2024

Report on Healthcare and Wellbeing

User Needs and Requirements

#EUSpace

EUSPA
European Union Agency for the Space Programme

Executive Summary

Segment and Operational Scenarios

The Healthcare & Wellbeing segment is increasingly influenced by environmental factors, climate change, and technological advancements. The interplay between these elements has led to a rise in heat-related illnesses, respiratory ailments, and other health issues. This segment leverages Earth Observation (EO), Global Navigation Satellite Systems (GNSS), and Satellite Communication (SATCOM) to monitor and manage these challenges.

In this context, environmental health and human safety monitoring is a critical application, utilizing EO for air and water quality monitoring, UV radiation tracking, and heatwave detection. These technologies provide essential data to understand and mitigate the impacts of environmental changes on human health. Additionally, assistive technologies and precision tracking employ GNSS to support visually impaired individuals and enhance IoT applications, offering precise location-based services that improve daily living and safety.

Digital healthcare is another significant area where SATCOM plays a vital role. By enabling telemedicine, SATCOM facilitates the provision of healthcare services in remote and underserved areas, ensuring that patients receive timely medical consultations and treatments regardless of their geographical location. This integration of satellite technologies into healthcare and wellbeing applications is transforming the way health services are delivered and managed, making them more accessible and efficient.

Key User Needs and Drivers

The user communities within the Healthcare & Wellbeing segment are diverse, including public health authorities, infrastructure owners and operators, standardization bodies, research institutes, universities, and end users such as citizens, the elderly, vulnerable groups, and sport enthusiasts. Public health authorities require accurate monitoring of air and water quality, UV levels, and disease spread. Infrastructure owners and operators need data for urban planning and heat resilience. Standardization bodies focus on GNSS performance criteria and EO standards, while research institutes and universities are active in health and wellbeing research. End users need real-time, accurate data for health management.

The primary drivers for these needs include legal obligations for environmental monitoring, the necessity for real-time, accurate data for public health and urban planning, and technological advancements in EO, GNSS, and SATCOM.

Challenges, Gaps, and Opportunities

Despite the advancements, several challenges and gaps hinder the full utilization of these technologies. One significant challenge is the lack of standardized data quality certifications which affects regulatory acceptance and compliance. Additionally, there is limited high-resolution data for comprehensive monitoring, and regional disparities in education and expertise in EO technologies further complicate the situation. Data privacy and protection concerns in healthcare applications also pose significant challenges.

There are notable gaps in the integration of EO data with ground-based measurements and in building trust among users and regulatory bodies for new methods. The availability of skilled developers for integrating advanced technologies such as AI and machine learning with domain-specific knowledge is another gap that needs addressing.

However, these challenges and gaps present several opportunities. Developing certifications and standardization frameworks for EO data can enhance trust and regulatory acceptance. Public awareness and adoption of EO technologies can be improved through campaigns and EO training programs. Investing in AI tools and processing power for advanced data analytics can maximize the potential of EO data. Engaging public authorities in standardization efforts can build trust and regulatory acceptance, facilitating the creation of new regulations that incorporate EO data.

To fully benefit from these opportunities, support tools such as dedicated training programs for EO technologies, development of AI and machine learning tools for data processing, regulatory frameworks and certifications for data quality, and technical and scientific support from public institutions are essential.

Current and Prospective Use of GNSS, EO, and SATCOM in Healthcare & Wellbeing

Currently, EO is used for monitoring air and water quality, UV radiation, and heatwaves. GNSS supports visually impaired individuals and IoT applications, while SATCOM facilitates telemedicine in remote areas. Looking ahead, the use of these technologies is expected to evolve. EO services need to improve data quality, frequency, and resolution, and integrate with AI for predictive analytics. GNSS services require advancements in accuracy and robustness to support diverse applications. SATCOM services should focus on reducing latency and increasing bandwidth for real-time healthcare applications.

The European Space Programme plays a pivotal role in addressing the evolving needs of the Healthcare & Wellbeing segment. By enhancing data quality, standardization, and integration with advanced technologies, the programme can significantly improve public health management and urban planning. Collaborative efforts between public institutions, regulatory bodies, and commercial entities are essential to overcome challenges and fully leverage the potential of EO, GNSS, and SATCOM technologies in healthcare and wellbeing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION AND SCOPE OF THE REPORT

1.1 Scope

The User Consultation Platform (UCP) is a process developed by the European Union Agency for the Space Programme (EUSPA) to collect user needs and requirements. These inputs are utilized to provide space data-based services driven by user demands within the EU Space Programme.

