Satellite applications for infrastructure maintenance in cities

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The Nordic Edge Expo

What makes a city smart? For the private companies and the local administrations participating in the Nordic Edge Expo, a smart city is a place where communities' needs, new technologies and innovation meet. An ecosystem of urban planners, IT and renewable energy companies, community development experts, universities, research clusters, and residents, pursuing the common goal of building the city of the future.

In Nordic countries, the main themes at stake are technological education, support to entrepreneurship, attractive public spaces, efficient services and citizens' participation. In Norway in particular, the issue of "smart cities" is seen as an opportunity to both increase the efficiency of public services and to find new markets for local companies. Indeed, Innovation Norway, the Norwegian government's main instrument for innovation and development, mentions "smart cities" as one of the six emerging markets with the potential to help the Country face the expected decline in exports from oil and gas[1].

Regional and international collaboration is an important element to both export the "Nordic model" and to gather ideas from other contexts. Indeed, the event also featured experiences from other countries, such as Germany, Spain, France, and even China, with several presentations on current efforts to reduce the impact of Chinese cities on the environment.

Among the dozens of technological solutions presented at the Expo, many rely on satellite applications: satellite imagery as a first layer to build Geographic Information Systems (GIS) to monitor green areas, place solar panels, monitor water levels and the environmental impact of hydropower stations in the fjords, or to respond to flood risks; satellite navigation (Sat Nav) embedded in apps highlighting parking spaces, or in vehicles transporting hazardous goods, in connected streetlights and in all kind of sensors to monitor air, noise or passers-by.

Indeed, satellite applications have a role to play in the building of more sustainable, efficient and increasingly connected cities. This was the message of the speakers of the session organised by Eurisy on the last afternoon of this three-day event.

[1] Innovation Norway website: http://www.innovasjonnorge.no/no/mulighetsomrader/

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The Eurisy session: Satellite applications for infrastructure management

The Eurisy session, lasting one hour and a half and focusing on Satellite Applications for Infrastructure Management was organised under the Eurisy Space for Cities initiative, aiming to explore current and potential uses of satellite-based services to increase quality of life in cities.

Keynotes

Anja Strømme, Senior Advisor on Earth Observation at the **Norwegian Space Centre**, opened the session talking about "**Satellites for Smarter Societies**".

Anja underlined how satellite applications are essential to many of the hot trends presented in the context of smart cities, the Internet of Things (IoT) in particular. Indeed, satellite navigation has already found its way into many devices and digital services used in cities to locate measurements about pollution, soil movements, etc. Things that we need to ensure the sustainability of our cities.

Moreover, with an increasing number of Galileo satellites becoming operational, satellite navigation signals will become much more precise and reliable, improving existing services based on Sat Nav, and enabling the creation of new applications in cities and elsewhere. Norway has been an early adopter of Sat Nav for dynamic positioning and it is currently exploring ways to use it to enable autonomous ships and intelligent transport systems, as well as accurate indoor navigation. Moreover, satellites are not only important sources of data and signals. Satellite communications will also play a role in enabling 5G, the next generation of mobile networks, which will also help connecting remote areas.

Concerning satellite imagery, Anja considers that the great promise of Copernicus, the European family of Earth Observation satellites, is to turn research into governance. "*We are entering a new era where long, continuous, reliable and uniform Earth Observation data-series will increase and lead to a great increase in products and services*", she said.

Indeed, in Norway Copernicus data are being tested to detect avalanches (e.g. in the isle of Kvaløya in April 2017), monitor rock slides and visualise subsidence along the railway network in the Oslo area. As an example of an innovative application in cities, Sentinel data has been used to detect lawn wear's changes in the Oslo's Tøyen Park before and after the popular Øya music festival.

The challenge for public administrations at the local level is currently related to the extraction of information from the datasets made available through the Copernicus online portals. Overcoming this challenge will only be made possible by creative IT and software companies able to turn the Copernicus data into useful information.

Indeed, **supporting the downstream sector is of paramount importance for Copernicus to deliver its benefits to society**. Funds are being made available both by the space community, and

under other innovation frameworks, such as the EC Horizon2020 programme. In this regard, Innovation Norway has just closed its first call to fund projects with a satellite component relevant to smart cities and the maritime sector.

Grazia Fiore from **Eurisy** delivered the second keynote speech, aimed at presenting Eurisy, its work to connect space and society and the **Space for Cities initiative** of the association.

