A CLOSER LOOK INTO SATELLITE-BASED SOLUTIONS FIGHTING COVID-19

Challenges and opportunities from GNSS and EO case studies across Europe

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Eurisy would like to thank the contributors to this publication for their readiness to share their experiences, and the time and effort they have put into helping Eurisy to produce this report.

Foreword

Dear readers and Eurisy members,

We are approaching the end of such a historical year. We faced one of the biggest pandemic outbreaks since 1918 that disrupted our lives, forcing us to keep social distancing, to work from home and to limit our movements in cities, regions and across our borders. In these last weeks of December, a glimpse of light can be seen at the end of the tunnel: the President of the European Commission Ursula Von der Layen, launched the vaccination campaign against COVID-19. It will take some time before we can go back to our old lives, and until then, most of us will be facing another lockdown. Nonetheless we look with optimism at the future keeping bold in our actions maintaining our usual spirit of innovation and opening with renewed enthusiasm to cutting-edge endeavours!

The global uncertainty related to the swing of the infection's curve highlighted the need to have technology-based tools to support tracing social distancing and enforcing containment measures imposed by the governments, to monitor the trend of the virus around Europe, and to take accurate policies to protect the population. In this context, space technologies proved to support decision-makers to take timely and informed decisions and to monitor the evolution of the pandemic.

Satellite data does not only provide unique information about the virus, it also provides key data and figures on the impact of persistent lockdowns on society, the economy and the environment. As such, space assets do not only offer great strategic and scientific value, but they also provide real benefits for society in its daily routine.

The objective of this report is to present a non-exhaustive list of GNSS-based and EO-based solutions developed to fight COVID-19, and the challenges and opportunities offered by the current context. To conclude this overview a set of recommendations to favour the uptake of satellite-based solutions by public authorities has been defined.

With the hope this publication can provide some insights on the endless opportunities space can offer also in emergency situations. Enjoy the read.

Sincerely Yours,

Dominique Tilmans

Eurisy president

Introduction

Since March 2020, the COVID-19 pandemic started to heavily impact our everyday life, with visible consequences not only on our health but also on our habits and social life. The rigid lockdown imposed in several countries during the spring months determined a sharp slowdown in the speed of transmission of the virus that allowed the possibility of limited travelling within European borders and a progressive re-opening of public and private spaces implementing measures to avoid large crowds. With the beginning of the fall season and the limited reprise of our daily routines, the majority of the countries across the worlds assisted to a resurgence of cases that brought to a new series of impositions and, in certain cases, limited full lockdowns.

According to the European Centre for Disease Prevention and Control (ECDC), on the 17th December 2020, the confirmed number of cases of COVID-19 around the world reached 71 503 623 cases, of which 15 130 100 cases have been reported in the EU/EEA and the UK. [1]

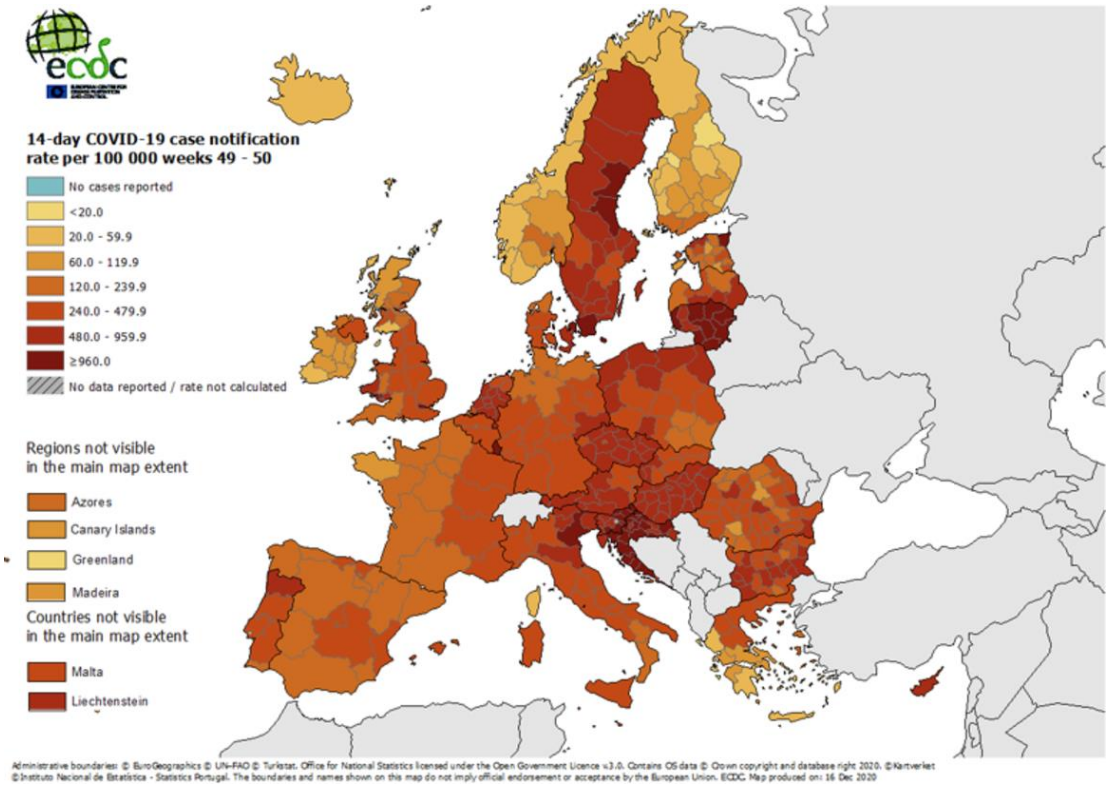


Figure 1. 14-day COVID-19 case notifications rate per 100 000. The map refers to the temporal timeframe 30 November-13 December 2020. Source ECDC

In the meantime, vaccines have been approved by the European Medicines Agency (EMA) and relevant vaccination campaigns will begin before the end of the year. However, there is still some way to go before going back to normal life.[2] Meanwhile, since last spring many countries set up an intense tracing campaign to limit the spread of the virus to allow a partial safe re-opening of cultural and leisure spaces, of bars and restaurants, and especially of schools, public places and borders.

