

Switzerland's Journey into Space

30 years of PRODEX – PROgramme de Développement d'EXpériences scientifiques



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Cover photo, front:
2017 – The search for another Earth. The aim of the CHEOPS (CHaracterising ExOPlanet Satellite) mission will be to study, with the help of a Swiss-built space telescope, the characteristics of planets outside our solar system.

Cover photo, back:
1969 – A giant leap for research. The first “flag” planted in the lunar soil by US astronaut Buzz Aldrin, part of the team to make the first Moon landing, was not the Stars and Stripes but a solar wind collector developed by Bern University.



Dear space fans

It is a generally well-known fact that the Apollo 11 astronauts were wearing Swiss watches when they made the first Moon landing. However, what is less well-known is that the only non-American scientific experiment on board came from Switzerland, and that it was set up even before Buzz Aldrin planted the Stars and Stripes in the dusty lunar soil.

However, this solar sail, which was developed by the University of Bern, was not Switzerland's earliest foray into space. Thanks to its education system, research funding and industrial innovation, Switzerland had already notched up its first success in satellite space exploration as far back as the 1950s.

Given the resources needed for space activities, we have always understood that the only way we can win and keep our seat at the space research table is through international cooperation. Consequently, as a founding member, Switzerland played its part in the development of the European Space Agency. A tangible result of this commitment to space research is PRODEX. The aim was to put in place a programme that would give smaller states access to ESA's project management and technical expertise when it came to developing scientific instruments. As a result, nations with few resources and structures at their disposal had a chance to contribute to the development and construction of high-grade and complex instruments for space research.

The way in which science and industry work together on these projects is exemplary and has been a source of mutual inspiration. As well as the transfer of skills and knowledge, involvement in these projects allows these key economic players to extend their network of contacts, build trust and provide a launch pad for successful careers. All in all, a recipe for success that we also want Swiss research and innovation policy to follow.

I was delighted to provide the foreword for this publication which celebrates the achievements of PRODEX throughout its 30-year history. For the last three decades, Switzerland has carried out projects which have helped Europe make amazing progress in the field of space science. ESA is now one of the most innovative space agencies in the world. Thanks to its scientists, engineers, firms and PRODEX, Switzerland has forged an excellent working relationship with all of the world's major space agencies, including ESA. A stellar achievement made possible by Switzerland's science and foreign policy.

Enjoy!

A handwritten signature in black ink, appearing to read 'Mauro Dell'Ambrogio'. The signature is fluid and cursive, with a large initial 'M'.

Mauro Dell'Ambrogio
State Secretary for Education, Research and Innovation

Why PRODEX? Other countries have their say

The PRODEX programme (PROgramme de Développement d'EXpérience scientifique) aims to build Europe's space and scientific capabilities. Involvement in PRODEX allows smaller ESA (European Space Agency) Member States with no national space agency and/or with limited resources at their disposal to draw on ESA's outstanding expertise and experience in order to advance their own work in this field. Their participation also gives them a valuable opportunity to put their cutting-edge scientific and technological knowledge to good use by contributing to the success of European and international space missions.



“We pool our knowledge and expertise to improve our understanding of space” Interview with Michel Lazerges, Head of the PRODEX Office at ESA, Noordwijk, NL 6

Facts & Figures The Swiss Space Cluster. 9

Learning from Mars Profile of Ruth Ziethe, Project Manager, Space Research & Planetary Sciences, University of Bern 10

Mapping the Universe Profile of Stéphane Paltani, Principal Investigator, Institute of Astronomy, Geneva University 12

The sunny side of research Profile of Margit Haberreiter, Project Manager, Davos Physical-Meteorological Observatory PMOD 14

Switzerland and the James Webb Space Telescope Profile of Adrian Glauser, Lead Instrumental Scientist, Institute of Astronomy, ETH Zurich 16

30 years devoted to Rosetta Profile of Professor Kathrin Altwegg, Executive Director, Center for Space and Habitability, University of Bern 18

On the trail of neutron stars Profile of Enrico Bozzo, Project Manager, Department of Astrophysics, University of Geneva 20

Switzerland’s direct line to the International Space Station (ISS) Profile of Alexandra Deschwanden, BIOTESC, Lucerne UAS. 22

“The reason we don’t still live in caves today is because of humans’ innate curiosity” Interview with Professor Willy Benz, Head of the Physics Institute, University of Bern 24

Facts & Figures Milestones in Swiss instrument development. 27

Ultra-reliable circuits from the Bernese Lowlands Profile of Nanotronic GmbH, Lyss 28

A family-run business soars to new heights Profile of APCO Technologies AG, Aigle 30

Designing electronics for space Profile of Art of Technology, Zurich. 32

Precision and dependability on the ground and in space Profile of RUAG Space, Zurich 34

Delivering software solutions to the space research community Profile of SixSq Sàrl, Geneva 36

“Swiss companies are world-beaters in their niche markets” Interview with Frédéric Boden, Founder and CEO of MetalUp3 38

Facts & Figures The Swiss space industry 41

Investigating what makes planets tick Profile of Peter Zweifel, Head of the Aerospace Electronics and Instruments Laboratory, Institute of Geophysics, ETH Zurich. 42

“Society also benefits from space innovation” Interview with Professor André Csillaghy, Institute for 4D Technologies, University of Applied Sciences of Northwestern Switzerland (FHNW) 44

Facts & Figures Swiss PRODEX projects at a glance 47



“We pool our knowledge and expertise to improve our understanding of space”

As the initiator of PRODEX, Switzerland occupied a crucial position within the programme. 30 years on, has this changed in any way?

Michel Lazerges: As a country without its own national space agency, Switzerland has been very good at exploiting the benefits that cooperation with ESA brings. Thanks to its involvement in PRODEX, Switzerland has access to ESA's experience, expertise and know-how, and can harness these resources to further its own space-related projects. Switzerland has been so successful that it now takes part in every single ESA scientific mission, and its scientists are also sought-after by American, Chinese and Japanese space missions.

Was this not the case 30 years ago, too?

Not exactly. Swiss policy makers had the foresight all those years ago to plough their energies into working with PRODEX rather than setting up a national space agency, because the programme would give them access to the structures and tools that it would need to maintain its sharp competitive edge. As well as helping to develop scientific instruments for space missions, Switzerland is part of several other ESA programmes. Its involvement has been a boon for the Swiss space industry and technology sectors. But it is not all one-way traffic: ESA is equally delighted to count Switzerland as a partner.

What countries are currently involved in the PRODEX programme?

Most of the Participating States have elected not to set up their own national space agency on efficiency grounds. Nonetheless, they are still very keen to drive key, and often critical, developments forward. So, they have chosen to draw on the expertise and skills of the European Space Agency, ESA, instead. At the present time, Switzerland, Norway, Denmark, Ireland, Belgium, Austria, the Netherlands, the Czech Republic, Poland, Romania and Greece are all part of the PRODEX programme, with Hungary hoping to come on board in the very near future.

How does Switzerland's role differ from that of other Participating States?

PRODEX is an ESA programme with all the inherent rights and obligations expected of such a structure. So, there are no real differences to speak of. However, one thing is clear about Switzerland – from the outset it has worked tirelessly to develop instruments and ensure the transfer of knowledge and technology between academia and industry. This clear-cut strategy and the experience it has gathered over the last 30 years has put Switzerland at a locational advantage and has paid dividends for the programme. As my compatriot Alexandre Dumas expressed it: “One for all, and all for one!”

What skills and expertise does Switzerland bring to PRODEX?

As I said earlier, Switzerland has the necessary scientific and technological credentials to handle almost every aspect of the instrument development process. Added to this is the fact that it comes to the table with a deep pool of knowledge in a number of niche areas that would take other countries many, many years to acquire.

You have been with PRODEX for around four years now. What is your take on cross-country cooperation?

The one thing that everyone has in common is their passion for the subject. Not only does this galvanise resolve but it also means that cross-cultural decision-making poses no obstacle to the advancement of the programme.

We are able to focus our efforts on dealing with the often highly complex interfaces that exist within individual projects. Added to the technological complexities, coordination has become an increasingly important part of our work due to the growing number of partners, suppliers and manufacturers who have come on board over the last few years. Having said that, I would like to point out that all this added effort is worth it not only from the perspective of the ESA itself, but also for the Participating States, the PRODEX programme, space science in general, and our other institutional and industrial partners.

How do you manage these complexities?

At the PRODEX Office, our goal is to ensure a more streamlined, transparent process. To begin with, all activities must be defined with the utmost precision, and roles must be clearly assigned. When a delegation commissions us to design an instrument, we initially stick strictly to the proposal put forward by the lead scientific partner, but during the actual development process we try to give the project lead as much latitude as possible. Technical advisors from the PRODEX Office are on hand to help with the technical aspects of the project. They also ensure that the specifications are correct, and oversee the testing procedures as well as the project's internal and external interfaces. PRODEX also has a team of in-house contract law experts who work with institutional and industrial partners to establish a legal framework to underpin the project. This work also includes country-specific calls for industry project proposals.



Biography

Michel Lazerges holds a PhD from the University of Toulouse. The subject of his doctoral thesis was "Engineering, medical technologies/instrumentation and neuroscience applied to space". He worked as an engineer at Institute for Space Physiology and Medicine in Toulouse, before taking up the post of senior engineer with ESA in 2000. He has been Head of the ESA PRODEX Office since 2011.

So, PRODEX does a lot more than simply manage and hand out money?

Absolutely! It is the responsibility of the delegates to manage the financial side of things. The job of PRODEX and, by extension, the PRODEX Office is to ensure that each instrument development contract is completed on time and on budget, and produces high-quality results. Ultimately, our job combines project management, quality assurance, trouble-shooting and the provision of general or specific support on administrative, legal or technical/technological issues.

What is the role of the PRODEX delegates in each country?

They represent the countries within the PRODEX programme and are the direct point of contact between the PRODEX Office and the delegations. Given that budget management is one of the tasks assigned to delegates, they have the authority to green-light and, in extreme cases, suspend operations. This means that the reciprocal information-sharing process is not confined to the bi-annual bilateral meetings and the annual conference of PRODEX Participating States.

Getting back to the PRODEX Office, what about collaboration with other parts of ESA?

We work very well together, with each of us having clearly defined and assigned roles. While PRODEX focuses on developing scientific instruments, the ESA project department is responsible for building satellites which will carry and use this apparatus.

Thanks to short communication paths to the superordinate structures, technical details can be discussed directly with the mission managers and their teams, thereby ensuring that, should any friction occur, losses are kept to a minimum. Furthermore, PRODEX has access to the entire ESA pool of experts, from legal consultants for international space agreements to financial auditors and specialists in optical or mechanical systems. Should we encounter any difficulties, we and our clients are able to locate the right expert for the job pretty quickly. In nearly all cases, we manage to find a solution to the problem.

What value-added does PRODEX generate?

We bring together experts with different backgrounds and from different fields in the interests of advancing our understanding of space. We also help to include innovative space exploration technologies that are capable of capturing and delivering new data to researchers, who then process this information and deliver new insights into how the Universe works. Last but not least, we help participants to sharpen their competitive edge, boost their innovation potential and provide them with an international platform where they can share information and showcase the advances they have made.

