Swiss Space Implementation Plan within Education, Research and Innovation for 2018-2020

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Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER
State Secretariat for Education,
Research and Innovation SERI

This "Swiss Space Implementation Plan within Education, Research and Innovation for 2018-2020" has been approved by the Head of the Federal Department of Economic Affairs, Education and Research on 28 August 2017.

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1 MANAGEMENT SUMMARY

Switzerland actively pursues endeavours in space. Pushing the boundaries of knowledge, niches and applications drive this engagement. Curiosity fuels excellence in science and the public's larger interest in space. Niches and technological innovation secure a competitive edge for our industry in the institutional and commercial space markets. Finally yet importantly, services and applications based on space infrastructure for telecommunication, earth & climate observation and precision timing and navigation are elements that enable and support the digital transformation for the benefit of the citizens.

Space is an essential driver of our digital and knowledge society. Today's space-based infrastructure not only contributes to tackling significant societal challenges such as climate change, management of natural resources or migration and digital transformation. It also brings humanity closer to answers for such fundamental questions as the existence of life in the universe.

The Swiss Space Implementation Plan of the Federal Department of Economic Affairs, Education and Research EAER supports the federal government in the task of putting space to use for the country.

The initial version of the Swiss Space Implementation Plan (SSIP 2014-2023) recognized and strengthened elements of success of the past, while at the same time created the common grounds to tackle the future.

This revision (SSIP 2018-2020) presents an evolution of the initial plan. It looks at the events and achievements since initial publication and focuses on the following aspects:

- **Strategic challenges and opportunities** – ESA remains Switzerland's main instrument to implement space policy. At the same time, the EU has confirmed its interest towards space. The latter is heavily investing in the operational phase of the two large space infrastructure programmes Galileo/EGNOS and Copernicus, initially developed and funded by ESA. ESA itself is also evolving, driven by new member states and new dynamics due to the increasing EU ambitions in space. Globally, slow-moving, high-impact trends shape our collective future. The response to these trends, and to the strategic challenges and opportunities the Swiss space domain faces, are two crucial elements of space policy and the implementation plan. Eventually, it remains up to the Swiss actors to answer to these challenges and opportunities, to offer space-based services for sectorial politics or to seize economic opportunities for services and applications within these emerging fields of action.
- **Space ecosystem building** – Over the past four years, Switzerland has seen a cumulative annual growth rate of more than 10% of newcomers in the space ecosystem. This increase has enlarged the ecosystem and the diversity of relationships between actors considerably. In parallel, the ecosystem also evolves in the longer term, for example in scientific instrument building or in the domain of launchers, where decade-long commitments are necessary to secure the success of Switzerland. This creates the potential to tackle new, future challenges in practical ways. It also allows individual players in the ecosystem to leverage on inherent strengths, and to better use the network effects that this ecosystem can build upon.

This revision considers the decisions taken by the Federal Council for the ESA Council Meetings at Ministerial level in 2014 and 2016.

The measures suggested in this revision of the SSIP are intended to foster a competitive, sustainable, national space ecosystem (See Chapter 6 below):

- Increasing the excellence and competitivness of our science and our industry,
- contribute to the Digital transformation of Switzerland, and
- strengthen the Swiss space ecosystem, specifically to
  - o enable stronger networking and clustering, and to
  - o promote education and training initiatives.

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3 INTRODUCTION

Switzerland actively pursues endeavours in the space sector, focusing on:

- Development and use of space applications to improve the quality of life for citizens, tackling societal challenges and the digital transformation.
- Long-term commitment to space exploration and science for the progress of innovation and of the knowledge society.
- Significant scientific, technological and industrial contributions that make Switzerland a competitive, reliable and vital partner.

For Switzerland as a founding member, the European Space Agency (ESA) remains the most important and necessary instrument for the implementation of the Swiss Space Policy.

Among others, ESA provides advanced scientific and technical excellence, expertise, technical and managerial capacity, and knowledge of the European Space sector. Switzerland secures excellent contributions, both in the development of scientific instruments and in the subsequent exploitation of the generated data, through the various science and exploration programmes of ESA. All instruments funded via PRODEX, such as for the Rosetta mission, as well as the first Small ESA Mission CHEOPS under Swiss scientific leadership are results of our continuous and successful contribution to excellence in space science. For industrial actors, the Swiss participation to ESA programmes – granting them access to procurements – represents the main vector for innovation. This allows them to subsequently compete for operational systems and commercial projects, linked mainly to telecommunication and increasingly also to commercial earth observation and navigation applications and services.

The 22 Member States of ESA confirmed the political importance of the Agency during the last ESA Council Meeting at Ministerial level, which took place in December 2016 in Lucerne. The event also marked the end of a successful Swiss-Luxemburg co-presidency of the ESA Council during which Member states decided on the development of the Ariane 6 launcher (in 2014), the continuation of the International Space Station (ISS) until 2024, the 2020 ExoMars mission, and on other ESA programmes in all space domains.

The European Union (EU) has also become a major player in Europe. The two European flagship programs, EGNOS/Galileo and Copernicus, both entered into operations after their development by ESA. In 2016, the European Commission published a Communication on the Space Strategy for Europe outlining its future ambitions. To reinforce the coordination and complementarity of activities between ESA and the EU, the executives of both organizations have signed a "Joint Statement on Shared Vision and Goals for the future of Europe in Space" in 2016. Future EU programs under discussion include a Governmental Satellite Communications initiative (GOVSATCOM), as well as the reinforcement of the EU Space Surveillance and Tracking (SST) support framework, the latter also being an activity already pursued by ESA. Moreover, the EU is promoting an EU R&D and capacity building defence programme, which may include space activities. Switzerland should contribute to EU programmes, which mainly build on ESA development, technology and studies funded also by Switzerland and with contributions of Swiss actors. This ensures access to services and data from these operational space infrastructures and leverages Swiss competencies by granting Swiss actors access to procurements under these programmes.

