COVERSTORY

SES (Société Européenne des Satellites), based in Betzdorf, Luxembourg, was created in 1985 and has become a major player in the development of space technologies and satellite broadcasting.

Photo: SES

SPACE ECONOMY

LUXEMBOURG IN THE CONQUEST OF SPACE

Since the launch of the SpaceResources.lu initiative in 2016, which aims to provide a favourable environment for businesses by offering solutions for the commercial exploration and use of space resources, Luxembourg has become fertile ground for new international space companies with no end of *savoir-faire* and a multitude of technologies, spurred on by the conquest of space. The companies established here believe Luxembourg has all the necessary ingredients to become a global centre of the space economy during the next decade.

Text: Marie-Hélène Trouillez
Translation from French: Martin Davies

Luxembourg launched its space adventure in 1985 by planting its flag in space with the *Société Européenne des Satellites* (SES), now the world's leading satellite operator. This successful gamble has made it possible to develop an entire industry around this major player in the Luxembourg spacescape. Whilst the creation of SES was the first small step in Luxembourg's history in space, the country's accession to the European Space Agency (ESA) was a giant leap in its evolution in space. Following fruitful collaboration with ESA as a cooperating member in the telecommunications programme, Luxembourg became a full ESA Member State in 2005, thus laying the foundations for the participation of companies from the Grand Duchy in ESA's R & D and space exploration projects. Today, the Grand Duchy is again reaching for the stars. Since the creation of a legal framework for the exploration and use of space resources was announced in 2017, numerous companies and players in the sector have launched businesses in ▶

Photo: Boeing

01.

Asteroid Day

Founded in December 2014 by Queen's guitarist Dr Brian May, US astronaut Rusty Schweickart, the President of the California based B612 Foundation Danica Remy, and filmmaker Grig Richters, Asteroid Day gained visibility when in 2016, the UN decided to make it an international day to raise awareness and educate the public about asteroids and how to prevent collision with the Earth. Asteroid Day is held every year on 30 June, commemorating the 1908 explosion of an asteroid above Tunguska in Siberia. Having been chosen as the official seat of the Asteroid Foundation, Luxembourg now plays a leading role in Asteroid Day. In June 2017, more than 700 events involving astrophysicists, astronomers and space agencies took place simultaneously in 190 countries, with a live broadcast from Luxembourg. Asteroid Day is supported and funded by the Government and industrial partners, including SES, OHB and ECB. BIL, the Chamber of Commerce, SNCI, GLAE, and the B612 Foundation also support the initiative.

www.asteroidday.org

Luxembourg. In just two years, some fifteen international space companies have chosen to touch down in Luxembourg.

In September 2018, the Government of Luxembourg took a new step by setting up a national space agency, the *Luxembourg Space Agency* (LSA), whose main objective is to support the development of the space industry. The agency also manages SpaceResources.lu, develops skills needed by the space industry and has implemented financial solutions to meet the needs of this emerging sector. More recently, on 22 May 2019, Luxembourg announced the creation of the LSA Data Centre to help Luxembourg companies gain access to space data. Thus, in the European pioneering spirit, Luxembourg is determined to capitalize on its potential in the aerospace sector and has the 'stellar' ambition of becoming a welcoming haven for international companies wanting to develop space-based commercial activities.

A LEGAL FRAMEWORK FOR RISING STARS

Following the 2016 launch of the SpaceResources.lu initiative, Luxembourg's desire to develop a space sector culminated with a vote on 20 July 2017 on a law dedicated to the exploration and use of space resources, particularly through private entrepreneurship. In force since 1 August 2017, this law was passed with a large majority and is, therefore, considered by the Luxembourg Minister of the Economy as '*strong political support for the SpaceResources.lu initiative and a strong signal for companies and investors active in this sector*.'

Following the example of the United States, which

Photo: SpaceX

02.

adopted the Space Act in 2015 – a law allowing the exploration and commercial exploitation of space resources – the Grand Duchy became the first European country to set up a legal framework that guarantees private operators working in the space sector the ownership of resources extracted in space. It also regulates the accreditation and monitoring of exploration missions and the use of space resources. This legal framework is one of the main pillars of the Government's strategy under the SpaceResources.lu initiative to develop the exploration and spatial resources sector. Indeed, Deputy Prime Minister and Minister of the Economy Etienne Schneider said in a statement from the ministry, '*as the first country in Europe to put in place a legal framework for activities relating to the use of space resources, Luxembourg confirms its position as a pioneer and European* ▶

01. The first ASTRA 1A satellite was launched in December 1988. The ASTRA 1 satellites are receivable in Europe from the orbital position of 19.2 degrees east thanks to a satellite dish at least 60cm in diameter. Continuing to expand, SES is one of Europe's leading telecommunications satellite operators with a global presence.
02. The Luxembourg satellite GovSat-1, which took off from Cape Canaveral, Florida on 31 January 2018 aboard a SpaceX Falcon 9 rocket, has been in operational service since March 2018. It provides advanced and highly secure communications capabilities for government and institutional users. Gov-Sat 1 is the first satellite of GovSat, a public-private partnership between the Luxembourg government and SES, the world's leading satellite operator.

