2023 NATIONAL SPACE STRATEGY 2027

Successes and impacts
of the previous action plan

LUXEMBOURG
SPACE AGENCY

Luxembourg's commitment to developing a space sector dates back to the 1980s with the formation of Société Européenne des Satellites (SES). The policy objective was clear at the time, and remains so today: to make spacetech one of the pillars of the Luxembourg economy.
Since 2016, the space ecosystem has developed signifcantly. Nowadays the Grand Duchy of Luxembourg is home to more than 70 space-related public and private enterprises, together employing over 1400 people.

Moreover, the space sector has discovered a new sense of dynamism in recent years. Developments in technology, miniaturisation, and lower launch prices are among the factors which ultimately have facilitated and driven new business initiatives in this field. These developments resulted in the increased use of Earth orbits, presenting new risks of congestion.
A meeting of the ESA Council at Ministerial Level led to a renewal of Luxembourg's strategy and its ambitions to develop the civil space sector, backed by a commensurate financial package.

Successes and impacts of the previous action plan

1.1 Key results from the previous period (2020-2022)

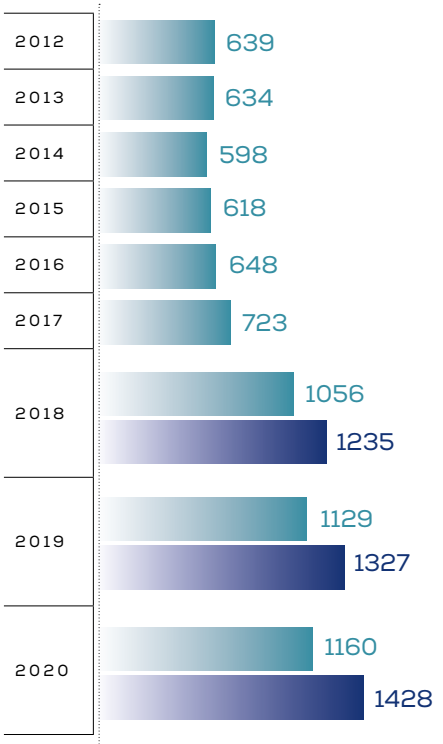
Since 2020 the sector has continued to record significant growth, with 19 startups or new establishments added to the sector in Luxembourg between 2020 and 2022. The trend in the number of businesses since 2012 shows growth by a factor greater than 4 over a 10-year period:

NUMBER OF BUSINESSES IN THE SPACE FIELD IN LUXEMBOURG SINCE 2012

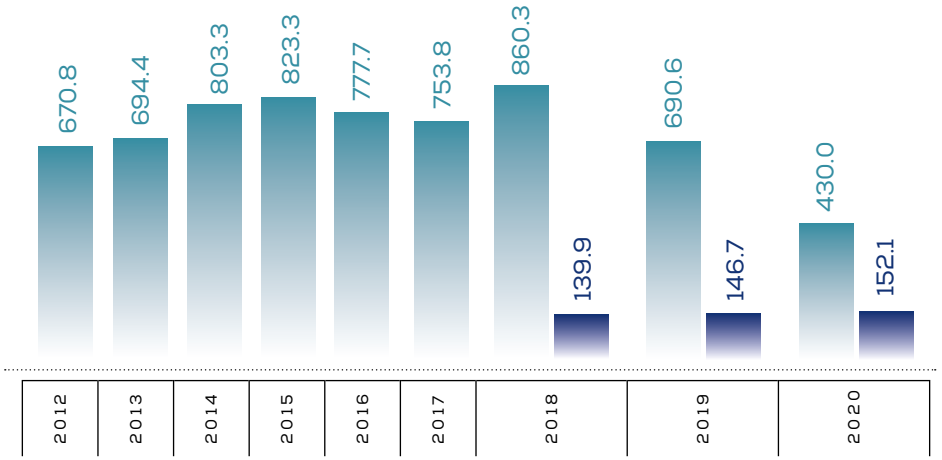
2012	16
2013	18
2014	18
2015	19
2016	22
2017	30
2018	32
2019	39
2020	48
2021	58
2022	67

In terms of new jobs, the statistics highlight a near-doubling in **employee numbers** within these businesses in Luxembourg. Add to this the number of space-related jobs in public research bodies, and the employees exceed 1400 in number.