The purpose of this report is to serve as a reference for the EU Space Programme and the Healthcare & Wellbeing community. It details the latest user needs and requirements in the Healthcare & Wellbeing market segment concerning the application of Global Navigation Satellite System (GNSS), Earth Observation (EO), and satellite telecommunications (SATCOM) technologies. The report addresses user needs and requirements, considering market conditions, regulations, and standards. It serves as a reference for end users, service providers, and the EO community in planning and decision-making. The report aims to inform technical discussions on systems engineering and guide the development of the EU's satellite navigation systems (Galileo and EGNOS), Earth Observation system (Copernicus), and future initiatives like Space Situational Awareness, GOVSATCOM and IRIS[2].

The present RUR is the first edition prepared for the Healthcare & Wellbeing segment within the UCP framework. As envisaged in the User Consultation Platform, this RUR will be enhanced in the coming years by updating the existing applications and operational scenarios, as well as incorporating new ones.

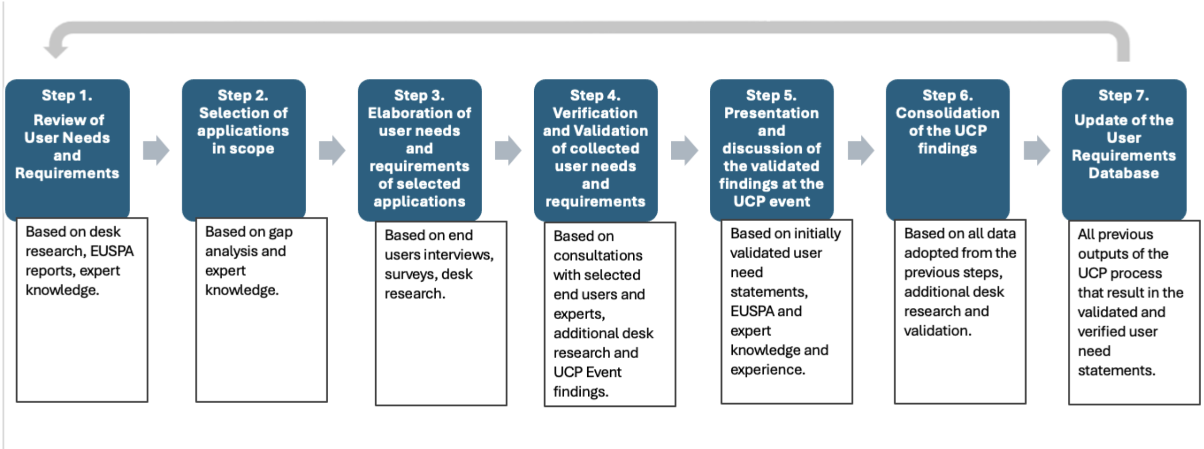
The report is organised as follows:

- Section 2.1 gathers information on the role of the European Space Programme to meet the evolving user needs, highlighting identified limitations and gaps.
- Section 2.2 presents the market evolution and key trends in the Healthcare & Wellbeing segment, together with definitions of main user groups and actors active in the value chain.
- Section 2.3 describes the market drivers (regulations, standards, etc.) underpinning the development of the segment's service offering as well as organisations relevant to the analysed industry.
- Section 2.4 presents the main user needs, expectations and requirements relevant for EO/GNSS/SATCOM applications/operational scenarios analysed in this RUR. Further, the section describes the current use of EO/GNSS/SATCOM services and data for the analysed applications, key trends that are driving the development of these services, limitations and gaps driving new requirements vis-à-vis the services and data in focus.
- Finally, Section 2.5, summarises the main User Requirements for the Healthcare & Wellbeing segment in the applications domains analysed in this report.

1.2 Methodology

The UCP process follows systematic steps that are implemented in a continuous, repetitive manner. The logical steps allow transparency and continuous updates of the results, considering the new market developments and evolving user needs and requirements.

Figure 1. User Consultation Process methodology with continuous steps



.

UCP user needs and requirements collection and analysis is based on one hand side on desk research and on the other, on stakeholders' consultations and experts' knowledge.

