Operational uses of satellite-based applications in the public sector
A case-study review

CASE-STUDY REPORTS

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Please cite this publication as:
Eurisy (2015), Operational uses of satellite-based applications in the public sector: a case-study review – Annex: Case-study reports, Paris (France), January 2015.

ISBN 978-2-9551847-0-7

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ANNEX: CASE-STUDY REPORTS

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The case-study reports present information on the geographic and institutional frameworks in which the public authorities considered in the analysis operate, describe their internal competencies and previous knowledge of satellite-based services, the challenge or problem that prompted them to turn towards these technological solutions, the mechanisms leading to the uptake of the services, the challenges encountered to first adopt and then use them, and the benefits experienced.

Since what works in a context might not do in another, these reports are not meant to provide precise guidelines on the adoption and use of satellite-based services. Each public authority will need to adapt the satellite-based solutions, as well as the mechanisms and processes to implement and use them, according to its own requirements and circumstances.

The section on the **public authority** provides an overview of the entities' structure and mandate and of their awareness of satellite-based data and services and of available support mechanisms to use them. Key fact tables report on the nature, the area of operation, the sources of funding, the annual budget, and the number of staff of each public authority.

The section on the **challenge** describes the drives and motivations behind the adoption of the satellite-based service. When relevant, it presents key facts on the solution previously used to face the same challenge -including its implementation and operational costs- and information on the alternatives to the satellite-based solution that were considered by the public entity.

The section on the **satellite-based solution** includes information on the steps to first adopt or implement the services, on the mechanisms to procure them and the partnerships established, and on their operational use; it also reports on the challenges faced to adopt, use and sustain the services. Key facts are provided on the implementation framework, the partnerships established, and the implementation and annual operational costs of the services.

The section on the **benefits of the satellite-based solution** qualifies and, when possible, quantifies the positive impacts reported by public authorities after the adoption of the satellite-based solutions. The benefits mentioned include improvements in service efficiency and provision, monetary and time savings and positive impacts on the society and the environment.

Most of the information presented in the case-study reports is included in the previous sections of this publication as aggregated results of the analytical review.

Operational uses of satellite-based applications in the public sector

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ANNEX: CASE-STUDY REPORTS

List of case-studies

© Aurigny

Use of EGNOS to support approaching and landing at Alderney Airport

THE USER

Air Traffic Control, Guernsey and Alderney Airports Division

Bailiwick of Guernsey, Channel Islands
www.guernsey-airport.gov.gg

KEY FACTS

EGNOS provides vertical and lateral guidance, allowing pilots to land with no guidance from the ground, including under adverse weather conditions

Implementing the system cost less than EUR 20,000

To achieve the same precision with ground equipment would have cost an estimated EUR 1,278,000

Both implementation and operation of the service account for less than 1% of the Airport's annual budget

Since 2011, aircrafts landing in Alderney use EGNOS to enhance the safety and regularity of flights in adverse weather conditions.

"The EGNOS system ensures service continuity and operational safety, while also reducing workload for both airline flight crews and for the traffic controllers on the ground"

Frank McMeiken, Manager ATC, ATC Guernsey and Alderney Airports

Use of EGNOS to support approaching and landing at Alderney Airport

The context

The Channel Islands are British Crown Dependencies, including two separate bailiwicks: the Bailiwick of Jersey and the Bailiwick of Guernsey.

Located in the Bailiwick of Guernsey, the island of Alderney has a surface of approximately eight square kilometres, with a population varying between 1,800 and 2,000 inhabitants, according to the season.

Alderney's Government has created a favourable administrative and financial framework for the development of small and medium-sized businesses. The economy of the island relies mainly on fishing (responsible for the majority of Alderneys physical export market), agriculture, hostelry, construction and, especially, finance.

Tourism is also an important activity, given the beauty and range of the landscapes.

The Alderney Airport

Unique amongst Channel Islands airports, Alderney has three operational runways: the main runway 26/08 is 877 metres long and is mainly bitmac (tar-based macadam pavement); the two secondary runways are both grass, 14/32 being 732 metres long and 03/21 497 metres long (Ref. 12).

Flying is the easiest and most convenient way for transporting people to and from the island.

Aurigny Air Services, the local public owned airline, operates regular, charter and private passenger and freight flights between the Channel Islands, Western France and England.

Key facts on the Alderney Airport	
Nature	Public institution
Area of operation	Country, Local
Sources of budget	Local public funds
Annual budget	€10m - €50m (2013)
N° staff	40 (regular staff)

Reports from the UK Civil Aviation Authority indicate that in the year 2013, the airport managed more than 60,000 passengers with approximately 7,000 total movements (Ref. 16).

Regular flights are vital for the small Alderney community, since the island depends on air transport for the routine supply of goods, including post and daily newspapers, and for evacuations in case of medical emergencies (medical facilities are limited).

The Alderney Airport is administrated by "Guernsey and Alderney Airports" one of the six divisions of the Public Service Department of the States of Guernsey.

The Director of Civil Aviation (DCA) has overall responsibility to ensure the safety and security of civil aviation in the Bailiwick of Guernsey and its airspace.

Under its authority, Air Traffic Control, Guernsey and Alderney Airports, is responsible for ensuring the safe and efficient management of operational air traffic (Ref.13).

Previous knowledge of satellite services

The staff of the Alderney Airport had neither previous knowledge nor experience using satellite-based services. Satnav was used by an external company for survey purposes on the airport, but was not applied to operations.

The challenge

Weather conditions and constraints created by the proximity of French airspace, can make it very difficult even for experienced pilots to approach the runways of the Alderney Airport.

In particular, bad weather conditions regularly force operators to delay, divert or cancel scheduled flights, with negative consequences for the airline and its passengers, and also for the local economy. Public Services have been working with Alderney to identify ways to address the decline in passenger numbers and the resulting increasing deficit at Alderney Airport which, in 2011, stood at EUR 959,509 (GDP 750,000) (Ref. 10).

The vast majority of costs in Alderney Airport are associated with fire and air traffic control, and that leads on from the classification of the airport (Ref. 3).

The Alderney and Guernsey Airports have indeed the status of UK domestic airports, submitted to compliance with UK and EU legislation for procedures and safety standards.

Guernsey is in effect a British Crown Dependency and, through the UK's ratification, is a party to the Chicago Convention on International Civil Aviation, governing all arrangements for civil aviation, including safety).

The previous solution

Alderney had always had a non-precision approach (NPA) supported by a non-directional radio beacon (NDB) to support landing operations. This approach provided lateral but not vertical guidance to pilots.

Moreover, coastal refraction made its signal provide a potentially unstable course on the final approach track and, because no vertical guidance was offered, the approach was associated with a high minimum descent height, the point at which the pilot had to be able to see the runway, and complete the landing visually.

This created high workload for the single pilot, who needed accurate directions from air traffic controllers to ensure safe operations into the island, especially in conditions of reduced visibility such as during rain, fog or low cloud.

Key facts on the previous solution	
Cost of implementation	< €20k in 2010 < 1% of annual budget in 2010
Cost of operation and maintenance	< €10k in 2010 < 1% of annual budget in 2010

Alternatives to the satellite service

Alderney's main runway is placed on a cliff-top, which makes the airport unsuitable for ILS installations, ground-based "instrument landing systems" relying on radio beam transmitters, which provide lateral and vertical signals to guide aircraft approaching the runaway.

Hence, because of the position and the nature of the terrain, it would have been very difficult (and costly) to install ground-based equipment to provide vertical guidance to pilots approaching and landing in Alderney.

The satellite-based solution

The implementation

In 2011, ESSP (European Satellite Services Provider) proposed to the local airline, Aurigny, to test the EGNOS system on its aircrafts landing in Alderney.

Funding was offered by EUROCONTROL (an organisation mandated to achieve safe, efficient and environmentally-friendly air traffic operations in Europe) and by the European Commission to Aurigny and NATS (the UK air traffic control-

provider for commercial flights), through the European Commission's Trans European Networks (TENs) programme, which supports the global International Civil Aviation Organisation strategy to move away from ground-based and towards space-based landing systems.

Understanding the usefulness of the service for the local economy, Guernsey and Alderney Airports also contributed to the funding of the system with a small monetary contribution for regulatory oversight and expertise.

Key facts on the implementation	
Implementation framework	Demonstration project (EC Trans European Networks -TENs- programme) resulting in an operational practice
User's economic contribution	Own budget (public local funds) < €20k in 2011 < 1% of annual budget in 2011
Partners	Aurigny Air Services NATS (formerly National Air Traffic Services) Eurocontrol Pildo Labs ESSP (European Satellite Services Provider)

Service availability and procurement

The EGNOS system was already available for use with instrument approaches, but it required the aircraft operators to install appropriate avionics in their aircraft fleets, and the airport to design, gain approval for, and implement associated procedures to its individual runways.

The adaptation of the EGNOS system to the requirements of Aurigny and Alderney Airport was performed by ESSP.

Organisational aspects

The airports' authorities were convinced of the usefulness of the new system by Aurigny and took the decision to participate in the test autonomously.

The system's requirements (type and frequency of signals, and service standards) were identified by the CAA (the UK Civil Aviation Authority). ESSP was in charge of demonstrating to the airport authorities that the EGNOS system was reliable and safe, and the airport authorities had to demonstrate to the Director of Civil Aviation that the system met international standards.

All parties worked together to design a simple, logical and compliant instrument approach that could easily be integrated into existing operations. The Airport authorities participated in both designing and testing the procedures. The Instrument Approach Procedures (IAP) were designed by NATS with inputs from ATC Guernsey Airport and Aurigny Air Services, and were agreed among project members.

The system was first tested on two of Aurigny's Britten-Norman Trislanders and was then extended to the whole airline fleet. The new Low Visibility Procedures (LVP) were implemented by NATS in November 2011, and the operation was certified by the European Aviation Safety Authority in December of the same year. The testing phase lasted 12 months before the introduction of the system on an operational level during 2012 (Ref. 4).

Underpinning the entire process was a rigorous safety assessment, which was a step of paramount importance in convincing both the airport personnel and the airline pilots of the reliability and safety of the new system and of the convenience of adopting it on the whole fleet at completion of the pilot phase and after training the controllers.

Implementation challenges

Technical

Integration of the EGNOS equipment into the Aurigny aircrafts.

Organisational

No organisational challenges were encountered to adopt the new system.

Since the new procedures were designed to be integrated with those previously used by the pilots and the controllers, ATC staff only needed limited training to understand and appreciate the operational benefits offered by the system and the controlling techniques to use the approaches.

Administrative

A safety case had to be presented to obtain approval before implementing the system on the entire Aurigny fleet.

Operating the system

Key facts on the operation	
User's economic contribution	< €10k per year < 1% of annual budget in 2014

The system is currently installed on six Britten Norman BN2A Mk.III Trislander aircrafts, and has been used every day during the last two years. The aircrafts were equipped with Garmin 430W GPS systems, integrated with the aircrafts' Century III autopilots.

EGNOS uses three geostationary satellites and a network of ground stations to verify the accuracy of and correct the U.S. GPS and Russian Glonass positioning signals to less than 2-meter accuracy.

The new system provides both lateral and vertical guidance, with the pilot crosschecking his altitude with the altimeter.

Planes can hence approach the runaway with no need for ground-based navigation support, including in low-visibility conditions which might have prevented or delayed landing in the past.

Operational challenges

No operational challenges are currently encountered. The Airport Authorities have an agreement with ESSP to ensure service continuity and integrity, and to notify service outages to Aurigny and the airport authorities

Benefits of the satellite-based solution

Service efficiency and provision

Although the economic benefits of the system are difficult to quantify (as they vary on a day-to-day basis according to weather conditions), the airport authorities are enthusiastic about the system.

Indeed, EGNOS reduces errors in GPS data and provides pilots with both lateral and vertical guidance and better minima (i.e. decision height and runway visual range), allowing them to approach and land on the Alderney runaways in difficult weather conditions. As a result, fewer flights are cancelled, delayed or diverted.

In September 2012, Aurigny experienced a punctuality record on the whole of its fleet (including flights departing and arriving in Alderney). 72% of Islanders rated the punctuality of Aurigny flights as "good" or "very good", as compared to 64% in 2010, 57% in 2008 and 45% in 2004 (Ref. 2).

Cost-benefit

One of the advantages of the system is that it does not require the installation of additional equipment on the ground, thus limiting expenses. The only relevant costs for the airport authorities are those related with the initial design and the maintenance of the approach procedures. As compared to the previous system, no monetary

savings were noted since the implementation of the EGNOS system.

Nevertheless, Mr Ken Ashton, an official at NATS, estimated in December 2012, that "*It would take EUR 1,278,746 (GDP 1,000,000) of equipment on the ground to achieve what EGNOS can do with avionics and space technology*" (Ref. 14).

Society and the environment

The use of the EGNOS system makes the Alderney airport far more accessible for commercial operations, ensuring safety and continuity of air services from and to the island.

It also enhances the competitiveness of the local airline, by minimising delays or costly diversions (which also have an impact on the amount of fuel burned), it increases comfort and safety for the passengers, and it better supports the local economy which relies on air transport.

Other benefits

The system, interoperable with the U.S. Wide Area Augmentation System (WAAS) and the Japanese Multi-functional Satellite Augmentation System (MSAS), proved to be so successful that it has been incorporated into the procedures of numerous European airports since 2011. A complete list of European airports with EGNOS-based approach procedure can be found on the EGNOS website (Ref. 7).

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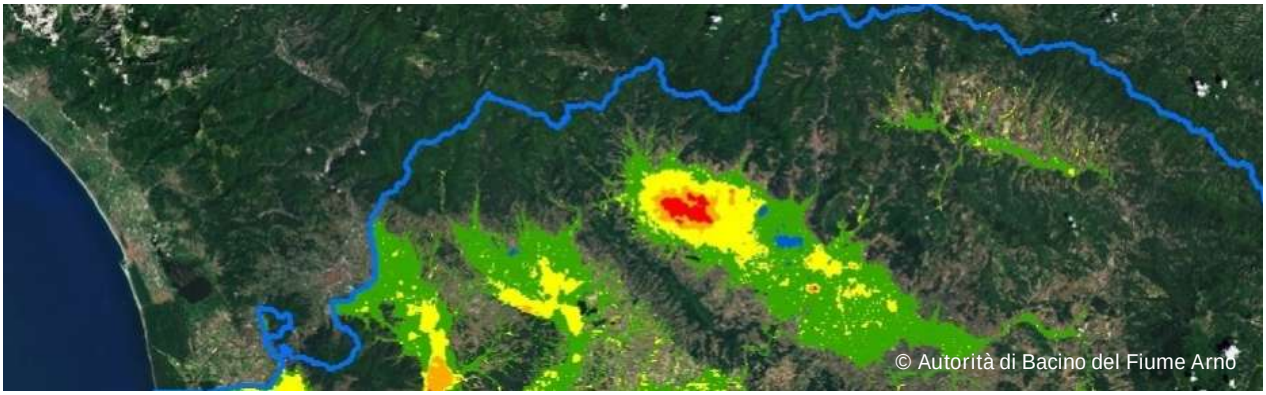

The Arno River Basin Authority uses satellite imagery to improve monitoring of hydro-geological phenomena

THE USER

Arno River Basin Authority

Florence, Italy
www.adbarno.it

KEY FACTS

Slope instability and risk were mapped across 8,830 km2

27,000 landslides were identified and 10,000 of them were classified as active

The satellite-based information shows slope movements throughout time. Combined with thematic maps, it provides an overview of environmental conditions and changes that was not achievable with previous instruments

Since 2005, satellite-derived information allows the Arno River Basin Authority to monitor old and new unstable areas and to plan conservation measures along the major river in Tuscany.