EMPLOYEES WORKING IN THE SPACE SECTOR SINCE 2012



Estimates indicate a slight increase in value added by the businesses most recently established in Luxembourg, despite the pandemic – a very encouraging sign of their development. However, this trend excludes SES, whose business has been affected by a downturn in the market for satellite TV broadcasting. Figures are in € million.



› ESA

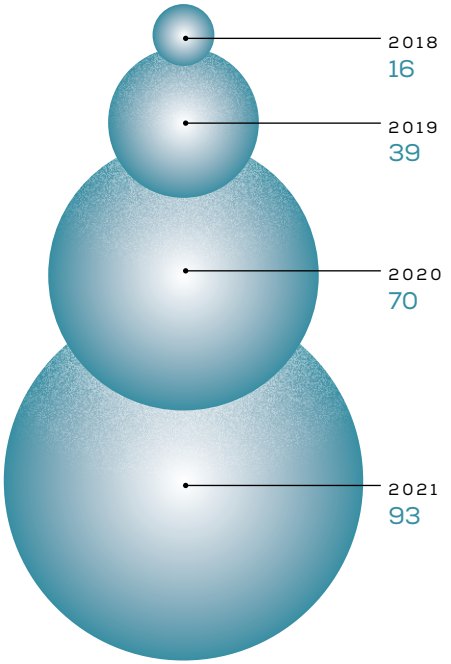
Luxembourg's businesses and public research institutions have been successful in winning a share of ESA programmes, with an industrial return coefficient slightly less than, or equal to, one. This coefficient is one of the main indicators used by the ESA to determine whether Member States are receiving a fair share in the Agency's programmes in return for their financial contributions. This is a reflection of the targeting of Luxembourg's investments on activities carried out in Luxembourg.

› LuxIMPULSE

In addition to the optional ESA programmes, Luxembourg has an agreement with the ESA to implement a national programme called LuxIMPULSE. Its purpose is the development of technologies, products, and services by Luxembourg businesses with a view to market launch. As the sector has expanded in size, LuxIMPULSE has seen significant growth in its activities.

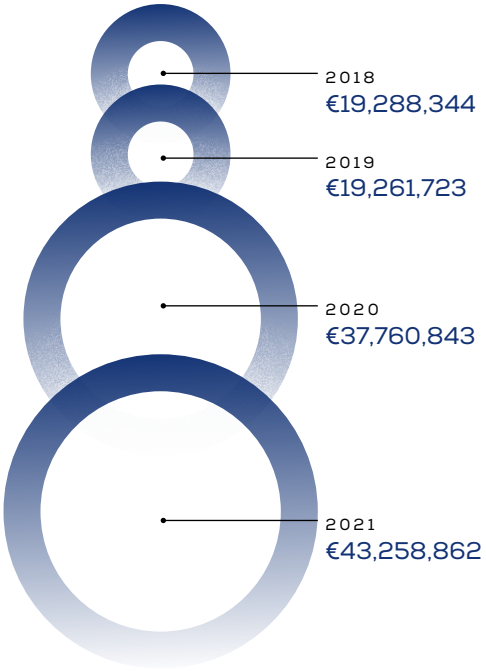
CUMULATIVE NUMBER OF PROJECTS

Cumulative number of project supported within the frame of the LuxIMPULSE national programme



ANNUAL FIGURES

Evolution of the Luximpulse Budget since 2018



1.2 Commercial successes

Spire Global, Inc.

(NYSE: SPIR) is one of the world's leading suppliers of space data, analysis and services. The company offers access to these unique data sets and information with added value, so that organisations can make their decisions with complete confidence. Spire uses one of the largest constellations of multi-purpose satellites in the world to obtain these unique data, which it then enriches for industries in the maritime, aerospace and meteorological fields. With Luxembourg's support, Spire has been able to develop new services in these three fields.
Since opening its European headquarters in Luxembourg in 2018, Spire has grown exponentially, both in the Grand Duchy and on a global scale.
Note that Spire has received an investment from the Luxembourg Future Fund and has been listed on the New York Stock Exchange since August 2021.

Bradford Space

Bradford Space has operated in Luxembourg since 2016, where it now has around ten employees. Bradford Space recently signed an MoU with a commercial client with a view to supplying up to 42 units of its Comet water-based propulsion system for a constellation of microsatellites. Six Comet 1000 systems have already been delivered; 15 are still in production; an additional 21 are planned. Furthermore, an order has been received for eight thrusters from the top-of-range system (Comet 8000), four of which have now been delivered. An R&D contract awarded in the context of LuxIMPULSE has made it possible to develop the Comet technology and bring it to maturity.
While work is still ongoing to produce the technology at scale, a major success and unprecedented return on investment have already been recorded.