The survey implemented by Eurisy in 2015 on 106 European local, regional and national authorities from 19 countries, indicated that satellite applications are operationally used in the sectors of environmental protection, agriculture, risk prevention and management, transport and logistics, urban planning, water management and forestry. These observations are well aligned with the efforts of ESA, the European Commission and other international organisations who have worked to promote the use of satellite data and signals in these areas over the last decade. A majority of the surveyed administrations reported benefits in terms of time savings and improvements in the quality of the public services delivered and of the information available for decision making.

However, only 18% of the administrations taking the Eurisy survey worked at the local level. This prompted the association to launch **Space for Cities**, an initiative focusing on local administrations, private companies and NGOs operating in cities. Indeed, in Europe 72% of people live in cities. Hence, urban areas represent a privileged place to prove the benefits of satellite applications for civil society.

There are several examples of how satellite applications can increase the efficiency of public services. The Municipality of Exeter, in the UK, is using a system based on satellite navigation to optimise waste collection, saving £240k in capital costs for collection tracks and £150k in revenue expenditures each year. In Lyon (France), radiation data derived from satellite imagery was used to build and maintain a PV solar park in a new ecological neighbourhood. Here, the satellite data cost about 1% of the value of the energy annually produced by the solar systems. In Alban, a small village in the south of France, SatCom allows for the remote monitoring of the village's only drinking water reservoir. Among the many satellite-based mobile applications benefitting people living in cities, I Wheel Share, an app relying on satellite navigation, helps persons with impaired mobility to plan their routes and build a shared mobility map in real time. Moreover, satellite data can also help local authorities better manage and monitor risks to the infrastructure, like in the cities of Diemen (The Netherlands) and Lemvig (Denmark).

These are only a few examples of satellite-based services that can improve quality of life in urban areas. **For the future, the challenge will be to enable the development of increasingly efficient, affordable and easy-to-use services responding to concrete needs. The feedback provided by the users themselves, and especially the early users of the Copernicus datasets, will be fundamental to guide this process**.

John Dehls, from the **Geological Survey of Norway**, closed the keynotes with a presentation on "**New developments in the use of remote sensing data for ground monitoring**".

John explained that satellite-derived InSAR data allows for the detection of ground movements with millimetre accuracy. The Geological Survey of Norway has been using this technique operationally to detect and understand unstable landslides over large parts of Norway. Due to the new European Sentinel 1 satellites, they can now extend this activity to the entire country. Since 2014, the Sentinels have ensured full coverage of Europe, delivering inSAR data every six days. According to John, thanks to Norway's position further north, overlapping images from satellites allow for data points to be updated even more frequently. Compared to the previously existing satellites, Sentinels offer much more powerful tools to monitor subsidence and landslides. The free and open data policy of the Copernicus Programme, combined with the frequent image acquisitions, makes it affordable to monitor regions, cities, neighbourhoods, and even single buildings.

The Geological Survey offers landslide maps based on Sentinel data to a range of public and private users, such as road and railroad authorities, municipalities, the Norwegian Water Resources and Energy Directorate (NVE), and residents. Maps of ground subsidence for infrastructure monitoring are produced using the same techniques, and are suited to the needs of city planners, public utilities, SMEs, insurance companies, and individuals.

Like in Norway, other European countries, such as Denmark, the Netherlands, Germany, Italy, and France, are working to build national ground deformation maps and services. Discussions are also ongoing carried out at the European level to create a new "Ground Motion" Copernicus service. In the meanwhile, private companies are already able to access Sentinel data for free and to process it to create new tools to monitor and intervene on soil deformation. **The more the data will be exploited, the better the services derived from it will become.**

User session

Ron Kaptijn, from the **Department of Spatial Management of the Municipality of Diemen (The Netherlands)**, provided a direct testimonial from a local administration autonomously deciding to experiment with **satellite imagery to improve infrastructure management**. The city of Diemen has approximately 26 000 inhabitants, and is built on soft soil, which can sink up to two centimetres per year. To remedy, the municipality was compelled to heighten the entire public space every two years, including all roads, sewers and public gardens.

Ron himself got interested in using satellite imagery to assess soil subsidence after he heard that the technique had been used following the heartquakes in L'Aquila (Italy) in 2010. He found a small local company (SkyGeo, a spin-off from the Delft University of Technology) producing subsidence maps from inSAR data for single buildings, and convinced them to realise a deformation map of the whole Diemen's area. The map cost around €10k in 2011 and no training was needed to start using it operationally.