INTERVIEW

ÉTIENNE SCHNEIDER
Deputy Prime Minister, Minister of the Economy

"It is important to be ambitious in the field of space development"

Why set-up a legal framework for space resources in Luxembourg?
The space industry is undergoing an extraordinary evolution. As national budgets tighten, governments are increasingly seeking to involve the private sector in all aspects of space transportation and exploration, which private companies are keen to do as the commercial imperative transforms the economics of space. Greater competition and ongoing scientific discovery will lower the cost of space exploration still further. Some of today's international space laws were drawn up long ago, well before the prospect of harnessing space resources had become a realistic option. The idea of using space resources was already around when the 1967 Outer Space Treaty was concluded. The treaty bans countries from appropriating celestial, outer space bodies, including the Moon. However, no international legislation so far has set rules about ownership of metals, minerals and other resources that may be found there. This legal uncertainty now needs clarification. Investors, companies and their customers rightfully expect certainty if they are to commit significant resources – human, material and financial – to long-term projects. Luxembourg is the first European country ,and the second country worldwide after the United States, to offer a legal framework that secures property rights for space resources. As more countries develop their own legal framework, Luxembourg is ready to join international efforts to harmonise global rules for the peaceful exploration and utilisation of space resources. Luxembourg is also enhancing cooperation with other countries, which will enable us to identify and discuss our common interests in the exploration and use of space resources.

Do you maintain your forecasts for increasing the space sector from 1.8% to 5% of Luxembourg's GDP over the next decade?
It is important to be ambitious in the field of space development. The space sector today already accounts for almost 2% of our GDP, one of the highest rates in Europe. I am confident that Luxembourg has the potential to double this rate in the future. Just look at all the changes over the last two decades, since the year 2000, following the involvement of American entrepreneurs like Musk, Bezos, etc., the space industry has known important developments. While these commercial developments in the space industry captured the attention of the American public, they have not always been as visible in Europe. Besides the US, we should not forget that NewSpace is happening all around the world, i.e. Japan, as well as China and India. Europe has all the ingredients needed: skills and talent, funding and R&D, but what Europe needs to do is stay competitive and use these ingredients to the fullest. We can't afford to be too slow, otherwise we will miss out on various opportunities.

Photo : Ravil Sayfullin/123RF.com

03. The idea of exploiting space mining resources is to use these raw materials directly in space, in order to limit the current costs of putting them into orbit. Once the material supply chain is in orbit, it will be possible to develop new services for earthlings.
04. The launch of the Luxembourg Space Agency (LSA) was announced to the press on 12 September 2018 in front of a full house, including many prominent authorities.

03.

leader in a sector with strong development potential.' Going back in time a bit … several United Nations treaties and principles relating to outer space set the international legal framework as early as the 1960s. In 1967, the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, known as the Outer Space Treaty (OST), was ratified by many countries. Twelve years later, in 1979, the *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies* – the 'Moon Agreement' – was adopted, but neither Luxembourg nor any of the major powers involved in space ratified it. Since then, Luxembourg's initiatives in the space industry have multiplied. Georges Schmit, who was Consul General in the United States from 2009 to 2016, identified an opportunity and informed Minister Schneider. He, in turn, recognised the potential that exploration and the use of space resources held, particularly for the diversification of the national economy. Created with the aim of developing Luxembourg's private space sector and welcoming companies operating in this field, the SpaceResources.lu initiative developed from there. In the light of scientific and technological progress, the Luxembourg Government naturally expressed its desire to update the applicable legal framework so that it remains in step with this emerging potential.

Since the law came into force, operators wishing to explore and use space resources for commercial purposes must obtain a permit, granted on a personal and non-transferable basis, for specific missions, by the Minister(s) responsible for the economy and space activities. At the same time, Luxembourg is deepening international cooperation in the space sector to provide a basis for increased collaboration in a wide range of space activities, including research, exploration, defence and the exploitation of space resources.

To date, Luxembourg has signed bilateral agreements in the space sector with eight countries: the United States, the United Arab Emirates, Japan, China, the Czech Republic, Portugal, Poland, and Belgium.

BUT WHAT THE DEVIL ARE THEY GOING TO DO ON THE MOON AND THE ASTEROIDS?

Earth's mining industry remains active, but the planet's reserves are being exhausted and it is more

Photo: LSA

04.

NewSpace Europe returns

Organised by the Luxembourg Space Agency, NewSpace Europe is the only annual conference in Europe to focus exclusively on the NewSpace industry and emerging opportunities related to the space sector. Leaders of large space groups, entrepreneurs, investors and government agency representatives are meeting in Luxembourg to explore how the space industry can generate economic growth and advance the commercial space industry. The NewSpace Europe 2019 conference will be held on 13 and 14 November at the European Convention Center Luxembourg (ECCL) and will be dedicated to the theme 'Driving Momentum'. Lunar economy, investments and opportunities to stimulate the growth of communications will be discussed at the conference.

www.newspace-europe.lu

and more complicated to extract materials that are no longer in a concentrated form, but which are scattered around in rock, sand, or in the depths of the oceans. As a result, extraction techniques have become more and more invasive and are ravaging ecosystems. The consumption of raw materials such as biomass, fossil fuels, metals and non-metallic ores aggravates the pollution of air, water, and soil, and contributes significantly to climate change. The exploitation of these deposits may have developed strongly during the industrial revolution, but it has exploded in recent years and it is clear that, today, we are consuming the Earth's natural resources faster than they can ever be regenerated.