"Satellite imagery allows us to monitor changes of hydro-geological phenomena spatially and throughout time, thus enabling us to concentrate the restoration effort where it is more needed"

Giovanni Montini, Arno River Basin Authority

The Arno River Basin Authority uses satellite imagery to improve monitoring of hydro-geological phenomena

The context

The Arno is the second most important river in Central Italy, covering a densely populated area of about 9,131 km2 in the Tuscany and Umbria regions.

The Arno basin is rich in superficial and underground water resources, intensively exploited in the past for drinking and industrial uses. The soil of the area is particularly affected by erosion, which has been also favoured by the continuous modifications to the territory occurred since Roman times and by the extractions of materials, especially nearby inhabited sites.

Moreover, the young, uplifting orography the area makes it particularly vulnerable to hydrogeological risks. The Arno River flooded the city of Florence regularly in historic times. In November 1996, a large flood inundated the town and large portions of the adjacent flood plain, causing 40 deaths and considerable damages to many public and private properties and to the art heritage.

Despite new conservation measures inspired by the disaster, soil deformation and landslides are still usual phenomena in the region: more than 2,500 areas are currently at high risk of landslides and more than 600 landslides have been mapped between March and April 2013 only (Ref. 1).

The Arno River Basin Authority

The Arno River Basin Authority is a specialised governmental administration, which institutional and technical committees are formed by members of regional and national bodies.

The Arno River Basin Authority is in charge of safeguarding and valorising the soil, and of ensuring the correct use of the water resource in the basin. The institution is funded by national public funds, provided by the Italian Ministry of Environment.

Key facts on the Arno River Basin Authority	
Nature	Public
Area of operation	Regional
Sources of budget	National and EU public funds
Annual budget	€2m - €5m in 2014
N° staff	34 (regular staff)

Three departments carry out the Basin Authority mandate:

- the Area for Planning, Protecting and Managing Water Resources;
- the Area for Planning and Prevention from Hydrogeological Risks; and
- the Area for Technological Systems, Innovation and International Relations, which is responsible for the management of environmental data and of geographic information systems in computerised form, and for research and application in the fields of technological and process innovation.

Previous knowledge of satellite services

The Arno River Basin Authority has an extensive knowledge of the use of satellite-based information and three of its staff (an executive and two functionaries) have specific expertise in satellite based services.

Before using satellite-based data operationally, remote sensing was used every now and then to map flooded areas and land changes. The Basin Authority was also involved in the activities of the Earth Sciences Department of the University of Florence, using interferometric data to monitor landslides (Ref. 13), and of the Department of Civil Engineering of the University, applying remote sensing to assess moisture conditions.

The Basin Authority is also involved in the implementation of the Extraordinary Plan of Environmental Remote Sensing, an agreement programme between the Ministry of Environment and Territory of the Sea and the Ministry of Defence, in collaboration with the Regions and Autonomous Provinces. The main aim of this plan is to create and make available within the public administration the spatial information necessary for the creation of high-value products. The data is obtained from remote processes, or from remote capture on the territory and the environment (Ref. 10).

The challenge

Ground instabilities are among the most widespread geological hazards on Earth. Climate change, together with population growth, intensive land use, and expanding human infrastructure, is increasing the risks associated with ground movements. Thousands of deaths and injuries, and enormous economic loss are regrettable evidence of worldwide slope instabilities.

Identification and mapping of vulnerable areas are of paramount importance to monitor slope movements and to formulate better policies and recovery plans to reduce the socio-economic toll that developing as well as developed countries pay every year (Ref. 5).

Because of its geographic, geological and climatic features, Italy is particularly affected by landslides, which have been causing an average of 54 deaths per year during the last half century (Ref. 7).

The area of the Arno basin, in particular, is characterised by a high number of mass movements and by a high number of elements exposed to landslide risk. Indeed, about 16,000 civil buildings, 460 industrial areas and 350 km of roads are directly involved in gravitational movements (Ref. 8, p.1).

Within its mandate, the Arno River Basin Authority is responsible for annually updating the Inventory of Landslides in Italy -IFFI for the Tuscany Region (in line with the regulations contained in the Water Framework Directive) and for using it to implement the Basin Plan, including a description of water-related risks, water quality, excavations, and the actions planned to reduce hydro-geological risks.

To perform its tasks, the Basin Authority needs uniform information about water and soil that can be compared over time.

The previous solution

Before using satellite imagery as a base to map landslides, the Arno River Basin Authority relied on historical cartography and on in situ observations to monitor soil movements.

Alternatives to the satellite service

After considering various solutions to strengthen its monitoring capacity, the Arno River Basin Authority found that no solution would have been as effective as using satellite imagery as a base for the cartography of the area. Indeed, other

solutions, such as surveys on the ground and aerial imagery would have been too costly, both in terms of time and human resources, to be performed on a regular basis, and they would have not provided an overview of soil movement on the whole basin area.

The satellite-based solution

The implementation

In 2003, the European Space Agency (ESA) proposed to the Basin Authority to participate to the SLAM project (Service for Landslide Monitoring), funded under the ESA Data User Programme.

The project lasted from May 2003 until May 2005 and had a total cost of EUR 1,200,000.

It targeted three organisations working at national level in Switzerland and in Italy (the Federal Office for Water and Geology -FOWG, the Italian Ministry of Environment, the Italian National Research Council Group for Hydro-geological Disaster prevention -GNDCI), and the following local institutions: the Arno National Basin Authority, the Campania Region (Assessorato all'Ambiente e alla Difesa del Suolo) in Italy, and the Canton of Berne, the Canton Valais, the Canton of Fribourg, and the Canton Ticino in Switzerland.

350 satellite images taken by ESA's ERS satellites were provided by ESA free of charge and combined with ground data to build a web GIS to map and assess slope instability and risk across 8,830 km2 in the Arno basin area.

The project budget was used to contract the service providers developing the system, while the Arno River Basin Authority contributed in kind, making available staff and expertise to process the raw satellite data into information.

The contribution of the Basin Authority ranges from EUR 50,000 to 100,000 (about 1% of the annual budget of the public authority), including the cost of human resources.

Key facts on the implementation	
Implementation framework	Demonstration project SLAM "Service for Landslides Monitoring" project (ESA Data User Programme)
User's economic contribution	Own budget (Public national funds) €50k - €100k (2005)* 1% - 5% annual budget (2005) *Including staff costs.
Partners	European Space Agency Planetek Italia S.R.L. (I) Gamma Remote Sensing A.G. (CH) Geotest A.G. (CH) Spacebel S.A. (B) Tele-Rilevamento Europa - T.R.E. s.r.l. (I) University of Firenze, Earth Science Department (I)

Service availability and procurement

The service was not already available on the market on its final form, and it hence had to be designed especially to meet the operational needs of the Arno River Basin Authority.

The interferometric analysis was based on the Permanent Scatterers technique, developed and patented by the Politecnico di Milano (Italy) and improved by Tele-Rilevamento Europa. This methodology shows the measure and the displacement velocity of some points on the ground with millimetre accuracy (Ref. 12, p. 23).

Organisational aspects

The decision to participate to the SLAM project was taken autonomously by the Basin Authority.

The satellite imagery was provided by ESA, contractors were in charge of building the web-

GIS platform and of analysing the optical images with high spatial resolution, while the staff of the Basin Authority provided the data and expertise needed to assess instability and landslide risks in the area of interest.

The development of the service was carried out in four steps (Ref. 11, p. 5):

- Service Consolidation (May 2003 - July 2003): assessment of user requirements, identification of test sites and acquisition of available data. The assessment of the needs of the public administration, both in terms of data and procedures, was realised with the support of Tele-Rilevamento Europa - T.R.E. s.r.l., a spin-off company of the Polytechnic University of Milan. Based on this assessment, the consortium produced the technical specifications of the solution needed.
- Service Prototyping (July 2003 - February 2004): building of a service prototype, prequalification and product refinement through comparison with ground data;
- Service Implementation (April 2004 - November 2004): service implementation in test sites, final service qualification and critical assessment with end-user;
- Results spreading and promotion (November 2004 - March 2005): service sustainability study, dissemination of results.

The satellite-based deformation map was developed in order to fit into the existing working and decision-making practices of the Basin Authority.

Key facts on the operation	
User's economic contribution	€20k - €50k in 2014* 1% - 5% of annual budget (closer to 5% than to 1%) *This amount includes the cost of human resources

Implementation challenges

Technical
It was a challenge to process the large amount of data available. Also, at the beginning it was difficult for the staff of the Basin Authority to take up the new solution: training sessions were offered by T.R.E. within the framework of the project.
Economic
The ESA support allowed the organisation to overcome economic challenges.
Organisational
No additional staff or organisational changes were required to adopt the service.

Operating the system

The project developed three tools to monitor soil instability with the technique of radar interferometry: different satellite images of the same site - acquired over ten years of Earth observation - are combined to identify minuscule soil changes between the acquisitions.

Based on the comparison of satellite images taken at different times, three tools were created (Ref. 7):

1. The Landslide Motion Survey, which shows, within a large area of interest (i.e. 1,000 - 10,000 km2), soil movements at one centimetre with a spatial resolution of 20 metres, and which is used by the Arno River Basin Authority to identify new unstable areas and automatically update slope maps;
2. The Displacement Monitoring Service, with a spatial resolution of five metres, which measures soil movements of few millimetres to monitor small variations in known landslides;
3. The Landslide Susceptibility Mapping, which integrates the satellite-based data with all available thematic maps, showing inclination, land use, geomorphology and other

parameters to create geological maps of the slope risk.

Operational challenges

Operational

The Authority would like to profit from regular training to update the expertise of the staff. Unfortunately, no appropriate budget is available.

Sustainability

It might be a challenge to maintain the satellite-based solution in the future, since it is necessary to constantly update internal competencies with increasing budgetary limits.

Benefits of the satellite-based solution

Service efficiency and provision

Information collected through satellite imagery permits a uniform overview of the entire area to monitor subsidence, landslides and building stability and to plan interventions in the areas exposed to major risk.

Indeed, the satellite-based information enabled the Arno River Basin Authority to calculate soil deformation between 1992 and 2007 with millimetre-accuracy on an area of 8,830 km2. 27,000 landslides were identified and 10,000 of them were classified as active.

Cost-benefit

Before the development of the satellite-based cartography, the landslide risk was monitored mainly through ground observations. Today, thanks to the satellite-based cartography, the Basin Authority is able to concentrate ground measurements in the areas were the landslide risk is higher, hence saving time and resources.

Prior to the implementation of the system, the Basin Authority had no resources to perform ground measurements on the whole surface of the Arno River Basin. Hence, even though the development of the satellite-based cartography did not entail monetary savings as compared to previous monitoring costs, it did increase the monitoring capacity of the Basin Authority, by improving the quality and quantity of the information available on soil movements on the whole area.

Society and the environment

Satellite-based information makes possible to compare slope movements throughout time. In combination with thematic maps, it provides an overview of environmental conditions and changes that was not achievable with previous instruments.

The deformation maps are used to foresee slope movements and take relevant measures to protect the territory and human settlements.

The cartography provides the Basin Authority with the elements to verify the correlation between subsidence and human activities. For example, in the Prato alluvial plain, an area historically affected by subsidence, it has been possible to verify that the decrease in the demand of industrial water has caused a lift of the soil and a rise of the water table.

Other benefits

Private and public external entities have also access to the web-GIS containing the satellite-based information, including municipalities and professionals working for the municipalities.

Within the framework of the project, training was provided by Tele-Rilevamento Europa to the regional association of geologists to analyse the satellite-based data contained in the GIS.

According to Lorenzo Sulli, geologist at the Arno River Basin Authority, "*the experience of being a SLAM end-user has been very positive. Most of all because it has been possible to combine the*

technical and scientific information with the way we normally work, in support of decision making. This is not always possible with such highly innovative projects" (Ref. 6).

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Central Command for Maritime Emergencies: remote sensing to intervene on oil spills

THE USER

Central Command for Maritime Emergencies

Cuxhaven, Germany
www.havariekommando.de/en

KEY FACTS

Between 2007 and 2011, 1,855 satellite images were provided for free to the CCME through CleanSeaNet

Amount and size of oil spills detected in German Seas have been consistently decreasing

It is estimated that to monitor by aircraft the surface area covered by CleanSeaNet in all member states between 2007 and 2011 would have cost at least EUR 30,000,000

Since 2007, the CCME (Germany) has received satellite-based information on potential oil spills, to increase rapidity and precision of interventions aimed at removing them and identifying polluters.

"Thanks to CleanSeaNet we have better, objective information to intervene rapidly in case of incidents, and to identify potential polluters with more certainty. The fact that we can share and compare this information with other member states, allows for a coordinated protection across European seas"

Dirk Reichenbach, Central Command for Maritime Emergencies (CCME)

Central Command for Maritime Emergencies: remote sensing to intervene on oil spills

The context

The presence of oil in marine wildlife is normally not a natural occurrence, but the result of accidents or of deliberate discharges of oil waste from vessels into the sea.

Oil spills can affect almost any form of life and oil can be detected in the environment even 30 years after discharge (Ref. 1, p. 6).

On top of this, oil spills are not only a threat to the environment, but also to local economies, especially in the summer time, as beaches are important sources of revenue for coastal regions. Indeed, oil spills represent a significant cost for national economies.

For instance, two major tanker accidents in the Hamburg area in 1981 and 1982 (Ref. 8) entailed total cleaning costs of about USD 11,000,000 (approx. EUR 8,000,000 at current exchange rates).

The Central Command for Maritime Emergencies

The Central Command for Maritime Emergencies (CCME) is a joint institution of the German Federal Government and the five German Coastal States.

Headed by a federal official, the CCME is responsible for handling maritime incidents in the North and Baltic Seas, including on beaches, shorelines and coastal waters. These tasks are carried out in close cooperation with all authorities and institutions of the Federal Government, the Coastal States and private organisations responsible for the sea and the coastal area.

The CCME is composed of five sections:

- Maritime Emergencies Reporting and Assessment Centre (MERAC)
- Maritime Emergencies and Marine Pollution Response
- Marine Pollution Response
- Fire Fighting, Rescue and Medical Response
- Public Relations

During daily work routine the five sections form a "centre of competence", which deals with all questions related to maritime emergencies.

Key facts on the CCME	
Nature	Public
Area of operation	National and regional
Sources of budget	National public funds
Annual budget	€10m - €50m in 2013
N° staff	36 (regular staff)

Previous knowledge of satellite services

The Central Command for Maritime Emergencies has staff with experience working with satellite imagery and can also rely on the support of other national agencies like the German Federal Institute of Hydrology - BfG and the German Aerospace Center (DLR).

Indeed, the CCME started exploring the potential of satellite imagery to monitor sea pollution back in 1999.

In 2003, the CCME was among the public and private institutions participating in the European project OCEANIDES "Harmonised monitoring, reporting and assessment of illegal marine oil discharges".

Funded under the European Commission's Energy, Environment and Sustainable Development Programme of the Fifth RTD Framework Programme (FP5-EESD), the project aimed at collecting data from satellites, vessels, and aircrafts in a Pan-European, harmonised and standardised oil pollution database.

It started in 2003 and lasted 30 months, involving the EC Joint Research Centre, the GAUSS Institute for Environmental Protection and Safety in Shipping (Germany), the German National Pollution Control Authority, the German Federal Institute of Hydrology, the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC), and other private and public institutions from Norway, Denmark, Finland and the UK (Ref. 2).