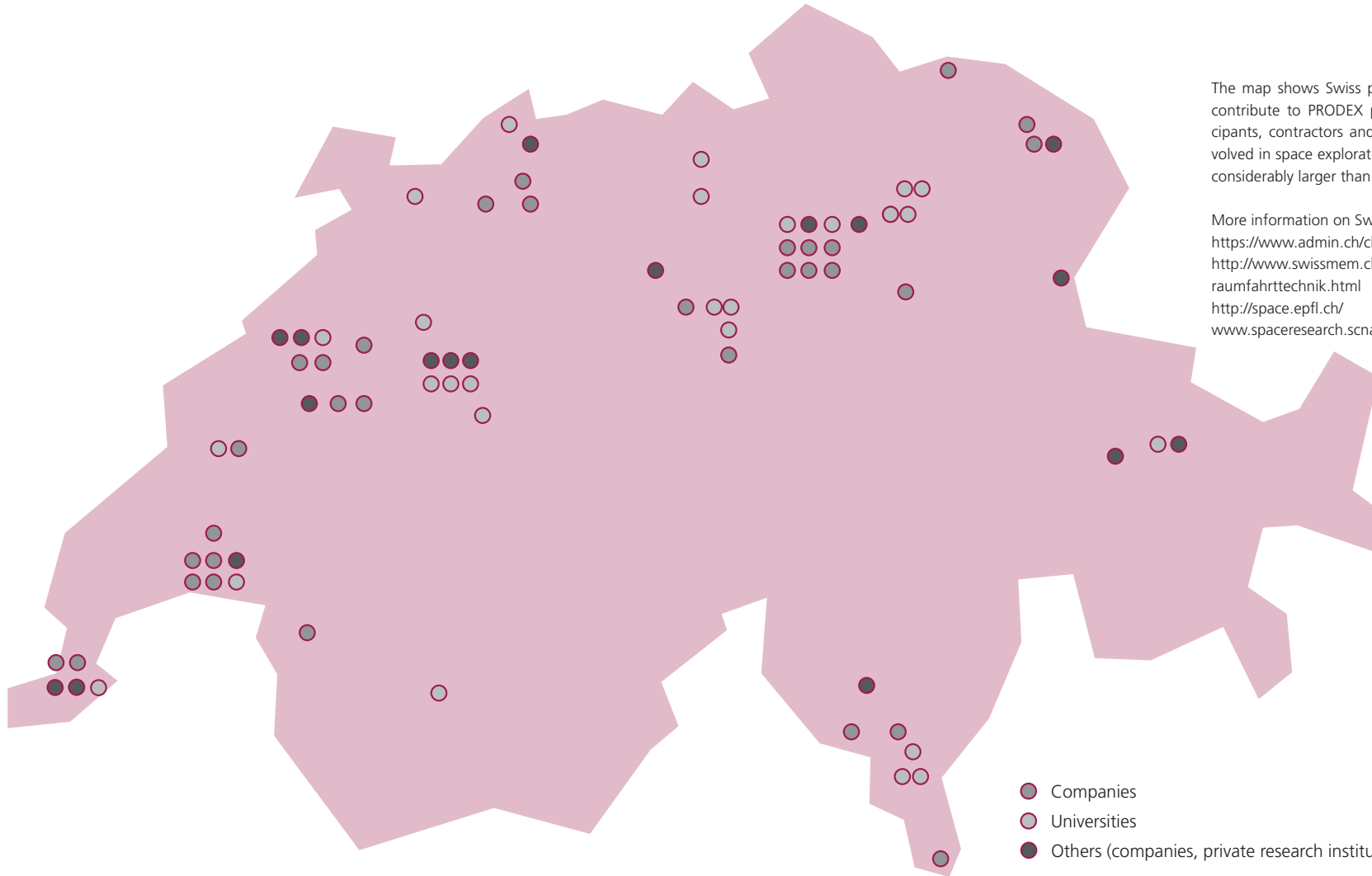
Where will PRODEX be in 10 years' time? Or, to put it another way, what do you hope the programme will achieve?

I have made it my mission to ensure that all Participating States implement the programme in accordance with their national needs. I would also like to help them boost their industrial competitiveness and bolster their scientific and technological capabilities. It is important for me that the national funding institutions know that financial investment in PRODEX projects is money well spent. The returns this investment generates include the development of new technologies, which in turn brings value-added for the home country.

I also want to ensure that people who do not work in the space industry appreciate the usefulness of the PRODEX programme and therefore support their national government's decisions to earmark funds for space research.

>> sci.esa.int/prodex/

The Swiss Space Cluster

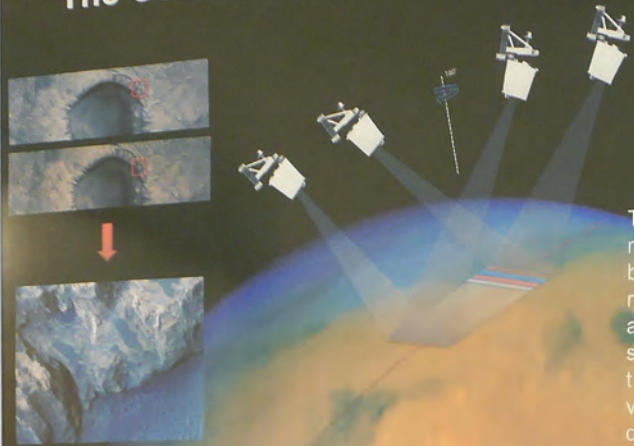


The map shows Swiss public- and private-sector players who regularly contribute to PRODEX projects. However, there are many more participants, contractors and sub-contractors from Switzerland who are involved in space exploration efforts. As a result, the Swiss space sector is considerably larger than shown.

More information on Switzerland's space-related activities:
https://www.admin.ch/ch/d/cf/ko/gremium_4.html
<http://www.swissmem.ch/organisation-mitglieder/fachgruppen/raumfahrttechnik.html>
<http://space.epfl.ch/>
www.spaceresearch.scnatweb.ch

The Colour and Stereo Surface Imaging System

CaSSIS is the imaging system on the ExoMars Trace gas orbiter to be launched in 2016.



The camera is nadir but is boresight rotating around the surface region twice from viewing angles construction of image pair.

Science Objectives

- o To characterize sites which have been identified as potential sources of trace gases
- o To investigate dynamic surface processes (e.g. sublimation, erosional processes, volcanism) which may contribute to the atmospheric gas inventory
- o To certify potential future landing sites by characterizing local slopes, rocks, and other potential hazards.

Facts & Numbers

Mass	17.7kg
Aperture	14cm
Focal length	880mm
Orbit height	400km
Orbit duration	2 hours
Mission Duration	1 Mars year
Resolution	2m/px
Colours	4
Swath Width	8km
Colour swath	8km
Mars Coverage	2%

- o SCIENCE E... Nicolas Thom... Cremonese...
- o CONTRIBU... University of...
- o INDUSTRY... ES (Focal F...



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Learning from Mars

Bern University is set to play an important role in ESA's next Mars mission thanks to the work of one of its teams. The CaSSIS project, led by Ruth Ziethe, has developed a new kind of stereo camera to map the surface of the Red Planet. Researchers are hoping that the images which the ExoMars camera will start sending back sometime in 2016 will provide important new insights into the surface environment of Mars and even into the history of Earth itself.

Four years ago, Ruth Ziethe jumped at the chance to become project manager for the ExoMars camera CaSSIS. "Although planetary science is my specialist field, I was already pretty familiar with the work that goes into planning and executing space missions, and developing the necessary hardware." A further draw for the researcher was the opportunity to build something here on Earth that could function as far away as Mars and have the capabilities to send back usable information.

A passionate project manager

Even as a young girl Ruth Ziethe was drawn to space, avidly reading about the planets in an astronomy encyclopaedia she had received for her 12th birthday. She went on to study geophysics at Münster University, and later specialised in planetary physics. After her PhD, she held several post-doc posts, the last one at ESTEC, ESA's technology centre. "My job there was to develop and apply a numerical model to simulate the thermal evolution of Earth-like planets."

Despite her clear passion for fundamental research, Ziethe has no regrets about giving it up to manage the CaSSIS project. As she explains: "My job now is making sure that my boss, Professor Nicolas Thomas, can present ESA with a working camera by autumn 2015." It might sound simple, but the CaSSIS project is extremely complicated. The complexity and challenges involved are all grist to the mill for Ziethe: "It is down to me to keep one eye firmly on the detail and the other squarely on the bigger picture."

One of her responsibilities as project leader is to direct and support the team of engineers designing, building and testing all of the instrument's components to ensure that, once assembled, they work perfectly together. Given that another part of her job is liaising with ESA, spacecraft providers and developers, communication – verbal and written – take up a great deal of her time. "To avoid any mix-ups, I always try to understand exactly what the other person wants to say before passing the message on." If something goes wrong, it is her fault, she adds with a

wry smile. "But if everything goes to plan, it is the engineers who get a pat on the back!" However, Ziethe sees problems as opportunities: "When problems crop up, you can handle them in a really progressive way and watch how the situation ultimately changes for the better."

Wide-ranging collaboration

The CaSSIS team has worked closely with industry. As Ziethe explains: "Everything that we couldn't manufacture in our workshop at the university, we outsourced to our partners either here in Switzerland or abroad." For example, Ruag Space was responsible for the carbon-fibre structure which holds the camera's mirrors. Mecha and Connova manufactured complex parts made from more exotic materials, and Montena saw to the electronics unit. Italian partners provided the detector and the electronics that go with it. Balzers in Jena developed special filters and the Space Research Centre in Warsaw delivered the power converter.

As project manager, Ziethe also had to travel regularly to the Cannes offices of Thales Alenia Space, the lead company in charge of building the satellite. She was also the point person with PRODEX. "We enjoyed a supportive and helpful working relationship and remained in close contact throughout." The contractual partnership between the PRODEX Office and RUAG Space came as a relief to Ziethe because it allowed her to focus her energies on managing the technical side of the project.

When CaSSIS blasts off in early 2016 for Mars, Ruth Ziethe hopes that she will still be able to be part of her 'baby's life'. "Of course, I'll not be spending as much time on it. But the experience I've gathered over the last four years could still come in useful if the camera needs to be recalibrated or when analysing the images it sends back." Her work on the CaSSIS project will also help advance her first love – understanding our planets.



Mapping the Universe

The avid instrument developer and astrophysicist, Stéphane Paltani, from Geneva University is currently involved in not one but several space projects, including the Euclid mission to map the large-scale structures of the Universe. The hope is that this work will shed more light on dark energy and dark matter, as well as answer the fundamental question of why the Universe, contrary to expectations, is expanding at an ever-faster rate.

We know that dark energy makes up roughly 70 per cent of the Universe, dark matter 25% and “normal” matter – suns, stars and planets – the remaining 5%. It is precisely this dark energy which intrigues Stéphane Paltani, Principal Investigator at the Institute of Astronomy of Geneva University. He considers his involvement in the Euclid space telescope project a major milestone in his 30-year voyage of discovery through the captivating world of physics.

A passionate cosmologist

Paltani was 8 years old when he developed a fascination with physics and space. “After all, I was born around the time of the first Moon landing. So, it’s maybe not so surprising!” explains the instrument developer from Geneva, for whom the cosmos and the Universe have become a real passion.

It was his doctoral studies that led Paltani into space science. He was part of a team working on a telescope to study ultraviolet rays that do not reach the Earth’s surface. His experiences during this time prompted him to pursue his “on-orbit” research. “You don’t necessarily need satellites to probe space. Earth is also a rich source of information. But I was so fascinated by the many unanswered questions surrounding dark matter and dark energy that I decided to carry on developing instruments for use in space missions.”

After he completed his PhD, Paltani worked on the ASTRO-H satellite, the successor to INTEGRAL. Scheduled to launch in 2016, the satellite will relay data and images back to Earth, where they will be studied by researchers in order to improve our understanding of black holes.

Paltani is also part of Euclid, the largest mission ever to map the structures of our Universe which, it is hoped, will help to clarify why the expansion of the Universe is happening at an ever-faster rate. Paltani and his colleagues are currently developing a filter wheel and a miniaturised X-ray detector for the mission.

Astrophysics knows no bounds

Besides his fascination with astrophysics, international cooperation is a great source of inspiration for Paltani. “This field is not confined by geographical borders and steadfastly remains above the political fray. For proof of this, you need look no further than ISS.” The dedicated researcher also cites PRODEX as another great example of nations joining forces for a common cause. “If it weren’t for this programme, Switzerland would not have the same high status and renown that it enjoys within the space research community today.”

While he accepts that, unlike pharmaceutical research, research into dark energy and dark matter does not generate any direct benefit for humankind, Paltani is in no doubt that countries should support such work. “We all benefit from the technological advances that stem from space exploration.”

Paltani is committed to fundamental research, which is why he embraces the opportunity to share his passion for the subject by supervising PhD and post-doc students. “We have lots of projects, which mean we need to employ lots of people.” Indeed, the Institute has seen its workforce grow in recent years to 145.” Paltani, though, quickly points out that “It’s not always easy finding people. Astrophysics research posts are thin on the ground in Switzerland, so upcoming astrophysicists must be prepared to live and work abroad.”



pmod wrc

Physikalisch-Meteorologisches Observatorium Davos
World Radiation Center

The sunny side of research

It is fair to say that the Davos Physical-Meteorological Observatory (PMOD) is a little closer to the Sun than elsewhere. Of course, its elevated location plays a part. But the main reason is its research and measurement of solar irradiation. One scientist, Margit Haberreiter, is currently involved in the Solar Orbiter mission which she hopes will enhance her knowledge of the physical processes in the solar corona and improve our understanding of how the Sun and the Earth interact.