According to the OECD's 'Global Material Resources Outlook to 2060', the global use of raw materials is expected to double by 2060, accompanying an expansion of the global economy and a rise in living standards. The study also '*sees global materials use rising to 167 gigatonnes in 2060 from 90 gigatonnes today as the world population soars to 10 billion people and average global income per capita rises to converge with the current OECD level of USD 40,000.*' Other studies suggest that elements such as lead, zinc, tin and phosphorus, not to mention gold, will be depleted in 50 years. Prized by the digital, energy, automotive and even aerospace-defence industries, strategic metals (chrome, tin, nickel, cobalt ...) are increasingly coveted. The dependence of many industries on these metals has provoked several successive crises, consequences of a geo-strategic context causing tensions in certain markets: rare earth elements, cobalt, aluminium. In this context, although the extraction of asteroid minerals is not easy, it offers the prospect of new large-scale deposits of minerals and metals so essential to us earthlings.

In an interview with the online magazine Slate, the astrophysicist, Francis Rocard, notes that in 5% of metallic meteorites found on Earth, we find about 90% iron and 10% nickel, as well as traces of iridium, chromium, cobalt and gallium: '*The rare pearl would be an atypical metallic asteroid containing these trace elements in large quantities, the only ones potentially to have a commercial interest. But we must recognize that, for the moment, no one has been able to prove it exists.*' Rocard, however, is more confident about the hypothesis of extracting water. Hydrogen and oxygen could be decomposed, to be used as fuel to supply rockets or to maintain a breathable atmosphere in space. In liquid form, it could serve as ▶

Photo: LSA

05.

drinking water. It may thus be possible to create a real network of 'service stations' in space and to maintain bases on the Moon or on host asteroids which would allow significant savings. Two billion tons of water could be available on so-called 'near earth objects' (NEOs), that is those which regularly cross the Earth's orbit.

Minerals, metals and gases on the Moon, asteroids and other NEOs could therefore be exploited to be used directly in space, as a source of energy, or to build rockets, satellites and other equipment beyond Earth's atmosphere. Some could be brought back to Earth to meet the economic needs of a growing population.

Currently, the space industry is being held back by the astronomic cost of launching equipment and supplies into orbit. Because of these costs, estimated at several million dollars per tonne, the number of satellites that can be launched is limited. As a result, commercial activity related to space has slowed down. The idea of exploiting resources mined in space is to provide raw materials that could be used directly in space. Large quantities of raw materials at a relatively low operating cost would make current satellites more efficient and less expensive. Satellite operators would be able to improve services to their customers on Earth.

Once a supply chain for materials is established in orbit, new applications and business models would be encouraged, while entrepreneurs would be able to expand the services offered on Earth. The possibilities are truly limitless!

These new ambitions in space exploration could open new possibilities for resources and opportunities to build prosperity-generating economies beyond what we know on Earth today, and to enable humans to become an interplanetary species.

PUBLIC ORGANISATIONS AT THE SERVICE OF PRIVATISATION IN AEROSPACE RESEARCH

If, historically, investors have been mainly the large public agencies (NASA, ESA, etc.) due to the ambitious nature of the programmes, it is essential today to open the market to private investors and companies by providing a favourable playing field and communicating the advantages of Luxembourg. In 2018, as part

Photo: MECO

06.

05. From left to right: Stéphane Pallage, Rector of the University of Luxembourg Yves Elsen, Chair of the University's Governing Council; Etienne Schneider, Deputy Prime Minister, Minister of the Economy of Luxembourg; and Marc Serres, CEO of the Luxembourg Space Agency, at the official launch of the agency.
06. On 10 May 2019, a Memorandum of Understanding (MoU) on Space Cooperation between the United States and Luxembourg was signed by Wilbur Ross, US Secretary of Commerce (left) and Etienne Schneider, Deputy Prime Minister, Minister of the Economy of Luxembourg. The goal is to facilitate and strengthen collaboration by identifying projects of common interest to both governments, research institutes and space companies in the private sector. To date, Luxembourg has signed bilateral agreements in the field of space with eight countries.

of the NewSpace Europe conference, which brought together people from the space sector in Kirchberg, Nicolas Chamussy, Vice President of Space Systems, Airbus Defence and Space declared, '*the actors who will be able to finance themselves will be able to survive. (…) Europeans need to continue to reinvent themselves, through an industry that will combine public and private funding. We need to combine a new funding approach that will take into account risks.*'

To enable space industry players to develop and be associated with international networks, specialised structures have been made available to businesses and research centres. Thus, the Luxembourgish Group of Aeronautics and Space (GLAE) was founded in 2005. As a direct result of Luxembourg's accession to the European Space Agency (ESA), GLAE acted as interlocutor with the Government on all matters relating to the authorities' initiatives in ESA programmes and the formulation of space policy in the Grand Duchy of Luxembourg. It operates under the auspices of FEDIL – The Voice of the Luxembourg Industry, in order to facilitate exchanges between companies and research centres active in aerospace and to help its members forge links between themselves. Other national research institutions such as the University of Luxembourg and the Luxembourg Institute of Science and Technology (LIST) have developed a close partnership with the business world to increase the relevance and effectiveness of technological developments. Thus, in 2019, the Japanese company ispace, which has been in Luxembourg since the beginning of 2017, and LIST established a strategic partnership to develop a first mission, called the Roving Spectrometer Program, to explore lunar resources, including detecting and analysing water. The stakes are high and half a dozen researchers are funded by a grant of EUR 500,000 from the National Research Fund (FNR). From 2020, a first ispace shuttle will be launched to the Moon, with a moon landing scheduled for 2021.