Globally, many expectations generated by the concept of "New Space" are becoming reality. Developments following a commercial logic have surged and are diffusing into institutional markets. This evolution has been the result of a paradigm change in which government and public players do not solely act as system architects anymore, but have engaged in public-private partnerships by procuring "turnkey" solutions, essentially shifting development risks towards industry.

The subsequent emergence of low-cost micro and nano-satellites has led to a lowering of the entry barriers and allowed for many nations and commercial actors to launch their satellites and build their national space programmes and initiatives, leading to the creation of new realities for policy-making. Finally, yet importantly, the increasing vulnerability of operational space and ground-based critical infrastructure to human-made and natural threats in and from space may put at risk services on which modern societies heavily and increasingly depend.

On the national scale, things have also changed significantly. The past four years have seen a surge in newcomers entering the space ecosystem, as well as the emergence of the subsidiary of a Large System Integrator and the establishment of a Satellite Operator, amongst others. These changes may alter well-established patterns of partnerships and competition and create a new dynamic that should create new opportunities for individual actors of the space community in Switzerland.

These latest developments within ESA, in Europe and in the world mean that Switzerland, as a nation active in space, must further define its position in terms of

- the increased dependency on space infrastructure as a modern state;
- promoting its interests in an extended ESA (new actors, new initiatives);
- its role in European space efforts as a non-EU member;
- the limited access to market for Swiss actors in space (absence of national market, limited access to EU markets);
- the increasing global competition from public and private actors.

3.1 Objectives

The Federal Department of Economic Affairs, Education and Research EAER has responded to the challenges that the space industry and academia are facing with the initial version of the Swiss Space Implementation Plan (SSIP 2014-2023) in 2013. This has been a significant step for Space in Switzerland. It recognized and strengthened elements of success of the past, while at the same time created the common grounds to tackle the future through measures implemented within the ERI funding instruments.

The objective of this revision (SSIP 2018-2020[1]) is to adapt the existing measures and to propose new ones where appropriate and necessary. It is prepared through consultation with Stakeholders and shall remain a tool to support the decision-making process on the allocation of the financial resources defined in the current ERI Dispatch 2017-2020. It also looks at the events and achievements since 2013 and is in line with the review schedule set out in the initial version.

3.2 Methodology

This revision has gone through a process of analysis to gather insight from within and outside the Swiss space ecosystem. It considers the decisions taken by the Federal Council for the ESA Council Meetings at Ministerial level in 2014 and 2016. Feedback collected through diverse working groups within and outside the administration, informal consultations, material made available by the European Space Agency ESA and a strategic process performed by the Federal Commission for Space Affairs (CFAS) contribute to that. For the external analysis the current themes observed in the space sector were juxtaposed with slow-moving, high-impact trends to understand fundamental drivers. The outcome is reflected in chapter 4 for an inside view of the Swiss ecosystem and in chapter 5 for the external drivers. We present the resulting recommendations and proposed measures in chapter 6.

3.3 Implemented measures

The most notable of the implemented measures recommended in the initial version of the SSIP are:

- Elaboration and the subsequent implementation of a concept for Space Business Incubation. The result was a competition for and the establishment of the ESA Business Incubation Centre Switzerland.[2]
- Implementation of a PPP (Public-Private Partnership) Scheme for the ESA BIC Switzerland and selection oflarger community-driven projects and programs within ESA.
- The Applications Push, fostering the uptake of space-based or -augmented services and applications in non-space communities.[3]
- Call for a next small mission and selection of a mission (up to Phase A)[4]

During the planning and implementation of individual actions, it became clear that some of them are ripe for consolidation and would allow an increase of the impact. Bringing together the initiative for Applications (IAP Ambassador Platform) with the Business Incubation initiative is probably the most obvious.

There also exist some European and national initiatives for the matter of community building that are complementary to measures from the initial version of the SSIP. Many new ideas and initiatives have sprung up in the past years. ESA initiatives, as well as from various other organizations and actors[5] create awareness and momentum. However, they also compete for attention and resources in Switzerland and threaten the best use of resources and effort within the community. To use these and catalyse them through Switzerland's participation in ESA programmes remains therefore a priority.

[1] Compared to the initial version, this revision looks at the medium-term, in line with the ERI Dispatch 2017-2020, spanning the next three years.

[2] ESA BIC Switzerland opened its doors in November 2016. Since then, two selection campaigns have already led to the conclusion of 10 successful incubation contracts with start-ups. More information at http://www.esabic.ch.

[3] The application push, together with the running of the Ambassador Platform, resonated beyond the Space community. The result is a pipeline of high-quality projects that bring services and applications based on satellite data and infrastructure down to earth. More information at http://www.ap-swiss.ch.

[4] The implementation of this Phase A is currently under way.