Since 2004, even before the European Maritime Agency had become operational, the CCME had been also participating in the meetings of the European Group of Experts on remote sensing Monitoring of Marine Pollution (EGEMP), created by the Joint Research Centre (JRC) in collaboration with the EC DG Environment (Civil Protection Unit) to exchange experiences and ideas on how satellite-based information could be used to improve monitoring of oil spills in Europe (Ref. 7).

The challenge

At global level, pollution from vessels has been recognised by the UN Convention on the Law of the Sea (UNCLOS) (Ref. 10) as one of the main threats to the marine environment. To address the problem, UNCLOS has acted mainly through the International Maritime Organization (IMO) to develop a multilateral set of rules and standards to control and monitor the environmental impact of shipping.

Among these, the most important is the International Convention for the Prevention of Pollution from Ships -MARPOL 73/78 (Ref. 6), which identified some "Special Areas" where oil spills are mainly caused by illegal discharges. In 1978, these included the Mediterranean, Black, and Baltic seas, while the North Sea was designated as a Special Area in 1999.

The MARPOL designation of Special Areas was indeed important, but remained without effects in the absence of appropriate law enforcement tools.

Indeed, nations which are party to MARPOL 73/78 have the obligation to follow up on any possible violation against the regulation and therefore to verify potential spills.

The creation of the European Maritime Safety Agency, ratified in 2002, has increased multi-country cooperation to prevent and clean oil spills. This enhanced cooperation, together with technological progress and a growing awareness of the consequences of marine pollution on the environment, the economy and health, have allowed European coastal authorities to better formulate their technical and operational needs to maximise their intervention capacities.

In terms of operational needs, in order to respond efficiently to marine pollution, and in particular to oil spills, the CCME needs information on potential threats as quickly as possible, before the spills get dispersed into the sea or reach the beaches.

In effect, it is much more expensive, both in terms of money and time, to clean up the coast than to eliminate the fuels while they are still in the sea. Moreover, an oil spill reaching the coast is not only a threat to the environment, but also to citizens' health and to the local economies relying on tourism in the summer season).

The previous solution

Before starting to experiment with satellite imagery, the CCME used only helicopters, aircrafts or boats to identify oil spills.

Aerial surveillance has reduced oil spills from vessels during the last decades, but this method is both technically and economically impossible to implement over the entire pollution responsibility zone of a country like Germany. In fact, monitoring waters by aircraft only requires a huge and constant availability of staff and equipment.

To maximise its surveillance and intervention capacity on large areas, the CCME started looking into other surveying methods that, combined with aerial monitoring, could provide them with frequent information on potential oil spills and increase the accuracy and rapidity of their response.

Alternatives to the satellite service

To improve their monitoring and intervention capacities, the CCME had thought about using unmanned aerial vehicles (UAV). Unfortunately, operating such vehicles is challenging, since they fly in a space used by other aircrafts. Furthermore, it is today forbidden to operate large UAVs in Germany.

No other alternative technology was hence available to provide the CCME with sufficient information to detect and intervene on oil spills in a timely manner.

The satellite-based solution

The implementation

Since the experience of the OCEANIDES project, satellite surveillance started emerging as a complementary operational tool to boat and air surveillance to help fighting illegal discharges over wide areas.

In early 2006, during one of the meetings of the European Group of Experts on remote sensing Monitoring of Marine Pollution (EGEMP), EMSA consulted the national authorities of the EU member states and coastal EFTA states and the space industry on the needs of public bodies responsible for oil spill detection and on existing surveillance resources from satellites.

The CCME, who had previous experience using satellite remote sensing, was able (among other European coastal authorities) to express its needs in terms of number of images needed, frequency of delivery, resolution, and other parameters.

Based on this assessment, EMSA defined the specifications of a new service to provide coastal managers with satellite-based data on potential oil spills through a harmonised Pan-European platform, and launched a call for tenders to select the providers who would have developed the system starting from 2007. The call was then renewed twice, leading to the current operational set.

Key facts on the implementation	
Implementation framework	Operational framework
User's economic contribution	None
Partners	European Maritime Safety Agency -EMSA Federal Republic of Germany German Coastal States' public authorities Member States' coastal authorities

Service availability and procurement

The resulting system, CleanSeaNet, is a near real-time European satellite based oil spill monitoring and vessel detection service. Based on satellite images, it provides aggregated products on possible oil spills, pollution alerts and related information to the operational maritime administrations.

The current service was designed to take into account the experience gained in previous years and recommendations from the users. The CleanSeaNet data centre, hosted and operated in-house by EMSA, has been fully operational since February 2011.

CleanSeaNet is provided to all European Member States and EFTA States free of charge. The images and the software are provided by the European Maritime Safety Agency (EMSA), while the CCME contributes with human and technical resources to operationally use the information provided by the imagery on its area of responsibility.

Organisational aspects

The CCME was among the promoters of the service. Hence, it did not face any challenge to convince its staff of the usefulness of CleanSeaNet.

Indeed, the CCME participated in the design and development of the service with EMSA and the selected service providers, to make sure that the solution responded to the operational needs of the concerned public authorities.

After implementation of the service in April 2007, no pilot period was needed to test it.

Implementation challenges

Technical
Training sessions were organised by EMSA for the national operators of the service to start using the GIS platform.
Material
EMSA had to launch a call for tenders to select the service providers. Based on the feedback provided by users, the service was then improved until reaching its current form.

Operating the system

Key facts on the operation	
User's economic contribution	None in 2014 *This amount does not include the cost of human resources

The service is based on radar images obtained from synthetic aperture radar (SAR) satellites. In cooperation with the CCME, EMSA plans and orders satellite images to meet their requirements. Accordingly, satellite data are acquired via a network of receiving stations (Ref. 3).

Operators analyse the images with particular attention to dark spots, to assess the likelihood of the presence of oil on the sea surface and to assist in identifying the source of the pollution.

The CCME receives approximately 450 satellite images per year, each covering between 900 and 1,600 km2 (also including areas belonging to neighbouring countries), and containing a classification of the dark spots detected according to the likelihood that they be oil spills and their potential impact.

SAR images, results of oil spill and vessel detection analysis, and relevant auxiliary data (wind and swell detection, vessel traffic information, nautical charts, meteorological, oceanographic information and oil drift models) are made available to Coastal states through the web-based and user-tailored CleanSeaNet portal (Ref. 3) within 30 minutes from the capture of the images. Moreover, by combining information on potential oil spills and their position relative to vessels, the CCME is also able to identify the potential polluters, further discouraging illegal behaviour.

The first generation of the service cost EMSA EUR 2,700,000 per year, including development, implementation and maintenance of the service, satellite image license prices, processing and analysis of the images, and the yearly fixed costs (Ref. 4, p. 5).

Operational challenges

Economic
None, the service is provided free of charge and the only operational costs for the CCME are those related with human and technical resources.
Operational
No assistance is needed to use the service; EMSA provides training every year on the operational use of the software to the staff of the CCME.

Benefits of the satellite-based solution

Service efficiency and provision

Thanks to the CleanSeaNet service, the Command receives, in near real-time, more satellite images than ever available before, and it could hence improve its surveillance capacity. The images contain a classification of the dark spots detected in the covered sea surface, according to their resemblance to oil spills. The spots could in effect be oils spills, but also algae blooms or other look-alike phenomena.

As a standard procedure, one hour after the satellite has passed over the German seas the CCME sends an aircraft on the area where the image was captured, to verify the nature of the dark spots detected by the satellites. The aircraft, directed by the satellite observations, gives then feedback to the headquarters via Satcom.

Subsequently, further measures are taken to remove the spills and to collect evidence to identify the possible polluters.

During the first phase of deployment (April 2007 – January 2011), 1,855 satellite images covering the German seas were acquired by EMSA and made available to the CCME through the CleanSeaNet service, with a rate of confirmation of 30% when the spill is checked by aircraft no later than three hours after satellite acquisition.

As a result, in the first year of implementation of the service, the number of oil spills detected by verifying the satellite-based information almost doubled (from 59 in 2007 to 117 in 2008). In the following 2 years it started to progressively decrease (61 in 2009 and 50 in 2010).

In effect, as a consequence of the exacerbation of the legislation concerning sea pollution and of the enhanced surveillance capacity of the CCME, in the two years preceding the full implementation of the CleanSeaNet service, the number of polluters identified (46 in 2006 and 29 in 2007), was higher than after the full deployment of the service (9 polluters identified in 2012 and 21 in 2013).

These results show the usefulness of satellite imagery to both support response operations in case of maritime accidents, especially in large areas, and to detect and deter illegal oil discharges.

Moreover, the shared online platform proved to be a useful tool to measure the state of the European seas (means, variation, trends), to inform policy makers, and to assess the success or otherwise of the actions taken (Ref. 5).

Cost-benefit

The CleanSeaNet service supplies over 2,000 images a year to the 26 participating states free of charge.

The report on the first generation of the service estimates that satellite monitoring to cover wide and/or remote areas is up to 10 times cheaper than aerial surveillance. The report also claims that the surface area covered by CleanSeaNet between April 2007 and January 2011 would have cost at least EUR 30 million to monitor by aircraft, against the approx. EUR 8 million spent to develop, implement and maintain the service during the same period (Ref. 4, p. 5).

Indeed, the experience of the CCME shows that satellite imagery, in combination with aerial

surveying, allows coastal managers to supervise large extensions of water, which would have been impossible to constantly monitor with the use of aircrafts only, saving money and human resources.

By addressing the issue of oil spills in seas through a shared system among member states, it was possible to reduce the costs of both building and operating the service. Indeed, on average, one CleanSeaNet image covers the alerting area of 2.6 Member States. By ordering images centrally, it is possible to significantly reduce the number of images needed to fulfil coastal states' national coverage requirements. Sharing the system also helped to put pressure on service providers to improve the service (Ref. 4, p. 5).

Society and the environment

The Baltic and the North Seas are both "Special Areas" under MARPOL, and the discharge of oil is hence forbidden since 1983. The Baltic Sea in particular is an important area for wintering birds, notably seaducks, which are especially affected by oil spills. It is therefore extremely important for the CCME to count on the most innovative technological tools to ensure that maritime species are protected against these threats.

As a consequence of increased law enforcement capabilities, polluters are now aware that routine controls have been increased (together with legal and reporting requirements for boats).

Over the years not only the amount, but also the size of the oil spills detected in the German Seas have been continually decreasing. Today, it is rare to have an oil spill of 10m3 (often produced by accident), while before the CCME detected spills up to 60 m3.

This service proves that the EU can be an example in enforcing existing and new legislation which can help protecting the marine environment and the species relying on it, while reducing the costs related with marine pollution monitoring and response in single Member States.

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City of Diemen: Coping with soil resilience with the support of satellite imagery

THE USER

Department of Infrastructure, City of Diemen

Diemen, The Netherlands
www.diemen.nl

KEY FACTS

The satellite-based deformation map costs 0.25% of the Department's annual budget for maintenance works

There are no short-period maintenance costs associated with the use of the map

No special training or organisational change is needed

To assess soil resilience with field measurements would cost at least ten times more

Since 2011, the Department of Infrastructure of the City of Diemen can rely on precise information on soil sinking to better target public infrastructure maintenance cycles.

"The satellite-based deformation map of the city enables the Department of Infrastructure to provide a more efficient planning of maintenance of roads and sewers"

Ron Kaptijn, Policy Officer, Infrastructure Team of the City of Diemen

City of Diemen: Coping with soil resilience with the support of satellite imagery

The context

Diemen is a municipality in the Netherlands with a population of around 26,000. The city is located in the province of North Holland, east of Amsterdam, within the capital's metropolitan area.

The name of the city originates from the river Diem, which comes from the words "die eme" (water) in Dutch. Indeed, Diemen is crossed by three watercourses, the Diem, the Weespertrekvaart and the Amsterdam-Rijnkanaal, which favoured the flourishing of the area in the past centuries and which continue characterising the city's landscape.

The Department of Infrastructure of the City of Diemen

Key facts on the Department of Infrastructure	
Nature	Public
Area of operation	Local
Sources of budget	Local and national public funds
Annual budget (year)	€2m - €5m in 2014
N° staff	60 (regular staff)

The Department of Infrastructure is one of the six divisions managing public services in the City of Diemen. The Department is responsible for maintenance of roads, sewers, and other infrastructure. For these tasks, a budget of about EUR 4,000,000 is available each year. The Department accomplishes its missions through two teams, in charge of infrastructure and district management.

Previous knowledge of satellite services

The Department of Infrastructure of the City of Diemen has staff with some knowledge but no specific expertise on satellite-based applications. Nevertheless, they heard that some Italian scientists were using satellite imagery to monitor soil movements after the L'Aquila earthquake of April 2009 in Italy. This made them aware of the potential uses of Earth observation to prevent and manage soil resilience.

The team got interested in the new opportunities offered by satellite-based technology and would be keen in profiting from support mechanisms, both at the national and European levels, to seize their potential benefits.

The challenge

The city of Diemen is located in a glacial basin, filled up over the centuries with fluvial clay and peat bog. Therefore, the ground is very vulnerable and affected by subsidence, which means it can sink up to two cm per year (Ref. 3).

Over time, differences in subsidence can cause serious damages to the infrastructure. Maintenance in Diemen is urgent where subsidence approaches eight inches, the diameter of sewage pipes.

As a result, the municipality is forced to heighten the entire public space about once every twenty years as a preventive measure, including all roads, sewers and public gardens (Ref. 3).

Heightening an entire district is very costly. Indeed, subsidence rates vary substantially between neighbourhoods, due to variations in soil composition. That's why the municipality must be sure that money is spent where it is most necessary.

The previous solution

The maintenance cycles to prevent and manage the effects of resilience were usually planned based on visual inspection and on the experience of individual observers.

Visual inspection is neither precise, nor does it offer complete coverage. As a result, in many cases maintenance works were performed either unnecessarily early or too late.

Alternatives to the satellite service

An alternative to use satellite-derived information would have been to perform regular ground measurements of soil resilience on the entire municipal territory. This solution was considered by the Department of Infrastructure as being too expensive and time-consuming to be operationally adopted as a regular practice.

The satellite-based solution

The implementation

After thinking about using satellite-based data, the Department started looking for companies which could use this information to assess the resilience speed-rate of the municipal soil.

In 2011, the Department of Infrastructure of the City of Diemen was able to order a city-wide deformation map based on satellite imagery from a local company.

To build the map, over one hundred radar images recorded by ESA satellites from 1992 to 2010 were used. It was thus possible to map subsidence in millimetres for specific locations throughout the municipality (Ref. 2).

The service was funded with the regular budget available to the Department for maintenance of roads, sewers, and other infrastructure, that is about EUR 4,000,000.

Key facts on the implementation	
Implementation framework	Operations
User's economic contribution	Own budget (local public funds) €10k in 2011 0.25% of annual budget for maintenance works in 2011
Partners	Hansje Brinker B.V.

Service availability and procurement

The satellite-based deformation map of the City of Diemen was developed by Hansje Brinker B.V. (www.hansjebrinker.com/en), a service provider based in Delft and specialised in infrastructure monitoring.

The company was already using satellite remote sensing to monitor dykes but had never worked with cities before, so it had to create a tailor-made solution in collaboration with the Department of Infrastructure to meet their specific needs.

Organisational aspects

The Department of Infrastructure took the decision to invest into this innovative solution after performing an analysis of needs, and participated to the service design before its implementation.

The Department did not need any external support to assess its needs and did not go through a pilot period of testing before its operational use.