WHO ARE THE COMPANIES ACTIVE IN THE LUXEMBOURG SPACE SECTOR?

In the early 1980s, the Grand Duchy of Luxembourg took a step forward by focusing on the potential of the satellite industry. This success has encouraged the first concentrated wave of dynamic compa- ▶

07.

Photo: Max Alexander

LuxCube

The University of Luxembourg's LuxCube satellite project allows students to enter the interdisciplinary field of space exploration by developing a mini cube satellite. LuxCube highlights the collective work of students from different fields of study, researchers, professors and members of the aerospace industry, in collaboration with two satellite companies, Planet (USA) and Gomspace (DK/SE). The objective of the project is to learn how to design, programme, build, test and operate a specialised aerospace machine. Created in 1999, the 'CubeSat' satellites have a compact size of 10 cm^3 and weigh 1.33 kg. The LuxCube will be put into orbit in 2021 with the mission of recording images of the Earth and Luxembourg in particular, and will communicate measurement data taken from space. In addition, Luxembourg will host the 11th European CubeSat Symposium on 11–13 September 2019, organised by the Luxembourg Space Agency and the University of Luxembourg, in partnership with the Von Karman Institute. The aim of the symposium is to present trends, innovations and feedback in the areas of CubeSats.

https://luxcube.uni.lu and *www.cubesatsymposium.eu*

nies in the aerospace sector in Luxembourg: Euro-Composites, Gradel, Hitec, Luxspace … to name a few. With the establishment of a legal framework, the number of companies and players in the sector who have chosen to set up in Luxembourg continues to grow, forming a veritable Luxembourg ecosystem of space technologies.

In order to give a global and in-depth overview of the Luxembourg space sector ecosystem, the Luxembourg Space Agency published the LSA Space Directory in May 2019. The document lists the different research organisations and space companies present in Luxembourg, as well as their main activities, and the type of products and services they offer in major space projects.

The Grand Duchy currently has about 50 companies and research laboratories active in the space sector, employing more than 800 people.

Three segments are clearly identified:

- the space segment, focused on the manufacture of satellites and instruments, the integration of micro-satellites and electrical propulsion systems, robotics, space manufacturing and composite materials;
- the terrestrial segment, focused on the development of ground stations, ground assets (fixed and mobile equipment, software and various tools required for assembly, integration, testing, control and investigation activities, which are not intended to fly) mechanical and electrical integration of satellites and communication networks;
- the services segment, including satellite communication services, teleports, risk management and maritime surveillance services.

LUXEMBOURG SPACE AGENCY (LSA)

The Luxembourg Space Agency (LSA) was put into orbit on 12 September 2018 with the aim of promoting the economic development of the Grand Duchy's space industry by attracting businesses, developing human resources, providing innovative financial solutions and by supporting educational and research infrastructures. To carry out this mission, the LSA started with a dozen employees. The agency has a budget of EUR 30 million for research and development (R & D) projects.

Unlike some of its foreign counterparts, the agency's task is essentially economic, and it does not directly undertake research or launch missions, but it encourages collaboration between key play-

Photo: ispace

08.

ers in the space industry, with the essential mission of accelerating the emergence of innovative companies.

According to one LSA study, the use of space resources should generate a global turnover of EUR 73 to 170 billion between 2018 and 2045, whilst contributing to employment. The study puts the figure at 845,000 to 1.8 million full-time jobs created. As for technological and knowledge-related spillovers, such as materials science, manufacturing, additive manufacturing, robotics and data analysis, they could be in the order of EUR 2.5 billion over 50 years. At the same time, the costs associated with the development of this industry are expected to decrease by EUR 54 to 135 billion with technological developments. Finally, the study believes that space exploration and exploitation should contribute to the preservation of the environment by reducing dependence on the Earth's limited resources.

The LSA brings together the former Directorate of Space Affairs from the Ministry of Economy and the Luxinnovation space affairs team, notably in charge of the former Space Cluster. Luxinnovation is an integral part of the Ministry of Economy. It operates through systems of partnership with the main national organisations and communities in academia, research, and business, and with other public institutions within Luxembourg's vast ecosystem of public and private sector stakeholders. To date, twelve partners have signed agreements with the LSA (ADEM, Chamber of Commerce, Luxembourg Group of Aeronautics and Space (GLAE), Institute of Intellectual Property Luxembourg (IPIL), Luxembourg Science Centre (LSC), Luxembourg Space Tech Angels (LSTA), Luxinnovation, National Research Fund (FNR), SES, National Credit and Investment Company (SNCI), Technoport and University of Luxembourg). '*Luxembourg is ready to welcome, support and help the development of space industry players who can move forward together. The deepening and expansion of Luxembourg's space sector is a priority for the country's future. The LSA will carry out its mission through a network of national partners that will provide it with the skills, expertise and capabilities needed to meet the needs of commercial space contractors. This strategy based on multi-stakeholder partnerships aims to create an attractive and buoyant ecosystem for the growth and development of space companies*,' said Marc Serres, CEO of the LSA at a press conference announcing the launch of the space agency. ▶

07. Although this is only the third time it has taken part, in 2019 Luxembourg is playing a leading role in Asteroid Day. Hosted in Luxembourg, the Asteroid Foundation organises a series of events broadcast live on www.asteroidday.org.
Photo: Astronaut Dorin Prunariu surrounded by children live from the Broadcasting Center Europe (ECB) at RTL-City in Kirchberg in 2018.
08. The third company to have set up activities in Luxembourg as part of the SpaceResources.lu initiative, the Japanese company, ispace, is specialised in the development of robotic technology for space applications.