[5] like Eurisy, events like the European Satellite Navigation Competition, the Copernicus Masters, the ESA Grand Challenge or much smaller, targeted initiatives

4 THE INSIDE: STATE OF THE SWISS SPACE SECTOR

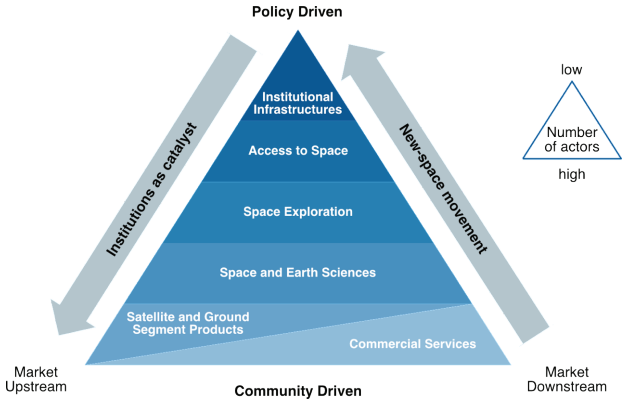
Switzerland strives to position its space sector for global competitiveness or within unique domains of strategic value. This secures our aim to be a competitive, reliable and vital partner. Excellence and competitiveness in science and industry are enabling forces for this and the SSIP supports this through its focal areas, measures and actions.

This chapter reviews the evolution of the National Focal Areas identified in the initial version of the SSIP and provides a strategic framework to better put the fields of activity in perspective.

4.1 Strategic framework and current fields of activity

The transversal nature of activities in the space sector drive the need to sharpen and provide more clarity about strategic intent for individual segments in which Swiss actors are active. Synergies, both for academic and industrial actors, as well as the evolution of the sector and competencies over time are important additional factors to consider.

The following framework represents a view taken by the EAER, both strategically and operationally, on the relative nature and drive of segments where Switzerland is active in space, including both scientific and industrial capabilities.



The framework illustrates the traditional trend in which developments and approaches initially intended for institutional use catalyze the development of commercial products, but also highlights a newer trend, understood by some as the "New Space" movement or "Space 4.0", where commercially driven developments find their path into the institutional markets.

Despite the limited market size, Swiss entrepreneurs and researchers have achieved healthy and substantial positions in various segments through competition in European institutional space programs and the commercial market. We review the most notable ones hereafter.

4.1.1 Institutional Infrastructures

Large institutional infrastructures like EUMETSAT weather satellites, the Galileo and EGNOS Satellite Navigation systems, the Copernicus earth and environment monitoring or the envisaged GOVSATCOM governmental telecommunications systems are areas of strategic importance for a modern state. They provide access to many different applications and services like meteorological information, precision navigation or information for the protection of critical infrastructures to name a few.

These infrastructures also enable sectorial politics and are an area of cross-departmental collaboration at federal level. A strategic approach, bridging the organizational gaps, is necessary and supports economic growth, digital economy and transformation, security and protection of citizens.

Switzerland must continue to participate to the development and exploitation of space-based infrastructures that allow to constantly improving the quality of life of citizens. The scientific, technological and industrial contributions are the competencies that make Switzerland a competitive, reliable and vital partner in these developments. The resulting applications and services, in fields of meteorology, navigation, climate change, security, or disaster management not only contribute to our economic fabric and security, but also help to tackle today's societal challenges.

4.1.2 Access to Space

Independent access to space is for Europe and Switzerland of high strategic importance. The development of the Ariane and Vega launch systems by ESA secures this access. ESA also contributes to the further evolution of these launch systems through new technologies targeted at improving reliability, increasing lift capability and reducing operational costs. Finally, ESA provides significant support to measures that maintain and supplement launcher production, improve launch services and support operations at the European spaceport in French Guiana (Centre Spatial Guyanais CSG).

At the Council at Ministerial level in Luxemburg 2014 the decision was taken to start the development of Ariane 6,

a new launch system, which should provide at least the same performance capabilities on the market as the existing Ariane 5, but at significantly lower costs. In parallel, the Vega launch vehicle will be further consolidated (Vega-C) to improve reliability and to reduce launch service costs. Along with this decision came an important change of paradigm: these two European launchers will respond to almost all European launch service needs. The private sector in charge of the developments will take on more responsibility and bear more risks in exploitation. It is expected that a stronger European institutional exploitation of these new launchers will further contribute to the launchers competitiveness. More recently, at the Council at Ministerial level in Lucerne in 2016, steps were taken to further prepare European launchers for future requirements regarding market demand and technology push. Given the increased market of small to tiny satellites, the study of new concepts allows responding to their launch service requirements, based on either existing European launchers (Ariane and Vega) or commercial micro-launchers.

However, space debris and the overall increase in space traffic threaten Europe's access to space. Space Situational Awareness and Space Traffic Management are becoming important topics in securing this access. Initiatives at ESA and EU level aim to prepare Europe to respond to these threats.

Switzerland considers its participation in all these efforts as a critical strategic contribution to European access to space, and continues to support European preference in access to space.

4.1.3 Space Exploration

Space Exploration at a global level continues to be a very visible source of inspiration for the larger public and is the canvas for many of the aspirations of the private sector in space. The public closely followed the Moon landings during the Apollo programme and the flights of the Space Shuttle during a period of 30 years, including the flights of the first Swiss astronaut Claude Nicollier. All this helped to establish human spaceflight as a highly visible element of space. Despite the highly political motivation of these spaceflight efforts, science has always been an integral part of these programmes.