Flawless photonics

Flawless Photonics settled in Luxembourg in 2020 and specializes in manufacturing optical glasses, fibres, and components in microgravity. The company produces the so-called Space FiberTM, an optical fibre from a fluoride glass called ZBLAN, produced in microgravity conditions in Low Earth Orbit (LEO).
The Luxembourg-based office has been working on R&D developments in the framework of the Luximpulse programme and counts 14 "machine builders" - from space engineers and robotics experts to chemists. The whole team has been actively working in close collaboration with NASA and the European Space Agency (ESA) to design a production system able to create flawless fibre.
Flawless Photonics recently started producing fibre using ZBLAN onboard the International Space Station (ISS) resulting in the production of almost 12 kms of high-quality fibre in space. Building on its successful experiment, it is the first company to achieve such a feat in microgravity.

LuxSpace

LuxSpace, an OHB Systems Group subsidiary, established in Luxembourg since 2004, develops complete microsatellite systems. It currently employs about 50 people. With the backing of the ESA, it has been able to develop the necessary technology to supply a modular platform capable of serving different types of application. This summer, LuxSpace won its first commercial client. In competition with two other suppliers, the LuxSpace solution was finally selected. This is a satellite which will have 15 experiments on board, in fields ranging from communication to navigation, Earth observation and materials science. This first contract will pave the way to other commercial opportunities in a market enjoying strong growth.

GRADEL

In 2018, GRADEL decided to diversify and adapt its corporate strategy to market trends in the spacetech sector. GRADEL has identified ultralight structures, fabricated using innovative technology, for in-house development as a business opportunity. This new sector relies on digital process technology known as "xFK in 3D," which makes it possible to wind a bundle of fibres to form complex 3D structures without resorting to the use of industrial robots. Due to a LuxIMPULSE R&D contract in 2020, Gradel has qualified this new process for space applications under ESA supervision with three partners: Airbus Defence and Space, OHB Systems, and Thales Alenia Space. This project was completed in close cooperation with the Luxembourg Institute of Science and Technology (LIST), in a laboratory shared with the Institute. The GRADEL patented process achieves weight savings of up to 71%.
The outcome of three years of focused development is a system produced and marketed under the GRAM brand, which stands for GRADEL Robotic Additive Manufacturing. The system can impregnate and wind complex, but durable ultralight 3D structures. Deployment of the process on this scale is a world-first. This new technology is aligned with the Green Deal targets, because it facilitates sustainability in the aerospace industry, reducing its consumption of material and energy resources. The plan is that the first components manufactured by GRADEL will be used onboard satellites by the end of 2023.
GRADEL currently employs 65 people. Spacetech accounts for around 45% of the company's turnover. At present, 13 GRADEL employees are working on GRAM. GRADEL has launched a €7 million investment programme (2022-2025) to expand this new business sector in house. Market opportunities exist in similar number on the terrestrial side, in the automotive, aerospace, and architectural fields.

Redwire Space Europe

Established in Luxembourg in 2018, Redwire Space Europe currently employs 24 people. The company's core business in Luxembourg is the development of an affordable, highly modular robotic arm called STAARK. The first customer, an American company called Momentus, commissioned Redwire to explore the possibility of using STAARK on their satellite for a future space transport mission. Redwire has also received a procurement order for a terrestrial version of the robotic arm from the SnT interdisciplinary centre in Luxembourg. The company, Thales Alenia Space UK, has commissioned a utilisation study, now at an advanced stage, from Redwire with a view to developing a lunar version of the arm for an ESA mission. Redwire has discussions ongoing with over 30 international partners for other STAARK sales contracts.