Photo: Lala La Photo / Maison Moderne

INTERVIEW
JULIEN-ALEXANDRE LAMAMY
Managing director, ispace Europe

> **Thanks to SpaceResources.lu, Luxembourg has emerged as a key player**

How did your adventure with ispace start?
In July of 1997, I watched the landing of the Pathfinder mission and the first rover explore the red rocks of Mars. At that moment, I knew my future lay in the exploration of the space frontier. My journey took me to the NASA's Jet Propulsion Laboratory (JPL) – the team that had launched Pathfinder – where I worked on missions such as the Mars Phoenix Lander, which confirmed the presence of water at the Martian Poles. After 10 years at JPL and later Orbital ATK, I was eager to join the NewSpace movement and contribute to a startup with a compelling vision. This I found in ispace: a bold vision to unlock the resources available on the Moon and enable a new space economy, which will eventually lead to the creation of a new city on the Moon. This will start with small landers and rovers exploring the lunar landscape and confirming the presence of water at the poles – only this time on the Moon, and with startups like ispace leading the way.

Why did you choose to settle in Luxembourg?
The NewSpace movement is growing worldwide. Thanks to SpaceResources.lu, Luxembourg has emerged as a key player and ispace made the strategic decision to locate its European headquarters here two years ago. My family and I relocated from the US and we are now happily settled in Differdange – more red rocks. At our office, people have relocated from as far as Australia, South Africa, and Japan; all are thrilled to be living and working here as pioneers in the exploration of space resources.

What are your projects for ispace Europe?
In two years, the office has grown from 1 to 18 employees, and we have expertise in fields as diverse as lunar geology, space robotics, mine planning, and data engineering. Our unique team is focused on developing the critical technologies needed to find and utilise space resources. To achieve these goals, we have built strategic partnerships. We are developing new rover navigation systems with the University of Luxembourg. To test our solutions, we worked with Paul Wurth InCub to build the first "lunar yard" in Luxembourg. We support the Luxembourg Institute of Science and Technology (LIST) in adapting mass spectrometers for space. And we look forward to adding our lunar datasets to Luxembourg's Space Data Center. All this is happening now. And it's happening in Luxembourg.

Photo: Euro-Composites

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For more than three decades, Luxembourg has pioneered the commercial and cooperative initiatives that have shaped a dynamic space economy that now accounts for 1.8% of the GDP, one of the highest ratios in Europe, and which Luxembourg aims to increase!

STRENGTHENING ESA-LSA RELATIONS

While the Law on Space Resources and the Government supported SpaceResources.lu's initiative aimed to create an atmosphere conducive to attracting investors and companies from various sectors, other actions have also been implemented in the region aiming to develop space expertise skills. To this end, Luxembourg has strengthened its collaboration with ESA in an increasingly wide range of programmes ranging from telecommunications to Earth observation (Copernicus programme) and navigation (Galileo and EGNOS programmes), to name but a few.

In addition to participating in ESA's general programmes, Luxembourg has implemented a national programme, LuxIMPULSE, managed by ESA. This programme makes it possible to effectively develop new skills in the space sector. Thus, participants benefit from ESA's technical expertise, and from its experience in the administrative and contractual management of space projects.

Every year, the Luxembourgish Young Graduate Trainee (LuxYGT) programme offers young Luxem-

09. Present in Luxembourg since 1984, Euro-Composites is strongly focused on research and innovation and will invest EUR 160 million on its Luxembourg site over the next 10 years to remain a leader in the competitive aviation and aerospace markets. Space exploration attracts startups, but also presents a growing opportunity for established industrial companies that master advanced technologies..

10. The University of Luxembourg has announced the launch, in September 2019, of an interdisciplinary master's programme in the field of space, for a period of two years. This training, developed in collaboration with the Luxembourg Space Agency, aims to provide students with the necessary skills in engineering, entrepreneurship and project management to work in this booming new sector.

Photo: alphaspirit/123RF.com

10.

bourg graduates who have obtained their Bachelor's or Master's degree in the previous two years the opportunity to obtain a first professional experience in the aerospace sector by working at ESA for one to two years. The monthly remuneration is approximately EUR 2,400, exempt from taxes. This is a first-class initiative to train future recruits for space companies.

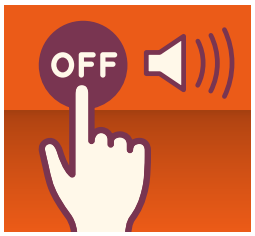
Finally, at the beginning of 2017, four partners – the Government of the Grand Duchy, FEDIL, the Chamber of Commerce and Luxinnovation – initiated HelloFuture, a project that aims to promote the professions of industry and technology to students with a strong focus on aerospace professions.

In addition to these approaches, bilateral or multilateral collaborations have been set up, notably with the National Centre for Space Studies (CNES) in France, the German Aerospace Centre (Deutsches Zentrum für Luft- und Raumfahrt, DLR) in Germany, and NASA in the United States, to make a targeted contribution to attaining the objectives set by strengthening Luxembourg's role on the international space scene.

