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NEDERLANDSE VERENIGING VOOR RUIMTEVAART

2018|3

RUIMTEVAART

SSP18 Special

Space and the Netherlands

Editor-in-chiefs note:

The magazine you have in your hands right now is the world's longest running space magazine, being published by the Netherlands Space Society NVR continuously since 1951. The frequency of publication has varied over time, but in recent years we have managed to publish the magazine four times a year, each edition with 48 pages of content.
Occasionally we publish a special issue focussing on a distinct topic such as small satellites, space telescopes, atmospheric research, and spin offs, or for a special event such as an International Astronautical Congress being hosted in the Netherlands.
The current issue is especially prepared for the 31st annual Space Studies Program (SSP) session of the International Space University (ISU) that will convene in the Netherlands during the summer of 2018. Most of the content is written by NVR corperate members, a membership exclusively for companies and institutes.
The NVR counts more than thirty corporate members, ranging from large companies and institutes to start-ups, which are making use of the benefits and network advantages such a membership offers. In addition, we boast a network of more than 1000 individual members – and counting. These range from students (free membership) and space enthusiasts to established professionals. We organise community building functions such as film nights, symposia, lectures and much more, both independently and in collaboration with our corporate members.
This special issue of our '*Ruimtevaart*' magazine was created by guest editor Nick Kivits with copy editing support from our executive editors Frank Wokke and Michel van Pelt. We hope that the magazine will provide you with a good overview of the space sector in the Netherlands. We thank all authors, and especially Nick, for their contributions.

Peter Buist

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Should you want to contribute to future editions of Ruimtevaart or should you have any suggestions, feel free to contact our editors at **redactie@ruimtevaart-nvr.nl**. We reserve the right to shorten or decline any and all submitted pieces.

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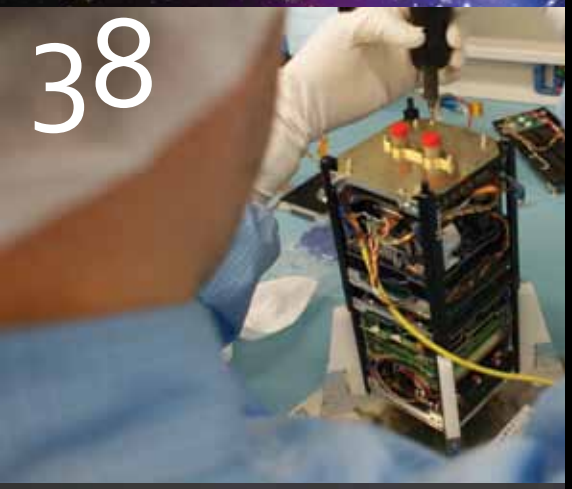


A Sizzling Summer of Space

Nico van Putten, Deputy Director of Netherlands Space Office, the formal local SSP18 host organisation

Can the Netherlands host a Space Studies Program (SSP)? The journey to find the answer to that question started in 2013, when the Netherlands Space Office (NSO) initiated a feasibility study in order to analyse the possibilities. What are the potential Dutch contributions to the academic program? What are the major logistic conditions? What are the budget requirements? And how strong is the support of key organisations and institutions?

And now, five years later, here we are. The summer of 2018 will be a 'Sizzling Summer of Space' in the Netherlands, with the organisation of the 31st annual Space Studies Program in close cooperation with the International Space University (ISU) and an extensive programme of space activities for the general public. During nine weeks, ISU and the Netherlands – as a cooperation between the NSO, Delft University of Technology, Leiden University and ESA-ESTEC – will offer a programme for 130 international young space professionals in the fields of seven distinct disciplines and dedicated team projects.

After almost four weeks of core lectures and workshops, often given by the very best specialists, academics and astronauts from all over the world, the participants get to choose one of the seven disciplines to specialize in: space science, space engineering, space applications, human performance in space, space humanities, space policy, economics and law and space management and business. Moreover, they learn to work in an international, intercultural and interdisciplinary environment.

The Netherlands and space

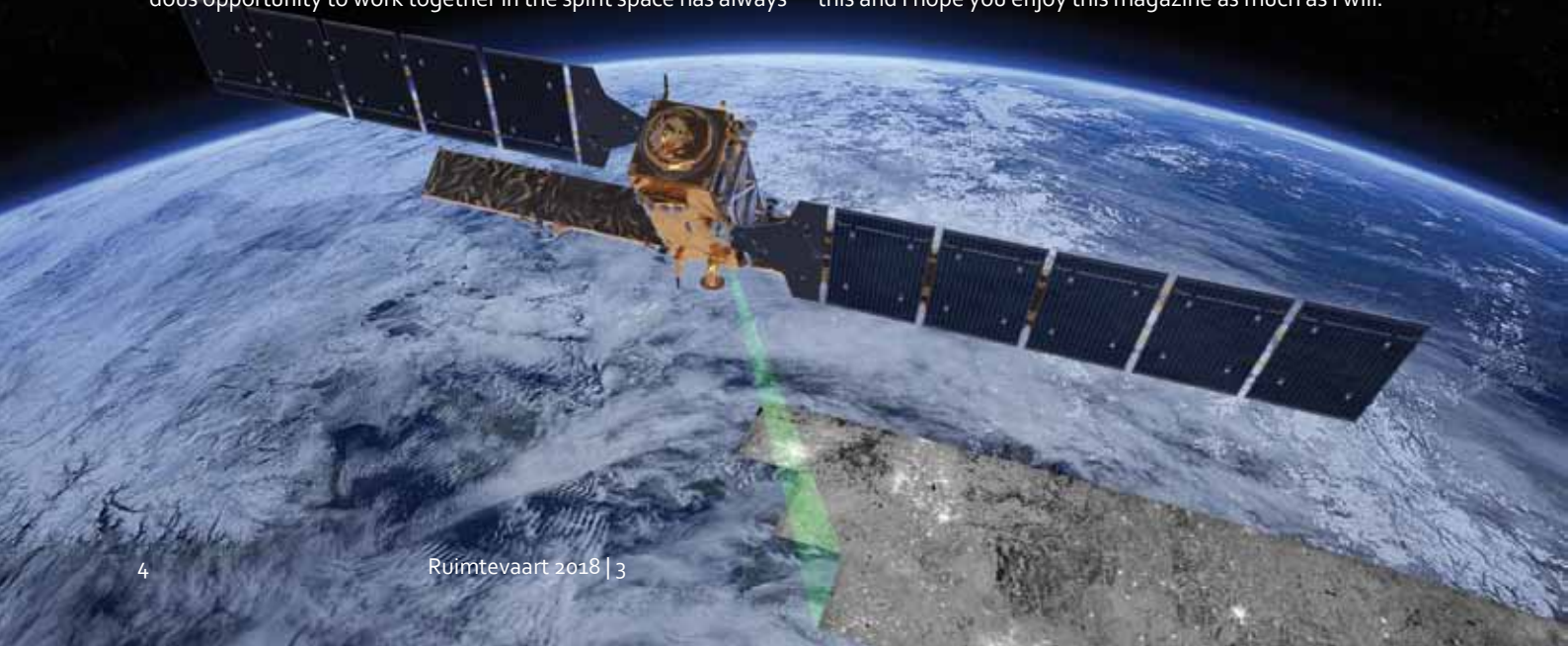
Along the way, participants of the Space Studies Program learn a lot about the role the Netherlands play in the international space community. In fact the ISU SSP network gives all of us a tremendous opportunity to work together in the spirit space has always done. The International Space Station (ISS) is a good example of collaboration but in our view space in itself has this spirit as well.

The Netherlands absolutely is a country of space, which not only houses the European Space Agency's Research and Technology Centre (ESA-ESTEC) testing facility (the largest ESA-facility in all of Europe) and the Galileo Reference Center (GRC), but also hosts a vast array of small, medium and large space companies and institutes. The work of ESTEC is focussed on developing, building and testing advanced high-tech systems and components for many ESA missions and beyond. GRC independently monitors the signal of the Galileo system and will create new business opportunities. Companies and institutes develop ground breaking technology or satellite applications that offer solutions to global challenges.

In the Netherlands alone, about thirty companies develop and build these systems. Aside from that, more than forty user institutes, space organisations, laboratories, and universities are actively involved in projects in the field of space science, Earth observation, meteorology, communications, navigation and space technology. Without these Dutch companies and organisations, space as we know it would look very different. And not just space, but also the Netherlands itself. Every euro spent in the Dutch space industry, gives an estimated return on investment of two to five euros.

The Netherlands and space are closely linked. That is why the Nederlandse Vereniging voor Ruimtevaart (NVR) presents to you this special edition of our magazine Ruimtevaart. This edition will give you a look into the Dutch space sector. How big is it? Who are active in it? What are the success stories? And what will the future hold?

I am happy the NVR used the ISU SSP as an occasion to highlight this and I hope you enjoy this magazine as much as I will.



The Netherlands is all about space

How big is the role of the Netherlands in space?

The Netherlands at night, as seen from space. [ESA / André Kuipers]

Space in Europe has always been an international affair, in which a lot of different countries have banded together to conduct research and launch technology into orbit. The Netherlands has played an important part in space for well over fifty years.

Nick Kivits

Satellites and probes that want to visit space have a big trip ahead of them. Before they can leave the Earth's atmosphere they have to be placed atop a rocket which shoots them up with a speed of at least 7.9 kilometres per second. But there is another way to access the vacuum of space. Hidden behind the sand dunes of the small Dutch town Noordwijk is a little piece of space. Right here on Earth. It is the Large Space Simulator (LSS), one of the test chambers of ESTEC, the technical management facility and test centre of the European Space Agency (ESA).

Standing in front of the LSS it is hard to see what's going on inside the fifteen meter high and ten meter wide chamber. Inside, full-sized spacecraft are being exposed to some of the hostilities of space. A vacuum is created by pumping all the air out of the room, while a huge gantry of extremely bright xenon lights reproduces the light of the Sun. Liquid nitrogen circulating around the room recreates the cryogenic temperatures that all satellites and probes have to deal with in space. Entering the LSS without a pressure suit would spell certain doom. Just like space.

Indefinitely linked to space

Having ESA's test centre located in Noordwijk has inextricably linked the Netherlands to space. And that has been the case for many years. An old "Polygoon" journal from 1968 – which was shown in movie theatres at the time and can still be seen on YouTube – took viewers inside the test centre for the first time, complete with unsettling "alien" bleeps and pings as a soundtrack. The journal talks about the testing of the first European satellite ESRO-1. That same year ESTEC was officially opened by her royal highness, Princess Beatrix.

But the Dutch link with space didn't start with the construction of ESTEC: the Netherlands was one of the founding members of ESRO, the European Space Research Organisation, the precursor to ESA. When a small group of European scientists – led by the Italian Edoardo Amaldi and the Frenchman Pierre Auger, who were both key actors in the process of setting up CERN, the European organisation for nuclear research – started talking about forming a joint space organisation in 1959, the Netherlands quickly showed interest.

Two years later – in March 1961 – the European Preparatory Commission for Space Research (COPERS) started exploring the possibilities. At the first COPERS convention a council of European space scientists was formed, with the Dutch professor Hendrik van der Hulst being one of the scientists. Seven months later – in October – a 77-page document was presented, which outlined ESRO's scientific programme and its technology centre, among others things.

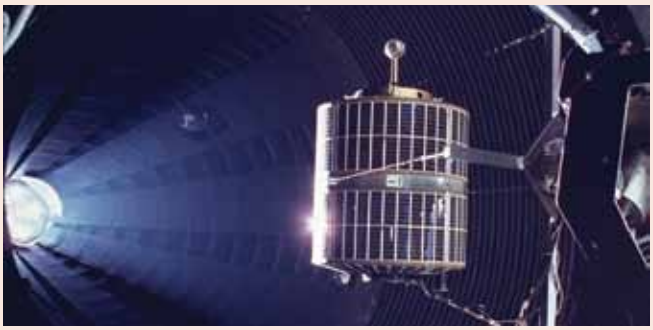
In March 1962 the Netherlands was one of the countries (alongside Belgium, France, Germany, Italy, the United Kingdom and associate member Australia) which stood at the cradle of ELDO, the European Launch Development Organisation, a research organisation developing rockets to launch satellites to space. Two years later, Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom founded ESRO. The Netherlands has since remained front and centre in the space business. ESRO and ELDO were merged to form the European Space Agency (ESA) in 1975, in which the Netherlands has played a key role ever since.

The space chain

In 2018, the space sector in the Netherlands has an annual revenue of 140 million euro. There are over 4,000 employees

The first satellite in the Netherlands

ESA's very first satellite, ESRO-1, was also the first satellite tested in the Netherlands. Fifty years ago this summer, ESRO-1A arrived at ESTEC. After testing it was launched in October of that same year. It concentrated on measuring solar and cosmic radiation and its interaction with Earth. The satellite re-entered Earth's atmosphere in June of 1970.



ESRO-1 being tested at ESTEC. [ESA]

ESTEC: simulating the hostilities of space

Virtually all spacecraft built by Europe have to pass through the Netherlands on their way to space. Right next to the sand dunes of Noordwijk lies ESTEC, the European Space Research and Technology Centre. It incorporates the largest testing facility for spacecraft in Europe, where satellites and probes planned to leave Earth's atmosphere are exposed to all the hostilities of space.

Aside from the Large Space Simulator – which is mentioned on the next page – ESTEC's test centre houses a number of unique simulation chambers. One of which is Hertz, a huge chamber lined with foam spikes that are meant to absorb radio waves, but do the same for sound waves. The foam spikes are so adept at this, that entering the room and shutting the door behind you creates such silence that one can hear their own blood flow. The Hertz chamber simulates the eerie silence of space and is used to test antennas for spacecraft.

Although space itself is silent, the road to it is filled with noise. A rocket launch can create over 200 decibels of sound (in at least one instance the launch of a Saturn V rocket produced 204 dB). Sound waves are basically vibrations, and vibrations – if strong enough – can destroy materials. That's why European spacecraft get placed in the Large European Acoustic Facility (LEAF), which is a room connected to enormous sound horns. These horns recreate the sounds of a rocket launch, to check if the tested probes and satellites don't fall apart.

Testing the integrity of a spacecraft structure is also the goal of the QUAD Shaker, which is the biggest of all of ESTEC's shaking platforms. The QUAD Shaker is used to give satellites and probes a good rattle. Rocket launches not only produce a lot of sounds, but also a lot of vibrations. The QUAD Shaker simulates these by as much as 2000 vibrations per second. The idea being that if a screw falls out, it's better to know on the ground then during launch. It can produce up to 20 G of force, which would make almost all human beings pass out and see stars.

These are just some of the testing facilities ESTEC houses. At ESTEC, over 2500 people from over twenty countries are working every day to make the European space missions a success. They not only test spacecraft, but also design the missions and manage their development. With this centre being located in Noordwijk, it truly makes the Netherlands a hotspot for space.

Start of the construction of ESTEC in 1965. [ESA]

The European Union and space

Prepare for the increasing role of space in the future and reap the benefits of space now. With that mission the European Commission set-up the space components of Horizon 2020, the eighth European framework programme for research and technological development.

The programme funds a wide variety of research and innovation projects. It covers not only the two European space flagships, namely Galileo (for satnav) and Copernicus (for Earth observation), but also focuses on protecting the Earth and space infrastructure by setting up a space surveillance and tracking system.

The programme strengthens the European competitiveness in space, the utilisation of investments in space infrastructure for civilians and looks to increase Europe's attractiveness as a partner for international cooperation in space research and exploration.

For the period of 2021 to 2027, the European Commission proposes for its space programme a total budget of over 15,000 million euro.

MetOp being tested in the Large Space Simulator. [ESA]

working directly in the space sector. While – according to studies done by the Organisation for Economic Cooperation and Development (OECD) – every euro invested in space yields 1.5 euro in return, space investments in the Netherlands have a much higher return. Because of the scope of the space sector and because ESTEC is located in the Netherlands, every euro invested in the Dutch space sector boasts a profit of five to six euro. Money well spent.

The space sector in the Netherlands includes a number of companies and institutions, all of which are linked together. This year for instance, Airbus Defence & Space Netherlands in Leiden opened a new assembly facility for producing parts that are necessary for launching European rockets. Those rockets bring all kinds of satellites to orbit which are used by a number of space and non-space companies. Data gathered by these satellites provide farmers with accurate weather forecasts, help companies track lost possessions and allow us to communicate with each other, among many other things. Not only in the Netherlands itself, but worldwide.

The Dutch space chain includes R&D institutes, companies, laboratories and universities, many of which conduct scientific research with the help of the space sector. The universities of Nijmegen, Groningen, Leiden and Amsterdam all conduct research in the fields of astronomy and astrophysics, in which they work closely together with the Netherlands Institute for Space Research (SRON). Simultaneously the Wageningen University, the Delft University of Technology (TU Delft) and the universities of Amsterdam and Utrecht are active in the fields of Earth observation, Earth sciences and meteorology.

And that is just the tip of the iceberg. The universities of Amsterdam and Utrecht are also active in the field of planetary research. The previously mentioned TU Delft calculates precise orbits, does material research and builds its own satellites, one of which – the Brik II – is developed in cooperation with the Royal Netherlands Air Force. Brik II is planned to be launched in 2019. The Technical University Eindhoven and the Technical University Twente are also active in space, working on new antennas, telecommunications, meteorology and nanotechnology. Naming all of the accomplishments and research projects going on in the Netherlands right now would turn this magazine into a very (very!) thick book.

Dutch work on European projects

All in all, over thirty Dutch companies build high quality products, instruments, components and software for space, like solar panels, solar sensors and astrophysics instruments, but also testing equipment for use on the ground.

The biggest space company in the country is Airbus Defence and Space Netherlands (Airbus DS NL), which started as a subsidiary of the Dutch airplane manufacturer Fokker in 1995 (then named Fokker Space). The company – which changed its name to Dutch Space in 2002 and became part of the Airbus group under the name Airbus DS NL three years later – built the solar panels that allowed ESA's Rosetta spacecraft to chase down the comet 67P/Churyumov-Gerasimenko for ten years.

Airbus Defence and Space Netherlands is also one of the oldest space companies in the country, building upon the space heritage of Fokker. Another space company with a long history is Bradford Engineering, which was founded in 1984. Bradford has contributed to over one hundred successful missions, and has built over 1600 products which have successfully been flown to space. Besides products like valves for satellites, the ATV spacecraft and the ISS, the company built glove boxes which were, and still are, used for researching materials and biological systems on the ISS. It also built sun sensors for satellites and constellations like the European satnav constellation Galileo and the Iridium satcom constellation.