SES

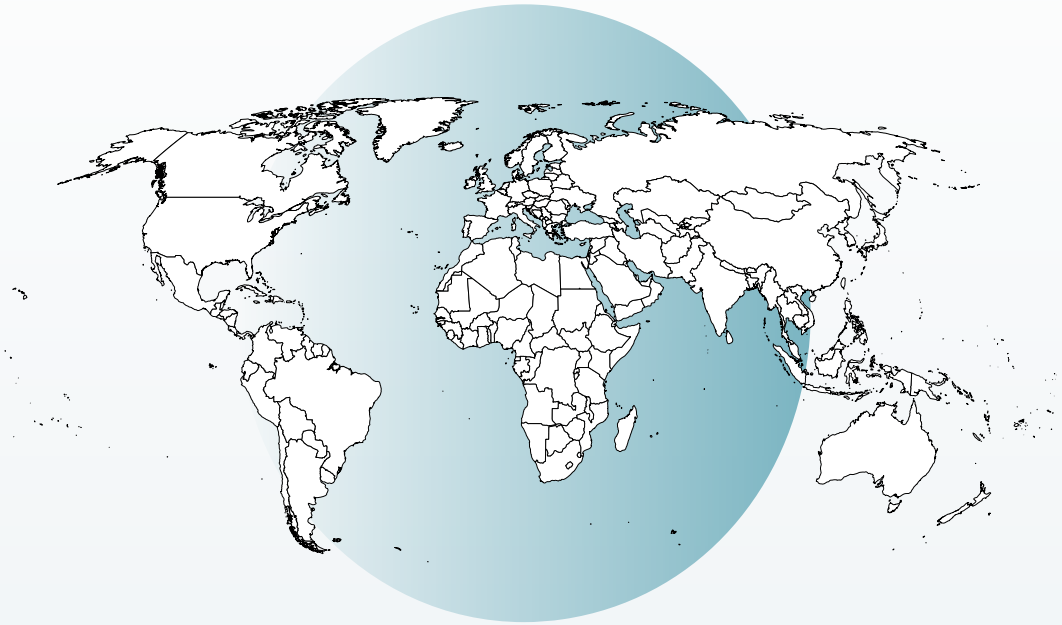
At the International Astronautical Congress in Paris, SES announced that it had signed a contract with the ESA for the design, development and deployment of a satellite-based quantum key distribution system. Named EAGLE-1, this mission serves the primary objective of demonstrating and validating cyber security services in orbit, based on quantum technology. This demonstration will open the way to new applications and the commercial prospects look promising.

1.3 International cooperation

International cooperation with Luxembourg has grown, beginning with the Australian State of New South Wales in January 2020. It continued at the International Astronautical Congress in Dubai in October 2021 with the Italian and French space agencies, with the Indian space agency in February 2022, and with the Canadian Space Agency in June 2022. This followed on from existing projects in cooperation with Belgium, Portugal, the United Arab Emirates, Japan, China and the USA.

› Artemis Accords

In October 2020, Luxembourg also signed the Artemis Accords with the USA. Artemis is the US exploration programme which envisages sending the first woman and the next man to the Moon's surface by 2024. The stated objective of the Artemis Accords, set up by NASA, is to guide future cooperation activities carried out through bilateral agreements. The international cooperation under the auspices of Artemis seeks not only to support space exploration, but also to strengthen peaceful relations between nations. The Accords are a very good fit with the efforts made by Luxembourg at both national and international levels in support of peaceful exploration and the sustainable use of space and its resources for the benefit of humanity.



MOU SIGNING

- Australian State of New South Wales — January 2020
- Italian and French space agencies — October 2021
- Indian space agency — February 2022
- Canadian Space Agency — June 2022

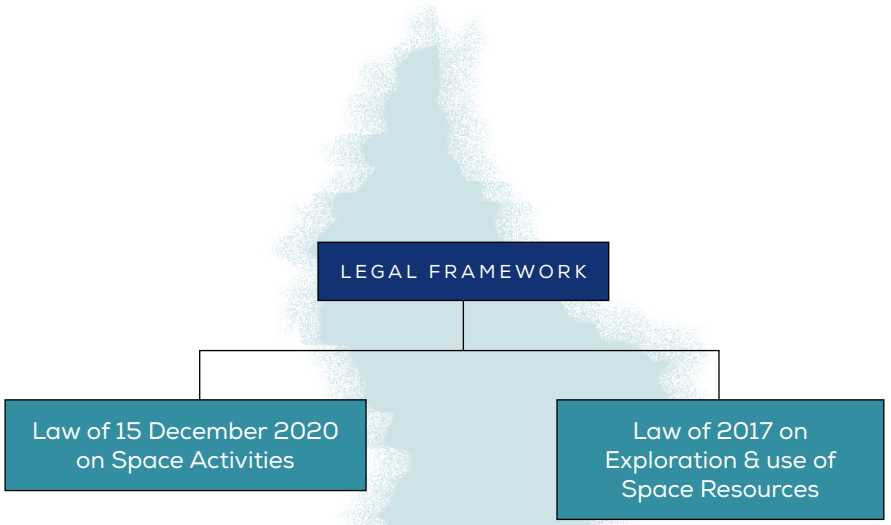
NATIONAL STRATEGY

1.4 National regulation

At **regulatory level**, two new laws took effect in Luxembourg on 1 January 2021:

