How Luxembourg becomes Europe's commercial space exploration hub

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During its short history as an independent nation, Luxembourg had to reinvent itself continuously, adjusting to changing conditions beyond its control and taking advantage of new opportunities, in order to open up new spheres of value creation and national development for the benefit of its citizens and residents. The most prominent example is certainly the transformation, within a generation, of its economy based on world leadership in technology and production of steel and steel-based products to one of the planet's most significant financial centers. Luxembourg, known for its fruitful utilization of radiofrequencies since the 1930's, now aims at becoming Europe's commercial space exploration hub.

It all started with radio frequencies

The utilization of space-based technologies, in particular communication technologies, has been part of the country's economic DNA since the utilization of radio frequencies – a national resource – for the distribution of commercial radio programming in the early 1930s. To do so, Compagnie Luxembourgeoise de Radiodiffusion (CLR), in 1929, was granted a license by the Government to use long wave radio frequencies. These rights were extended to frequencies for television signal distribution in the 1950s. 30 years later, in the mid-1980s, a commercial, Luxembourg based, public-private partnership corporation was pioneering the use of fixed service satellite communication technologies to distribute television and radio programming via geostationary orbit-based satellites at 36000 km over the equator. Such orbital positions or "slots" had been assigned for use to Luxembourg by the International Telecommunications Union (ITU), a specialized agency of the UN that is responsible for issues that concern information and communication technologies, at its Conference in Geneva in 1977. Thus, Luxembourg had been allotted a "space resource" for exclusive use for telecommunication services, while other unassigned slots were allowed for use on a "first come" basis.

Scientific and technological development and legal rule setting processes had thus extended the economic and commercial sphere of Luxembourg to 36000 km over the equator. Since then, additional space-related services and businesses have developed in Luxembourg and today these commercial activities represent close to 2% of GDP.

The next step: becoming Europe's commercial space exploration hub

In 2005, Luxembourg joined ESA as a full member, creating the foundation for Luxembourg business participation in ESA's R&D programmes and space exploration missions. The awareness, experience and benefits of the continuous expansion of the economic sphere of Earth towards ever more distant outer space frontiers, the accelerating speed of technological advancement and the emergence of privately funded commercial startups in the "new space" business segment have encouraged the Government of Luxembourg to further explore the long term economic opportunities provided by outer space.

Humanity is eager to seek new frontiers as it aims to learn more about the Solar System and our Galaxy, gain new knowledge about the Universe and look out for biological existence and intelligence in Outer Space. Many Government Space Programmes such as those of NASA or ESA, as well as private entrepreneurs are preparing for the establishment of permanent human settlements in space. Central to these exploratory endeavours will be the space resources that can be identified, mined and transformed for use in space.

Launch of the Luxembourg Space Agency

In September 2018, Luxembourg launched its own space agency. Unlike similar organizations abroad, the Luxembourg Space Agency will not directly conduct research, or launch missions. Its goal is to foster

collaboration between key players in the space industry, with the core mission of accelerating the emergence of innovation-driven businesses.

The focus will be on supporting a sustainable ecosystem for the space industry and offering a platform in Europe for commercial space development.

Over the last 3 years, around 20 space companies have established a presence in Luxembourg, bringing the total to 50 public and private players. Attracted by the unique framework we've been developing, for the exploration and commercial utilization of resources in space.

Access to funding is a key issue for growing companies in any industry, and space is no exception. With this in mind, the Luxembourg Space Agency is currently drawing up plans for a financial instrument designed to provide equity funding for new companies developing the kind of ground-breaking ideas and technologies from which our future space industry will be built. Luxembourg is also working closely with the European Investment Bank to bridge the information gap and develop financing solutions for the space sector.

An equally important 'source of capital', will be the talent and skills the country develops. This is why, starting in the 2019 academic year, the University of Luxembourg will offer an inter-disciplinary Space master's degree, markedly different from programs by other institutions. The course will provide participants from an engineering or scientific background with additional technical expertise in areas needed to support Luxembourg's space industry. This training will be twinned with a strong grounding in business. Perhaps one day the graduates of this course will be true space-age entrepreneurs.

Resources in space: a universe of potential

Celestial bodies – including the Moon or near-earth objects (NEOs) such as asteroids – are naturally forming objects found beyond Earth's atmosphere. Many planets, moons and asteroids contain a rich diversity of inert physical substances such as metals, along with gases and water that could be used as energy sources and means to sustain human life as we venture deeper into space.

Many of the metals found within the Moon and other celestial bodies are already scarce on Earth. One day, we may use them not only to construct equipment in space but transport them back to support terrestrial activities, employing on Earth the technologies developed to explore and mine resources in space.

NEOs are close to Earth in astronomical terms. Nudged by the gravitational pull of nearby planets, they are within 1.3 Astronomical Units (1 AU = 150 million kilometers).