[1] European Centre for Disease Prevention and Control (ECDC). https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases

[2] As per today, Europe fixed three EU vaccination days: the 27th-28th and 29th December 2020. Deutsche Welle (DW), "COVID: EU to start vaccinations on December 27". Dec. 17th 2020. https://p.dw.com/p/3mrI9

The key role of technology-based solutions to track the spread of the virus and its impact.

Since the early pandemic outbreak, technology is being brought to the forefront for its potential to provide solutions for contact tracing to limit infections while enabling effective recovery responses. In particular, space technology helps the fight against the COVID-19 pandemic using satellites as assets or by favouring a technology transfer.

Satellite systems have been essential to monitor and assess the development of crises and unforeseen events in the past, managing and mitigating their hazardous consequences on the population and the environment. The COVID-19 pandemic is no exception. Satellite data is widely used to provide a diverse range of stakeholders with timely and reliable information to observe the effects of the pandemic, the impacts of the lockdown and the movements of infected people.

Remote sensing enabled the monitoring of environmental, climate and other variables in vast areas by collecting images and data processed to estimate the impact of this epidemic on socio-economic activities and supporting the deployment of emergency operators. Satellite navigation has been extensively used to support authorities and citizens with accurate location-based information to better manage physical movements around cities or along the borders.

Satellite communications are also a key asset for disaster management, ensuring large and stable bandwidth also to remote and white areas.[3] During the lockdown, satellite communications represented a crucial infrastructure for telemedicine, allowing healthcare professionals to help their patients through remote diagnosis and periodic checks.[4] Similarly, tele-education and teleworking have increased the need for broadband capacity. Satellite operators providing broadband connectivity directly to consumers, especially in rural areas, have seen a 15 to 70% (depending on the country) increase in data traffic across Europe and the Americas on satellite communications both during the lockdown and recovery phase.[5]

For emergency services, satellite imagery in combination with early warning indicators is another powerful tool to support the implementation of safety measures to be implemented in case of natural disasters, such as earthquakes, floods, etc.

In the case of COVID-19, remote sensing through images captured in different timespans demonstrate how profoundly the virus was affecting social life and economic activities, as well as the environment.[6]

In some industries, such as aviation, the use of satellite-based data enabled the enforcement of measures to monitor the short-medium term changes in economic and social activities especially after the first phase of the pandemic, when many companies underwent internal revolutions to cope with the challenges posed by the re-organisation of specific markets due to COVID-19. [7] In the case of aviation, last March, the European Commission Department for Defense Industry and Space (EU DG DEFIS) issued an urgent request for EO-data analysis that could provide insights into the economic and logistical impact of COVID-19. As will be further illustrated in the paragraph dedicated to the European

[3] ESOA, "Keeping people connected, informed and protected", 27 April 2020, https://www.esoa.net/press-room/keeping-people-connected-informed-and-protected.
[4] Eurisy, "The strengthening of the health sector after the COVID-19 outbreak", 10 April 2020, https://www.eurisy.org/article-the-strengthening-of-the-health-sector-after-the-covid19-outbreak_48.
[5] ITU, "Pandemic in the Internet Age: communications industry responses", Discussion Paper on ensuring connectivity and business continuity – key lessons learned, June 2020, https://reg4covid.itu.int/wp-content/uploads/2020/06/ITU_COVID-19_and_Telecom-ICT.pdf.
[6] J. FELDSCHER, "Social distancing from space", POLITICO, 17 March 2020, https://www.politico.com/news/2020/03/17/social-distancing-coronavirus-134621.
[7] M. HUDECHECK, C. SIRÉN, D. GRICHNIK, and J. WINCENT, "Monitoring the COVID-19 Crisis From Space", MIT Sloan Management Review, 17 April 2020, https://sloanreview.mit.edu/article/monitoring-the-covid-19-crisis-from-space/.

Figure 2 Copernicus Sentinel-2 images. Copernicus Sentinel data (2020), processed by ESA, CC BY-SA 3.0 IGO

Space Imaging use cases, satellite images collected with WorldView-3 and GeoEye-1 showed a growing number of planes grounded in the main airports around Europe, such as Charles De Gaulle Airport in Paris or Heathrow in London. The images highlight the impact of the virus on the transport sector and provide the viewer an immediate sense of the economic losses affecting the industry. The picture on the side shows commercial airports located in several countries across the world transformed in parking lots during the first phase of the pandemic. Indeed, Copernicus Sentinel-2 images captured during the lockdown clearly framed the entity of the situation with hundreds of aircraft grounded making the management of large-scale storage sites challenging. Satellite data supported local authorities in the identification of suitable and available locations for a long-term storage.[8] The identification of the appropriate site is core for long stationing because weather conditions could fatally undermine the carrier, threatening the very survival of numerous airlines. [9]

What does Eurisy do?

To fulfil its mission in these unprecedented times, Eurisy has engaged in raising awareness of the use of satellite data to respond to the pandemic. Several articles have been produced to provide our readers with an overview and a concrete perspective on how satellite-based data and solutions could be used to take effective fact-based decision, as well as the funding mobilised by government to support space companies to develop scope-specific solutions, and eventually on the lessons learnt for the benefit of key societal sectors:

- What we can learn from the coronavirus crisis with satellite data
- Call for space assets in response to COVID-19
- The strengthening of the health sector after the COVID-19 outbreak
- COVID-19 tracing apps and data protection
- How satellite navigation tackles COVID-19 in sports

In the wake of this series of articles, the present report is intended to provide a further angle by including a non-exhaustive list of solutions integrating either Global Navigation Satellite System (GNSS) and Earth observation (EO) satellite data to tackle a diverse range of factors enabling citizens and public authorities to make informed decisions in the specific context of the global pandemic outbreak.

[8] European Space Agency, "Parking in a Pandemic: Where Are All the Airplanes and Cruise Ships During COVID-19?, Scitech Daily, 9 June 2020, https://scitechdaily.com/parking-in-a-pandemic-where-are-all-the-airplanes-and-cruise-ships-during-covid-19/.

[9] European Space Imaging, "EU Commission Asks EO Community for Help With COVID-19", 1 April 2020. https://www.euspaceimaging.com/eu-commission-asks-eo-community-for-help-with-covid-19/.

Eurisy conducted direct interviews with app developers and service providers across Europe. This report combines the main outcomes of the interviews and highlights the potential of these satellite-based services in response to the crisis and the setbacks encountered, as well as the goals and expectations of the developers in terms of potential future business growth.

