Science Meets Parliaments
Space solutions for sustainability on Earth

Overview

Under the framework of the European Commission’s Joint Research Centre’s (JRC) call “Science Meets Parliaments / Science Meets Regions”, the Ministry of Economy, the Luxembourg Space Agency, the University of Luxembourg – Faculty of Law, Economics and Finance, and the Luxembourg Institute of Science and Technology (LIST) co-organized a one-day conference on the 4th of October 2019 held at the Chamber of Deputies, titled Space Solutions for Sustainability on Earth.

The conference focused on domestic environmental topics and the use of space technologies to support policymakers by using selected European space programs – Copernicus and Galileo. Most importantly, the conference had a special focus on Luxembourg’s strategy under the environmental objectives of the United Nations Sustainable Development Goals (SDGs).

The conference was structured in two parts. The first, saw keynote speakers address the environmental and political needs of Luxembourg pursuant to Luxembourg’s SDGs. The latter was dedicated to the use of space technologies for environmental applications focused on two main axes:

1) The use of Earth Observation (EO) for agriculture, land management and disaster response,

As part of the discussions held on the day, the objective for the panels was to identify five key points as listed below.

1. Current status of private and public sector in space applications. Goals for space use in the region
2. Promising good practices implemented by the private sector to promote use of technologies
3. Strategies that can be used to engage the private sector, government and civil society in collaborative efforts
4. Key recommendations (specific goals and targets) and related key actions required to strengthen strategies and goals for ensuring private/public sector initiatives that have an impact on the use of space applications at the local level
5. Signs of progress (indicators) if any in Luxembourg that would indicate the growth of the use of space applications in the environmental policies.

This report provides an overview of the keynote presentations, moderated discussions and observations made as part of the conference.
Introductory remarks

Speakers:
- Fernand Etgen, President of the Luxembourg Chamber of Deputies
- Prof. Stéphane Pallage, Rector of the University of Luxembourg
- Prof. Isabelle Riassetto, Vice-Dean of the FDEF, University of Luxembourg
- Dr. Thomas Kallstenius, CEO LIST

Master of Ceremonies:
- PJ Blount, University of Luxembourg

The conference was initiated by a panel of four speakers from the various organising bodies, who provided an insight into the work carried out by their respective institutions and focused on the collaborative approach that Luxembourg pursues between its public and private sector entities to achieve a common goal.

- Fernand Etgen (President of the Luxembourg Chamber of Deputies), extended his warm welcome to the organizers, panellists, audience members and to the deputies in presence. His remarks set the tone for the day, one that focused on understanding the body of work being carried out today, Luxembourg’s involvement in the domain, identifying key challenges and perhaps more importantly how such an event could help bridge the disconnect between parliamentarians, scientists and the general public by providing equal footing and information to all.

- Prof. Stéphane Pallage (Rector of the University of Luxembourg), stressed that Luxembourg was a country of space innovation, with a proven track record of being a world leader in space legislation; especially around the exploration of space resources. There are currently over 50 companies involved within the space domain in Luxembourg, many of which were initiated at the university and supported by a combination of private, EU and Horizon 2020 funding. The university encourages and focuses its space research in the areas of legislation, robotics, science and communication. He also introduced a new master program being offered by the university aimed at students with a technical background who might feel they lack the resources of pursuing a career in the space sector. The new master’s program would include topics associated with management, finance and space communication.

- Prof. Isabelle Riassetto (Vice-Dean of the FDEF, University of Luxembourg) mentioned space has been a key flagship theme within the Law, Finance and Economics faculty. Current work is focused around sustainable development, with the aim of offering a cross-disciplinary approach within the faculty. The faculty also considers preserving nature and resources as one the primary challenges at present, and is working on better understanding the environmental challenges we collective face along with the financial impact on Luxembourg. The faculty aims to broker discussions and links between academics and public/private sector entities.

- Dr. Thomas Kallstenius (CEO LIST), mentioned that research activity in Luxembourg is fundamentally based on four key pillars.
- The ability to act with speed and agility
- Working as one team (1 university and 3 research institutes), focusing more on collaboration than competition
- Acting as the window to Europe (both geographically and economically)
- Providing a nationwide digital testbed.

He went on to mention that LIST is looking at how Luxembourg as a city and a country could provide a testbed for innovation; and how in terms of sensing and agriculture one could move from local sensing to remote sensing (e.g. using drones to assess crops providing a targeted agricultural response).
Keynote Presentations

Speakers:
- Maren Hunds, European Commission, JRC
- Alan Belward, European Commission, JRC
- Marc Serres, Luxembourg Space Agency, Luxembourg
- Jorge Del Rio Vera, United Nations Office for Outer Space Affairs
- Prof. Mahulena Hofmann, University of Luxembourg, Luxembourg

“Science Meets Parliaments” Initiative

Maren Hunds, European Commission, JRC

The Joint Research Centre (JRC) is part of the European Commission’s science and knowledge service, working across all policy fields, providing scientific evidence to support decision makers in policy making.

The ‘science meets parliament’ scheme was launched to avoid misunderstandings and make sure that collaboration is beneficial and possible. The flagship initiative originated in 2015 with a pilot project. This was expanded to include the ‘science meets regions’ events in 2016, which were launched in cooperation with the European Parliament Science and Technology Options Assessment (STOA) panel.

The annual event in the European Parliament highlights the importance of building closer links between scientists and EU policy-makers. It promotes regular dialogue as a vital tool to establish and improve a culture of evidence informed policy-making. Based on its initial success, the European Parliament entrusted the JRC to expand the initiative across the European Union.

The pilot project has a total available budget of one million Euro, spread between three key action areas.

1) Events – approximately 600k for events and innovation camps, with 19 being held so far.

2) Studies – 14 studies have been conducted so far with an available budget of approximately 200K. JRC directly contracts local actors to carry out studies related to the topics of the events. The studies can be carried out before the event as preparatory work, or after the event as a follow-up focusing on policy impact.