The UCP process starts with review and analysis of the most up-to-date sources related to the user needs and requirements in selected market segments. This step leverages on the previous UCP Reports on User Requirements, latest EUSPA EO and GNSS Market Report, Technology Reports and other expert publications and knowledge. The selection of relevant applications in each market segment is made based on the market analysis, the gap analysis from the earlier editions of the UCP and EUSPA, as well as external experts' know-how.

After the initial desk research, the stakeholders' consultations are carried out, both representing end users and intermediate users (service providers), in order to validate the findings and collect missing information (Step 3). Validation of user needs requires additional feedback from relevant users' representatives that review the draft version of the Report on User Needs and Requirements, prepared in advance of the UCP event.

UCP event is organized by EUSPA on an annual basis and offers a forum to present and discuss the finding, being additional layer of updates and gaps filling in the process. All the information and data gathered during the previous steps are consolidated in the segment-specific, presented here Report on User Needs and Requirements (RUR) and later on in the EUSPA User Requirements Database (Step 7).

2 HEALTHCARE AND WELLBEING

2.1 The role of the European Space Programme to meet the evolving user needs

The European Space Programme, defined by the EU Space Programme Regulation [RD6] implements space activities in the fields of Earth Observation, Satellite Navigation, Connectivity, Space Research and Innovation. The Programme is providing unique satellite-based data and services, strengthening both the upstream and downstream industrial ecosystem, boosting innovation and competitiveness.

EUSPA is the user-oriented operational agency of the European Union Space Programme. It adopts user-oriented strategies to stimulate uptake of the satellite-based services. In the execution of its mission, EUSPA counts on strong partnerships with the European Commission, European Parliament, Member States, European Space Agency, and private actors across the EU.

Key EUSPA competences are:

- Provides state-of-the-art, safe and secure positioning, navigation and timing services based on Galileo and EGNOS, cost-effective satellite communications services for GOVSATCOM and soon IRIS², and Front Desk services of the EU Space Surveillance Tracking whilst ensuring the systems' service continuity and robustness;
- Promotes and maximises the use of data and services offered by Galileo, EGNOS, Copernicus, GOVSATCOM and soon IRIS² across a broad range of domains.
- Fosters the development of a vibrant European space ecosystem by providing market intelligence, and technical know-how to innovators, academia, start-ups, and SMEs. The agency leverages Horizon Europe, other EU funding, and innovative procurement mechanisms.
- Implements and monitors the security of the EU Space Programme components in space and on the ground with the aim to enhance the security of the Union and its Member States. To do so, EUSPA operates the Galileo Security Monitoring Centre (GSMC).
- The EU Space Programme Security Accreditation Board is established within the Agency, representing the security accreditation authority for all of the EU Space Programme's components.

The Agency brings all space stakeholders together, allowing them to leverage the synergies between the Space Programme's individual components, and to have an impact on the evolution of the EU space programme. The end users can contribute to the flagship EUSPA activities to better understand the ever-evolving market, user requirements, as well as gaps and challenges, and that includes:

- User Consultation Process and Platform
- Market and Technology Monitoring and Forecasting Process
- R&D Funding Needs Definition and Implementation
- Piloting of innovative applications
- Acceleration of innovative commercial ideas via CASSINI Programme
- International cooperation, participation in working groups, and other.

Through participation in these initiatives, the end users have an impact on the evolution of the EU Space programme in line with user needs.

COPERNICUS

Copernicus is the Earth Observation component of the European Union's space programme, looking at our planet to support the management of the environment, mitigate the effects of climate change and ensure safety and civil security across Europe. Copernicus delivers its data and services with a free and open policy. It consists of three main components:

Space Component, which delivers data from a fleet of dedicated observation satellites (the 'Sentinels') and other Copernicus Contribution Missions (CCM). Six Sentinel satellites families are designed to serve a wide range of users and are provided with a free and open access globally. They ensure an independent and autonomous Earth Observation capacity for Europe with global coverage. The satellites provide observations which serve a wide range of users for a multitude of applications in the areas of climate, land and ocean services, emergency management, atmosphere and air quality, among others.