The interviews

The interviews were conducted between May and June 2020. The selected interviewees are all European-based start-ups, SMEs and Research Centres. Each selected organisation comes from a different European country, namely: the UK, Romania, Italy, Germany, and Greece. To ensure geographic diversity, it is important to picture the different approaches across Europe. Since the last few months, in the countries of provenance of the interviews a resurgence of cases was noticed leading in some cases to announce new lockdowns.[10] As showed by the most recent figures, the Rt0 - the transmissibility rate that assesses the level of circulation of the virus - is active again in all of these countries.

The purpose of the interviews was to better understand how the companies are integrating satellite data and if they could benefit for the development of the proposed solutions of specific funding schemes. The interviews have been developed based on structure described below.

1. The main features of the app, challenges, and opportunities;
2. The expected results;
3. The business-related questions.

Three GNSS apps were selected:

- Crowdless, developed by the UK-based start-up Lanterne;
- CovTrack, developed by Romanian in Space (RISE);
- Digital Ariadne, developed by the University of Urbino (Italy) and Digit Srl.

Similarly, two companies working with EO data have been selected:

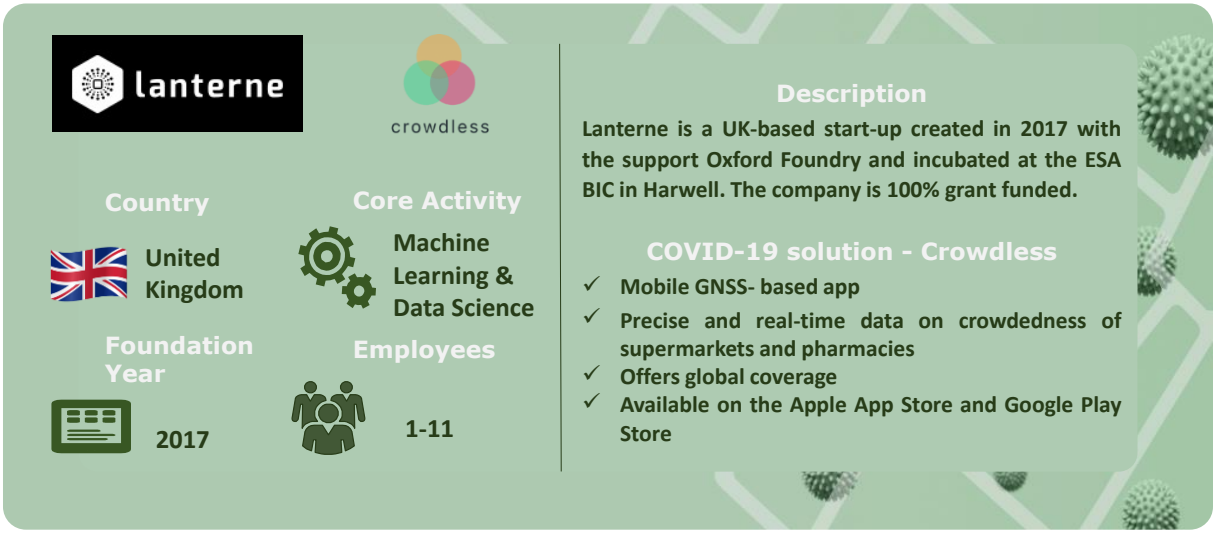
- European Space Imaging, a private company based in Munich;
- BEYOND Centre of EO Research & Satellite Remote Sensing based in Greece.

GNSS-based solutions

During the interviews a series of business-related questions have been posed to the different developers to learn more about their value proposition, business models and their future perspectives.

Considering the health crisis and the impact on their businesses, the three start-ups interviewed decided to put their know-how at the disposal of society to respond to the challenges posed by the pandemic.

[10] A. Berry, "German lockdown: Merkel announces tough new COVID curbs". Deutsche Welle (DW). Dec. 13th 2020. https://www.dw.com/en/german-lockdown-merkel-announces-tough-new-covid-curbs/a-55921912

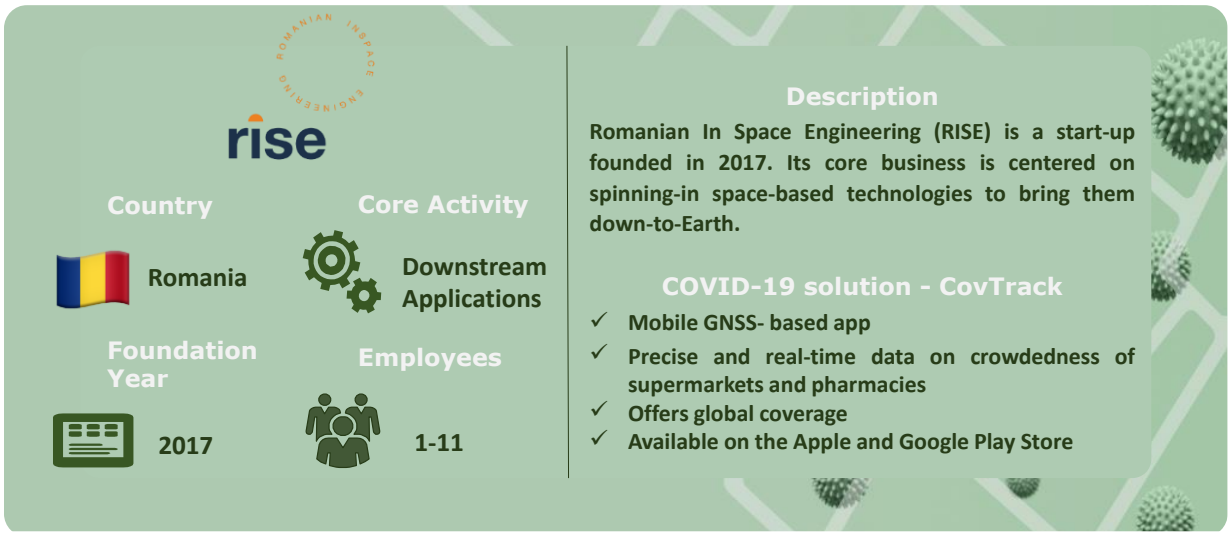


1. Crowdless: monitor the business of supermarkets and shop safely

Keeping social distance is one of the key counter-measures to adopt to contain the spread of the virus, not just in supermarkets, restaurants, bars, or offices, but also in open-air locations. To respond to such a challenge, Lanterne launched the mobile app Crowdless: a mobile tool that aims at helping people respect social distancing while going for groceries or to the pharmacy. The app, developed in a short time and launched during the second half of April, provides real-time data on how crowded a supermarket or a pharmacy is so that people can choose the best place and best time to visit it. Crowdless acts as a crowdsourced platform integrated with satellite-based location information allowing users to obtain precise, real-time, and accurate information. The app, available for download on Android and Apple Stores, has global coverage. Currently, the app counts more than 100,000 downloads, mainly in the UK, Germany, and Spain. Outside Europe, the app reached a certain success in Australia and Egypt. Crowdless is available in English, French, Italian, Spanish, Catalan, German, Portuguese and Turkish.