Implementation challenges

Technical
The staff of the Department of Infrastructure was immediately able to use the map to plan maintenance cycles, and no additional training was needed to use the cartography operationally.
Economic
The Department did not face any economic challenge to commission the satellite-based map, which was funded from the regular yearly budget available for maintenance of roads, sewers, and other infrastructure.
Material
It was a challenge for the Department to identify a company which could build the satellite-based deformation map.
Organisational
There were no difficulties to convince the staff of the Department to start using the satellite-based deformation map. Since the technical building of the map was outsourced, the Department did not need to hire new staff or to perform internal organisational changes.

Operating the system

Knowing what the resilience rate of the soil is in specific locations enables the Department of Infrastructure to foresee damages caused by soil resilience to roads and sewers with no or little need for expensive, time-consuming ground measurements.

The map therefore guides the staff of the Department when calculating maintenance cycles at every level (streets, neighbourhoods and districts), so as to first target venues at higher risk and better prevent possible sewer emergencies (Ref. 3).

Using the map does not entail any maintenance costs. It will need to be updated with new satellite data approximately every ten years.

Key facts on the operation

User's economic contribution	None in 2014* *The satellite-based map does not need updates in the short/medium periods

Operational challenges

Economic
None, since the system does not need any maintenance in the short-term.
Operational
After the deformation map was created, staff did not need any support or special training to use it to plan maintenance cycles.

Benefits of the satellite-based solution

Service efficiency and provision

The satellite-based deformation map shows the resilience rate of the soil over the past 18 years (Ref. 3) with millimetre accuracy.

The satellite-based deformation map was used by the Department of Infrastructure of the City of Diemen to prove to the City authorities the extent of the soil resilience phenomenon and its consequences on expenditures and security by relying on objective data.

Indeed, thanks to the map, for the first time ever, major infrastructure works are planned in Diemen on the basis of a complete set of quantitative data (Ref. 2).

The staff of the Department of Infrastructure can now know subsidence rates for every neighbourhood based on hundreds of measurements per square kilometre (Ref. 2). This information is used to prepare and sustain policy proposals and budget expenditures, targeting first the areas more affected by resilience in the short-term.

The Department is hence able to provide a more efficient planning of road and sewer maintenance, offering better services to the inhabitants of Diemen, while also optimising budget expenditures and reducing the inconveniences associated with construction works.

Cost-benefit

One of the results of the use of the deformation map is that the cost of subsidence has been quantified for the first time ever: indeed, with over EUR 1,000,000 per year this turned out to be the biggest item in the maintenance budget for the City's infrastructure (Ref. 2).

As stated above, using the satellite-based deformation map allows the Department of Infrastructure to reduce the costs annually associated with maintenance works by targeting them where the resilience rate is higher, with considerable savings also in terms of time and human resources.

According to Mr Ron Kaptijn, Policy Officer within the Infrastructure Team of the City of Diemen, to assess soil resilience with traditional methods (i.e. ground measurements) would entail an effort in terms of money and time of at least ten times the cost of the satellite-based deformation map.

Society and the environment

The satellite-based map shows the dynamics of the subsidence measured at each location, and it hence allows the administration to prevent sewer emergencies which would have negative effects on the life of the inhabitants of Diemen and on the city's economy and environment.

The economic and human resources which were previously employed to perform regular infrastructure maintenance can be now used by the Municipality to increase other public services in Diemen.

Other benefits

The Department of Infrastructure has been communicating on the new system at the regional and national levels. Some municipalities have been inspired by the Diemen's experience and are now using satellite-based data for similar activities. It is interesting to notice that most of the municipalities approached by the staff of the Diemen Department of Infrastructure were not aware of the potential services for cities relying on satellite information.

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DREAL Alsace uses EO to save the European hamster from extinction

THE USER

Alsace Regional Directorate for Environment, Planning and Housing - DREAL

Strasbourg, France
www.alsace.developpement-durable.gouv.fr

KEY FACTS

The habitat map supported the implementation of effective conservation measures for the hamster, avoiding severe economic penalties for several million euros to France

The map cost approx. 2% of the annual budget of the DREAL "Hamster mission"; the update around 5%

Between EUR 12,000 and 24,000 per year were spent to monitor 500 km2

Between 2010 and 2014, the DREAL Alsace used satellite-derived data to monitor the habitat of European hamsters and to plan interventions to safeguard the species.

"The maps produced from satellite images allow for a quick and accurate assessment of the quality of the hamsters' habitat around population centres. Complementary agricultural measures could thus be promptly implemented in critical sites identified."

Cécile Bouquier, Project Manager, DREAL Alsace

DREAL Alsace uses EO to save the European hamster from extinction

The context

The European hamster is a rare and localised species. In France it only exists in Alsace, mainly in the Bas-Rhin, and is a protected species since 1993.

The European, or common hamster is protected nationally and internationally under the Bern Convention, classifying the European Hamster among strictly protected species since 1990; the Habitat Directive (1992), stating that the species is of public interest and needs strict conservation measures; the Ministerial Decree of 23 April 2007, listing terrestrial mammals protected on the national territory; and the Ministerial Orders of 2012, which specify which conservation measures must be put in place to protect the rodent (Ref. 8, pp. 15-17).

The European hamster is an integral part of the regional animal heritage of Alsace. The habitat of this species is an open environment, in loose soil; neither humid nor flooded, with fertile, deep and cultivated soils. The species lives indeed mainly in cultivated fields (alfalfa, wheat, barley), at low altitude on deep and stable terrains (loess, clay, etc.).

Therefore, its habitats are a very attractive environment for development and are normally coveted for various economic, agricultural and urban activities, or for infrastructure development.

Historically regarded as harmful, the common hamster has long been hunted (with traps). Since 1972, a reduction of the hamster's area of repartition was noticed and, despite the conservation measures implemented in Alsace, the species has decreased of about 75% between 2001 and 2012 (Ref. 8, p.4).

Indeed, habitats most favourable to its development have gradually disappeared and became fragmented due to changes in cropping patterns and farming practices and to land use projects.

As a result, between 2001 and 2007 the number of hamsters has dramatically fallen, as evidenced by the decrease in the observed number of their burrows (one burrow representing one animal) in the 'main areas' from 1,160 to less than 180 (Ref. 3, p.1).

The Alsace Regional Directorate for Environment, Planning and Housing

The Alsace Regional Directorate for Environment, Planning and Housing (DREAL) was created in 2011, as a result of the Reform of the State decided in 2007 by the Council for the Modernisation of Public Policies. It took over the responsibilities previously assigned to the three Alsace Regional Directorates for the Environment (DIREN), Infrastructure (DRE) and for Industry, Research and Environment (DRIRE) (Ref. 2).

Under the authority of the prefect of the region, the DREAL has responsibilities in several areas of operation: weather, air and energy, territorial management, hydrology and natural risks, territory, water and landscape, chronic risks, mines, accidental risks, sustainable transport and road safety, road works, road transport regulation, knowledge, environmental monitoring, and sustainable development in the Alsace Region.

The DREAL applies the directions of the Ministry for Environment, Sustainable Development and

Energy (MEDDE) - which also provides funds to the Directorate - and of the Ministry for Housing and Territorial Equality (MLET) at the regional level. It coordinates its work on the territory through two regional units in the Haut-Rhin and the Bas-Rhin.

Two persons are in charge of the "Hamster mission", aimed at monitoring the quality of the habitat of the species and at fostering conservation measures.

Key facts on the DREAL	
Nature	Public institution
Area of operation	Regional
Sources of budget	National public funds
Annual budget of the Hamster mission	€525k in 2010
N° staff	250 (2 for the Hamster mission)

Previous knowledge of satellite services

Since 2009, the French Ministry for Environment, Sustainable Development and Energy has created an Expertise and Innovation cluster (Pôle de competences et d'Innovation) to promote satellite-based applications, identify potential users and provide technical support on satellite applications and telecommunications

Moreover, the DREAL Alsace regularly collaborates with the SERTIT (Regional Service for Image Treatment and Remote Sensing of the University of Strasbourg). This institution runs an image-processing and remote sensing service at the regional level to extract and format information derived from satellite imagery. This collaboration was essential to encourage the DREAL to start using satellite-derived information within the Hamster mission.

The Regional Directorate has also internal expertise in using Geographic Information Systems within its Knowledge Unit.

The challenge

The Habitats Directive requires Member States to ensure strict protection of endangered species, in order to effectively avoid the deterioration or destruction of breeding sites and resting places.

Since 2007, the European Commission had been warning France that, if adequate measures to protect the species were not taken, the Country would be fined for as much as EUR 17,000,000 (Ref. 5).

To stop the process of decline of the species, France launched a National Actions Plan for the Protection of the Common Hamster for the period 2007-2011, aiming to restore the populations of the common hamster in *priority action zones*, revert the declining trend, and stabilise the total population of common hamsters in zones located in the South of Strasbourg (Ref. 1).

Despite these measures, the hamster population did not increase. As a consequence, in June 2011 the EU Court of Justice considered that France had not taken adequate measures to ensure strict protection of the European Hamster in Alsace in 2008, and hence that the country had failed to fulfil all its obligations (in particular Article 12) under the Habitats Directive, the objective of which is to promote maintenance of biodiversity (Ref. 3).

The Court threatened France with EUR 17 million fines if it did not make progress protecting the species. If eventually imposed, the fine could run to EUR 200,000 - 300,000 per day thereafter, and penalties could have reached EUR 55 million by 2013 (Ref. 7).

For the period 2012-2016, efforts to save the species were intensified: the National Actions Plan for the Protection of the Common Hamster committed, among others, to triple the number of hamsters as compared to the years 2010 - 2011, striving towards the viable populations' objective of 1,500 individuals. The Plan also envisaged to improve the quality of the species' habitat via the

implementation of hamster-friendly agricultural ground cover (at least 22% favourable crops in the strict protection area, as defined in 2012, and in high density sectors, and 30% by 2016) (Ref. 8, p.51).

The DREAL is responsible for leading the National Actions Plan for the hamster. In order to protect the Hamster, the NAP advocated for a wider knowledge of the species and its habitat.

To achieve this objective, it was essential for the Directorate to periodically receive information on the distribution and the kind of cultures implemented on the Alsatian territory to: a) locate and quantify the existing habitats; and b) take measures to create new habitats where the species is more likely to thrive.

The previous solution

The fragmentation of the habitat of the common hamster and the exploitation of these areas for different uses, had restrained the implementation of decisive protective measures to safeguard the habitat of this species before 2010.

It was only after that date that it was decided to regularly map the hamsters' habitats in Alsace as a basis to implement conservation and repopulation measures.

Alternatives to the satellite service

To identify favourable habitats for the common European hamster to reproduce, the DREAL could rely on the information on the type and surface of crops, provided in May by farmers in their annual statements under the framework of the EU Common Agricultural Policy. Lamentably, the results of the statements were only elaborated by the Departmental Direction of the Territory (DDT) and made available in December, when the hamsters are already in their hibernation period, and it is hence too late to implement targeted conservation actions.

A possible alternative to map the hamster's habitat could have been to send staff from the DREAL to perform a field survey on the regional territory. Nevertheless, the high cost of field surveys as a way to monitor habitat quality meant that they could not cover the hamster's habitat entirely.

The satellite-based solution

The implementation

In 2010, the DREAL decided to contract SERTIT (Regional Service for Image Treatment and Remote Sensing of the University of Strasbourg) to realise an easily updatable cartography of the common hamster's habitats.

The acquisition of the satellite-based cartography was funded with the regular budget of the DREAL. In addition to the SERTIT, the initiative also involved private and public stakeholders, who were called to implement the protection measures recommended by the DREAL.

Service availability and procurement

The satellite-based cartography was fully outsourced to the SERTIT. The service was already partially developed when the Directorate started using it. It was however adapted to the specific needs of the DREAL.

Organisational aspects

The decision to invest into the satellite-based system was autonomously taken by the DREAL.

Before implementing the system, an assessment of needs was conducted by the institution.

Indeed, the DREAL had a very precise idea of the information needed to identify and monitor the hamster's habitat, while the SERTIT was in

charge of defining the technical specifications of the images needed to realise a significant cartography.

From 2010 to 2013, the DREAL and the SERTIT acted in concert to continuously improve the system, modifying the kind of images acquired and defining new levels of information to be extracted. This refinement was aimed at providing environmental managers with indexes and information on the species' number and behaviours that would allow to better evaluate conservation measures and to follow the species' evolution throughout time.

Key facts on the implementation	
Implementation framework	Operations
User's economic contribution	Own budget (public local funds) €10,500 in 2010 2% of Hamster mission's annual budget in 2010
Partners	Academic or scientific institutions (SERTIT) Local authorities Private companies

Implementation challenges

Technical
No technical barriers were encountered by the staff of the DREAL to use the satellite-based cartography realised by the SERTIT.
Organisational
Since the technical solution was outsourced, the DREAL did not need to perform any organisational changes or to hire new staff to use the satellite-based cartography for its operational needs.
Administrative
No resistance was encountered by the DREAL to convince its staff of the convenience of taking-up a new satellite-based service to enhance the protection of the European hamster.
Other
It has been difficult for the DREAL to convince stakeholders, like farmers, of the reliability of the satellite-based cartography and of the convenience of using it to create corridors within the plantations to protect and feed the hamsters.

Operating the system

Key facts on the operation	
User's economic contribution	€27k in 2013* 5.14% of Hamster mission's annual budget in 2010 *This amount includes the cost for contracting external consultants

The land cover of the whole area populated by common hamsters in Alsace has been mapped from automatic classifications of high and very high resolution satellite imagery, and then validated via photo-interpretation and field observations within a radius of 600 meters around hamster burrows; this area corresponds to the roaming territory of the rodent (excerpt from Ref. 6, p. 486).

Since 2010, the DREAL has been using the satellite-based cartography of the hamsters' habitats as a routine methodology listed in the current action plan for the species (Ref. 6, p. 489).

Each year, from 2010 to 2014, new satellite imagery was acquired to get an updated habitat map in spring. Such cartography allowed the DREAL to perform an annual analysis of the small rodents' biotope. Indeed, it was possible to identify favourable crops and the main threats to the hamster, e.g. landscape fragmentation,

expansion of bare soil areas and urban pressure on habitats, and to plan conservation and repopulation measures.

This early spring mapping highlighted hamster-friendly crops (winter cereals and feed crops - alfalfa, clover), bare soils (corn and other spring crops), artificial features (urban areas and large transport infrastructure), and other features of the green and blue landscape (forest, prairies, vineyards, water bodies), and was meticulously carried out around hamster burrows every year, giving an accurate idea of the situation at the end of the rodent's hibernation period (end of March / beginning of April). This period appears as a key moment for hamster survival, as spring crops, which constitute a large majority of cropland, are not yet planted or are still underground, they do not provide protection against predators or food (excerpt from Ref. 6, p. 486).

To put the results of the habitat mapping to use, the DREAL tried to communicate on the importance of the protective measures through meetings and its website, with the aim of involving other environmental managers and stakeholders.

Operational challenges

Economic
Between EUR 12,000 and 24,000 per year were spent to map approx. 1,500 km2. It is normally difficult to find funding for activities related to habitat conservation, but the solicitations of the European Commission helped to make these resources available.
Sustainability
Since 2014, the DREAL decided to stop buying satellite imagery to update the habitat map on the basis of the farmers' declarations.

The staff of the DREAL had no difficulties accepting the adoption of the satellite-based solution and did not need any additional assistance to use the satellite-based habitat cartography.

Nevertheless, after 2013, farmers claimed that differences existed between their annual statements (made under the framework of the EU Common Agricultural Policy) and the information provided by the satellite imagery. The farmers challenged the validity of the satellite-based cartography and that entailed difficulties for the DREAL to keep using the service.

In 2014, it was hence decided to stop acquiring the satellite images and the DDT (Departmental Direction of the Territory) was asked to elaborate the information contained in the farmers' declarations earlier, so as to transfer it to the DREAL in June, when conservation measures for the season can still be implemented.