A MASTER'S DEDICATED TO BUSINESS AND TO SPACE TECHNOLOGY

In the autumn of 2019, the University of Luxembourg will launch a master's degree entitled Interdisciplinary Space Master (ISM), for which the government will disburse more than EUR 4 million by 2021. The vocation of this original interdisciplinary master's is not only to train highly skilled specialists, but to enable them to become space entrepreneurs. Developed in collaboration with the LSA, which co-finances the programme, this new master's degree aims to provide students holding a scientific or technical degree with additional engineering skills suitable for supporting Luxembourg's space industry, and to bring in-depth knowledge to managing commercial activities related to space. Luxembourg intends to lead a unique space strategy focused on creating an attractive and growing ecosystem for space age actors, also known as NewSpace. Tonie Van Dam, Vice-Rector for Strategic Projects and Course Director of the Interdisciplinary Space Master (ISM) at the University of Luxembourg underlines that this master's will be aimed at an 'elite' and is confident the master's will arouse interest from local companies. Some companies already support the programme and plan to offer internships. More than 400 jobs should be created in the sector and will be added to the current 800 jobs.

In February 2019, in presenting the new Interdisciplinary Space Master to the press, Minister Etienne Schneider commented, '*the interdisciplinary master dedicated to space strengthens the dynamism of the national sector driven by the SpaceResources.lu initiative as well as the potential and attractiveness of the* ▶



Astronauts on strike

The first strike in the history of space was proclaimed on 28 December 1973 on the Skylab orbiting station that had been launched by NASA, the US Space Agency. The astronauts, having become less effective for some time because of fatigue, could no longer keep up with the work schedule imposed on them. NASA had imposed 18 hour workdays on them to recover lost time and carry out all planned experiments. The crew reacted by cutting off all communication with Earth for 24 hours to get some rest. As a result of this incident, a large-scale psychological study on stress was conducted and its findings are still considered essential for the success of any space mission.

Space Resources Week

Space Resources Week will be held for the first time from 7 to 11 October 2019 in Luxembourg. Organised by the Luxembourg Space Agency with the support of numerous national and international partners, the event, exclusively for professionals and experts, will offer a week of theme-based days dedicated to space resources.

In the programme:
7 and 8 October: Professional course for senior executives organised in collaboration with the International Space University of Strasbourg and the Colorado School of Mines from the United States.
Location: Chamber of Commerce.

9 October: Mining Space Summit organised by the Luxembourg Space Agency with the support of the European Space Agency.
Location: Luxexpo the Box.

10 and 11 October: Technical Workshop on Moon Resources for Space Professionals, 'What next for Space Resources Utilisation?' Organised by the European Space Agency (ESA), with the support of the Luxembourg Space Agency (LSA).
Location: Luxexpo the Box.

Registration required:
www.space-agency.lu

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Photo: Dominique Gaul

space sector. (…) by training qualified specialists with business acumen, the master's programme is part of the Luxembourg Government's objective to become the European hub for NewSpace's activities, especially in the field of exploring space's resources.'

Stéphane Pallage, the rector of the University of Luxembourg, said, '*the master's is aimed at scientists who need additional training to learn about space and about entrepreneurship and project management. This is a profile in huge demand by companies in Luxembourg and globally.*' The course includes an internship in a company in the second semester, and the student is responsible for presenting a thesis on an important topic for the company.

Since then, university professors have been recruited and include lecturers from the University of Luxembourg, but also experts from the International Space University (ISU) in France, the Colorado School of Mines in the United States, the Tokyo University in Sendai, Japan, the German Aeronautics and Astronautics Centre (DLR), SES, LIST, ESA, LSA, and Spire Global, a young American company specialised in the exploitation of small satellites and their data, which in 2017 settled its European headquarters in Luxembourg.

About twenty students are expected for the first entry of 2019, and eventually, this should quickly rise to 40 or 50 students.

A LUXEMBOURG SPACE FUND WITH EUR 100 MILLION

To finance space innovation, the LSA is in the process of establishing, with public and private partners, a venture capital vehicle, which will be set up as a reserved alternative investment fund, and which will receive financial support from the public sector and from private investors. The public-private partnership model can be particularly effective as the state, as a partner, guarantees a certain stability. The base of available capital is widened

Photo: Marie-Hélène Trouillez

12.

and optimised, and it is up to public and institutional investors to target high-potential projects.

The Luxembourg Space Fund targets an initial capital of EUR 100 million. The state remains a minority in the fund and several private partners are expected. The objective of the Luxembourg Space Fund is to provide equity financing for new space companies with innovative vision and technologies. '*The announcement of the creation of the LSA and a dedicated fund in a way completes the process of setting up the Spaceresources.lu initiative*,' Minister Etienne Schneider said in a statement. '*We are now ready to welcome and support the development of space industry players who can progress together*.'

PROMOTING ACCESS TO SPACE DATA: THE MISSION OF THE NEW LSA DATA CENTRE

On 22 May 2019, at the Space Forum 2019, Marc Serres, CEO of the Luxembourg Space Agency, ▶

11. On 22 May 2019, Marc Serres, CEO of the Luxembourg Space Agency (LSA), announced the launch of the LSA Data Centre as part of the Space Forum at the European Convention Centre Luxembourg-Kirchberg.