1) the law of 15 December 2020 approving the Convention on Registration of Objects Launched into Outer Space, adopted by the General Assembly of the United Nations in New York on 12 November 1974

2) the law of 15 December 2020 on space activities amending:
- > the law amended on 9 July 1937 on insurance tax known as the "Versicherungssteuergesetz;"
- > the law amended on 4 December 1967 on income tax. The second law concerns a system of authorisation and supervision of space activities carried out from Luxembourg. The first authorisations were issued in late 2022.



1.5 Talent development

Talent development initiatives have continued successfully, despite difficulties caused by the COVID-19 pandemic.

› ISM

The **Interdisciplinary Space Master (ISM)**, a master's degree in space science, has continued to attract international students from Europe and elsewhere. Seven students finished their course and graduated in December 2022. Three of them found employment in Luxembourg, and one other is continuing an academic career by studying for a doctorate at the University of Luxembourg, in cooperation with NASA's Ames Research Center.

LuxYGT programme

Young recent graduates have joined the **LuxYGT programme** which seeks to offer initial working experience within the ESA. Six candidates were admitted in 2022 while, in 2023, five applicants were able to join the ESA. The selection process for 2024 is still in progress, with a shortlist of six candidates.

Alpbach Summer School

As an ESA Member State, Luxembourg is eligible to send students to the **Alpbach Summer School**, organised by the Austrian space agency in cooperation with the ESA. N.B: the Luxembourg aerospace grouping GLAE and the national research fund FNR contribute financially to the selected students' costs. In 2022 and 2023 three students from Luxembourg attended the school's summer programme.

Luxembourg Tech School

The LSA has maintained its support for the **Luxembourg Tech School** in its development of extra-curricular activities on the utilisation of space resources. Specific modules have been developed to teach the basics to secondary school students. These students have also taken part in ESA challenges and educational initiatives, such as CanSat and Astro Pi.

ESERO Luxembourg

In June 2018, Luxembourg inaugurated **ESERO Luxembourg**, a resource office within the Luxembourg Science Center. This educational programme, launched by the ESA and rolled out nationwide by the LSA, seeks to raise young people's awareness of opportunities in the field of space and motivate them to go into the technical and scientific sectors. It also offers tools for STEM teachers, encouraging them to use space as a powerful source of inspiration. The course catalogue now comprises nine modules for primary school teachers and six for secondary teachers. Two additional have been developed for student teachers at Uni.lu. About 12 teacher trainings are delivered to 140 primary and secondary teachers reaching 1000 kids per year. They also organise highly impactful school projects, such as CanSat and Climate Detectives, reaching about 1200 kids per year.

Frontier Development Lab.

Since 2017, Luxembourg has also participated in the **Frontier Development Lab (FDL)**, organised by the SETI Institute with major involvement by NASA. In 2020 and 2021, the FDL programme had to adapt to the pandemic and took place remotely. There was one participant and two mentors from Luxembourg in 2020, one participant and three mentors in 2021, and two participants and three mentors in 2022. In 2024, Luxembourg participated in both the US and European FDL.

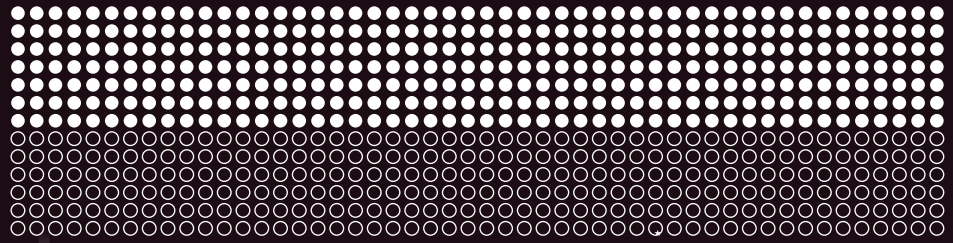
1.6 Communication

› TV programmes

Communication efforts since 2020 have focused on the international significance of the Luxembourg space ecosystem.
The communication activities at all levels have been many and varied. Luxembourg's utilisation of space resources continues to interest and galvanise the international press. LSA representatives have taken part in many documentaries and radio and **TV programmes on the subject** (Arte " La réponse à presque tout", Bloomberg " Giant Leap" and ZDF, to name but a few).