Today space exploration is based on international collaboration between many spacefaring nations. The International Space Station ISS is a truly international collaboration between the USA, Russia, Canada, Japan and ESA, representing more than 10 of its Member States, including Switzerland. The primary objective of the Swiss participation in the exploration programmes is the scientific utilization of the ISS, the development of scientific instruments for ESA missions and industrial contributions to both ISS development and exploitation and other exploration missions. The competencies found in Swiss industry reflect these scientifically relevant areas. These skills allow the creation of synergies within Switzerland and close collaboration between the academic and industrial sectors.

Looking forward, spacefaring nations have started the discussions about the next steps in space exploration beyond Low Earth Orbit (LEO). The Global Exploration Roadmap (GER) forms the baseline of international efforts towards the next steps in space exploration. The development of a Deep Space Gateway (DSG), a small space station near the Moon, appears as the emerging next step after the ISS. In parallel, efforts will continue to commercialize the access to LEO, for both crew and cargo, as well as the utilization of the ISS. Private actors could become an integral part of this space exploration architecture. Finally, development of new technologies should close strategic gaps, reduce the dependence on Earth, and enable long-term missions to the Moon and beyond.

Switzerland already participates in the development of missions identified in the Global Exploration Roadmap, such as the ExoMars mission. It also supports the programmatic framework for the development and evolution of ESA's space exploration ambitions as well as ESA's decisive role at European level in international initiatives to foster cooperation at global level, such as the International Space Exploration Forum (ISEF). Switzerland will have to decide its strategic and political priorities in this context. The long-term priorities of Switzerlands investment have to be assessed in view of these developments, building on excellence in science and competitive industrial contributions in this area, and including approaches to ensure certain coordination in these domains of activity.

4.1.4 Space Science and Earth Observation

Science activities form the backbone of Swiss Space Policy. The heritage and excellence of Swiss science provide a solid starting point for major instrumentation designs. The design and performance of such instruments provide the bases for outstanding science. Fundamental science as well as applied research have a long-ranging impact on Space technology and beyond. Research areas include Solar physics, planetary science, astrophysics and cosmology, but also Earth sciences related to the atmosphere, cryosphere, biosphere, hydrosphere, and other aspects. The ground-breaking science of Earth Observation missions play a fundamental role in understanding how the Earth works as a system and what factors affect Earth's delicate balances. The cross-fertilization of science and technology not only paves the way for pushing the science boundaries further but also offer means to better understand and respond to the challenges of global change.

The Swiss research community has not only developed and built instruments and experiments for ESA's major missions. Pooling up with the national industry Swiss instruments are

also flying on various national missions in Europe and worldwide. This strength in designing, building and operating space-based instruments positions Switzerland among the leading nations at the global level of Space science. Obviously such activities also present opportunities for long-term research networks in areas of strategic importance, yet it also increasingly requires improved coordination and prioritization within the community.

4.1.5 Satellite and Ground Segment Products

Satellite and Ground Segment Products represent the upstream part of the satellite market where most industrial space actors in Switzerland have positioned themselves to supply hardware. In terms of commercial activities, telecommunication represents the biggest market for satellite and ground segment products. It is also a domain where public-private partnerships are most common with ESA.

Satellite and ground segment products may experience significant cyclicality within institutional and commercial demand. The position of the Swiss actors is in a "bottom-up" manner and requires constantly adjusting their competiveness and unique selling proposition. In particular, through the "new space" movement globalisation of the sector, verticalisation and streamlined industrial processes can best be seen within this segment.

4.1.6 Commercial Services

Commercial services based on satellite telecommunications, navigation and earth observation data and infrastructure represent the biggest economic opportunity of the Space Sector today. They offer unique opportunities for substantial economic growth in Switzerland.

Companies developing and marketing such commercial services have become an important element of the Swiss space landscape. Many of these companies do not have a space background but use these space assets in unique, value creating ways in their original industry.

In all these efforts, the government plays the role of an enabler and catalyst that creates and supports excellent boundary conditions. Targeted initiatives help to raise awareness of the value of space data and infrastructure and leverage ESA's own expertise and network. They also bring together entrepreneurs with private investors and generally support efforts to highlight the economic and societal benefits of having solutions and services using space.

4.2 Technology Axes

One element of the Swiss Space Policy is the technology axes. The five axes defined in Switzerland's Space Policy are still valid but have evolved to respond to new market needs. Much of the policy setting and application will continue in the same way as during the past years. However, it also becomes clear that the rising interest for space-based solutions, the growing ecosystem and hence increased competition across different space domains (See section 4.3 below) require a review of the mechanisms and instruments for priority setting in place.

4.2.1 High-precision mechanisms and structures

High-precision mechanisms and the associated systems have evolved to become a significant area of expertise. Swiss industry and academia have the potential, through continual innovation, to retain their recognized position on the worldwide market of mechanisms in and for space. Structure capacities are also based on a strong academic and industrial heritage although they face increasing competition. Innovation in new materials and advanced manufacturing processes, such as additive manufacturing and process automation are essential to ensuring that Switzerland retains a competitive edge; it will also help to solve the fundamental challenge in space, namely cost-efficiency, time-to-market, and weight-reduction.

For both themes, capacities are currently available, and the market is dynamic. In line with the initial version of the SSIP, this technology axis will have to be re-assessed depending on the innovations achieved in the meantime.

4.2.2 Atomic clocks

Switzerland's position in atomic clocks, and especially in the field of Rubidium and Passive Maser technologies, is world class and secures a strong position on the global market. To stay at the forefront, fundamental capacities at an academic and industrial level in the area of Time & Frequency are of high importance.