Margit Haberreiter has been ploughing her energies into studying the Sun since 2001. After she graduated from the University of Tübingen with a degree in astronomy (the subject of her dissertation was stellar spectra), she applied for a doctoral position at the Davos Physical-Meteorological Observatory (PMOD). “My aim was to acquire a deeper understanding of the Sun by measuring solar spectra,” she recalls.

Taking the Sun’s temperature

After building on her astrophysics knowledge during a subsequent post-doc at PMOD, Haberreiter left in 2008 to spend two years at the Laboratory for Atmospheric and Space Physics (LASP) in the American town of Boulder, where she further honed her skills in relation to calculating stellar spectra. In 2010 she was awarded a fellowship from the Holcim Foundation and returned to Davos. She currently heads up the Solar Physics Group there, as well as the European SOLID Project, a post she has held since 2012. This collaborative project, involving ten institutions from seven European countries, is devoted to exploiting solar irradiance data. As Haberreiter explains: “We want to use measurements to find out how the solar spectrum and UV light, in particular, behave over an entire solar cycle. A key concern here is separating the part of the signal generated by the degradation of measurement instruments in space from the real measurement signal emitted by solar irradiation.” The Solar Physics Group is involved in the long-term continuous measurement of solar irradiation with a view to finding out whether solar activity will actually wane over the coming 50 to 100 years, as several indicators suggest. According to the avid solar scientist, “If this is the case, we are heading for a cooling period, like the ‘Little Ice Age’ in the 17th century.”

One of the many missions in which Margit Haberreiter and her fellow researchers are involved is Solar Orbiter. Engineers at PMOD have developed a low voltage power supply and precision-engineered components (‘SPICE Door Mechanism’) for the EUV spectrographs, SPICE (Spectral Imaging of the Coronal Environment). These instruments are designed to measure the Sun’s surface and its lower corona, while the SPICE Door Mechanism regulates the width of the beams entering the spectrometer. The PMOD also coordinates work on the optical table of the EUV

full-Sun and high-resolution imagers (EUI). These will provide image sequences of the Sun’s atmospheric layers. None of these projects would have seen the light of day, never mind the Sun, without support from PRODEX.

Meticulous planning

Solar Orbiter is a once-in-a-lifetime experience for the solar scientist. “Humans have never sent a satellite so close to the Sun,” a thrilled Margit Haberreiter explains. However, there are technical concerns, such as “Will the shielding around the satellite withstand the heat? Will the solar panels function under these conditions?” Added to this is the fact that the measurement data which the satellite is expected to send back will be uncharted territory for the scientists, and could hold a few surprises. The hope is that this new information will help explain the process that enables the solar corona to reach a temperature of millions of degrees. “We’re also hoping to gain new insights into the variability of extreme UV light and improve our understanding of how the Sun and the Earth interact.”

As the 2018 launch of the Solar Orbiter draws closer, the more time Margit Haberreiter spends on the project. For example, she is responsible for coordinating the on-board hardware. “Because the satellite is so far away from Earth, the rate at which data can be sent back to the ground station is limited,” she explains. “This means that all of the on-board instrumentation has to work in perfect sync.” To this end, the scientists devise precise plans, setting out in minute detail which instrument measures what and when.

For this committed solar scientist, the Sun will always be the centre of her Universe. “The Sun is our closest star. Understanding it better will help us understand the Universe better too.”



A man in a dark coat and striped shirt stands on a rooftop, pointing at a large, black, circular robotic device mounted on a robotic arm. The device has a perforated metal backplate and various electronic components. The background shows a cityscape and mountains under a blue sky.



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Switzerland and the James Webb Space Telescope

A small but perfectly-formed group of astronomers from the ETH Zurich is part of the team charged with building the spectacular James Webb Space Telescope (JWST). The group, led by astrophysicist Adrian Glauser, helped to develop one of the instruments, which will measure a specific kind of infrared light. When the Webb finally launches into space (currently scheduled for 2018), Glauser will be more than happy to watch the product of 15 years' hard work disappear into thin air!

With a primary mirror measuring 6.5 metres in diameter and tipping the scales at over six tonnes, the Webb is a monster of a telescope. It is one of the most sophisticated and largest satellites ever built for the express purpose of studying the origins of the Universe. But it is also one of the most expensive. Indeed, costs are among several reasons why this joint mission between NASA, ESA and the Canadian Space Agency (CSA) has been regularly postponed. As things currently stand, the launch is slated for 2018.

A long history

The JWST has been part of Adrian Glauser's life for over a decade. His involvement in the project began in 2003 when he left CERN, after his MSc in experimental particle physics, to take up a doctoral post at the Paul Scherrer Institute (PSI). "As a young undergraduate, I had been on the PSI's summer student programme which was the reason I got the chance to work on the Mid-Infrared Instrument, or MIRI, for the JWST," recalls Glauser. The MIRI is made up of a camera and spectrograph, both of which detect infrared light with a wavelength range of between 5 and 27 microns.

Following the retirement of the previous MIRI project leader, the original group was dissolved. Glauser, now 38, found himself having to juggle his doctoral studies with his new role as MIRI project manager.

"Of course, I found myself thrown in at the deep end," smiles Glauser, "But I had learnt an incredible amount by then and the complexity of the job suited me down to the ground." As well as performing physical calculations, the astrophysicist also had to assume the roles of system engineer and constructor. If this was not enough, he was responsible for coordinating the work of ESA, industrial partners and the 16 institutes involved in the project. When asked whether, as a first-time project manager, he might have taken on too much, Glauser explained that planning and calculations make up 75% of a project like MIRI, while implementation accounts for the other 25%, adding "Even back then, I was pretty good at planning and performing calculations."

Glauser and his colleagues who were also involved in the project benefited from PRODEX support, and not just financially. "If it wasn't for the professional help we received from PRODEX, we would have certainly come unstuck during negotiations with our industrial partners." It would be fair to say that these kinds of skills tend to lie outside the core competencies of academic researchers.

Projects in space and on Earth

Glauser, who already had experience of working with the German Aerospace Centre (DLR) during his time as a post-doc student at Heidelberg University, is convinced that the ESA programme is the perfect fit for Switzerland. "Given that we don't have our own space agency, membership of PRODEX means that Switzerland receives a slice of the funds managed by ESA, which in turn generates value-added back at home." To this end, instruments must be not only developed in Switzerland but also built here. Glauser, though, believes that there are not enough space industry suppliers in Switzerland. "A bit more diversification and competition wouldn't hurt."

This self-confessed 'tinkerer' would welcome greater diversification in Switzerland's space research activities too. "One reason why I took this job a year ago was my desire to expand both the Institute's 60-strong workforce and our portfolio." Glauser has made it his mission to make the ETHZ a much more active and visible player in the space business.

With this in mind, Glauser and his team are involved in other space projects besides MIRI and the CHEOPS mission. They are also part of two terrestrial astronomy projects: the European Extremely Large Telescope and the Very Large Telescope. This industrious and enterprising scientist also has plans to make his expertise in the field of low-temperature testing available to others. He has fitted out a laboratory with the necessary hardware to turn it into a test centre for future projects. "We'll be able to carry out work that isn't stretched out over years, or even decades, as is so often the case with space projects."



30 years devoted to Rosetta

Kathrin Altwegg originally wanted to be an archaeologist. But a change of heart led her to study physics instead. As Principal Investigator of the Rosina mass spectrometer for the ESA Rosetta mission, it is her job to search outer space for clues to the origins of life, work which satisfies both her professional and personal aspirations. Altwegg is also the executive director of an interdisciplinary research institute dedicated to solving the mystery of how the planets were formed and identifying the first building blocks of life on Earth.

According to Professor Altwegg, space researchers must have patience, curiosity and imagination. Even after more than 30 years in academic research and teaching, Professor Altwegg still has these three essential qualities in abundance. It was largely by chance that astrophysics became her career, or rather her vocation. Having graduated with a degree in solid-state physics from Basel University, Kathrin Altwegg headed for New York with her then partner, now husband, to study and work at the Physical Chemistry Department of the city's University for Technology, Design and Architecture. When they returned to Switzerland, the couple decided to look for jobs in the same city. They struck gold in Bern, where Altwegg joined the university and her partner a telecoms firm. "I ended up in academia because the industry job wasn't advertised for a woman," laughs Altwegg.

Under her mentor Professor Johannes Geiss, she was involved in evaluating data from the European space probe Giotto which flew past Halley's Comet (1986) and its smaller cousin the Grigg-Skjellerup (1992). Altwegg spent the following decade sifting through the wealth of information sent back by the spacecraft. "It was the ideal job because it allowed me to keep on top of the latest scientific developments while still having time for my two daughters." It was also during this period that Altwegg also wrote, and successfully completed, her PhD thesis on the physics of the solar system.

The power of interdisciplinary collaboration

In 1996 the then Director of the Physics Institute, Professor Hans Balsiger, appointed her as the principal investigator on the ROSINA mass spectrometer project, part of the ESA's Rosetta mission. Some 18 years later, in mid-November 2014, the Philae robotic probe on board the Rosetta spacecraft landed on comet Churyumov-Gerasimenko, and began sending back its first set of data to Earth.

This moment was the culmination of a ten-and-a-half year journey over 6.4 billion kilometres. As the longest and most complex mission in the history of European space exploration, the success of Rosetta and ROSINA was a feather in the principal investigator's cap, and an outstanding

achievement by ESA. Researchers hope that the data collected during the mission will shed new light on the origins of our solar system. But Rosetta is also a perfect example of the power of close cooperation between universities, universities of applied sciences and industry. "We work with 10 scientific institutes both at home and abroad, as well as with countless small and major firms." About 1,000 people are involved in the project.

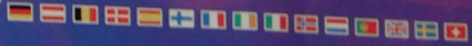
Support from PRODEX was a major factor behind the success. "And not only financially either," Altwegg is quick to point out. "The legal assistance and general advice PRODEX gave us during difficult discussions and tricky situations with industry always kept us going and renewed our courage."

Life after Rosetta

Since 2011 the avid space researcher has headed up the newly created strategic research centre of Bern University, the "Center for Space and Habitability" (CSH). Here physicists, chemists, geologists and biologists work together to discover the origins of planets and their atmospheres, while combing through information and images for clues to the origins of life. Space education and public outreach projects are also high on the agenda of the director and her institute. Through the work of the CSH, Professor Altwegg wants to show that Switzerland is an international leader in this field.

Although Rosetta is set to wind down, Altwegg's work will continue to influence the Earth-bound research community for many years to come. "After two years' worth of measurements, we now have over one million mass spectrometer images which need to be analysed," explains Altwegg. Enough data to feed her insatiable curiosity for the foreseeable future.

esa



INTEGRAL

Seeking out the extremes
of the universe
Aux extrêmes de l'univers



INTEGRAL

On the trail of neutron stars

In the distinctly earthly setting of an old manor house in Versoix, a small town on the shores of Lake Geneva, data that have been relayed from space are analysed and processed. But in another part of the building scientists are hard at work developing an array of instruments to help advance our understanding of black holes and neutron stars. One of the driving forces behind this innovative work is 35-year-old researcher Enrico Bozzo.

Enrico Bozzo had always dreamt of becoming an architect. But that all changed when the teenager read the book 'Alice in Quantumland'. From that point onwards, the young man devoted his energies and talents to unravelling some of the unsolved mysteries of quantum physics. "I remember seeing a cartoon about a black hole on the very first day I started my physics degree. Immediately, I decided that I wanted to study astrophysics too."

His doctoral supervisor, Luigi Stella, a brilliant theoretician from the Rome University of Tor Vergata, spotted his student's great talent for putting his theoretical knowledge into practice. "This allowed me to appreciate the potential limitations of theory, as well as the limitations of instrument design and development."

Data analysis for all

Having spent time as a visiting researcher at the University of Colorado and having completed a postdoc in Italy, Enrico Bozzo moved to Switzerland in 2009 to work as a postdoc researcher and INTEGRAL operations coordinator with the Science Data Center for Astrophysics (ISDC) of Geneva University. INTEGRAL, or INTERnational Gamma-Ray Astrophysics Laboratory to give it its full name, is a satellite that was launched by ESA in 2002 to monitor x-rays and gamma radiation in space. The ISDC team develop the requisite data and analytical software which they then share with scientists around the world.

In 2012 Bozzo was appointed manager of the LOFT (Large Observatory for X-Ray Timing) project. "The aim of LOFT is to study the behaviour of matter in close proximity to black holes and neutron stars, to measure black hole masses and spins, and to study the equation of state of ultra-dense matter." Switzerland, Italy and the Netherlands lead this project, which brings together a total of 469 people from 28 countries. "Around 12 of the LOFT team are based in Switzerland. Some work in our institute, while others work in CERN, Bern University, EPFL Lausanne or Geneva University."