- Sentinel-1A provides all-weather, day and night radar imagery for land and ocean services. Sentinel 1-B was retired in December 2021.
- Sentinel-2A & -2B provide optical imagery for land and emergency services.
- Sentinel-3A & -3B provide optical, radar and altimetry data for marine and land services.
- Sentinel-5P provides atmospheric data, bridging the gap between ENVISAT and future Sentinel-5 data.
- Sentinel-4 & Sentinel-5 will fly aboard EUMETSAT MTG-S and Metop-SG satellites. They will monitor air quality, trace gases and aerosols over Europe at high spatial resolution and very high frequency.
- Sentinel-6 provides radar data to measure global sea surface height observations for climate monitoring and ocean and seasonal forecasts. It continues a time series of mean sea level rise measurements dating back to 1992.

CCMs complement the data portfolio in the Sentinel satellites missions with another layer of value to meet user needs, providing data from commercial data providers. There are around 30 existing or planned contributing missions, encompassing various technologies like SAR, optical sensors, spectrometers and altimetry systems.

In-Situ Component collects data acquired by a multitude of sensors at air-, sea- and ground-level, and includes geospatial reference data.

Service Component of Copernicus programme transforms the various data into timely and actionable information products. The Copernicus Services deliver value-added information products in six thematic areas:

Atmosphere	**Climate**	**Emergency**	**Land**	**Marine**	**Security**
Atmosphere Monitoring Service (CAMS)	Climate Change Service (C3S)	Emergency Management Service (CEMS)	Land Monitoring Service (CLMS)	Marine Environment Monitoring Service (CMEMS)	Security Service (CSS)[1]

[1] Copernicus Security Service is provided to registered public users only.

In the Healthcare & Wellbeing sector, EO technology plays a crucial role in monitoring environmental factors that directly impact public health. **Accurate and reliable data** is essential for air quality, water quality, UV, and heatwave monitoring. As the volume and variety of space-borne data grows, users from scientific communities, government agencies, industries and end-users require assurance that the data they rely on for decision making is accurate, consistent and validated.

Certifications are crucial for establishing **standardization frameworks**. They ensure that data collection, processing, and distribution adhere to high-quality standards and undergo regular audits and reviews. The lack of such certifications currently restricts service providers from expanding their business since conservative users may prefer traditional data sources for their specific needs. Harmonized regulatory frameworks and standardized approaches are necessary to facilitate the adoption of EO-based solutions [RD4]. Clear regulations and standards can help build trust and ensure the responsible and effective use of EO data.

By championing data validation through certifications, the European Space Programme not only enhances the trust and utility of its own data, but also sets a precedent for global data providers. **The commitment to quality helps foster a competitive and innovative market for space-borne data applications**, driving further advancements in the field and supporting a wide array of sectors that depend on accurate EO-data. Funding for demonstrators and pilot projects can support the validation of EO-based solutions and bridge the gap to market adoption [RD4]. These projects can provide proof of concept and showcase the practical benefits of EO data, encouraging broader usage.

Support is essential for data derived from ground-based sources, which are crucial in complementing EO data. These sources are often quite costly and challenging to collect, with limited geographical coverage that typically spans only neighbourhoods or cities. This issue is particularly relevant for estimating UV radiation derived from satellite measurements. While satellite data provides comprehensive spatial coverage, it must be noted that the **absence of detailed ground information** on influential parameters at specific locations can limit the accuracy of the final service. Additionally, given that UV radiation poses a health risk, any information or warning services related to UV exposure must be reliable and avoid false negatives.

There are also technical barriers, such as the **shortage of developers skilled in integrating the necessary technologies** (machine learning, AI, EO) with domain-specific knowledge. Investing in AI tools and processing power is crucial for managing the substantial volumes of satellite and non-satellite data, enabling advanced analytics and correlations [RD4]. **AI facilitates the processing and analysis of large datasets**, revealing patterns and insights that would be challenging to identify using traditional methods. This investment is imperative for maximizing the potential of EO data in various applications.

Another challenge hindering the full utilisation of EO data in Healthcare & Wellbeing applications is the **disparity in regional development**, particularly concerning education and expertise. It would be beneficial to provide support through training programs.

Addressing **data anonymity and protection** is crucial, especially when using AI and machine learning in healthcare [RD4]. Ensuring data privacy and protection is essential to gain the trust of healthcare providers and patients alike. There is also a need for standardized methods to measure and compute EO data parameters relevant to healthcare. This standardization would help in creating consistent and reliable data that can be easily integrated into healthcare systems. Additionally, balancing data resolution and cost is essential for developing viable business plans. High-resolution data can be expensive, and finding a balance between cost and benefit is crucial for widespread adoption.