This method allows the DREAL to implement the same preventive measures it would have previously launched based on the satellite cartography. Unfortunately, this method does not allow to automatically detect the changes in the habitats throughout the years, but the comparison of the habitat status should be made manually by the DREAL staff.

Benefits of the satellite-based solution

Service efficiency and provision

The integrated use of field surveys and satellite imagery to monitor the common hamster's habitat became a routine methodology of the DREAL between 2010 and 2014, listed in the action plan for the species.

The information obtained helped to better identify priority sites in which agricultural measures should have been taken in the following year to improve the hamster's habitat.

As an example, farmers were advised to focus on wheat or alfalfa plantations providing food and protection to the hamster in spring and in early

summer, or to leave some plots of land unharvested to provide hamsters with coverage against predators.

Cost-benefit

The images allowed the DREAL to take concrete measure to avoid further controversies with the EU Court of Justice and to comply with the requirements of the Habitat Directive, hence avoiding monetary penalties to France for several million euros.

The map cost approx. 2% of the annual budget of the DREAL "Hamster mission"; the update around 5%. Cecile Bouquier, project manager of the Hamster Mission at DREAL Alsace, estimates that to acquire the same quantity and quality of information through traditional methods, like field and aerial survey, would have requested a much more considerable amount of time, although difficult to quantify.

Society and the environment

The information obtained enabled a better identification of agricultural activities and measures to be taken to protect the hamster's habitat.

Sharing this information with all stakeholders, in particular with regional environmental protection associations, local communities and relevant professional associations, these had also the opportunity to become more than mere observers by acting efficiently according to the needs of the species.

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Flood mapping of River Thames derived from Landsat 8 satellite data acquired on 07/01/2014. © Environment Agency 2014

The Environment Agency, England, uses satellite imagery to manage flood events

THE USER

Environment Agency

Bristol, UK
www.gov.uk/government/organisations/environment-agency

KEY FACTS

The EA is able to produce cartography of the flooded area within 24 to 48 hours from the activation of the International Charter

No external assistance is needed to use the images

The only expense of the EA is the cost of the images: those provided by the International Charter are free of charge, additional imagery in 2014 cost EUR 12,785 (GBP 10,000)

Since 2007, the Environment Agency has been using satellite imagery to facilitate and accelerate recovery measures after major floods.

"Satellite data provides us with an overview of flood extent and damages in a reliable, timely and cost-effective fashion"

Andrew Richman, Applications Manager, National Operations, Geomatics, Environment Agency

The Environment Agency, England, uses satellite imagery to manage flood events

The context

Since December 2013, storms and heavy rain have caused floods across the United Kingdom.

In January 2014, an estimated 300 properties had been flooded and one person was reported dead (Ref. 8).

Abundant rain saturates the ground and can cause major rivers, like the Thames, the Severn, and the Stour, to flood. Between 2013 and 2014, flooding has affected very severely the South East and West of England. Roads and train services were disrupted (Ref. 8), causing distress and inconveniences among residents.

The Environment Agency

The Environment Agency (EA) is a non-departmental public body, established in 1996 to protect and enhance the environment in England (and, until 2013, also in Wales). The EA pursues its missions acting at the local, regional and national levels in the English territory.

The Agency is funded by the Department for Environment, Food and Rural Affairs (DEFRA) and through business licenses. It then administrates its resources autonomously. An extra-ordinary budget for flood management is also available.

Of the 10,000 people employed by the Agency, about 3,000 work specifically on forecast, mitigation and recovery activities related to flood and coastal risk management.

Key facts on the Environment Agency	
Nature	Public institution
Area of operation	National, regional and local (England)
Sources of budget	National public funds Private funds
Annual budget (year)	> €100m in 2014
N° staff	10,000 (3,000 of which for flood-related activities)

Previous knowledge of satellite services

Approximately 30 people within the National Operations and Flood and Coastal Risk Management Directorates of the Agency are experts in remote sensing and satellite-based services.

Indeed, the Agency has been carrying out several research activities to assess the potential of satellite applications for flood and water management.

In 2007, based on their background skills and previous experience, the staff of the Environment Agency thought of starting using Earth observation for flood forecast, assessment and management.

The challenge

A study performed by the Environment Agency in 2009 (*Investing for the future, flood and coastal risk management in England, a long-term investment strategy*), revealed that one in six properties in England is at risk of flooding from rivers, sea and surface water (Ref. 4, p. 4). More than five million people live and work in the 2.4

million properties that are at risk of flooding from rivers or the sea, one million of which are also at risk of surface water flooding. A further 2.8 million properties are exposed to surface water flood risks alone (Ref. 4, p. 4).

Floods inflict damages of an average cost of more than one billion pounds annually, costs which are borne by households, businesses, central and local government and other entities, including insurance companies (Ref 4, p. 8).

The Environment Agency is responsible for monitoring flood-related risks and for delivering timely and reliable information on flood extent to regional and local administrators in charge of recovery measures.

In 2009, the EA estimated that every pound invested in new and improved flood risk management assets reduces the long-term cost of flooding and coastal erosion damages by around eight pounds (Ref: 4, p. 8).

Indeed, the Agency has been actively exploring new techniques and solutions to assess flood damages more efficiently and for less.

The previous solution

Traditionally, the Environment Agency has been using aerial imagery or ground measurements to assess flood extension. This requires sending aircraft over the flooded areas and specialists on the field to record water levels and to register the information into shared maps.

Alternatives to the satellite service

Deploying aircraft and staff on the ground is more costly and time-consuming than using satellite imagery to assess the flood extent on large areas. Moreover, these methods do not allow the Agency to receive information on large flooded areas quickly enough to plan recovery measures in the short time. This is especially true during multiple events, when a consistent number of staff and/or aircraft should be available to rapidly assess the extent and the nature of the damages produced by floods on urban, rural and natural assets.

The satellite-based solution

Implementation and operational use

Since 2007, the Environment Agency uses EO for forecast, management and recovery of flood events. The Agency collaborates with universities and research centres to explore the potential of satellite imagery and to develop new services.

Key facts on the implementation	
Implementation framework	Operations
User's economic contribution	Own budget Public national funds €12,788 - one-off cost in 2013 and 2014
Partners	Academic institutions Public service bodies International organisations

Service availability and procurement

After assessing their data requirements in case of flood events, in 2007 the Environment Agency took the decision to acquire satellite imagery to better monitor water levels.

Some of the satellite-based services exploited by the EA to face flood emergencies were already available on the market and ready to be used, while others have been developed by the Agency staff, in collaboration with academic and scientific institutions, to suit their specific needs.

The EA has internal expertise to analyse the images and extract the relevant information.

Hence, their only expenses are linked to the acquisition of the raw satellite data.

Satellite imagery used to perform these activities is acquired under different frameworks and at different costs.

For forecasting activities, the Agency acquires satellite imagery to monitor water levels and floods in collaboration with the Met Office.

For the assessment and recovery phases instead, the EA profits from two international schemes:

The EU Copernicus programme (www.copernicus.eu); and

The International Charter on Space and Major Disasters (www.disasterscharter.org).

The UK is indeed a member of the International Charter on Space and Major Disasters, which provides data from various satellite assets for relief operations during major disasters (the private company Disaster Monitoring Constellation International Imaging -DMCii is in charge of representing the UK at the Charter meetings on behalf of the UK Space Agency).

Organisational aspects

In 2013 and 2014, England and Wales have been affected very severely by an exceptional run of storms, culminating in serious coastal damage and widespread, persistent flooding. Both times the Agency asked the Civil Contingencies Secretariat of the Cabinet Office to activate the International Charter, while also benefitting from the satellite data made available by the EU Copernicus programme.

Since the images provided by the Charter cover only the peak of the disaster, on both occasions the Agency also acquired satellite images (at a cost of EUR 12,788, or GBP 10,000, each time), to continue mapping the flood water extent and its decrease and to then target recovering measures where they were most needed.

The EA did not need assistance to request or process the images and no pilot period was needed to start using the satellite-based information operationally. These activities are funded with the regular budget of the EA and through special funds made available for flood management.

Implementation and operational challenges

Technical
The EA is able to analyse and process the images autonomously to assess flood extension and to plan recovery measures. Regular training is provided to the staff of the EA to ensure that their abilities to interpret satellite data are constantly up-to-date.
Economic
The cost of the images was a problem at the beginning, but has become less relevant throughout the years.
Material
When the EA started using EO for flood monitoring and forecast, satellite imagery availability was still a challenge, but the International Charter and the Copernicus programme have largely contributed overcoming this problem.
Organisational
At the beginning (2007), it was difficult to convince the staff of the Agency of the reliability and convenience of using satellite imagery instead of traditional methods. It was hence necessary to prove the added value and the accuracy of the satellite-based information. The EA also needed to hire new staff with specific expertise to analyse and use the satellite imagery. The organisational changes were not performed all the once, but new experts were selected throughout the years to adapt to the new operational needs of the Agency.

Operational

After the initial training and the organisational changes needed, the EA did not require any external assistance to process satellite data and use the information.

Sustainability

The Agency does not consider as a challenge to keep using satellite-based data in the future. Their benefits have indeed been proven and their use is expected to continue as an operational practice of the EA when dealing with floods.

Benefits of the satellite-based solution

Service efficiency and provision

During the floods in England in 2013 and 2014, between 24 and 48 hours after the activation of the Charter 'Space and Major Disasters', the free satellite imagery received enabled the EA to produce and disseminate a cartography of the flooded area.

This showed flood extent, damages and infrastructure in agricultural, recreational, commercial, industrial, residential, and urban areas over a significant part of Southern England.

Using satellite imagery allowed the Agency to have an overview of the flood extent and damages on a large area. In effect, particularly when big areas are affected, satellite imagery allows breadth and scale to be quickly assessed, targets for high resolution imaging to be identified, and change detection maps to be created for year-to-year, or event-to-event comparisons (Ref. 5).

The Charter allows national civil protection authorities to access a pool of free satellite data to assist with immediate disaster relief operations, and for creating accurate maps of at-risk areas for future mitigation plans.

Cost-benefit

The EA estimates that by using satellite imagery they are able to realise savings both in terms of time and economic resources.

Traditional methods like aerial photographs and ground measurements are still used by the EA when facing flood events, but combining these with satellite imagery allows the Agency to react much more quickly and at a fraction of the cost of assessing the flood extent with the sole support of ground-measurements.

Society and the environment

EA's satellite-based maps are shared with the administrations in charge of mitigation and recovery at the local level. The information can also be combined with other geo-data, such as infrastructure and community information, to identify the areas which are most at risk and target mitigation and recovery measures. Indeed, in the last activation some of the post-event analysis was used in longer term modelling. The experience proved to be so successful that it already inspired competent authorities in Wales and Scotland to follow suit.

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The Flemish Agency for Roads and Traffic uses Satnav to optimise transit of regional trams

THE USER

Flemish Agency For Roads and Traffic
Traffic and Telematics Division

Brussels, Belgium
www.wegenenverkeer.be

KEY FACTS

The estimated yearly savings of the satellite-based system are approx. EUR 140,000

Designing and developing the system (including its pilot phase) cost about 7% of the Agency's yearly budget for reducing public transport congestion

Since 2008, the Flemish Agency for Roads and Traffic implemented a system of virtual loops, supported by satellite navigation and short range radio signals, that helps manage traffic lights so as to give priority to public trams while reducing maintenance costs.

"Not only does the new system have financial advantages, both in terms of investment and maintenance, it is also more reliable in giving green light to trams, since it permits a precise monitoring of the position of the vehicles and of the time it takes for a tram to pass a traffic light"

Ethel Claeyssens, Director-engineer for routes

The Flemish Agency for Roads and Traffic uses Satnav to optimise transit of regional trams

The context

The Flemish Region, commonly referred to as Flanders, is one of the three official Belgian regions, covering an area of approximately 13,000 km2.

The Flemish Agency for Roads and Traffic

Key facts on the Agency	
Nature	Public
Area of operation	Regional
Sources of budget	Regional public funds
Annual budget	€600m in 2014
Annual budget to reduce congestion for public transport	€18m in 2014
N° staff	1,500

The public administration of the Flemish Government is divided into 13 policy areas, each with an executive department and multiple agencies. The Flemish Agency for Roads and Traffic is one of the five agencies which form part of the policy area Mobility and Public Works.

The Flemish Agency for Roads and Traffic is a semi-independent government entity in charge of building and maintaining the road network in the region.

Under the authority of the Flemish Ministry for Mobility and Public Works, the Agency manages 6,970 km of regional roads and motorways and approximately 6,700 km of bicycle paths.

Proposals for major infrastructural adjustments or innovations are initiated by the Agency and then submitted to the Minister of Mobility and Public Works for approval.

The Agency consists of six so-called 'vertical' divisions and three 'horizontal' divisions. The vertical divisions jointly design, build and maintain roads and bridges on Flemish regional roads. They also manage and operate the electrical, electromechanical and telematic equipment along the regional roads, waterways, ports and airports.

The three horizontal divisions are responsible for coordinating the vertical divisions to make sure that they are all working towards the same goals. Their tasks include preparing mobility policies on traffic safety and electrical, electromechanical and telematic equipment, building up expertise, and providing technical advice to the vertical divisions on traffic policies, modification of intersections, traffic lights, road signs, and road construction, among others.

Previous knowledge of satellite services

Within the Agency, every division has one or two experts in Geographic Information Systems (GIS) and the Agency already had experience in using satellite navigation to optimise its services. Indeed, the building plans of all installations of the Agency are geolocated on a GIS system.

Moreover, the Agency can count on external expertise and support from the Flemish Agency for Geographic Information (Agentschap Geografische Informatie Vlaanderen - AGIV), which is in charge of implementing the INSPIRE Directive by collecting and distributing

geographic data to other regional public administrations.

The challenge

Within the Agency, the Traffic and Telematics Division is responsible for operating traffic lights on regional roads, and for ensuring priority in traffic for the trams and buses of the Flemish transport company De Lijn (The Line).

The Agency of Roads and Traffic has an annual budget of EUR 18,000,000 to reduce the effects of traffic congestion on public transport. In 2007, it decided to spend a part of this budget to test a new system for optimising the traffic of public trams on regional roads while reducing maintenance costs.

The previous solution

Key facts on the previous solution	
Cost of implementation	> €2m for 58 traffic lights < 1% of annual budget in 2007
Cost of operation and maintenance	€140k in 2007 < 1% of annual budget in 2007

Until recently, priority to public trams at traffic lights was assured by a system of loops placed on the street pavement of regional tram roads at about 300 - 500 metres from the traffic lights, and connected to them by electric cables. When a tram passed by a loop, a signal was sent to the traffic light through the electric cable, and a green light priority was given to the public vehicle.

This system was efficient but presented a few disadvantages: the loops were very fragile, and when they broke they disturbed the operation of the priority system. Moreover, they were fixed to the street pavement and their position could only be changed through infrastructural works that would disturb traffic.

To install this old system on an existing traffic light installation costs between EUR 20,000 and 80,000, depending on the size and location of the installation (town centre versus countryside). Most of the cost is represented by the price of the cable, which can be as long as 500 metres per loop. If the cable has to be placed in an urban area, the street pavement has to be broken up, which substantially increases the cost.

The loops were fragile and rather expensive to install and maintain: for the 58 traffic lights along the coast, the cost might be over EUR 2,000,000.

These disadvantages prompted the Flemish Agency for Roads and Traffic to look for alternative solutions to regulate street lights.