Such is the interest in and esteem for LOFT among the wider scientific community and the people at ESA that the project is currently being considered as a possible M4 candidate mission for the Cosmic Vision Programme. However, if LOFT is chosen, the mission will only be launched in around 2025. The wait does not bother Bozzo in the least. "The journey itself is so exciting that time seems to just fly by," he happily declares.

A finger in many pies

Bozzo is also involved in another ESA mission, Euclid, which is scheduled to launch in 2020 on a Soyuz vehicle from Kourou in French Guiana. The Euclid space telescope will explore the dark Universe, gather data on dark energy and dark matter, and extensively map the large-scale structure of the Universe. He is also the project manager for the ATHENA mission (Advanced Telescope for High ENergy Astrophysics) to probe black holes. The launch is scheduled for 2028. As part of the JEM EUSO (the Extreme Universe Space Observatory) mission, Bozzo is in charge of overseeing the development of a special millimetre-sized laser testbeam. The experiment which will study cosmic rays will be mounted on the side of the International Space Station in around 2018. Another project in which he is involved is XIPE (X-ray Imaging Polarimetry Explorer). If ESA selects this mission as an M4 candidate, Geneva University will assume the same role in the XIPE consortium as it currently holds in the INTEGRAL project.

Bozzo finds the complexity and protracted nature of his projects neither troublesome nor off-putting. The technical complexities fade into insignificance compared to the outcomes that these projects will hopefully achieve. "If we manage to find out more about black holes and dark energy, we might move a few steps closer to solving one of the most fundamental questions: why is the Universe expanding at an ever-faster rate."

The realisation that PRODEX is built on the principle of "science first" proved to be a game changer for the researcher during his initial dealings with the programme in 2011. "Practically everything I work on today is supported by PRODEX. Without it, neither I nor my research would be where we're at now."



Switzerland's direct line to the International Space Station (ISS)

BIOTESC, which is part of the Aerospace Biomedical Science and Technology Support Centre of the Lucerne University of Applied Sciences and Arts, oversees ESA-commissioned space experiments. The team is also responsible for a number of infrastructure units on the international space station ISS, and provides astronauts with step-by-step instructions on how to carry out experiments in space.

In 2008 ESA's seven-metre-long Columbus research module docked on the ISS space station. Over its planned 10-year lifespan, various astronauts will perform an array of scientific experiments in KUBIK, its box-shaped laboratory. Every year, at the behest of ESA and under the leadership of Alexandra Deschwanden, the ten-strong team at the Biotechnology Space Support Centre (BIOTESC) in Hergiswil trains between two and three astronauts to carry out space experiments correctly and on time.

In spring 2015 the SpaceX rocket transported an immune cell experiment to ISS, which was to be performed by Italian astronaut, Samantha Cristoforetti. Deschwanden and her team closely monitored Cristoforetti's every move in space. While User Support and Operations Centre staff can hear what the astronauts are saying to each other and can see what they are doing, they are not allowed to speak to them directly. "Only a select few in the Munich Flight Control Team are authorised to do that," explains Deschwanden. "We follow every single move the astronauts make when they are carrying out the experiments and can immediately help them out, via Munich, if they get into difficulties."

A varied working day

Most of the work of the BIOTESC team is concerned with on-orbit experiments and tutoring the astronauts. Scientists and industry jointly develop experiments that will take up as little of the astronauts' time as possible. After all, time is money, especially in space. "It is relatively easy to carry out experiments inside KUBIK," explains Deschwanden. However, the same cannot be said of the experiment development process.

The BIOTESC team also test runs experiments and writes step-by-step instructions for the astronauts. All spaceflight crew receive a brief overview of the on-orbit experiment as well as the necessary training. Staff at Hergiswil painstakingly checks all of this documentation before it is distributed.

Deschwanden and her team are also responsible for maintenance work on KUBIK. It is their job to ensure that the astronauts know what, where and how things must be done. They also maintain all of ESA's hardware on board the biological laboratory, which is located on the Russian spaceport Baikonur. Given that this hardware only becomes operational a few days before a rocket launch, an essential part of the job of the BIOTESC team is to constantly check the technical equipment and hardware. This allows the researchers to keep up to speed on the hardware and instruments that are available on site.

Major Swiss contribution

Alexandra Deschwanden could never have imagined in her wildest dreams that she would work for the international space industry following her Masters in human biology. "In 2010 I was looking for a job where I could combine my biology expertise with a more administrative, coordinating role." She happened upon a job vacancy in the Space Biology Group, which was at that time a research group within the ETH Zurich, but which was transferred to Lucerne University of Applied Sciences in 2013. "Everything just fell into place," she recalls.

BIOTESC serves as the point of contact between ESA, the Swiss Confederation and scientists from a range of disciplines. In doing so, it represents a visible part of Swiss involvement in ISS and makes a major contribution to the scientific exploitation of this mission. According to the trained biologist, there has never been a dull moment in the five years she has worked at BIOTESC. "Our work is incredibly varied and multifaceted, and the people we deal with come from all over the world – a dream job." However, she is set to leave her post in 2015, as personal reasons mean that she will be relocating abroad. Her successor will be Bernd Rattenbacher.



The reason we don't still live in caves today is because of humans' innate curiosity

You worked in the US for many years. How does American space research differ from space research in Switzerland and the rest of Europe?

Willy Benz: When I arrived in America in 1984, it led the world in astronomy. At that time Europe had yet to achieve the political and economic integration that it has today. However, we have caught up considerably over the last 20 years and have managed to forge a strong scientific identity. Look at the discovery of the first planets outside the solar system – a Swiss success story. Or the Rosetta mission – an incredible feat of engineering and technology!

How do you think Swiss space research rates alongside research in other countries?

We can hold our own with the best of them. Of course, we are a small nation and haven't as many top researchers as larger countries. But the few we do have are first-class. Our super education system and excellent contacts allows us to stay extremely competitive.

What influence do programmes like PRODEX and Horizon 2020 have on Swiss space research?

There would be no space research in Switzerland if it were not for PRODEX. These are long-term projects that require a huge amount of resources and infrastructure. Support from universities

and the Swiss National Science Foundation alone would not be enough to build experiments destined to fly on board satellites.

Why?

The technologies developed specifically for space exploration are expensive. They involve special materials and expertise, and have to work perfectly. After all, it is not as simple as sending a mechanic or an engineer into space to do a bit of repair work...

Money from universities and the Swiss National Science Foundation fund the pre-development phase, where we scientists put our ideas down on paper. In some instances, there is enough money to build a prototype. This means that we can then tender for space missions across Europe. If we are awarded the tender, then the really hard work begins because transforming prototypes into flight instruments is a major challenge and accounts for around 90% of the costs. This is where we rely on the capabilities of PRODEX and industry.

You mention industry. How does cooperation function between fundamental research communities and industry?

Without industry Switzerland would have never managed to get an instrument on board a space flight. We depend on industry. But industry also depends on us, at least when it comes to building scientific instruments.

Is this a partnership borne of necessity or one of mutual inspiration?

Collaboration is one of the PRODEX rules, and the overall record in this regard is very good. As a university, we would not be capable of building these instruments on site, while for industry involvement in space projects brings prestige and provides confirmation of the reliability of their work. While the financial benefits from developing these one-off instruments are not substantial, companies can apply the resulting process and technology innovations to other products, which they can later market.

Besides the clear scientific profile that you mentioned earlier, what else is needed to be a leader in the space exploration business?

You need to have the necessary resources at your disposal: funds, the appropriate infrastructure like laboratories and workshops, as well as qualified personnel. There is more to space research than crunching data in an office, you know! You need more than brainy physicists with a few ideas. You also need the people who can turn these ideas into a reality: mechanics, engineers, as well as the administrative staff who write up the reports and analyses.

How do you go about recruiting such people? Is Switzerland well-connected in this regard?

It is very difficult to find engineers with space experience. The few there are, we can't afford to hire. This is why we employ young, motivated engineers who stay with us for a few years before moving into industry.

What came first in Swiss space research: engineering skills or science?

Science, because not many engineers were needed in the early days. Professor Geiss from Bern University is the father of Swiss space research, launching it back in the 1960s. It was his idea to collect solar wind on the Moon, and to use a kind of aluminium foil for the purpose. This was the only non-NASA experiment on board the Apollo 11 mission. It raised Switzerland's profile and became the launch pad for Swiss involvement in international space exploration efforts. Since then, the instruments have become ever more complex and subsequently the demand for



Biography

Willy Benz studied Physics at Neuchâtel University and was awarded a PhD in Astrophysics from Geneva University in 1984. He went on to study at Harvard University and the University of Arizona. He then returned to Switzerland, and in 1997 was appointed as a professor at the Institute of Physics of Bern University. He has been the Head of the Institute since 2002.

engineers has grown. They play a much more important and extensive role than in the early days when space hardware was a little bit simpler.

What contribution does space research make to the economy?

The question of whether we are alone in the Universe has preoccupied humankind since time immemorial. Of course, space research has no commercial value in the short term, but its intangible value is immense. The reason why we still don't live in caves is because of humans' innate curiosity and love of experimentation.

Most taxpayers and politicians show woefully little interest in such philosophical questions...

It is a sad fact that most taxpayers and politicians are not particularly interested in such philosophical questions. Indeed, some people believe that the research we carry out is extremely inefficient and that the money simply disappears, without a trace, into the laboratory. This could not be further from the truth. If it weren't for space research, we would have no mobile phones, satnavs or reliable weather forecasts. When a major disaster strikes, satellite images are a huge help to crisis management efforts. A major benefit for society is that most of the people we train move into the private sector. Only a minority aspire to an academic career.

If you were granted one wish, what would it be?

As a scientist, my main concern is that our politicians continue to believe in and promote fundamental research. It has no direct market value but constitutes a long-term investment in the future of our country. What we research today and the technology we develop may be useful for our daily life in 20 to 30 years' time.

Further information

>> cheops.unibe.ch

Milestones in Swiss instrument development

30 years, 100 projects, 300 million Euros: These three figures sum up the incredible performance that Swiss universities and industry have achieved with help from PRODEX. A host of space missions, past and present, have benefited from Swiss input and expertise. The instruments developed in Switzerland have ranged from minute yet essential machines, high-precision and dependable components and systems, right up to complete instruments and experiments. Despite being a small country with limited resources, Switzerland has managed to carve out an important place for itself within the European and international space community.

Year	Instrument	Mission	Institute	Mission launch	End of Mission	Scientific field
1988	CELIAS	SOHO	UniBE	02.12.1995	ongoing	The Sun
1994	Reflection Grating Spectrometer	XMM-Newton	PSI	10.12.1999	ongoing	Astrophysics
1996	ROSINA	Rosetta	UniBE	02.03.2004	ongoing	Solar system
1997	ISDC DATABASE	INTEGRAL	UniGE	17.10.2002	ongoing	Astrophysics
1997	APEX	Airborne	UniZH	31.12.2005	ongoing	Earth observation
1999	HIFI SPECTROMETER	Herschel Space Observatory	ETHZ	14.05.2009	17.06.2013	Astrophysics
2002	SHM ACES	ISS-ACES	CSEM	01.07.2016	-	Fundamental physics
2003	MIRI	James Webb Space Telescope	PSI	01.10.2016	31.12.2026	Astrophysics
2008	HARPS-N	TNG, INAF	UniGE	01.08.2012	ongoing	Astrophysics
2010	CaSSIS	ExoMars 2016	UniBE	01.04.2016	-	Solar system
2010	POLAR	Tiangong 2	UniGE	01.01.2016	-	Astrophysics
2011	SPICE	Solar Orbiter	PMOD/WRC	01.10.2018	-	The Sun
2011	Euclid VIS	Euclid	UniGE	01.01.2020	-	Astrophysics
2012	CHEOPS	CHEOPS	UniBE	01.11.2017	-	Exoplanets
2013	CLARA	NORSAT-1	PMOD/WRC	01.11.2015	-	The Sun

The table shows the most important contributions that Switzerland has made to the space exploration business since the founding of PRODEX 30 years ago. A complete list of Swiss-PRODEX projects is available at: www.sbf.admin.ch/prodex-meilensteine



Ultra-reliable circuits from the Bernese Lowlands

For more than 10 years, Ruag Space has relied on the electronics expertise of Nanotronic, a small firm based in the canton of Bern. The company has been quick to capitalise on the space technology know-how it has acquired over the last decade by integrating it into products developed for other sectors which require ultra-reliable circuits and components, such as the medical and railway technology industries.