3) Educational packages – with an available budget of 120K, the training package enables policy makers to process scientific information as a basis for evidence-informed policy. It also provides scientists with an opportunity to understand how government works and how they can contribute their knowledge.

So far, the JRC has held 26 events in 22 member states. The events benefit, national, regional and local authorities; bringing together scientists, policymakers, private sector, stakeholders and citizens and obviously space solutions for sustainability on earth. Event topics have ranged from jobs & growth to migration and demography.
When considering space solutions for sustainability on earth, it is important to remember that the land is what provides us with food, fuel, fibre and living space. The Joint Research Centre helps provide space solutions for common agricultural policy focusing on the following key areas.

1) Ensuring access to abundant nutritious and safe food,
2) Protecting and enhancing our environment and biodiversity,
3) Growing awareness on the vitality of mitigating and adapting to climate change,
4) Sustaining landscapes and rural livelihoods.

The JRC currently has access to a lot of spatial data. Between 1982 and 2013 alone there were 185 earth observation satellites launched. Living in an era of massive observation of the planet enables us to provide better and more informed policy decisions.

This high availability of spatial data, allows JRC to monitor farms across Europe on a weekly basis to ensure that the contractual agreements are adhered too and maintained. In doing so they focus on the land parcel identification system to determine where a farmer might use land for agriculture, and the ground sampling distance (GSD) to establish where the farmer actually uses the land for agricultural purposes.

At present roughly 172 million hectares of land is being observed on a regular basis. By harnessing the power of cloud computing it is now possible to analyse millions of individual fields and interact directly with millions of EU farmers. At present the reference database has identified 71 million land parcels.

The ability to interact directly with farmers, gives them access to information that is date/time stamped for a given authenticated user, has geo-location attributes and provides a fit-for-processing picture.

Spatial solutions being used at present provide a societal benefit to 513 million EU citizens, empowering EU farmers to produce up to 3432 calories per person per day and supporting roughly 44 million jobs.

This replicable, quantitative, updateable and validated control system has empowered decision makers across Europe and ensured that 1856.23 Euros per second is spent accountably, fairly and effectively thanks to spatial solutions.
Luxembourg space activities

Marc Serres, Luxembourg Space Agency, Luxembourg

Luxembourg has been an active player in the space domain for over 30 years. Space is a success story for Luxembourg as SES is world leading satellite operator with an estimated turnover of 2 billion Euros.

Luxembourg became a member of the European Space Agency in 2005 and in 2018 the Luxembourg Space Agency was created. Upon its creation it immediately implemented a policy to identify the requirements/stakes for Luxembourg, focusing on

1) Economic opportunity via diversification
2) Extension of competencies at a national level
3) Internal cooperation.

As part of its approach the agency defined its mission objectives as below

a) Help companies create economic value
b) Develop national skillset
c) Develop and foster talent across Luxembourg
d) Extend commercial reach
e) Foster international collaboration

At present there is a drive to invest in satcom and applications (e.g. satellite imagery for agricultural analysis), however the agency is also focusing on the possibility of utilizing space resources in the future. Looking forward the agency has identified a number of challenges, some of which include technology, legislation (national and international – especially space resource utilization by the private sector), financing (scale of funds, allowing private entities to invest alongside the state), defining a common market and developing a value-added chain.

The agency believes that a lot more needs to be done in order to promote this effort, as as this is a topic is not well known until recently.

Luxembourg has advocated and pursued policy initiates to support the mining and in-situ utilization of space resources. With other space faring nations like United States, identifying this a research and development budget priority, Luxembourg has identified a key opportunity where it can position itself.

The current ecosystem consists of approximately 50 public/private companies working in the space sector, with roughly 700 employees contributing 1.8% to the GDP. The space sector was previously the domain of nation states, which pushed it into a silo. It has now come out of this silo with public/private partnerships helping to create/provide benefits to society at large.

The space sector is undergoing rapid change and with it is bringing about a number of opportunities, for Luxembourg and beyond.
Sustainable Development Goals (SDGs) and the use of space technologies

Jorge Del Rio Vera, United Nations Office for Outer Space Affairs

In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development that includes 17 sustainable development goals (SGD’s).

As part of the agenda all 193 member states recognised a rise in global temperatures over time (with most years being classed as above average in the past few decades), changes in global temperatures directly impacts the climatic events we face today, our introduction of plastic and other elements in to our global environment has a direct impact on wildlife and while there is a steady increase in the global population the size of arable land has become stagnant.

In light of the SDG’s how can we as an established space community help? Amongst others, there are 3 principal areas that we can focus on.

1) Quality education – over 50% of internationally renowned scientist publications in Nature admit to being inspired by the Apollo program. 89% agree that human spaceflight inspires future generations.

2) Affordable and clean energy – space is already pioneer in the use of clean solar power. National agencies are in the process of conducting studies on setting up solar power plants in space.

3) Responsible consumption and production – International Space Station is a prime example, with 93% of water and 40% of oxygen being recycled. There are additional studies in place to look at further reutilizing astronaut by-products.

The United Nations Office of Outer Space Affairs (UNOOSA) is actively involved with projects including costal management and marine systems, space for disaster management, Kibo-cube (university led launches from the ISS) and projects on space law and policy. It is also working on bridging gaps between especially when it comes to the global digital divide.

Looking at Earth Observation, it has been around since 1946 and was primarily driven by military technologies. Over time this has become part of the civil, military and commercial domain. Primary uses have also evolved from military and research to more commercial ventures. The amount of data we collect has rapidly expanded over time and can be classed as either open (public) or private data. This expansion has also introduced a number of new players and new markets for spatial data, such as manufacturers, launch services, supply chain for small satellites, IT and midstream infrastructure, EO data providers and off-stream companies.