Lanterne is a relatively young start-up established in 2017 with the support of Oxford Foundry. The company is 100% grant-funded. The organisation benefitted from further expertise and know-how from experts both in space and business field.[11] Thanks to the support received at the ESA Business Incubation Centre in the UK, Crowdless, initially launched as Keep Your Distance, was born in few weeks reorienting the scope of a previous app.[12] Lanterne's initial value proposition focused on the development of a tool for operators working in unstable or conflict zone to allow them to move and work safely. Lanterne integrated GNSS-based technology, mainly GPS, for its tool in combination with open and crowdsourced information and high-resolution imagery to develop predictive models to estimate where an incident took place.[13] When interviewed about the future of their app Crowdless, the Co-Founder and Co-CEO, Yohan Iddawela, believed that it could be scaled up in the future. The app could be used to manage more efficiently crowds and queues in several places such as outside theatres or museums, giving Crowdless a different connotation rather than just being a social tool. This would allow the company to implement the app furtherly and to boost its B2B and B2C businesses.

[11] The London School of Economics and Political Science, LSE students and alumni develop app to help with social distancing. 2nd April 2020, http://www.lse.ac.uk/News/Latest-news-from-LSE/2020/d-April-20/LSE-students-and-alumni-develop-app-to-help-with-social-distancing.
[12] European Space Agency, Social distancing app uses space to save lives. ESA, 20th April 2020. https://www.esa.int/Applications/Telecommunications_Integrated_Applications/Social_distancing_app_uses_space_to_save_lives
[13] Lanterne.ai. Using data to improve safety and economic development. https://www.f6s.com/lanterne.ai.

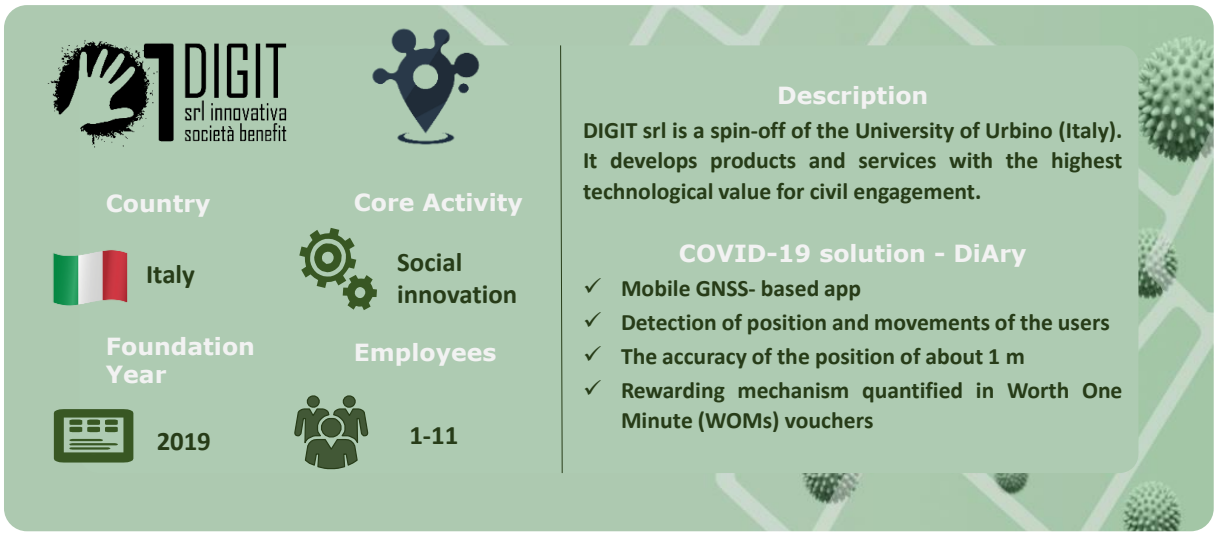


2. CovTrack: an easy alert in case of infected vicinity

Social distancing is not the sole element to halt the contagion but proved to be effective in slowing down the chain of transmission. During the early stages of the pandemic, GNSS has been key to track different macro situations, such as movements at the borders. Currently, it is also exploited at micro-level: this is the case of the Romanian mobile app, CovTrack. It aims at identifying potential transmissibility vectors of COVID-19 relying on Bluetooth and satellite positioning. The concept of **CovTrack** is to use Bluetooth technology to determine whether close contact has been made, recording where it was made. The app only saves the location where close contacts occurred, without actively tracing the users' location. Through an online database of confirmed COVID-19 patients addresses, managed by governmental authorities, the app informs users and institutions. If a contact with an infected person has been identified, the user is notified. The app has been published for open-source usage on GitHub and provided the basis for an integrated informatics system developed for the Romanian government.

Romanian In Space Engineering (RISE) is a start-up founded in 2017 as a spin-off of the Institute of Space Sciences in Romania. The core business of RISE is centred on transferring space technologies down-to-Earth, as well as to spin-in terrestrial once to develop cheaper solutions for space. CovTrack has been developed building on AGORA, a mobile app primarily used by large event organisers to improve the management of available resources from staff allocation to vendor products, also demonstrating a huge potential during emergencies. The project was jointly financed by the ESA's Navigation Innovation and Support Programme (NAVISP) and RISE.[14] Alexandru Pandele, RISE GNSS Manager, declared that originally a commercial future for CovTrack was not actually foreseen especially due to the need for continuous close collaboration with national authorities, core to provide updated data. Although RISE experiences some difficulties in collaborating with public authorities, a consortium including RISE has won a governmental competition for the rapid development of an integrated informatics system aiming to address COVID-19 issues. The integrated system shall use statistics collected from CovTrack module to model the evolution of the pandemic. It is now in the process of implementation, the first version of the system should have been released by the end of September.