NEOs take different forms. Comets, which are formed in the cold outer planetary system, are mostly frozen water embedded with dust particles. Rocky asteroids are formed closer to home, in the warmer inner solar system between the orbits of Mars and Jupiter, from the residue of the material that constituted Mars, Mercury, Venus and Earth itself. Asteroids show a large variety of material composition, such as carbon-rich (C-type), metallic (M-type) or mineral-rich silicate (S-type).

Around 15,000 near-earth asteroids of various sizes had been identified and listed by the end of 2016, according to the US National Aeronautics and Space Administration (NASA), and their number keeps growing.

The Moon is gravitationally bound to the Earth and is roughly 400,000 km away. Since the 1960s, 12 people have set foot on the lunar surface and close to 400 kg of lunar rock and regolith have been brought back to the Earth. These samples helped us to realize the immense resource potential available on the Moon.

Significance of space resources

Earth's natural resources are already under pressure from the planet's growing population, estimated to reach nearly 10 billion by 2050. Rising demand for resources will eventually push the economic balance in favor of harvesting resources from space to sustain our lives on Earth.

But for now, the clearer and more immediate benefits from mining resources are for use in space. Both, the Moon and NEOs contain significant, highly concentrated quantities of metals such as iron, nickel, tungsten cobalt and Rare Earth Elements, while ammonia, nitrogen, hydrogen and other useful gases have been detected. Frozen water, billions of tons which exist at the lunar poles and on NEOs, could be among the most important assets as man ventures further into the unknown. These valuable materials can be applied to technologies used in space and to sustain life in space.

Not long ago, space exploration was the preserve of national governments and international agencies with access to the necessary financial resources. Today, private investors and companies utilize lower-cost technologies and have at their disposal the financial resources to launch satellites to explore the opportunities for mining resources on NEOs or the Moon. In doing so, they increase the knowledge on these bodies and may also contribute to help defend Earth against asteroid impacts, preventing material damage and human casualties.

First steps

Mining space resources may well come surprisingly quickly. Expeditions to near-Earth asteroids and to the Moon have already yielded remarkable discoveries.

The European Space Agency's Rosetta probe, which was launched in 2004, astounded the world with images and data sent back from its Philae module after landing on a comet in 2015.

The first Japanese Hyabusa ("Peregrine Falcon") probe brought some 1,500 grains of material back from the Itokawa asteroid in 2010. A second Japanese Aerospace Exploration Agency probe should reach the Ryugu asteroid in 2018. If all goes well, its samples will be back on Earth two years later.

Photo © Spacecraft: ESA - J. Huart, 2014; Comet image:ESA/Rosetta/MPS for OSIRIS Team MPS/

Artist's impression of the Rosetta orbiter deploying the Philae lander to comet 67P/Churyumov–Gerasimenko.

"The European Space Agency's Rosetta probe, which was launched in 2004, astounded the world with images and data sent back from its Philae module after landing on a comet in 2015."

The Moon was visited several times by the United States, the former Soviet Union and most recently China. The samples returned by the various missions and the data gathered since then proves the mineral wealth of the lunar rocks and dust. Moreover, the recent orbital missions, such as NASA's LCROSS and Lunar Reconnaissance Orbiter, and India's Chandrayaan-1 mission further increased the attractiveness of the Moon by showing large deposits of water ice in several locations scattered throughout the lunar poles.

Many future missions are planned, by both national space agencies and private commercial entities. These missions promise to further unveil the resource potential and help us better understand the extraction and processing methods required to utilize the resource in space or on Earth.

The economics of space

Greater competition and ongoing scientific discovery will lower the cost of space exploration still further.

Today, the biggest impediment to space exploration is the cost of escaping Earth's atmosphere. Lifting heavy equipment and cargo requires a great deal of thrust – and fuel.

Building new spacecraft or servicing existing ones in the weightlessness of space could be more economic if the necessary resources are already close at hand. And those resources could serve as well as the basic materials for additive manufacturing in space of a variety of critical equipment and parts.

Once in space, the emphasis switches to the resources necessary for sustaining human habitat. At present, astronauts must ferry all their fuel, food and water with them, adding to already hefty payloads.

Water is the critical component for drinking, nourishing plants, and as an element in the ongoing production of energy and air. Without it, there is virtually no prospect for deep-space travel and habitats. Ice from asteroids or the Moon could be harnessed for both biological and energy needs in outer space.

The legal challenges of space

Having the right materials in the right place at the right price is just one component of the space exploration equation.

Some of today's international space law was 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 at a time when the United

States and the former Soviet Union were competing to reach the Moon. 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 harmonize global rules for the peaceful exploration and utilization of space resources. Access to space resources is clearly a global issue and the number of countries collaborating with Luxembourg is increasing all the time. Belgium is latest to join a list which includes China, Japan, the United Arab Emirates, Russia, Poland, Czech Republic and Portugal.