Space has always been good for generating data sets, and data is key. Going forward, artificial intelligence will play a key role in providing actionable insights from the vast amounts of data being collected today. While there some ethical concerns around the development and use of AI, there are already studies in progress to align the national and commercial interests while preserving personal liberty and freedoms.

Earth Observation is transforming rapidly, and has an ever-increasing market for applicable services. Big Data and AI will help humans better monitor and predict everything from serious weather events, sea level increases to disaster relief and provide decision makers with a way to make evidence-based decisions on national, regional and global policy.
The Outer Space Treaty (1967) and the Liability convention (1972) make States liable for damages caused by space objects owned/operated by national entities or private companies authorised by the State. In 1991, Luxembourg introduced the Law on Electronic Media, which set the first rules on the authorization and supervision of space activity. The law would help guarantee that only experienced and financially stable companies conduct space activities. The problem was that this was limited to satellite broadcasting.

In 2016, Luxembourg announced the spaceresources.lu initiative that positions Luxembourg as a pioneer in the exploration and utilization of space resources. This initiative has attracted operators and researchers alike leading to an exponential expanse of space activity within the country.

This brought its own legal concerns, such as how does one authorize and supervise such missions? To alleviate this, in August 2017 the ‘Law on the exploration and use of space resources’ entered force. The law’s scope is defined as “missions of exploration and use of resources for commercial purposes”.

Article 1 states that ‘resources are capable of being appropriated’. Articles 2 through 18 go on to clarify the obligatory authorization requirements, domicile and registration requirements of an entity within Luxembourg, risk assurance through personal financial means or insurance policies, responsibility of operators for any damage caused, sanctions that can be imposed on owners/operators and the ability of the courts to declare discontinuance of operations that contravene provisions of the present law.

In addition to the above, a draft of the ‘general space law’ was submitted to the Chamber of Deputies in June 2018. The scope was defined as, all space activities of Luxembourg (from the territory or installations under the jurisdiction of Luxembourg, and by natural and legal persons of Luxembourg), with the exception of space resources activities. Like the law related to space resources the ‘general space law’ defines the need for obligatory authorization of activities, insurance/financial requirements for covering risk, applicable sanctions and the possibility to take measures to avoid any risk to security, environment and the international liability of Luxembourg (including the deorbiting of a space object).

The new space legislations of Luxembourg, contribute to the transparency of the authorization procedure. They act as a replacement for the 1991 Law on Electronic Media, and directly contribute to the process initiated under UN Resolution No 68/74 on national legislation.

All in all, the Law can be a significant factor influencing international competition.
Discussions with the Audience

Moderator: Niklas Hedmann, United Nations Office for Outer Space Affairs (UNOOSA)

Q: We have an interest in helping develop international space law. Could the University of Luxembourg contribute in drafting a new space treaty? Could we assist in or hold preparatory meetings with the UN and other interested nations to facilitate discussion on revising the space treaty?

A: The University of Luxembourg is already involved in this process. Hague working groups are currently elaborating on a document that could work as a solution to the future of space resources. There are informal working groups that already bring together academics, industry and legal experts along with decision makers.

Real discussions will happen at the United Nations. Current discussions are primarily between specialists, with a request to UN OOSA to further open the dialogue to external players.

Moderators note: The legal-subcommittee is processing discussions on space resources. There will be structural debates in 2020 that may lead to future working groups.

Q: What (unique) role can Luxembourg play in the future, spin-ins/outs for other exploration opportunities?

A: Luxembourg has demonstrated that it is an active and proactive member of current discussions. They are active in the legal-subcommittee and their support for university-led research. Luxembourg acts as a motivational force for other actors and entities to proactively contribute in a global discussion.

The background around the political discussions for the space resources sector, was the idea of creating a new niche i.e. space mining. While there were suspicions at first, especially around the appropriation of resources; the focus shifts from mining to space resource utilization has proved rather beneficial.

There has been a shift in the political discussion within Luxembourg in the last two years. It is important for Luxembourg to collaborate in discussion groups and other fora, ensuring that the development of the space sector works for the common/greater good.

Q: The ethical point of law – mass observation is a possibility because of the use of satellite technology. How do we consider the two objectives/goals of data protection and security together?

A: When considering Data, we talk about data use and the automatic use of data. It is important to ensure that data is protected, and there is always a legal framework that supports data protection. As an entity that processes data, there is a legal obligation to only provide requested data.

In order to protect people and data, we need to share enough data to be able to filter data properly. A way to achieve this would be to have a data register, that explains how data is collected, analysed and the different processes involved.

This is an important initiative, and there needs to be a change in the way data is communicated, especially as space is still a highly technical domain. The technical aspects of the way it is
communicated is often a case for concern among journalists and parliamentarians. Parliamentarians have the responsibility to effectively communicate this technology with citizens, and as such there need to be better tools in place that enable parliamentarians to publicise the technologies and raise awareness.

This is a big topic of interest for the Luxembourg parliament. There is an importance in capacity building by discussing such topics in schools and universities. The more we know about these topics, the less we’re scared/afraid of them. It is an investment into our future.

**Q:** Space is an infinite market, with an unlimited growth for profit. How do we ensure that the wealth created by space exploration is shared equally? How to ensure that space exploration does not create a dystopian future? Will here be a fifth pillar of space diplomacy to ensure that space doesn’t benefit the few but the many?

**A:** The Luxembourg parliament is keenly aware of this issue. There is a risk to this market, which is without boundaries, especially if the market is appropriated by a limited number of actors. We must switch our mind-set to look at the greater good, and be careful and cautious with how we approach this as politicians and parliamentarians.

Massive steps have been taken in the last 10 years to provide free access to data. Utilization of data that is now free and open has benefited many institutions massively as the same datasets would have been upwards of $3000 before. There is a greater emphasis on building capacity and infrastructure so that people can actually deal with the data in hand. It’s not just about the providing free data, but ensuring that partners are educated in utilizing said data.