Galileo is one of the key space pro-

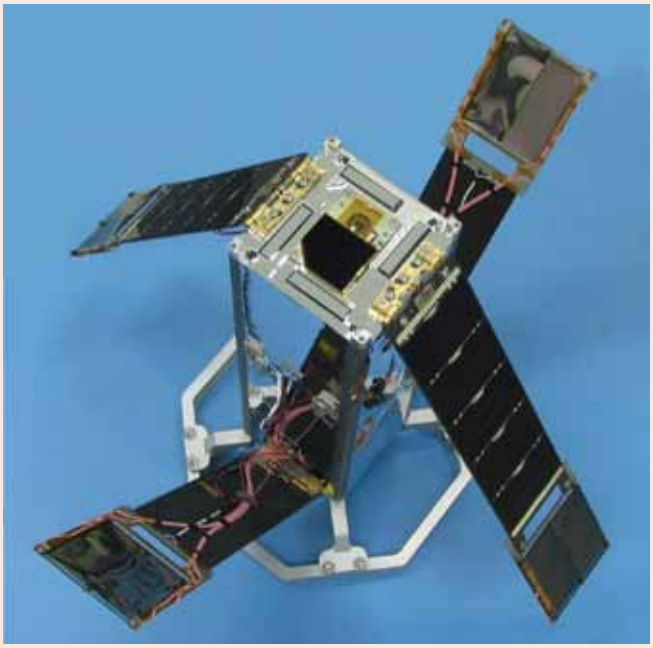
Big in small satellites

Good things come in small packages. And that is especially true for small satellites, some of which are no bigger than a milk carton. The Netherlands is a frontrunner in the field of small satellites. In 2016 the Netherlands Aerospace Centre was put in charge of a European research program to look into the possibilities that a dedicated launcher for so called CubeSats can bring to the table.

Because of their size and weight, launching CubeSats is a lot cheaper than launching big satellites. This makes it easier for newcomers to catch a break in the space sector. "To stimulate the use of CubeSats, the launching price should be brought down to 50,000 euro per kilogram", said MEP Cora van Nieuwenhuizen in 2016 at the start of the project, for which the European Union reserved four million euro. "One of the goals of this initiative is to make this a reality."

Cubesats provide universities the opportunity to conduct more research in space. TU Delft is one of the institutes that already uses CubeSats. In 2008 it launched its first small satellite – Delfi-C^3 – into space. Delfi-C^3 was completely developed by students at the university and was the first nanosatellite hailing from the Netherlands. It carried new types of solar cells, a solar sensor developed by TNO, and a high-efficiency amateur radio transceiver to space. Although Delfi-C^3 was meant to only last one year, it is still operational ten years later.

In 2013 the TU Delft followed up on the project with the launch of Delfi-n3xt, a nanosatellite built by students that is testing out new space technology and innovations in space. The Delfi-C^3 project also indirectly led to the formation of Innovative Solutions in Space (ISIS), one of the leading companies in the fast-growing small satellite market. ISIS now designs and delivers small satellite platforms for single missions and constellations, tailored to the needs of the mission at hand. The company also brings the small satellites to space through its subsidiary ISL showing that a small country like the Netherlands is big in the field of small satellites.



The Delfi-C^3 satellite was built by students of the Delft University of Technology and has been in space for ten years. [Delft University of Technology]

Astronauts from the low lands

Throughout history, over five hundred people have left Earth's atmosphere and travelled into space. Of these travellers, three were born in the Netherlands. In April and May of 1985, scientist Lodewijk van den Berg flew aboard the Space Shuttle Challenger, for an eight-day trip. During the trip Van den Berg researched the growth of crystals in space.

Only six months later, our fellow countryman Wubbo Ockels went to orbit, also aboard Challenger. Because Van den Berg lived and worked in the United States and had become a US citizen a year before his flight, Ockels is widely regarded as the first Dutch person in space. During his one-week stay (from October 30 to November 6, 1985) Ockels and the rest of his crew conducted over 75 experiments in fields ranging from physiological sciences and materials science to biology and navigation.

After Ockels, it took almost twenty years for another Dutchman to fly to space. In 2004 André Kuipers flew to the International Space Station (ISS) for an eleven-day mission, during which he conducted 21 experiments. Kuipers also involved children from primary schools in one of his experiments, in which he grew plants in space while the children did the same on Earth. Kuipers then compared his plants with those of the children, as part of an educational space programme.

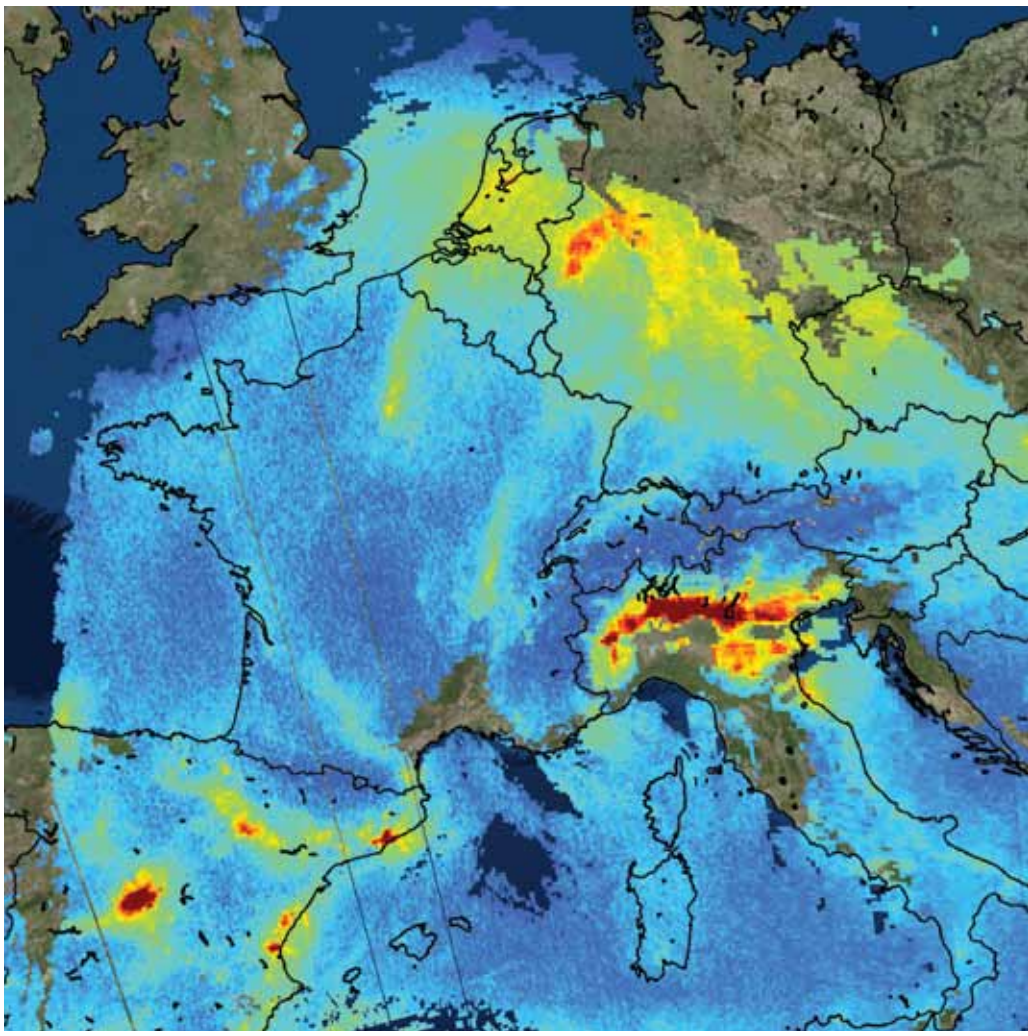
In 2011 André Kuipers became the only Dutch astronaut to fly to space multiple times. Kuipers returned to the ISS for a period of six months, to live and work in space. During the trip he broke the record for longest stay in space of any European. The record is currently held by the Italian astronaut Paolo Nespoli.

The Dutch astronaut André Kuipers floating in the ISS. [ESA]

Representatives of the Royal Netherlands Airforce, ISIS, National Aerospace Laboratory and TU Delft, with a Brik-II model. [Dutch Ministry of Defence]

grammes started by the European Union. As a matter of fact, it is not only the biggest European space project off all time, but actually the biggest single infrastructural project funded at European level. And the Netherlands has a major role in it. Not only does the aforementioned Bradford provide the sun sensors for the satellites (fun fact: one of the satellites carries the Dutch name 'Tijmen' as a nickname), also the solar panels and software used are made in the Netherlands (by Airbus DS NL and CGI respectively).

ESTEC is the place where the technical development of the current system was managed and where also the next generation takes place. The performance is monitored in Noordwijk by the Galileo Reference Centre (GRC), a technical centre of the European GNSS Agency (GSA), established right next door to ESTEC. The GSA is the EU agency responsible for operating and managing the Galileo system. Aside from Galileo, the Netherlands also plays a big part in another big European space project. Copernicus is the largest single Earth observation programme in the world, which looks to build a network of satellites to monitor Earth. It does so by launching a slew of Sentinel satellites into space, which provide radar imaging of land and oceans (Sentinel-1), high resolution optical imaging (Sentinel-2), ocean and land monitoring (Sentinel-3) and data



Sentinel-5P's TROPOMI-instrument – which was made in the Netherlands – sees nitrogen dioxide over Europe. [ESA]

Investing in space

A few years back, Dutch government investments in space were on the fence. Back in 2011, at the high point of the economic crisis that was sweeping over Europe, the Dutch government decided to cut back on its space budget by tens of millions of euro, dropping from 100 million in 2012 to 63 million euro in 2015. After protest from the space sector, strengthened by the success of the then recent space mission of Dutch astronaut André Kuipers, the House of Representatives (Tweede Kamer) voted against the cutbacks.

Currently the Dutch space budget stands at 94 million euro annually, at least for this year and 2019. Every year the Netherlands contribute 42 million euro to ESA as part of its membership to the organisation, according to the Netherlands Space Office. Aside from this mandatory contribution, the country invests almost 20 million euro a year to ESA's Earth observation programmes and the development of new technologies.

The remaining part of the budget is invested in national programmes, which stimulate the Dutch market by helping companies and organisations reach their full potential. The Netherlands is also active in EU space programs, like Galileo and Copernicus, and has multiple Memoranda of Understanding with countries like Japan, China, South Korea and Kazakhstan, declaring the intent to work together on space related subjects.

The future is bright

For decades, the Netherlands has been front and centre in the space sector. And that is not likely to change anytime soon. All across the country, companies are working on products that incorporate space technology.

One of the more ambitious ones is Hiber, which looks to build an Internet of Things (IoT) network with the help of small satellites. The company is set to launch its first satellites this summer. Hiber develops small modems which can be placed on all kinds of moving objects, ranging from fishing boats to train units. The modems communicate with the satellites, which in the future should provide a near real-time location service for companies.

Satellites are key in many of the Dutch space tech innovations being worked on today. Viridian Raven – a participant of ESA's Business Incubation Centre (BIC) in Noordwijk and winner of the 2015 ESA App Camp in Barcelona – uses satellite data to assess forest areas for possible damage by insects. The system can scan trees for weaknesses and predict an attack by bark beetles, a type of beetle that feasts on trees.

At JOHAN Sports, satellites are used for their localisation capabilities. The company – also a member of ESA's BIC – builds systems that allow sports teams to track their players' movements on the field. The system consists of wearable sensors that use precise GNSS services to track movement, acceleration, speed and locations of players. JOHAN Sports, which is already being used by different sports teams, allows trainers to make the ideal training schedule for each individual player, thus helping them get better results.

These are just some of the examples of Dutch businesses that use space to build a better world.

SBIC startup JOHAN Sports uses satellite data to track football players on the field. [JOHAN Sports]

Dutch astronomy

The Dutch have always been an inventive people. The country has provided the world with lots of interesting inventions, ranging from submarines to the compact disc. Here are three (well, actually four) famous Dutch scientists and inventors who contributed a lot to the discovery of space.

1. Christiaan Huygens – Looking back on his accomplishments, it's not surprising that Christiaan Huygens was voted 'greatest Dutch scientist of all time' back in 2016. During the seventeenth century Huygens was active in many scientific fields, ranging from math and physics to astronomy. He is widely regarded as the father of theoretical physics. He also discovered the Saturn-moon Titan and was the first to present an explanation for Saturn's rings.
2. Jan Hendrik Oort – The Oort Cloud is an extended shell of icy objects that circle the outer most part of our solar system. It is named after Jan Hendrik Oort, who was a pioneer in radio-astronomy. During the twentieth century he conducted research into star systems. Oort was the scientist who discovered that the Milky Way is not standing still, but rotates like a giant wheel. He also pointed out that each of the stars in our galaxy travels independently through space. By the time of his death in 1992 – he was 92 years old – he was recognised as one of the greatest astronomers of the twentieth century.
3. Hans Lippershey (or Zacharias Jansen) – Although it was Galileo Galilei who first thought of the idea to point a telescope to the sky, it was a Dutchman who actually invented the 'viewing tube'. But... which one? Both spectacle-makers Hans Lippershey and Zacharias Jansen claimed to be the inventor. Lippershey applied the first patent in 1608, but Jansen – according to his son – already invented the 'tube to see things afar' in 1590. Whoever is right, one thing is for sure: the telescope was invented in the Netherlands.

The Galileo Reference Center in Noordwijk monitors the signal of the Galileo system and creates new business opportunities. [Van Rhijn Bouw]

for atmospheric composition monitoring (Sentinel-4).

The Dutch involvement in Copernicus is most extensive in the Sentinel-5 mission: the TROPOMI instrument aboard satellite Sentinel-5P – which maps air pollution in higher detail than ever before – was built in the Netherlands as a joint effort of the Netherlands Space Office, the Royal Netherlands Meteorological Institute (KNMI), SRON, the Netherlands Organisation for Applied Scientific Research (TNO) and Airbus DS NL. The satellite provided its first results in December 2017, showing a map of nitrogen dioxide pollution in Europe with disturbingly high concentrations of the gas in parts of Italy, Germany, Spain and… the Netherlands.

For the love of satellites

For such a small country, the Netherlands has always been big in using satellites to our advantage. It's for good reason that TomTom, the company that brought satellite navigation to cars, was born right here in 2001 (although its origins can be traced back to ten years earlier).

And to this day satellites and the Dutch go hand in hand. The Frisian town of Burum for example houses one of the biggest Inmarsat facilities in the world. The facility controls fleets of Inmarsat-satellites, which let users conduct calls and send data from anywhere in the world. In 2004 the Société Européenne des Satellites (SES), the biggest commercial satellite communications operator in the world and also the owner of the O3b satellite network, also gained a foothold in The Hague when they acquired New Skies Satellites N.V., which started out in 1998 as a commercial spin-off of Intelsat.

Aside from communications, the Netherlands is also very adept at using satellites to observe the Earth. With organisations such as TU Delft, SkyGeo, Sensar and PPO.labs it is one of the leading countries in the field of InSAR (Interferometric Synthetic Aperture Radar), a technique used to measure and calculate movement of ground surfaces.

The use of satellite data is stimulated in the Netherlands: the Dutch government shares its satellite data on the Netherlands with Dutch users through its *Satellietdataportaal*, free of charge. The *Satellietdataportaal* allows Dutch farmers to keep an eye on their crops from space and gives local governments insight in soil subsidence in districts that are built on soft grounds. It also provides value adding companies with basic data and imagery on which they can build their own services.

The Netherlands is also one of the front runners in the field of small satellites (see also 'Big in small satellites'). These miniature artificial moons – some no bigger than a soda can – are revolutionising the space sector, providing satellite solutions at a fraction of the cost of their larger and more traditional counterparts. With over ten years of experience in the field, the Dutch company Innovative Solutions in Space (ISIS) is one of the leader in the small satellite business, and a spinoff of the TU Delft, which launched its first nanosatellite Delfi-C^3 to space as early as 2008.

A host of fields

Satellites – big or small – are vital for many things that can only be done from space, but before they are of any use they have to get there first. Aerospace Propulsion Products (APP), a company in the small Dutch town of Klundert, helps them get there. APP designs, manufactures and qualifies ignition systems for the European Ariane and the smaller Vega rockets, both developed by the European Space Agency.

APP was originally founded by TNO. This organisation has been active in developing optical instruments for over fifty years, and it has also built large instruments for many European satellites, – in cooperation with Dutch industry. Instruments designed and built by TNO map air pollution and make secure broadband connections possible, among other things.

TNO develops technology which some-

Liftoff of ESA's Vega booster, which transports small and medium sized satellites to orbit. [ESA]

times, like in the case of APP, leads to the founding of a stand-alone company. In other cases the organisation cooperates with companies to help them create their innovations. Because that's what the Netherlands is good at: bringing together different parties to make one great end-product. It's part of our culture.

Aside from the companies and organisations already mentioned, Dutch companies and institutes like Airborne Composites, Ajilon Technology Aerospace, CGI, cosine, ETS, HE Space, Hyperion Technologies, IP Star, Jive, Leidse Sterrewacht, Lens R&D, LioniX, Netherlands Aerospace Centre, Planet Labs, S[&]T Corp, Sapienza, SBIC, Space Expo, SRON, Terma and T-Minus (all of which have taken the opportunity to tell you more about themselves later on in this magazine) are active in a host of fields, ranging from instruments, propulsion, software, ground testing equipment, engineering and nanosatellites. The Netherlands truly is all about space.

Looking ahead

These past fifty plus years, the space sector in the Netherlands has laid a solid foundation on which to continue building for the future. In the coming decades a whole range of space related markets will flourish. The commercialisation of space has taken a huge leap forward these past few years, partly thanks to the emergence of international companies like SpaceX and Blue Origin. Because of this growth, more and more satellites can and will be launched to help us manage our lives on Earth.

This asks a lot from the space sector, which will continue to push itself to produce more ground breaking technology in the form of even smarter instruments and more innovative launch systems. The past decade the sector has shown an annual growth of 4 to 5 per cent, which is one and a half times as much as the international average. According to the 'Nota Ruimtevaart', an advice report outlining the Dutch government policy on space, there is a lot of potential for further growth.

Throughout history, the Netherlands has been leading in a number of fields, especially astrophysics and atmospheric research. But as a country we also look ahead to new opportunities in different fields. Over at ESA's Space Business Incubation Centre (SBIC) in Noordwijk for example, a number of start-ups is using space technology to develop new solutions for problems on Earth. The solutions coming out of SBIC range from sensors that can track the position of the Sun more accurately (and at lower cost) then current products, to monitoring systems that use satellite data to map the health of trees that are likely to be on the menu of devastating bark beetles.

Many of the solutions built at SBIC (and all around the space sector in the Netherlands) use satellite data in one way or another. Data gathered by satellites has become invaluable for our society, both nationwide and globally, but also locally. Satellite data gives governments the opportunity to optimise processes with smart solutions ranging from the monitoring of nature to keeping an eye on our dikes. It also allows aid agency's to map disaster areas and provides accurate meteorological data, which can help predict extreme weather. Those smart solutions have to be designed, developed and built. The Dutch space sector has the knowledge and experience to make that happen.

In the near future, society will become more and more dependent on space. All of the big challenges that lie ahead – ranging from sustainability and safety to migration and climate change – will be answered with information coming from space. Space will therefore become even more relevant to society and civilians then it is now. As it has done for decades, the Dutch space sector will keep providing relevant contributions to international space projects to make our planet sustainable for future generations. We are indeed… all about space.