Alternatives to the satellite service

Spie Belgium (www.spie-be.com), which had supplied the loop system in Flanders for many years, was well aware of the advantages and disadvantages of this system. When evaluating available alternatives to substitute the system of physical loops on the street pavement, Satnav was immediately considered as the most adequate and feasible solution.

The satellite-based solution

The implementation

In 2008, Spie Belgium proposed the Flemish Agency for Roads and Traffic to test a system of virtual loops, supported by satellite navigation and short range radio signals, on the regional coastal tramway.

Service availability and procurement

The satellite-based service was already developed and available on the market when the Agency decided to adopt it on its regional roads.

However, it had to be adapted to their specific needs.

Organisational aspects

Key facts on the implementation	
Implementation framework	Operational framework
User's economic contribution	Own budget (local public funds) €1.2m for 58 traffic lights and 68 trams in 2008 0.2% of annual budget in 2014
Partners	Spie Belgium (contractor) De Lijn (public transport company)

The system was implemented by Spie Belgium in consultation and collaboration with the Flemish regional public transport company De Lijn and with the support of the Agency both for the design and implementation phases.

Before implementing the system, the Agency carried out a cost/benefit analysis which concluded that the Satnav solution would entail consistent monetary savings for the Agency.

The Satnav solution was first tested on one tram and five traffic lights in 2008. In 2009-2010, it was extended to 14 intersections and 10 trams and finally, between 2011 and 2013, to the whole coastal tramway network, including 58 crossroads with traffic lights and 48 trams (plus 20 extra trams during the summer season).

The annual maintenance of the system of virtual loops requires between EUR 200 and 400 per intersection, according to the size.

The design and development of the system (including its pilot phase) cost about 0.2% of the Agency's annual budget and about 7% of the yearly budget for reducing public transport congestion (EUR18,000,000).

Implementation challenges

Technical
Special training was needed for the staff of the Agency and the provincial operators to start using the new system.
Economic
The initial cost for installing the satellite-based system was indeed a challenge at the beginning.

Operating the system

Key facts on the operation	
User's economic contribution	€10k - €20k (2014)* < 1% annual budget (2014) *This amount includes the cost for contracting external consultants

Every coastal tram is now equipped with a GPS and a radio transmitter, connecting it to control cabins which have been placed at each crossroad and are equipped with GPRS devices.

As a tram approaches a crossroad (detected through the GPS connection), it starts sending signals to the control cabin continuously until the tram has passed the crossroad. These signals communicate information on the tram number, line and itinerary. Based on such messages the control cabin gives a green light priority to the tram, taking into account waiting times for other road users. When the tram has passed the traffic light, a last message is sent to the traffic control cabin.

Once the Satnav system was installed, no further training or assistance was needed by the staff of the Agency to use it.

Operational challenges

Sustainability

According to future budgets and priorities, it might be a challenge to maintain the solution in the future

Benefits of the satellite-based solution

Service efficiency and provision

While the previous system allowed trams to send only two messages to the control cabin, vehicles now remain in contact with the cabin until they have passed the light, hence increasing precision and reliability in traffic control.

After the adoption of the satellite based service, staff performance improved. Workflows are significantly smoother thanks to an increased amount of available information, which also enables the Agency to take better informed decisions.

Moreover, the Agency no longer needs to break the pavement to install, restore or test new locations for loops, which caused traffic disturbances to both public and private vehicles. The streetlight control service remains in effect permanently available also when performing maintenance or when testing new loops. This is probably also the reason why tram drivers are enthusiastic about the new system.

The Agency plans to further improve the system by focusing on the positioning of the loops. Indeed, since they can be easily moved, the Flemish Agency for Roads and Traffic can easily perform tests to define their ideal position.

Cost-benefit

The new system allows to control traffic lights and to give priority to public trams with considerable savings both in terms of money and human resources.

A first assessment of the new system estimates savings of around EUR 140,000 per year.

Indeed, annual maintenance costs are significantly reduced, since the loops detecting trams approaching are now 'virtual', and they can easily be moved and repaired with no need for infrastructural works.

These savings result from:

- Reduced annual maintenance costs
- No more pavement works for installation and reparation of broken loops and cables
- Reduced costs when repositioning the loops
- Reduced costs when installing a new traffic light.

This savings assessment did not take the costs of traffic disturbances into account when installing or restoring loops or the costs of the system's unavailability due to broken loops.

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Lyon Confluence: satellite data support solar energy production in a sustainable new city quarter

THE USER

SPL Lyon Confluence

Lyon, France
www.lyon-confluence.fr

KEY FACTS

The satellite-based solution costs 1% of the value of the energy annually produced (approx. EUR 125,000)

Operating and maintaining the installations without the satellite solution would cost the double, requiring at least one working hour per day on each installation

It would take several days to spot malfunctioning that is instantly detected by the system

Since 2009, the Lyon Confluence district has relied on satellite-based data to monitor photovoltaic (PV) panels.

"Satellite-data enabled Lyon Confluence to find an easy way to daily monitor PV installations remotely and at reasonable cost as compared to the energy output"

Maxime Valentin, Lyon Confluence

Lyon Confluence: satellite data support solar energy production in a sustainable new city quarter

The context

In the European Union, buildings account for 40 % of the total energy consumption and for 33% of CO2 emissions. 70% of the EU's energy consumption and a similar share of greenhouse gas emissions take place in cities (Ref. 4).

To try to reduce the impact of CO2 emissions on the environment and on health in cities, in 2005 the European Commission's Directorate General for Energy launched the Concerto initiative (www.concerto.eu), aimed at demonstrating that energy-optimisation of districts and communities as a whole is more cost-effective than optimising each building individually; the condition for this optimisation being that all relevant stakeholders work together to integrate technologies in a smart, efficient way (Ref. 4).

Within the 6th European Research Framework Programme (FP6), and with a budget of over EUR 175 million, Concerto funded 22 projects, comprising 58 communities and sites, in 23 European countries, allowing for the creation of a large database on energy-optimisation (Ref. 4).

The Concerto initiative has now been completed. The successor programme, "Smart Cities and Communities Information Systems" is expected to start in November 2014 (Ref. 4).

These funding schemes are supported, at the political level, by the "Europe 2020 strategy for smart, sustainable and inclusive growth" (Ref. 10), adopted in 2010 and setting the so-called 20/20/20 EU targets of the climate and energy package (Ref. 9). These aim for a reduction of greenhouse gas emissions of at least 20% below 1990 levels, and for an improvement of energy efficiency leading to a decrease in primary energy use of 20%. Moreover, by 2020 20% of final energy consumption should come from renewable sources.

The Covenant of Mayors (Ref. 5), joined by 3,700 local authorities by March 2011, has committed to go even beyond these targets (Ref. 19).

The SPL Lyon Confluence

With an area of 52,715 ha at the earth of the French Rhône-Alpes region, and a population of 1.2 million spread among 58 municipalities, the Urban Community of Lyon is the second largest agglomeration in France.

The SPL (Local Public Society) Lyon Confluence is the local public-redevelopment entity created in 1999 by Grand-Lyon to manage the Lyon Confluence initiative, a major urban project of requalification of the Confluence neighbourhood.

The area, covering 150 hectares near the historic centre of Lyon, has been long devoted to manufacturing and transport activities. Isolated from the rest of the city by the Lyon-Perrache railway station and the highway, the neighbourhood has been long characterised by poor living conditions.

Since 1997, the Lyon authorities have been studying a strategy to double the size of the city centre by upgrading this area.

The initiative includes the requalification of factories and dismissed buildings to create apartments and offices. The new Confluence neighbourhood includes a commercial centre, a museum, and the Rhône-Alpes Region offices, among other facilities, and it should attract

10,000 more residents, bringing the population to 17,000, and create 20,000 new jobs by 2030 (Ref. 24).

Key facts on the SPL Lyon Confluence	
Nature	Public
Area of operation	Local
Sources of budget	Local public funds EU funds
Annual budget	€15.7m in 2012 (Ref. 23)
N° staff	23 (regular staff)

With a staff of 23, and a share capital of EUR 1,800,000 in 2012 (89% of which are hold by Grand Lyon), the SPL Lyon Confluence is a public development organisation with extensive experience in urban development.

It is mandated to manage all activities related with the requalification of the Lyon Confluence site, including:

- Performing all studies prior to redevelopment and construction operations;
- Conducting all acquisitions of buildings or unbuilt-on plots;
- Drawing up all contracts and agreements in order to control land and sales of land to third parties for construction purposes;
- Conducting all necessary studies and financial, commercial, industrial and property operations;
- Conducting/commissioning the operation, management, maintenance and enhancement of public infrastructures; and
- Promoting the Lyon Confluence initiative (Ref. 16).

Indeed, reclaimed from the waters in centuries past, this riverside site is re-embracing its banks and natural environment. The redevelopment is gradually highlighting an outstanding location and unique landscapes. This project represents a pioneer experience in Europe, a major challenge for the metropolitan area, and an opportunity for its residents (Ref. 15).

Previous knowledge of satellite services

The staff of the SPL Lyon Confluence has experience in urban development and project management.

The entity has no internal expertise or prior experiences working with satellite services.

The challenge

Under the Concerto framework, the urban agglomerations of Zaragoza (Spain), and Lyon started in 2005 the Renaissance project "Renewable Energy Acting In SuStainable And Novel Community Enterprises" (today completed) aimed to create smart, environmentally friendly neighbourhoods. The Region of Lombardy (Italy) took also part in the project as an observer partner (Ref. 3).

In total, 19 organisations participated in this project, involving a large range of diverse stakeholders, from local authorities to technical and socio-economical experts, non-profit organisations, universities, energy services companies and real-estate developers.

In Lyon, the Renaissance project aimed at creating a group of energy efficient buildings in the Confluence neighbourhood. The construction took place between 2007 and 2010 on a floor area of 79,000 m2 and was implemented by three real estate developers (Ref. 8).

The goal of the project was to build a neighbourhood in which 80% of heating and 50% of electric consumption in common areas of housing buildings, and 30% of electricity produced for air conditioning in office buildings come from renewable sources of energy.

Solar was among the green energy sources chosen. The implementation of a photovoltaic (PV) system presented two challenges:

- first, it was necessary to select the location of the PV systems to maximise the potential of the installations;
- then, a monitoring system had to be implemented to monitor their correct functioning.

Alternatives to the satellite service

The biggest challenge for the project partners was to find a way to monitor the different PV systems with little investments, both in terms of time and of human and economic resources.

In effect, although PV is a reliable technology with little maintenance needs, experience of large urban scale projects installed in Europe shows that when large numbers of small photovoltaic (PV) systems are installed on buildings in urban areas and then left for ordinary building occupants to operate with no or little professional support, this can lead to loss of performance in the longer term (Ref. 19, p. 45).

As noted in final report of the Renaissance project, although there are good products suited for single PV systems on the market, there was no product available for monitoring a large group of technically non-homogenous PV systems in an easy, time-effective and convenient way (Ref. 19, p. 45).

It was hence necessary to build an innovative, comprehensive monitoring system for the whole group of panels.

This system had to be compatible with all kind of inverters, include a single platform to monitor a large group of PV systems, automatically detect any kind of failure, and generate an alarm to the PV owner in case of failure.

The Satellite-based Solution

The implementation

Key facts on the implementation

Implementation framework	Demonstration project (6th European Research Framework Programme - FP6)
User's economic contribution	External funding (EU funds) < €20k in 2009 < 1% of annual budget in 2009
Partners	SPL Lyon-Confluence HESPUL Local Agency on Energy of Greater-Lyon (ALE) Engineer Office ENERTECH Centre for thermal energy of Lyon (INSA-CETHIL) Nexity-Apollonia (LOT A) Bouwfonds-Marignan (LOT B) ING Real Estate - Atemi (LOTC)

To comply with the project objectives, in addition to wood chip boilers and solar thermal systems, 11 PV systems have been installed in the Confluence neighbourhood for a total power of approximately 250 kWp.

The assessment of the energy potential and the implementation of a PV monitoring tool were entrusted to Hespul, a local association with experience in renewable energy development and energy efficiency, which was also part of the Renaissance project consortium.

Based on data extracted from satellite imagery, Hespul analysed solar radiations to a) assess the potential energy output of the panels in their location, and b) monitor the proper functioning of the installations by comparing the energy potential of a solar panel with its actual output.

Service availability and procurement

On the one hand, the initial assessment of the energy potential of the installations was performed using the satellite-based data provided free by the EC Joint Research Centre (JRC), in Italy.

Hence, implementation costs for the solar potential assessment could be limited to less than EUR 20,000, mainly represented by the cost of human resources.

The result is a solar cadastre showing the potential energy output of the 11 PV systems installed in Lyon Confluence.

On the other hand, monitoring the installation required the creation of a software to compare the actual output of the PV systems with their energy potential automatically and remotely.

Meteotest (www.meteotest.ch), a company specialised in meteorology, environment and information technology, had developed a software integrating satellite-based data to monitor single PV installations. Hespul decided to capitalise on this tool to produce an improved version of the software which would monitor different PV systems at once.

The software produced, EPICES (www.epices-energie.fr), gives an overview of the good operation of all PV systems of this district, showing the energy output of each installation. The PV system monitoring tool for the Confluence district is online and can accessed here: www.renaissance-project.eu/spip.php?article208&lang=en

Organisational aspects

EPICES, the software created to monitor PV panels remotely was first tested by Hespul in 2009 on a 13 kWp existing PV system, in order to assess the level of complexity to install such a system, the reliability of data transfer by GSM and also the sensitiveness of the automatic failure detection algorithm.

As the conclusion of this experiment was quite promising, the software was further developed and installed on all PV systems within the Renaissance project in Lyon. In 2011, a first version of the improved software was made available (Ref. 19, p. 45).

Implementation challenges

Technical
No technical challenges were faced by the SPL Lyon Confluence, since both the solar potential assessment and the software to monitor the PV systems were implemented by Hespul.
Economic
The costs to implement the solar power assessment and the PV monitoring system were funded through the Renaissance budget and they did not represent a challenge for the SPL Lyon Confluence.
Material
Hespul faced material challenges in improving the pre-existing Meteotest software to monitor a large number of solar installations.
Organisational
Hespul was known by SPL Lyon Confluence, which trusted its capabilities. Hence, there was no internal resistance to use satellite-based data to perform the power assessment and then monitor the installations. No organisational changes were needed within the SPL Lyon Confluence to implement the system.

Operating the system

The satellite based system allows users to compare the estimated hourly output of each PV panel with actual production data. This comparison is performed every hour using satellite imagery provided by Meteotest. In case

of difference, an alert is sent to one of the project participants so that the faulty PV system can be repaired as soon as possible.

The power potential assessment and the monitoring of the installations were first funded under the Concerto/Renaissance project. Today, Hespul continues monitoring the PV systems within the framework of a new EU-funded project, "Lyon Smart Community" (Ref. 17), involving NEDO (New Energy and Industrial Technology Development Organization, Japan) and aiming at testing the economic feasibility of a smart-grid energy network in the Confluence neighbourhood (Ref. 1). In 2016, when this project will also be completed, new funding schemes will have to be evaluated to ensure service continuity.

Key facts on the operation of the satellite solution	
User's economic contribution	Free of charge during the demonstration project. After project completion: Approx. €1,500 per year for 10 installations (2013) < 1% of annual budget in 2013

Operational challenges

Economic

No challenge has been encountered so far by the SPL Lyon Confluence to contract the services of Hespul.

Operational

Since the monitoring of the installations is performed by Hespul, no technical difficulties are encountered by the SPL Lyon Confluence and no training is needed by their staff for the service to be operated. It is nevertheless important to underline that the monitoring system is more likely to be compatible with the PV installations if the decision to connect a PV system to the urban scale PV monitoring tool is taken at the time of designing and installing the PV system itself.