This is regularly discussed in the space resources working group. The operators should seek all possible means to allow other(s) to participate in projects.

**Moderators note:** In relation to the point above, developing countries often have access to data, however they don’t always have the resources to process and understand the data.

**Q:** At the intersection of space observation and privacy – is it possible to observe citizens (personal data)?

**A:** There was an attempt a few years ago in the European Union to setup a resolution on the use of High-Resolution data. This is already regulated by countries themselves (who are owners of such systems) and there are a number of national laws enacted/applied that stipulate how EO data can be used.

On the issue of consent, there is clearly a huge are of research with regards to ethics and EO especially when we consider the use of artificial intelligence. If we were to collect the data once and use it multiple times, while there is reduction is cost, it does raise a question of ethics.

From a legal perspective, there is already European legislation in place. If collected data allows you (an individual) to be identified, you are required to provide consent prior to use. If the data cannot identify you (an individual) it is technically free. There is also a difference between right of access versus right of privacy. Copernicus regulations for example state that there are limits to free access, especially for high-resolution data. This is primarily to protect the privacy and the integrity of citizens.
Q: During the keynotes a reference was made to the direct/indirect impact of space technology in achieving the 17 sustainable goals. Is there a risk to over-prioritise certain goals? This is a sector driven activity with different sectors dealing with different aspects.
A: At present there are 3 key indicators
1) Have data
2) Have algorithms but no data
3) Have no data and no algorithms

The risk today is introduced by the complexity around measuring the targets, which in turn means that certain points on the agenda might get left behind.

Q: Who is accountable for failing the UN sustainability goals? There isn’t much progress because no one is accountable?
A: The sustainability development goals are a balancing act. Space, especially remote sensing helps provide tools to work on this balancing act. The path to reaching the goals is as important as the goals themselves. We are all collectively responsible, we are making efforts to understand where the failings might lie. There are pros and cons to all sustainability agenda at the UN, as they need to be agreed by all 193 member states and are often political agendas.

Q: There is issue in communication – space community, user community, end users. Do you see problems in this communication?
A: The disconnect exists because of the complex nature of space development. There is a current deficit of knowledge. While in most cases things start with a use case, space usually starts with capability. Engaging with users and bridging communities is critical. We are currently measuring the impact of technology but not necessarily the value it provides to the user community and the end user.

A way to solve this is education. Large number of satellites lead to a large amount of data. Translating technical messages to user appropriate messages is very important, this also applies to governments (as users) since they are already using available resources. The JRC hosted a one-day event that brought together 40 farmers from member states, forcing them to think differently and deliver a user centric message.

In addition, there is a move to try and bring together space technology family with all sorts of users. Although in its initial phases, ESA and the EC have put in place provisions for users to adopt and apply space technologies.

Q: Could European countries lead a cooperation movement so no European country is left behind?
A: Legislation (national space law) is the responsibility of member states. There are several European countries that already have comprehensive state acts that regulate national space activity already, and there is already a very strong cooperation within Europe.

**Moderators comment:** UNOOSA is actively looking at capacity building in space law and policy.
Panel I: EO for a sustainable Luxembourg

**Topic:** The use of Earth Observation for land management, weather and disaster management (floods).

**Proposed discussion items:**

1) There is a lot of potential for the use of EO data in the public sector, but for the moment there is only a marginal use.
2) What are the barriers to foster the use of EO data?
3) What should be done in a legislative way to increase the use of EO data by public administrations? For example, EU law impulses the use of EO data for Common Agriculture Policy (CAP) and yet disparities in member states exist regarding skills and capabilities. What are the best practices?
4) How can the private and public sector synergise to create an EO market? For example, is there an opportunity to include in the short-term future a Luxembourg’s Office of Science and Technology Policy? What are potentially interesting applications? Other opportunities? Show stoppers?
5) Is there a need of a legislative change to uptake R&D in the private sector to push for innovation in Luxembourg’s EO sector? For example, in the Réglement Grand-Ducal of 1996 only public institutions and non-profit organizations can lead research projects.

**Moderator:**
- Geoff Sawyer, EARSC

**Speakers:**
- Prof. Lucien Hoffmann, LIST, Luxembourg
- Steven Krekels, VITO, Belgium
- Anne Peschon, Ministère de l’Agriculture, de la Viticulture et du Développement rural
- Guy Schumann, RSS-Hydro, Luxembourg

**Panel Discussion:**
- Anne Peschon, Ministère de l’Agriculture, de la Viticulture et du Développement rural
- Guy Schumann, RSS-Hydro, Luxembourg
- Martijn Houtepen, Skygeo, the Netherlands
- Steven Krekels, VITO, Belgium
- Prof. Lucien Hoffmann, LIST, Luxembourg
The Value in Earth Observation

Geoff Sawyer, EARSC

The European Association of Remote Sensing Companies (EARSC) is a membership based non-profit European organization based out of Brussels. It coordinates and promotes the activities of European companies engaged in delivering EO geo-information services. EARSC currently comprises of 120 EO companies from 24 countries.

EARSC is setting up a process to help businesses and researchers to bring the results of their work in to commercial realization under the initiative ‘From Research to Business’. The initiative includes expert support for researchers and innovators, from whatever their background, to access the most relevant support available for the stage of maturity which they have reached. The introduction of the concept of Exploitation Readiness Level (ERL) reflects the level of maturity of technical solutions, business plan, exploitation roadmap, marketing material, successful demonstration and successful sale amongst many others.

A 2019 survey into the state and health of the European EO service industry, showed an involvement of 515 companies, supporting 8396 jobs and generating over 1.2 billion euros in revenue, with a steady growth rate of just over 10%. Its Sentinel benefit studies, measure the impact of EO-based services using Sentinel data throughout the value chain. It has conducted a number of full and short (in green) case studies as illustrated below.