● Onsite
○ Online

2023
650 participants



NEW SPACE EUROPE

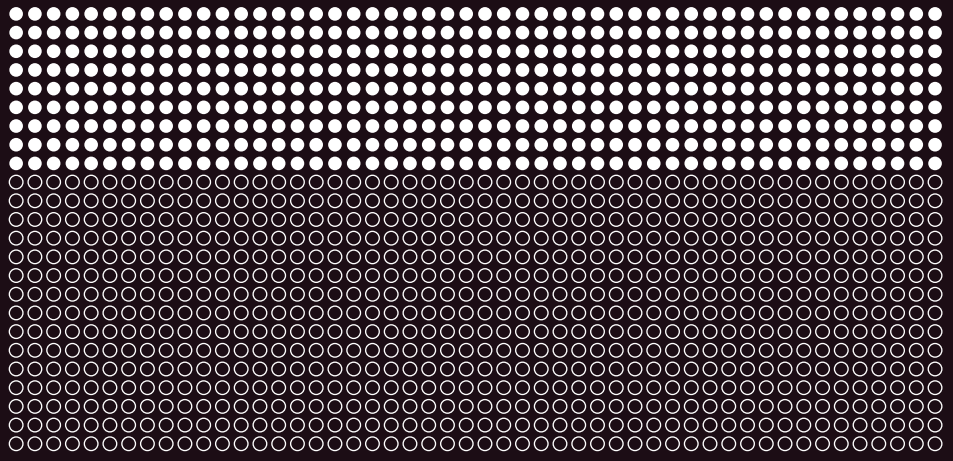
› Events

The **events** organised by the LSA (Space Resources Week and NewSpace Europe) have resumed since the pandemic and grown in scale and public profile. The 2021 editions attracted more than 1000 and 800 participants, respectively. Parallel to this, the LSA and the Luxembourg ecosystem have become more closely involved in international **spacetech events** (Le Bourget, the International Astronautical Congress and Space Tech Expo Europe in Bremen). National industry representatives have given presentations in the pavilions provided.

LUXEMBOURG SPACE RESOURCES

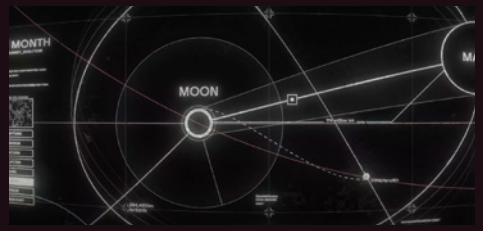
● Onsite
○ Online

2023
1250 participants



Communication via social media, especially LinkedIn, has increased and is structured to ensure consistent messages. It relies especially on video productions which highlight the Luxembourg ecosystem's priority themes and competences. One example is the video **"Space Resources, Driving the Future of Space Exploration,"** which has won several prizes and is an excellent illustration of Luxembourg's vision for space resources.

LSA and its partner programs have launched multiple initiatives to continue the work of raising public awareness about the space sector.



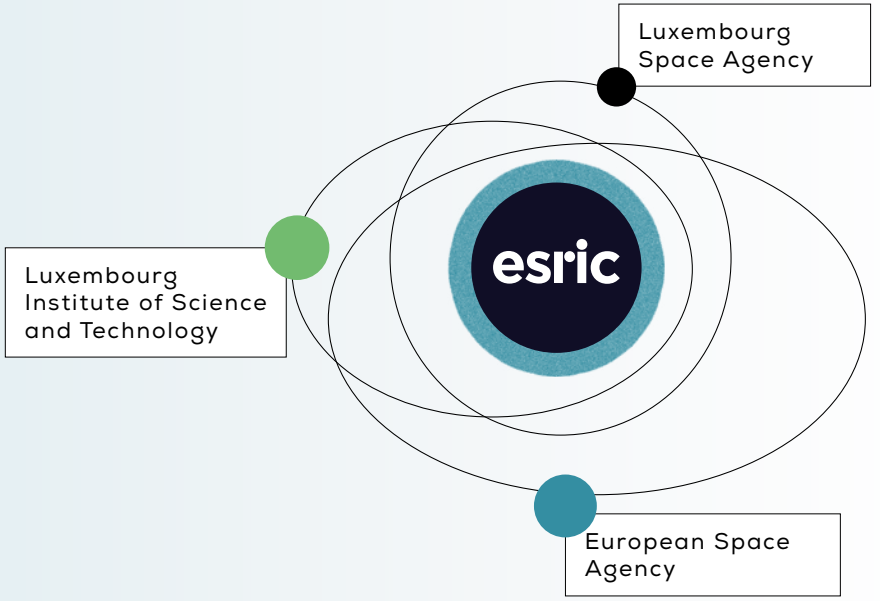
Space Resources, Driving the Future of Space Exploration

