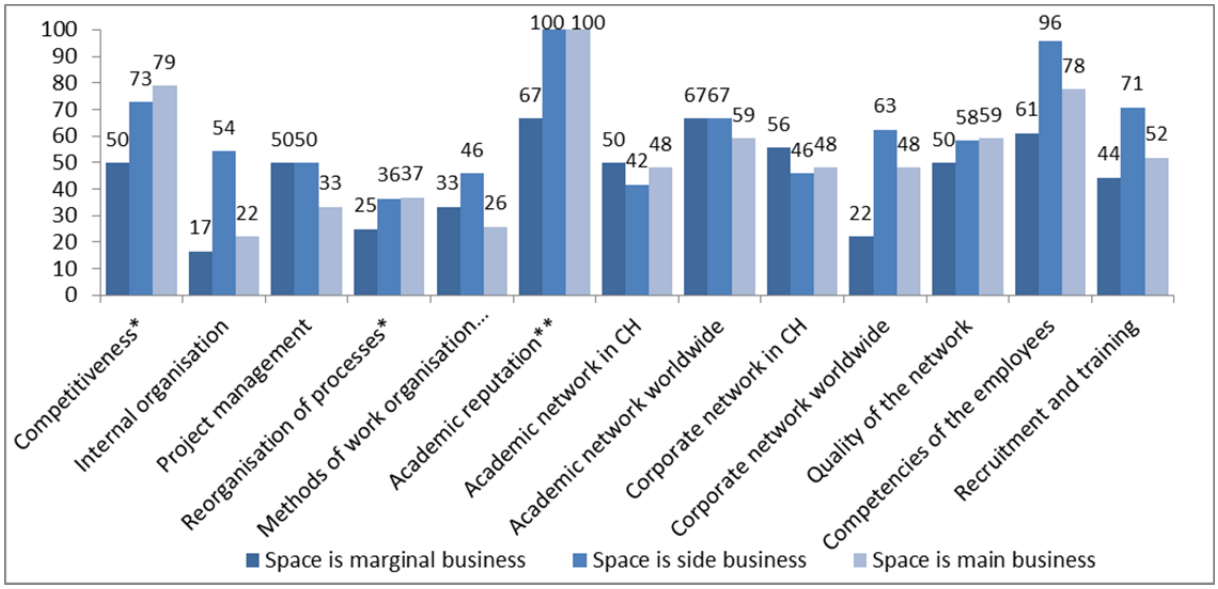
Source: FHNW Swiss space sector survey 2014/2015.

Among companies the influence on competitiveness and also on competencies were evaluated as positively by three out of four of the respondents; for companies little effects resulted on the internal set-up, be it internal organisation, project management practices, process reorganisation, or work organisation and decision-making.

In an open-ended question we also gave the respondents the opportunity to express their view on any additional outcomes of ESA/ANC projects on their organisations. Many respondents pointed to the positive effects on the reputation of their organisation resulting from the institutional space projects. They attract good employees and contribute to developing other funding/business (see Table 15 in the annex).

We would expect that outcomes of the funding are more pronounced the more organisations are committed to space activities. Figure 22 shows this is not generally the case. Some internal outcomes, in particular changes of the internal organisation, new methods of work organisation and decision-making, growing competencies of employees, and better recruitment and training of new staff as well as (positive) effects on the global linkages to companies are more common among companies for which the space business is (just) a side business that contributes less than a quarter (but more than 5%) to sales/funding. How can this be explained? A few suggestions result from the interviews: 1) Companies very involved in the institutional space business frequently stated that they are organised in a way that makes this business possible; they rejected a particular contribution of the funding in this regard, stating at the same time that their business models are shaped according to the ESA business; 2) Organisations from both sectors of the space community stated that even at European level the space business depends on rather few players; after having been involved in a few projects it is not so likely to further extend one's network.

Figure 22: Positive organisation-related outcomes of ESA/ANC projects by importance of space activities for the organisation (in % of all responding organisations)



* Only asked to companies; ** only asked to academic organisations. Space is marginal business: n=18 (*n=12; **n=6); space is side business: n=24 (*n=11; **n=13); space is main business: n=27 (*n=19; **n=8).

Source: FHNW Swiss space sector survey 2014/2015.

4.8.2 Academic, technological and economic outcomes of funded space-projects

In a similar set-up, the project questionnaires contained questions on different academic, technological (product innovations, process innovations, patents) and commercial outcomes (such as volume and diversification of sales, cost reductions). Most items were put to both, research institutes and companies, except for scientific publications, academic theses and academic education offers, which were only asked to academic institutes. The contribution of the public space funding to academic outcomes, measured as academic scientific publications and academic theses, was mostly rated as positive; for academic education offers it was as often considered as relevant as not (see Table 9).

Table 9: Generation of or contribution to academic outcomes of funded projects

		Negative contribution	No contribution	Positive contribution	Median	Not applicable	Total
Academic institutes	Scientific publications	0%	7%	93%	Positive	3	54
	Academic theses (e.g. PhD, MSc)	0%	38%	63%	Positive	4	53
	Academic education offers (courses, programmes)	0%	53%	47%	No contribution	7	53

Percentages only refer to cases where the outcome was rated as applicable.

Source: FHNW Swiss space sector survey 2014/2015.

The funded projects contributed above all to technological outcomes, in particular product innovations on space markets (five out of six projects agreed to this, see Table 10). Only patents or other Intellectual Property Rights resulted in few projects. With regard to commercial outcomes we also often see a positive contribution of the institutional space projects to sales on space-related markets, a diversification of clients and of target markets.

Table 10: Contributions to technological and economic outcomes of funded projects (in %)

	Negative contribution	No contribution	Positive contribution	Median	Not applicable	Total
Product innovations for space-related markets	0%	15%	84%	Positive	17	150
Product innovations for non-space markets	2%	36%	62%	Positive	34	150
Process innovations	2%	34%	64%	Positive	32	149
Patents or other Intellectual Property Rights	2%	78%	20%	No cont.	44	150
Sales on space-related markets	1%	38%	61%	Positive	45	150
Sales on non-space markets	0%	64%	36%	No cont.	58	150
Diversification of clients	0%	42%	58%	Positive	41	148
Diversification of target markets	1%	43%	56%	Positive	40	148
Cost reductions of space activities	4%	69%	27%	No cont.	52	150
Cost reductions of non-space activities	2%	82%	15%	No cont.	65	150

Percentages only refer to cases where the outcome was rated as applicable.

Source: FHNW Swiss space sector survey 2014/2015.

The picture does not vary fundamentally if we distinguish between academic and corporate respondents. For technological outcomes there is virtually no difference between both sectors (see Table 20 in the annex). We find that commercial outcomes are not applicable for half of projects on which academic institutes reported (see Table 21 in the annex). If commercial outcomes were relevant, the funding in few cases contributed to reaching these outcomes. In companies, the average funded space project contributed positively to the following outcomes: sales on space-related markets, the diversification of clients and of target markets. There was no contribution to the sales on non-space markets and to cost reductions neither of space nor of non-space activities. The contribution to outcomes did not differ systematically from the overall results for the following classifications/variables (results are therefore not shown in the report): TRL-level classes, programme families, project size (budget), project type and main business of the organisation.

4.9 SWOT analysis

Academic institutions (see annex Table 22) and companies (see annex Table 23) share similar future outlooks in terms of internal strengths and weaknesses and external opportunities and threats (SWOT).

While academic institutions describe their high expertise as the strongest asset followed by being a niche player and their good reputation, enterprises perceive their networks, strong expertise and their skilled employees as major internal strengths. Additionally, enterprises judge their flexibility as a particular strength which echoes the rather small average size of the companies in the Swiss space industry. In terms of weaknesses, both organization types fear that too few employees (academic) or being a small organization (companies) are disadvantages in the space market. Another major weakness that concerns especially academic institutes is the dependence on individuals and the risk of losing qualified staff. For enterprises, missing access to key ESA or other industry decision-makers and liquidity constraints are key weaknesses (see also section 4.6 above).

In terms of external opportunities academic institutes foresee an increasing demand for their knowledge, competencies and technologies. Privatization and commercialization of the space business are also considered as opportunities. Threats are identified in uncertain funding policies, the political environment (e.g., Masseneinwanderungsinitiative), and fluctuating demand. For enterprises the largest opportunities are also seen in growing markets plus privatization and com-

mercialization; four corporate respondents connected strong opportunities with advancing from made-to-order to serial production. Enterprises described the exchange rate Swiss Franc/Euro as a key threat - mostly already before the recent abolition of the minimum exchange rate by the Swiss National Bank. In addition, Switzerland's status outside the EU is considered by some respondents as a danger for their space activities. The economic as well as the political environment can also pose threats to enterprises.

5. Summary and conclusions

5.1 Relevance, effectiveness and effects of the space-related funding

The terms of reference suggested that this evaluation of Swiss/ESA space-related funding focuses on three key aspects:

1. *Relevance, consistency and coherence* of the instruments and their implementation rules,
2. *Effectiveness*, referring to the degree of goal attainment,
3. *Effects*, distinguishing between type of effects, beneficiaries, sustainability and additionality of the funding.

The following section will summarise the findings of the analysis with regard to these three constructs and give recommendations which can help to further develop the strengths of the funding, fill some gaps and further improve the impact of the funding.

5.1.1 Relevance, consistency and coherence

This section discusses 1) the relevance of the funding with regard to the needs of the Swiss space sector; 2) coherence and complementarity of the ESA and national space-related support (internal consistency); and 3) coherence and synergies with other Swiss national institutions, actors or funding instruments (external consistency).

Relevance

We consider the overall positive response on the influence of public funding on space activities, the confirmed relevance of the funding approach, the positive results of the supported projects, the high level of technological goal achievement, and the stated input additionality – the funding supports mostly projects which would not be conducted at all or at least at very different scale – as proofs for the general relevance of the space funding and the need to continue it. It should be noted that 7 out of 10 projects would not have been realized without the contribution from ESA programs or the national complementary measures.

In addition, certain funding schemes introduced more recently – at national level the complementary national measures (ANC), at ESA level a PhD funding scheme and framework contracts for laboratory support – were mentioned as functional for specific needs. With regard to the ANC two different opinions came to light: on the one hand the ANC were described as functional to increase the stability of funding for the space sector, given the fluctuations and insecurities inherent to ESA funding. They are a good measure, too, to promote national interests at low TRLs. On the other hand, it was criticized that they focus on low TRLs only. One interviewed expert stressed

that funding would be needed as well for higher TRLs and the commercialization and conversion of developed technologies into products.

With our Recommendation 1 we endorse the recommendation "Continue investing in space activities" made in the previous Evaluation of Switzerland's Investments in Space Activities (Balthasar, Inauen, & Walker, 2011).

At the same time, it seems that certain areas require more attention to ensure Switzerland's long-term success in the space sector. It needs to be secured that new technological opportunities are not ignored because of a (too) strong focus on existing technologies and players.

> *"Companies will always try to make the maximum use of their technologies and products and not push for the best or most innovative solution. So this type of projects can be adverse to innovation. For some technologies we have come to the point that the academic work is completed, but no company wants to pick up the technology and we cannot commercialize it, we "put it in the freeze" so to say and go to the next technology." (Academic interview AF134)*

Several interview partners openly stated that they see little benefit in making access to ESA/national space-funding easier for new players as long as the "overall cake" does not grow. Still, some interview partners pointed to the ongoing transformation of our understanding of space and the merger between space and aerospace with new flight technologies for altitudes below low earth orbit. Others stressed that the commercial and public use of space-borne data in Switzerland lags behind other European countries, which in our understanding is also confirmed and explained in the SSIP with the good ground networks and infrastructure (Swiss Confederation Federal Department of Economic Affairs Education and Research, 2013). According to our interviews, in particular the development of business and public use cases for space-data uses lags behind the practice in other countries. Together with the relevant players from the Swiss space community but also by means of collecting information on the state-of-play in other countries, the SSO could explore and support such business and public use cases (Recommendation 12).