The value-chain methodology used, ensures direct/indirect beneficiaries include the whole value chain stakeholders including the vast support industries. An example of this is shown in the illustration below.

Source: EARSC
While Luxembourg is becoming a space champion in areas such as space mining/resources and communication, there are a number of applications using EO that are relevant to a country of its size. As the government is a legitimate and important user of space technology, investing for the future is critical.

Source: EARSC
Copernicus is a flagship program for the European Union, that monitors the Earth, its environment and ecosystems, prepares for crises, security risks and natural or man-made disasters. It adopts a full, free and open data policy and is a tool for economic development and a driver for the digital economy. In addition, it also contributes to the EU's role as a global soft power.

From the beginning of the program and up to 2020, the total investments in the Copernicus are forecasted to reach EUR 7.5 billion. Over the same period, this investment is forecasted to generate an economic value between EUR 10.8 and 13.5 billion. This economic value is generated through the added value created in the upstream industry, the sales and transformation of Copernicus data by EO companies (downstream industry) and the exploitation of Copernicus-enabled products by end users in various economic sectors. The estimated monetary benefits of the program between 2008 and 2020 are illustrated below.

Source: European Commission

The Luxembourg Institute of Science and Technology (LIST) currently has a number of departments using space data for biodiversity, land management, disaster management (flood management) etc. Copernicus is user driven, i.e. users develop the requirements of what they need/require to improve their business as illustrated below.
Collectively the Sentinel - 1 and Sentinel – 2 satellites contribute to land monitoring, marine environment monitoring, emergency management, climate change monitoring and security services.

Copernicus is a very important program that helps the EU in fulfilling its policy objectives, such as protecting people and assets, monitoring the environment, advancing environmental policy, fostering downstream applications in a number of fields, helping in managing emergency and security related situations and facilitating adaption to climate change.
International Case Study

Copernicus Sentinel data use for potato farming in Belgium

Steven Krekels, VITO, Belgium

VITO looks at how we can use technology to make a faster transition to sustainability. This in part can be achieved by de-risking current technology and the risks associated with emerging technologies. It operates in 5 key research domains; energy, materials, health, chemistry and land use.

VITO helps provides objective measuring of data from a number of sources for key markets such as agriculture, land use and biodiversity, climate, water and coast along with infrastructure and security as illustrated below.

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*The Belgian Potato case*

The potato industry is a growing industry in Belgium. Due to the quality of the soil the yield per acre is much higher (almost triple) in Belgium than in China, which is the largest producer of potatoes in the world. Potato processing (as a raw material) has risen steadily since 1990, with over 5 million being processed in 2018 as shown below.
Due to the size and commercial importance of the industry, Belgian potatoes are monitored during the growing season from space using EO. Data is provided, to insurers, banks and factories that rely on growth yields. Remote sensing has helped enable further digitization of the potato value food chain as illustrated below.

Utilising space-based data has helped develop a digital platform for agriculture (WatchItGrow), that helps improve quality and quantity, rebalance profits via transparent information, deliver automatic crop advice and enable precision agriculture thereby reducing fertilizer and irrigation requirements.

Source: Vito
European policy around agriculture is very strongly regulated. In 2017 member states were encouraged to use Sentinel data for agriculture monitoring. In 2018, the regulation was modified to allow member states to conduct classical (spot) checks by a procedure of regular and synthetic observation, tracking and assessment of all eligibility criteria commitments and other obligations which could be monitored using Sentinel images.

LEO4CAP was initiated in 2019 to evaluate the performance of an operational monitoring system for Luxembourg. It would analyse available EO time series for crop type mapping and agricultural practice detection, by using appropriate algorithms and machine learning processes. It would process applications within the selected schemes along the 2020 season in order to provide compliance verdicts and adjust algorithms. Doing so would develop an understanding of the technical system requirements for an operational system and acquire knowhow through training on the job in the 2020 season.

The project is being conducted in partnership with the University of Louvain la Neuve, over a period of 24 months in 2 phases. Starting in June 2019, the project will use data from 2017, 2018 and 2019 along with Sen4CAP data. The selected use cases are as below.

1) Crop type mapping and crop diversification
2) Permanent grassland ploughing detection
3) Detection of catch crops (crops that are only used in winter)
4)Parcel delineation check and land cover classes mapping.

The project aims to have an automated system to verify farmer declarations throughout the season(s) using Sentinel imagery. The project performance evaluation is based on the processing of sentinel images (sentinel 1A/2A and 1B/2B), defining a ‘feature of interest’, marker definitions (period of occurrence, presence/absence, importance) and scenario definition (behaviours of a specific marker in specific agricultural cases).

The purpose and function of monitoring is to improve sustainable development in farming. In a policy context, this helps shift from a compliance based to performance-based CAP model, in turn moving away from control and penalties to helping farmers comply with their obligations by providing early warnings. The system can be used to report on area based indicators, advancing environmental and climate policy, management of farming activities including precision farming, monitoring agricultural resources and providing a farm advisory system.
The use of Copernicus data in flood management and disaster assistance

Guy Schumann, RSS-Hydro, Luxembourg

Floods are extremely disruptive and are currently increasing in annual cost, with most societies still having a very low resilience to impact. Although a number of data streams and products are available, response and recovery are still not supported by all available data. Further research and innovation are needed to make products and services more interoperable and actionable. There is also a need to work with emergency management and response teams for effective validation of EO products and services during disasters in Luxembourg and elsewhere.

In order for Luxembourg to be a flood ready nation, it should consider the following key areas.

1) Knowing and monitoring the hydro-meteorology
2) Understanding the hazard
3) Formulating the risk
4) Building a resilient society
5) Being prepared
6) Open data
7) Innovation – science driven products and services
8) Research based analysis

In the past, flood mapping activity was limited to research institutions as free imagery was difficult to obtain. Now there is abundant data available in regards to remote sensing of floods, from ESA, Japan, Germany and the United States.