Dutch involvement in famous space missions

ESA's Rosetta spacecraft chased down the comet 67P/Churyumov-Gerasimenko for over ten years. [ESA]

Many European space missions wouldn't be able to leave the ground if it wasn't for technology and research being developed and conducted in the Netherlands. Ariane and Vega rockets use ignition systems designed in the Netherlands, while our home grown solar panels, position control systems and sensors make sure satellites can do their job. Listed on these pages are just some of the important space missions in which the Netherlands played a key role.

Nick Kivits

AMS-02

Creating high energy particles on Earth requires major installations such as those available at CERN in Switzerland. In space however, such particles pass by for free. On this premise, the Alpha Magnetic Spectrometer (AMS-02) – a sophisticated particle detector weighing over 8,500 kg – was installed on the International Space Station to search for antimatter, dark matter and to measure cosmic rays. The particle detection systems require a high level of temperature stability, which is hard to come by in space as the ISS alternates between full sunlight and the cold blackness of space. The Netherlands Aerospace Centre NLR built the critical thermal control system making this possible, incorporating a state-of-the-art mechanically pumped two-phase carbon dioxide cooling loop.

[NASA]

ANS

The Astronomical Netherlands Satellite (ANS) was the first large Dutch contribution to space. The satellite was designed, built and launched by the Netherlands and was packed with four instruments for astrophysical research. The instruments did research in the fields of X-ray and ultraviolet radiation and taught us much about the life of stars. ANS – which was launched in 1974 – was the first satellite ever to have a reprogrammable computer. The computer was designed by Philips.

[ESA]

Ariane 6

Although ESA's Ariane 6 won't be going to space until 2020, the rocket already has a distinct Dutch signature. Not only will Ariane 6 use ignition systems built in the Netherlands (see Vega for more information), the new incarnation will also use engine frames built and designed by Airbus Defence and Space Netherlands in Leiden. The engine frames from Leiden will be used to hold the engines of the first and second stage of Ariane 6 in place.

BeppoSAX

The Italian-Dutch satellite BeppoSAX was used for X-ray astronomy. It was the first

[ESA]


[ASI]

satellite to deliver optical usable positions of gamma-ray bursts with arc minute precision. BeppoSAX consisted of five scientific instruments, two of which came from the Netherlands: the Wide Field Camera developed by SRON and the Low Energy Concentrator Spectrometer developed by ESTEC. The solar panels were provided by Fokker.

Envisat

At launch, ESA's Envisat (ENVIronmental SATellite) was the largest civilian Earth observation satellite ever brought to space. At the heart of the satellite there were eight instruments, one of


[ESA]

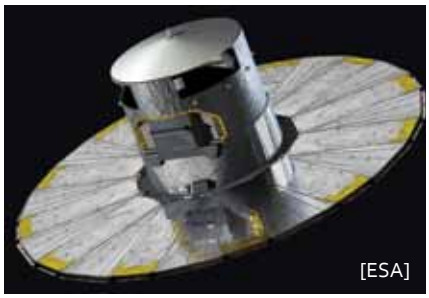
which was the SCanning Imaging Absorption SpetroMeter for Atmospheric CHartographY (SCIAMACHY). The Dutch built instrument compared light coming from the sun to light reflected by the Earth. It used this information to map the concentration of trace gases and aerosols in the Earth's troposphere and stratosphere.

EOS-Aura

The Ozone Monitoring Instrument (OMI) was launched aboard NASA's EOS-Aura satellite in 2004. OMI is a visual and ultraviolet spectrometer that can identify different aerosol types like smoke, dust and sulphates. It also measures cloud pressure and coverage. The instrument was built by Airbus Defence and Space Netherlands, SRON and TNO. The instrument has provided insight in air pollution and greenhouse gasses, and keeps an eye on our ozone layer.

Gaia

After less than five years in space, ESA's Gaia mission has already proven its worth. Just recently Gaia's team presented the world with the most detailed star map ever produced. The map shows the position and movements of 1.7 billion stars. To create a map this precise, you need to make sure the telescope is absolutely stable. On Gaia this is the job of the Basic Angle Monitor (BAM), a highly sophisticated system that uses mirrors and laser to detect even the smallest deviation in stability. The BAM was built by TNO.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Galileo

Aside from the solar panels used to power the Galileo satellites in space – which are produced by Airbus Defence and Space Netherlands – there is more 'Dutchness' to be found aboard the GNSS satellites. The sun sensors the satellites use to position themselves towards the sun are created by Bradford Engineering. The technical development for the current system took place at ESTEC, and this activity is continued for the next generation. The performance is monitored independently of the system and operator, by the Galileo Reference Centre, a technical centre of the European GNSS Agency (GSA), in Noordwijk.

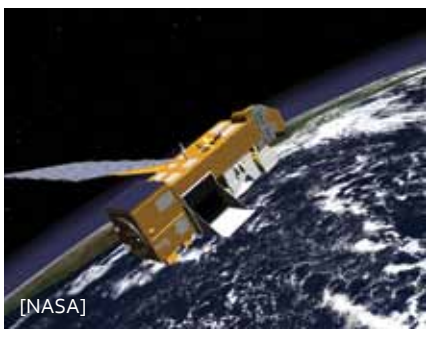
Herschel

The space telescope Herschel, launched in 2009, observed celestial objects at wavelengths never explored before. One of its instruments was HIFI, the Heterodyne Instrument for the Far Infrared, which was developed by a consortium led by SRON. TNO, TU Delft and Mecon also played major roles in its development.


[ESA]

IRAS

The InfraRed Astronomical Satellite (IRAS) was the second national satellite for the Netherlands, and the first-ever space telescope to perform a survey of the entire night sky at infrared wavelengths. Although half of the spacecraft was built by the United States, and the United Kingdom developed the mission's ground segment, the Netherlands provided a key instrument with the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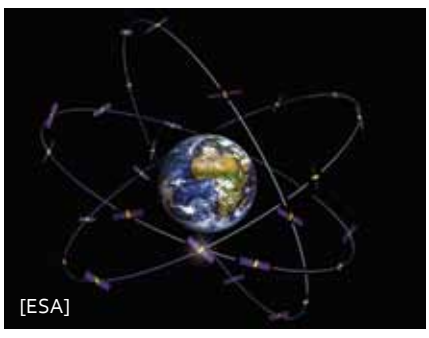
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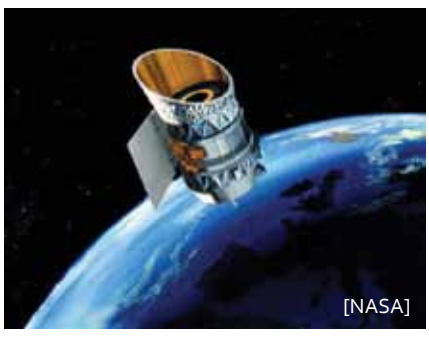
[NASA]

Dutch Additional eXperiment (DAX). The instrument – which was built by a consortium of Dutch companies, including Fokker, NLR and Philips – was used for further examination of objects detected by the main instrument of the satellite. IRAS detected 350,000 different objects in space, ranging from stars to solar systems.

Mir, Spacelab, Space Shuttle & ISS

When conducting biological experiments in zero gravity, you don't want materials floating away. That is why astronauts aboard the Space Shuttle and the Mir and ISS space stations use gloveboxes for these experiments. Gloveboxes are see-through cases in which astronauts can conduct experiments using gloves. They are made by the Dutch company Bradford Engineering. The company provided the ISS with two big gloveboxes and made several smaller ones for Mir, the Space Shuttle and Spacelab.

Sentinel-5P

Mapping air pollution in higher detail than ever before. That is the mission of the Sentinel-5P satellite, which was launched in October of last year as precursor to the EU's Sentinel 5 series of satellites. The main instrument of the satellite – TROPOMI – was built by a joint venture of the Netherlands Space Office, the Royal Netherlands Meteorology Institute, SRON, TNO and Airbus Defence and Space Netherlands. It provided its first images in December 2017.

Vega

Without proper ignition, a mission to space falls flat. ESA's Vega rocket – used to send small satellites into space since 2012 – uses ignition systems that were created by the Klundert based Aerospace Propulsion Products (APP). All three solid rocket motors of Vega are started by APP igniters. APP also develops the Vinci Ignition System for the upper stage of the new Ariane 6 rocket.


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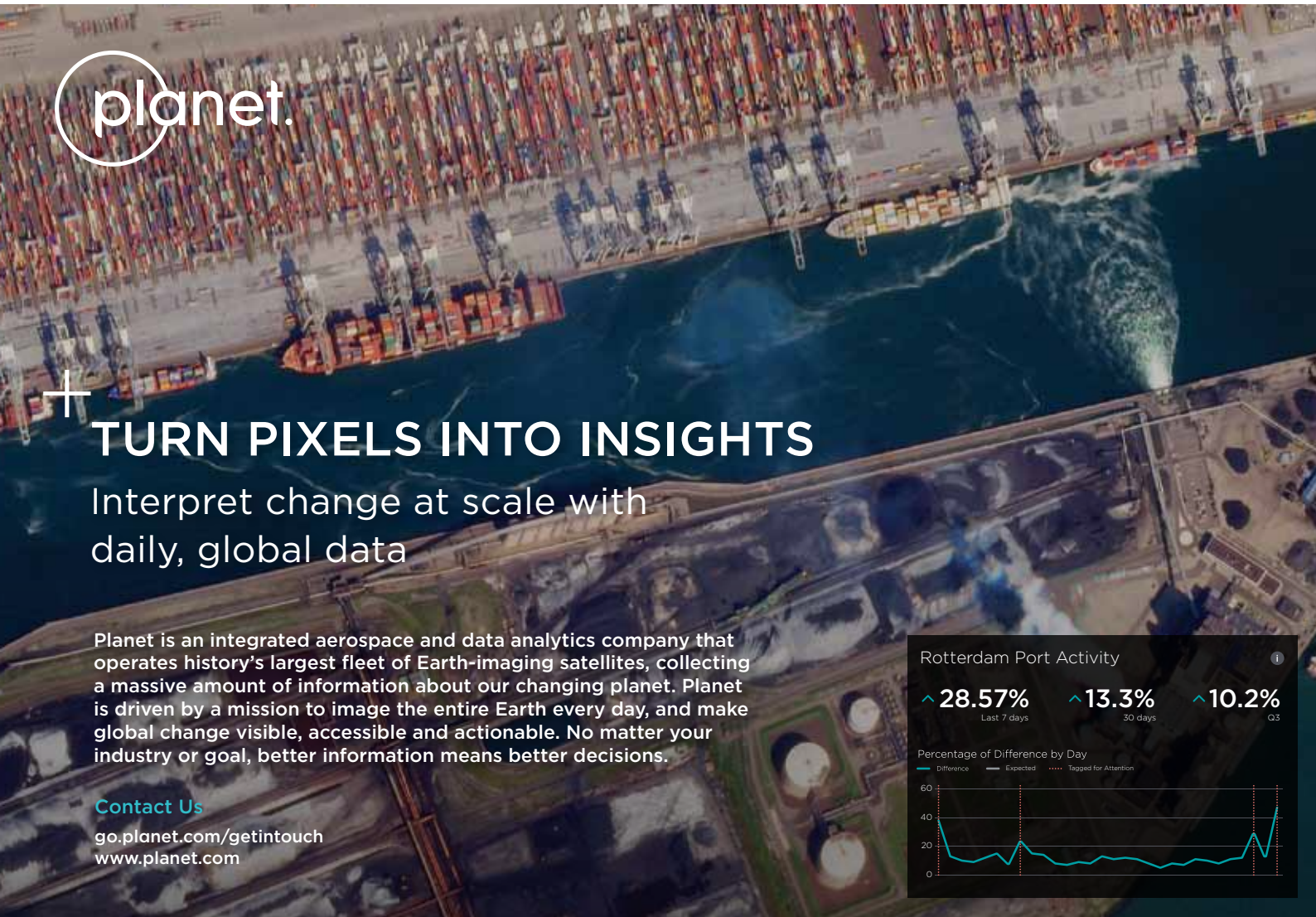


Netherlands Space Society - NVR

The space society for the Netherlands since 1951

About the NVR

The *Nederlandse Vereniging voor Ruimtevaart* (NVR) was founded in 1951. It currently has over one thousand individual and company members. The society organises lectures and film screenings, as well as networking events. It also publishes its own quarterly magazine called *Ruimtevaart*.

For over sixty years, the Netherlands has had their own space society. The *Nederlandse Vereniging voor Ruimtevaart* (NVR) – which translates to the Netherlands Space Society – looks to motivate, inspire and connect all those with an interest in space.

Nick Kivits

What use is space to us here on Earth?

Chairman Gerard Blaauw: "Space is a driving force of innovation. Without it, we would miss a whole lot of products and services we enjoy on Earth on a daily basis. For example, the navigational system in your car would not be possible without space. And without satellites it would be a lot harder to make accurate predictions of the weather. And those are just two of the many examples."

What part does the NVR play?

Board member Peter Buist: "We want to get people to start thinking about the possibilities space will provide for the future. To make this a reality, we focus on three target groups: people who are working in the space sector, students attending a space related program at university and the general audience. The latter group is very important for us. We want to show them what space actually brings to the table, while at the same time we want to try to motivate and inspire them."

Motivate, inspire and connect? Why is that so important?

Buist: "Because space is for everyone, but no one can achieve much without the right network. The NVR is a platform for space professionals from or working in the Netherlands, and tries to inspire the next generation. A few decades ago, a young boy who was about ten years old at the time attended one of our lectures. That same boy spent six months aboard the International Space Station in 2011 and 2012. He was the Dutch astronaut André Kuipers, who is now an honorary member of our society."

Kuipers' second space mission in 2011 and 2012 really peaked the Dutch interest in space, right?

Blaauw: "It did. But what many people don't know is that the Netherlands has always been a big player within the international space community. It's not for nothing that ESTEC – the research and technology centre of the European Space Agency – is situated here. We are one of the top players of the world."

The NVR was founded in 1951. Was there already a space industry back then? It took ten years from that point for the first people to fly to space…

Blaauw: "Moreover, when the NVR was founded there weren't even satellites making their laps around Earth. Even so, back then the goal of the society was the same as it is now: to think about the possibilities of space. A military space industry already started developing during World War II and the first members of our society were already fantasising about the possibilities of space."

What will space bring us in the future?

Buist: "A few years back we set up an essay writing contest for our members in which we asked them to answer that exact same question: how will the space industry look in 2071. We ended up with a ton of interesting articles. One of the winners described how mankind would have spread out across our solar system by then. I think that could well enough be a real possibility."

www.ruimtevaart-nvr.nl

NSO

A Dutch perspective on space

The wide applicability of space technology and satellite data creates a number of opportunities for the Netherlands. But what opportunities should the country choose to capatalise on? The Dutch space agency NSO (Netherlands Space Office) advises the government and realises Dutch space policy.

Since the launch of the first rockets and satellites in the 1950s, the space sector has expanded considerably and has now become a global business. Satellites circumnavigate the entire globe. They regularly and precisely observe almost every location on Earth as well as in the sky, make direct contact with all parts of the world possible and provide geo-positioning of unparalleled accuracy.
The wide applicability of space technology and satellite data is creating opportunities to make life on Earth safer, more sustainable and prosperous and to obtain more scientific insights. Governments are responding to this with international collaborations to develop programmes such as Galileo and Copernicus, as well as scientific missions like Rosetta and Bepi-Colombo. Due to the growing demand for the availability of information, there is a global market for satellite applications that both governments and commercial parties are interested in.
The opportunities for the Netherlands in this largely new and virgin market are without a shadow of a doubt favourable. The Netherlands has the climate and the qualities to acquire a substantial part of this market worldwide. It has an outstanding reputation in the area of space technology, is an internationally recognised specialist in several usage themes relevant for space, and is home to a large number of small innovative companies that develop high-quality satellite applications. Furthermore, the Netherlands has an attractive location and investment climate with a high-quality education system that can also provide the necessary human capital in the future.

Advising and realising Dutch space policy

The Netherlands Space Office (NSO), located in The Hague and founded in 2009, is the space agency of the Dutch government. NSO's task is to advise on and realise Dutch space policy. NSO reports, both financially and substantively, through its director to its clients, who are united in the steering group NSO. These are the Ministry of Economic Affairs and Climate Policy, the Ministry of Education, Culture and Science, the Ministry of Infrastructure and Water Management, and the Netherlands Organisation for Scientific Research (NWO). The Minister of Economic Affairs and Climate Policy is the coordinating Minister.
The government ministries that are members of the steering group NSO and the Netherlands Organisation for Scientific Research (NWO) jointly determine Dutch space policy and the budget that is available for it. As the official secretary and on behalf of his colleagues, the Minister of Economic Affairs and Climate Policy sends a memorandum once every three years to the Dutch House of Representatives. This document explains the contours of the space policy and the associated budget.
The reason behind such a policy memorandum is usually the preparation for an ESA Ministerial Council: the moment when the ESA Member States indicate which ESA programmes they are registering for and with how much funding. As part of the preparations for the policy memorandum, NSO writes an advisory report at the request of the government ministries involved. The most recently published advisory report was published in November 2016. It formulated the vision and ambition of the Dutch space sector and made a proposal for a set of instruments needed to realise it. The key idea is that the use of space for scientific, societal and economic applications takes centre stage.

www.spaceoffice.nl

Airbus Defence and Space Netherlands

A huge passion for technology

Over the past 45 years, the almost 300 experts working at Airbus Defence and Space Netherlands have contributed to numerous projects, ranging from Sentinel-5P's TROPOMI instrument to solar arrays for missions like BepiColombo and JUICE. The future promises to be just as exciting.

When the European Ariane 6 launcher takes flight for the first time in 2020, it will do so with the help of Airbus Defence and Space Netherlands (Airbus DS NL). The structure frames that hold the engines of two stages of Ariane 6 in place are currently being developed by the Leiden-based company. Airbus DS NL is the largest space company in the Netherlands, and its up to 300 employees have one thing in common: they share a huge passion for technology.

"The assignment for the Ariane 6 launcher perfectly fulfils this passion", says Airbus Defence and Space Netherlands CEO Arnaud de Jong, who since five years stands at the helm of the company. Earlier this year Airbus DS NL finalised the building of a new assembly facility for the production of the Ariane 6 structures: the main engine frame for the lower propulsion module Vulcain engine (VUAB) and the engine frame for the upper propulsion module Vinci engine (VITF). Here, the two structures will be developed, built, tested and qualified. "Both engine frames are complex structures. They have to transfer the large engine thrust loads to the launcher structure and also accommodate the many propulsion parts", De Jong explains. "The new facility, located near our Leiden site, is equipped with 'Industry 4.0' robotisation and automation capabilities, in order to be prepared for the anticipated production rates of up to 24 engine frames in total per year." The site has a direct connection to the Rotterdam sea port, enabling safe and rapid transport of the large VUAB structure – which has a diameter of 5.4 metres and is 5.2 metres high – to ArianeGroup in Les Mureaux, France for final assembly with the Ariane 6 launcher. The VITF engine frame will be transported to Bremen by road.

Driving force

The engine thrust frames for Ariane 6 is just one of the many examples of projects Airbus DS NL is involved in. The company is also one of the driving forces behind the TROPOMI Earth observation instrument, which currently circles the Earth aboard the European Sentinel-5P satellite that was launched in October of 2017. Six months later TROPOMI completed its in-orbit commissioning phase.