The satellite-based deformation map shows subsidence in millimetres for specific locations, allowing the Department of Spatial Management to prioritise maintenance work and intervene

where it is most needed. Using traditional methods (e.g. ground measurements) to assess soil subsidence would entail an effort in terms of money and time of at least ten times the satellite-based map.

As new satellites offer better resolution, the municipality is now exploring with their service provider the possibility to use new satellite data (i.e. Copernicus datasets) for their next assessments of soil subsidence.

Closing the workshop, **Lars Nørgård Holmegaard** from **Lemvig Vand og Spildevand**, the company responsible for managing pipelines in the **Municipality of Lemvig (Denmark)**. Lars showcased an experience of use of **satellite imagery to optimise maintenance work of water and wastewater pipelines.**

The Municipality of Lemvig has a population of 21 500 on an area of more than 500 km2. Lemvig Vand og Spildevand (100% owned by the Municipality of Lemvig) manages 575 km of waste-water pipelines and 580 km of drinking-water pipelines in the area. The company became interested in satellite imagery when they noticed that soil subsidence would cause pipes in Thyborøn to break faster than in the rest of the Municipality (30 years as compared to 75 years of average lifetime).

In the late '90s, the company started using InSAR data to monitor soil subsidence. In the last years, and thanks to a collaboration with the Lemvig Municipality, the Danish Costal Authority and the Danish Agency for Data Supply and Efficiency, Sentinel data were used to assess land movements in the area, documenting a subsidence up to one centimetre per year in Thyborøn.

Lemvig Vand og Spildevand is now able to better manage its assets and to position the pipes where they are expected to last longer. They are so satisfied of the results obtained so far, that they are now working to launch a modelling pipe programme that would use Sentinel data to visualise the position of the pipes dynamically. This system would increase pipes' lifetime of at least 10% and is expected to generate €500k of revenues per year.

Main conclusions and recommendations

- **Can satellite-based services help cities become smarter?** The Geological Survey of Norway, the Department of Spatial Management of the Municipality of Diemen in the Netherlands and Lemvig Vand og Spildevand in Denmark all testify that they are able to make smarter decisions thanks to the insights provided by satellites.

  Satellite data help them assess soil deformation well in advance with great precision in specific places, reducing the need for site inspections. This means that local administrations can target maintenance works where they are most needed, and have better information to plan the building of new infrastructure and works.

  Diemen and Lemvig represent great examples of how satellites can benefit the European society. Indeed, most of European citizens live in small cities and Diemen and Lemvig prove that satellite applications can be used at the local level, that they do not need large investments, and that they enable local administrations to save time and money, while ensuring better services.

- **The uptake of satellite-based services at the local and regional levels can be definitely facilitated by public administrations working at the national level**, as proven by the example of Geographic Survey Norway. Their nation-wide soil deformation map based on satellite data provides a set of information that is ready-to-use for private and public organisations working at the local and regional levels, hence allowing a virtuous transfer of tools and competences to civil society.

  It is not impossible for single local administrations to autonomously look for and to find the satellite-based services needed (as proven by the example of Diemen). Nevertheless, public administrations at the national level can use their larger resources (both in terms of money, staff and skills) to "mediate" between space data and final users and facilitate the use of satellite-based services by local administrations. In this respect, the experiences of countries providing nation-wide soil deformation maps (such as Italy, France, the Netherlands, and Germany) have proven successful.

- **Nowadays, fostering the development of efficient, easy-to-use and relevant services based on satellite applications is one of the key challenges to the full exploitation of satellites' potential.**

  From their side, European cities are building open data portals to facilitate the development of new services by local companies, start-ups and individuals. Indeed, open data is today a key concept when talking about innovation in cities: many of the technological solutions that will improve tomorrow's cities will rely on the open data made available by local administrations. As an example, an app allowing people to find parking spaces can only work if all parking spaces are connected and if information on parking spaces is collected in real time by local authorities

and placed in a publicly accessible cloud, from which apps and gadgets can drain information to be transferred to motorists.

How relevant will the data collected through satellite navigation, imagery and communication be for tomorrow's cities? Who owns this data? How easy will it be to access it and to embed it into cities' open portals? These questions remain open for discussion. Future legal, technical and administrative developments will help providing an answer. In the meanwhile, we acknowledge the successful results of using satellite-based data to monitor soil movements in cities. We also recognise the crucial role played by national administrations to enable access to satellite data, and of private companies to transform such data into operational services.