[14] ESA Navigation Innovation and Support Programme (NAVISP), "Smartphones plus satellite navigation for safer, smarter festivals", https://navisp.esa.int/news/article/AGORA.



3. DigtalAriadne: social distancing for social rewarding

DigitalAriadne (DiAry) relies on a different concept. The rationale is based on individuals' awareness and social responsibility. The app automatically detects the position and movements of the users and saves this as background information on the personal device. The app generates daily statistics of movements and time spent in a certain place. Also, through DiAry, the data collected and stored in the mobile phones of the users can be matched with other public utility data to favour the implementation of local policies or concrete actions. In the context of the current sanitary crisis, the statistics and data produced have a twofold objective: to inform the user of his own trajectories on one hand, and the authorities on general movements on the other. As in previous apps, GNSS is a crucial component enabling the users to get precise locations and to trace their movements. The accuracy of the position is of about 1 metre.

DiAry also involves another interesting feature: the app includes a rewarding mechanism that is quantified in Worth One Minute (WOMs) vouchers, special certificates that recognise the social value of individual actions. These vouchers do not have a fixed value, but retailers (restaurants, bars, etc.) can attribute a value to them by granting discounts. Such a rewarding mechanism could also impact on the revitalisation of the economy of territories involved while improving social cohesion. As for CovTrack, DiAry has been adopted mainly at the national level, even if it targets a wider audience.
Unlike Lanterne and RISE, DIGIT Srl cannot be labelled as a space company as it mostly works on digital solutions. DIGIT Srl is a spin-off of the University of Urbino (Italy). It can be defined as a social enterprise whose core business is to develop, produce and commercialise products and services with a high technological value, along with sustainable digital platforms enabling participative social innovation by involving all citizens. DiAry, unlike other apps previously described, has not been developed based on an existing product. However, at the moment Digit Srl and the University of Urbino are considering to scale-up the business upgrading DiAry enlarging the scope and the potential uses. As stated by Mr Alessandro Bogliolo, Professor at the University of Urbino and one of the developers of DiAry, in the future the app could be exploited in the tourism domain: users could literally use the app as a diary. The app would collect museums, historical sites, monuments visited, and the path is done to reach them. Also, the app could still include the social rewarding system, in this case awarding with vouchers for special events with social relevance, boosting civil engagement.

Earth Observation (case studies) to help decision-makers

EO can play a significant role in supporting decision-makers to adopt the right measures to tackle the sanitary crisis. During the first phase of the pandemic, satellite imagery captured the effects of the lockdown picturing empty cities and showing unprecedented drops of nitrogen dioxide in the air of major European cities.

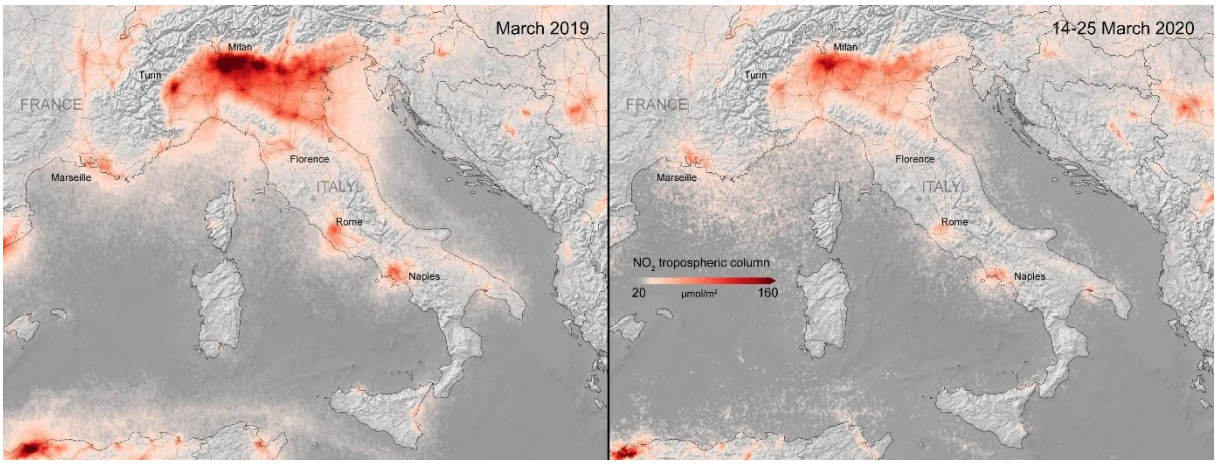


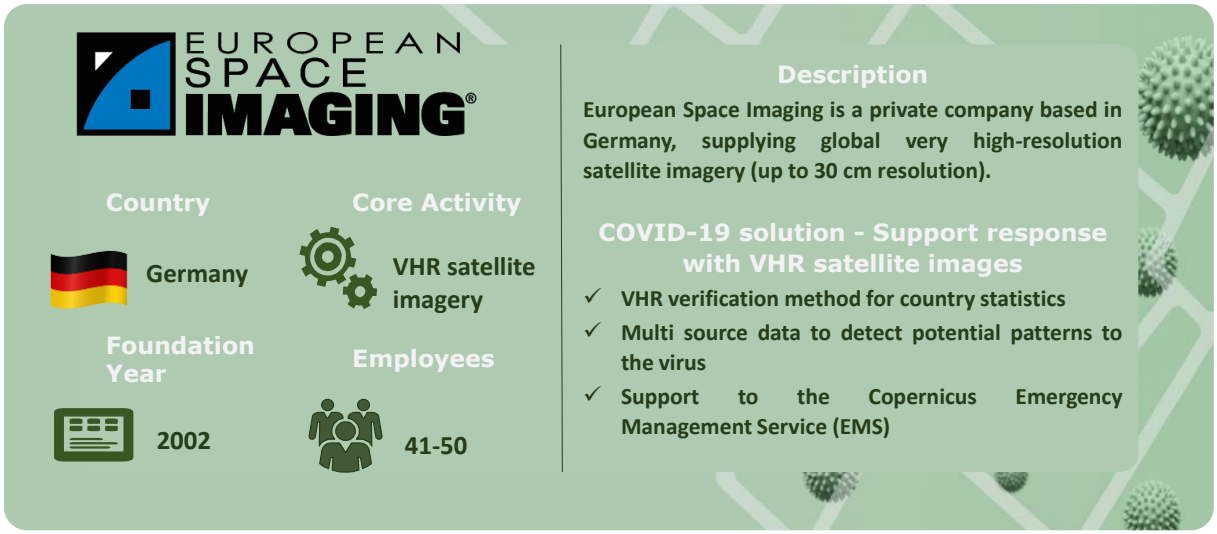
Figure 3 Average nitrogen dioxide concentrations from 14 to 25 March 2020, compared to the monthly average concentrations from 2019 Copernicus Sentinel 5P

Furthermore, satellite imagery proved to be a relevant tool for risk assessment and situational awareness, enabling decision-makers and emergency operators to assess the impact of the pandemic on traffic or to map temporary health facilities as well as public gathering spaces. In combination with in-situ data, EO also provides new information about the virus, such as its correlation with temperature, humidity, or air quality supporting epidemiologic research activities.