Our interviews provide clear evidence that public funding can positively influence the success of space science and space business. However, it also points to other influences which are of key importance (see section 4.4). The question is: Can space policy also shape these factors? With regard to two of them we see a need for space policy to become and remain active: 1) Qualified personnel and 2) partner networks.

1. Qualified personnel. Obtaining and keeping space heritage at organisation level is a key requirement for long-term success. At the same time, it is a specific problem for research institutes, as institutes might be reorganised or even shut down when scientists retire. Moreover, knowledge generally moves with the scientists and researchers when they take on new positions in industry or abroad. In addition, the availability of young engineers with an appropriate basic qualification for becoming space engineers has been frequently mentioned as a challenge. Many other European countries offer degrees in "Aerospace Engineering" which, as far as we know, does not exist in Switzerland. Higher education institutions (HEI) should be made aware of the needs of the space community and the job opportunities for qualified aerospace engineers (Recommendation 13). A cost-effective approach to setting up such an offer could consist of pooling the distributed competencies across HEI.

In addition to a solid basic science and engineering education, training on the job has been described as essential for the qualification of space engineers. Personnel exchange schemes between academic institutes and companies contributes to the transfer of skills and knowhow and increases the mutual understanding of the requirements and restrictions. We received positive comments on "industrial PhD" schemes as well as the exchange of senior scientists and engi-

neers. However, in particular SMEs tend to lack the internal resources to engage in such schemes and it should be tested under which conditions and funding constellations their uptake could be advanced in SMEs (Recommendation 14).

2) Partner networks. We were frequently told that one key ingredient to success in the space sector is the network of academic and corporate partners as well as good linkages to ESA. Organisations have built these relationships over time and being involved in funded projects reinforces them. This requires also knowing, as early on as possible about new space initiatives, technological needs and requirements, consortia being formed and more. Several respondents still uttered their frustration with obtaining information on time and finding the right person in charge. Staff exchange or visitor programmes which include ESA and take into account the restrictions of SMEs with regard to time and resources could contribute to weaving tighter networks (see Recommendation 14).

Our interview partners suggested that the Swiss Space Office, the Swiss Space Center and other intermediary organisations in the Swiss space sector could play a stronger role as well, make their contact networks available and open doors to the right people at the right point in time (i.e. when new technology generations are being launched and it is possible to join new consortia that are being formed for this purpose). The various funding opportunities with space relevance, in particular those at national level and those in relation with ESA, but also the EU Framework Programme for R&D (Horizon 2020), the European Research Council (ERC), the European Science Foundation (ESF), or the European Institute of Innovation & Technology (EIT) require a professional approach to networking and communication. In particular for SMEs and minor academic or corporate players in the space sector, this is too costly.

It seems that the previous evaluation and the corresponding recommendation "Enhance Swiss ESA participation by providing information and advice to potential ESA contractors" (Balthasar et al., 2011) has already started this professionalization and contributed to improving the situation. The SSO and SSC – the latter mandated by SSO – have started several activities and the improvement was recognised by the Swiss space community (more transparency, more communication). However, further improvements and widening the impact should be still an objective (Recommendation 4). SSO and SSC could support companies in at least two ways: 1) Let Swiss organisations participate as much as possible in their networks and involve them as early as possible in the preparation and design of new initiatives. 2) Push the key information to Swiss organisations in real time through customised electronic services (e.g. RSS feeds, tweets etc.) and offering comprehensive information on the web for Swiss organisations.

Internal consistency

First and foremost, the European (ESA) and national space-related support measures (*Activités Nationales Complémentaires,* ANC) have generally received positive marks from the respondents to our interviews with regard to their consistency. Our interview partners agreed that the ANC can support early technology development and the build-up of competencies for being successful in subsequent ESA calls. SSO, with the support from SSC, provides services that are being considered as very useful for acquiring and successfully running institutional space-projects with the prime contractors and big players in Europe. The ESA projects themselves generate new knowledge and advance existing technologies (see section 4.7) and contribute to scientific, technological and commercial outcomes (see section 4.8). However, a number of interviewees missed an overarching (scientific or technological) strategy in the national measures and some of

the ESA programmes. In addition, some interviewees criticised that the ESA measures oriented toward R&D and innovation were overambitious and underfunded creating potentially a catch 22 situation for successful tenderers.

This frequently led to the comment that a space science/space technology plan and well-equipped space programme at Swiss level would be needed. An additional advantage of such a programme at national level would be the smaller administrative overhead and shorter lead times. Some interviewees linked such a space programme to the call for a Swiss Space Agency and a more pronounced role of space policy as well as more federal funding for space activities in general. If more funding would be provided it should not be routed through ESA or other international organisations, but become the financial basis for a Swiss Space Programme which formulates and pursues national goals (Recommendation 2). Notably, such a programme should ideally not lead to a reduction of the Swiss ESA engagement, as different types of activities need different scales; mid-sized and large activities still need the European level, and small national initiatives could constitute an ideal bridgehead for further strengthening the Swiss influence at European level. However, this should not be understood as a mere call for more money. It rather expresses the desire to increase the possibilities of technology development according to national priorities and to steer and govern these activities independently of the European competitors. Several of our respondents perceived that the competition for space-related funding has increased over the past few years. The question about changes in European or national funding policies usually led to a discussion about the role of Switzerland in European politics and a need for more lobbying and influence on European space policy.

A second point refers to the Swiss public support infrastructure for working in the space business or engaging in space research. The services provided by SSO, SSC and others have been considered as relevant and generally useful. However, the writing of proposals, fulfilment of formal requirements and – in case of success – administration of funded projects is still seen as challenging; especially by smaller or not mainly space-orientated organizations which have no dedicated resources for this type of work. They benefit considerably from external support and eventually even the outsourcing of some of the work. The legal complexity of ESA contracts and General Terms and Conditions even asks too much of experienced players in the space sector as we frequently heard in the interviews. One of our interview partners, an expert in the field of space law, suggested dedicated workshops and training for companies/academic institutes (and their lawyers) on laws and regulations relevant for entities in the space sector. We can only endorse this with a broader scope on general framework conditions to do space activities. We recommend that general but also topic-specific (e.g. on space law) workshops and training offers, or (subsidised) coaching from competent specialists or public intermediaries should be provided on a regular basis (Recommendation 3). Such offers should help to increase the understanding for all administrative matters related to the institutional space business in the Swiss space community.

Providing general support to the acquisition and implementation of space projects is again one of the tasks of SSO with the support of SSC. This report stresses the strong necessity of such services. At the same time, some interviewees complained that the division of labour and the connections between SSO and SSC are not fully clear. This adds to the perceived intransparency and time and efforts needed for getting started on space projects. The division of labour between both institutions, i.e. the mandate given to the SSC, should be intuitive and well communicated to the Swiss space community (and organisations wishing to enter this community, see also Recommendation 9).

External consistency

This section refers to the consistency of space-related funding with other related funding sources: at national level SNF and CTI funding and at European level the Framework Programmes for Research & Development. The views on SNF and CTI differ to some extent:

- SNF was acknowledged as one of the main national funding channels for space research: *"We build instruments with 80-90% ESA funding. […] However, we build these instruments to answer scientific questions and this work is funded by SNF or the university itself."* (Academic respondent AF137). SNF grants are also used to co-fund PhD projects and secure funding over the entire duration of a PhD. Though funding is not always seamless and, of course, subject to considerable efforts in proposal writing, academic respondents generally evaluated SNF and ESA as functional for covering different aspects in the value chain of space-related research. The only exception mentioned was the funding of infrastructure and operational part of missions for which it is challenging to obtain support from any type of funding agency. Some corporate respondents criticized the orientation of SNF to basic research and academic institutions which had led to their exclusion from grant proposals even though their academic collaborators had endorsed and justified their participation.
- CTI was mentioned by all respondents, corporate as well as academic, rather few times though some had participated in CTI-funded projects. In particular for companies this is surprising, as several corporate respondents stated that their main current development focus is in the area of product development and the conversion of made-to-order production or services into serial production.

SSO, SNF, and CTI must discuss the needs of Swiss space research and space industry on a regular basis. In addition, we would suggest that joint information events and information material could be an important contribution to making academic institutes and companies aware of their offers (Recommendation 5). This would contribute to further enhancement of the network quality and align funding possibilities and it might lead towards a consolidated offer of the SSO and the two funding agencies for the Swiss space community.

EU funding, above all the framework programmes for R&D (FP 6 and 7, Horizon 2020), are known widely in the community and used above all by academic institutes. Companies tend to perceive this as an instrument that mainly supports R&D and no other aspects of innovation and therefore view it as less relevant for their needs.

5.1.2 Effectiveness

A second key concern of any evaluation is to what degree the measures and instruments reach their goals. In the current report this does not refer to the goal attainment of individual measures and instruments which would have overburdened the analysis; for instance, the specific objective of the Swiss national measures is to contribute to optimizing the Swiss scientific and technological positioning in European space programmes. In order to evaluate whether this goal is reached, it would not only be necessary to analyse the projects in detail, but we would need to look at the trajectories of technologies and partnerships in order to see whether they lead to ESA or commercial follow-on projects. Doing this – and corresponding work for the multiple ESA programmes – requires a different project set-up and timelines. We suggest that such work is facilitated through regular monitoring and reporting activities (Recommendation 15). Such activities should

include regular surveys, but also the analysis of existing administrative data from contract management (OECD, 2014, p. 32).

This report needs to take a more "bird's eye perspective" and focus on the contributions of the funding to meeting the goals of Swiss space policy. From a policy perspective, Swiss space-related funding should contribute to

a) Developing and using space applications with the goal of improving the quality of life in Switzerland,
b) Ensuring Swiss long-term commitment to the exploration of space to the benefit of creating innovations and a knowledge society,
c) Supporting the provision of important scientific, technological and industrial contributions through which Switzerland can position itself as a competitive, reliable and irreplaceable partner (Staatssekretariat für Bildung und Forschung, 2008, p. 2, FHNW translation).
   In addition to this latter point, Swiss ESA participation should contribute to reinforcing the image of "Swissness" as a synonym for top quality, reliability, unique competency and internationally highly competitive technology (Dispatch on Education, Research and Innovation 2013-16, p. 3250).

Improving the quality of life in Switzerland

The final goal of scientific and technological progress in the space sector as well as in any other domain will be to raise the well-being and quality of life in Switzerland. As we tried to argue above (see Figure 1 above on the logic model) this can be achieved in an extended cause-effect chain, which requires internal (within organisations in the space community) and external contributions in all phases as well as the transfer of technology, applications, and data from the space sector to other sectors in the economy and society as a whole, e.g. the health system, the public systems for monitoring weather and climate, earthquakes or other natural hazards, the military and internal security system and the like. This is a long-term cause-effect chain that covers the use of knowledge on space and its influences on life on earth, technologies created for space missions, ground technologies, as well as the use of data on space or originating in space. Analysing it would require coverage not only of the space community, but all these other societal domains and organisations benefitting from the work of the space community in one way or another. This, of course, is not possible within this study. As we frequently stated in this section, the analysis lets us believe that Switzerland punches over its weight in the exploration of space and development of space technologies. Securing the societal benefits of the space funding should be one of the top priorities of all space-related activities, as this is the final aim of this investment and a necessary justification of any future investment in space. The "Integrated applications push" described in the SSIP (Swiss Confederation Federal Department of Economic Affairs Education and Research, 2013) seems to be one important step in this direction, as well as Swiss participation to the exploitation phases of operational space infrastructure programmes such as Galileo or GMES/Copernicus. Dedicated analyses of the wider impacts of space activities on different societal areas in Switzerland could become part of the suggested regular monitoring and reporting activities (see Recommendation 15). Conceptualising and better measuring both the upstream and downstream sectors of the space community should also be included in this exercise (see footnote 2, p. 12).