Timing and Navigation remains an area of strategic importance. Taking a strong position in future technologies has to be assessed.

4.2.3 Photonics

Photonics that is the generation, detection and manipulation of light (photons) has the potential to become a central element of future spacecraft technology. Technological advances in materials, processes and system engineering, as well as miniaturization and continued reliability engineering, will lead to unparalleled performance gains of photonics technologies. It will allow the development of novel sensing concepts for space science, Earth Observation and will be one solution for the ever-increasing need for bandwidth in data generation, handling, and transmission. Fostered through its national NCCR Switzerland is well advanced in developing key competencies in these technology domains, ranging from optical components and lasers, to applications and systems in micro-electromechanical systems (MEMS). At higher level electro-optical data transmission, LIDARs and quantum optical systems are evolving towards market up-

take. Implementing spaceborne photonics will lead to novel scientific and commercial applications, significantly extending the capabilities and competitiveness of current space assets. An area of increasing market dynamic with elements of potential strategic importance, this axis will be re-assessed within the timeframe of the next SSIP revision.

4.2.4 Technologies for scientific instruments

While scientific instruments will continue to play a central role in the Swiss space policy the required and invested resources have to be carefully evaluated. Scientific instruments are most often unique and used in experiments that are only conducted once. However, some instrument technologies see continuous improvement (e.g. detector characteristics) as part of on-going research programmes and some clear the grounds for day-to-day applications in non-space markets. An increased focus on scientific excellence should support efforts for prioritization, combined with measures for cost-reductions (e.g. through recurrence and reuse) as well as more hands-on management.

4.2.5 Technologies for user-funded applications

Innovative small system approaches (optical, light detection and ranging - LIDAR, synthetic-aperture radar - SAR) are essential to capture relevant processes at regional scales typical for Switzerland and similar topographic areas. High-quality small systems such as these provide a technological challenge and could also provide a direction to go for future small flexible systems. Novel and innovative data exploitation and processing methods, such as linkage to onboard hardware modules (e.g. chips), combining data from various sources, and fast processing methods, need to be pursued in parallel to the above.

Integrated solutions/products combining data from different sources or using combining different space infrastructures remain an essential element of user-funded applications. The research focus continues to be driven by the need to understand and quantify environmental processes more accurately and from an end-to-end perspective. From a technology perspective, we expect smaller, flexible systems that are dedicated to answering specific questions. At the other end of the value chain, the data gathered must be translated into actionable information to support a variety of user communities, decision making, and societal benefits. In that context, the interaction, communication, and networking between basic science and practical applications are of high importance. An assessment of Switzerland's participation in various, applications related areas and the generated impact shall happen within the next three years, in line with the programmatic phasing at ESA.

4.3 Growing Space Ecosystem

We consider that the space landscape is a business ecosystem: a dynamic structure which consists of interconnected small firms, large corporations, universities, research centres, public sector organizations, and other parties which influence the system. Such an ecosystem view allows looking at the nature of the relationships between actors, which can be for example, parasitic or mutualistic, as research has shown[6].

Over the past four years, Switzerland has seen a cumulative annual growth rate of 10% of newcomers in this space ecosystem. This increase has enlarged the ecosystem and hence the number of relationships considerably: The landscape has become much more diverse, including the creation of a Satellite Operator business, the establishment of a Large System Integrator's subsidiary and numerous smaller actors with a high potential. Many of the newcomers are start-ups.

This growth impacts established patterns of operation and collaboration, both within Switzerland and internationally, and between academia and industry. It increases competition for resources and funding and challenges established relationships. However, it also creates new opportunities for successful domains of activity. Many, if not most, of the newcomers enter the market with new technologies or technological capabilities, further supporting technology and knowledge transfer.

From a policy point-of-view, both the medium as well as the shorter-term decision cycles in the institutional setting must adapt to this reality too, and in a reliable, consequential way. Trade-offs between very different domains for potential technology developments need to be done. Higher-risk customer driven new markets to low-risk core markets need to be encompassed across all segments of the strategic framework.

With a relatively small but thriving ecosystem spanning the whole spectrum from fundamental research to services and applications, bringing in new domains and creating new mutualistic relationships into many non-space fields is a further challenge. One particular issue here is the potential for increased technology- and knowledge-transfer. This core task of the ERI (Education, Research, and Innovation) domain can arguably enhance the impact of the R&D funding in space by a magnitude and can help strengthen the whole ecosystem.

[6] Mazzucato M., (2013), The Entrepreneurial State: Debunking the Public vs. Private Myth in Risk and Innovation. London: Anthem

Technology axes will remain, but the Swiss space sector is at a crossroad where it may choose to embrace stronger mutualistic relationships among traditional space actors, downstream service providers and users. If this succeeds the Swiss ecosystem might well gravitate towards space enabled business clusters. Such clustering could start emerging around next generation satellite telecommunications, timing & navigation and big data from space.

5 THE OUTSIDE: EMERGING THEMES

Slow-moving, high-impact trends – also known as megatrends – are shaping our collective future. Elaborating responses to these, and looking at the strategic challenges the space domain faces, are two crucial elements of space policy and the implementation plan.

In its Science and Technology Outlook 2016, OECD laid out eight megatrends shaping our collective future . The authors write : "Ageing societies, climate change, health challenges and growing digitalisation are, among other factors, expected to shape future R&D agendas and the scope and scale of future innovation demand. Novel markets are likely to emerge, creating new skills needs and new growth and job opportunities. New approaches to sustainable growth, e.g. through the circular economy, are making their way."