For company co-founder Philippe Hersberger, one thing is clear: in a fast-paced world where short turnaround times hold sway, it is good to have medium- to long-term orders on the book. Ever since Nanotronic began operating back in 2000, it has set its sights firmly on attracting customers from the space, aviation, medical and railway technology industries.

As a young electronics engineer, Hersberger began his career with Ascom (a telecommunications giant), working in its development division. After he had completed several economics and business training courses, he realised that working for a large company afforded less rather than more freedom. So, he decided to strike out on his own. His first order was producing customer-specific ASICs for his former employer.

Wide variety of products

Since then, the situation has changed somewhat. The company has grown year-on-year, funded entirely from its own capital. In 2006, Nanotronic's other co-founder decided to explore new horizons, leaving Philippe Hersberger the sole proprietor of the firm.

The 16-strong workforce spread over two sites in Lyss and Mägenwil offer a wide variety of products and services. They develop customised embedded systems and VHDL designs, right the way from idea through to end product. They help their customers make informed choices about the type of technologies they should be using, and develop system designs, microelectronics and firmware. They also design printed circuit boards and turnkey hardware solutions, which can range from analogue to digital circuits, as well as high-tech products that are built around cutting-edge technologies. "We also specialise in ultra-reliable circuits for the railway technology, medtech and space industries," adds Hersberger. Almost all of the products his firm supplies are either safety-critical, health-related or both. "This always requires a high degree of normalization."

A foot in the university camp


Normalisation is also extremely important for the space industry. Today, around one-third of Nanotronic's orders come from this sector. Over the last decade, the small firm in the Bernese Lowlands has been a subcontractor for the engineering department of RUAG Space. It also regularly works for Syderal as well as Bern University, where it is involved in scientific instrument development.


For example, Hersberger and his team took over the project management and system engineering for the electronics behind the mass spectrometer in the NGMS project, as well as the software and FPGA development side. According to the electronics engineer, projects in which universities are involved are exciting but it can be difficult striking the right balance between the specifications inherent to the product and those of the scientists. "We're a business after all. So, it's vital that we stay on time and within budget."

The system engineers from Bern also successfully juggle their work for the space and medical technology industries. While miniaturisation and the very latest technologies dominate medtech, space-related applications are concerned with getting the most out of established but slightly outdated technologies. "It is fascinating and challenging working for these sectors because they push us to the very edge of what is technologically possible."

SENTINEL 3
SPORT CONTAINER
HALES ALENIA SP

APCO
TECHNOLOGIES

 COG TSC LOADED

 COG TSC EMPTY



A family-run business soars to new heights

APCO Technologies has been developing products for commercial and scientific space missions since 1993. This family-run company has gone from strength to strength. It now employs 250 people and is the only Swiss firm to have an office sited at the European Spaceport in French Guiana.

APCO is a real textbook SME (small and medium-size enterprise). Founded by André Pugin in 1992, the family-run firm has a 250-strong workforce, 160 of whom are based at the company's headquarters in Aigle, a French-speaking town in Western Switzerland, and its order books are bulging at the seams. The company owes its success largely to the responsible corporate policy pursued by its founder. However, another factor was the firm's decision to diversify its operations in three core areas: the manufacture and engineering of components for heavy industry; provision of maintenance services to the French nuclear industry; and the development and manufacture of plant components for the space industry. Its work for the space industry has earned it renown well beyond the continent of Europe.

Diversified product range

APCO had its first business dealings with the space industry back in 1993, when the company was contracted to manufacture the mechanical ground support equipment used in the Envisat mission. Much has changed since then and it is now the only Swiss company with an office at the European Spaceport in French Guiana. The 40-strong team stationed in Kourou maintain and test satellites prior to their launch. These include satellites on board the Ariane, Vega and Soyuz spacecraft. These specialists also manufacture satellite transport systems and containers worth millions of Swiss francs.

Over the years, APCO has diversified its range of space industry products, too. It is currently designing the outer casing of the booster pack for Ariane 6. For the Rosetta mission, it successfully created a slimline version of the RTOF (Reflectron Time of Flight) spectrometer, which was developed by Bern University, shaving a massive 291 kg of its weight (from 300 kg to 9 kg). It has also designed a vibration test adapter for the James Webb Space Telescope, which is scheduled to launch in 2018. Likewise, APCO works with Geneva University on the Euclid mission, and with PMOD in Davos to manufacture two instruments for the Solar Orbiter mission.

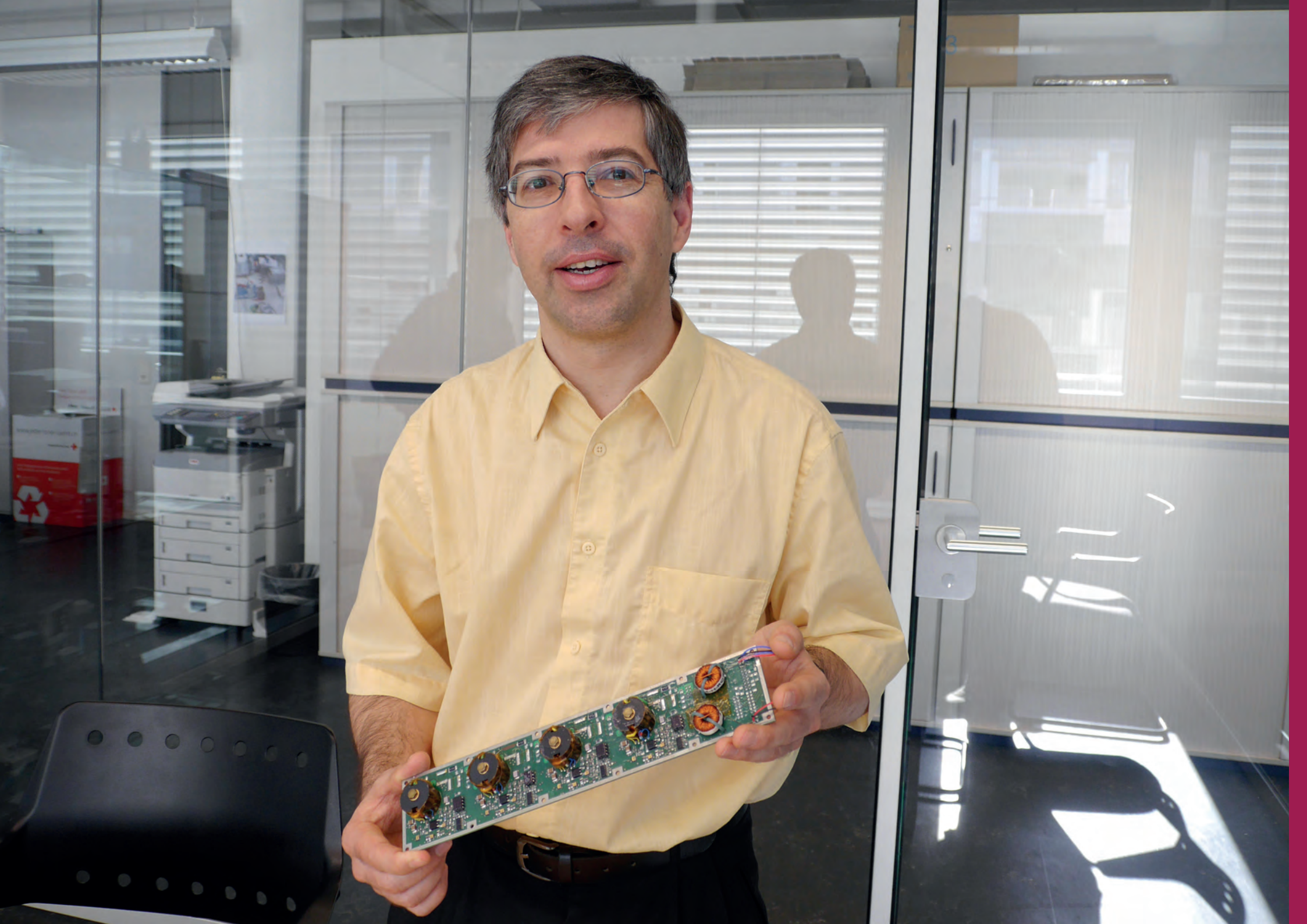
APCO's involvement in the Rosetta mission was the first time that it collaborated with PRODEX. For Aude Pugin Toker, daughter of the company's founder and the financial, personnel and ad-

ministrative director of the company for the last six years, the programme opens doors to more key space missions, "It expands existing networks, and its collaboration with universities brings innovation and progress."

Pugin Toker also firmly believes that the programme has an indirect but non-negligible influence on its industrial partners. "For us, involvement in such prestigious scientific projects is a first-rate hallmark of quality and cements our international reputation as a sound and reliable business partner." This is also why APCO accepted the contract to build 70 satellite panels for third-generation weather satellites, or MTG, one of its first repeat orders from the space industry. According to Pugin Toker, working on such high-spec contracts also pays dividends for the company's two other core activities. "This certainly helps us win more orders in our two other main lines of business."

Organic growth

Since the company moved the administrative and manufacturing arms of the business to the new Aigle site, it has grown steadily. "And organically," Pugin Toker proudly adds. "We have our great workforce and their outstanding expertise mostly to thank for our success." Everyone in the APCO team is hugely dedicated to their job. "Once you start working on space technology, it is hard to stop," beams the financial director. "It is not just the incredible scale of the work that makes these projects so thrilling, but also the realisation that they bring huge technological advances and represent a giant step for mankind."



Designing electronics for space

When developing electronics for space exploration, it is essential that all of the components work together in an efficient and effective way. Art of Technology helps companies and universities optimise their electronics design and make these systems as compact as possible. The Zurich-based firm applies the same know-how to its orders for the medical technology industry, as certain parallels exist between medtech products and those of the space industry.

When the Solar Orbiter is finally launched in 2018 (current schedule), it will be a dream come true for Etienne Hirt and Rolf Schmid. When the two men founded Art of Technology, their greatest wish was to work with the space community. However, reaching this goal took much longer than they had expected.

In 1995 Etienne Hirt was a postgrad at the Institute of Electronics of the ETH Zurich, busily writing his doctoral thesis on electronic miniaturisation, when he observed that lots of companies were coming up with interesting developments but that their electronics design let them down. So, with his colleagues Rolf Schmid and Geert Bernaerts, Hirt decided to set up a company offering design optimisation services, electronics design advice as well as turnkey engineering solutions.

Parallels between medtech and space

The first orders they took were for the development of electronics systems for satellite communication and industrial computing. It was not long before the medical technology industry came knocking at their door. But it was in 2001 that they finally got the longed-for call from the space industry. "Contraves commissioned us to carry out a study on a seismometer that was going to fly to Mars," explains Hirt. "Our job was to work out how to cover the chips in a lightweight plastic casing instead of the usual heavy ceramics." This was as far as the project would go for the company. "Unfortunately, we were still finding our feet in the business world at that time, so it was difficult for us to get fully on board a space project," adds Hirt.

This experience prompted the company founders to focus their energies on honing their skills for the benefit of their other customers. Since roughly half of its orders came from the medtech industry (and still do today), Art of Technology discovered that developing products for this sector was not unlike developing products for space. "The first motto when developing for the medical sector is 'do no harm to humans'. For the space industry, it's 'do no harm to satellites'." The same applies to error tolerance. In other words, the product must still be able to function even when a fault occurs. "Mind you," continues Hirt, "I can build more redundancy into space products."

In 2012 Geneva University contacted Art of Technology, as it was looking for an industrial partner to advise it on developing an instrument for the PRODEX project POLAR. Once on board the Chinese space station, the device will detect and measure gamma-ray bursts. "What started out as a consultancy project became a fully-fledged order to develop the instrument's redundant low-voltage power supply, as well as the high-voltage supply system," explains Hirt. The story also goes to prove why the company, which now has a 15-strong workforce, keeps going from strength to strength. "We listen very carefully to what our customers tell us and don't bombard them with as many products or services that we possibly can. Instead, our approach is to develop products that our customers really need, as this holds the key to continued success in the future."