Sustainability

To ensure service continuity after 2016, PV owners could pay a fee to continue its services. This fee should not constitute an economic challenge, compared to the annual outputs of the PV system.

Benefits of the satellite-based solution

Service efficiency and provision

Thanks to satellite data, all PV systems of the CONCERTO Renaissance installed in the Lyon-Confluence are controlled each day to make sure that they operate properly and that malfunction is detected very quickly.

The tool monitors all the 11 PV panels everyday with daily performance available on one single Internet website. It detects automatically any kinds of malfunctioning and it is easy to use (Ref. 19, p. 46).

It would take normally several days of site inspections to detect malfunctioning which is automatically spotted with the satellite-based solution.

Cost-benefit

The PV installations (2,000 m2 of solar panels) produce 250 kw per hour, for an annual production of approximately EUR 125,000 at the current cost of electricity.

Therefore, the cost of using the satellite-based monitoring system corresponds to only 1% of the value of the energy annually produced, and it is expected to decrease thanks to service improvements.

Indeed, the satellite-based solution entails savings both in terms of money and time to monitor the solar panels. Hespul estimates that to operate and maintain the installations without

the satellite-based solution, it would cost approximately the double, requiring at least one hour of work per day on each installation.

Overall, the Confluence initiative shows that drastic reductions in conventional energy consumption (up to 70%) are achievable at reasonable costs and acceptable financial risks on energy saving investments (Ref. 3).

Society and the environment

The software makes solar-panel monitoring less costly and more attractive to producers interested in building large solar fields, therefore encouraging the reduction of the carbon footprint.

The Renaissance project demonstrated that practical solutions to local energy needs, applied in highly innovative ways, have a large and immediate potential for replication across the rest of Europe, paving the way towards Post-Carbon Cities (Ref. 3).

Other benefits

Immediately after the installation of the solar equipment in the neighbourhood of Lyon Confluence, the Region of Rhône-Alpes contracted Hespul to assess the potential of and to monitor solar installations on the roof of their premises. A user manual has also been provided to the Region, for them to autonomously monitor the correct functioning of the installations.

The use of the system by Lyon Confluence also inspired other public or private organisations all around Europe. Indeed, capitalising on its experience in Lyon Confluence, EPICES, the tool developed by Hespul, is used to monitor today several PV fields in France, Belgium and Switzerland, among others.

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University Hospital Coventry and Warwickshire NHS Trust: Satcom use in public health campaigns

THE USER

Breast Screening Unit, University Hospitals Coventry and Warwickshire NHS Trust (UHCW)

Coventry, United Kingdom
www.uhcw.nhs.uk/our-services/a-z-of-services?sID=84

KEY FACTS

The cost to adopt and use the service accounts for about 2% of the annual budget of the Breast Screening Service

The solution is cost-neutral compared to the previous system. It entails significant time-savings and ensures that no clinical data are lost during their transfer to the hospitals

Since 2013, the Breast Screening Unit at UHCW, in West Midlands, UK, uses a satellite connection to safely and securely transfer mammography images from its mobile screening units back to the hospital for reporting.

"The introduction of a telemedicine service via satellite improved the effectiveness of our breast cancer screening programme and heads towards a paperless / paperlite working environment, with positive consequences on the hospital's workflows and on women's health."

Sharon Hoffmeister, Supt. Radiographer, Breast Screening Unit, UHCW

University Hospital Coventry and Warwickshire NHS Trust: Satcom use in public health campaigns

The context

Although breast-cancer mortality decreased significantly in most European countries between 1989 and 2006, breast cancer remains the most common form for women. In Europe only, it caused 13.01 deaths per 100,000 population in 2009 (Ref. 6).

According to the World Health Organization (WHO), evidence from high-income countries indicates that early cancer detection thanks to mammography screenings highly increases chances of recovery, and if combined with adequate funding and infrastructure for treatment can lead to a reduction in breast cancer mortality of at least 20% in women aged over 50 (Ref.6).

For these reasons, several countries have started investing in prevention and early detection of breast cancer (Ref. 3) and most European countries are running or setting up population-based screening programmes for breast cancer based on mammography (Ref. 6).

In 2009 there were 48,417 new cases of breast cancer in women in the UK, and 371 in men (Ref. 4). The UK National Health Service (NHS) has been running a Breast Screening Programme (NHSBSP) to reduce breast cancer mortality since 1987. Indeed, it is estimated that breast screening saves 1,400 lives each year in England (Ref. 1).

The Breast Screening Unit at UHCW

The University Hospitals Coventry and Warwickshire NHS Trust (UHCW) is one of the largest teaching hospitals in the UK. Located in the English region of West Midlands, the UHCW comprises the University Hospital of Coventry and the Hospital of St Cross in Rugby.

The UHCW is a public institution funded by the English National Health Service (NHS), and serves a population of over a million people.

The Breast Screening Unit at the UHCW operates with a staff of 40. It provides a free breast screening service in the Coventry, Solihull and Warwickshire boroughs.

Key facts on the Breast Screening Unit at UHCW	
Nature	Public
Area of operation	Regional and local
Sources of budget	National public funds
Annual budget	€500k - €2m (2014)
N° staff	40

Previous knowledge of satellite services

Before 2013, the staff of the UHCW's Breast Screening Service had not had any experience of use of satellite-based applications within the framework of their tasks.

The challenge

To increase chances of an early detection, the NHS Breast Screening Programme invites women aged between 47 and 73 for free routine breast screening every three years. Once women reach the upper age limit for routine invitations

for breast screening, they are encouraged to make their own appointment.

In addition to the hospital facilities, women have the opportunity to be screened also in one of the 180 mobile Breast Screening Units (Ref. 3) deployed across the UK. These are vans with screening equipment which are stationed in front of well-frequented locations, like supermarkets or leisure centres for ease of access. Eligible women are invited to attend for screening, and receive test results directly to their home within two weeks of the screen.

The routine breast screening examination consists of a 4 view X-ray examination and lasts between five and ten minutes, while the whole visit takes no more than 15 minutes. The tests are then sent to radiologists in the hospitals to be analysed.

Within the National Breast Screening Programme, the UHCW has two mobile breast screening units available.

The challenge for the Breast Screening Programme of the UHCW was to find a reliable and safe way to transfer the mammography images from the mobile units to the hospital, while avoiding the risks of data loss and delay during their transport.

The previous solution

Key facts on the previous solution	
Cost of operation and maintenance	Approx. 2% of annual budget of the Breast Screening Unit in 2012

Until 2012, the images and clinical paperwork were transported by car on a daily basis by a staff member. The clinical images were downloaded onto an encrypted hard disk and were then transferred to the hospital by car.

Physically transporting the screening tests entailed challenges in terms of patient data security (results could indeed get lost during the transport), speed of turnaround, requirement for a courier and lack of live administration systems.

Alternatives to the satellite service

To overcome some of these hurdles, while also moving forward to a paperless system, the mobile vans were connected via 3G to the hospital network system, allowing a live administration system to be used, but not allowing transfer of images.

A paperlite environment was then attempted. However, as the 3G connection would drop out quite often due in part to the weak network coverage at the mobile vans' locations, a different and more resilient solution was needed to efficiently sustain a paper free screening environment.

The satellite-based solution

The implementation

In December 2012, the UHCW Breast screening service was invited by RedFoot Technologies (, a UK-based company providing satellite-based services Ref. 5), to test a satellite connection on the vans within the framework of the Mercury project (Ref. 3).

The project was funded by the European Space Agency's Advanced Research in Telecommunications Systems (ARTES) 20 Integrated Applications Promotion (IAP) programme.

The ARTES 20 IAP programme supports the development, implementation and pilot operations of integrated applications, which combine data from at least two existing and different space assets, such as satellite communication, Earth observation, satellite navigation, human spaceflight technologies and others (Ref. 2).

Key facts on the implementation	
Implementation framework	February 2013 - July 2014: ESA ARTES 20 IAP Mercury project From August 2014: Operations
User's economic contribution	Own budget (public national funding) < €20k in 2014 2% of the annual budget of the Breast Screening Service at UHCW* *This figure includes initial contracting, operation and maintenance costs after completion of the ESA-funded project (including the cost of human resources and the expenses associated with the physical transport of the tests)
Partners	European Space Agency RedFoot Technologies Ltd, UK

The project involved different UK hospitals and aimed at developing, integrating, testing and demonstrating an effective and commercially viable service providing end-to-end secure transmission of medical images through the use of multiple space assets (Satcom, Satnav) from remote mobile breast-screening units directly to the central hospitals' radiologists.

The ultimate objective of the Mercury project was to establish an incontrovertible business case for the adoption of a new managed service that could deliver full communications via satellite to mobile breast screening units in the UK (Ref. 3).

Service availability and procurement

The Satcom/Satnav service already existed and was available on the market, but it was adapted to the specific needs of the Breast Screening Unit of the University Hospitals Coventry and Warwickshire and was improved during the duration of the Mercury project.

RedFoot was in charge of defining the technical specifications of the service, in consultation with the staff of the hospital, and of developing it.

The satellite-based solution was provided to the UHCW Breast Screening Service free of charge during the duration of the Mercury project (February 2013 - July 2014).

After its completion, appreciating the usefulness and efficiency of the project results, the UHCW decided to contract RedFoot directly, to continue the provision and improvement of the satellite-based service.

Today, the service is paid with the regular funds of the Breast Screening Service at UHCW and its cost represents approximately 2% of their annual budget, the same percentage of the previous system.

Organisational aspects

After performing a needs' assessment and defining the technical specifications of the service with RedFoot, since February 2013 the Breast Screening Service at UHCW has been equipping its mobile units with a satellite antenna, allowing the staff of the hospital to send the mammography images directly to the hospital.

Implementation challenges

Technical

To record and transfer the mammography results, a software was especially created. To learn how to log into the software, send information via the Satcom connection and access data to generate administrative documents and work lists, the staff of the Breast Screening Service received some initial training within the framework of the Mercury project.

Economic
During the demonstration project, the service was provided for free and did not entail any economic challenges. When the hospital decided to contract the services of RedFoot, the initial investment was considered as quite important by the hospital authorities. The economic viability and sustainability of the service had hence to be proven before deciding to finance the service with the institution's budget.
Organisational
No organisational changes had to be performed and no new staff was needed to use the satellite-based service to transfer the screening tests from the mobile units to the hospital.

Operating the system

Key facts on the operation	
User's economic contribution	Free of charge during the demonstration project. After project completion: approx. 2% of Unit's annual budget (2014)

After completion of the Mercury project, the UHCW decided to keep the service by contracting RedFoot directly. The decision followed a cost-benefit analysis of the service, showing that the satellite-based system was cost-neutral for the Coventry service when compared to the previous system, which included the costs of a courier and a car to physically collect and transfer the tests to the reporting centre.

The mobile screening units are now equipped with a satellite antenna, which allows the sending of screening tests directly to the hospital. The satellite connection ensures a secure online access to the hospital intranet, while supporting the transmission of screening patient data back to the remote units.

Moreover, the system includes pre-packaging of the images and embeds indelible GNSS data into the patient medical records, for date and location identification (Ref. 3).

Operational challenges

Economic
The cost-benefit assessment proved that the system does not entail additional costs when compared to the method previously employed.
Operational
After adopting the satellite-based solution no assistance was needed to use it operationally. Following the initial phase, no training was necessary for the staff of the hospital to use the system.
Sustainability
Despite its enhanced efficiency compared to the 3G connection, the transmission of screening results still presents issues from time to time. This is partly due to the software used by the NHS Breast Screening Programme to record the outcomes of breast screening appointments and a woman's screening history (the system is known as the National Breast Screening System - NBSS). RedFoot is currently working with the software provider to try and solve these issues.

Benefits of the satellite-based solution

Service efficiency and provision

Physically transporting large amounts of data from one location to another has long been regarded as a risk to the patients and the medical organisations within the mobile X-ray environment (Ref. 3). The satellite connection avoids these risks by providing an easy-to-use solution to transfer medical tests in a virtual environment.

Moreover, the personnel of the Breast Screening Service at UHCW considers that the satellite-based solution improved staff performance and

smoothened workflows, while both the quality of the service and customer satisfaction increased.

Cost-benefit

Even if the initial investment is quite important in the short period, the satellite connection leads to a decrease in administrative and staff expenses, while avoiding the costs and embarrassment associated with possible data loss. Indeed, the new system based on Satcom and Satnav is cost neutral when compared to the system previously used.

Not only it entails time-savings for transporting and analysing the tests, but it also allows the staff of the hospital previously in charge of transporting the tests around to use that time for other work-related activities.

Society and the environment

The staff of the mobile breast screening units is able to attend 120-160 women per day, for a total of about 300 women per week, who receive their test results within ten working days.

Furthermore, the GNSS data (date and location) that are embedded into the patient medical records could be useful for identification purposes, auditing, mobile units tracking, as well as statistical mapping of breast cancer using anonymous data (Ref. 3).

Finally, the Satcom solution is environmentally-friendly, since it supports the shift towards a paperless or paperlite environment and avoids the use of polluting vehicles to transport the screening tests.

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Satellite-based map for Wales

THE USER

Natural Resources Wales/ Cyfoeth Naturiol Cymbru
Former: Countryside Council for Wales

Cardiff, Wales, United Kingdom
www.naturalresourceswales.gov.uk
www.ccw.gov.uk

KEY FACTS

In 2012, Wales released a satellite-based habitat map covering 8,022 km2

The CCW developed the methodology, produced the survey and performed two partial updates at less than a forth of the cost of the previous map

Since 2012, Wales relies on a satellite-based cartography to classify, monitor and protect natural habitats.

"We have produced a complete habitat map of Wales and intend to keep this up to date in the future to detect changes in land cover, habitat and possibly habitat condition and land use."

Alan Brown, Remote Sensing Manager, National Resources Wales

Satellite-based map for Wales

The context

Wales is one of the four official countries which make up the UK. Covering an area of approximately 20,800 km2 at the South East of Great Britain, it is mainly composed of mountain, moor, heath, and down land. Protected areas represent 30% of the territory. They include three national parks, five Areas of Outstanding Natural Beauty (AONB), more than a thousand Sites of Special Scientific Interest, twenty Special Protection Areas and ninety-two Special Areas of Conservation.

Since the 1st of April 2013, Natural Resources Wales (NRW) has taken over the functions carried out by the Countryside Council for Wales and Forestry Commission Wales, the devolved functions of Environment Agency Wales and some functions that are currently carried out within the Welsh Government (Ref. 9).

The Countryside Council for Wales and Natural Resources Wales

The Countryside Council for Wales (CCW) was the advisory body in charge of ensuring the conservation and sustainable public access to the natural heritage of Wales (Ref. 3). The institution was an official consultative body under the authority of the Welsh National Assembly, which appointed the members of the Council and provided its annual budget. With two directorates and three regional offices, the CCW employed 500 people and had offices throughout Wales.

The newly-formed institution Natural Resources Wales is mandated to take informed decisions about managing natural heritage, as well as public access to it. Furthermore, it must report every year to the Welsh Government on whether or not the targets set by Ministers are met.

The process of internal organisation of NRW is still ongoing. The entity currently employs approximately 2,000 staff. At present, one person is in charge of updating the habitat map of the Welsh territory.

Mapping of Wales is part of Flood Risk & Incident Management plan which is one of the four highlighted priority of NRW (Ref. 10).

Key facts on Natural Resources Wales	
Nature	Public
Area of operation	National (Wales)
Sources of budget	National public funds
Annual budget	€226,239,000 in 2014 (Ref. 9)
N° staff	2,000

Previous knowledge of satellite services

Before 2004, the CCW had no experience of use of a satellite-based application and *a fortiori* of satellite imagery.