Creating innovations and a knowledge society

Though we did not collect any information from peers nor subjected Swiss space science to any scientometric analyses (i.e. analysis of scientific output and impact by means of publications and citations), we learned in the conversations with academic and non-academic interview partners that Swiss space science is very well reputed internationally in its core fields. Our survey stressed that Swiss space industry is nationally among the most research-intensive and innovative industries. The space-related funding supports this commitment to research and innovation activities. In other words, we find considerable scientific and technological expertise in both parts of the Swiss space community.

The specific set-ups of the ESA science and technology funding and the national complementary funding measures ensure that academic institutes and companies pool their expertise and collaborate in the preparation of scientific experiments and R&D for space technologies. This has without doubt several advantages and is a good way to strengthen linkages between both sectors. However, there are a number of reasons for flexibility in the funding arrangements, if the main view is to create innovations and knowledge:

- Swiss space industry and space science are both small communities which frequently makes it challenging to find adequate partners.
- Interests of scientists and companies still differ, even if they join forces in joint projects; it can be challenging to combine scientific breakthroughs and technological progress, and, it might raise overall success and support the realisation of innovative projects, if one objective is relaxed in order to achieve the other.
- Existing companies might not want to pick up academic inventions, because of many reasons, not least because of already existing profitable solutions.

In practical terms this implies that certain situations require some degree of flexibility of funding regulations, for instance with regard to the condition of working with Swiss partners, or the requirement of a specific share or funding of partners from industry/science (Recommendation 6). The necessity of flexible solutions and even direct funding to SMEs to support research and innovation was already suggested for Swiss innovation policy several years ago (OECD, 2006).

SSO's Business Incubation initiative is aimed at stimulating entrepreneurship and innovation in the space sector. However, a few things need to be taken into account in this context: first, for start-ups it is often challenging to work in ESA contracts (for the same reasons that apply to other SMEs, see section 5.1.3) and it rarely goes beyond research funding. Second, Swiss public support is concentrated on research and development and low Technology Readiness Levels (TRL) of usually up to TRL 5. This makes it challenging for start-ups to develop a technology up to higher TRLs or create a product because of a lack of funds. To avoid that ideas and companies "die" between TRLs 5 and 9 support measures for technologies at higher TRLs should be evaluated (Recommendation 7).

Supporting the image of Switzerland as a source of high technology and high quality

The recent and spectacular successes of the Rosetta mission to comet Churyumov–Gerasimenko and the significant contributions of Swiss science and industry to this success document better than our data the positive reputation effects that can result from space missions. Our respondents generally agreed that the European space community – in science as well as in industry – is well aware of the Swiss contributions. However, the Swiss general public, parliamen-

tarians and decision-makers at Federal and Cantonal levels might not yet be aware of this. As the institutional space business depends on public money and the willingness of taxpayers and governments to dedicate funds to it, a public awareness initiative could be an important means to make the Swiss public aware and proud of its space community (Recommendation 10). This resonates with the recent OECD (2014, p. 10) suggestion that "the flow of evidence-based information to decision-makers and citizens needs to be improved". Components of such an initiative were suggested by different interview partners: systematically informing policy-makers and decision-makers in society about the space community, exploring the possibilities to cooperate with Swiss TV channels to produce documentaries on space, using social media for spreading information and creating communities of followers which can serve as multipliers (the recent short video "Switzerland in Space", was praised as a good start).

5.1.3 Effects

Outputs and outcomes

Outputs. Outputs are the short-term and direct results of funded projects. Our survey found that (see section 4.7):

- Two out of three projects generated new knowledge,
- More than 35% of the projects directly generated new or substantially changed products (goods or services),
- Projects contributed to technological progress and advanced the TRLs considerably,
- Seven out of ten projects would not have been realised without public funding.

Outcomes. Taking a mid- to long-term perspective, the results of funded projects lead to further academic, technological and economic benefits (see section 4.8); benefits in other societal domains could not be analysed in this study though it is likely that they exist as well.

- Academic institutes assessed the contribution of public space funding to academic reputation, the size of the global academic network, employees' competencies, and the recruitment and training of staff as positive. Public space funding contributes to academic outcomes, i.e. academic scientific publications and academic theses,
- Companies attributed a positive contribution of public space funding to competitiveness and to competencies of their personnel.
- Technological outcomes are quite prominent for most types of projects, usually in the form of product innovations or process innovations, and for both, space markets as well non-space markets.
- Positive commercial outcomes are mostly related to sales (and little to costs) and space markets (compared to non-space markets).

The contribution of public space funding to innovations is often indirect and not direct. In other words, projects conducted with the participation of Swiss companies generated considerably more often new knowledge and understanding than new applications or product innovations. Also enhancement of competencies and a general increase of competitiveness are of key importance among the mid- to long-term outcomes of the engagement in publicly supported space projects.

Converting the results of funded projects into innovations requires considerable follow-up activities by companies and immediate economic returns to the funding are therefore rather the exception than the rule. Together with the above mentioned challenges of ESA/space-funding, this

stresses the requirement of a long-term strategy and long-term funding security before the decision to enter the space business is being made. This provides a logical background for the calls for more funding of development work in higher TRLs made by companies for industrialization and the reduction of costs. However, this would eventually also raise the risk of more windfall effects, i.e. public funding of activities which companies would be able and willing to fund from other sources/their own funds as well. Still, the question whether more public support is needed to secure the conversion of new knowledge and technologies at low TRLs into marketable offers needs to be discussed in the Swiss space community (Recommendation 7).

Sustainability

With few exceptions the space business is for both, academic institutes as well as business enterprises, predominantly a European business, and neither a national nor a global one. All in all, it seems that the surveyed academic institutes are less focused on space activities than the surveyed companies though they have been active in the space sector for considerably longer (on average more than 10 years). However, space companies dedicate a larger share of their employees to space activities and they obtain a higher share of their budgets from ESA. Though this share was on average only 5% for all companies with space activities, it grew to 20% for those companies actually receiving ESA funding between 2010 and 2014. For four out of ten companies in the Swiss space industry ESA is a key client which was responsible for at least 25% of their total sales in 2013. This strong dedication to institutional space activities was often stated as necessary to obtain space heritage and maintain critical mass, which were described as preconditions for success. A considerable built up of knowledge, long-term investment in material as well as immaterial assets (e.g. contacts and networks), and critical mass are essential to be successful.

At the same time the space business has been described as a challenging business by both, research institutes and companies. Competition is high and margins are rather low. The main client in Europe, ESA, is like many other large multinational organisations by no means an easy client: processes are complex and can be slow, reputation and track records of successful projects are preconditions for being considered in funding decisions, decisions are subject to multiple influences, and generally the timing of decisions can be difficult to predict, making it nearly impossible to plan resources and activities. This can translate into considerable fluctuations of acquiring ESA contracts over time.

This combination of long-term upfront investment and considerable funding insecurity creates a potentially unsustainable situation for the Swiss beneficiaries, above all for SMEs and start-ups with little cash flow, strong dependency on timely ESA payments, and lack of capital and buffers.

The ANC might be one remedy to this (see above), however, it is also an application-based funding measure, pursues specific and narrow goals and is not appropriate in all situations. A key goal for many space companies should be to diversify their clients and find additional customers, either from the non-European institutional space sector, the commercial space business or non-space markets. Such business development is essentially the task of every company. However, the current situation also demands that companies put a focus on reducing costs and increasing efficiency. Our findings endorse the focus on "internationalisation and export" of the SSIP (Swiss Confederation Federal Department of Economic Affairs Education and Research, 2013) and suggest allocating additional effort and resources to this (Recommendation 11).

Another related problem stems from the fact that ESA payments are subject to an authorisation procedure that has been described as complicated and lengthy the lower an organisation is

placed in the hierarchy of a contract. Requesting interim payments is often not a solution (at least for subcontractors), as this essentially creates additional administrative work which the main contractors avoid.

This creates and exacerbates cash flow problems of SMEs for which market solutions seemingly do not exist. According to some interviewees banks are unwilling to provide bridge funding as they cannot assess the involved risks with reasonable costs; export risk insurances, such as the Swiss Export Risk Insurance SERV, provide protection against non-payment of foreign debtors – delayed payments from subcontracts to international contracts are difficult to cover with this. Companies, in particular SMEs will rarely be able to find satisfactory solutions for bridge funding and first steps to finding a solution would be to analyse how other countries deal with this situation and whether adequate solutions exist or can be found with the involved stakeholders, including ESA (Recommendation 8).

5.2 Recommendations

We distinguish two types of recommendations: the first type refers directly to the space-funding implemented by SSO and ESA. The second type concerns additional measures which can guarantee the success of the funding and improve the general conditions for being successful in space science or space industry. The latter measures tend to require the input of other institutions in the public sector, business associations and private companies themselves in order to be effective. However, SERI and its supporters in the space sector could be important moderators and present the needs of the Swiss space community.

Recommendations oriented towards space-related funding

Recommendation 1: Continue investing in space activities.

Recommendation 2: Work towards a Swiss Space Programme for space science, technology development, and space data use.

Recommendation 3: Provide support – directly or indirectly through involving topic experts, trainers and coaches – on all non-technical (administrative, legal, economic) matters related to the acquisition and management of institutional space projects.

Recommendation 4: Enhance the communication of business-related information to the Swiss space community.

Recommendation 5: Discuss the needs of the Swiss space community on a regular basis with SNF and CTI and offer joint information events and information material for academic institutes and enterprises.

Recommendation 6: Ensure a flexible approach in the implementation of funding measures (including ratio between academia and industry, and direct funding to industry) to ensure that the overall goal of creating innovations and a knowledge society can be reached, along the whole value chain.

Recommendation 7: Analyse – in discussion with key players from the Swiss space sector – whether further support to innovation, technology development in TRLs 7-9 and product development is needed, including support to industrialization and cost reduction programmes.

Recommendation 8: Analyse possible contributions for stabilising the cash flow of SMEs, such as bridge funding for ESA contracts or reimbursements of costs for preparing offers.

Recommendations on additional measures

Recommendation 9: Communicate clearly the responsibilities of SSO and SSC.

Recommendation 10: Design a public awareness campaign on the successes of the Swiss space community.

Recommendation 11: Find – in discussion with key players from the Swiss space sector – ways to support the global business development of the Swiss space industry.

Recommendation 12: Explore and support business and public use cases for space-data.

Recommendation 13: Discuss with ETH/Universities/UAS representatives possible ways to strengthen the role of "Aerospace Engineering" in the STEM fields (and in particular in postgraduate engineering education).

Recommendation 14: Pilot and test the acceptance of support to cross-organisational mobility schemes between academia, industry and ESA for graduate students as well as senior engineers and scientists.

Recommendation 15: Regular (annual or biannual) monitoring of and reporting on the Swiss space community involving industry associations at national level (SSIG) and at European level (Eurospace), as well as ESA and other relevant actors

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Annex

Annex 1: Questionnaires

Survey "Impact of space-related funding in Switzerland" (Version CF)

This survey is conducted on behalf of the Swiss Space Office, State Secretariat for Education, Research & Innovation SERI, by the School of Business, FH Nordwestschweiz.

For questions or comments please contact: Olga Samuel, olga.samuel@fhnw.ch, +41 62 957 2403 or
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All your answers will be treated as strictly confidential.

Module A. General questions

1. In 2013, was your enterprise part of an **enterprise group**?

> A **group** consists of two or more legally defined enterprises under common ownership. Each enterprise in the group can serve different markets, as with national or regional subsidiaries, or serve different product markets. The head office is also part of an enterprise group.