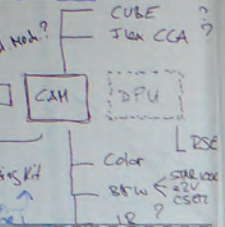
Added benefits for society

Following the great work on the POLAR project, the company received another order from PRODEX in 2013. This time it was for the STIX project and the Solar Orbiter's on-board telescope for imaging X-rays. As well as providing the electronics design, the firm was responsible for building the sensor electronics, including the cooled sensors, high-voltage assemblies and "warm" readout electronics. "This project, which was managed by the University of Applied Sciences of Northwestern Switzerland (FHNW), saw us working closely with other industrial partners and research institutes both in Switzerland and abroad." Despite this complex arrangement, Hirt recalls that it all went surprisingly well because everyone who was involved shared a commitment to building an instrument that could function in space.

Whether they are developing space-specific or medical applications, Hirt, his business partners and workforce derive a great deal of encouragement from the fact that their components generate added benefits for society. "In the field of space exploration, this means new knowledge and insights. In medicine, it means improved health and a better quality of life."



SENSING



Precision and dependability on the ground and in space

RUAG Space is perhaps best known for the payload fairings that have featured on all Ariane rockets since 1976. As well as developing and producing instruments for the space industry, the company takes part in pioneering European space research projects. With Elisabetta Rugi Grond at the helm, RUAG Space explores not only uncharted technological territory but also the uncharted territory of the Universe.

RUAG Space has been one of Europe's leading suppliers to the space industry for several decades. Over the years, it has built up an outstanding reputation as a developer and manufacturer of launcher structures and separation systems, satellite structures and mechanisms, digital electronics for satellites and launchers, as well as satellite communication equipment and instruments.

Specialisation is the name of the game

Stars have been the enduring passion of Elisabetta Rugi Grond ever since she was a little girl. When she completed her aeronautics degree, she decided that she wanted to pursue her engineering career within the space industry. In 1996, after a short spell in France, Rugi Grond joined RUAG Space. Four years later, she was promoted to project manager, working on prestigious European space research missions like Rosetta, ExoMars, Solar Orbiter, Galileo and BepiColombo, Europe's first mission to Mercury. Rugi Grond and her team designed a mounting system for that mission's laser altimeter's receiver. The data collected by the altimeter will then be used to create a 3D map of Mercury's structure. What makes it particularly special is that the instrument is made from gold and hot- and cold-resistant beryllium, and that the engineers have succeeded in creating a beryllium mirror that is not flat.

The BepiColombo project is a fine example of the excellent working relationship RUAG enjoys with its many high-specialised industrial partners in Switzerland and elsewhere. "Synchronising all of this is a challenge," explains Rugi Grond, with a smile. "But we have one common denominator – developing instruments that can deliver precise data to the scientific community." For her, this shared goal is the glue that keeps them together. Work on BepiColombo is also the largest PRODEX project in which Switzerland has been involved to date. "The programme is very important to us because it allows us to build and develop our profile as an innovative space research partner."

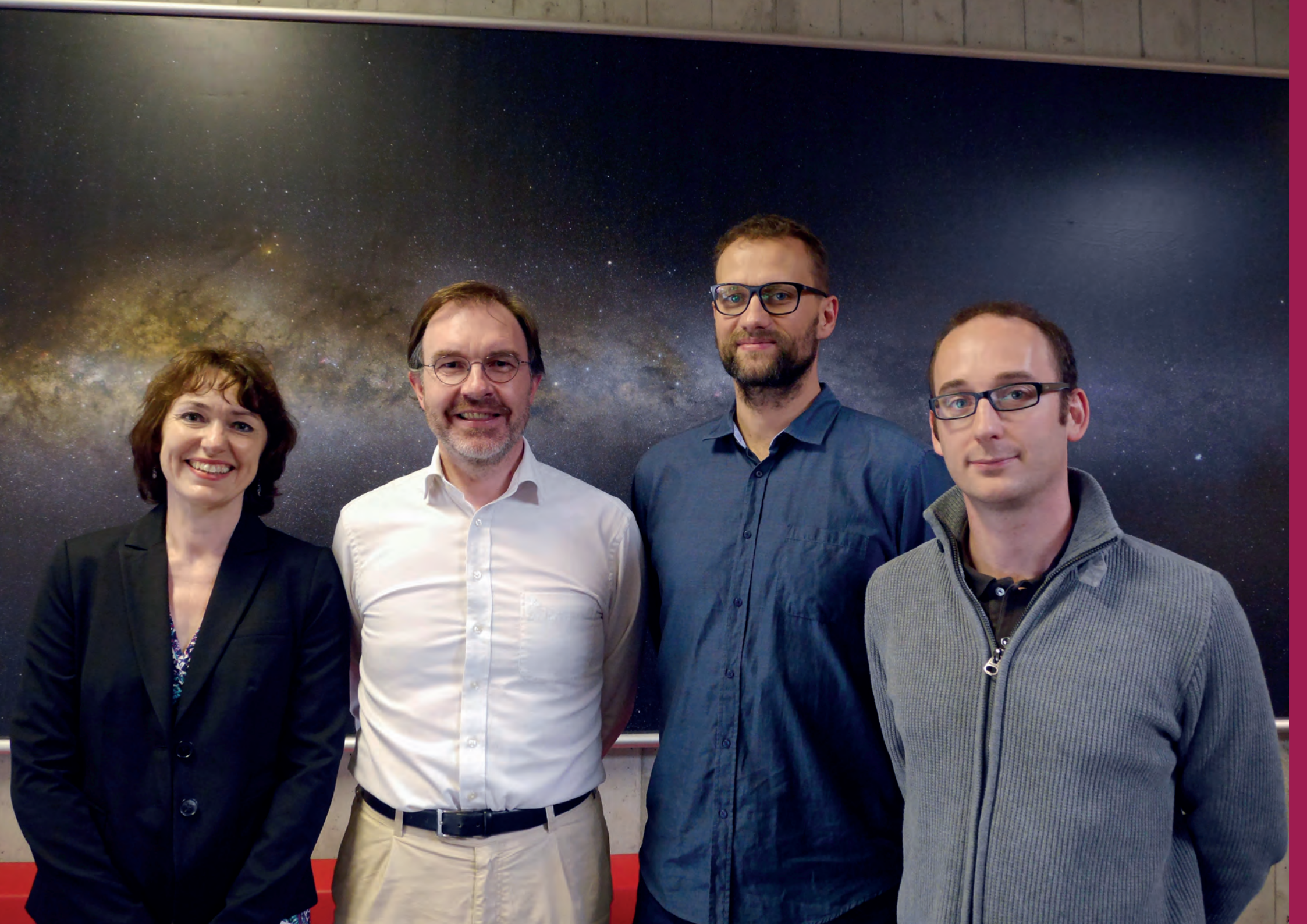
The first PRODEX project for RUAG Space was the ROSINA instrument used on the Rosetta mission. A further milestone in space research is CaSSIS (Colour and Stereo Surface Imaging System), a new-generation space camera. The engineers at RUAG were heavily involved in developing this carbon-fibre telescope for the ExoMars 2016 mission. As of 2016, the instrument should start relaying high-resolution images from Mars and its surroundings, providing new information on the planet's surface.

As a business unit within an international corporation, RUAG Space, alongside its research activities, manages a clear, comprehensive and highly structured portfolio. Some 570 employees in Switzerland, and as many again in Sweden and Austria, develop and manufacture a diverse range of products for the space industry worldwide. These include payload fairings, launcher structures, receivers and converters for use in telecommunications satellites, laser altimeters, optical communication systems, radiation-resistant flight electronics, thermal hardware and mechanical ground support equipment like containers and trolleys. The company also provides services like the manufacture of components and electronics, industrial measuring services and testing.

Eternal search for new frontiers

Since 2012 Elisabetta Rugi Grond has been at the head of RUAG's 80-strong Optoelectronics & Instruments Division. For this dedicated engineer, her new role means more management responsibilities but with it comes a greater say in the shape that the company's technology strategy should take. "We're already looking ahead to 2025!" For Rugi Grond, this long-term mindset is a real antidote to today's world of instant gratification and short-term thinking.

There is a never dull day at work, "it is fascinating to realise that each instrument or piece of hardware that is developed pushes back not only the technology frontier but also the frontiers of space."



Delivering software solutions to the space research community

The huge number of satellites that are currently orbiting the Earth send back unimaginable volumes of data. Extracting workable data is therefore a massive undertaking and requires input from firms like SixSq in Geneva.

One of the hot topics in technology at the moment is the all-conquering mega-trend of “big data.” Their field of application is vast and interest in this information extends across a host of sectors, including space exploration.

To make it easier for scientists to find usable information in this ocean of data, access to gifted software engineers is a must, as they know exactly where and how to extract these golden nuggets. The Geneva-based firm SixSq, founded in 2007 by Louise Merifield, Charles Loomis and Marc-Elian Bégin, has a pool of such talent at its disposal. The SixSq ten-strong team delivers smart cloud-computing solutions to a range of clients, such as ESA

In the beginning, there was Gaia

The history of the company dates back to the Gaia space observatory. In his previous job, Marc-Elian Bégin had acquired contacts within ESA. When a former colleague told him that the space agency was on the look-out for a partner to process data from the Gaia mission, Bégin saw a chance to move a small step closer to realising his childhood dream of becoming an astronaut.

Since the Gaia project began back in June 2008, SixSq has had two of its software engineers posted at the Geneva University Observatory in Versoix. Their job is to package the data relayed from space correctly and forward this information in a well-ordered format to the researchers. As co-founder, Louise Merifield explains: “This used to be done manually, but today it is our software that does the job.”

Merifield, Loomis and Bégin have found ESA and, by extension, PRODEX, to be supportive and even-handed business partners. “They have opened doors for us to take part in other exciting projects,” recalls Merifield. This led the company founders to make a strategic decision in late 2014 to sell part of their shares to the Belgian engineering and software group Rhea System which specialises, among other things, in the manufacture of products used in space missions. “We hope that this new arrangement will lead to more contracts from ESA.”

Operation Europe

Another key to the company’s success is its cloud management platform, Slipstream. The brain-child of two of the co-founders, Bégin and Loomis, it is built on cutting-edge, open-source technology. It is also extremely easy to use and affordable, even for medium-sized firms. “In the past, applications had to be manually placed in the cloud. Today, our software does this for you,” adds Merifield.

Ever enterprising, SixSq is also involved in three major cloud projects - Scissor, Cyclone and PaaS-word - all of which are part of the wider European development programme, Horizon 2020. All three projects also use the NuvlaBox, the latest innovative cloud computing solution from the SixSq stable. Like Slipstream, NuvlaBox, a plug-and-play device offering SMEs and private individuals their own cloud, was built using open-source technologies. Its internal wireless network can connect to any device, enabling users to connect to the cloud services they want. According to Merifield, NuvlaBox “offers small and medium-size enterprises (SMEs) and private individuals a more affordable alternative to existing server and cloud-computing solutions.” It can even be used in emerging countries which often do not have the necessary infrastructure to support reliable communication solutions. “Not only do our innovative products help further our understanding of the Universe but they also help to make the world we live in today a little bit better.”



“Swiss companies are world-beaters in their niche markets”

What role has the Swiss space industry played over the last 30 years?

Frédéric Boden: Back then, it was still in the pioneering and visionary phase. On the academic side, only Bern University was involved in space projects, while Contraves was the only industry player.

However, to be fair to industry, there were not so many ESA missions around then. When ESA began increasing the number of missions, industry tentatively got on board. By the time I joined APCO Technologies 15 years ago, a handful of firms were becoming actively involved in the space sector and cooperation between academia and industry had become a well-established process.

How has the situation changed since then?

The big difference is that, alongside longstanding hardware suppliers like RUAG Space, APCO Technologies and Syderal, there are an increasing number of start-ups offering space-related services and products. This trend is set to continue in the years to come, particularly for services that deal with the data collected during spaceflights. These new providers are devising special services

in response to modern society's growing need for data to monitor earthquakes, avalanches, the weather and even traffic flows.

Why is Switzerland proving to be fertile ground for these firms?

This trend is also prevalent in other European countries too. However the Memorandum of Understanding, which Federal Councillor Johann Schneider-Ammann and ESA Director General Jean Jacques Dordain signed earlier this year, laid the foundations for the creation of an ESA Space Incubator right here in Switzerland. It is only a matter of months before this happens and more and more firms will start to appear on the radar.

What impact will the ESA Space Incubator and these new start-ups have on longstanding space industry providers?

Existing companies will not go under but the arrival of new firms will bring a welcome breath of fresh air to the sector and challenge the established order somewhat.

What role does PRODEX play in this regard? Does the programme influence these developments in any way?