National governments may be more inclined to adopt new techniques if there is pressure and support from the EU level, particularly for programs such as Copernicus [RD4]. Support at the EU level can facilitate coordination efforts and provide the necessary resources for implementing EO-based solutions. **EUSPA can significantly contribute by derisking innovation development and supporting regulatory advancements**. By offering technical and scientific support, EUSPA can assist in addressing the challenges related to developing and implementing new EO-based technologies. Overcoming barriers and promoting the adoption of EO-based solutions require collaborative efforts from European institutions and support from national governments. Public health agencies and research institutions should be primary targets for EO data applications, given their mandate to monitor health on a large scale. These entities can greatly benefit from the extensive data provided by EO, which enables them to monitor and respond to health trends more effectively.

Finally, the European Commission's role as a data provider is welcome, but the possibility of the Commission becoming more involved in the development of EO-based products and services is seen as a potential concern for commercial companies already working in this area. **Technical and scientific support provided by public institutions is regarded as crucial and has room for improvement**.

European Global Navigation Satellite System (EGNSS)

EGNSS is the European satellite navigation program designed to provide highly accurate and reliable positioning, navigation, and timing services on a global scale and ensuring Europe's technological autonomy. EGNSS offers high-precision and multi-constellation capability. There is a free positioning service available to the public, as well as encrypted services for government and commercial use, like the Public Regulated Service (PRS) for government-authorized users. EGNSS includes two main systems:

- **Galileo** is the European satellite navigation system that provides highly accurate global positioning and timing information. It offers several unique features, including higher accuracy (especially in urban areas), improved availability, and an authentication service to prevent signal spoofing. Numerous EU economic sectors rely on Gelileo, from transport and agriculture to border management and search and rescue. Its 20cm accuracy makes Galileo a game changer for autonomous driving and commercial drones. Already more than 3.5 billion smartphones are Galileo-enabled.
- **GNOS** (European Geostationary Navigation Overlay Service) is a satellite-based augmentation system (SBAS) that improves the accuracy, integrity, and reliability of the navigation services to aviation, maritime and land-based users in over 30+ countries, and already operational in 426 airports and helipads.

In the Healthcare & Wellbeing sector, GNSS technology is essential for applications such as supporting the visually impaired and integrating with IoT devices for health monitoring. High precision and reliability are crucial for these applications. Investing in R&D to improve the accuracy and reliability of GNSS data is necessary. There is also a need for seamless integration with other technologies like IoT and AI to enhance the effectiveness of GNSS in healthcare applications.

European Secure SATCOM

The EU Secure Satellite Communication System, known as **GOVSATCOM** is an investment made by the EU, which aims to provide secure and cost-efficient communication capabilities to security and safety-critical missions and operations. **IRIS², **the new multi-orbital constellation of 290 satellites will provide secure connectivity services to the EU and its Member States as well as broadband connectivity for governmental authorities, private companies and European citizens, while ensuring high-speed internet broadband to cope with connectivity dead zones**.** The program is part of the EU's broader strategy to strengthen its autonomy, security, and defence capabilities, especially in response to increasing geopolitical challenges and cybersecurity threats.

In the Healthcare & Wellbeing sector, reliable communication channels are essential for telemedicine, enabling remote consultations, diagnostics, and patient monitoring. Ensuring coverage in remote and underserved areas is crucial. Investing in SATCOM infrastructure to ensure reliable communication for telemedicine services is necessary. Expanding coverage to remote and underserved areas will ensure accessibility.

2.2 Market Overview & Trends

2.2.1 Market Evolution and Key Trends

Introduction to Healthcare & Wellbeing

The interplay between environmental factors, climate change, and human health is a subject of increasing concern, as the implications of a changing climate become more evident in various aspects of human well-being. Rising global temperatures are leading to more frequent and severe heatwaves, which in turn contribute to a rise in heat-related illnesses and fatalities. The escalation in temperature also exacerbates air quality issues by increasing the likelihood of wildfires, which release smoke and fine particulate matter into the atmosphere. This deterioration in air quality has been linked to an increase in respiratory ailments, such as asthma, as well as cardiovascular diseases. Additionally, the ozone layer's ability to shield the Earth from harmful ultraviolet (UV) radiation is impacted, resulting in increased exposure to UV radiation and raising the risk of skin cancer and cataracts.