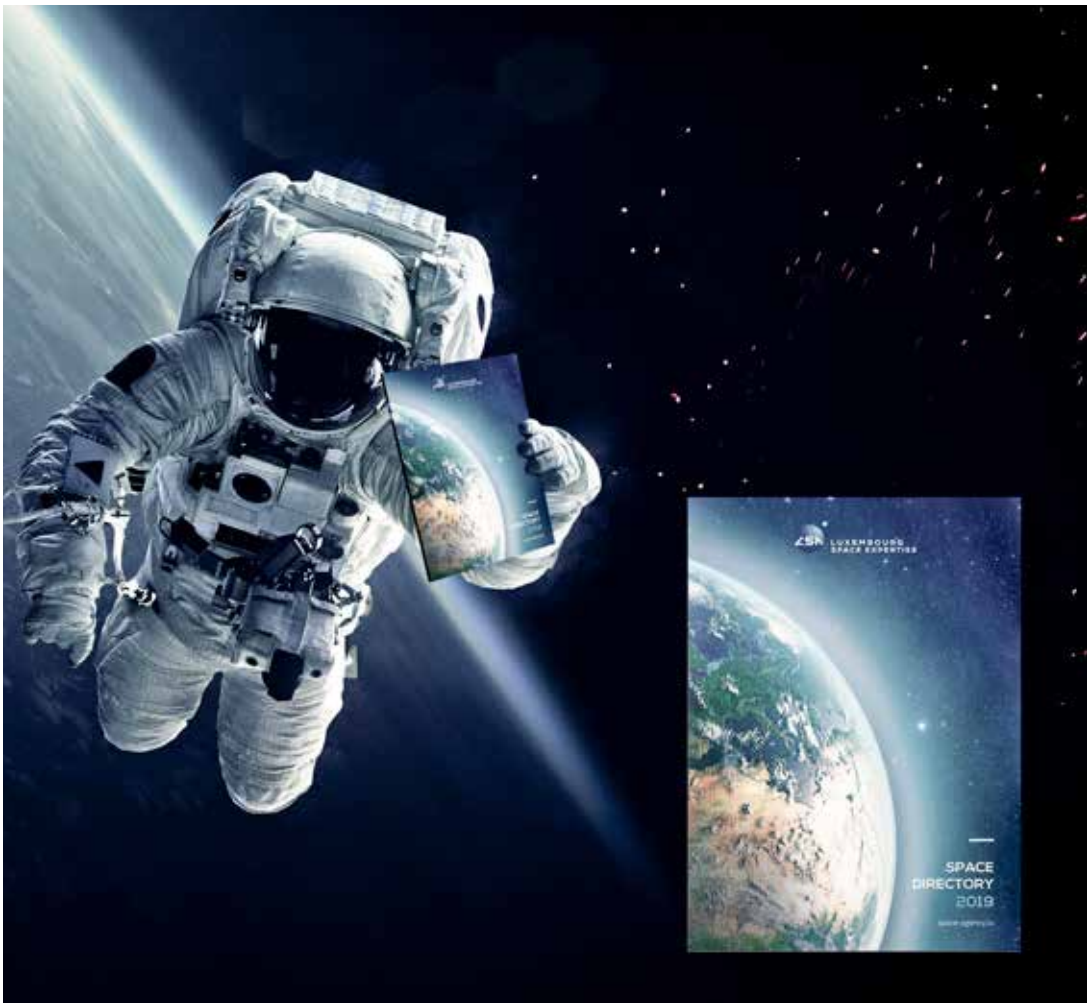
12. The Space Forum took place on 21-22 May 2019 at the European Convention Centre, Luxembourg-Kirchberg. The event brought together space experts, business angels, satellite operators, satellite industry entrepreneurs, etc. Several key topics were discussed at conferences attended by more than 5,000 participants, 70 countries and 500 companies: financing, technology, entrepreneurship, competitiveness, exploration, conquest of space and space mining.

INTERVIEW
MARC SERRES
CEO, Luxembourg Space Agency

"ESA member states appreciate that Luxembourg has a very good business mindset for the space sector"

How do you see the Luxembourg Space Agency develop?
The agency was launched in September 2018 with the goal of developing the national space sector. We are committed to seeing this continue and will make the means available to develop new activities. The LSA fosters new and existing companies, develops human resources, facilitates access to funding and provides support for academic research. The agency is already in the process of further developing its activities as it is now in charge of the implementation of the national space strategy. In addition to this, we also manage national space research and development programmes, and lead the SpaceResources.lu initiative. The LSA also represents Luxembourg within the European Space Agency, as well as the space-related programmes of the European Union and the United Nations. Furthermore, we have started all the necessary preparations for the Space19+ ministerial ESA council later this year. Ministerial councils bring together ESA's member states and observers every two to three years to decide on new proposals and funding for ESA's next years of work. The last one was in 2016. In this context, we are working on the national space strategy and budget for Luxembourg, including further developments for the space agency itself.

How is Luxembourg perceived by other ESA members?
Luxembourg joined ESA in 2005 and has developed an excellent collaboration since then. We are perceived as a reliable partner. Luxembourg decided early on to invest as a priority into the commercial market, starting with telecommunications and also applications. This is why Luxembourg, in the context of programmes such as ARTES, is a key member state. At the end of the '90s, ARTES was the first programme of its kind, created as a consequence of the deregulation of the telecommunications sector. It induced a huge transformation of the industry, and of the agencies that were busy working on telecommunications. Finally, ESA member states appreciate that Luxembourg has a very good business mindset for the space sector. As ESA director, Magali Vaissiere, said during her last visit to Luxembourg: '*Luxembourg is a member state that is very careful about making sure that we set the right environment and the right regulations, so that space businesses can flourish.*'



13.