PRODEX has helped to bring industry on board, though only when it comes to scientific instrument development. Most of the work which Swiss industry carries out for space projects is led by ESA or is intended for commercial applications. Today, PRODEX accounts for only five percent of Swiss industry's space-related business, and ESA projects 10 percent.

When all's said and done, Switzerland would not have such a high level of expertise in instrument building and would not be such a high profile partner in scientific missions if it were not for PRODEX. Having said that, Switzerland would still have a space industry even if the programme didn't exist because it already has the capabilities to build other kinds of instruments.

Such as?

Swiss companies are strong in satellite and launcher technology, in payload fairings for launch vehicles and in the construction of scientific instruments, as well as in atomic clocks which are found in most European, Chinese, Indian and Argentinian satellites. Syderal also supplies the electronic equipment that flies on ESA and commercial satellites.

How does the Swiss space industry compare to other countries? Does it even stand a chance in the international market?

Yes, absolutely! Swiss companies are niche players, but they are European leaders and even world beaters in their chosen fields. European countries like France, Germany, the UK and Italy have a structural problem owing to the presence of huge firms like Airbus Defence & Space and Thales Alenia Space. These have a massive market share and swallow up almost all ESA and national space-related funding, thus leaving smaller firms pretty much out in the cold. Switzerland does not have this problem.

And how does it compare with the international market?

Space exploration is still an extremely strategic market, with every major power seeking to protect its own. As a result, Switzerland and other European countries cannot simply go it alone, hence the importance of cooperation within Europe. Here, Switzerland has hit the ground running unlike its collaboration with other space super powers like the US and China, which has yet to get out of the blocks.



Profile

Frédéric Boden is a mechanical engineer by training. He has held several posts with the turbine manufacturer Hydro Vevey and worked for APCO Technologies in Aigle for 15 years. As APCO sales director, he was largely responsible for expanding the company's space-related activities. During this time he was also vice president of the Space Group within SwissMem and a member of the Strategy Commission of the Swiss Space Centre. In summer 2015 he founded his own firm MetalUp3, which supplies 3D-printed metal components to the space industry.

Thanks to the excellent collaboration that exists within Europe, ESA is now a highly regarded and highly visible player on the international space stage. Furthermore, Europeans make a little money go very far. We manage to generate excellent scientific results while spending a lot less money than NASA, for example.

Why?

Because all European countries fight tooth and nail for their missions. This type of constructive fighting spirit does not exist in the US. It simply has NASA, which gets its money from Congress.

In Europe, however, the ESA must lobby individual countries and struggle for every cent it receives. Conditions are therefore tougher and only proposals of exceptional quality will secure funding. We should also remember that there is stiff competition on the research and scientific side. Because a single idea out of 50 proposals will be chosen for a mission, only the very best scientists will receive money and have the opportunity to work with industry and build their instrument. The disadvantage is that implementation is not necessarily easy for industry because researchers tend to push the boundaries of what is possible, virtually ad infinitum.

Does this mean that it is difficult to transfer knowledge from academia to industry?

It is definitely a struggle. We always face problems turning scientists' ideas into a product with the financial and personal resources available to us. It is also a challenge to build something together that satisfies everyone's requirements.

What do participants have to do to make such a mission impossible or possible?

(smile) Of course, in an ideal world there would be an endless flow of money and time.

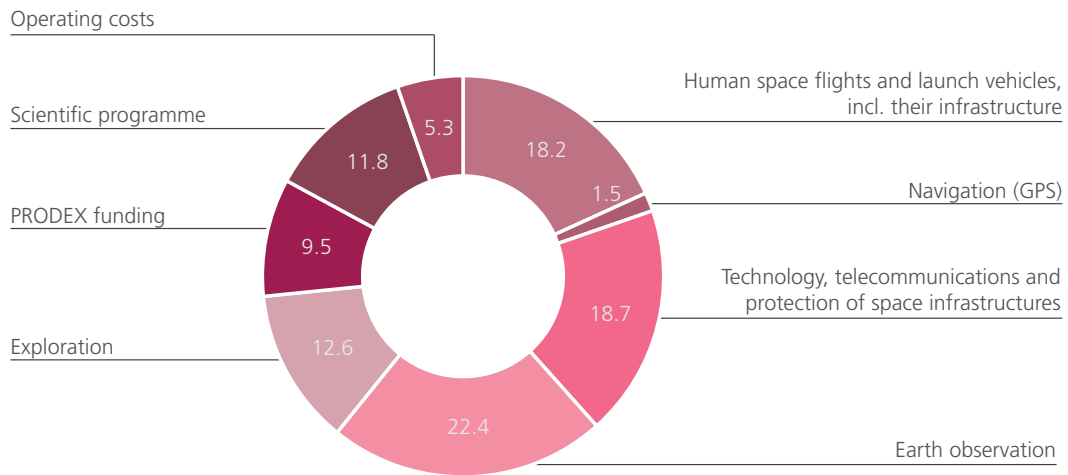
But that's completely illusory...

Of course. The bind that we find ourselves in when it comes to working on projects involving the scientific community is that they are highly complex yet really exciting and enlightening at the same time. However, there is always a financial risk involved because generally speaking it is the industry partner who supplies most of the funding. This is why it is vital that firms who are active in the space sector also have other sources of revenue.

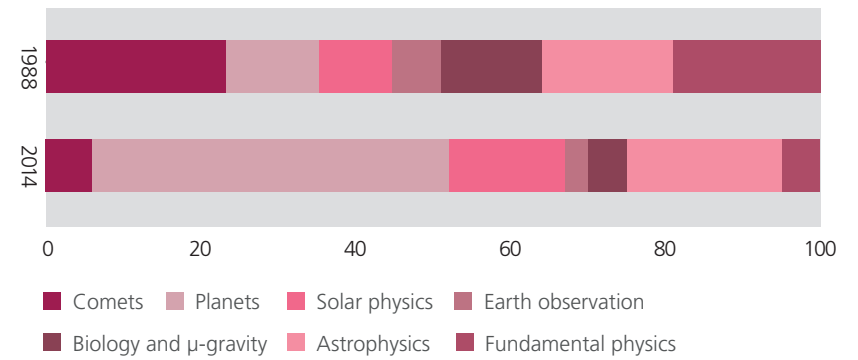
So, why do firms continue to take part in space projects?

Out of conviction and sheer passion! All of these firms have someone in higher management who says: We do this because it is incredibly fascinating and because it allows us to move forward. Space projects keep companies on their toes because of the stringent and transparent processes they have to follow. Involvement also breaks down technological barriers and allows firms to become even better.

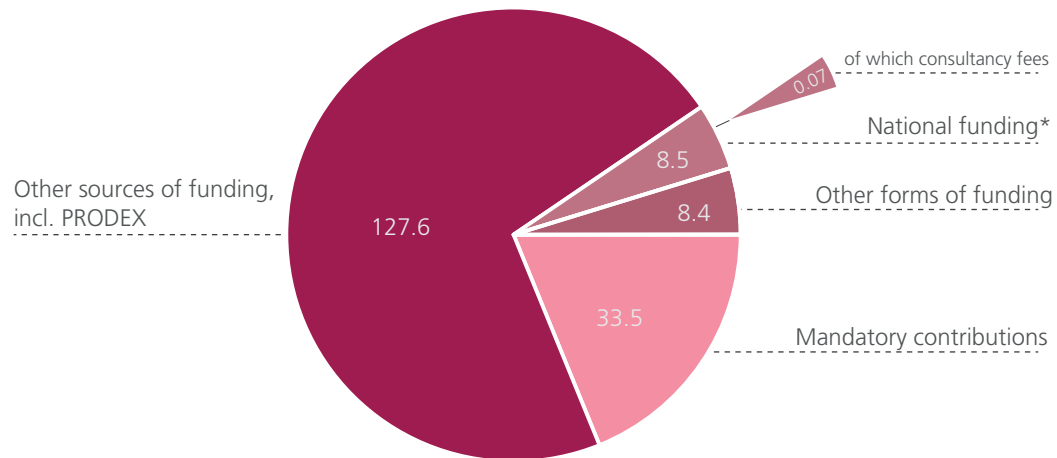
Breakdown of Swiss space investment in 2014 according to activity (in %)



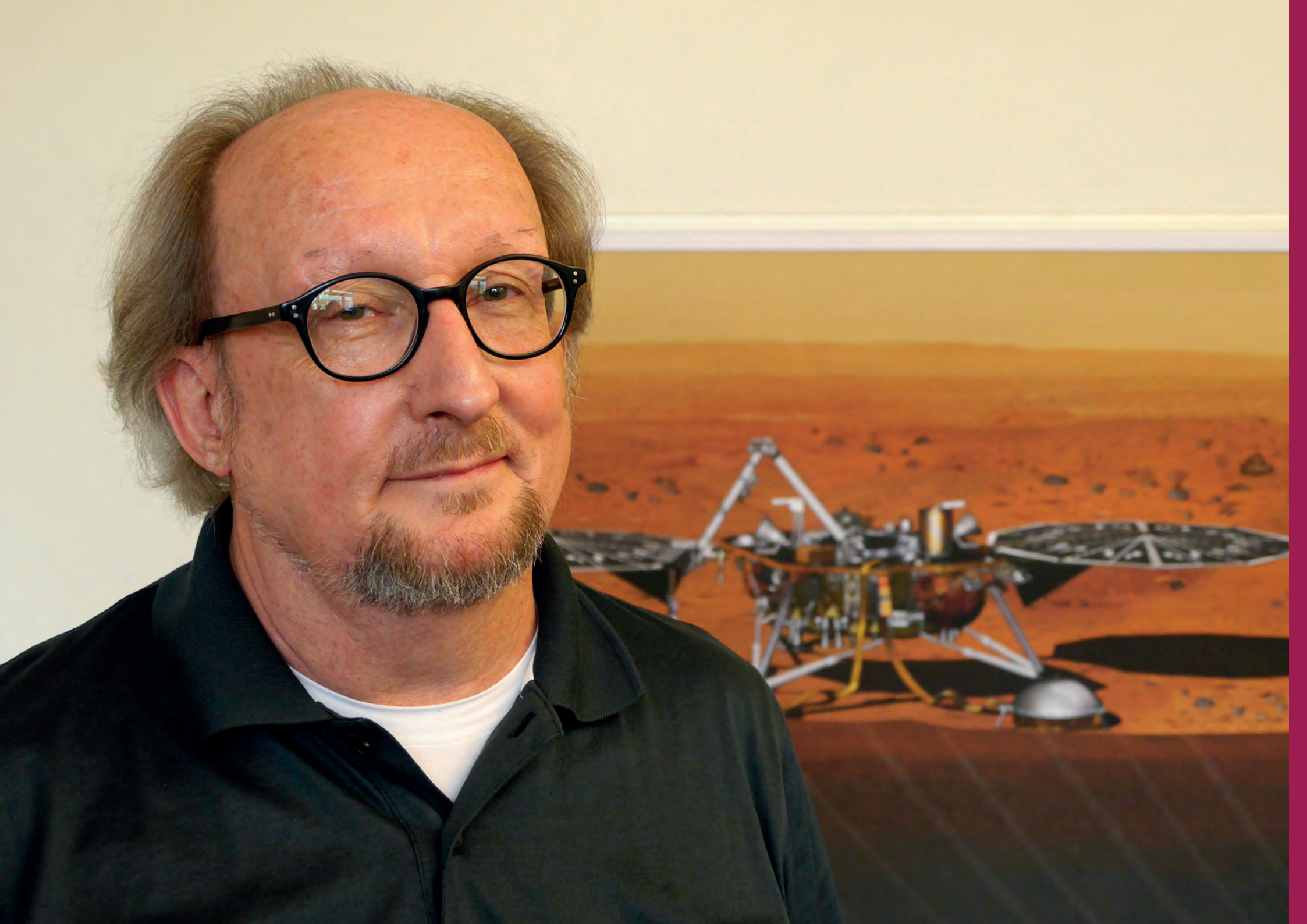
PRODEX funding over time (in %)



Swiss space investments 2014 (in CHF million)



* e.g. for the Swiss Space Centre and various project contributions



Investigating what makes planets tick

For over 15 years Peter Zweifel has been at the helm of the Aerospace Electronics and Instruments Laboratory of the Institute of Geophysics at the ETH Zurich. Working hand in hand with the scientific community allows him to develop instruments that benefit from state-of-the-art technology and the latest scientific knowledge. Indeed, this resourceful engineer will have the privilege, not once but twice, of seeing two of his instruments being launched into space in the near future (2015 and 2016).