In this segment, EO performs several critical functions. By monitoring air quality, water quality, and UV radiation, EO provides essential data to address contemporary issues of rising interest in the consumer domain. For example, vector-borne diseases, which are influenced by weather conditions, can be tracked to understand their spread and impact on human health. Information about meteorological conditions of locations used for sports or tourist facilities makes these services usable not only by individuals but increasingly by businesses that want to fully exploit their potential. Finally, some data are useful for policy creation and decision-makers, who are in charge of providing public services and ensuring environmental health.

GNSS are relevant to a great number of sub-segments presented under "Consumer Solutions, Tourism & Health" in previous EUSPA publications but are now part of the Healthcare & Wellbeing category. Position and navigation data are central to the existence of many applications. The essential functions fulfilled include the increasing accuracy at which it is possible to link activities, information, and services to a specific location. Additionally, the capacity to monitor objects and people, and the consequences that can result from this, is gaining importance for businesses and personalized health applications.

SATCOM has revolutionized the delivery of healthcare, particularly in regions where access to medical facilities and specialists is limited by geographic or infrastructural limitations. SATCOM overcomes this challenge by connecting patients with healthcare providers across vast distances.

It is important to emphasize that data from the GNSS system, EO, and SATCOM can be strategically combined and integrated to achieve better results in terms of the services offered through the application.

The healthcare market has seen significant evolution with the integration of space technologies. The rise of super apps is a notable trend, providing users with a seamlessly integrated experience via a one-stop solution that solves different needs and purposes simultaneously. These apps are changing the way people interact with their phones, integrating various applications such as social and communication platforms, e-commerce, transport and ride-hailing services, financial services, food delivery, bill and utility management, and healthcare services. Large companies like Meta and Amazon have started integrating such features, and Twitter has announced plans to build its super app, X, which will offer a range of services from social networks to purchase apps while providing personalized entertainment based on the user's location and preferences. The role of geolocation, cybersecurity, and privacy is extremely important in this context, as users' personal data is aggregated on a single platform, enabling the seamless operation of such super apps.

Climate change may affect and worsen air quality through increasing temperature, air pollution, and the increasing risk of wildfires, all of which may exacerbate asthma attacks, a condition already affecting 30 million Europeans. In this context, the Copernicus Atmosphere Monitoring Service (CAMS) represents a key source of information to monitor and address climate change and the health issues it might cause. As the healthcare sector embraces Copernicus data, a new era of understanding and tackling health-related challenges is set to unfold. The global pharmaceutical company Teva is investigating the link between wildfire air pollution and asthma triggers with the help of CAMS. CAMS, which offers comprehensive atmospheric data, aids Teva's research by providing insights into global wildfires and air pollution. This collaboration represents a major step forward in addressing respiratory diseases amid climate change.

To date, the integration of innovative technologies, such as 5G connectivity, robotics, augmented reality (AR), and 3D printing, is poised to revolutionize healthcare and disease monitoring. This transformation is bolstered by the harnessing of big data platforms and advanced analytics, facilitating more robust and proactive public health efforts. Notably, apps like GIDEON's interactive disease outbreak and distribution map are already in use and continually updated with fresh data. Similarly, Lyme app, a mobile and web-based app, provides users with risk maps for their specific locations, exemplifying the synergy between technology and public health for enhanced monitoring and response.

The sections below will depict the main applications making use of EO, GNSS, and SATCOM in Healthcare and Wellbeing. The listed applications are non-exhaustive, and the list is expected to potentially grow and adapt according to the expected adoption of space technologies in the coming years and the innovations that come with it. The current report being the first version of the Healthcare and Wellbeing report on user Needs and Requirements relevant to EO, GNSS, and SATCOM is an evolving document that will periodically be updated and expanded by EUSPA in its next releases.

This issue of the RUR does not cover all applications in detail. A categorization was performed prioritizing some applications based on their maturity level and relevance to market trends and drivers. Other applications are foreseen to be covered in more detail in future versions of this RUR.