"It proves to be the powerful instrument for pinpointing sources of pollution we anticipated", says De Jong, "For instance, with just one single image TROPOMI is able to reveal the trail of nitrogen dioxide left in the air as ships move. This means, the route that vessels use to navigate can now be easily discerned. With predecessors of TROPOMI, it took months of collecting data to see the same picture".

TROPOMI is a collaboration between Airbus DS NL, the Royal Netherlands Meteorological Institute (KNMI), the Netherlands Institute for Space Research (SRON) and the Netherlands Organisation for Applied Scientific Research (TNO), commissioned by the Netherlands Space Office (NSO) and ESA. As prime contractor Airbus DS NL was in charge of the design, construction and calibration of the instrument. The scientific leadership of TROPOMI is in the hands of KNMI and SRON, while TNO provided the optical hart of the instrument.

Vital for everyday life

The solar arrays, satellite instruments and structures for launchers that Airbus DS NL designs and builds, are among the best in the world. "Our technology, encompassing the expertise of other Dutch companies, knowledge institutes and universities, enable missions that are vital for our everyday life on Earth, such as

satellite navigation, communication and the ongoing monitoring of air quality."
When it comes to the development of solar arrays, Airbus DS NL has a vast track record: it has provided up to 125 satellites and probes with the power to conduct their work in space, with a one hundred percent 'deployment after launch' success rate.
Around two thirds of all satellites that the European Space Agency (ESA) sends to space use Dutch solar arrays to provide them with power. Amongst them are a few of the biggest European space missions of all time, like comet hunter Rosetta, several of the Sentinel Earth observation satellites, the satellites for the Galileo navigation system and the resupply spacecraft ATV (Automated Transfer Vehicles), which flew supplies to the International Space Station from 2008 until 2015. Airbus DS NL also works for clients outside Europe and has provided the solar arrays for the American resupply spacecraft Cygnus for example.
The next line of spacecraft using solar arrays from Airbus DS NL is already waiting. The joint ESA and JAXA (Japan Aerospace Exploration Agency) mission BepiColombo, which is scheduled for launch in October this year, will fly to planet Mercury to investigate the magnetic field and thin atmosphere of the smallest planet in our solar system. The solar arrays experts in Leiden equipped the 7.5 meter long, 260 kilogram weighing wing with dedicated thermal shielding to keep maximum temperatures below 200 °C.
ESA's JUICE (JUpiter ICy moon Explorer) will also be powered by Airbus' solar arrays during its journey to Jupiter to study its moons, starting in 2022. The company also develops the solar wings for the service module of Orion, NASA's new spacecraft set to take humans back to the moon and into deep space in the next decades.

Future opportunities

The strong heritage of Airbus DS NL plays a pivotal role in the years ahead. "Previous projects give us and our Dutch ecosystem of partners and suppliers a pole position for future missions", De Jong says. "While TROPOMI is delivering on its promise right now, a societal challenge like climate change is asking for new solutions. We are discussing possibilities for the next generation instruments, which would be smaller, yet with the ability to monitor a specific area even more precise."
Also a future development like the optical feeder link technology is interesting, says De Jong. "To meet the exponentially growing demand for bandwidth, such a link will be able to transmit up to several terabits. This solution will make use of light travelling through our atmosphere, which happens to be the area in which the Dutch TROPOMI team has gained in-depth knowhow."
But there is more. In the solar array market for instance, the stowed volume is a hot topic. To be able to come up with the desired flexible solution, new technologies are being developed. De Jong: "Also the small satellite market, ranging from 100 to 250 kg launch mass, is growing, which will result in an increase in terms of numbers and financial figures."
When it comes to space data services, Airbus is also cleverly teaming up with its international colleagues to provide intelligence geared towards the needs of Dutch customers, especially in the field of defence and security.
De Jong: "At the heart of our heritage and demanding future are smart people. Inside and outside our organisation. As success boils down to having access to these bright minds and to building fruitful collaborations, we put effort in developing talent, in treasuring existing strong partnerships and in identifying new allies."

www.airbusDS.nl

LioniX International BV

Developing and producing Photonic ICs

The telecom and datacom networks of the future require even more optical functionality to be integrated into Photonic Integrated Circuits. World leader LioniX International BV designs, develops and assembles these modules.

LioniX International BV is a leading global provider of customized microsystem solutions in scalable production volumes. We provide customized solutions for OEMs and system integrators for tele/datacom, life sciences, process control and space. From design to fully assembled modules, by vertical integration in scalable production volumes.
LioniX focuses on Photonic Integrated Circuits (PIC) enabled modules based on our proprietary, ultra-low-loss waveguide technology (TriPleX™), in addition to the other core competences microfluidics, opto-fluidics and related surface functionalisation, and MEMS.
Advances in photonics and fiber optics have brought telecom and datacom into the high-speed digital arena of today. The networks of tomorrow require even more optical functionality to be integrated into Photonic Integrated Circuit (PIC) modules to enable more advanced methods.
Our PICs for microwave photonics and high frequency (1-100 GHz) signal processing provide significant benefits over conventional, micro-electronics RF by improving performance as well as reducing size, weight and power consumption. Dense systems are enabled by TriPleX™ and hybrid integration technology for adding a unique laser concept, modulators and detectors to produce a fully integrated photonics-based RF system for antenna beamforming.
The combination of integrated photonics, microfluidics and surface functionalisation gives an unrivalled position in the area of lab-on-chip (LoC). The advantage of LoC devices for space applications is evident in the tremendous reduction of resources (mass, volume, power, reagents) compared to standard laboratory procedures.
A shining example is the life marker chip, which has been in development in the framework of the ExoMars rover payload and which detects specific bio-organic molecules in a LoC device, potentially indicating past life on Mars.
www.lionix-international.com

MELiSSA

Building circular economies for Mars

The MELiSSA foundation is a non-profit organisation created by the MELiSSA consortium for the purpose to manage a fund dedicated to finance a pool of PhD students and postdocs.

In space, the survival of astronauts requires very large masses of oxygen, water and food, which are very expensive and too bulky to ship. For example, a standard mission to Mars will need a minimum of thirty tons of metabolic supplies. These supplies eventually turn to waste. Therefore we need to find ways to recycle carbon dioxide and organic waste into food, oxygen and water. But how do we do that?
To find the answer to this question, ESA set up the MELiSSA multidisciplinary project (Micro-Ecological Life Support System Alternative) over 28 years ago. Since then, the project has been studying the possibility to valorise all the waste of a mission to meet the vital needs of astronauts. Many experiments have already taken place on-board the International Space Station (ISS), with extremely promising results!
Today, the MELiSSA project is often considered a great example of circular economy, with results in a lot of technology transfers and R&D synergies with terrestrial research. Some successes already include the water recycling process for the Koningshoeven Brewery (NL) and the consultancy study for the Total and Roquette companies.
In this context, the planet Mars, and all the stages between the Earth and Mars (for example CIS lunar orbit), are clearly targeted. Transforming all waste, managing chemical and microbiological contaminants, using sunlight as a source of energy, and of course supplying the astronauts with oxygen, water and food are the challenges studied by ESA and a very large European community of universities, research institutes, and private companies.
www.melissafoundation.org
www.ipstar.io

HE Space

Tips for starting a space career

Entering the world of work is not always easy. As a human resources service company, HE Space offers positions in the space sector to engineers, scientists and a wide variety of other professions.

HE Space is the only human resources service company exclusively dedicated to providing highly skilled space professionals. With locations in the Netherlands, Germany and the USA, it is internationally positioned. Many companies and agencies in the international space business have been close partners for more than three decades.
Kirsten Gibbs is working as recruiter at HE Space. Engineers Anna Adamczyk, Tineke Roegiers and Jörn Bergmann are working for HE Space on various projects.

How did your career start in the space industry?

Tineke Roegiers: "After moving to the USA in 2015, I was looking for a job in space. The position of science planner for the NASA Swift mission opened up right when my work permit was approved. This was perfect timing! After moving back to Europe in 2016 I started working as project information manager for the ESA Gaia mission through HE Space."

What's special about the recruiting process at HE Space?

Kirsten Gibbs: "HE Space are experts in aerospace engineering. We are looking for the ideal candidates for our customers. In addition to incoming applications, we specifically address people with interesting profiles. We use our database, social media channels, specialised space networks and, of course, personal recommendations from our employees. Then we check whether a candidate has the required skills and fits in well with the company and the team."

In your opinion, what was the best part of your application process?

Anna Adamczyk: "The most positive thing was the first interview with a recruiter from HE Space. We quickly found a common language and the conversation went on in a very nice atmosphere. It motivated and calmed me, so that I could go through the entire application process without stress."

What is particularly important in addition to qualifications when selecting career starters?

Kirsten Gibbs: "I pay particular attention to IT and language skills. English is an absolute must in space. The space industry is an international business. For integration into an intercultural working environment, foreign experience is also beneficial."

What advantages does it offer you to work for a HR service provider?

Jörn Bergmann: "The exchange with HE Space colleagues located at other companies is very interesting. You get to know new perspectives and can make contacts."

Why exactly did you choose your current employer?

Jörn Bergmann: "Why HE Space? The atmosphere was good from the first telephone interview. The company is relatively small and has a very good reputation. The job description matched exactly what I wanted to do, the contract offered was good and my gut feeling said "yes". The whole package convinced me."

How do you support your employees, especially career starters, so that they can start smoothly in a new job?

Kirsten Gibbs: "Before the job interview with the company, we prepare the candidates so they know what to expect and to relieve them of their nervousness. We also organise regular events to get to know our employees better and to encourage exchanges among colleagues."

Which tips would you like to give career starters in the space industry?

Kirsten Gibbs: "Apply with a clear, detailed and customised CV and do internships to differentiate yourself from other graduates."
Anna Adamczyk: "Do not be afraid to look for a job abroad. Because of the international work environment and the interesting people you never feel alone."
Jörn Bergmann: "The first job is usually the hardest to get. But do not get discouraged, it will work out someday."
Tineke Roegiers: "Have a chat with someone employed at the company you want to work with to get some information on the company and also on the types of jobs advertised."

www.hespace.com

Netherlands Aerospace Centre

Innovation in space

Assembling the AMS-02 tracker thermal control system.

To get an impression of the Netherlands Aerospace Centre's (NLR) space activities we asked Michel Keuning, manager of the ISR (Intelligence, Surveillance & Reconnaissance) and Space Utilisation department of NLR, a number of questions.

Q: In which areas is NLR active in the space domain?

A: "NLR covers a wide range of activities, from system development to applications, including testing, verification and validation. On the systems side we are focussing on constellations of networked satellites and small launchers. Other priority areas are space applications, satellite navigation, thermal management systems, antennas & RF technology, structures & materials, and space situational awareness."

Q: Tell me about those networked satellites?

A: "This is one of our focal activities in which we cooperate with users, industry and SMEs. We take a systems engineering perspective to new architectures and collaboration enabling technologies. The applications range from defence and security to precision agriculture."

Q: What activities is NLR involved in regarding satellite navigation?

A: "We have a lot of knowledge on the nature and impact of disturbances on navigation signals. Here our primary application is aviation. In order to use SatNav to safely navigate and land an aircraft, the integrity of the signals must be guaranteed, either through on board or ground based support systems. This applies to GPS as well as Galileo. We are also involved in testing the potential influence of (illegally) operated jammers on SatNav receivers, for instance to mitigate the impact on aircraft on their final approach to the runway. Another critical component of SatNav systems is the time service, on which many applications are heavily dependent. Furthermore, special attention goes to the new secure Galileo PRS service. We work closely with the Netherlands' Ministry of Infrastructure & Water Management in this domain."

Q: What about testing, verification and validation?

A: "We have many environmental test facilities for use in the space domain. Like a shaker which simulates the vibration and shock conditions of a rocket launch. Or a facility which simulates the thermal conditions in space, from extremely hot, representing the sunlit side, to extremely cold, representing the shaded side. And many more."

Q: And launchers?

A: "Aerodynamics play an important role in the development of launchers. We cover the range from CFD calculations in the design phase to wind tunnel testing of the launcher model. We also produce fully instrumented 'smart' models in-house, so as to get optimal results out of the wind tunnel measurements. Our materials expertise, in particular in the area of composites and multi-metal additive manufacturing, is applicable to launchers. In the slipstream of SmallSat developments we are also actively involved in small launcher activities, this to enable quick response, cost-effective access to space, into an orbit as required by the mission, rather than a piggy-back, best-we-can-offer, orbit."

Q: It seems you have some excellent technologies under your roof?

A: "Yes, the first one is on thermal control. NLR is world leader in pumped two-phase thermal control systems. In principle you don't want to have critical components in space, like pumps. But with telecom satellites, which have to deal with high power components and associated heat fluxes, pumped systems are unavoidable for the next generation of platforms.
NLR has developed the thermal control system of the single largest external payload on the International Space Station

Heat Controlled Accumulator.

(ISS): AMS-02. AMS-02 is an antimatter particle detector, comparable to that at the CERN facility on Earth. The thermal control system maintains a particular temperature within 0.2 degrees stability, while ISS is about half of the time in the sun and half the time in the Earth's shadow.
Another 'special' is our 'optical beam steering' antenna technology, to be applied on-ground, on board aircraft and on satellites. In aircrafts we integrate antennas in such a way that they are embedded in the fuselage or wing structure. In the near future you will see less and less bulges on aircraft, hiding satellite dishes, thus improving the aerodynamics and reducing weight. It is an enabler for improved internet connectivity for airline passengers throughout the flight."

Q: You also have a track record in Earth observation?

A: "Yes, we have. From the traditional remote sensing, to big data processing at present. We have moved beyond the traditional separation between 'upstream' and 'downstream', since collaborative constellations allow for novel approaches to computing, data processing, and data handling. We work with an integral 'information chain' perspective, from the on-board sensor to the end users' information needs.
In the RF domain we have a strong technology position, including sensing, on-board processing technologies, downlink, reception and on-ground processing. This includes multi-sensor data fusion, big data analysis and artificial intelligence (AI). Where in the early days we performed the analysis often on single images, using human intelligence, we now use AI to find 'hidden' characteristics or relations in a wide variety of large data sets, including larger time series, and even of different nature and sources."

Q: Can you tell a bit more on space situational awareness?

A: "Space situational awareness (SSA) is about anything that goes on in space regarding objects and natural phenomena that could harm our infrastructure. It can roughly be divided in two areas. The first is space weather, of which solar wind can impact SatCom and SatNav applications. We study the impact it may have on systems and operations. The second is space object tracking. In the past 60 years we have launched an awful lot of satellites, of which many have ceased operations and are slowly deorbiting and falling back to Earth. Since they orbit the Earth with high speed, collisions may generate a lot of debris which could harm operational satellites and even make some orbits useless. Also for safety of the Netherlands it is of great importance to know which objects are in space orbiting the Earth and what their characteristics are."

Q: Any international cooperation?

A: "Yes, on the research side we cooperate with our ESRE partners, currently DLR, INTA, CIRA and ONERA. ESRE being the association of European Space Research Establishments. Within ESRE we aim at establishing long-term relations with industry in the European member states, in order to perform R&D which will result in future products or services which can be delivered by this industry. In the context of the European space activities we participate in ESA programmes, EU programmes including H2020, Clean Sky & SESAR, and with EU bodies like the European GNSS Agency (GSA) and its Galileo Reference Centre."

www.nlr.org

Aerospace Propulsion Products

Getting rockets of the ground

Rockets are essentially huge tanks of fuel used to push payloads like satellites and probes out of the atmosphere. Firing one up, all starts with a powerful flame. Aerospace Propulsion Products builds the ignition systems that light up rockets, so that they can begin their journey.

Every time one of the European Space Agency's Ariane 5 rockets takes off, it relies on technology created by Aerospace Propulsion Products (APP). Located in the small Dutch town of Klundert, the company builds ignition systems for rockets. One of which is the first stage of the Ariane 5.

Igniting a rocket isn't as easy as it might sound. Although astronaut Alan Shepard – the first American in space – famously called out to NASA's scientists to 'light this candle', starting up a rocket engine is in fact a lot harder than that. ESA's two-stage Ariane 5 launcher is powered by the Vulcain 2, a rocket engine fed with liquid oxygen and liquid hydrogen which is produced by the French/German company ArianeGroup. Starting the engine requires three different products from APP.

The first product is the Thrust Chamber Igniter (TCI) that ignites the main combustion chamber of the engine. The second product is the Gas Generator Igniter (GGI), which ignites the gas generator that supplies a hot gas flow for driving the turbine pipes. The last product is the Turbine Pump Starter (TPS), providing a high mass flow of hot gas to increase the rotational speed of the turbine pump at engine start. Only when these three systems all work in accord, Ariane 5 can start its trip to space.

From Ariane to VEGA

Ariane 5's first stage isn't the only booster which is powered by APP's technology. The single body launcher VEGA – which first launched to space in 2012 – also doesn't fly without APP's products. The launcher is equipped with three solid propellant stages. Aerospace Propulsion Products' tech is used to ignite all three of these stages.

Looking ahead, APP is also currently working on new ignition products for Ariane 6, the successor of Ariane 5. For the first stage engine Vulcain 2.1, a new version of the Turbine Pump Starter has been developed to reduce the product cost significantly.

The new upper stage of Ariane 6 will be powered by a cryogenic hydrogen and oxygen fuelled restartable Vinci engine. The engine will feature an APP designed and built ignition system that is independent of the engine cycle. The system consists of an igniter feed system in which hydrogen and oxygen are stored under high pressure and an igniter – being a small combustion chamber in which the igniter gasses are ignited by an electrical device.

Although APP is most active in the field of space, the company also looks for new applications for its technology, right here on Earth. The company has for example developed a dry aerosol based fire suppression system, which holds a solid compound which converts to a cloud of nano-particles after activation. The aerosol interferes with the chain reaction in the fire and stops this chain reaction. For APP, finding ways to use space technology to solve problems on Earth is one of the ways of the future.

www.appbv.nl

CGI

About CGI

CGI is among the largest independent IT and business consulting services firm in the world. The space department in the Netherlands is located in Rotterdam and is part of the international CGI space practice.

Secure, reliable and innovative software-based space solutions

[ESA]

Software-based systems have made it possible for space programmes to provide humankind with many powerful benefits: from exploring the universe and monitoring the health of our planet to supporting agriculture and enabling people to navigate around our world more easily. CGI plays a key role in providing these benefits around the world.

Space systems are becoming increasingly sophisticated, relying on software-based intelligence to ensure their success. The nature of satellite communications requires any software used in these systems to be optimally secure. In addition, space software systems must be able to cope with complex technical operations, such as satellite control, Earth imaging, significant data processing, radio propagation and orbital mechanics. And finally, they must be ultra-reliable and delivered on time, eliminating the risk of costly launch delays.

Leader in space security

CGI delivers complex, mission-critical space software systems and is a recognised leader in space security and space-enabled applications. A European leader in space/ground systems, we have been supporting the European Space Agency (ESA) and the European space industry for more than 40 years.