13. On 5 June 2019, the Luxembourg Space Agency (LSA) announced the publication of the 'LSA 2019 Space Directory', giving a global overview of Luxembourg's space ecosystem.
14. On 26 February 2019, no less than 200 people took part in the sixth 'Space Café' at the headquarters of the International Bank in Luxembourg (BIL). The Space Café, organised by ispace Europe, is a forum open to the general public around the theme of space.

Photo : Chambre de Commerce

announced the creation of an LSA Data Centre to provide users with free access to research and the chance to download a fully indexed and referenced real-time geo-catalogue based on data from the European Copernicus Space Program via images from Sentinel 1 and 2 satellites. The idea is to promote the development of products and services which are based on accurate and constantly updated Earth observation data.

Marc Serres said, '*efficient and easy access to data is essential for companies that want to grow their business. This LSA initiative is only a first step to facilitate access to space data in order to stimulate new services provided by Luxembourg as a hub of the European marketplace.*'

The LSA Data Centre is the result of an extensive programme called 'Access to Space' on which the LSA is currently working. This programme aims to support the emergence of a data-driven economy and accelerate the digital transformation of the many strategic sectors of which the space industry is a part. Detailed optical or radar satellite imagery data has many potential uses, including environmental management, but also for understanding and mitigating the effects of climate change, or for civil security. Applications could be developed in the maritime, environmental, transportation, aviation, health or satellite industries.

SPACE EXPLORATION: YES, BUT ...

Today, there is no doubt that within a few years, asteroids will continue to be coveted before being exploited, particularly because they are full of precious minerals that are indispensable to many industries. Soon, they will be able to serve as refuelling stations for water, oxygen and hydrogen during future manned expeditions in space.

Despite the general enthusiasm, the dangers associated with the commercial exploitation of space are real. The first risk is financial. Indeed, if the 2016 signing of an agreement between the Luxembourg Government and a US asteroid mining company, Planetary Resources Inc., was part of this national policy that has positioned Luxembourg as a player

Photo : Space Europe

14.

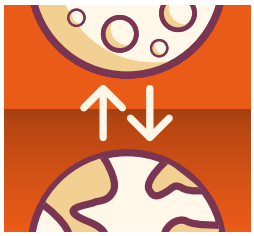
key in the field of NewSpace, remember that numbers in the red pushed the state to pull out two years later, with losses of EUR 12 million. On 10 August 2018, however, Minister Etienne Schneider defended his choices at a press conference, giving a political summary of the actions taken since December 2013, '*it is not unusual for innovative and technological startups to meet financial difficulties, or even face a failure*.' The risk was '*known and assumed (…) from the beginning*', according to the minister who does not question the economic development potential of the sector. The twenty or so companies from the space sector, which have established themselves in Luxembourg since the launch of the space exploration initiative, testify to this.

Beyond this cyclical risk of unfortunate investments, the conquest of space presents another major risk in terms of the environment. Earth's orbit has been invaded by space junk that has accumulated over 60 years of space exploration and the situation is worsening from year to year. Currently, some 750,000 pieces of debris measuring between 1 and 10cm orbit around the Earth. It is not yet possible to launch a satellite without leaving the upper stage of the rocket which propelled it into orbit. And we do not always know what to do with a satellite once its mission is accomplished. In space, utilisation rhymes with pollution. '*Tackling the problem of space debris is one of humanity's greatest environmental challenges, but it may also be the least known*', said the British scientist, Hugh Lewis, director of astronautical research at the University of Southampton. He spoke at the London Royal Astronomical Society during the November 2016 launch of a project initiated by artists and scientists to draw attention to the dangers posed by debris in orbit around the planet.

Without timely intervention, access to and exploitation of space may ultimately be just a memory. ●

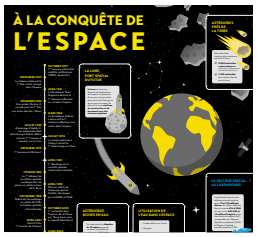
www.space-agency.lu
www.lsa-datacenter.lu

Special thanks to Lynn Robbroeckx (Luxembourg Space Agency) and Hoai Thu Nguyen Doan (Economic Affairs, Chamber of Commerce).



From the Moon to the Earth

The space sector is behind many technological discoveries and adaptations in everyday life. Here are some examples:
Cosmic radiation shields are used to protect homes from noise. Water purification technology is used in community water supply systems. Fire protection for steel structures is used in aircraft and acts as an insulating barrier. A hospital food service system (distribution trolley) uses a cooking-cooling concept for meals. Freeze drying of products solved the problem of feeding astronauts and, today, is in widespread use in the food industry. Vacuum metallisation techniques have led to a wide range of products, from multi-layer insulated outerwear to food packaging. The portable drill used by astronauts to core the moon was the first battery-powered tool. The sports shoe whose outer sole is manufactured using the 'direct injection' process, is adapted from the manufacture of the 'bubble' helmet.



The conquest of Space

Discover our poster on www.cc.lu/infographies