When considering Sentinel data vs models, there is a fairly good agreement of optical EO and radar EO models, but SAR under-detects in densely vegetated and urban areas. Models also tend to overestimate the extent of flooding when topography is not well represented. More recently however, although most of the algorithms applied are still pretty much the same, what is different now is the free (open access) imagery and a proliferation of sensors that allow a rapid and large-scale mapping and archiving.

There is now a more coordinated and rapid response effort in place. An example of this are the Louisiana floods of 2016. Once the disaster charter was activated, almost every agency with a satellite (especially SAR) posted imagery. Mapping from all major players was coordinated and disaster response was assisted effectively through a satellite monitoring timeline with emergency services on the ground collecting data to aid in rescuing people.

Looking at the future, we need to able to map floods better, faster and more reliably; have a better understanding of the relationship between big data and potential AI based algorithms that can assist; address the cloud cover challenge in optical/IR imagery; and lastly be innovative, interoperable, fast and reduce servicing latency.
Panel Discussion

Q: When using the data from the sentinel satellite, is the user (say farmer) using the data directly or they relying on a company to process the data?
A: VITO analyses the data; on an individual field level the farmer has full ownership. On an aggregated scale – the data is distributed as the data is not tied to a single parcel.

Q: What is the governments approach to these technologies - will this add an additional admin burden on the farmer?
A: We try to reduce the burden on the farmer. Technologies need to be in place that allow the farmer to provide information with a minimal overhead to the farmer. It is also import to build an advisory system to assist the farmer in this process.

Q: What is the prospect of using GNSS and distributed digital technology?
A: It is a digital platform. The source is usually an implementation. There is cost associated with the information and while it is possible to do more it depends on financial viability. Their needs to be an integration of data streams into functional processes, but organizations usually have an issue adapting to change in processes. There is a growing need for evidence-based policy making, with satellite data being a tool that can be used to facilitate and validate decision making.
Panel II: Global Navigation Satellite System (GNSS) for a sustainable Luxembourg

**Topic:** The use of GNSS for mobility, transport and land.

**Proposed discussion items:**

1) The participation of the private industry in the use of GNSS is minimal in Luxembourg, yet important for the future of smart cities and mobility. What is the role of the government in fostering such innovation in GNSS applications? Who can define the standards at a European level?

2) Should the EU define minimal standards for the use of GNSS services in member states?

3) Should the government be responsible for safety in the use of new technologies using GNSS such as autonomous cars? Or will be the responsibility of the private sector?

**Moderator:**
- Prof. Mahulena Hofmann, University of Luxembourg, Luxembourg

**Speakers:**
- Prof. F. Norman Teferle, University of Luxembourg
- Omar I. Valdés Solorzano, European GNSS Agency (GSA)
- Marti Jofre, Pildo Labs, Spain
- Bernard, Reisch, Administration du cadastre et de la topographie, Ministère des Finances, Luxembourg

**Panel Discussion:**
- Bernard, Reisch, Administration du cadastre et de la topographie, Ministère des Finances, Luxembourg
- Prof. F. Norman Teferle, University of Luxembourg, Luxembourg
- Omar Ignacio Valdes Solorzano, European GNSS Agency (GSA)
- Marti Jofre, Pildo Labs, Spain
- Juan Carlos Merlano Duncan, SnT, University of Luxembourg, Luxembourg
Introduction to GNSS

Prof. F. Norman Teferle, University of Luxembourg

GNSS is an abbreviation for the global navigation satellite system and is the general term for such systems. All GNSS networks consist of a constellation of satellites orbiting the earth in various planes and inclination planes. Depending on the constellation design the satellites orbit between 190000 and 240000 kilometres. The key components of these satellites are the signal generators, the antenna, processing and communication units and the atomic clocks. Ground control station back on Earth are used to compute satellite orbits.

At present there are five key GNSS systems in active service, GPS by the United States\(^1\), GLONASS by the Russian Federation\(^2\), BeiDou by China\(^3\) and Galileo by Europe\(^4\). In addition to these India\(^5\) and Japan\(^6\) have regional systems which are interoperable with both GPS and Galileo.

GNSS uses a satellite-based augmentation system (SBAS). This is a civil aviation safety-critical system that supports wide-area or regional augmentation through the use of geostationary satellites. SBAS broadcast the augmentation information, with the primary aim being to provide integrity insurance, which in turn increases accuracy.

In order for GNSS to work, satellites transmit microwave signals in 2 or more frequencies. These signals are received by user devices and then tracked, thereby providing information on satellite position and satellite time at signal transmission. A GNSS observation is a time measurement, i.e. how long did the signal travel from the satellite to the receiving device.

There are essentially two 2 observation modes for GNSS signals. Codes (pseudo-ranges) are straight forward and fast. Can be achieved by using cheap microchips, however are not very accurate. Carrier phases on the other hand use a minimum of 2 signals and require more complex devices providing millimetre to centimetre accuracy.

GNSS is ubiquitous, as evident with over 6 billion GNSS units in use globally. Up to 7% of Europe’s GDP, roughly 800 million euros, is directly dependent on GNSS. Applications are manifold and often grouped into Navigation (meter to decimetre level), Positioning (centimetre to millimetre level), Time measurement (Pico seconds to 0.000000000001s) and remote sensing.

GNSS is an enabling technology that has penetrated much of our professional and non-professional lives over the past 30 years. GNSS and positioning accounted for roughly 60% of the Geospatial market in 2019. There is a growing demand for location-based services as there is further proliferation of mobile devices. Industries such as agriculture, aviation and intelligent transport systems provide a growing need for GNSS. Without GNSS services like the internet, mobile telephony and electronic money transfer would cease to exist. The table below illustrates how GNSS supports innovation and technology development at present.