We are currently contributing to major European programmes in navigation, communication, science, exploration and Earth observation. Through these long-standing client relationships and our dedicated practice of space and satellite experts, we have earned a reputation for meeting technically difficult software challenges with secure solutions, delivered on time and proven to work every time.

Having supported the missions of more than 200 satellites, CGI is one of Europe's top three suppliers of mission-critical software systems and space security solutions. The company is the largest independent supplier of security systems for Europe's Galileo satellite navigation programme. CGI was recently selected to support ESA in defining the second generation of Galileo, which includes new functionalities and evolutions. We are responsible for the definition of the Ground Segment and support OHB in defining the Space Segment.

Space-enabled applications that add real value

As the number of satellite applications continues to grow, so does the value they can deliver. Today's space organisations seek to increase the value of their investments. With its innovative applications of space technology, CGI helps governments and commercial organisations to meet regulatory, societal and business challenges.

To this end, it draws upon its cross-industry network and knowledge partners. More specifically, we combine new space technologies, tools and data to develop innovative, space-enabled applications. These can save money, improve reliability and efficiency, and open up new avenues of business.

Down to Earth cases

A recent example of an application defined and developed by CGI in the Netherlands relates to the complex issues of migration. Many factors need to be monitored here, such as socio-economic indicators, origins, destinations, languages, causalities and initiators. *Migration Radar 2.0* combines Earth-observational data and social media analysis to generate indicators for near real-time monitoring of migration flows.

Another example of a space-enabled application is *S-TrackS*. This Secure Tracking Services application developed by CGI is based on Galileo and provides a robust and reliable service that allows the use of GNSS signals as (legal) evidence on geographic positions.

www.cginederland.nl

SRON

Conducting research in space

"The 21st century will be the century in which we will finally learn how the Earth and life on Earth formed", says astronomer Michiel Min from the University of Amsterdam. And SRON's ARIEL telescope will help us find the answers.

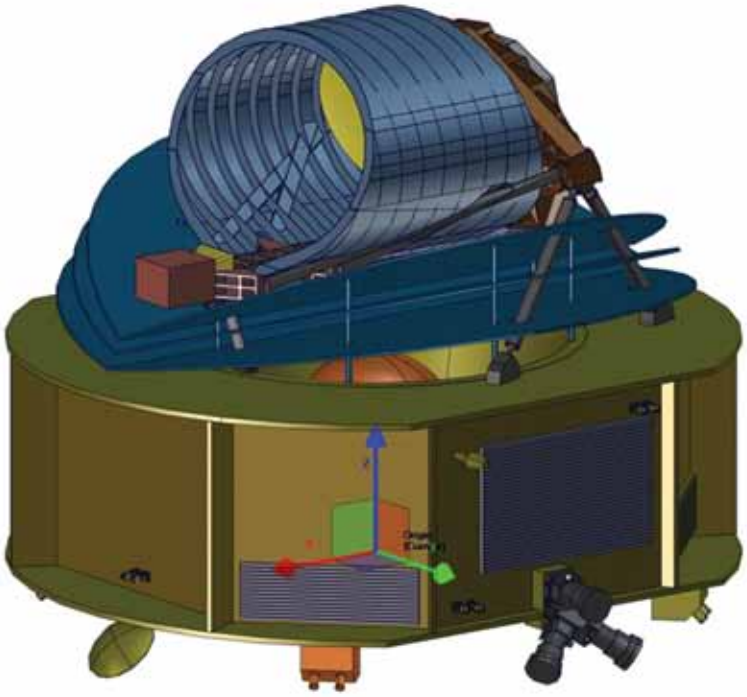
How did the Earth form? How did life on the Earth form? Are we alone in the Universe? Everywhere I look these questions pop up. In newspapers, on television, and with my fellow scientists. Is this because of my reasonably new professional focus? Perhaps, but I do think it is mostly because the answer to this question - which has been bothering humanity for centuries - is now within reach. I dare to predict the 21st century will be the century where we will find the answer to the question if there is life outside the Earth. And if I have anything to say about this, before my retirement. How amazing is that? But we are not yet there.

Forwards step by step

We can't wait till the 'magic of technological progress' does the work for us. Well... perhaps we could, but where I work we are supposed to make this magic reality.
Finding ways to figure out how things really work has always fascinated me. I always wanted to open the black box of the video recorder and figure out how each small wheel and screw help with putting a moving picture on the screen. I wanted to understand the wonderful, logical interplay of ingenious parts and ideas behind the magic.
This is exactly what makes working at SRON Netherlands Institute for Space Research so fascinating. To work with people at the frontline of technological progress. People that work in the lab day by day to solve apparently small problems in ingenious ways, to finally create something grand. These are the people that push the boundaries of possibilities. Therefore they can exactly explain how all this progress actually works.

The next step: ARIEL

The space telescope ARIEL (the Atmospheric Remote-sensing Infrared Exoplanet Large-survey) will provide the next step in our understanding how planetary systems like our own have formed. We just very recently got the green light from ESA to lift this mission – which will cost around 450 million euro – off the ground. A wonderful milestone.
For years we've already been busy with the preparations for this telescope, and for years to come we will be busy building it. ARIEL is a consortium of 15 countries in Europe, where each country builds its own ingenious piece of hardware. At SRON, for example, we will create the readout electronics for the detectors. A small, but crucial part of the telescope.
This might seem like a small effort, but in reality it is pretty complex. The biggest problem is the extreme cold at which this electronics must operate. With ARIEL, we want to look at infrared wavelengths, in this case thermal heat radiation from the planets.
At these wavelengths the most interesting fingerprints of molecules in exoplanet atmospheres are visible. However, we don't want the very weak signal of the planet to drown in the heat radiation from the telescope or its electronics. Therefore, the detectors have to be cooled to -220 degrees Celsius.
The electronics used in most devices on Earth can become pretty warm. Just check the mobile phone in your pocket. These electronics would completely ruin the signal from any exoplanet by overwhelming it with thermal radiation from excess heat. We thus have to create electronics that are absurdly precise, can operate at -220 degrees Celsius, can withstand vacuum conditions, and create no heat.
That is, to put it mildly, a challenge. How we are going to do this still needs to be figured out in detail. It is this research, and not the final fabrication of the electronics, that costs a lot of time and money. But this will result in a telescope that is going



to get amazing observations that will help scientists unravel important questions on the origin of planetary systems. With ARIEL we plan to get around 700 spectra of exoplanet atmospheres, giving us the molecular composition of these atmospheres in great detail.

The fingerprints of atmospheric molecules

So how does this work exactly? Well, the atmosphere of a planet consists of different molecules; water, methane, CO_2, etc. These molecules are good at absorbing specific wavelengths (colours) of light. For example ozone (O_3) is very good at absorbing UV light, and thus protects us from harmful UV radiation from the Sun.
CO_2 is a very good absorber of thermal, infrared radiation. This is why too much CO_2 prevents the Earth from cooling; the greenhouse effect. Exactly how much a molecule absorbs at each wavelength constitutes a detailed spectroscopic fingerprint that we can identify in a planetary atmosphere. This allows us to probe the atmospheric composition of an exoplanet in detail. ARIEL will do this for 700 exoplanets!
But why would we want to know how much CO_2 there is in the atmosphere of a planet many lightyears from here? Because with that information we can extract many details of how the planet formed. If we understand this, we can put our own solar system in context. How did it form, and was this normal?

Answering unanswered questions

Although we have a good idea of the way planets form, there are still a lot of questions unanswered. When did the planets form? Did the large planets or the small planets form first? What is the chance that planets form? Do planets end up where they form, or is there still evolution in the planetary orbits? Are planetary atmospheres enriched after formation?
Answering these questions is crucial if we ever want to find out if the formation process of our solar system is unique or normal. Studying the atmosphere of a planet can for example tell a lot about the temperature at which the planet was formed, but also teaches us about later enrichment of the atmosphere by colliding planetesimals, which might have changed the atmospheric composition. By probing the composition of the atmosphere we can trace back not only formation conditions but also later evolution of the planetary system.

The James Webb appetiser

ARIEL is not alone in its mission. NASA's James Webb Space Telescope (JWST) – which will launch in 2020 – is the largest and most expensive telescope humankind has ever launched into space. This telescope will also observe spectra of exoplanets, just like ARIEL will.
The data from these observations will undoubtedly revolutionise the research field. Especially since JWST will be the first telescope to look at exoplanets in a totally different wavelength region. This will provide us with access to many different molecules in the atmospheres. JWST is going to do a lot more (for example explore the early universe in great detail), and thus has only limited time available to look at exoplanets.
With the handful of exoplanet atmospheres we will be able to observe with JWST, we will get an appetiser of what ARIEL will enable us to do. With the much larger sample ARIEL will provide we will be able to confront our formation scenarios with statistical data, allowing us to trace how planetary systems typically form, and what is possible.
I can't wait till it is 2028 to watch ARIEL launch, but until that time we have a lot of exciting challenges ahead. And if you are wondering about the search for actual life: we are also working hard on the technology to make that happen, but this is even a bit further down the road. Exciting times ahead!

Dr. Michiel Min, University of Amsterdam

www.sron.nl

Airborne

European market leader in solar-array substrate panels

Making composites affordable for space, aerospace and other markets. That's the ultimate goal for Airborne, the market leader in solar-array substrate panels for European satellites.

Airborne was founded in 1995, focussing on developing industrialized manufacturing lines for thermoplastic composite pipes. Twenty years later Airborne was set to conquer high-tech markets by industrializing a wider range of composites manufacturing processes by automation. Our ultimate goal? Making composites affordable for (new) space, aerospace and other markets.
Today, Airborne is the market leader in solar-array substrate panels for European satellites. To this date Airborne delivered more than 200 sandwich panels for satellites. Our solutions on design, manufacturing, automation and industrialization of advanced composite materials, enable clients to be more competitive by radically reducing costs and saving time.
We are very proud to be part of satellites such as Sentinel 1 and 2, EarthCare, Galileo FOC, EDRS-C and Astrobus. And we are working on some fifty more panels, including Jason-CS / Sentinel 6, JUICE and MetOp-SG. We believe that in 20 years advanced high-end composites components will be commodity goods. Therefore, Airborne has set the first steps towards the fully automated and digital production of tomorrow.
We believe disruptive solutions are a must in the new space market. In the next five years we see the space market face a huge demand for affordable satellites, to fully bridge the digital divide by 2027, making internet access available and affordable for everyone. Suddenly challenged by the production of hundreds to thousands of satellites, time and cost saving solutions are urgently needed.
At Airborne we can assist with automating the manufacturing of space products, to help clients enhance or regain their competitive position in this evolving market. We do so by enabling advanced composite manufacturing as a service. This is based on a platform with the Airborne toolbox of digital twin engines and automation building blocks, which help customers develop much faster with significant benefits in term of efficiency and effectiveness.
www.airborne.com/space

[ESA]

SBIC Noordwijk

Supporting business based on space technology

The Space Business Innovation Centre (SBIC Noordwijk) supports entrepreneurs who want to use space technology and satellite data for applications on Earth.

Are you an entrepreneur with an interest in space? Or a rocket scientist with an interest in entrepreneurship? In both cases, the Space Business Innovation Centre (SBIC Noordwijk) is the place to be for you. SBIC Noordwijk supports entrepreneurs who want to use space technology or data for business applications for applications on Earth.
Space exploration can sometimes seem like a purely curiosity-driven venture. But space technology and satellite data have also led to many innovations and breakthroughs right here on Earth, from satellite navigation in our cars, to better understanding of our climate, to new materials such as memory foam.
Still, we believe that space technologies and data could and should be used even more. That is why SBIC Noordwijk supports (aspiring) entrepreneurs in every step of their journey to implement innovations from space right here on Earth.
Entrepreneurship is not taught in every school or university. So for many developers, designers and engineers, their first experience with entrepreneurship is joining a hackathon; a 24- or 48-hour challenge where they are asked to solve a societal problem using data or technology.
Entrepreneurs who already have a business idea can join one of our workshops or our "Rocket Program", a seven-week validation program. But our most important program is ESA BIC: the incubation program of the European Space Agency. We can select up to 10 start-ups per year, which receive a 50,000 euro incentive for product development, business support and exclusive access to ESA engineers and facilities for technical support. The main requirement for entering this program? That you bring space technology #downtoearth.
www.sbicnoordwijk.nl

Ajilon

Providing highly skilled professionals

European countries in the aviation, space and defence domain who are in need of support in the field of technical engineering, IT or life sciences (including flex staffing), can count on Ajilon Technology Aerospace & Defence to deliver.

Ajilon Technology Aerospace & Defense provides technical engineering, IT & life science consultancy and flex staffing solutions to the aviation, space and defence domain across Europe. We are proud to be a preferred supplier of staffing solutions to the European Space Agency for almost 35 years with 125 of our highly skilled professionals seconded to ESA-ESTEC in the Netherlands, ESA-ESAC in Spain, ESA-ECSAT in the UK and ESA HQ in France.

Specialised engineering expertise

As the satellite industry continues to develop at a rapid pace, from Earth observation to communication & navigation, satellites are an integral part of modern life and the most common reason for space flight today. Specialised engineering expertise is required for the development of technologies and systems for satellite applications.

In recent years, advancements in micro and CubeSat technologies are driving down the cost of satellite development, putting the power of satellites and the data they provide within the range of many more companies than was possible in the past. This democratisation of space is projected to continue at an even more accelerated pace in the coming years.

At Ajilon Technology Aerospace & Defense we are always looking for highly skilled professionals with experience in the Aerospace & Defence domain to join our team for our existing and future projects

in navigation, communications, Earth observation, design, systems & software, materials & components, quality management and legal & procurement.

Locally our professionals often require different levels of support from relocation to additional development. The structure and process Ajilon has in place are supported by our recruitment team, field managers and business managers.

From initial contact with our professionals employed by Ajilon Aerospace & Defense, we pay particular attention when supporting our professionals seconded to our clients. This is key to the success of our professionals and clients appreciating our flex staffing solutions, support and processes enabling completion of projects on time and budget.

Rebranding imminent

Later this year Ajilon will rebrand to Modis, as will Euro Engineering and DIS. Modis will become our single global brand for engineering, information technology & life sciences. Aligning our brands to Modis strengthens our aerospace and defence business thus providing more opportunities for our professionals coupled with greater flex staffing solutions for our national and international clients.

Our global network consists of close to 30,000 colleagues with cross-domain expertise in IT services, manufacturing, engineering and life science. Our colleagues can mobilise rapidly to help your business approach the design, testing and roll-out of innovative new designs and products.

How can we help you?

For more information contact Douglas Murdoch, Business Unit Manager – Aerospace & Defense: douglas.murdoch@ajilon.nl.

Inmarsat

Helping lives with satellite communication

Although fibre optic may be the present for communications, satellite coverage will help form a significant part of its future. Satellite has endless possibilities, which Inmarsat looks to make a reality.

As you view the latest must-watch series on Netflix while discussing the unfolding plot with your friends on WhatsApp, chances are you haven't given a second thought to the technology behind streaming video and instant messages. You may know which mobile phone network you're on or who your broadband supplier is, but you're unlikely to have given it too much consideration; unless Twitter goes down and you're wondering where to direct your ire. But what about the communications providers who make it all possible? Broadband cables are the past, fibre optic may be the present, but it is satellite coverage that will help form a significant part of the future. Inmarsat is at the heart of global mobile satellite communications and has been providing a broad portfolio of connectivity services for users on land, sea and air for almost forty years. Initially established by the International Maritime Organisation to provide safety services that seafarers could depend upon as a communications lifeline while at sea, it has since evolved to deliver the world's leading portfolio of global, mobile communication services at sea, on land and in the air. Today, in addition to the maritime market, Inmarsat delivers highly reliable, mission critical connectivity solutions for airlines, governments and a broad range of commercial enterprises.

Millions of lives

The Netflix scenario may be the most relatable example for many, but Inmarsat's solutions are deployed for mission critical applications that help protect millions of lives every day. That may sound dramatic to the casual internet user, but every day millions of people are dependent on Inmarsat's technology for reasons far more critical than attempting to beat the score on their favourite online game.

Pilots rely on our backbone global, mobile communications infrastructure to stay in contact with air traffic control. Ships' captains depend on the Global Maritime Distress and Safety System our global satellite network underpins, while our eHealth preventative monitoring solution provides vital medical assistance in some of the most remote areas of the world. Even the food on your table may have benefitted from our technology – developments in the deployment of satellite communication networks to support Internet of Things applications are transforming the agricultural sector and are making it easier for farmers to monitor their crop and livestock at the touch of a button.

While connectivity may be something we take for granted in much of the developed world – although leading nations including China (47 per cent), Russia (27 per cent) and the United States (24 per cent) still have significant percentages of their populations offline – huge swathes of the planet remain unconnected to the web.

The latest estimates suggest more than three billion people have no access the internet. This is due to a variety of issues including readiness, relevance, affordability and accessibility, and the International Telecommunication Union has a Connect 2020 Agenda which aims to radically improve the rate of connectivity in the developing world. Satellite technology won't solve this problem overnight, but it can definitely help remote regions make great strides in terms of coverage and connectivity.

A crucial global hub

Inmarsat is a truly global business, employing staff in over forty countries worldwide and while the United Kingdom may be its headquarters, the Netherlands is a crucial global hub for us. Our Burum site is a key antenna location and

teleport facility from where our satellite fleets are controlled, providing coverage not just within the Netherlands, but throughout mainland Europe and Africa. Inmarsat also has an administrative base in The Hague and a warehouse facility in Rotterdam, where it is able to install communications terminals on vessels; a service that we are also able to fulfil in nearby ports in the Netherlands, Germany and Belgium. Inmarsat's Dutch subsidiary was originally a distribution partner named Stratos that Inmarsat acquired in 2009 before fully integrating it into the business in 2012. Its key partners in the country include Radio Holland – who helped it meet a demand surge for Fleet Xpress – Network Innovations, Digital Skies, Marlink, Speedcast, Alphatron, and KPN.

Some of the company's leading personnel hail from the Netherlands too, including Ronald Spithout, the president of Inmarsat's maritime division and Frederik Van Essen, senior vice president in the company's aviation business, who previously worked for KLM, the Dutch flag carrier. Similarly, senior roles may be the ultimate goal for some of the young space professionals signing up to the 31st annual Space Studies Program (SSP) of the International Space University (ISU) being held in the Netherlands this summer.

Power to influence the future

Gerard Luursema, senior director of EMEA network operations for Inmarsat – based at the Burum site – says its Dutch division is conscious of the integral role it plays within the company's global infrastructure. "We are proud to host the most important teleport in the Inmarsat network supporting a very significant portion of the overall revenue, in the Netherlands", he says. "We're very pleased with the environment in which we operate such a unique and vital service. It is a mix of a highly skilled workforce, excellent terrestrial interconnect and great support from the government on several levels."

Luursema exudes the excitement he feels working for a company whose key concerns are space and satellites. "Working for Inmarsat in the sectors we serve means you have the power to influence the future and how satellites help define what that looks like," he shares. "That is exhilarating but also carries with it a responsibility to get it right." This youthful glee for all things out of this world is no doubt shared by the students signed up to this summer's SSP, who will cover modules on space-related science, engineering, applications, humanities, policy, economics, law, management and business, as well as human performance in space. Luursema says Inmarsat's involvement is not only aimed at increasing its own visibility, but equally at driving further cooperation between all those involved in the satellite industry.