☐ Yes

↳ In which country is the head office of your group located? Klicken Sie hier, um Text einzugeben.

☐ No

> If your enterprise is part of an enterprise group: **Please answer all further questions about your enterprise only for the enterprise for which you are responsible in Switzerland.** Exclude all subsidiaries or parent enterprises.

2. In what **year** was your enterprise established?
Please exclude mere legal status changes.

Klicken Sie hier, um Text einzugeben.

3. How many **employees** (FTE) did your enterprise have in Switzerland at the end of 2013?
Include apprentices; please calculate full-time equivalents (FTE) also for part-time positions.

a) **Overall**: … … … …
b) In **space activities**:* … … … …

> A **space activity** is considered to be any activity related to hardware or software which is either flown into space or used on the ground to enable utilization of space and space-derived data.

4. What was the **share of space activities** of the total market sales of goods and services of your enterprise in 2013?

a) Share of **space activities**: … … %
c) Share of sales to **ESA**: … … %

5. Please estimate the shares of different **geographic markets** in 2013 (in percent)?

Market region	**Overall sales**	**Only space-related sales**
Switzerland	… %	… %
Europe (without CH)	… %	… %
USA	… %	… %
Asia	… %	… %
Other markets	… %	… %
Total	**100%**	**100%**

6. What is the mid-term **development of demand** for your **space market goods and services**?

	Strong decrease -2	-1	0	+1	Strong increase +2
In the period 2012-14	☐	☐	☐	☐	☐
In the period 2015-17 (expected)	☐	☐	☐	☐	☐

Module B. Supportive and limiting conditions

B.1 Innovation activities and research and development activities

7. Has your enterprise realised **research and development (R&D)** activities in Switzerland from 2012-14?

☐ Yes
☐ No → ***Please continue with question 10.***

> **Research** refers to basic research and research activities with direct relationship to specific applications (applied research).

Development refers to the utilisation of established scientific knowledge for producing new or improving existing products and processes.

8. How frequently have you realised R&D activities in Switzerland?

   ☐ Occasionally
   ☐ Continuously

9. How many employees (FTE) of your enterprise were engaged in **research and development (R&D)** in Switzerland at the end of 2013?

   a) **Overall**: … … … …
   b) In **space activities**: … … … …

10. Did your enterprise introduce **innovations** in the time period 2012-2014 in space and non-space segments?

	Space-related	**Non-space**
Yes, **product** innovations.	☐	☐
Yes, **process** innovations.	☐	☐
No, we neither introduced product nor process innovations.	☐	☐

Explanation:

Product innovations are technically new or significantly improved products from the perspective of your enterprise, i.e. products which are new or significantly improved or changed with regard to their capability of use, quality, or the physical or interactive components employed in their production.

No product innovations are simple esthetical modifications of products (e.g. colouring, style) and product variations, e.g. because of client specifications which do not change at large the product (good or service) with regard to its technical basics and use characteristics.

Process innovations refer to the first use of technically new or significantly improved manufacturing or process technologies for producing goods respectively services for persons or objects. Though the product may change as well, raising efficiency is in forefront. New manufacturing technologies developed by you and sold to other enterprises are product innovations. Simple organisational or management changes are not subsumed among process innovations.

B.2 Space-related conditions

11. In what year did your organisation **start its space activities**?

    (e.g. conclude the first contract, make the first investment, build up competencies or the like)

    Klicken Sie hier, um Text einzugeben.

12. How do you summarise your current **strategy** on the **space market**?

    Please select only one single answer which describes best your main strategic approach.

    ☐ We develop or sell only for/in this market and **not** for/in other markets (space-only).
    ☐ What we develop or sell in this market needs to have other market(s) as well.
    ☐ We first develop for the space market and then analyse wider sales possibilities (transfer)
    ☐ Other, please describe Klicken Sie hier, um Text einzugeben.

13. How was the influence of the following factors on your space-related activities in 2012-14?

	Strong positive influence	**Positive** influence	**No** influence	**Negative** influence	**Strong negative** influence	**I don't know.**
Short-term demand fluctuations (business cycle, 3-5 years)	☐	☐	☐	☐	☐	☐
Long-term demand developments (5-10 years)	☐	☐	☐	☐	☐	☐
Supply of **qualified labour**	☐	☐	☐	☐	☐	☐
Supply of **capital** (equity, credits)	☐	☐	☐	☐	☐	☐
Your **network** of partners	☐	☐	☐	☐	☐	☐
Public subsidies to R&D or innovation	☐	☐	☐	☐	☐	☐
Political **framework** (e.g. with regard to taxation, labour, or trade)	☐	☐	☐	☐	☐	☐
Other factors, please summarise: Klicken Sie hier, um Text einzugeben.	☐	☐	☐	☐	☐	☐

Module C. Policy interventions and funding programmes

14. Which **ESA/European** funding programmes or sources for space-related activities do you know?

Klicken Sie hier, um Text einzugeben.

15. Which **Swiss** funding programmes or sources for space-related activities do you know?

Klicken Sie hier, um Text einzugeben.

Please answer the following question 16 only, if you have tried to obtain funding either from

- ***the European Space Agency ESA or from***
- ***Swiss National Complementary Measures (Activités Nationales Complémentaires, ANC), previously called Mesures de positionnement technologique (MdP).***

16. Challenges of ESA and/or Swiss funding
    a) What challenges have you had in trying to obtain ESA/Swiss contracts?

    Klicken Sie hier, um Text einzugeben.

    b) How have you overcome the challenges?

    Klicken Sie hier, um Text einzugeben.

    c) What measures or changes do you suggest to help Swiss firms in accessing ESA contracts?

    Klicken Sie hier, um Text einzugeben.

17. Have there been any **changes** in the European or national funding since 2010 which affect your enterprise?

    Klicken Sie hier, um Text einzugeben.

18. Has the Swiss/ESA space funding to your enterprise contributed to any of the following **outcomes** between 2012 and 2014 **in your enterprise**?

	Strong positive contribution	**Positive** contribution	**No** contribution	**Negative** contribution	**Strong negative** contribution	Not applicable.
Organisation-related outcomes						
Competitiveness of the enterprise	☐	☐	☐	☐	☐	☐
Change of the **internal organisation** (e.g. creation of a new unit, outsourcing)	☐	☐	☐	☐	☐	☐
Change of **project management** practices	☐	☐	☐	☐	☐	☐
New organisational procedures (e.g. supply chain management, re-engineering, lean production, quality management, etc.)	☐	☐	☐	☐	☐	☐
Methods of **organising work** responsibilities and **decision-making** (e.g. new system of team work, integration or de-integration of units, new education or training systems)	☐	☐	☐	☐	☐	☐
Size of the **Swiss academic** network	☐	☐	☐	☐	☐	☐
Size of the **international academic** network	☐	☐	☐	☐	☐	☐
Size of the **Swiss** network in **industry**	☐	☐	☐	☐	☐	☐
Size of the **international** network in **industry**	☐	☐	☐	☐	☐	☐
Quality of the network (e.g. strength of ties, cohesiveness, density of interaction)	☐	☐	☐	☐	☐	☐
Competence and skill-related outcomes						
Competencies of **existing** staff	☐	☐	☐	☐	☐	☐
Hiring and training of **new** staff	☐	☐	☐	☐	☐	☐

19. Has the Swiss/ESA space funding generated or contributed to any **other outcomes** in your enterprise?

    ☐ No ☐ Yes, please summarise: … … … … … … … …

Module D. Outlook

20. If you look ahead 3-5 years:

    a) Where do you see the main **internal strengths and weaknesses** of your enterprise's space activities?
    Klicken Sie hier, um Text einzugeben.

    b) Where do you see the main **external opportunities and threats** for your enterprise's space activities?
    Klicken Sie hier, um Text einzugeben.

*Project questionnaire - **CORPORATE***

Survey "Impact of space-related R&D funding"

This survey is conducted on behalf of the Swiss Space Office, State Secretariat for Education, Research & Innovation SERI, by the School of Business, FH Nordwestschweiz.

For questions or comments please contact: Olga Samuel, olga.samuel@fhnw.ch, +41 62 957 2403 or
Prof. Dr. Franz Barjak, franz.barjak@fhnw.ch, +41 62 957 2684

All your answers will be treated as strictly confidential.

Introduction

According to our data you participated in the following project «CONT_Title» (contract no. «CONT_ID») which obtained ESA funding from the programme «IP_PROGRAM_DESCRIPTION».

We would like to evaluate your experience with participating in this programme, the goal attainment of this particular project and its outputs and impacts on your organisation.

Module A: General information

1. What was the role of your enterprise in the project?

☐ Project leader
☐ Partner
☐ Sub-contractor/supplier
☐ Other, please specify: Klicken Sie hier, um Text einzugeben.

2. In what year did the project start?
Project **start** refers to the start date included in the contract.

… … … … … ☐ I don't know.

3. In what year did the project end?
Project **ending** refers to the end of the contract and ext. funding.

… … … … … ☐ The project is still ongoing.

4. What was the **total budget** of this project?

… … … … … … … … … ☐in Euro ☐in Swiss Francs
☐ I don't know.

5. How many different organisations participated in this project?
(Please include your own organisation.)

… … … … organisations ☐ I don't know.

6. What was the project's **main type**?
Please select **only one** type.

☐ Co-financed technology development (Industry initiated)
☐ Technological development (Agency initiated)
☐ Development for a mission (built to order)
☐ PRODEX
☐ Other, please summarise: ……

Module B: Funding programme

This section refers to the programme in which the project was funded.

7. Do you remember any particular strong or weak points of the **application procedure and criteria**?

	Agree +2	+1	0	-1	Disagree -2
Procedure and criteria were **hard** to understand.	☐	☐	☐	☐	☐
We benefitted from the support of other Swiss organisations.	☐	☐	☐	☐	☐
The application resulted in a **lot of paper work**.	☐	☐	☐	☐	☐
The funding **decision** was made **quickly**.	☐	☐	☐	☐	☐

8. Do you remember any particular strong or weak points of the **programme management**?

	Agree +2	+1	0	-1	Disagree -2
The programme management was **well organised and transparent**.	☐	☐	☐	☐	☐
We **waited long** for the payment after invoicing.	☐	☐	☐	☐	☐
Communication between programme management and the project was **efficient**.	☐	☐	☐	☐	☐
The **administrative work** required during project execution was too complex and time-consuming.	☐	☐	☐	☐	☐

Module C: Effectiveness and effects of the project

9. How would you have realised the project **without** the ESA funding?

   Multiple responses are possible.

   - ☐ Not at all
   - ☐ With funding from other sources
   - ☐ The project would have taken longer.
   - ☐ The project would have been smaller.
   - ☐ The consortium of partners would have been different.

10. Has the project reached its **goal(s)**?

	Fully	Mostly	Barely	Not at all	Not applicable	Don't know
Scientific	☐	☐	☐	☐	☐	☐
Technological	☐	☐	☐	☐	☐	☐
Economic	☐	☐	☐	☐	☐	☐
Environmental	☐	☐	☐	☐	☐	☐
Social	☐	☐	☐	☐	☐	☐
Other goals, please summarise: Klicken Sie hier, um Text einzugeben.	☐	☐	☐	☐	☐	☐

11. What **outputs** resulted from the project?

    Project outputs are understood as the results generated during project realisation by the participants. Multiple responses are possible.

    - ☐ (a) New data
    - ☐ (b) New knowledge and understanding
    - ☐ (c) Advancement of existing technologies
    - ☐ (d) New technology/technologies
    - ☐ (e) New application(s)
    - ☐ (f) Product innovation(s)
    - ☐ (g) Other outputs, please summarise Klicken Sie hier, um Text einzugeben.

12. **Main project output**

    a) What was the main project output?