1.7 Focus on SpaceResources.lu (including ESRIC)

In 2016, the **SpaceResources.lu** initiative was launched with the aim of promoting peaceful exploration and the sustainable use of space resources. It seeks to establish a coherent ecosystem for the development of private-sector economic activities in the field of space resource utlisation through policymaking, legal and regulatory initiatives, public research, education programmes, and partnerships within the finance field. In the space of a few years, Luxembourg has won international acclaim for its ambitions surrounding the use of space resources. SpaceResources.lu has also contributed to the sector's development and to the Luxembourg ecosystem more generally.
In recent years, the international scene has changed dramatically. Many public and private entities are now interested in using space resources, and the field continues to make rapid progress.

In November 2016, the Council of Government of Luxembourg decided to create an **Advisory Board on Space Resources**, tasked primarily with advising the government on space resource utilisation. The Advisory Board consists of international experts, especially the former ESA director general, Jean-Jacques Dordain, and the ex-director of NASA's Ames Research Center, Dr Simon Peter Worden.
Meeting most recently in May 2022, this Advisory Board drew some highly positive conclusions about the results achieved since the launch of SpaceResources.lu. In particular, it noted the business growth of the 10 Luxembourg enterprises in this field, which thus heighten the economic impact of the space sector.
Other positive developments have been the creation of a working group on space resources in the Committee **Committee on the Peaceful Uses of Outer Space at the UN (COPUOS)**, the 2021 and 2022 editions of Space Resources Week, the projects implemented under LuxIMPULSE, and the progress made towards a contribution to NASA's Artemis programme.

The LSA and ESA cooperated to create a European Space Resources Innovation Centre (ESRIC) in Luxembourg in November 2020. ESRIC is home to the research activities of both SpaceResouces.lu and the ESA. The cooperation, formally recorded in the Memorandum of Cooperation in the Field of Space Resources in November 2019, signed in the margin of the last meeting of the ESA Council at Ministerial Level (Space19+) in November 2019 in Seville, strengthens Europe and Luxembourg's position in the space resources field. ESRIC was set up within LIST in August 2020 and announced at a launch event in November 2020.



ESRIC continued its development in 2021 and 2022 in close cooperation with its three strategic partners. A first team of around 12 researchers was recruited, and R&D and innovation work began in the core sections of ESRIC. Notably, ESRIC has installed laboratories on the LIST campus at Belvaux. The first ESA demonstrator has arrived (oxygen extraction by hydrogen reduction from lunar regolith) and R&D activities have begun on space resource processing.
ESRIC has secured an FNR PEARL project on the sustainable use of space resources. This has attracted a high-level scientist, Kathryn Hadler, to Luxembourg, and she has become the Director of ESRIC.
The ESA and LIST have cooperated on the development of a knowledge management platform.

To boost cooperation with the private sector, ESRIC has entered into partnerships with companies such as Air Liquide, Maana Electric, and Airbus Defence and Space. In this way, these companies will contribute to ESRIC's R&D work. Furthermore, ESRIC has launched a programme of support to start-ups in the field of space resources, in cooperation with Technoport and the ESA. This is the world's first incubation programme dedicated to space resources. A first call for projects identified about 20 teams, five of which were admitted to the programme's first stage. A "challenge" on prospecting for space resources was launched with the ESA. The first round, in which 13 teams competed, took place in the Netherlands and the final, with five teams, was held in September 2022 at the Rockhal venue in Belval, Luxembourg.

NOTES:

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