The challenge

As the landscape is subject to continual change (whether by a natural processes or due to human intervention), the Welsh government needs a means of acquiring spatially accurate, up-to-date information on landscape changes and on the habitats affected.

These data are necessary to fulfil the legal requirements of the EU Habitat Directive (Ref. 1), which demands to monitor habitat types and species of interest for the European Union.

Moreover, environmental data are strategic and have to be available for environmental managers and stakeholders. Indeed, the Environmental Framework released by the Welsh Ministry of Environment and Sustainable Development in 2011 (Ref. 13) demands for a more sustainable use of the land, air and water of Wales. In practice, this means that new construction, agriculture and land-use plans need to be assessed with regard to their environmental impact or feasibility before getting approval from local and regional administrators.

To support the Welsh and UK governments complying with the Habitat Directive, the CCW before and NRW today need to identify and map land cover to locate and classify natural habitats.

This cartography has to be realised in a cost/efficient fashion and to be easily shared with environmental managers and stakeholders.

Finally, the cartography has to be easily updated in order to monitor changes in land-use and habitat extension and distribution throughout time.

The previous solution

To comply with its mandate, the CCW has relied on a map based on field surveys between 1979 and 1997, complemented by aerial photography. However, the use of these methods proved very costly.

Indeed, the field-based mapping process requires wide endeavour and involves dozens of workers during several months. In addition, the field season does not exceed 150 days per year, so that each skilled employee is barely able to map approximately 450 km2 per year (three km2 per person per day).

Taking into account frictional costs (training, sick leaves, maternity, etc.), the field-based mapping of a country like Wales would require 60 person-years of work.

With pay and overheads for the surveyors, the cost of a wholly field-based project would easily reach between GBP 2,000,000 and 2,500,000 (corresponding to EUR 2,556,000 and 3,195,000).

In addition, transport costs, administration (as writing to landowners for permissions) and digitisation costs also need to be taken into account, taking the total closer to GBP 3,500,000 (EUR 4,472,360). In fact, Mr Alan Brown - who coordinated the project at CCW and is currently responsible for it at the NRW - points out that "*the original field survey* (to create the first habitat map of Wales) *took longer than this and, in today's money, might have cost GBP 4,000,000 (EUR 5,111,267) for the survey and two partial updates*".

Apart from its cost, the field-based cartography does not offer the quality of detail required to enable groups of two or three trees to be identified, which can act as corridors for certain species.

This was perceived as a serious limitation as the focus for biodiversity conservation switched from protecting habitats through protecting the surrounding sites, towards considerations related to the connections between, and the fragmentation of habitats across the landscape.

Alternatives to the satellite service

Mapping and monitoring of habitats can be performed with field surveys or with aerial images. While the first solution would require an excessive amount of time and human and economic resources (as explained above), the latter would not provide environmental information on the whole territory of interest.

These considerations, together with the opportunity of profiting from a national funding scheme to test satellite-based solutions, prompted the CCW to consider alternative technologies to be integrated into traditional surveying methods.

The satellite-based solution

Key facts on the implementation	
Implementation framework	Demonstration project (Government Information from the Space Sector - GIFTSS programme, of the British National Space Centre - now UK Space Agency)
User's economic contribution	Own budget and external funds €894,441 (£700,000) from 2004 to 2012 > 20% of CCW's annual budget in 2004
Partners	British National Space Centre - BNSC, now UK Space Agency Aberystwyth University Environment Systems Ltd

The implementation

In 2000, when the Countryside and Rights of Way Law entered into force, guaranteeing the public right of way through the countryside (Ref. 2), it became necessary to have a detailed map of the Berwyn Mountains region which showed the public footpaths. This was an opportunity to assess whether remote sensing was the most appropriate and effective method for updating the existing habitat maps, as well as for determining if this approach could be generalised to the whole country.

The British National Space Centre (BNSC) funded the 50% of the feasibility study and of the test of the satellite-based solution, while the CCW contributed to the other half.

The feasibility study cost EUR 38,333 (GBP 30,000), while mapping the four test areas cost EUR 57,500 (GBP 45,000). Finally, the first update of the map of natural habitats in Wales based on satellite data cost EUR 255,555 (GBP 200,000) for the whole Country (Ref. 12, p. 37). In addition, other costs (including staff costs) reached EUR 638,794 (GBP 500,000) so that the global estimated amount stood at EUR 894,441 (GBP 700,000).

Service availability and procurement

In 2004, the decision to use remote sensing was facilitated by the assistance provided by the British National Space Centre (BNSC), now UK Space Agency, under the GIFTSS programme (Government Information from the Space Sector), which aimed to encourage public authority access to information derived from satellite services.

At the time, the service did not exist and had hence to be developed especially to meet the needs of the CCW.

In addition to co-financing the feasibility study, the BNSC also entered into a contract with the service provider, Environment Systems Ltd (www.envsys.co.uk) on behalf of the CCW, consequently sharing the inherent risks.

Organisational aspects

The CCW appointed internally as Project Coordinator Mr Alan Brown, an expert in topography and remote sensing. Mr Brown consulted with the personnel of the CCW throughout the project to find out about their needs and requirements. This operation required about two to three weeks' work per year for the staff.

The CCW participated to the design and led the uptake of the satellite-based solution, which took place in four distinct phases between 2004 and 2012 (Ref. 12, p. 24):

Stage 1 - Feasibility study: The study looked at the possible benefits of using satellite imagery for updating habitat maps.

Stage 2 - Test phase: A successful test was carried out on four geographically and ecologically distinct areas, including the Berwyn Mountains.

Stage 3 - Updating the existing maps: The existing habitat map, based on topographical surveys and aerial photographs from 1979 to 1997, was updated using satellite-imagery and the software developed within the project.

Stage 4 - Integrating the updated map into the CCW information system and its dissemination to environmental managers and stakeholders.

The service provider Environment Systems Ltd (Ref. 5), with its experience in ecology and nature conservation, was awarded the contract for the field tests, as well as the main contract to update the habitat maps.

These contracts included developing the methodology, producing the mosaic and interpreting the images. Environmental Systems then sub-contracted part of the work to the University of Aberystwyth (the Remote Sensing Department) because it is highly-skilled in developing and applying methodology. As a result of the innovative character of the initiative, the Project Manager at the CCW benefited from the expertise of both the BNSC and the University of Aberystwyth.

A scientific methodology and a software to process data (eCognition©) were developed. Once the vectoral habitat map (produced using satellite imagery) was created by the service provider, it was transferred to the CCW where it underwent testing by the end users in the central directorates and the regional offices. The testing was carried out by comparing the new map with the existing maps and other data, before being sent to the GIS Unit for integration into the CCW's central GIS system.

The CCW's GIS experts all have experience in the field of ecology, and with assistance from the Evidence and Advice Directorate they contributed to the quality control.

From the start of the project (2004), and more specifically during the first two phases, an expert on assisting users of remote sensing was available to provide advice and assistance in evaluating the quality of the bids for the field tests, which had been received by the CCW following an open tender.

In 2012, a first up-to-date habitat map was released.

Implementation challenges

Technical

The selected service providers dealt with technical issues during the implementation phase of the project. The main challenge encountered during the trial referred to the limited capacity of the hardware and the software (Ecognition©) to take into account seasonal and bio-geographical variability on the whole of the Welsh territory. Indeed, early versions of the software only allowed to map 49 areas in the zone of interest. This issue has been overcome with further developments of the software.

Moreover, grouping together the different sets of spatial information data in a GIS using geoinformatics was seen as a source of difficulties for the staff of the CCW.

Finally, to start using satellite-based data to realise the habitat cartography raised uncertainties, inherent in all new ways of working, such as how to check the accuracy of a vector map or how to reproduce the map.

Economic
Given the risk of the project not working, the cost of acquiring the initial satellite imagery was rather high. Through the whole duration, the Coordinator preferred to buy archive satellite images, due to the fact that they are less expensive and it is possible to check their quality before purchase. In effect, the CCW's financial year ended in March/April. As the most useful images are taken during this period, it was quite difficult to commission images at that time from an administrative point of view. Buying archive images enabled the CCW to overcome this problem.
Organisational
Two training sessions involving eight people each time were offered by Environment Systems to the staff from the CCW's regional offices, central directorates, and GIS specialists, as well as to end users from local organisations. At first, the project raised some internal concerns among the staff of the CCW. In particular, some managers had doubts about the technical reliability of the surveying technique, given the need of the institution for very high accuracy in some areas (in the case of scarce habitats). In addition, the CCW had to manage the continuity between the wholly field-based map and the new methodology.
Other
Expectations from satellite remote sensing were very high and had to be managed, especially in an organisation which traditionally relied on very detailed ground-surveys.

Operating the system

Until 2012, the main interest for the legacy body (CCW) was to obtain accurate information on land cover and habitat mapping, in order to monitor the natural habitats and to report against the Habitats Directive.

Once the updated habitat map was integrated into the GIS system, it could be used by different types of end users. Internally, the personnel from the Evidence and Advice Directorate of the CCW intended to use the information on the maps to design and establish long-term strategies aimed at nature conservation, and to advise the Welsh Government.

The satellite-based cartography allows for the identification of possible corridors between protected sites (or their insufficient numbers) which enable species to migrate safely, to protect them (from the construction of a road, for example), or to move them.

The personnel in the regional offices of the CCW used the areas on the maps related to their regions to study the possible impact on the landscape of building planning applications and public projects, advising on the measures to be taken and working with land owners to manage protected sites.

Key facts on the operation	
User's economic contribution	€20k - €50k in 2014* < 10% of NRW's budget for habitat monitoring* *Estimated figures, the actual cost will depend from the organisation of the NRW and the availability and cost of Sentinel imagery.

After 2013, the CCW was merged into the newly created Natural Resources Wales and the production and update of the habitat cartography will have to be integrated into the operational procedures of the new organisation.

Given the organisational changes occurring in the Welsh Government and the merging of the CCW's mandate with the activities of Natural Resources Wales, only estimates can be done on the future costs and benefits of the satellite-based service at this stage.

Concerning expenses linked to the operational use of the satellite-based cartography, these are represented by the cost of the staff and of the satellite imagery needed to update the map. The software and methodology have been created to embed data from the EU Sentinel satellite-

constellations. Their price and availability will be hence crucial to determine the cost of the operational use of the satellite-based surveying method in the future.

Operational challenges

Economic

The solution entails substantial costs to purchase the imagery and maintain the eCognition software licenses. Hence, in the mid-term, the availability of free imagery from GMES/Copernicus will be critical to keep using the service.

Organisational

When the service was managed by the CCW, no organisational challenges were faced to collect satellite data and transfer the information to other environmental managers and stakeholders.

The reorganisation of the habitat monitoring within NRW represents currently a challenge to the smooth use of the satellite-based service.

Operational

After implementation of the system, no assistance was required by the staff of the CCW to use it. However, NRW might suffer from a lack of skilled satellite-data analysts, hence delaying the full uptake of the satellite service by the new organisation. Indeed, very few GIS users have an understanding of data analysis and of geoinformatics.

Sustainability

Current challenges relate to the cost of the imagery and the organisational changes entailed by the recent creation of NRW.

Benefits of the satellite-based solution

Service efficiency and provision

After completing the development of the software, the CCW was able to update its old habitat cartography to produce in 2012 a map which combines satellite, aerial and field-based information.

A three-colour traffic light system has been created for maps (high/medium/low probability) for potentially rich grasslands in order to target the field work accordingly, which has resulted in a decrease in the overall cost of the project and in a large increase in the number of sites found.

On the one hand, the new cartography is more detailed on a spatial level than the previous one, and could supplement the field work, for which inaccuracies still remained; on the other hand, the satellite layer ensures that further updates will be far less time-consuming than in the past.

Furthermore, since the data are objective and accurately geolocated, successive updates of the cartography will lead to a very precise monitoring of habitat changes throughout the years.

The CCW did not perform an assessment of quantitative benefits provided by the satellite-based cartography. As explained by Alan Brown, "*This was initially a test project and (at the start) would not have been capable of delivering the benefits which will come once we have a steady supply of (Sentinel 2) data. For example, earlier versions of the eCognition© software did not provide the detail necessary to segment hedges from air photographs across such large areas*". The intention of the CCW was not to implement a 'business case', but rather "*a steady development of methods with increasing potential, alongside risk management.*"

Unlike EC FP7 projects (7th Framework Programme for Research and Technological Development), which have a set timetable, adequate budgets and fixed objectives, at the CCW "*we simply kept the year-on-year costs of this work very low and developed the next steps in the process as the improvements in software allowed. The question was not whether satellite-based methods could map Wales but the more modest objective of using these new methods to*

update our existing field maps in so far as this is possible. The final cartography is a sophisticated fusion of the original fieldwork and the satellite-based map".

Cost benefit

The development and the implementation of the satellite-based service cost approximately GBP 700,000 (including staff costs) until 2012. Contractual costs (approx. EUR 638,793 or GBP 500,000) represented more than 70% of overall expenditures.

Producing the new map using satellite data represented a minimum financial investment compared to the previous version produced only using traditional surveying methods.

Indeed, the CCW was able to develop the methodology, to produce the survey and to perform two partial updates at less than a forth of the cost of the previous map, realised using data from a field study involving three teams of ten field researchers over 15 years.

In the words of Mr Brown, "*To repeat a survey of Wales (with field-measurements), would cost an estimated GBP 3.5 million (EUR 4,473,000)*". If we exclude the research phase (developing the methodology used to determine the sequence of images to be analysed and their interpretation methods), the new approach represented less than a tenth of the cost of the ancient map.

Beyond these estimations, the cost of the system for NRW will largely depend from the new organisational structure and the availability of free or inexpensive imagery. As Mr Brown points out "*Within our new organisational framework, and as a rough estimate, assuming we can get Sentinel 2 imagery and can process larger areas at once in the future, the repeated updates would cost as little as GBP 50,000 (EUR 63,871) on contract plus staff time, say between GBP 100,000 (EUR 127,742) and GBP 150,000 (EUR 191,696). I must repeat that these are only rough estimates, however.*"

Society and the environment

The map allows for the very detailed visualisation of the Country's overall landscape and for the identification of fragmented habitats and resources, such as carbon and biomass.

These data were shared with stakeholders at national and local level. For example, the valleys in the County of Glamorgan in the south of Wales have used the information derived from the map to identify possible Sites of Specific Scientific Interest (SSSIs) and were able to estimate that 65% of the land that would have been the subject of a study were excluded from the list of habitats of interest (arable land, grasslands, etc.) (Ref. 12).

Other benefits

The NRW has wider responsibilities than the CCW. The satellite imagery could hence provide valuable information also for flood mapping and modelling; reporting against the Water Framework Directive; monitoring inshore waters; and measuring biomass and detecting diseases such as Ash dieback (Colara) and Phytophora infestation of Larch (Larix) in forests.

The new map presents a sufficient level of accuracy and contains an adequate number of layers, which will eventually enable several agencies in charge on environmental protection to collaborate using the same base data.

Indeed, access to the updated habitat map could help other public bodies in carrying out their remit. Moreover, as some stakeholders also hold information in the form of geographic data sets which could be of use to the NRW, the Welsh Government is stimulating increased cooperation between public agencies to share their data sets into a common GIS platform.

Finally, the experience of the CCW raised interest in the environmental British community towards the potential of satellite-based data for habitat mapping and protection. The Joint Nature Conservation Committee (JNCC), statutory adviser to the UK Government and devolved administrations, is working with various partners to develop new EO methods for mapping habitats and assessing their condition (Ref. 7).

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