    Insert one letter from question 11 above: (……)

    b) At project **start:** What was the Technology Readiness Level TRL of the **main project output**?

    TRL … ☐ Not applicable.

    c) At project **ending:** TRL of the **main project output**?

    TRL … ☐ Not applicable.

TRLs are a set of management metrics that enable the assessment of the maturity of a particular technology and the consistent comparison of maturity between different types of technology - all in the context of a specific system, application and operational environment.

Level	Definition	Engineering/R&D Terms
TRL 1	Basic principles observed and reported	Scientific research
TRL 2	Technology concept and/ or application formulated	Systems analyses, Pre-phase A studies
TRL 3	Analytical and experimental critical function and/or characteristic proof-of-concept	Laboratory experiments
TRL 4	Component and/or breadboard validation in laboratory environment	Component, breadboard
TRL 5	Component and/or breadboard validation in relevant environment	High-fidelity breadboard, brassboard, engineering breadboard, function-oriented model
TRL 6	System/subsystem model or prototype demonstration in a relevant environment (ground or space)	High-fidelity lab prototype, engineering qualification model, subsystem model, development model, system model
TRL 7	System prototype demonstration in a space environment	System demonstration
TRL 8	System completed and "flight qualified" through test and demonstration (ground or space)	Theoretical first unit, flight unit, flight spare
TRL 9	Actual system "flight proven" through successful mission operations	Mission operations, flight qualified hardware

Module D. Project outcomes

13. Has the project generated any of the following **technological or commercial outcomes** or contributed to them **in your enterprise**?

    Project outcomes are understood as the (short- to mid-term) effects resulting from the project during and after project realisation on the participants' premises.

	Strong positive contribution	**Positive** contribution	**No** contribution	**Negative** contribution	**Strong negative** contribu…	**Not applicable**
Technological outcomes						
Product innovations for **space-related** markets	☐	☐	☐	☐	☐	☐
Product innovations for **non-space** markets	☐	☐	☐	☐	☐	☐
Process innovations	☐	☐	☐	☐	☐	☐
Patents or other Intellectual Property	☐	☐	☐	☐	☐	☐

	Strong positive contribution	**Positive** contribution	**No** contribution	**Negative** contribution	**Strong negative** contribu-	**Not applicable**
Rights						
Commercial outcomes						
Sales on **space-related markets**	☐	☐	☐	☐	☐	☐
Sales on **non-space markets**	☐	☐	☐	☐	☐	☐
Diversification of **clients**	☐	☐	☐	☐	☐	☐
Diversification of **target markets**	☐	☐	☐	☐	☐	☐
Cost reductions of **space** activities	☐	☐	☐	☐	☐	☐
Cost reductions of **non-space** activities	☐	☐	☐	☐	☐	☐

14. Has the project generated or contributed to any **other outcomes** in your enterprise?

☐ No ☐ Yes, please summarise: … … … … … … …

Survey "Impact of space-related funding in Switzerland" (Version AF)

This survey is conducted on behalf of the Swiss Space Office, State Secretariat for Education, Research & Innovation SERI, by the School of Business, FH Nordwestschweiz.

For questions or comments please contact: Olga Samuel, olga.samuel@fhnw.ch, +41 62 957 2403 or
Prof. Dr. Franz Barjak, franz.barjak@fhnw.ch, +41 62 957 2684

All your answers will be treated as strictly confidential.

Module A: General questions

1. To which type of organisation does your institute belong?

   ☐ ETH sector
   ☐ University
   ☐ University of applied sciences
   ☐ Non-university research institute
   ☐ Other, please describe Klicken Sie hier, um Text einzugeben.

> Please answer all further questions only for your research institute and **not** for the entire organisation unless this is requested explicitly.

2. In what **year** was your institute established?
   Please exclude mere status changes.

   Klicken Sie hier, um Text einzugeben.

3. What was the **total budget** of your institute in 2013?

   a) **Overall**: … … … … CHF
   b) For **space activities***: … … … … CHF
   c) From **ESA**: … … … … CHF

> A **space activity** is considered to be any activity related to hardware or software which is either flown into space or used on the ground to enable utilization of space and space-derived data.

4. Please estimate the contributions of different **geographic areas to your funding** in 2013 (in percent)?

Area	Overall budget	Only space-related budget
Switzerland	… %	… %
Europe (without CH)	… %	… %
USA	… %	… %
Asia	… %	… %
Other areas	… %	… %
Total	**100%**	**100%**

5. How many **employees** (FTE) did your institute have at the end of 2013?
   Include PhD students, apprentices; please calculate full-time equivalents (FTE) also for part-time positions.

   a) **Overall**: … … … …
   b) In **space activities**: … … … …

Module B. Supportive and limiting conditions

6. In what year did your institute **start its space activities**?
   (e.g. conclude the first contract, make the first investment, build up competencies or the like)

   Klicken Sie hier, um Text einzugeben.

7. How was the influence of the following factors on your space-related activities in 2012-14?

	Strong positive influence	**Positive** influence	**No** influence	**Negative** influence	**Strong negative** influence	**I don't know.**
Short-term demand fluctuations (business cycle, 3-5 years)	☐	☐	☐	☐	☐	☐
Long-term demand developments (5-10 years)	☐	☐	☐	☐	☐	☐
Supply of **qualified labour**	☐	☐	☐	☐	☐	☐
Supply of **private** funding	☐	☐	☐	☐	☐	☐
Supply of **public** funding	☐	☐	☐	☐	☐	☐
Your **network** of partners	☐	☐	☐	☐	☐	☐
Political **framework**	☐	☐	☐	☐	☐	☐
Other factors, please summarise: Klicken Sie hier, um Text einzugeben.	☐	☐	☐	☐	☐	☐

8. What is the mid-term **development of demand** for your **space activities**?

	Strong decrease -2	-1	0	+1	Strong increase +2
In the period 2012-14	☐	☐	☐	☐	☐
In the period 2015-17 (expected)	☐	☐	☐	☐	☐

Module C. Policy interventions and funding programmes

9. Which **ESA/European** funding programmes or sources for space-related activities do you know?

   Klicken Sie hier, um Text einzugeben.

10. Which **Swiss** funding programmes or sources for space-related activities do you know?

    Klicken Sie hier, um Text einzugeben.

Please answer the following question 16 only, if you have tried to obtain funding either from

- ***the European Space Agency ESA or from***
- ***Swiss National Complementary Measures (Activités Nationales Complémentaires, ANC), previously called Mesures de positionnement technologique (MdP).***

11. Challenges of ESA and/or Swiss funding
    d) What challenges have you had in trying to obtain ESA/Swiss contracts?

    Klicken Sie hier, um Text einzugeben.

    e) How have you overcome the challenges?

    Klicken Sie hier, um Text einzugeben.

    f) What measures or changes do you suggest to help Swiss research institutes with accessing ESA contracts?

    Klicken Sie hier, um Text einzugeben.

12. Have there been any **changes** in the European or national funding since 2010 which affect your institute?

    Klicken Sie hier, um Text einzugeben.

13. Has the Swiss/ESA space funding to your institute contributed to any of the following **outcomes** between 2012 and 2014 **in your organisation**?

	Strong positive contribution	**Positive** contribution	**No** contribution	**Negative** contribution	**Strong negative** contribution	Not applicable
Outcomes with regard to internal organization						
Competencies of **existing** staff	☐	☐	☐	☐	☐	☐
Hiring and training of **new** staff	☐	☐	☐	☐	☐	☐
Change of the **internal organisation** (e.g. creation/ closure of a lab or group)	☐	☐	☐	☐	☐	☐
Change of **project management** practices	☐	☐	☐	☐	☐	☐
Methods of **organising work** responsibilities and **decision-making**	☐	☐	☐	☐	☐	☐
Outcomes with regard to external collaboration						
Academic **reputation**	☐	☐	☐	☐	☐	☐
Size of your **Swiss academic** network	☐	☐	☐	☐	☐	☐
Size of your **international academic** network	☐	☐	☐	☐	☐	☐
Size of your **Swiss** network in **industry**	☐	☐	☐	☐	☐	☐
Size of your **international** network in **industry**	☐	☐	☐	☐	☐	☐
Quality of the network (e.g. strength of ties, cohesiveness, density of interaction)	☐	☐	☐	☐	☐	☐

14. Has the Swiss/ESA space funding generated or contributed to any **other outcomes** in your **organisation**?

    ☐ No ☐ Yes, please summarise: … … … … … … …

Module D. Outlook

15. If you look ahead 3-5 years:

    a) Where do you see the main **internal strengths and weaknesses** of your institute's space activities?
    Klicken Sie hier, um Text einzugeben.

    b) Where do you see the main **external opportunities and threats** for your institute's space activities?
    Klicken Sie hier, um Text einzugeben.

Survey "Impact of space-related R&D funding"

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Prof. Dr. Franz Barjak, franz.barjak@fhnw.ch, +41 62 957 2684

All your answers will be treated as strictly confidential.

Introduction

According to our data you participated in the following project [project title] (contract no. [no.]) which obtained ESA funding from the programme [programme name].

We would like to evaluate your experience with participating in this programme, the goal attainment of this particular project and its outputs and impacts on your organisation.

Module A: General information

1. What was the role of your institute in the project?

   ☐ Project leader ☐ Sub-contractor/supplier
   ☐ Partner ☐ Other, please specify: Klicken Sie hier, um Text einzugeben.

2. In what year did the project start?
   Project **start** refers to the start date included in the contract.

   … … … … … ☐ I don't know.

3. In what year did the project end?
   Project **ending** refers to the end of the contract and ext. funding.

   … … … … … ☐ The project is still ongoing.

4. What was the **total budget** of this project?

   … … … … … … … … … … ☐in Euro ☐in Swiss Francs
   ☐ I don't know.

5. How many different organisations participated in this project?
   (Please include your own organisation.)

   … … … … organisations ☐ I don't know.

6. What was the project's **main type**?
   Please select **only one** type.

   ☐ Co-financed technology development (Industry initiated)
   ☐ Technological development (Agency initiated)
   ☐ Development for a mission (built to order)
   ☐ PRODEX
   ☐ Other, please summarise: ……

Module B: Funding programme

This section refers to the programme in which the project was funded.

7. Do you remember any particular strong or weak points of the **application procedure and criteria**?

	Agree +2	+1	0	-1	Disagree -2
Procedure and criteria were **hard** to understand.	☐	☐	☐	☐	☐
We benefitted from the support of other Swiss organisations.	☐	☐	☐	☐	☐
The application resulted in a **lot of paper work**.	☐	☐	☐	☐	☐
The funding **decision** was made **quickly**.	☐	☐	☐	☐	☐

8. Do you remember any particular strong or weak points of the **programme management**?

	Agree +2	+1	0	-1	Disagree -2
The prog. management was **well organised and transparent**.	☐	☐	☐	☐	☐
We **waited long** for the payment after invoicing.	☐	☐	☐	☐	☐
Communication between programme management and the project was **efficient**.	☐	☐	☐	☐	☐
The **administrative work** required during project execution was too complex and time-consuming.	☐	☐	☐	☐	☐

Module C: Effectiveness and effects of the project

9. How would you have realised the project **without** the ESA funding?
   Multiple responses are possible.

   ☐ Not at all
   ☐ With funding from other sources
   ☐ The project would have taken longer.
   ☐ The project would have been smaller.

☐ The consortium of partners would have been different.

10. Has the project reached its **goal(s)**?

	Fully	Mostly	Barely	Not at all	Not applicable	Don't know
Scientific	☐	☐	☐	☐	☐	☐
Technological	☐	☐	☐	☐	☐	☐
Economic	☐	☐	☐	☐	☐	☐
Environmental	☐	☐	☐	☐	☐	☐
Social	☐	☐	☐	☐	☐	☐
Other goals, please summarise: Klicken Sie hier, um Text einzugeben.	☐	☐	☐	☐	☐	☐

11. What **outputs** resulted from the project?

Project outputs are understood as the results generated during project realisation by the participants. Multiple responses are possible.