The following is a mapping of these mega trends to emerging themes that have relevance from a space perspective. Close cooperation with national and international entities (e.g. CFAS, ESA) is necessary for the implementation of strategic measures that position the Swiss space sector within these topics.

5.1 Theme 1

Ubiquitous connectivity and increased cyber security needs

Economy, society, and government are requiring ubiquitous connectivity with growing cyber security requirements. Observed trends are

- Flexible, high data throughput satellites with beam steering capabilities enabling high data rate streaming to mobile ground terminals
- Development of inter-satellite communication capabilities and decrease in latency
- Increase in infrastructure resilience through adaptable satellite systems and mega-constellations
- Creation of in-orbit commercial services, such as servicing and de-orbiting
- Secure communication for governments and critical infrastructures (e.g. through quantum-safe cryptographic solutions)
- Growth in the demand to launch payloads into orbit
- Large constellations leading to greater focus on Space Situational Awareness (SSA) / Space Traffic Management (STM) and space debris mitigation

5.2 Theme 2

Push for ambitious exploration goals and extending human economic reach beyond low-Earth orbit

In an increasingly multi-polar world, the significant world powers will challenge each other on who will lead humankind in space exploration. The anticipation of lucrative exploitation of resources will accelerate the trend.

Observed trends and possible impacts

- Build-up of a human outpost by the U.S., in partnership with other spacefaring nations, around the Moon and preparation of a human mission to Mars
- Expansion of Chinese human exploration programme with a space station in low Earth orbit and focus on human exploration of the moon, deep space exploration with robotic probes.
- First exploratory missions to scout for possible targets for space mining (Moon, Mars and Near-Earth Objects for water, ore, minerals, and others)
- Public-private partnerships in exploration (e.g. ISS, in-orbit refuelling, cargo delivery, and others.)
- Increase of the duration of human independence from Earth

5.3 Theme 3

"Big Data" on Planet Earth

Spatial and temporal resolution of global monitoring for environment and security from space is increasing. Interpretation of the data is a Big Data challenge with many fields of application.

Observed trends and possible impacts

- Near real-time availability allows to monitor and deepen our understanding of climate change
- Innovative agriculture technologies allow improving the yield and reduce the use of water and fertilizer
- Food security assessment and harvest estimation allow to improve humanitarian aid efforts
- Improved air quality monitoring and mapping of pandemic outbreaks
- Selection and management of renewable energy production sites
- Coordinated forecast and response to major disasters and humanitarian crisis

- Better control of borders and maritime traffic allows improving security
- New commercial services for banking, insurances or commodities producers

5.4 Theme 4

Fundamental questions in science such as the search for life

The mastery of ever more complex scientific missions and recent discoveries such as those done through the comet-chaser spacecraft Rosetta or Exoplanets in habitable zones will allow obtaining additional clues or even proof of fundamental questions regarding the existence of life elsewhere in the universe.

Observed trends and possible impacts
- Analysis of the atmosphere of Exoplanets from space-based observatories
- Mission to study phenomena of fundamental physics such as gravitational waves
- New robotic missions to the outer solar system, in particular to moons where liquid water is suspected
- Sample return missions to Mars and to comets

5.5 Theme 5

Generational change and global competition for talent

Globalization and demographic changes will lead to a generational shift and competition for talent.
Observed trends and possible impacts
- Innovation and investment in skills drive growth
- Generational change leads to the loss of know-how and the need for aerospace engineers worldwide
- A more globalized world allows for easier human mobility with increased competition for talent, global centers of excellence establish themselves to be able to compete in a sector

5.6 Theme 6

Accelerated industrialization of the space sector

Globalization and Societal Needs for data and connectivity is leading to an accelerated industrialization of the space sector.

Observed trends and possible impacts
- Product life-cycles and lead times are decreasing
- Larger batch sizes are leading to integrated supply chains, with production becoming digitalised and lean
- Accelerated know-how exchange of advanced manufacturing processes between industries
- The use of low-cost commercial-off-the-shelf components is becoming more acceptable
- Plug-and-play low-cost platforms are becoming readily available to new actors

5.7 Theme 7

Space tourism

Reduction in recurring cost for suborbital and orbital launches may eventually lead to the emergence of space tourism.

Observed trends and possible impacts
- Suborbital flights with tourists become affordable
- More and more ventures moving from suborbital flights to orbital flights into low-Earth orbits
- Emergence of commercial space stations used for research and as "hotels" for space tourists

6 THE RESPONSE: NEW MEASURES

This first revision of the SSIP aims at defining new, targeted measures, described in further detail below. The measures inform the work of the EAER related to space over the coming years. They reinforce the Swiss position in its focal areas and supports the Swiss space researchers and industry to reap benefits from the emerging themes.

The growing ecosystem, the evolution of ESA and the EU's current and future role in space are the strongest medium-term drivers for measures in this revision of the SSIP. These drivers also represent challenges for policymaking and the economic perspective. Dedicated measures enable inclusive development of the space ecosystem in Switzerland. These measures should also be seen in the context of the strategic framework outlined in section 4.1 and may target individual segments.

6.1 Foster competitiveness and excellence

Looking at the community driven ("bottom-up") initiatives is above all looking at the innovation funnel, its dynamics, critical hurdles and enabling elements, and the various stages an idea might take from its inception to its transformation into innovation. The role of the EAER in that context should be the one of a catalyst for development through targeted measures and best possible boundary conditions setting. It aims at a robust and integrated innovation funnel within or enabled by the space sector in Switzerland and beyond.