While he was working as a test engineer with the hearing-aid manufacturer Phonak in the 1980s, Peter Zweifel could never have dreamt that one day he would be involved in building space hardware to measure planetary seismic waves. Yet, the electronics engineer has always had a fascination for the Earth sciences and satisfied his intellectual curiosity by regularly reading *Scientific American* in his spare time. At the age of 40, Zweifel decided that a career change was in order, and when someone told him in 1992 that the ETH Zurich was looking for someone to head up an electronics laboratory run by the Swiss Seismological Service and the Institute of Geophysics, he applied. The rest, as one says, is history.

Seismograph for Mars

Zweifel had barely started working on seismic instruments and hardware when his former boss and institute director, Professor Domenico Giardini, asked him if he would be willing to work with industrial and international partners on developing a seismometer for a mission to Mars. "I felt that I had what it took, so I said yes," recalls Zweifel. "Mind you, I had no idea what was in store for me." In 1997 Peter Zweifel founded the Aerospace Electronics and Instruments Group of the Institute of Geophysics, which he headed alongside his management of the Swiss Seismological Service (SSS) lab. He and his colleagues continued to work on the seismometer for the Mars Netlander mission, a consortium led by the French space agency CNES. Unfortunately, the mission was halted in 2003 by the newly-elected French government as part of a cost-cutting drive, and the prototype seismometer was mothballed.

Thanks to his excellent network of industry contacts, Zweifel was still able to work on space projects, such as the ESA-led LISA Pathfinder. This was the forerunner of the LISA (Laser Interferometer Space Antenna) mission to record gravitational waves in space. Zweifel and his team were responsible for devising the specifications for the gravitation reference sensor's electronics system. Between 2005 and 2009 Contraves Space (today RUAG Space) used their work to develop and build the electronics.

Zweifel recalls how delighted he was with the support, not only in the form of funds, which he received from PRODEX during his time working on both projects. "On the one hand, PRODEX Office experts helped us select our industry partners and advised us on the negotiation process. We also greatly benefited from their spaceflight expertise." Although he found himself involved, as if by magic, in space projects, in the early days he lacked the specialist expertise and sometimes overstretched himself despite the knowledge and insight he quickly acquired on the job: "We needed expert help to ensure that we complied with all of the standards and produced the required documentation."

All's well that ends well

To his great surprise, the Mars project was resurrected in 2012. In cooperation with CNES, the Institut du Physique du Globe in Paris, Imperial College London, the Max Planck Institute for Solar System Research in Göttingen, as well as the American Jet Propulsion Laboratory, the data recording electronics for the seismometer, which Zweifel and his team had devised, was finally built by Syderal, and in record time. By early 2015, it had gone from prototype to usable flight hardware.

In March 2016 the seismometer is set to be on board NASA's InSight mission to Mars, and should land on the Red Planet six months later. Zweifel awaits this moment with great anticipation. "It is an enormous privilege to watch an instrument developed by my team being used in space and see the results it generates." Zweifel will also have another opportunity to witness his work being used in space when the LISA Pathfinder launches in 2015.

Why use seismic data to explore Mars? "The three-dimensional records will deliver information about the different layers of the planet and its structure, just as terrestrial seismic networks do for Earth. The big challenge, however, is that there will only be one instrument on Mars to do all of this work."



“Society also benefits from space innovation”

Why are Universities of Applied Sciences (UAS) involved in space research?

André Csillaghy: At the University of Applied Sciences of Northwestern (FHNW), we're interested in research that deals with the development of observation instruments for use in space. There are a lot of technical considerations involved here which industry alone cannot tackle. This is where applied research comes in. In certain instances, new developments are needed which could have potential uses in other fields.

Thanks to our direct line to industry, we are well-placed to nurture this kind of knowledge transfer. This is why space research is totally in line with the brief of Swiss UAS.

Is that the only reason?

Of course, there are other reasons too. Space research is an exciting field for students and colleagues to work in, and helps nurture their innovative spirit. Space projects also are great at inspiring the next generation of cutting-edge researchers. As such, space projects generate both scientific and social benefits.

What does space research do for society?

Besides nurturing the next generation of talented scientists, the innovations generated by research are also relevant for society. This is not always immediately evident, and seem so far removed from our day-to-day life back on Planet Earth. But take the ESA's Solar Orbiter mission. It will not have any direct bearing on our lives, but its indirect impact is unmistakable.

Can you explain?

Thanks to Solar Orbiter, solar research has made a quantum leap. For example, solar eruptions can compromise the performance of infrastructures like GPS and other communication satellites. If we are able to exploit the data sent back from this mission to improve the accuracy of solar eruption forecasts, then this should allow us to protect communication systems more effectively.

You mentioned your direct line to industry. How does collaboration work between you both?

Very well. We have a dense network of contacts. At the moment, we're working with Almatec, Art of Technology, and Syderal. But there also are a lot of other firms who develop or make components for us. We're also working with companies who are interested in developing certain components for us, whose manufacture we currently outsource to the US.

So, you try to generate value-added wherever possible for Switzerland?

Yes, absolutely. A longer term goal of the FHNW is to create jobs in the space sector through our project work. Of course, we would prefer to have a critical mass of expertise available locally. But we simply need a little more time even though the STIX project, which began five years ago, has strengthened our resolve to build our space-related capabilities.

How did the FHNW become involved in STIX?

We were involved in STIX from the word go, although we only had a bit-part initially. At that time STIX was an ETHZ project and we were responsible for the data analysis software. When it transpired that the ETH wanted to cut back on its solar research activities, it made perfect sense for the FHNW to take over the management of the project.

We were convinced that we had the right people and expertise to build instruments, although we had yet to set up a basic research group at that time.

UAS generally don't carry out basic research. Why was this important for the project?

When we build an instrument for solar research purposes, we want to have access to the results. But we also need people specialising in basic research involved in the instrument development process. We all agreed that the PRODEX-led STIX project would allow us to acquire new insights. So, we set about looking for an expert who could help us build the X-ray telescope. By hiring Säm Krucker, a highly experienced solar researcher from the University of California, Berkeley, we not only gained a Principal Investigator but we brought a talented homegrown scientist back to Switzerland. I should hasten to add that we do not intend to start rolling out basic research across the natural sciences. But I believe that it is important and inescapable that we explore specific fields as deeply as we possibly can.



PROFILE

Professor André Csillaghy has been director of the Institute for 4D Technologies at the University of Applied Sciences of Northwestern Switzerland (FHNW) since 2008. After receiving his PhD from ETH Zurich, the computer scientist worked at the Space Sciences Laboratory in UC Berkeley for three years.

Is your Institute within the FHNW a stand-alone structure or do you work with other FHNW institutes?

We work closely with several institutes. The Institute of Products and Product Engineering develops and manufactures certain parts of the hardware, while the Institute of Plastics Engineering and its offshoot within the Paul Scherrer Institut (PSI) have built the sensors. We also benefit from the FHNW clean room. We cooperate with the Institute of Microelectronics and the Automation Institute too. Within Switzerland, our academic partners include the Physical and Meteorological Observatory Davos, Bern University and ETHZ.

What about cooperation with universities abroad?

Nothing would happen if we didn't! Space research is real team-work. Although large parts of the software are produced in Switzerland, the board computer comes from Poland, the core of the detector electronics is developed and manufactured in France, while the crystals for the detectors are bought in Japan. The board software is from the Czech Republic and Germany is responsible for the optical system. There are 40 engineers and scientists working on this project.

Is PRODEX your only source of funding?

It is important that our future development is not reliant on a single experiment or on a single source of support. We want to carve out a long-term role for ourselves. Instrument development is funded by PRODEX, while the Swiss National Science Foundation funds the basic research side. With money from Horizon 2020 we are able to cover other related costs. We are involved in the EU project FLARECAST, with responsibility for developing an automated reporting system for solar eruptions. This work will benefit not only space research. An advantage of the EU projects is that the budgets factor in communication costs, which makes it easier for us to share our research activities with the general public and interested parties.

You have been involved in only one PRODEX project so far? Do you think you might have the opportunity to develop other instruments?

We are currently working on two PRODEX projects. The second concerns software for the ground segment of Euclid. But getting back to your question, of course we want to be involved in more satellite missions. We already have a couple in our sights. Wherever an instrument is being developed that involves X-ray detectors, we want to be in on it, too.

Further information

>> fhnw.ch/technik/spectrometer-telescope-for-imaging-x-rays

>> blogs.fhnw.ch/sonnenforschung

Swiss PRODEX projects at a glance

New-generation space camera

The CaSSIS (Colour and Stereo Surface Imaging System) camera, a project led by Bern University and built by RUAG, is a high-resolution colour stereo camera that can capture the surface structure of Mars with a resolution of up to five metres per pixel. The images recorded by CaSSIS will be used to glean information on the geological context of the source of trace gases which have been detected by the NOMAD and ACS instruments.

See profiles, page 11 and page 35

Successful landing

In November 2014 the ROSINA (Rosetta Orbiter Spectrometer for Ion and Neutral Analysis) mass spectrometer successfully arrived the Churyumov-Gerasimenko comet. The data that it has already sent back should provide clues to the origins of the solar system. This is a lot to ask of an instrument, but the ROSINA has capabilities that go far beyond any space mass spectrometer that has been built to date. These include a high resolution mass, very wide dynamic and mass ranges, coupled with incredible sensitivity. ROSINA can also determine the speed and temperature of the gases emitted by comets.

See profile, page 19

Biological research in space

The Columbus research laboratory has been on board the International Space Station (ISS)

since 2008. BIOTESC in Hergiswil is responsible for ensuring that the biomedical experiments performed there run without a hitch. Some of the space experiments and instruments developed in Switzerland:

- White blood cells: The "PA-DIAC" project of the Aerospace Biomedical Science and Technology Support Centre (University of Applied Sciences and Arts Lucerne, HSLU) investigated why white blood cells under zero gravity do not react to certain growth factors and subsequently fail to produce an effective immune response. The experiment was transported to ISS in 2010.
- Tumours: The Spheroids experiment investigates the influence of zero gravity on the formation of tumours and their blood vessels. Launch scheduled in autumn 2015
- Yeast: The Bioreactor project led by Dominika Kauss from HSLU aims to understand how yeast cells – which can also cause disease – behave under microgravity conditions and under exposure to environmental stimuli. Launch scheduled for 2018.

See profile, page 23

Planetary pulse monitor

When it launches in March 2016, InSight, a NASA Discovery Programme mission, will seek to place a stationary lander on Mars. One of the many devices on board the lander will be a seismometer co-developed by the

ETH Zurich as well as a heat flow probe to study the early geophysical development of Mars. It is hoped that the mission will improve our understanding of the Moon and Earth-like planets in the solar system (Mercury, Venus, Earth and Mars).

See profile, page 43

Mapping outer space

Euclid is the name of the ESA space telescope to explore dark energy and dark matter. It is slated to launch on a Soyuz ST-2.1b spacecraft from Kourou in 2020 and will begin to orbit the L2 Lagrange Point six months later. Some three to six months after it reaches its destination, it will embark on a six-year-long mission to map outer space. Euclid will use two instruments, both of which will observe the same region of the sky through a 1.2-metre Korsch telescope which has three mirrors and a focal length of 24.5 metres.

See profiles, pages 13 and 21

Search for other life forms

Neighbouring solar systems have countless planets which circle their own stars, just as the Earth circles the Sun. Sophisticated instruments such as the CHEOPS telescope (CHaracterizing ExOPlanet Satellite) have been developed to study their properties. Alongside the Bern Center for Space and Habitability and the ESA, Professor Willy Benz and his team are in charge of not only the telescope but the entire mission.

CHEOPS measures 33 centimetres and flies at an altitude of between 650 and 800 kilometres, precisely above the day/night terminator. This means that the solar arrays have a source of light while the telescope looks into the dark. It will be the first mission to study the transit of bright stars already known to host planets.

See page 27

The Sun up close

STIX – Spectrometer Telescope for Imaging X-rays – is an X-ray telescope developed by the FHNW, which is scheduled to be launched into space on the Solar Orbiter spacecraft in 2018. It will leave the ecliptic plane and travel to within one-quarter of the Earth's distance from the Sun. The aim of the mission is to measure the solar wind and charged particles as close as possible to their point of origin, and to observe the sun in high resolution. It is expected that the first set of data sent back will be analysed within 18 months of the mission launch.

See interview, from page 44



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