☐ (a) New data
☐ (b) New knowledge and understanding
☐ (c) Advancement of existing technologies
☐ (d) New technology/technologies
☐ (e) New application(s)
☐ (f) Product innovation(s)
☐ (g) Other output, please summarise Klicken Sie hier, um Text einzugeben.

12. Main project output

a) What was the main project output?

Insert one letter from question 11 above: (……)

b) At project **start:** What was the Technology Readiness Level TRL of the **main project output**?

TRL … ☐ Not applicable.

c) At project **ending:** TRL of the **main project output**?

TRL … ☐ Not applicable.

TRLs are a set of management metrics that enable the assessment of the maturity of a particular technology and the consistent comparison of maturity between different types of technology - all in the context of a specific system, application and operational environment.

Level	Definition	Engineering/R&D Terms
TRL 1	Basic principles observed and reported	Scientific research
TRL 2	Technology concept and/ or application formulated	Systems analyses, Pre-phase A studies
TRL 3	Analytical and experimental critical function and/or characteristic proof-of-concept	Laboratory experiments
TRL 4	Component and/or breadboard validation in laboratory environment	Component, breadboard
TRL 5	Component and/or breadboard validation in relevant environment	High-fidelity breadboard, brassboard, engineering breadboard, function-oriented model
TRL 6	System/subsystem model or prototype demonstration in a relevant environment (ground or space)	High-fidelity lab prototype, engineering qualification model, subsystem model, development model, system model
TRL 7	System prototype demonstration in a space environment	System demonstration
TRL 8	System completed and "flight qualified" through test and demonstration (ground or space)	Theoretical first unit, flight unit, flight spare
TRL 9	Actual system "flight proven" through successful mission operations	Mission operations, flight qualified hardware

Module D. Project outcomes

13. Has the project generated any of the following **outcomes** or contributed to them **in your organisation**?

Project outcomes are understood as the (short- to mid-term) effects resulting from the project during and after project realisation on the participants' premises.

	Strong positive contribution	**Positive** contribution	**No** contribution	**Negative** contribution	**Strong negative** contribution	**Not applicable**
Academic outcomes						
Scientific **publications**	☐	☐	☐	☐	☐	☐
Academic **theses** (e.g. PhD, MSc)	☐	☐	☐	☐	☐	☐
Academic **education** offers (courses, programmes)	☐	☐	☐	☐	☐	☐
Technological outcomes						
Product innovations for **space-related** markets	☐	☐	☐	☐	☐	☐
Product innovations for **non-space** markets	☐	☐	☐	☐	☐	☐
Process innovations	☐	☐	☐	☐	☐	☐
Patents or other Intellectual Property Rights	☐	☐	☐	☐	☐	☐
Commercial outcomes						
Sales on **space-related markets**	☐	☐	☐	☐	☐	☐
Sales on **non-space markets**	☐	☐	☐	☐	☐	☐
Diversification of **clients**	☐	☐	☐	☐	☐	☐

	Strong positive contribution	**Positive** contribution	**No** contribution	**Negative** contribution	**Strong negative** contribution	**Not applicable**
Diversification of **target markets**	☐	☐	☐	☐	☐	☐
Cost reductions of **space** activities	☐	☐	☐	☐	☐	☐
Cost reductions of **non-space** activities	☐	☐	☐	☐	☐	☐

14. Has the project generated or contributed to any **other outcomes** in your **organisation**?

☐ No ☐ Yes, please summarise: … … … … … … …

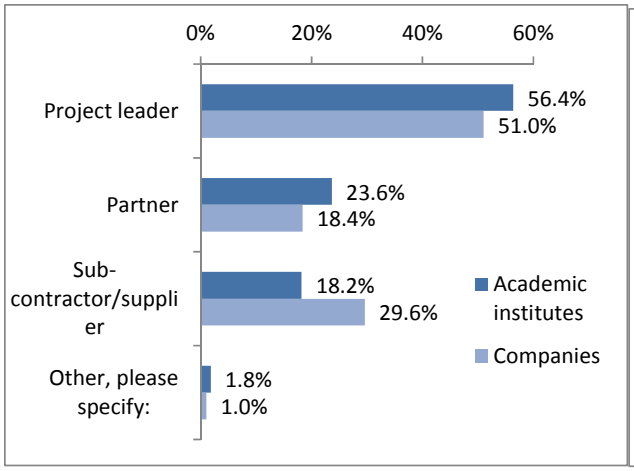
Annex 2: Experts interviewed for the evaluation

Name	Function and organisation
Dr. Stéphane Berthet	Commission fédérale des affaires spatiales (CFAS)
Dr. Gabriela Seiz	Federal Office of Meteorology and Climatology MeteoSwiss Interdepartmental Coordination Committee for Space Affairs (IKAR)
Johann Richard	Swiss Space Office Swiss Delegate to ESA for Technology, Telecommunications and Navigation Programmes
Prof. Werner Schmutz	President of the Swiss Committee on Space Research
Prof. José Achache	Lead AP-Swiss, ESA-IAP Ambassador Platform
Dr. Peter Guggenbach	President of the Swiss Space Industries Group (SSIG)
Prof. Volker Gass	Director Swiss Space Center, Ecole Polytechnique Fédérale de Lausanne (EPFL)

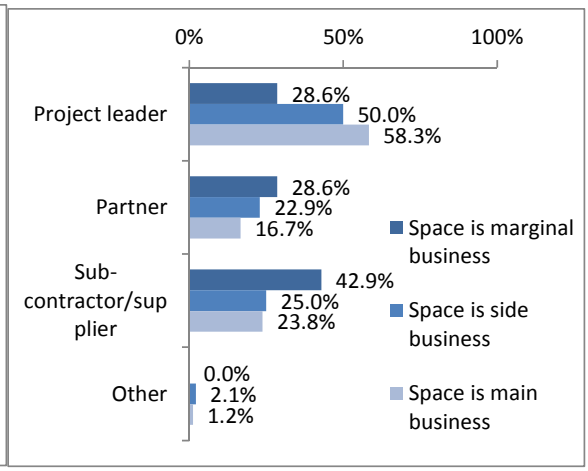
Annex 3: Additional tables and figures

Figure 23: Role of responding entity in space project

a) by sector



b) by level of space involvement



Note: Academic institutes n=55, Companies n=98, Space is marginal business n=14, Space is side business n=48, Space is main business n=84.

Source: FHNW Swiss space sector survey 2014/2015.

Table 11: Influences on space activities in the academic sector

	Negative influence	No influence	Positive influence	Median	N
Business cycle	18.5%	70.4%	11.1%	no influence	27
Long-term demand	13.8%	37.9%	48.3%	no influence	29
Supply of qualified labour	26.7%	60.0%	13.4%	no influence	30
Supply of capital/ private funding	13.8%	75.9%	10.3%	no influence	29
Partner network	0.0%	6.9%	93.1%	strong positive influence	29
Public subsidies	17.2%	17.2%	65.5%	positive influence	29
Political framework	3.6%	64.3%	32.2%	no influence	28
Others	46.2%	15.4%	38.5%	no influence	13

Source: FHNW Swiss space sector survey 2014/2015.

Table 12: Influences on space activities in the corporate sector

	Negative influence	No influence	Positive influence	Median	N
Business cycle	15.0%	52.5%	32.5%	no influence	40
Long-term demand	4.7%	32.6%	62.8%	positive influence	43
Supply of qualified labour	15.0%	57.5%	27.5%	no influence	40
Supply of capital/ private funding	15.4%	61.5%	23.1%	no influence	39
Partner network	4.8%	11.9%	83.3%	strong positive influence	42
Public subsidies	7.0%	23.3%	69.8%	positive influence	43
Political framework	9.7%	56.1%	34.2%	no influence	41
Others	30.0%	15.0%	55.0%	positive influence	20

Source: FHNW Swiss space sector survey 2014/2015.

Table 13: Contribution of space funding to organisation-related outcomes in academic institutes

	Positive contribution	No contribution	Negative contribution	Not appli-cable	Median	N
Competitiveness					[not asked]	
Internal organisation	41%	56%	0%	4%	No contribution	26
Project management	56%	37%	0%	7%	Positive contribution	25
Reorganisation of processes					[not asked]	
Methods of work organisation and decision making	44%	48%	0%	7%	No contribution	25
Academic reputation	93%	7%	0%	0%	Strong positive contri-bution	27
Academic network in CH	52%	37%	4%	7%	Positive contribution	25
Academic network worldwide	89%	7%	0%	4%	Positive contribution	26
Corporate network in CH	59%	26%	0%	15%	Positive contribution	23
Corporate network worldwide	41%	37%	4%	19%	No contribution	22
Quality of the network	67%	30%	0%	4%	Positive contribution	26
Competencies of the employees	93%	7%	0%	0%	Strong positive contri-bution	27
Recruitment and training	85%	15%	0%	0%	Positive contribution	27

Source: FHNW Swiss space sector survey 2014/2015.

Table 14: Contribution of space funding to organisation-related outcomes in companies

	Positive contribution	No contribution	Negative contribution	Not appli-cable	Median	N
Competitiveness	74%	26%	0%	8%	Positive contribution	39
Internal organisation	32%	62%	6%	24%	No contribution	34
Project management	44%	50%	6%	24%	No contribution	34
Reorganisation of processes	39%	58%	3%	17%	No contribution	36
Methods of work organisation and decision making	34%	63%	3%	20%	No contribution	35
Academic reputation					[not asked]	
Academic network in CH	49%	49%	3%	14%	No contribution	37
Academic network worldwide	53%	47%	0%	11%	Positive contribution	38
Corporate network in CH	49%	51%	0%	14%	No contribution	37
Corporate network worldwide	55%	45%	0%	11%	Positive contribution	38
Quality of the network	57%	43%	0%	14%	Positive contribution	37
Competencies of the employees	81%	19%	0%	14%	Positive contribution	37
Recruitment and training	47%	50%	3%	24%	No contribution	34

Source: FHNW Swiss space sector survey 2014/2015.