Satellite has endless possibilities and two of the prominent projects Inmarsat is working on at present include the establishment of the European Aviation Network that will give airplane passengers access to WiFi in the clouds and the Iris Service Evolution that aims to improve the efficiency of European airspace through enhanced traffic management.

Coupled with developments in its maritime, enterprise and governmental sectors, these are exciting times, not just for Inmarsat but for the satellite communications sector as a whole. As an elder statesman of the industry, Inmarsat enjoys a unique vantage point of these new horizons, backed with four decades of know-how to help inform the next stage of the journey. It remains at the forefront of innovation in global satellite communications services and continues to invest in delivering pioneering new networks that will drive advanced new solutions on land, sea and air.

www.inmarsat.com

Leiden Observatory

The oldest university observatory in operation

Is Earth the only habitable planet in our universe? And what is the true nature of dark matter and dark energy? These are just some of the questions the Leiden Observatory looks to answer.

Leiden Observatory is the astronomical institute of the Faculty of Science of Leiden University. It was established in 1633, and is the oldest university observatory in operation today. Leiden Observatory carries our world class research in the formation of structures in the universe and the origin and evolution of galaxies, the detection and characterization of a large range of properties of exo-planets, and the formation of stars and planetary systems.
We offer an excellent educational programme at the Bachelor's and Master's levels and a renowned PhD programme. Within the Faculty of Science, the institute closely collaborates with the Leiden Institute of Physics, the Mathematical Institute and the Leiden Institute of Advanced Computer Science.
Our ambitious research programme focuses on observations using the world's most powerful ground-based and space telescopes, on theoretical astrophysical and astrochemical modelling, on large scale simulations, and on laboratory experiments that mimic space conditions.
Our world-class astronomical research is supported by the development of key technologies for ground-breaking astronomical discoveries and translates into an excellent educational programme at the Bachelor's and Master's levels.
Our education and PhD programme delivers scientists that find employment in astronomy, industry and society worldwide. Through our work, we also seek to engage the public with the wonders of the universe and share the scientific, technological, cultural and educational aspects of astronomy with society.
Research at Leiden Observatory is organised in two broad themes: galaxies and the structures in which they are embedded, and exoplanets, star and planet formation. Our research covers the fundamental physics of the origin and evolution of the large scale structures and galaxies in the universe as well as the origin of stars and their planetary systems. Questions we study include: what is the true nature of dark matter and dark energy, and is Earth the only habitable planet in our universe?
www.strw.leidenuniv.nl

[ESA]

Lens R&D

Creating affordable and extremely high reliable sun sensors

Reliable sun sensors are normally quite expensive. Lens R&D designs, builds, qualifies and calibrates reliable and affordable sun sensors for space and terrestrial applications.

Lens R&D is a small but highly specialised company designing, qualifying and calibrating sun sensors for space and terrestrial applications. Established in March 2012 the current team of six people is in the process of building and qualifying sun sensors that are exhibiting an extremely high reliability while still being very affordable due to the high degree of optimisation for volume production.
The shown model BiSon64-ET-B is an analogue fine sun sensor currently being qualified over a very wide temperature range (from -125 °C to 125 °C). Like all other BiSon sun sensors, this sensor is based on radiation hardened photodiodes that have been tested to over 1 Mrad, where the integrated baffle of this unit optimises the measurement accuracy.
Calibrated on the proprietary supercontinuum laser-based calibration setup, the sensors can be obtained at less than half the cost of competing similar products. Although 20 of these sensors are to fly on the ESA Proba-3 mission – the sensor was originally designed to allow mounting directly on extendable solar panels of Geostationary satellites – they are small enough to fly on almost any mission requiring a high reliability solution.
Next to the shown sensor, several standard BiSon64-B units are expected to fly on a number of satellites in 2018. Lens R&D is the only European company currently developing a miniaturised true digital sun sensor in the frame of an ESA Artes contract. The sensor is intended to be used on geostationary satellites that use electric orbit raising (consequently requiring an extremely high radiation tolerance). Through this contract, ESA recognises the expertise of our staff and suitability of our facilities to engage in very challenging developments.
https://lens-rnd.com

Lens R&D

cosine

Building miniaturized instruments

The smaller the instrument, the cheaper it is to bring to space. Warmond-based cosine builds miniaturised instruments for use in space. The company also develops X-ray mirrors for ESA's Athena mission and brings measurement systems used in space back to Earth.

cosine is a Dutch company that develops and builds optical and in-situ measurement systems for space, air, field and factory. cosine is working on several development contracts for the European Space Agency (ESA), but also develops its own space products with support from ESA and the Netherlands Space Office. In addition, cosine develops and builds measurement systems for non-space applications.

Building miniaturised instruments

The remote sensing group of cosine develops a range of miniaturised instruments for use in space as well as on manned or unmanned aircraft and in the field, both stationary and on vehicles. cosine has led the development of a miniaturised hyperspectral camera for nanosatellites called HyperScout.

The first HyperScout was launched into space on February 2nd, 2018 and first light was achieved on March 26th, 2018. These images are the first Earth observation images of their kind captured by an instrument onboard a nanosatellite. This opens the possibility to operate a constellation of HyperScouts to provide near real-time operational services.

HyperScout can be used for crop water management, fire hazard monitoring, flood detection, change detection of land use, as well as algae and vegetation monitoring. HyperScout is the first of five miniaturised instruments that cosine is developing, also including a miniaturised thermal imager, a LIDAR, a high-resolution imaging spectrometer and a polarimeter.

X-ray vision

The high-energy optical systems group of cosine develops the X-ray mirrors for Athena, the next European X-ray satellite observatory. This key mission for X-ray astronomy will provide a much larger collecting area and spectral resolution than the current ESA X-ray observatory, XMM-Newton.

Athena will enable us to study X-ray sources outside our galaxy, including the cosmic web and black holes. Based on new technology, invented by cosine and ESA, cosine is developing and setting up the process to manufacture the X-ray mirrors for Athena. This technology is also being adapted for other X-ray astronomy missions, for other high-energy radiation such as gamma rays, as well as ground applications in the medical and material analysis field.

Using space technology on Earth

The inspection systems group of cosine develops and builds measurement systems for non-space applications. Here cosine makes use of the extensive measurement knowledge and technology that has been developed for space research. This includes remote sensing techniques such as spectral imaging in the visible and more exotic parts of the electromagnetic spectrum.

This technology can be used for product inspection in the factory, for agricultural products or environmental monitoring, but also for sensors placed in or on the object to be measured, for example to measure forces or monitor the integrity of structures.

cosine has its own clean rooms and testing facilities for small space instruments and space optics in Warmond, the Netherlands. With an international team of physicists and engineers, cosine develops measurement solutions for the future using technology available today.

www.cosine.nl

TU Delft Space Institute

Linking people and institutions

Contributing groundbreaking and cutting-edge solutions to the space domain to serve scientific, economic and societal needs: that's what TU Delft Space Institute (DSI) stands for. How is the TU Delft Space Institute doing this? By combining and creating expertise across various faculties of Delft University of Technology, and by making expertise usable at a local, regional and global level through knowledge institutes, companies, agencies and governmental bodies.

TU Delft Space Institute (DSI) joined forces with TNO last November to organise the 'Innovate your Space' Symposium, with the aim to connect and promote innovation, research and engineering development in the space field. All of 'Space Nederland' gathered at the Symposium: 120 experts from industry, knowledge institutes, government and academia attended the day.
Different keynote speakers addressed "hot" topics, such as: SRON's technology program, existing and future technologies to identify Earth-like planets, and New Space Systems paradigms, e.g. cloud computing. The attendees also discussed with fellow specialists and investors scientific, engineering or societal questions and possibilities of collaboration.
Several key statements were reviewed in a plenary discussion. Topics included commercialisation in space, fundamental space research, the extra resources allocated by the new government, and collaboration between industry and knowledge institutes. The DSI stimulates annual Space gatherings like this, and is taking the lead in organising a new symposium in November 2018.

Two TKI projects

The DSI also has an important coordinating role for companies, institutes and other universities in the domain of space. To further achieve its ambitions in this field, the DSI participates in several TKI projects. TKI stands for Top Consortia for Knowledge & Innovation. Two of these TKI's are now running:

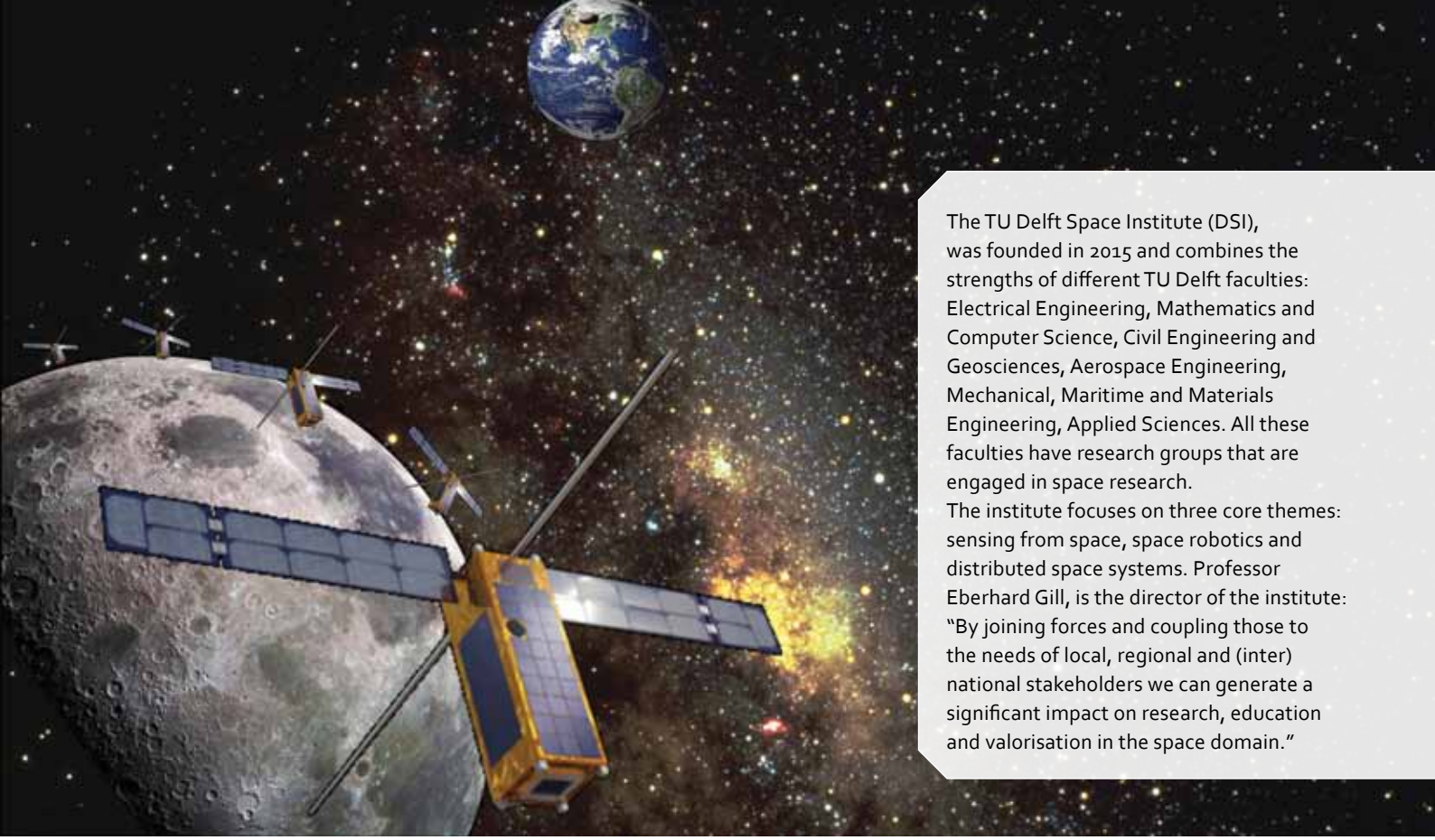
"Enlarging the spatial resolution of mini-satellite platforms"
This first TKI project addresses current problems linked to Earth observation (EO) systems. High resolution EO data has become invaluable for a wide variety of applications, ranging from defence and security to environmental monitoring and disaster response. Currently, high resolution imaging data are captured by large, heavy and expensive EO systems. As a result, data produced by these satellite systems are also very expensive.
The goal of the proposed work is to design a deployable optical system that can reach similar resolutions as state-of-the-art Earth observation systems, while using a fraction of the volume and mass. The launch costs of these systems are therefore expected to be substantially smaller with the ultimate result: a much lower cost per image. There are additional challenges, for instance, the telescope will be operating in a Low Earth Orbit, where thermal-mechanical loads are changing continuously.

"Solution to the data-congestion problem"
This second TKI project aims to solve large problems in today's inter-satellite communication and satellite-to-ground station communication for small satellites or more specifically, downlink data congestion and a lack of high-speed inter-satellite links for swarms that form interferometers.
The intended practical results of the project include a "black box" that accepts (I/Q) baseband signals and produces RF output in a power and spectrum efficient way. Another aim is a design methodology that describes how modern commercial-of-the-shelf (COTS) RF technology can be adequately used in space applications. The results will be highly useable for terrestrial applications, so the impact will be beyond just the Dutch space industry.

Three PIPP proposals

TU Delft Space Institute is also involved in the Knowledge Network Regulation PIPP (Partnerships for Space Instruments & Applications Preparatory Programme). PIPP is aimed at promoting the international position of the Netherlands in the development and use of space instruments by supporting knowledge networks. Two proposals for PIPP coordinated and submitted by the TU Delft have been selected by NSO on behalf of NWO:

"Breakthrough Technologies for Interferometry in Space"
Interferometry (swarms of large quantities of small satellites and sensors) is a key technology in future spaceflight. This program aims at breakthroughs in localisation, high-data rate links, distributed



The TU Delft Space Institute (DSI), was founded in 2015 and combines the strengths of different TU Delft faculties: Electrical Engineering, Mathematics and Computer Science, Civil Engineering and Geosciences, Aerospace Engineering, Mechanical, Maritime and Materials Engineering, Applied Sciences. All these faculties have research groups that are engaged in space research.
The institute focuses on three core themes: sensing from space, space robotics and distributed space systems. Professor Eberhard Gill, is the director of the institute: "By joining forces and coupling those to the needs of local, regional and (inter) national stakeholders we can generate a significant impact on research, education and valorisation in the space domain."

computing, satellite cluster control and many more technologies that will enable many different commercial and scientific multi-satellite missions. Two scientific missions, the moon orbiting radio telescope OLFAR and the two-element THz interferometer EHI, will be used as drivers and precursors for the research.

"Dutch Network on Small Spaceborne Radar Instruments and Applications (NL-RIA)"
This network aims at establishing a long-lasting collaboration framework in the field of spaceborne microwave remote sensing instruments and missions. The initial specific objectives relate to the study of breakthrough technologies to allow the implementation of miniaturised radar instruments compatible with SmallSat Earth observation missions. Two classes of instruments are initially being considered: radar altimeters, and Synthetic Aperture Radars. Of particular interest are multistatic mission concepts, with several spacecraft acting as a single distributed radar system.
TU Delft coordinated the preparation for these two proposals and gathered all Dutch key players in the field.

"Breakthrough technologies for direct imaging and characterisation of exoplanets from space"
This third PIPP proposal in which TU Delft is participating, is about a future generation of instruments that will allow the detection and characterisation of planets orbiting in the habitable zones of neighbouring stars. The project is developing methods to take images of the exoplanetary systems from space with unprecedented resolution - while at the same time suppressing the light from the stars. This will enable separation of the weak planetary signal from the background. A further aim is the development of a new generation of highly capable sensors that are sensitive to the variations in wavelength and polarisation distribution that constitute the characteristic fingerprints of the observed planets.
The TU Delft Space Institute has already stimulated quite some activities and projects in the space domain, but there is still a lot more to do!

Sensing from space

Sensors are of critical importance to any spacecraft. Amazing progress has been made in this field, due to miniaturisation and the development of new technologies. An example is the characterisation of a new technology, called Fourier phase grating. This allows using multi-pixel beams at super-Terahertz frequency to open up a new window in astronomy. Better sensors and smarter measuring strategies are crucial for monitoring the earth and exploring the wider universe.

Space robotics

To sense, to plan and to act is the essence of robotics. Space robotics has enabled mankind to reach places where humans can't go. The TU Delft Space Institute develops and flies state-of-the-art robotic systems. Mechatronics is an important research domain within Space robotics. TU Delft has already successfully demonstrated space mechatronics systems in the Delfi nano-satellite missions.

Distributed space systems

Small satellites working together as a team are a major trend in spaceflight. Multi-agent systems can be cheaper and more robust than single spacecraft: if one component fails, the others will continue. Flight control, communication and decision making are the main challenges in this field. TU Delft has developed various algorithms, based on artificial intelligence (AI), to manage distributed space systems by making decisions onboard instead of relying on the command from ground stations.

www.spaceinstitute.tudelft.nl

Sapienza Consulting

Providing support to the European space industry

For almost half a century, Sapienza Consulting has provided the European space industry with support. Our company does this in three ways: by providing manpower, by offering IT and engineering services and with our web based Space Project Management software ECLIPSE.

Sapienza Consulting is a business partner and supplier within the space and defence industry. Since our inception, our company vision was to provide support to ESA-ESTEC and it has continued to be a driving force at the core of our business, growing to encompass the European space industry as a whole. What does this really mean? It means that we work with and provide support to our clients. We do this through three different business units: ECLIPSE software suite, manpower and IT and engineering services.

Supporting collaboration

ECLIPSE is our own proprietary software created as a response to the needs of the space industry, to support their satellites and missions projects. It is fully complaint with the requirements of the ECSS (European Cooperation for Space Standardisation), which is why ESA is our largest ECLIPSE customer. ECLIPSE is web based and supports processes in project management, product assurance, configuration management, product assurance and quality assurance.
It supports collaboration across organisations as well as information sharing, which helps our ECLIPSE customers to information within their organization and streamline their processes. Not only does it support large satellite projects, it also supports downstream services and applications. ECLIPSE is predominantly used in the space industry, but it has the possibility to be used across a multitude of industries.

Providing manpower support

Manpower is the recruitment arm of our business. We supply key personnel to the space & defence industry, whether that's working onsite with us at the Space Business Innovation Centre (SBIC) here in the Netherlands or supporting our clients across the United Kingdom, the Netherlands, Belgium, Luxembourg, France, Germany and Italy. Our heritage within the space sector is longstanding; we've supported over thirty ESA missions in the last twenty years (including Galileo, MTG, Copernicus and ExoMars).
We can provide support on a project, temporary or permanent basis and we cover a wide variety of roles across technical, engineering, operational and administrative domains. The diversity of roles we recruit for, means that our team is well versed across all domains and experience levels within the space industry. We continuously engage with the industry, meaning that our knowledge and network is continuously expanding and improving.