The measures build upon trusted and proven instruments and organizations, including the ones of the European Space Agency ESA, the Swiss Space Center, CTI/Innosuisse, H2020 and beyond while considering their respective complementarities. This also includes international partnerships with space powers worldwide[9].

[9] While underlining the importance of strengthening international cooperation for the peaceful use of outer space, the Swiss government will also need to evaluate the relevance of space products in export control policy and determine, if necessary, the establishment of boundary conditions facilitating exports.

Measures for the development of the ecosystem should have one of the following functions – directly or indirectly – to realize compound effects over time:

- **Attract** – Attract new ideas and actors as the fundament to grow and strengthen the network
- **Hunt** – Actively hunt new ideas, technologies, and knowledge with the potential to create a return in the space ecosystem
- **Select** – Continuously raise the selection standards for the development of new capabilities, both for scientific, institutional and commercial needs
- **Teach** – Ensure adequate training and education, for the short-term, but also for longer-term purposes
- **Support** – Support the growth and strengthening of the ecosystem with targeted measures
- **Invest** – Invest into R&D via the ESA R&D programs and by facilitating and promoting further access to capital, as well as by emphasizing economic/commercial viability of space R&D activities
- **Innovate** – Innovate the process for the development of the ecosystem continuously

In line with these functions, continued analysis of the evolution of the space sector and Switzerland's investments in ESA complement these measures, together with an in-depth assessment of the technology axes and the areas of excellence.

6.2 Contribute to Digital Switzerland

The chief role of today's satellites is to generate and handle enormous amounts of data on a daily basis. Except for few large data aggregators, mainly in the Silicon Valley, the pace of data generation has surpassed the capabilities of the industry, scientists and governments to follow and reap the full benefits of space data offered through today's and future space-based systems. This situation is due, in large part, to a lack of adequate human and financial resources allowing individual actors to build upon these capabilities. These capabilities not only have a profound impact on sectoral politics such as, environment, migration, and security but may also transform sectors, which have not traditionally depended on space-based infrastructures. Examples of such sectors are energy, banking, commodity trading, insurance, and cyber security.

The space sector is thus predestined to contribute significantly to digitalisation efforts. Satellite navigation, telecommunications, and geospatial space data, including in-

tegrated applications, services, and products, can benefit the Swiss private and public sectors, as well as society as a whole. Access to space data and infrastructure and therefore Switzerland's engagement in the domain, will continue. It can and even must integrate with public and private efforts to realize the digital transformation of the economy and the country at large.

To strengthen this uptake and awareness, measures could be threefold:
- intensified exchange with high-level decision-makers in the private and public sectors raise awareness about the potential of space data and infrastructures for the digital transformation;
- strengthening of the innovation chain by encouraging scientific research and university training as well as investments by the private sector in the development of innovative services leveraging space data and infrastructures; and
- work towards securing the access for Swiss actors to major space related data sources and infrastructures.

6.3 Strengthen the Swiss space community

6.3.1 Enable stronger networking and clustering

Due to its relatively small size, the space ecosystem in Switzerland is very sparse. Despite a long heritage, no real clustering has happened so far, in spite of existing instruments in Switzerland that would allow the community to implement clusters (e.g. Working Groups in the Swiss Space Center, private initiatives with networking workshops, the Swiss Space Industries Group, SCNAT commissions, and others).

On the other hand, robust and diverse networks and clusters are essential ingredients for innovation[10]. We, therefore, propose measures, which allow growth around the strong focal areas as well as expansion into new domains and at the same time, strengthen the network of space actors in Switzerland:
- foster network building between organizations and individuals from diverse backgrounds, allowing networking partners to gain radically different perspectives;
- broaden knowledge and technology transfer by connecting Swiss actors to knowledge and technology transfer initiatives at the Universities (national and cantonal) and programs such as ESA's own Technology Broker Network;
- work with organizations active in technology transfer to increase the effectiveness of these initiatives;
- strengthen existing centers of excellence showing the potential to streamline and foster collaboration among the actors efficiently;
- allow for bottom-up coordination between actors and roadmap based planning in segments, such as space sciences, where priority setting requires decadal planning, and emphasize on excellence;
- foster collaboration between the space sector and CTI/Innosuisse, allowing the space community to grow awareness beyond its tight-knit core.

6.3.2 Develop education initiatives

Education and training permeate the themes and measures presented above. At primary and secondary level, space sciences and technology awaken the curiosity and inspire children and youngsters to engage in Science, Technology, Engineering, and Math (STEM) subjects. At the tertiary level, the multi-disciplinary nature of space technology and science engages students to adopt a holistic view of systems and phenomena, and to acquire knowledge and experience in solving complex and challenging problems. Such characteristics and competencies are not only widely sought by the space sector, but also by industry in general.

More specifically, space-related educational hands-on projects such as rocketry or satellite building have turned out to attract exceptional youngsters and students. Such opportunities are often the catalysts for successful start-up creation or the launch of distinguished individual careers. With an outstanding tertiary education sector, Switzerland's institutions are recognized and much sought after partners in international projects. Also, they could play a more active role to foster collaborative projects across Europe.

During the 2016 ESA Council at Ministerial Level in Lucerne, the agency has also emphasized the importance to prepare the next generation of experts in science, technology, engineering, and mathematics, through investment in inspiring missions and support to education.