Table 15: Other outcomes of Swiss/ESA space funding

Outcomes	Type
Grosse Vorsicht bei der Projektakquise im öffentlichen Raumfahrtsektor und Einschätzung, dass industrielle Märkte attraktiver sind.	caution with regard to public institutional space business
We get the best PhD students that you can get because of space. It brings in very good people. Money is unimportant, it does not stay. The products resulting from the money are not important.	employees positive reputation
Without the support of the SSO space projects would be impossible for us. We would lose the qualified personnel, because you cannot let people wait for 2 years until an ESA contract finally starts. It is a strong message for us: without the Swiss funding it would be very hard for us to maintain the critical mass and realise ESA projects. If you cannot keep the people you will not be able even to win future projects, as this is a key criterion in evaluations of proposals. It is a challenge to keep qualified people with the insecurity of ESA business and it is not easy to find replacements. We always search at global level. We would be dead in some areas without ESA and in particular SSO, and now we are at the forefront. So it is good.	employees critical mass
Es ist möglich, besser qualifizierte Mitarbeitende zu gewinnen, die sonst nicht zu unserem Unternehmen kommen würden. Wir haben z.B. jemanden dank unserer Zusammenarbeit mit Space X und Beteiligung bei ExoMars bekommen, den wir sonst sicher nicht gewonnen hätten.	employees positive reputation
Die ESA-Finanzierung hat letztlich die Voraussetzungen geschaffen, auch SNF-Forschungsprojekte aufzugleisen, die dann mit den im Weltraum gewonnenen Daten arbeiten.	further funding
Resultate der Projekte sind kommerziell interessant, z.B. in der Form von lizenzierbarer Software oder Dienstleistungen	further funding/business
Erschliessung von neuem, potentiellem Geschäftsfeld	further funding/business
Impact on company strategy, entering into space applications opened new business opportunities.	further funding/business
Sensibilisierung auf hochtechnologischen Märkten. Da sind ganz andere Bedingungen. Reinräume. Anforderungen an gesamte Wertschöpfungskette sind sehr hoch.	growth of competencies
Durch die FuE für die ESA baut man insbesondere Kompetenzen auf, gleichartige Probleme auch lösen zu können, und weniger Produkte, weil die Serien sehr klein sind. Lösungen werden nur einmal oder zwei Mal gebraucht. Wir sind sehr erpicht auf den Aufbau von Knowhow und Kompetenzen. Mit dem Erfolg wächst auch das Selbstvertrauen, dass man nicht nur mitspielen kann, sondern auch innovative und relevante Dinge anstossen und realisieren kann.	growth of competencies
Obtained scientific knowledge on how the devices operate.	growth of competencies
ESA Projekte unterstützen den Einstieg in den kommerziellen Markt [der aber noch nicht vollzogen ist, sondern nun kommen soll]. Es hat uns gepusht, neue Kompetenzen aufzubauen und zu akquirieren; ohne ESA funktioniert das nicht. Sonst müsste man den Raumfahrtmarkt wie die Arzneimittelindustrie oder Halbleiterindustrie, mit immensen Investitionen am Anfang und dann grossen Stückzahlen. Das wird aber in absehbarer Zeit nicht möglich sein. [Zu Auswirkungen auf das Projektmanagement] Z.B. Internal Design Review - bevor wir zu einem IDR gehen, machen wir es zuerst intern, weil wir wollen nicht 2000 Review Item Discrepancies RID bekommen. Das ist also 1:1 auch in den anderen Geschäftsbereichen übernommen. Die Befruchtung ESA - kommerzielles Geschäft ist klar wichtiger als Space-Non space. Klar im Bereich Supply Chain Management haben wir ein System für Space/Non space, das sehr stabil läuft. Auch hinsichtlich Formalia, wie man Lieferanten betreut und kontrolliert, zum Beispiel, gibt es Befruchtungen.	growth of competencies
The Swiss mesures d'accompagnement are well suited to test new technologies and share the financial risks of high-risk projects and techniques. They give opportunities to both, the academic partners and the companies to try out and further develop techniques and find the limits and capabilities before too much money is invested. This is better than investing a lot, like for instance the Americans do, and then getting stuck in a technology. Product development can cost millions and if you have not tested everything you can be blocked by small parameters somewhere which forces you to start again. This can be avoided due to these measures. "For me, this [the national accompanying measures] is a risk mitigation to test some funny things invented by universities." It helps to make preparatory work and be better positioned when new ESA calls are published. We are always willing to participate when proposals, which usually come from institutes, have a business case behind.	growth of competencies testing technological ideas

Outcomes are very important for our business and technology development. Therefore from time to time we may participate in other areas outside our main business. For instance, we just qualify for "space soldering" investing 600k CHF from our own pockets. And now we may try to amortise this by doing soldering work for others as sub-contractors, because we have the tools, facilities and qualifications.	
Wir sind eine der wenigen Niederlassungen des Unternehmens, die auch Produkte hat. Die haben wir in den ESA-Projekten entwickelt, weil es keine Lösungen gab, die wir in unsere Systeme übernehmen konnten. Das gibt es nicht viel bei uns und deswegen bringen wir auch der Firma global etwas und unsere Kollegen an anderen Standorten fragen das auch nach. Aber es ist ein Nischenmarkt, weil selbst bei den Ground-Produkten die Anforderungen im Raumfahrtbereich höher sind, als sie in anderen Märkten gebraucht werden. Aber de facto haben uns diese Entwicklungen, die wir dank ESA machen konnten, auch anderes Geschäft gebracht. Die Koreaner wären sonst nie zu uns gekommen.	product development further funding/ business
[on mesures de positionnement] We did an MdP pre-development with IMT to demonstrate an idea. Then we developed the product to sufficient maturity and now it is nearly qualified. The initial investment just gave us the idea to trigger the customer on the added value we could offer with this. Then it was our investment, 2 or 3 times the initial investment to bring it to maturity. Now we try to sell it globally. We had the luck of getting a first opportunity. The funding allowed us to follow a product approach and demonstrate that we can do that. We learned some lessons and we improved our industrial processes. With the programme approach you bring up the credibility and build up a background and experience. A track record is key, showing that in this product you can perform. Demonstrating that you have (flight) experience is what is important. Without the institutional programmes our company would not be here. [Is the construction of funding to work with universities ok?] If we have the hand of the university, as it was in MdP, and we can say what we want them to do, then it is powerful. If you go through TRP or GSTP: it is an underfinanced activity where the only aim is to show that I am doing something, then it is useless. All the TRP that we have done are useless from an industrial point of view. We have never gained anything. Maybe this will change, but so far we never got a building block or technology out of this. If you want to do activities with half or a third of the necessary funding then it won't work. I would say that the people defining the activity do not have any understanding of what it will cost. They have a budget and then they write the call for the activity. This is the fundamental problem that the people defining the jobs have no understanding of the costs. For us only the MdP and some GSTP measures have worked out, but definitely not TRP.	product development growth of competencies
Technology spin-off and spin-in: we once had an ESA project that generated a new technology which then was used for developing a new system for re-winding mechanical watches. So we have this transfer of technologies into other areas. So space helps other markets to develop. And we also have the opposite direction where we use technologies from other areas in space.	technology transfer
Erkenntnisse für Produkte ausserhalb von Space	technology transfer
Donne des résultats prometteurs pour d'autres marchés et augmente notre crédibilité face à de grands groupes	technology transfer positive reputation
Dank der ESA Finanzierung konnte eine "Platform for Advanvced Scientific Computing" eingerichtet werden. Das CSCS hat einen Top-5 Rechner gekauft und unser Know-how aus den ESA-Projekten konnte in 2 weiteren Projekten eingesetzt werden und ist nun für eine Initiative auf Bundesebene relevant. Wir konnten auch neue Projekte akquirieren, weil wir auf Erfahrungen in der Arbeit mit Grafikkarten hinweisen konnten.	infrastructure further funding
Two things: an annual conference that is facilitated by ESA is a good event; second, the possibility for short term stays at ESA is good to learn the real thing; we have many former people who ended up working for ESA.	networking
Die internationale Zusammenarbeit im Raumfahrtbereich ist sehr offen und sie fördert. Dies hat einen hohen Stellenwert für mich.	networking
Partenaires academices dans des autres domaines.	networking
- collaboration with two other institutes within FHNW - collaboration with PSI - public outreach events (Tag der offenen Tuer, Vortraege, events etc)	networking positive reputation
Doing ESA projects is like a visit card. It is very good marketing for the institute.	positive reputation
Wir haben ein sehr gutes Image bei der ESA und man hat uns gesagt: "Wir möchten, dass die folgenden Projekte mit Swissness geleitet werden."	positive reputation
It has contributed to the perception of our institute. That we have expertise and knowledge. We get enquiries to participate in projects. So it helped us that we are perceived as good partners in a team.	positive reputation

Ich denke, dass die Akzeptanz der Fernerkundung gestiegen ist, dass aber die notwendigen Strukturen noch nicht bestehen. Das SSO hat mich ja für diesen Film Switzerland in Space auch gefragt.	positive reputation
A very positive aspect of executing ESA projects has been around reputation and public relations. Our working with ESA has attracted new business to the company and has lifted our reputation in the world. People view us very positively because of ESA contracts.	positive reputation
Increase of reputation, increase of knowledge	positive reputation
The commercial space business is a very conservative and in order to enter it one needs to have references and experiences. Companies always ask whether one has done this or this. ESA is very good for building up this track record. We would like to do business with Airbus in Toulouse, OHB in Germany etc. and this is impossible if you are not known from ESA. So we had to go through this phase and would like to diversify now. It is also an asset to get into new markets, e.g. watch industry, when they know that you work with ESA.	positive reputation
More people are sensitised for our work. Prime partner for Swiss Space Systems. Continous work. Sense of pride.	positive reputation
Man erfährt eine Reputationssteigerung. Erfolgreicher für weitere Eingaben. Ist eine gute Qualifikation.	positive reputation
Reputationssteigerung. Innovationspreis gewonnen. Hilft in allen anderen Bereichen. Plus die Qualifizierung. Sind die einzige Firma in der Schweiz. Das trägt intern und extern zum Qualitätsverständnis bei.	positive reputation
Stark positiver Beitrag auf die Weltraumwissenschaft	scientific progress
Wissenszuwachs, Etablierung neuer Forschungszweige auch dank der ESA-Förderung	scientific progress
very important: contribution to scientific output	scientific progress

Source: FHNW Swiss space sector survey 2014/2015.

Table 16: Project start year and duration by sector

		Project duration in years							
		<1y	1y	2y	3y	4y	more than 4y	still ongoing	Total
Academic institutes									
Project started between	1995-1999	0	0	0	0	1	0	0	0
	2000-2004	0	2	2	1	1	5	0	8
	2005-2009	1	3	1	3	4	8	2	26
	2010-2014	0	3	5	1	1	9	16	57
Total academic sector		1	8	8	5	7	22	18	79
Companies									
Project started between	1995-1999	0	0	0	0	0	0	0	0
	2000-2004	0	2	1	2	3	5	0	13
	2005-2009	0	4	7	2	11	13	5	42
	2010-2014	4	14	8	5	26	31	24	112
Total corporate sector		4	20	16	9	40	49	29	167

Source: FHNW Swiss space sector survey 2014/2015.

Table 17: Opinion on application procedure and criteria by sector of respondent

		Disagree	Neutral	Agree	N	Median
Academic institutes	Procedure and criteria were hard to understand.	46.4%	30.4%	23.2%	56	Neutral
	We benefitted from the support of other Swiss organisations.	37.5%	26.8%	35.7%	56	Neutral
	The application resulted in a lot of paper work.	17.9%	32.1%	50.0%	56	Neutral/Agree
	The funding decision was made quickly.	21.4%	35.7%	42.9%	56	Neutral
Companies	Procedure and criteria were hard to understand.	44.9%	35.7%	19.4%	98	Neutral
	We benefitted from the support of other Swiss organisations.	34.7%	42.9%	22.4%	98	Neutral
	The application resulted in a lot of paper work.	22.4%	38.8%	38.8%	98	Neutral
	The funding decision was made quickly.	24.5%	38.8%	36.7%	98	Neutral