Quality and flexible service

The space & defence project services are our third business stream and encompass a large portfolio. This part of our business is unique and tailored to each customer and their business needs; no two companies have the same needs. Whether it is IT infrastructure design & architecture, software engineering, space project configuration or technical support, our dedicated team – comprised of experts within their respective domains – works closely with our clients to support their business needs and provide a quality and flexible service which will enhance their business operations.
How do we do all this? The great thing about technology is that you are instantly connected; irrespective of their location we are able to provide our clients with continuous support. In addition, we have a number of offices across Europe that are in close proximity to our clients' sites, which again allows us to answer any queries, solve any problems and support them however possible.

Continuous support

For the last twenty-four years, we have remained at the heart of European space activities. Whether through ECLIPSE, manpower or services, we are providing support to the space industry; we are helping with the continuous growth and development of the industry by ensuring that projects are running smoothly, staff is fully trained and compliant and that there is a core infrastructure and foundation in place. With the entrance of new players in the space market and the rapidly changing space sector, Sapienza Consulting is looking forward to continuous developing partnerships with new and leading space actors.

www.sapienzaconsulting.com

European Test Services B.V.

[ESA]

Operating Europe's largest space test centre

When ESA took the decision to outsource the operation and maintenance of its Test Centre in the 1990s, European Test Services (ETS) B.V. was founded. The company is responsible for marketing, sales, management and maintenance of the ESA Test Centre.

Located in a dedicated building at ESA ESTEC, the ESA Test Centre is the largest environmental space test centre of its kind in Europe and one of the largest in the world. The ESA Test Centre is a unique environment with state-of-the-art facilities. It is serviced by highly-trained staff who work in close interaction with European industry.

Since 1967 the ESA Test Centre Division has ensured the maintenance and operations of the test facilities with the support of contractors who have been working mostly under a technical assistance contract or under a service-hire contract.

Outsourced

In the 1990s ESA has taken the decision to outsource the operation and maintenance of the ESA Test Centre. Since then the tasks related to the management, maintenance, marketing and sales of the test facilities have been publicly tendered. ESA remains the owner of the facilities and is responsible for all investments in the Test Centre. The definition, development, procurement and acceptance of new facilities, facility upgrades and modification remains the responsibility of the agency.

European Test Services (ETS) B.V. was founded on September 1st 2000 as a joint-venture of Intespace (now Airbus Defence & Space) and IABG and has been awarded with a contract on the maintenance, management, marketing and sales of the ESA Test Centre. The contract has been extended several times and ETS remained as the facility operator. During the previous years, the processes and interfaces between ETS and ESA have been improved in order to take full advantage of the extensive engineering capabilities of ESA.

Maintenance and marketing

ETS manages the activities related to the preventative and corrective maintenance, as well as marketing and sales of the test facilities under its responsibility. Furthermore, ETS is responsible for exercising an efficient management of the operations and test services of the test centre.

In the frame of *maintenance*, ETS is responsible for:

- Maintaining the test facilities according to their technical specifications;
- General reporting to the Agency;
- Establishment of necessary agreements with suppliers;
- Procurement of all spare parts and consumables required to ensure availability of minimum stock level of spare parts;
- Implementing minor facility modifications and upgrades;
- Keeping inventory of equipment made available to ETS.

The *marketing* activities of ETS are focused on the promotion of the operations and testing services of the concerned facilities. In this frame, ETS is responsible for:

- Carrying out an efficient and independent marketing and sales policy to achieve the maximum use of the capacity of the facilities;
- Development of initiatives for an efficient marketing and sales system;
- Proposing facility improvements to ESA that could increase the sales level.

Success stories

The ESA Test Centre has numerous successful references in space hardware testing covering mechanical testing, thermal testing, EMC testing and test related facility modifications. Both for large test campaigns on spacecraft level as well as for subsystem / component tests, ETS has proved to be a highly reliable and skilled partner. The following test campaigns can be highlighted as references for the successful partnership between ESA and ETS:

- BepiColombo STM & PFM
- JUICE TDM
- Galileo Giove A & B
- Galileo IOV SM and PFM
- Galileo FOC FM1 – FM22
- Herschel STM & PFM
- Planck PFM
- METOP PLM
- SMOS PLM STM & PFM
- GOCE STM & PFM
- Small-GEO STM
- CHEOPS STM
- ATV STM & PFM
- IXV PFM

In addition to the test services provided to the space industry, ETS has also become a major supplier of testing services to railway, marine and power/electric industry with customers such as ABB, Bombardier, Alstom, and General Electrics.

www.european-test-services.net

ISIS

Small satellites, made in Delft

Back in 2008, students from the Delft University of Technology launched their first nanosatellite into orbit. What started as a study project morphed into a spin-off company called Innovative Solutions In Space (ISIS), which is now one of the leading companies in the world of small satellites.

Delft is renowned for its Delft Blue Pottery and its excellent ecosystem of knowledge driven education, research institutes and high-tech companies. Since 2008, it is also known as the Dutch centre for small satellites. In that year, Delfi-C^3, the first satellite from the Delft University of Technology was launched into orbit. A very successful project: the 2.5-kilogram Delfi-C^3 satellite is still active after more than a decade in space. It yielded interesting test results on its payloads, delivered close to one hundred engineers to the job market with practical skills under their belt, and created a successful spin-off company: ISIS.

Innovative Solutions In Space (ISIS) was founded on January 6th, 2006 by five members of the initial student team of the Delfi-C^3 project. Since then it has become one of the leading companies in the fast-growing small satellite market. ISIS operates globally and serves customers worldwide in accomplishing their space missions and applications. After more than twelve years in the field of small satellites, ISIS has grown into a vertically integrated small satellite company with a varied, multi-disciplinary team of ninety people who design, build and launch small satellites for a living.

ISIS specialises in realising innovative turn-key small satellite missions including launch and operations for in-orbit delivery. ISIS designs and delivers small satellite platforms for single missions and constellations, either standardised or optimised in performance and size, tailored to the mission needs. Through ISL, its launch services subsidiary, ISIS launches all sizes of small satellites. In addition, the company builds space capability through training programmes, knowledge transfer as well as component sales.

Think outside the box

Spacecraft engineering offers complex problems to bright people. Especially in the domain of small satellites engineers are challenged to find innovative ways to obtain maximum performance with as little resources as possible. The multidisciplinary aspects of satellite engineering force you to think outside the box and consider a full system's view in order to solve the engineering challenges. Above all, ISIS is a company with a lot of dedicated people that are fun and pleasant to work with.

The company's core competencies lie in the application of space systems engineering in combination with an expertise in the following technical areas: radiofrequency systems and payloads, deployable systems and hold-down and release mechanisms, attitude determination systems, and embedded systems. Within this last category, sensor networks technology is also included.

People at the core

ISIS operates from its main site on the high-tech campus of Delft. At this site, ISIS also has its assembly, integration and test facilities that include a class 10,000 (ISO 7) integration cleanroom and a broad range of (environmental) test equipment and development labs. In addition, ISIS has a development branch office in South Africa, in Somerset West and the company has an international network of partners and reseller agents.

We cannot do what we do without our people. Despite the trends towards maturing the space sector, industrialisation for space hardware and software development, people are still at the very core of space innovation. We have a highly motivated team of people from all over the world and with all kinds of skills that ISIS needs, and the company keeps

adding new engineers, technicians and support staff to its ranks. A few of our team-members share some of their views on working at ISIS.

Kerwin Wijngaarde – Test Engineer

I'm a test engineer who mainly tests subsystems with some small design tasks in between. I have an intermediate vocational education degree in electronics and I'm currently busy with my bachelor degree in electrical engineering.
I started my first internship at ISIS in 2014 and my second internship in 2015. I started officially working at ISIS in 2016. Most of the day I'm testing subsystems and making procedures for testing subsystems. Between those activities I also do some small electrical design tasks.

Haley Doyle – Systems Engineer

I began studying aerospace engineering and working on CubeSats at the United States Naval Academy. Once I had to leave the Navy, I took up a contractor position at NASA to work on a space debris sensor, then I came here to join the systems engineering team. System engineers are responsible for the technical aspects of the satellite, ensuring that the design comes together successfully and the mission requirements are fulfilled.
My work is always different, depending on the project phase. At the beginning of a mission I'm doing more analysis, discussing requirements and working on satellite budgets and design. Later on I'm spending time writing procedures or working in the lab testing hardware. Towards the end of the project it gets really exciting when we're working in a cleanroom with the whole system, doing final checks before delivery to the customer or launch provider.
It's awesome to see a project develop from start to finish. One of my favourite rewarding moments was getting to load a CubeSat into its deployer, say goodbye and close the door, knowing that the next time it opened it would be in space! (And then hearing from it again was also nice.)

Nicolas Clemencin – Project Manager

I'm a project manager on both satellite missions and R&D projects. My job is to make sure that we deliver what we promised to our customers, on time, and within the allocated budget. I have been working at ISIS for one and a half years as a project manager, but I have actually started in this company as an intern more than two years ago.
My job leads me to do all kind of things, from preparing schedules and reporting to the board of the company, to chairing technical design meetings and managing satellite operations activities. I also contact suppliers, manage the relationship with the customers of my projects, and make sure the people working on those projects work nicely together.
What I like the most here is the freedom. Pro-active people really have the possibility to take action and change things. At ISIS you can really see the value of your work and you can very easily have a visible impact on the projects. It is very rewarding!

Gerard Aalbers – Embedded Systems Engineer

At ISIS I'm an embedded systems engineer, which is a good mix of both my education and my personal interests. I was one of the company's first full-time employees, joining not long after it had been founded. I had worked with the company's founders during our thesis project, the Delfi-C^3 nanosatellite, so this was a natural follow-up job for me.
My main focus is on designing, developing, and testing of the software and electronics that control the satellite and execute its mission. I'm also fortunate enough to be involved in the operations of some of the satellites after they have been launched, which is a big responsibility but a very exciting aspect of my job.

www.isispace.nl

JIVE

Joint Institute for VLBI ERIC: The sharpest view

VLBI (Very Long Baseline Interferometry) is a radio astronomy technique that studies radio emission from celestial sources. The Joint Institute for VLBI ERIC (JIVE) promotes and supports research and development of VLBI in Europe, and beyond.

The Joint Institute for VLBI ERIC in Europe (JIVE) is the central organisation of the European VLBI Network (EVN). VLBI stands for Very Long Baseline Interferometry – a radio astronomy technique that provides the highest angular resolution (i.e. the sharpest "view") by studying radio emission from celestial sources.
The main mission of JIVE is to promote and support the research and development of VLBI in Europe and beyond in the broadest possible sense. JIVE is hosted by the Netherlands Institute for Radio Astronomy (ASTRON) and co-funded by France, Latvia, the Netherlands, Spain, Sweden and United Kingdom, and also receives support via bilateral agreements with research organisations in Germany, China, Italy and South Africa.
JIVE fulfils its mission by operating and further developing the EVN Data Processor (often called "VLBI correlator") as well as supporting individual EVN users and the operations of the EVN as a facility.
The Institute also carries out a broad range of research and development activities in VLBI-related fields, such as radio astronomy data transport and processing, innovative applications of VLBI and radio astronomy technologies.
The latter includes a variety of space and planetary science applications, in particular encompassing ultra-precise tracking of deep space missions and conducting research with space-borne VLBI radio telescopes.
The JIVE personnel conduct a wide range of cutting-edge research in cosmology, extragalactic and galactic astrophysics, and studies of the Solar System.
JIVE is involved in the Space VLBI mission RadioAstron led by Roscosmos and Russian Academy of Sciences. It also leads, as a PI organisation, one of the experiments of ESA's Cosmic Vision L-1 mission JUICE that is to be launched in 2022.
The JIVE senior scientists are involved in educational activities, including lecturing and supervising MSc and PhD projects on radio astronomy and space science at several universities.
www.jive.eu

[ESA]

Hyperion Technologies

High performance components for small satellites

High performance missions require high performance components. Hyperion Technologies designs and builds components for small satellites, ranging from star trackers and sun sensors to on-board computers and bipropellant propulsion systems, like the new PM200 module.

Hyperion provides high performance components for small satellites, yielding high performance, while only consuming little power, using small volumes and having low mass. The current portfolio consists of star trackers, sun sensors, reactions wheels, GNSS-receivers, magnetorquers, on-board computers, payload processors, structures and propulsion.
The products of Hyperion are designed to outperform currently available systems. Our iADCS100 and iADCS400 series for attitude control are the smallest attitude information systems in the world. They offer a precision of over 30 arcseconds (3 sigma).
Both systems are based on our ST200 star tracker, which for years is the smallest star tracker available on the market. The ST200 has successfully flown on a multitude of satellites.
Our newest product is the PM200 propulsion system. This bipropellant system solves the problems of altitude changes, constellation control and de-orbiting.
The PM200 brings high thrust propulsion capability to 3-12U CubeSats and similar platforms. Low system complexity and zero propellant toxicity allow for simple and robust operations, both on the ground and during operation.
The PM200 offers active thrust vector control to minimize disturbance torque on the satellite platform and can be seamlessly integrated with the iADCS400 to provide a fully integrated GNC and ADCS solution. As the PM-propulsion series are additively manufactured, customization for specific missions can be accommodated. The PM200 will change the mission and constellation design for small satellites.
www.hyperiontechnologies.nl

S[&]T Corp.

R&D solutions for space, science and defence

Research and development projects are long-term investments, which at some points might require short-notice team scaling. Security [&] Technology Corporation (S[&]T) offers flexible R&D support for companies looking for an extra hand.

S[&]T is excited to help host ISU in the Netherlands this summer! We've always had a heart for ISU'ers, and at the peak more than 10 percent of our employees were ISU alumni. We'd love to increase that number! We are ready to find ways to partner with you, so feel free to get in touch, whether it's for projects, apps, jobs, or even a cool spin-off idea!
Here's a quick overview of the things that drive us at S[&]T:

- *Intelligent people*

S[&]T prides itself on developing long-term relationships with intelligent, interesting people. Our company was founded on trust between the current directors, developed during a satellite instrument calibration campaign. 18 years later, long-term relationships are always top of mind when we're looking into partnerships of various types. Our employees choose the flexibility to move through projects that best fit their career trajectory, whether those are internal or integrated at our clients.

We ensure that our clients have the brightest minds available. Our partners find us stable and flexible in forms of working together, from mutually beneficial consortia to spin-off companies. Oftentimes we even see that clients might become employees or employees might become partners or clients. We follow the most natural progression, ensuring a win-win scenario with an eye on the long-term relationship.

- *Interesting projects*

We like to keep our highly educated employees happy by giving them cutting-edge R&D projects to work on. Our original focus on Earth observation satellite data processing has expanded to include mission-critical software and applications for other domains. Our projects have expanded to include everything from software for the latest on-ground optical and radio telescope developments to sensor systems for better understanding re-entry and breakup of rocket stages and potentially other unpredictable objects.

- *Insightful applications*

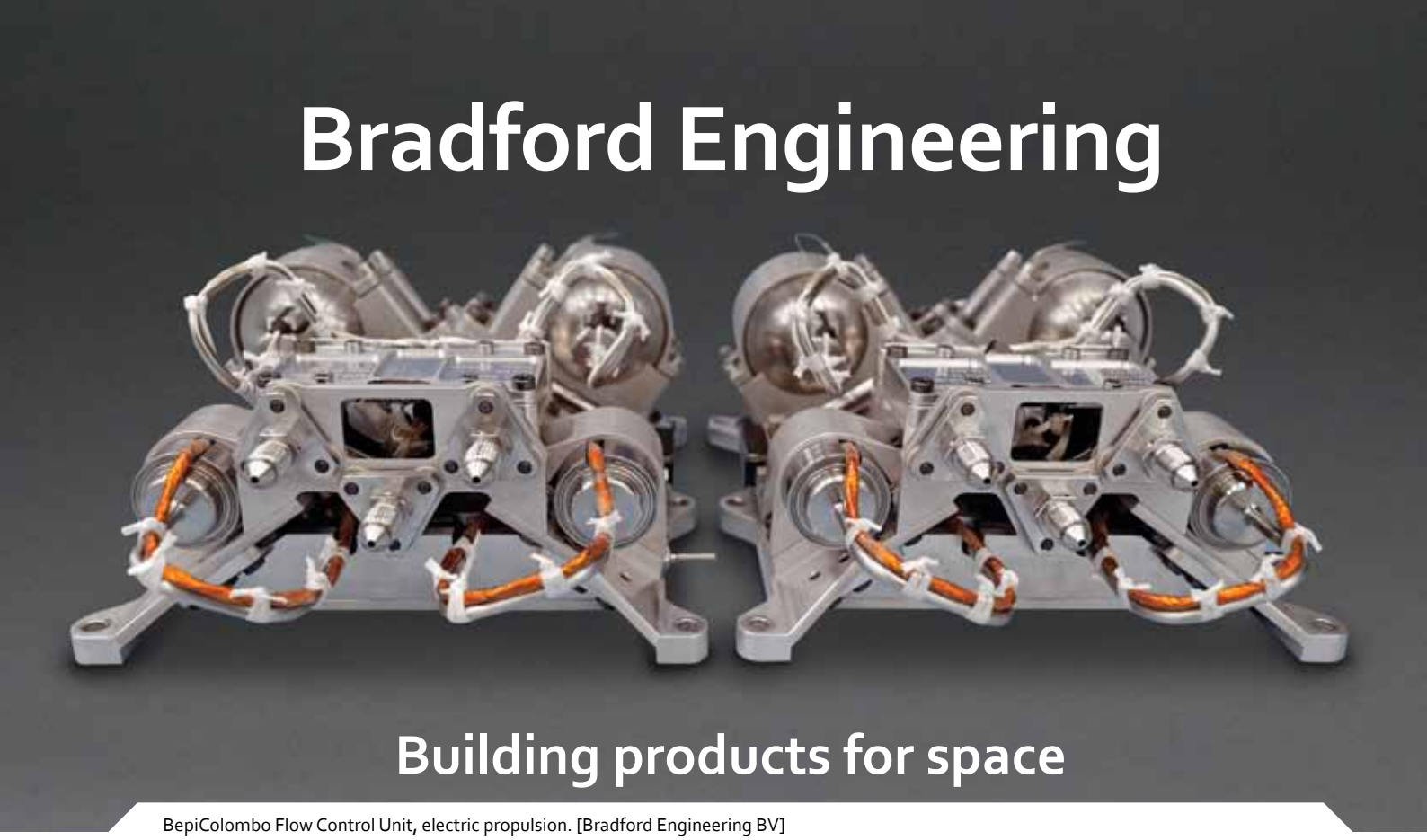
Our space software applications have expanded from data processing pipelines and scientific algorithms to products that are further down the processing pipeline, and apps that are fully integrated in other markets. For instance, planning and predictive maintenance applications originally built around our background in space safety and quality assurance are now integrated into planning and safety applications for police, public transport, and shipping. We're also an active player in the Copernicus downstream segment, with AirPortal currently leading in ground pixel resolution for air quality data worldwide.