In the post-lockdown phase, EO data could well be utilised to support economic recovery. As several activities have been relaunched in Europe, the Rapid Action on COVID-19 and EO (RACE)[15] was unveiled by the European Commission in early June.[16] The dashboard, developed in collaboration with the European Space Agency and a number of industrial and academic partners, monitors key environmental parameters, but also economic and human activities including industry, shipping, construction, traffic, as well as agricultural productivity. This platform is a prime example of European collective action demonstrating how the use of EO data can help shed new light on societal and economic changes currently taking place across all European countries.

As for the GNSS-based examples, Eurisy opted for a deep-dive into more local initiatives. Two entities that contributed to the COVID-19 counter-measures have been interviewed.

[15] Rapid Action on Corona Virus EO, https://race.esa.int/.
[16] European Space Policy Institute, "COVID-19 and the European space sector", https://espi.or.at/news/new-espi-special-report-on-covid-19-and-the-european-space-sector.



1. European Space Imaging: eye on Earth for informed decisions

European Space Imaging is a private company based in Germany, supplying global very high-resolution satellite imagery (up to 30 cm resolution). During the lockdown, the company provided images to public institutions and media outlets. Satellite imagery of deserted touristic hotspots, empty car parks, or limited airport operations made the economic and logistical impact of the global crisis very visual. The company utilised its core business to help governmental agencies coping with these extreme situations and was eventually approached by the European Commission to strengthen its policy in response to COVID-19. In support of the Copernicus Emergency Management Service (EMS), the company collected imagery with the WorldView satellite constellation showing long traffic jams on several motorways at the border crossing between different European countries.

Figure 4: 32 km long traffic jam at the Hungary - Austrian Border captured on 27 March 2020

This supported European political decision-makers to find a fast and unified European solution to the traffic issues, assisting to keeping the balance of protecting citizens whilst also ensuring that the necessary exchange of goods and freedom of travel within the Union was upheld. Furthermore, satellite imagery assisted authorities in finding unused spots of urban areas to be repurposed for temporary hospitals or testing facilities. Finally, governmental agencies also utilised Very High Resolution (VHR) imagery as a verification method for country statistics about COVID-19. For example, satellite imagery showing mass graves and cemeteries in remote areas helped to determine whether figures provided by countries concerning infection and death rates were accurate.

BEYOND
Centre of EO Research and Satellite Remote Sensing

Country
Greece

Core Activity
Remote sensing

Foundation Year
2013

Employees
21-30

Description

BEYOND is the Greek EO Centre of Excellence. The Centre supports the activity of other research centers through the National Observatory of Athens.

COVID-19 solution - Global GIS-web Platform

- ✓ Interactive map of the spatial distribution of the virus
- ✓ Multi source data and open technologies to detect potential patterns to the virus
- ✓ User contribution via data uploaded directly by the authorities

2. BEYOND: to forecast and map the spread of these diseases

The Greek Centre of EO Research & Satellite Remote Sensing BEYOND, launched a global GIS web-platform informing on COVID-19 outbreaks along with demographic, environmental, and atmospheric parameters. Over the last 10 years, the Centre gained expertise on the topic of epidemics, originally focusing on mosquito-borne diseases. BEYOND developed an Early Warning System relying on EO to forecast and map the spread of these diseases. By considering environmental parameters such as atmospheric pollutants, humidity, and temperature, the platform provides new indications such as how weather influences the spread of the disease. These observations can be critical for the evaluation of measures and behavioural patterns, assisting further decision making to contain the spread of the virus. The open portal merges Copernicus data with in-situ sensors, crowdsourcing, and public health data from official sources, specifically, the European Centre for Disease Prevention and Control (ECDC), the Johns Hopkins Coronavirus Resource Centre, the World Health Organisation (WHO), as well as the Worldometers statistical website. Furthermore, the platform also collects information gathered by national and local authorities on the number of cases, deaths and recovered patients. Another feature of the platform is a restricted area where authorities, especially at the municipality level, can include extra information such as local data acquired by health authorities and hospitals. The authorities' data can help to elaborate *ad hoc* policies and a risk assessment model for the next period or during future outbreaks. The WebGIS platform is updated on a daily basis and provides information about the COVID-19 spread worldwide. However, in the case of Greece, the platform allows for more specific insights.

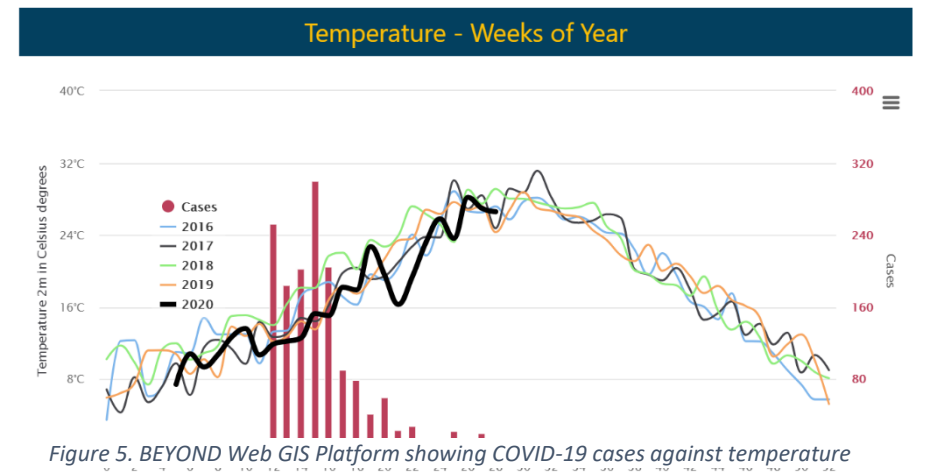


Figure 5. BEYOND Web GIS Platform showing COVID-19 cases against temperature

Opportunities and Challenges

The examples described above show how satellite-based data can be effectively exploited to tackle different aspects during the containment, cohabitation and partial recovery of the pandemic. Space-borne data enabled several services via easy-to-use mobile apps or intuitive online dashboards, providing end users and public authorities with swift information to make fast fact-based decisions for individual and collective safety. Notwithstanding the untapped potential of their synergies**, GNSS and Earth Observation data serve very different purposes. As emerged, both systems create an array of opportunities for new applications and business ideas in nearly every market segment, and above all in health and crisis management over the past few months.** However, a set of challenges in the uptake of the related services and the scale-up of business have also occurred.