Education initiatives tailored to the specificities of the cantonal and national systems must be an integral part of the Swiss space ecosystem. The primary objective of a coherent concept should, therefore, be to encourage Swiss academic actors to strengthen space-related training and to foster participation in education initiatives, such as the ESA-Lab. Further measures may focus on working with the cantons and teachers' associations to make optimal use of ESA's readily available teaching materials in our schools or running a specialist center such as the ESA-ESERO (European Space Education Resource Office).

[10] Harold Jarche, Diverse Networks, Strong Relationships, https://jarche.com/2015/09/diverse-networks-strong-relationships/, retrieved June 2017

7 ANNEX: OTHER FUNDING INSTRUMENTS

For the sake of completeness, other funding instruments in the ERI domain with relevance for space activities are briefly described below, and their complementarity to ESA programme participation and National Complementary Activities (NCA) is highlighted.

7.1 Swiss National Science Foundation

The activities supported by the Swiss National Science Foundation (SNSF) include research at a university or a university of applied sciences, including data acquisition, data processing and analysis and the publication of the scientific results. SNSF grants enable the funding of post-doctoral scientists, Ph.D. and graduate students as well as scientific collaborators. A limited support for the procurement and operation of laboratory equipment and access to research infrastructure is also possible. This complements the basic financing of the academic partners, such as the universities which are mainly at cantonal level and the Federal Institutes of Technology (FITs) at federal level.

With regard to space activities, the support from the SNSF is specifically relevant in relation to the development activities of scientific instruments for space missions. In ESA's Scientific Programme, as well as in the programmes related to robotic exploration and human spaceflight, ESA funding is used for the development and operations of the spacecraft, while ESA Member States contribute scientific instruments and experiments through other funding sources. In Switzerland, such instrument and experiment developments are funded through the ESA programme PRODEX (PROgramme de Development des EXperiences scientifiques), being an important vector of cooperation between academic and industrial partners and consequently of know-how transfer. This programme supports the actual development, manufacturing and testing of instruments and experiments, including software developments for the scientific ground segment, but does not provide funding for the data processing, data handling activities and any type of research activities. From that perspective Swiss funding in ESA programmes (including PRODEX), and the funding from the SNSF are fully complementary and need to be secured in the long term, as well as the commitment on the part of academic partners exploiting the data.

7.2 Commission for Technology and Innovation

As the Confederation's innovation promotion agency, the Commission for Technology and Innovation (CTI), and, in the future, Innosuisse, lends support to R&D projects, to entrepreneurship, as well as to the development of start-up companies. The CTI/Innosuisse helps also to optimise knowledge and technology transfer through the use of national thematic networks. The CTI/Innosuisse shares a number of common points with the goals of technology research and development within ESA programme frameworks. Both are of a subsidiary nature and both ultimately help create sustainable value for the Swiss economy. However, there are also a number of significant differences in the way they work, especially with respect to ESA programmes for technology research and development, which basically funds projects mostly in industry. Most notably, these differences are

- the international focus of ESA activities, with national and international cooperation;
- the role of ESA and its experts as the primary evaluator of technology developments and funding requests, with the Swiss ESA Delegation working as a gatekeeper to oversee the overall budgets allocated to ESA;
- the support for the very specific, and rigorous requirements for the development, qualification and certification of space borne products within ESA programmes, and
- the different timeframes for activities and breadth of domains: space related activities usually start at very low technology readiness levels, have long development cycles (several years) and products need to be flight-proven before being accepted by the market, whereas CTI funded activities are from their beginning already close to the market.

These differences are eventually the reason why CTI and ESA funded technology research and development are such complementary activities. Nevertheless, in sectors such as the promotion of applications & services derived from space-based data and Public-Private Partnerships, or in the area of clustering and networking, new forms of co-operation may be evaluated, especially also in view of the re-positioning of CTI as Innosuisse.

7.3 Framework Programmes for Research of the European Union

The European Space Policy, jointly developed by ESA, the European Union and their respective Member States, assigns complementary roles to ESA and the EU: R&D for satellites and payloads up to in-orbit-demonstration, are the responsibility of ESA, while the EU takes care of the deployment of operational infrastructures and the development of services to meet the EU's political and societal needs. Additionally, workplans in areas of common interest, e.g. for the development of future generations of operational constellations such as the European satellite navigation system Galileo, are elaborated through mutual consultation.

That is why the activities of ESA and the EU are not only complementary, but active participation in ESA programmes also prepares the ground for successful participation in EU-led phases of joint programmes such as Galileo or Copernicus, the European Earth monitoring capacity for environment and security. Switzerland's participation in the EU-led phase of Galileo is finalized, allowing Swiss based actors to fully participate in application and service developments.

8 ANNEX: ABBREVIATIONS AND ACRONYMS

CHEOPS	CHaracterizing ExOPlanet Satellite
CTI	Commission for Technology and Innovation
ERI	Education, Research and Innovation
ESA	European Space Agency
EU	European Union
FIT	Federal Institutes of Technology
LIDAR	Light Detection And Ranging
MEMS	Micro-Electro-Mechanical System
NCA	National Complementary Activities
OECD	Organisation for Economic Co-operation and Development
PRODEX	PROgramme de Développement d'Expériences scientifiques
R&D	Research and Development
SAR	Synthetic Aperture Radar
SME	Small and Medium Enterprises
SNSF	Swiss National Science Foundation
SSIP	Swiss Space implementation Plan
SSO	Swiss Space Office
USA	United States of America