- *Innovative spin-offs*

Some applications of our technology have developed to a point where we have spun them off into small R&D start-ups, with a focus on bringing space technology to other markets. Orbital Eye, an S[&]T company, uses Sentinel data, intelligent change detection, and custom notifications to provide oil and gas companies with pipeline safety solutions.
Another S[&]T spin-off, Spectral Industries, uses a spectrometer originally meant for Mars to make verification of materials for mining, security, and other industries as easy as 'point and shoot'. The spectrometer system would historically have only been found in a lab, but is now small, lightweight and robust enough for field applications. BioSparq also uses S[&]T software technology, but for the medical industry, providing real-time identification of bacteria in both air and liquids.

www.stcorp.nl

Bradford Engineering



Building products for space

BepiColombo Flow Control Unit, electric propulsion. [Bradford Engineering BV]

From solutions in attitude and orbit control to propulsion and avionics: Bradford Engineering has seen over 1500 of its products launched to space. The company now looks ahead to the future, by upgrading their famous gloveboxes to more future-proof workspaces.

Bradford Engineering Holding Company Ltd (Bradford Engineering in short) is a Netherlands based supplier of attitude and orbit control systems (AOCS), propulsion, avionics and thermal solutions for spacecraft. The holding company actually consists of two separate companies: Bradford Engineering BV and ECAPS BV. Both are experts in satellite subsystems and components, with special focus on a complete coverage of the propulsion technology domains (cold gas, electric and chemical). Bradford's solutions put the emphasis on the High Performance Green Propulsion (HPGP®) technology, which is patented by ECAPS.

Solid relationships

Bradford was established in 1984, starting its activities in the nuclear field. From 1986 onwards, space engineering – in the domain of human spaceflight instruments such as gloveboxes – became the focus of the organisation. The customer base is very divers. Bradford upholds a solid relationship with all government space agencies in the world (for example: ESA, NASA, JAXA), as well as most of the major satellite integrators, now moving towards the commercial New Space initiative.

In the latter market segment, Bradford Engineering recently became a proud partner of Astranis from San Francisco, USA. Astranis is a venture capitalist funded organisation with plans to change the economics of the GEO telecommunication market. Bradford has been selected as a partner, and will deliver HPGP propulsion systems, electric pressure regulators and sun sensors, and will perform the complete integration and loading cycle for these two propulsion systems.

Shortly after, Bradford Engineering BV joined the American Acquisition Corporation (AIAC) group, based on a 'long-term passion for space'. Bradford celebrated its 1000th product launched into space in November 2016. We are moving at an accelerated pace: the fifteen successful launches that took place in 2017 boosted the counter to more than 1500 commissioned, and successfully launched, products to space. Needless to say that we are very proud about this.

Quick delivery due to standardized components

This high representation in space projects worldwide is the result of a sophisticated strategy deployed years ago. The focus has shifted to a number of standardised components – of which our pressure transducers and sun sensors are the best known examples – that have found their way to most satellite platforms for telecommunication, Earth observation, science and navigation.

A good example of this can be found within the Iridium NEXT satellites. During the last calendar year no less than forty satellites have been launched, each equipped with eight sun sensors developed by Bradford. These sensors are used to determine the position of the spacecraft in relation to the sun.

However, during the same year there were also several science, Earth observation, navigation and geostationary communication satellites launched which were equipped with Bradford technology. Aside from that, a number of cargo ships were launched, equipped with Bradford parts and components.

From gloveboxes to workspaces

Around the turn of the century, Bradford was still focussed on the development of 'microgravity payloads'. These mini laboratories – in which all kinds of research can be performed whilst in a weightless state – are better known as "gloveboxes". The Micro-gravity Science Glovebox (MSG) was one of the first experiment

Astronaut Andre Kuipers working with the MSG. [NASA]

facilities on board the ISS, and celebrating its fifteenth operational year in 2017. This provided a great opportunity to implement a major upgrade in the form of a removable front window, which was successfully installed by astronauts in January.

Also in 2017 the preparation for the launch of the large Life Science Glovebox (LSG) started. The LSG has a volume of no less than 500 litres. After launch it will be the largest research lab in the space station. The LSG will be launched aboard Jaxa mission HTV7 in September 2018, after which it will be integrated into the Japanese Kibo module.

In addition we see a strong increase in the interest in gloveboxes and similar facilities, especially in the commercial 'New Space' market. This current interest will be supported by our rebranded 'workspaces'. A glovebox is just a type of place to do work in space – hence we chose to rebrand them as workspaces. The Workspaces initiative at Bradford is intended to expand what is possible on a space station.

Bradford gloveboxes have served their role well on past government-run space stations, but what will new commercial workspaces do? Will they provide a sophisticated workbench for manufacturing in space? A place to do maintenance on complex machinery? A place to prepare new foods for astronauts? Maybe a comfortable place for space travellers to keep their beloved pets safe while they travel in space? The possibilities are as vast as the frontier of space.

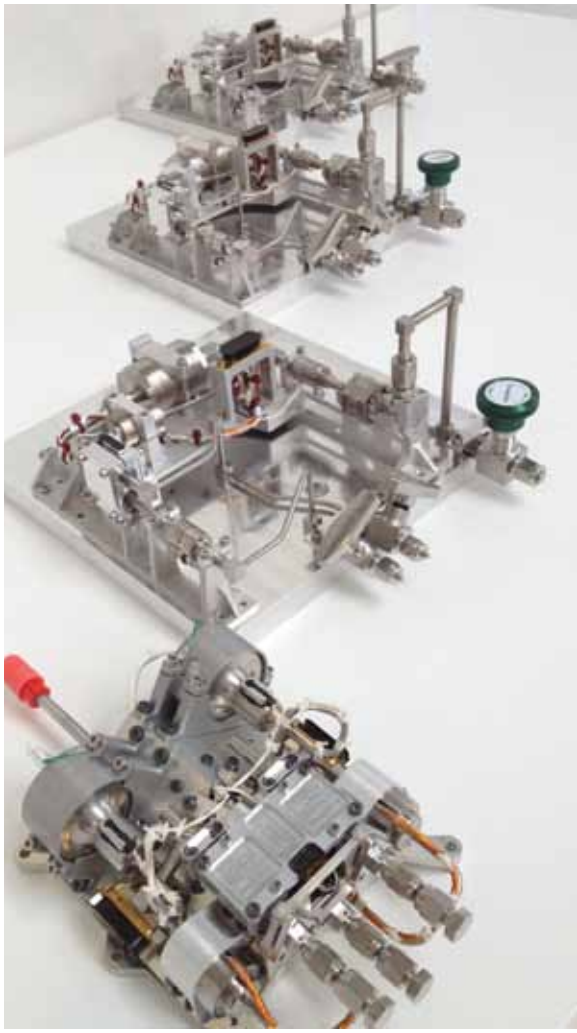
A global player

In July 2017 Bradford acquired the Swedish company ECAPS AB, capable of developing non-toxic propulsion systems and propellant for spacecraft. Over the course of more than twenty years Bradford provided solutions for everything between the fuel tank and rocket engine of a satellite. The acquisition proved to be a perfect match for both companies.

This cooperation between Bradford and ECAPS is not something new, which was proven on October 31st 2017, when six SkySat satellites were launched into space. Each satellite containing a propulsion system prepared by ECAPS, joined with a Bradford pressure transducer. The safety aspects, a lowering of total cost and environmental regulations yield a strong interest in non-toxic rocket propulsion worldwide.

With this acquisition, Bradford Engineering suddenly became a global player in this rapidly developing market; hence the enterprise grew by as much as fifty per cent.

www.bradford-space.com
www.ecaps.space



Flow Control Units, products [Bradford Engineering BV]

Space Expo

More than a museum

How is mankind helped by space technology? And which new know-how, materials and medicines has space technology given us? These and a lot more questions are answered at Space Expo, Europe's first permanent space exhibition.

Space Expo in Noordwijk is the first permanent space exhibition in Europe and the official visitors centre of ESA-ESTEC, the technological heart and the largest facility of the European Space Agency ESA.
At Space Expo, historical, current and future space events can be seen and experienced. The museum presents visitors with a unique look into the space sector in The Netherlands and Europe. It is a meeting place and showroom for the space sector, where not only interested visitors come to learn about space and society but also key players from governments, tourism and industry will recognise the value of Space 4.0.
The museum shows the connection between technological and scientific developments in space exploration and society. How is mankind helped by space technology? How can we deploy space technology for climate and environment issues? Which new know-how, materials and medicines are offered by space technology?
Space Expo gives these topics a place in society, by developing evocative and educational exhibitions. It does this as visitors centre of ESA-ESTEC and as showroom of the space sector in The Netherlands.
The exhibitions offer experiences, authenticity and relevance. Examples are the Soyuz simulator in which visitors can take a short ride, a real rock from the Moon, a real size replica of two modules of the ISS, the original Soyuz capsule of Dutch astronaut André Kuipers and a temporary exhibition called 'Back from Space', with 100 objects that have been to space. Some of the objects can even be touched.
When visitors know the exhibitions by heart and still want to learn more, they can take the Space Train on weekends and during school holidays for a guided tour behind the scenes of the European Space Agency.
www.space-expo.nl

T-Minus Engineering

Building a new generation of sounding rockets

Research institutes and universities looking to conduct science in the upper atmosphere, need rockets to get their instruments up there. T-Minus Engineering builds sounding rockets that provide a great balance between cost and performance.

The rockets used in the sounding rocket business are commonly leftover military products. These provide a great balance between cost and performance. The massive manufacturing power in the sixties and seventies made these rockets readily available at interesting prices for research. Push the clock half a century forward and they have become outdated and unreliable.
T-Minus Engineering is building the new generation of sounding rockets, starting with the T-Minus DART: a rocket that can bring payloads to 120 km altitude. The payloads are used to measure our upper atmosphere in-situ, which is impossible with techniques other than rockets. With these measurements, climate forecasting and reliability of radio communication can be improved.
Our customers, the research institutes and universities using sounding rockets, are always looking for a better way to do their science. We at T-Minus can accommodate the scientist from the design of a custom rocket or payload, to launching it at one of the world's sounding rocket ranges.
In the province of Zuid-Holland, the epicentre of space in the Netherlands, we have our office and workshop where we design and build our rockets. Every part, from graphite nozzles, aluminium body parts, launch infrastructure to flight electronics, is designed and built here. In our yet to be opened facility in Deventer, we will be able to produce our own rocket propellant. Paving the way for new products, always aiming higher and better.

www.t-minus.nl

Terma BV

Building test software for spacecraft

Artist's impression - The JUICE spacecraft at Jupiter (launch 2022). [ESA]

Every spacecraft that is looking to leave Earth's atmosphere must be rigorously tested. Terma builds software tools manufacturers use to test their spacecraft. The international company – headquartered in Denmark with offices worldwide including the Netherlands and Germany – also builds flight hardware and provides specialist support.

Terma has been present in The Netherlands for nearly 40 years. We started by providing specialist consultants to ESA-ESTEC and have expanded into different areas within The Netherlands, but are also active in Germany and Denmark.
Today, there are 50 space industry professionals, mostly engineers, working at Terma. We are active in many of the new space programmes, ranging from the latest ESA scientific missions such as JUICE (JUpiter ICy moons Explorer) to the newer very commercial programmes such as the OneWeb megaconstellation.

Testing spacecraft

The first main activity today in our Dutch office is spacecraft checkout and control systems. This is a tool which allows spacecraft manufacturers to test their spacecraft under close to true operational conditions prior to the launch. These systems make a significant contribution to the reliability of space missions today.
Today, much of the work is based on the software products we have developed, namely TSC and CCS5 (see **ccs.terma.com**). This product is being used in the OneWeb programme, where it will be testing up to sixty satellites in parallel at the main production line in Florida. Our products are also in use in many other missions such as MetOp-SG, JUICE, Euclid, Quantum, ENMAP, EDRS and Electra, to name but a few. These missions cover scientific, Earth observation and telecommunication purposes. We also provide spacecraft control systems for satellite operations.
The second main activity is to provide specialist services to ESA-ESTEC – ranging from highly specialist engineers to IT service teams.

Artist's impression of one of the 900 OneWeb Satellites. [OneWeb]

An international company

Terma B.V. is part of the larger Terma Group. Space activities are also performed in Denmark and Germany. We have developed the ASIM experiment which was recently – on April 2nd 2018 – launched on a Falcon 9. ASIM, for which Terma was the industrial prime contractor, is a climate research instrument that attaches to the outside of the International Space Station.
In Denmark we make flight hardware, such as power electronics for spacecraft, star trackers and remote terminal units. We also develop flight software.
In Germany, we make spacecraft control systems, spacecraft simulators and provide specialist support in areas such as flight dynamics to help spacecraft navigate to their correct destinations.
We have an excellent reputation for quality and innovation in all the areas in which we work today. Terma Group has a total of 180 people working in space.

www.terma.com

TNO

Fighting climate change, one optic at a time

TROPOMI, optical bench.

It's no wonder that the country where the microscope and the telescope were first invented is a big contributor to international space projects. Many telescopes use Dutch optics, as does ESA's Earth observation programme. Many of these technologies come from TNO, the Netherlands Organisation for Applied Scientific Research.

TNO is an organisation that, in its own words, stimulates innovations that can accelerate the work of Dutch companies. The organisation operates in a lot of industries, ranging from the medical to the maritime sector, but also the space sector. In cooperation with many different companies, TNO's technologies can be found on prominent satellites used for Earth observation (Sentinel) and exploration of the universe (GAIA).

Big in space

The Netherlands has always been an important player in the European space industry, being one of the founding members of ESA and providing a home for ESA's test centre ESTEC. This has led to the rise of a high-tech innovative space industry that makes important contributions to the European and international space programmes. Many of these innovations can trace their origin to TNO.

TNO's work in space revolves around a couple of fundamentals, says Kees Buijsrogge, director of space and scientific instrumentation within the organisation. The exploration of the universe as a fundamental science is important, but TNO also focuses on sciences closer to home. Analysing and combating climate change is an important aspect of their work, Buijsrogge says – perhaps the most important. Instruments designed and built by TNO map air pollution in high detail, which is obviously beneficial to the whole planet. "Fighting climate change starts with actually seeing and understanding it," Buijsrogge says. "The instruments we make with companies like Airbus and institutions such as SRON and KNMI can help policymakers fight pollution. We make it visible for them."

Besides climate change research, TNO increasingly focuses on making secure broadband connectivity happen. Buijsrogge: "The Internet of Things is becoming a big part of our lives, everything and everyone is getting connected. We do research and product development for laser satellite communication to communicate over higher speeds, and do it securely."

Strengthening the position of Dutch industry

All these research pillars have a more general goal that TNO wants to achieve, which is job growth for the country. "When we design an instrument that needs to be produced in large quantities, we don't do it ourselves," Buijsrogge explains. "Rather, the organisation tries to position Dutch companies for the manufacturing and selling."

It's difficult to say just how much economic benefit the Netherlands gain from TNO's work – there are too many variables to derive an actual figure – but Buijsrogge says there are plenty of examples that show TNO's value. Recently, the Enabling Technologies Group of the Eindhoven-based VDL was awarded a multimillion euro contract to make components for ESO's Extremely Large Telescope (ELT). The components were developed by TNO (with help from NOVA), which VDL will now mass-produce. "The key is to connect companies to international partners so that they can do their work optimally," Buijsrogge says. "That's something we're really proud of, and something we emphasise more and more in our space strategy."

This is what a small country like the Netherlands is good at, Buijsrogge says. Famous for its 'polder model', the country has the ability to bring together many parties to make one well-built end-product. "For instance, scientists from meteorological institutes indicate what

GAIA, Basic Angle Monitoring (BAM) system.

they need, and we try to connect them to the industry."

"As far back as the design process, we try to hook up businesses that might build and sell the products we design. That way, our work has maximum economic impact," Buijsrogge says.

Understanding the universe

In some cases, these principles come together. Buijsrogge: "We've been working in astronomy for years, which has given us plenty of practical knowledge on using laser technology to look through the atmosphere." He refers to instruments TNO has built that are used on the ELT or other telescopes. "Such knowledge is very useful for developing secure satellite communications."

Overall though, it's not just organisational capabilities that make TNO so vital for the Dutch space industry. Optics are the key to the work TNO does in regard to space sciences. Around 80 per cent of the work at TNO revolves around optics and photonics, fields that originated in the Netherlands.

Perhaps the most famous examples of these are the OMI and the improved TROPOMI instruments for ESA's Earth observation programme Copernicus. TROPOMI is currently operating on the Sentinel 5 satellite, measuring nitrogen dioxide in the atmosphere with a resolution of 7x3,5 km – a range that can pinpoint the levels of pollution on a city-wide scale.

In recent years, TNO has invested heavily in a facility for the realisation of optical components. "There weren't really any places where we could find such components, so we decided we wanted to keep and improve the ability to make those ourselves," Buijsrogge explains.

Commercial market needs

In the future, Buijsrogge sees huge potential for a commercial space industry, an industry which doesn't rely on the European Space Agency for its primary funding. "It's healthy for the industry to look beyond institutional funding."

It's a logical step, he thinks, because the scale of space-related applications is expanding. "That's something we haven't seen in the Netherlands before, there's a big opportunity there."

That doesn't mean ESA will be phased out or even have a diminishing role, Buijsrogge says. In fact, these classic models will exist in the future as well, with ESA funding the first preliminary research. "The difference is that subsequently commercial enterprises can take over development for applications like satellite communications," Buijsrogge says.

Not only is commercialisation a smart move economically, it's also a necessary one. Buijsrogge: "If we as TNO want to remain a significant player in the international market, we also need to take into account the commercial market needs as well as the institutional world of ESA and other similar bodies."

www.tno.nl/en/focus-areas/industry/roadmaps/space-scientific-instrumentation/

TROPOMI, optical bench.

The Netherlands Space Society (NVR) was founded in 1951. Its goal is to inform people who are interested in space about space research and technology, and to connect them to each other. Till this day our motto is:

The NVR aims to promote the knowledge of and interest in space, in the broadest way possible.

The NVR focusses on people who are involved in space because of their profession, students of space related studies as well as members of the general public who are interested in space. The organisation offers its members and stakeholders a platform for information, communication and activities. The NVR represents its members and aims to be a respected party in discussions about space regarding policies, research, education and the industry. Not just in the Netherlands but also internationally. For this reason the NVR has been part of the International Astronautical Federation since 1951. The NVR also forms strategic alliances with sister associations (such as the British Interplanetary Society) and other interested parties.

Members of the NVR regularly receive newsletters and mailings informing them about activities that are being organised, such as lectures and symposia. All members receive the quarterly magazine 'Ruimtevaart'. The magazine focusses on background information regarding current and future space projects, and also gives updates on developments in space research and technology. Articles give special attention to Dutch involvement in projects as much as possible.

Most of the authors affiliated with 'Ruimtevaart' are involved with Dutch space activities, and many of them are scientists, engineers or end users.

An individual membership of the NVR costs € 35,00 a year. Students can apply for a free membership, which comes with an electronic subscription to the magazine. For more information about individual memberships and corporate memberships, please visit our website at www.ruimtevaart-nvr.nl.

www.ruimtevaart-nvr.nl

NVR

NETHERLANDS SPACE SOCIETY