Satellite-based navigation systems or Global Navigation Satellite Systems (GNSS) provide signals that can be used to locate with high accuracy the position of people and places, and to provide safe navigation information for moving platforms such as ships, aircraft, and automobiles, anywhere on the surface of the Earth. Each of the satellites of a GNSS constellation is continuously broadcasting its position towards a receiver determining the distance by measuring the travel time of the signal. Those signals can be received and processed by users anywhere in the world (within the coverage of the system). Today all mobile phones are currently equipped with a GNSS receiver and, according to the European GNSS Agency (GSA), 95% of the companies that produce smartphone chips for satellite navigation enable the European GNSS Galileo.[17] This is a key feature behind the success of navigation-based services both in general and also in the specific context of crisis management.

The observed potential to create and launch the apps, usually featured in IOS and Android stores, certainly allows to reach a wide number of users, especially because they often offer a service of general interest. Moreover, GNSS apps have a simple interface enabling direct communication with the user.

This is not necessarily true for services that rely on Earth Observation data. Companies offering EO value-adding services are traditionally located at the end of the industry value chain, where raw or semi-processed data is used as input, and combined with others, whether aerial or ground-borne data, to bring value to end-users. **Today, the majority of the demand for EO services is driven by the public sector. Typically, governments and other public bodies at all levels (regional, national, and international) are the dominant customers of EO products**. The awareness of the benefits of existing services and the uptake of those services tends to be more sensitive to governmental policies.

The use of GNSS-based mobile applications reinforced the importance of having bottom-ups monitoring tools that rely on crowdsourcing data. In this way, citizens have the opportunity of monitoring their own movements and actions contributing to the partial definition of the general trend of the pandemic. EO-based technology, in general terms, tend to address institutions and public authorities, making the two technologies have a combined effect on the pandemic evolution.

[17] According to figures in the latest GSA GNSS Market Report, which is to be published soon, global annual GNSS receiver shipments are forecast to grow continuously across the next decade, from 1.8 bln units in 2019 to 2.7 bln units in 2029. Most of these shipments are for receivers costing less than €5, and 90% of receivers in this price segment are used in smartphones and wearables. European Global Navigation Systems Agency (GSA), GSA celebrates 1 billion Galileo smartphone users. 9th September 2019. https://www.gsa.europa.eu/newsroom/news/gsa-celebrates-1-billion-galileo-smartphone-users.

During the interviews, two main issues have been discussed: the privacy and data protection issues, that is primarily a challenge faced by the GNSS-app developers, and the technical challenges often faced by EO developers.

Privacy and data protection issues

The joint Eurisy-Space Generation Advisory Council (SGAC) webinar on tracing apps and privacy, brought some light on the ongoing discussion regarding the privacy concerns related to geo-location apps.[18] The majority of GNSS based apps do not share

To overcome the reported lack of confidence of the users, clear and transparent communication of the predefined scope - the safety of citizens in emergency circumstances - of the apps and precise information on the specific data use and storage seems to be key.

In this context, privacy issues do not represent an obstacle for the implementation of EO-based solutions, which are primarily designed to provide oversight of identified indicators at macro-level for the use of public institutions to make informed decisions. The services based on satellite imagery do not rely on personal data. EO data is mostly combined with environmental parameters or aggregated information like the total number of infected people, recovered patients, and deaths in a selected area communicated by authorities and official entities. Moreover, in the case of the BEYOND platform, all critical data is directly uploaded on a reserved page dedicated to authorities minimising the risk of data leaks or privacy issues.

Technical barriers

Additional technical barriers are encountered especially by developers of EO based solutions. Combining in-situ with EO data requires a considerable volume of data processing. Furthermore, cloud services and automated processes based on AI and machine learning are poised to become essential to predict and mitigate the devastating effects of disasters such as the current pandemic. This increases the need for data storage and IT infrastructure to support a proper information flow of online platforms.

For mobile app developers, the processing of such data is not always straightforward, however several platforms supporting the open access of Copernicus data, as Copernicus Data Hub, and the Data and Information Access Services (DIAS) platforms[19], can help developers by providing a programming environment (notebooks, virtual machines, codes, etc.) to edit and process satellite data.

[18] For what concerns CovTrack, the server stores only the Media access control address (MAC address) of the infected person. The MAC address is a device unique identifier formed by a 12-digit string which will include numbers and letters. No other personal data is associated with the code. What is available is the list of places visited by infected patients. This list can be accessed by public authorities for two weeks only. Similarly, DiAry has developed an internal privacy policy with the support of legal experts. When downloaded, the app does not require any personal data but the location prior to the acceptance of the policy. The data is stored in an external drive in the form of anonymous codes and on the phone of the users. Crowdless does not use any personal data and it does not require any login. The third parties involved in the app are not accessing these data.

[19] There are four main DIAS available: ONDA, Sobloo, CREODIAS and MUNDI Web Services. https://scihub.copernicus.eu/twiki/do/view/SciHubWebPortal/WebHome#dias-box

The COVID-19 impacts on business perspectives

COVID-19 crisis has affected the global space sector in terms of revenues, productivity and operations and the effects of the pandemic will very likely produce its effects also in the future.