Space technology applications in the Healthcare & Wellbeing segment include:

Table 1. Space technology applications in the Healthcare & Wellbeing segment

Sub-segment	Applications
Earth Observation	• *Air Quality* • *Water Quality* • *UV Monitoring* • *Heatwave Monitoring*
GNSS	• *Visually Impaired Support* • *Internet of Things*
SATCOM	• *Telemedicine*

2.2.2 Main User Communities

2.2.2.1 EO Key Users

As presented in the EO and GNSS EUSPA Market Report (See [RD1]), the main market players in the EO value chain are:

- Data Providers
- Infrastructure providers
- Platform providers
- EO products and services providers
- Information providers
- End users

Data Providers are entities that collect and supply raw EO data. Examples are: Blacksky, Planet and Umbra. They are responsible for ensuring the accuracy, quality, and availability of the data. In the context of healthcare and wellbeing, they provide essential data that can be used to monitor environmental factors affecting health, such as air quality, water quality, and climate conditions.

Infrastructure Providers are organizations that offer the necessary infrastructure to store, process, and distribute EO data, such as AWS and Google cloud. This includes cloud storage services, data processing facilities, and high-performance computing resources. They enable the efficient handling and analysis of large volumes of EO data, facilitating timely and accurate health-related insights and decision-making.

Platform Providers are companies or institutions, e.g. ADAM and PIESAT, that develop and maintain platforms or software solutions for accessing, visualizing, and analyzing EO data. These platforms often include tools for data integration, analysis, and visualization. They provide user-friendly interfaces and analytical tools that healthcare professionals and researchers can use to derive actionable insights from EO data, such as tracking disease outbreaks or assessing the impact of environmental changes on public health.

EO Products and Services Providers are entities that create value-added products and services derived from raw EO data. Examples of such entities are CGI, Macar and Datel. This includes processed data, analytical reports, and customized solutions tailored to specific needs. They offer specialized products and services that can be directly applied to healthcare and wellbeing, such as heat maps of disease prevalence, risk assessment models, and early warning systems for health hazards.

Information Providers are organizations, e.g. Airbus and Accuweather, that disseminate processed EO data and insights to a broader audience. This includes research institutions, government agencies, and non-profit organizations that focus on public health and environmental issues. They play a crucial role in raising awareness, informing policy decisions, and educating the public about health risks and preventive measures based on EO data.

End Users are the final recipients of EO data and insights, including healthcare professionals, smartphone developers, citizens and sports/health and wellbeing enthusiasts. They utilize the information provided to make informed decisions, implement health interventions, conduct research, and take preventive actions to improve health outcomes and wellbeing.

2.2.2.2 GNSS Key Users

As presented in the EO and GNSS EUSPA Market Report (See [RD1]), the main market players in the GNSS value chain are:

- Components and receiver manufacturers
- System integrators: Tier 1 suppliers and vehicle manufacturers
- After market device vendors
- Service providers
- (End) Users

As shown above, the main players in the GNSS Health and Wellbeing segment value chain are[8]:

- **Components and receiver manufacturers**: this includes the production of chips, antennas, and other inputs for GNSS receivers, as well as market specificities and added value conferred by device/product manufacturers. Examples include ST Microelectronics, u-blox.

- **Operating system developers**: this includes technical implementation of GNSS equipment into a complex segment. Examples include Google, Apple, Microsoft.
- **Device integrators and vendors**: includes the integration of various hardware devices with the related software application to create a functional system. This may include sensors, controllers, computers and network equipment. Examples are Garmin, Samsung, Polar and Alphabet.
- **Service & Content providers**: this refers to GNSS mobile network operators and assistance data providers. Some of which are mobile network operators: Telefonica (ES), Vodafone (UK) and Orange (FR).
- **App developers / Retailers:** organizations that market the final product to end users through mCommerce or mHealth. Vendors include META and FitBit.
- **App Stores:** examples are Apple App store, Google Play or Microsoft Store
- **End Users**: citizens, elderly and vulnerable groups, sports/health and wellbeing enthusiasts

2.3 Key market drivers – Policies, Regulations, Standards

The healthcare and wellbeing sector, heavily regulated to prioritize safety, efficiency, and quality, is undergoing a technological transformation. The emergence of advanced technologies, including space-borne data, is driving advancements in telemedicine, personalized medicine, wearable devices, and digital health platforms. While these developments offer significant promise, they also present challenges related to data privacy, secure transmission, and compliance with stringent regulatory standards.