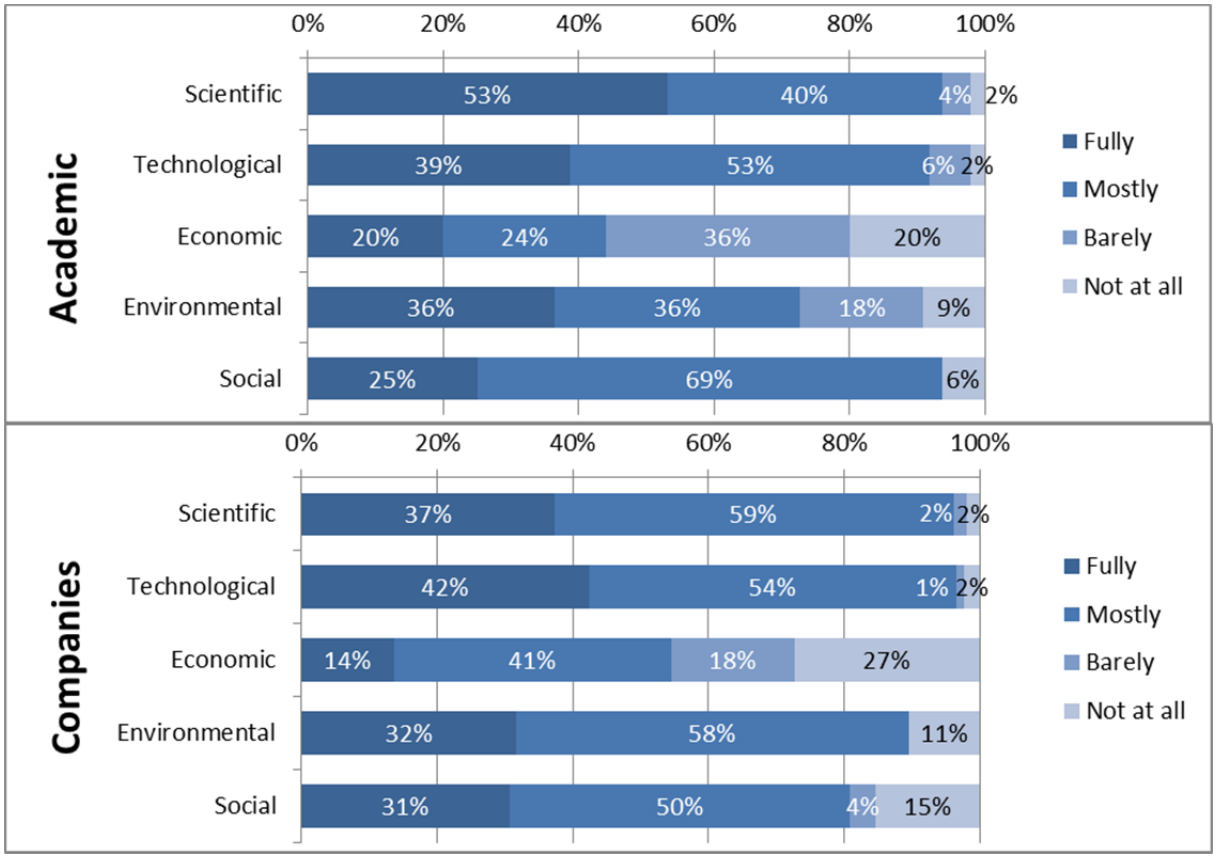
Source: FHNW Swiss space sector survey 2014/2015.

Table 18: Opinion on programme management by sector of respondent

		Disagree	Neutral	Agree	N	Median
Academic institutes	The programme management was well organised and transparent.	8.9%	42.9%	48.2%	56	Neutral
	We waited long for the payment after invoicing.	19.6%	48.2%	32.1%	56	Neutral
	Communication between programme management and the project was efficient.	8.9%	37.5%	53.6%	56	Agree
	The administrative work required during project execution was too complex and time-consuming.	12.5%	44.6%	42.9%	56	Neutral
Compa-nies	The programme management was well organised and transparent.	18.4%	19.4%	62.2%	98	Agree
	We waited long for the payment after invoicing.	34.7%	31.6%	33.7%	98	Neutral
	Communication between programme management and the project was efficient.	15.3%	21.4%	63.3%	98	Agree
	The administrative work required during project execution was too complex and time-consuming.	40.8%	31.6%	27.6%	98	Neutral

Source: FHNW Swiss space sector survey 2014/2015.

Figure 24: Goal attainment by sector



Academic institutes: Scientific n=47, Technological n=49, Economic n=25, Environmental n=11, Social n=16.
Companies: Scientific n=51, Technological n=85, Economic n=66, Environmental n=19, Social n=26.

Source: FHNW Swiss space sector survey 2014/2015.

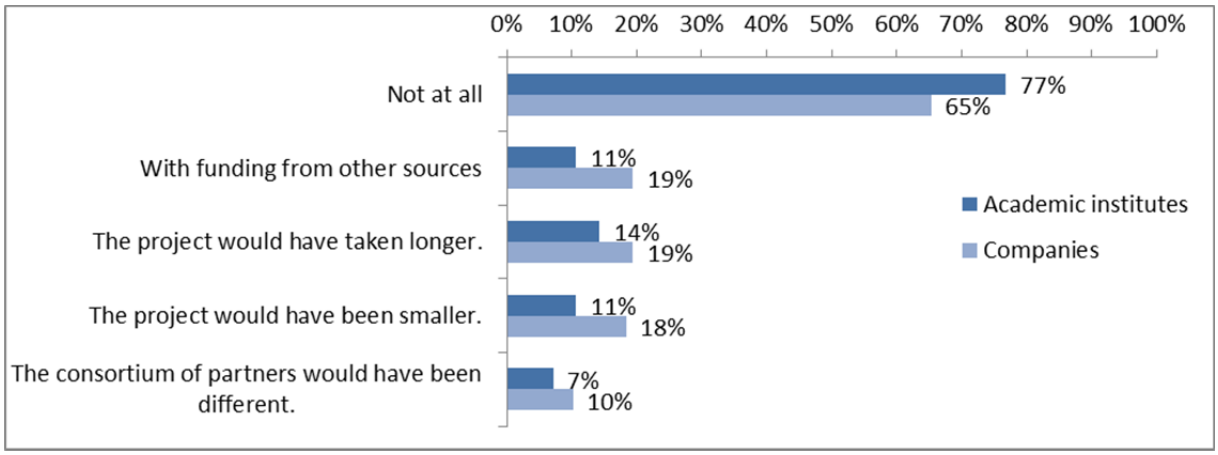
Table 19: TRL level of the main project output by sector of respondent

	TRL level	Minimum	Maximum	Median
Academic institutes	Project start	1	7	3
	Project end	1	9	5
	Increase	0	6	2
Companies	Project start	1	9	3
	Project end	2	9	5
	Increase	-1	6	2

Academic institutes: n=43, companies: n=54.

Source: FHNW Swiss space sector survey 2014/2015.

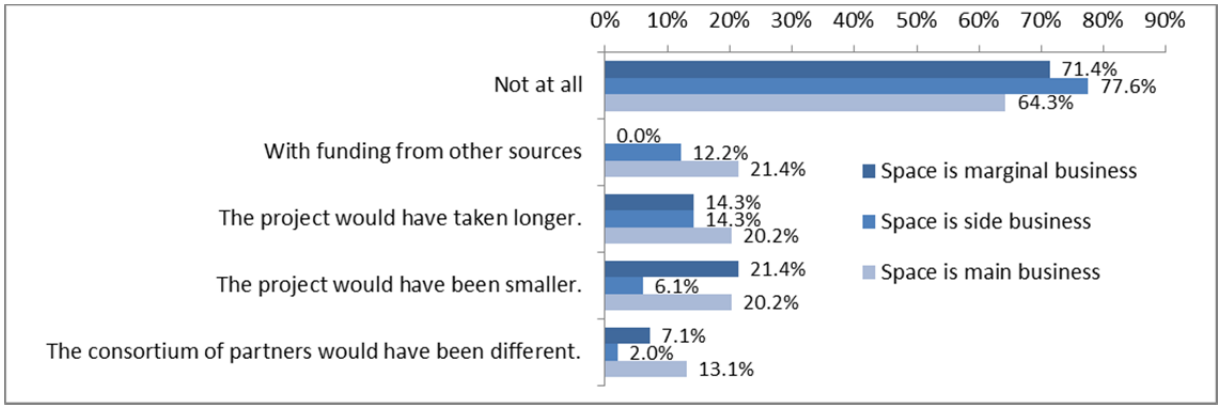
Figure 25: Realisation of project without public funding by sector of respondent



Academic institutes n=56. Companies n=98.

Source: FHNW Swiss space sector survey 2014/2015.

Figure 26: Realisation of project without ESA funding by level of space involvement



Source: FHNW Swiss space sector survey 2014/2015.

Table 20: Generation of or contribution to technological outcomes due to projects by sector

		Negative contribution	No contribution	Positive contribution	Median	Not applicable	Total
Academic institutes	Product innovations for space-related markets	0%	9%	91%	Positive	7	53
	Product innovations for non-space markets	3%	37%	61%	Positive	11	53
	Process innovations	0%	41%	59%	Positive	13	52
	Patents or other Intellectual Property Rights	0%	72%	28%	No contr.	14	53
Companies	Product innovations for space-related markets	1%	18%	81%	Positive	7	97
	Product innovations for non-space markets	1%	36%	63%	Positive	19	97
	Process innovations	2%	32%	66%	Positive	12	97
	Patents or other Intellectual Property Rights	3%	81%	16%	No contr.	27	97

Note: Percentages only refer to cases where the outcome was rated as applicable.

Source: FHNW Swiss space sector survey 2014/2015.

Table 21: Generation of or contribution to commercial outcomes due to projects

		Negative contribution	No contribution	Positive contribution	Median	Not applicable	Total
Academic institutes	Sales on space-related markets	0%	50%	50%	No contr./Pos.	25	53
	Sales on non-space markets	0%	88%	12%	No contr.	26	53
	Diversification of clients	0%	47%	53%	Positive	23	51
	Diversification of target markets	0%	53%	47%	No contr.	24	52
	Cost reductions of space activities	6%	72%	22%	No contr.	26	53
	Cost reductions of non-space activities	0%	88%	13%	No contr.	27	53
Companies	Sales on space-related markets	1%	36%	63%	Positive	10	97
	Sales on non-space markets	0%	59%	41%	No contr.	22	97
	Diversification of clients	0%	41%	59%	Positive	9	97
	Diversification of target markets	1%	40%	58%	Positive	7	96
	Cost reductions of space activities	4%	69%	28%	No contr.	17	97
	Cost reductions of non-space activities	3%	81%	16%	No contr.	28	97

Note: Percentages only refer to cases where the outcome was rated as applicable.

Source: FHNW Swiss space sector survey 2014/2015.

Table 22: SWOT for academic institutes in the space sector

Strengths	Weaknesses
- High expertise - Niche player - Reputation - Infrastructure - Excellent network - Geographic advantage - Lean management (quick) - Local network - High quality - Low fluctuation - Academic freedom	- Too few employees/small critical mass - Projects are individually oriented - Personnel fluctuation - One expertise only (niche player) - Small player - Not enough know-how in space activities - Project management - Administration - Finding suitable industry partners - No long-term experience with ESA projects - Not enough engineers
Opportunities	**Threats**
- Increasing demand for product - Privatization & commercialization - Political environment - International partnerships (e.g. China) - Development to mass-produced article	- Funding policies - Political environment - Fluctuating market - Decreasing demand - Increasing demand could not be satisfied - Increasing difficulty of hiring people from abroad - High wage level - No leading position in ESA projects - Swiss status in ESA projects

Academic institutes n≥27.

Source: FHNW Swiss space sector survey 2014/2015.

Table 23: SWOT for companies in the space sector

Strengths	Weaknesses
- Network - Strong expertise - Skilled employees - High flexibility - Niche player - Innovative - Reputation - Experience in space market - Diversification - Lean management - Quality - Advancement to non-space products - High customer satisfaction - Known for successful space market products - Independent from external funding	- Small organization - No or weak network - Liquidity - Administration - Resource constraints - Fluctuation - Space activities are a minor part - Long innovation cycles - Finding skilled personnel - Quality management - Financial dependency from ESA projects - Special projects are no fit in normal workflow
Opportunities	**Threats**
- Growing space market - Privatization & commercialization - Development to mass-produced article - New market - International outlet - Geographical closeness	- Exchange rate - Swiss status (small vs. big player) - Economic environment - Political environment (e.g., geo-return) - International competition - Increasingly difficulty of hiring people from abroad - Not enough STEM professionals - Intransparent policies - Market know-how - Lack of Swiss support (SSO) - Semi-closed market access (USA, China)

Companies n≥36.

Source: FHNW Swiss space sector survey 2014/2015.