As highlighted by the OECD[20], today due to the pandemic certain space segments, as space exploration, science, and satellite manufacturing are characterised by a drop-in production volume and a limited number of suppliers. According to a survey by Space Tech Expo[21] to understand how COVID-19 impacted the space industry and effected the supply chain, companies changed focus and started to prioritise specific aspects. In particular, before the pandemic outbreak, the space technology supply chain prioritised marketing and business development, R&D and technology development. With the reduction of business, many companies in the sector started to focus on health and safety, M&A and on hiring and developing new talents. **The results of the survey indicate that in the next 24 months, many organisations will reconnect with customers and competitors to pick up the business and to adapt to what the market trends will be.**

According to the 29% of the respondents to the Space Tech Expo Survey, there will be a growth in the downstream applications demand and services. The European Space Policy Institute (ESPI) in its Special Report, COVID-19 and the Space Industry[22], stated that the European space sector appears to be particularly reliant on the commercial programmes especially for what concerns the satellite, launcher and ground systems. As reported by ESPI, in a Northern Sky Research survey[23] on the COVID-19 impact on satellite and space markets, it has been estimated that the demand for space services will be likely negatively affected in specific sectors like energy or aviation. These losses can be balanced by growth for cellular backhaul and consumer broadband as a consequence for more solid connectivity. These changes in demand and market structures in the downstream segment of the space value chain may, in turn, have consequences for industrial activities at a later stage.

The COVID-19 crisis has proven the potential contribution also of EO data. As emerged during the interview with EU Space Imaging, the scarcity of available funding for EO solutions could explain why mobile app developers rely more on satellite navigation data, which is freely available in any mobile device that receives the GNSS signal. Including commercial satellite imagery, on the other hand, might be a financial hurdle. In general, this data is not free, but also the processing of data might require additional IT infrastructure and technical expertise. Again, a potential solution is offered by the open data policy of Copernicus. As the world's largest space data provider, currently producing 12 terabytes per day, Copernicus services are made available and accessible to any citizen *and any organisation around the globe on a free*, full and open access basis through the Copernicus Data and Information Services (as the DIAS) or the Conventional Data Hubs. [24]

[20] OECD, The impacts of COVID-19 on the space industry. August 2020, http://www.oecd.org/coronavirus/policy-responses/the-impacts-of-covid-19-on-the-space-industry-e727e36f/
[21] Space Tech Expo, Measuring the impact of COVID-19 on business operations and purchasing priorities across the space technology supply chain, August 2020. https://www.spacetechexpo.eu/assets/files/files/BRE/SPC-Industry-Report.pdf
[22] European Space Policy Institute (ESPI), ESPI Special Report - COVID-19 and the European space sector, July 2020. https://espi.or.at/news/new-espi-special-report-on-covid-19-and-the-european-space-sector.
[23] Northern Sky Research, COVID-19 Impact Survey Results: Satellite & Space, April 2020. https://www.nsr.com/wp-content/uploads/2020/04/NSR-April-2020-COVID19-Survey-Results.pdf
[24] Access to Copernicus data, https://www.copernicus.eu/en/access-data.

Conclusion

As the beginning of the current year, also its end is characterised by new measures and lockdowns all over Europe to prevent another dramatic wave of infections. Technology has been to the forefront since the beginning of the pandemic enabling solutions to halt the contagion. In this context, also the space sector provided its support to fight against COVID-19 by making available to different industries space technologies or, in some cases, several space companies temporarily reconverted their businesses to being part of the collective effort to fight the virus.

A direct contribution came from satellite signals and data that played a pivotal role in the functioning of society during the past months. The examples included in this report provided a non-exhaustive list of how satellite-based solutions supported our daily activities. Despite this, a series of barriers and challenges are still limiting the uptake of satellite-based solutions by public authorities, decision and policymakers.

In this context a set of recommendations can be defined to favour a wider uptake as well as the integration of satellite-based data in public policies in the long run.

- A **continuous and stable dialogue between space actor** (space agencies, industry, research centres and other relevant institutions dealing with space affairs) **and professional communities** should be strengthened. In particular, it is fundamental to identify the existing barriers to the uptake of satellite-based solutions and data both in terms of regulatory barriers, technology and financial ones;
- **Financial support should be granted** to assist entrepreneurs to recover from COVID-19 pandemic and its consequences on production and R&D processes. Existing funding mechanisms should be further implemented and expanded when possible;
- As emerged during the interviews with the case studies described in this report, **non-financial support is also a key** leverage for entrepreneurs. Hackathons, competitions, incubators and accelerators have been described as a valuable and effective instrument to nurture ideas and to develop solutions for specific challenges, such as health, environment and citizen engagement;
- **Stimulate the cross-fertilisation** of digital solutions with satellite-based data to address societal needs. This action is crucial to prove the versatility, reliability and effectiveness of satellite data and derived solutions for public policies that aim to guarantee the well-being of the citizens and economic growth.
- Finally, it is important to rethink the way technology-based tools are presented to final users that are not necessarily familiar with them. A **targeted communication** speaking the language of the audience would positively impact their trust in satellite-based solutions.

Special attention should be given to an additional aspect: COVID-19 sharpened the existing discrepancies when it comes to connectivity. Tele-education and smart-working ensured a certain continuity. For this reason, it is important to enhance the performance of satellite-based infrastructures for telecommunications to secure equal access to connectivity. It is also necessary to provide economic support to citizens that live in the so-called white areas to stimulate the demand for connectivity services.

Furthermore, EO providers should welcome the possibility of integrating GNSS to provide geo-referenced data resulting in a highly effective risk assessment solution. With its post-COVID urban sustainability initiative, the European GNSS Agency (GSA) aims to do exactly this.[25] Space services are

[25] GSA, "GSA initiative targets post-COVID urban sustainability: we want to hear from cities", 13 July 2020, https://www.gsa.europa.eu/newsroom/news/gsa-initiative-targets-post-covid-urban-sustainability-we-want-hear-cities.

playing a key role in the modernisation of cities, by exploiting synergies between Galileo and Copernicus our cities could become healthier, greener, more resilient and more sustainable. For instance, these combined satellite technologies offer an accurate location for vehicles and public transport, and provide advanced imagery to support urban planning as well as to monitor activities and emissions in cities.

In conclusion, space assets are not just important because of their strategic value and scientific relevance. Space has become an important component of our daily lives and the pandemic situation highlight its key role for health and emergency. For this reason, it is fundamental to provide a fertile ecosystem for SMEs and start-ups to develop space-based solutions and to better communicate about the opportunities and the purposes of space-based applications and services for societal development. With world-class satellite applications in communications, positioning, and imagery at their fingertips, developers can think out of the box and capitalise even more on European excellence in satellite technology.

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