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\(^1\) See further: [https://www.gps.gov/systems/gps/](https://www.gps.gov/systems/gps/)
\(^4\) See further: [https://www.gsa.europa.eu/galileo/programme](https://www.gsa.europa.eu/galileo/programme)
\(^5\) See further: [https://www.isro.gov.in/irnss-programme](https://www.isro.gov.in/irnss-programme)
\(^6\) See further: [https://qzss.go.jp/en/](https://qzss.go.jp/en/)
Internet of Things (IoT)  A major development in the role of the internet, the IoT allows physical devices, vehicles, buildings and other objects to be interconnected and controlled remotely across network infrastructures. IoT is relying on a wide range of different sensors and technologies, one of them being GNSS which provides localization and timing information.

Big Data  With traditional data processing unable to deal with the skyrocketing volumes of data that are produced every single day, complex systems are being created to allow for big data processing. GNSS is a major data source providing location and timing information to the world of Big Data. The proliferation of GNSS devices is boosting the quantity of location and timing data.

mHealth  Mobile Health (mHealth) is a sub-segment of eHealth and covers medical and public health practice supported by mobile devices. Key mHealth application categories include disability assistance, preventive medicine and emergency, and leverage fusion of big data with GNSS.

Augmented Reality (AR)  AR integrates digital information with the user’s environment. Unlike virtual reality, which creates a totally artificial environment, AR uses the existing environment and overlays new information on top. GNSS provides a globally available source of georeferenced information that brings augmented reality into the open. GNSS allows the creation of a direct link between the surrounding reality and digital objects.

Smart Cities  Smart Cities feature an integrated system for collecting, measuring, collating and broadcasting city data and for making it easily accessible to citizens, municipalities and city planners. GNSS is one of the key technologies used within infrastructure design and mobility of smart cities, offering numerous opportunities to citizens, local governments and city planners.

Multimodal Logistics  Multimodal logistics refers to the transport of goods by at least two different modes of transport in the framework of a single multimodal transport contract. Logistics service providers draw on GNSS for efficiency, security and safety. GNSS contributes to the monitoring of cargo along the entire supply chain and enables pivotal assets management applications.

A lot of value associated with Big Data purely relies on the location information obtained from GNSS. A growth in GNSS science applications such as meteorology, climatology and hydrology will help provide further accuracy and long-term consistency for current models.
Omar I. Valdés Solorzano, European GNSS Agency (GSA)

The European GNSS Agency (GSA) is responsible for market development and operations of Galileo and EGNOS. The GSA’s mission is to support the European Union objectives and achieve the highest return on European GNSS investment, in terms of benefits to users and economic growth and competitiveness.

Europe has 2 GNSS systems, Galileo and EGNOS or the European satellite-based augmentation system. Galileo is currently operation providing initial services. It consists of a constellation of 24 satellites with an addition 6 spares. Galileo provides 3 core services, OS, PAS and SAR. Like Galileo, EGNOS is operational and currently provides initial services. It has a nominal constellation of 3 payloads in geo-stationary satellites. It is widely used in applications requiring high accuracy at low cost and is suitable for safety-of-life applications.

A growing area for EGNSS applications is smart cities. Cities have a sizeable impact on our environment. As of 2014, 54% of the world’s population resided in urban areas. By 2050, 66% are predicted to be living in cities. Currently cities consume 75% of the world’s resources and energy, generate 80% of greenhouse gases and occupy only 2% of the world’s territory. The consequences of urbanization will get worse unless we make a difference in how cities operate. Smart cities help reduce public spending, increase efficiency and quality of service, provide support in decision making, promote innovation and provide information in real time. E-GNSS applications in smart cities include, smart city asset management with virtual reality applications, monitoring cultural heritage sites, management of parks, augmented reality applications for tourists, smart mobility solutions, provision of energy alerts and many more.

GNSS is either the paramount tool or a key enabler of many geomatic applications. As traditional surveying undergoes a rapid transformation, geomatics is an important cross-sectoral enabler. Galileo provides unique differentiators to the geomatics industry. The key challenge here is the integration of the different data together and translation of this ‘data package’ into actionable information.

GNSS is a core component in the digital farming ecosystem, enabling and supporting services such as precision farming, swarm and autonomous machinery, internet of things and drones.
While it is one of many elements in the complete production ecosystem, it is an eminently important one.

EGNOS provide affordable solutions for precision farming over Europe. It is an affordable entry-level solution for precision agriculture. It enables farmers to optimise yields, increase labour productivity and reduce driver fatigue, all with minimal investment. It supports machinery guidance solutions with sub-metre level accuracy which is suitable for basic-value crop cultivation. It also provides efficient management of farming activities such as spreading, spraying and harvesting.

Farmers across the globe can also strongly benefit from the added-value enabled by Galileo. Galileo provides improved positioning and timing information. As part of the Galileo open service, the signal design and multi frequency capabilities contribute directly to better operations, increasing availability, reliability and accuracy. As part of the High accuracy service (HAS), it is the only constellation offering ‘Free’ global high accuracy service directly from satellites without dependency on the internet or additional communication channels. The authentication service will offer increased robustness to spoofing thanks to its signal authentication service (SAS) and the open service navigation message authentication (OS-NMA).

With a budget allocation of over 100 million Euros, the GSA is looking to foster development of innovative applications for the use of EGNOS and Galileo in different market segments.
Luxembourg case study

The use of GNSS in the Land Registry and Topography Administration

Bernard, Reisch, Administration du cadastre et de la topographie, Ministère des Finances, Luxembourg

GNSS or the Global Navigation Satellite System enables one to track position based on longitude, latitude and altitude using a single GNSS receiver in real time. An average smartphone, acting as a GNSS receiver can provide navigational accuracy of up to 10m which is sufficient for over 75% applications.

However, there is a need for significant higher accuracy in order to create state of the art reference data for geodesy, topographical mapping including digital terrain and elevation modelling for flood prevention, land registry (covering property rights and regulated zones for environment and construction) and cross reference datasets enabling monitoring of SDGs on a global scale and global geospatial information management systems.

This higher accuracy also driven by industry needs in fields such as civil engineering, agriculture and smart mobility. We can argue that there is now a growing need for highly accurate reference and positioning data to be available in real time in a globally standardized format.

High precision positioning can be achieved by using either differential GNSS or precise point positioning. A differential GNSS system uses a satellite-based augmentation system (SBAS) and ground based augmentation services. The ground-based augmentation services are based locally or nationally, and either post process or provide real-time transmission of correction parameters. In the latter, we model GNSS system errors by using data generated from a global reference network.

GNSS has been in use at ACT in Luxembourg since 1990. The enhanced real-time GNSS service (SPSLux) was offered as a free public service by ACT in 2005. SPSLux started in 2005 with 6 (GPS only) stations, as a private public partnership with CREOS. It supported 30 maximum users connected via GSM/modem. Its legal mission was to provide a free public service providing real time kinematic correlations allowing 1-2 cm accuracy in position and 10cm accuracy in height on a national level as a 24/7 service. In 2010 SPSLux integrated 3 stations in neighbouring countries and upgraded to include GLONASS. In 2020 it aims to update services to support, GPS, GLONASS, Galileo and BeiDou.

Its current reference stations are equipped with state-of-the-art choke-ring antennas, mounted on pillars. The open horizon assures full visibility to satellites. The images below show the network design for the GNSS Data streams (left) and the real-time user interactions (right).
Between 2005 and 2010, the primary users for SPSLux were researchers and surveyors working in land registry, topography, GIS and construction. Since 2010, the user base has increased to include network operators (electricity, water, gas), local entities, fleet management, agriculture, UAV and many more. The current user base is roughly 700 and showing constant growth.

RTK-Network solutions are state of the art, indispensable for real-time high precision positioning and only at the beginning of their economic involvement. The future outlook for SPSLux here is the evolution towards multi-sensor data fusion, but the key challenge will be to analyze and evaluate these datasets in real-time with the highest possible accuracy.
Panel discussion

Q: How do we protect our satellites from interference, especially as they are so heavily relied upon and are a key economic asset?
A: There is currently a product called Fenix that helps with this exact issue. It allows devices to decode jammed signals and splits the GNSS signal from the interference signal using a combination of pattern mapping and pattern recognition.

Q: How far is the Galileo operational? Do we need end user installations for operations?
A: Galileo is operational and currently provides about 95% probability of (devices) systems using a minimum of 4 Galileo satellites. It is interoperable with other GNSS platforms and transmits in the same frequency range. In terms of a device, you’ll need one where Galileo has been enabled.

Q: How ready is Luxembourg to use GNSS data?
A: SES will be updating systems in 2020 and should be ready to use Galileo data at that stage.

Q: Can a company stop a device from getting a Galileo signal?
A: The FCC authorises all devices as they are classed as receivers. Galileo has received a waiver from the FCC in 2018 for E1 and E5, with E6 still pending. Galileo was the first constellation to receive a waiver under FCC rules.

Q: How will Brexit affect Galileo?
A: Galileo runs under ESA, so in that sense there should not be an impact. On the other hand, one of the first things the UK did was to look at how quickly could they build a constellation themselves. Given the UK’s involvement in the programme they may be able to achieve this for about 40 billion with little to no additional research.

The owner of the system is the European Commission. The EC hires ESA for the development of the system. Once the systems are developed the GSA takes over the operations of the system, as ESA is not an EU institution.

Q: What is the role of governments/organizations that support R&D nationally in ESA projects?
A: The European commission launches research and development proposals (calls) under the Horizon 2020 program. These calls are maintained by the GSA for downstream projects and directly by the commission for upstream projects. The last call under this scheme will take place in November 2019.

Member states provide a financial contribution to the European Space Agency. The contribution is returned to member states in terms of projects and supporting national programs. Some national funding agencies also contribute to projects that use/rely on GNSS.
Conclusions

At the end of the conference the following conclusions were discussed and approved:

1. The aim of the event was to analyze the potential of the key European space projects for the society of Luxembourg in an interdisciplinary manner.
2. The participants learned that there were already several important projects which are using space-based information in Luxembourg, also by public authorities.
3. The Members of the Chamber of Deputies present in the event were impressed by the technical capacity already installed and noticed that its use has still to be promoted. They were also informed about already existing inspiring applications in other European countries. Some MPs saw also a great potential in improving the efficiency of many economic activities by using satellite-based applications.
4. Given the great potential of space-based capacities that still needs – with some exemptions to be discovered, it is crucial to inform their future users about these possibilities in a targeted manner. In the educational process, the University of Luxembourg is and shall be an essential player through its Master programs, Faculties and research centers, together with other educational institutions.
5. The intense relation between industry and research in Luxembourg should be continued.
6. The European Union plays a significant role in spreading the information about the practical implications of the EU projects Copernicus and Galileo; the event “Science Meets Parliaments” is one of these opportunities to raise awareness of these programs.
Annex 1

Organisation team (in alphabetical order)

-University of Luxembourg
Laura Bianchi
PJ Blount
Sandra Cabrera Alvarado
Michele Gouverneur
Mahulena Hofmann
Maria Karavasili
Gabrielle Leterre
Chloe Maquet
Athanasios Mavroulis
Antonino Salmeri
Sandra Schwarz

-LIST
Lucien Hofmann

-Luxembourg Space Agency
Gregory Martin
Dovile Matuleviciute
Lynn Robbroeckx
Marc Serres

-Chamber of Deputies of Luxembourg
Claude Frieseisen
Timo Oesch

-Rapporteur: Tannay Sharma, University of Sussex