Public policies are increasingly driving the need for improved and innovative healthcare services. Satellite technologies, such as Earth observation (EO), satellite communications (SATCOM), and Global Navigation Satellite Systems (GNSS), offer exciting opportunities to enhance these services. However, their implementation requires careful regulatory oversight to ensure they meet the high standards expected by the healthcare industry.

2.3.1 Relevant organisations

International regulators

World Health Organisation (WHO): WHO is a specialised agency of the United Nations established in 1948 with the objective to promote and coordinate international public health efforts, fostering global security, particularly for vulnerable populations. The organization consists of 194 Member States, and, among various activities, it establishes international health standards, monitors health trends and provides technical assistance.[2] WHO is among the main promoters of the UN Sustainable Development Goal 3, "Good Health and Well-Being," which requires Member States to ensure healthy lives and promote well-being for all[3].

United Nations Office for Disaster Risk Reduction (UNDRR): UNDRR is the UN office dedicated to support decision makers through evidence-based information to better understand and act against risks to preserve peoples' wellbeing[4].

United Nations Environment Programme (UNEP): UNEP is the global authority on the environment, whose goal is to provide information on the environment status and risks, to inform and enable Member States to improve their wellbeing and that of future generations.[5]

Intergovernmental Panel on Climate Change (IPCC): The IPCC is the United Nations body for assessing the science related to climate change, its impacts, risks as well as options for adaptation and mitigation measures.[6] The Panel is divided in three Working Groups covering: I) the physical science basis, II) impacts, adaptation and vulnerability; and III) mitigation of climate change. Additionally, a fourth forum is the Task Force on national greenhouse gas inventories. The Panel prepares Assessment, Special Reports (on topics agreed to by its member states, including the impacts of climate change on Human's health and wellbeing), and Methodology Reports that provide guidelines.

European Commission

The EU has a shared competence (Article 4 of the TFEU)[7] in the domain of public healthcare for "common safety concerns in public health matters". Regarding the "protection and improvement of human health",

[2] https://www.who.int/
[3] https://www.who.int/data/gho/data/themes/sustainable-development-goals
[4] https://www.undrr.org/
[5] https://www.unep.org/
[6] https://www.ipcc.ch/
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:12008E004

the EU has a supportive competence (Article 6 of the TFEU)[8], meaning that it can support, coordinate, or complement the initiatives of the Member States. More specifically, EU Member States define and deliver their national health services and medical care, while the EU can complement national policies to promote healthier lifestyles, better healthcare (more innovative, efficient and sustainable), among other areas of intervention (Article 168 of the TFUE)[9]. Within the European Commission, the Directorate General for Health and Food Safety (DG SANTE) is responsible for the monitoring of the implementation of relevant laws and policies at Member States level, as well as for the consultation of relevant stakeholders and the proposition of laws and support projects.[10]

European Medicines Agency (EMA): Established in 1995, EMA's mission is to promote scientific excellence to the benefit of both public and animal health. Its mandate mainly consists in the assessment and supervision of medicines to rigorous standards, as well as in providing independent and sound information on medicines. EMA is a European agency and cooperates within the European medicines regulatory network together with the European Commission and the medicines regulatory authorities in the European Economic Area. [11]

European Parliament

The EU has a shared competence (Article 4 of the TFEU)[12] in the domain of public healthcare for "common safety concerns in public health matters". Regarding the "protection and improvement of human health", the EU has a supportive competence (Article 6 of the TFEU)[13], meaning that it can support, coordinate or complement the initiatives of the Member States. More specifically, EU Member States define and deliver their national health services and medical care, while the EU can complement national policies to promote healthier lifestyles, better healthcare (more innovative, efficient and sustainable), among other areas of intervention (Article 168 of the TFUE)[14].

Examples of relevant European associations

Heads of Medicines Agencies (HMA): In the European Economic Area, HMA is a network of the heads of the National Competent Authorities (NCA) whose entities are responsible for the regulation of medicinal products for human and veterinary use. The network promotes the exchange of best practices and cooperation on statutory and voluntary regulatory activities. It works in synergy with EMA and the European Commission for the European medicines regulatory network. [15]

European Public Health Alliance (EPHA): the EPHA is an international not-for-profit association that advocates for the protection and improvement of public health in Europe, both via health policies and across all other relevant policy areas that have an impact on health. The institution serves as a change agent by facilitating the participation of its diverse member organisations, that include civil society organisations, group of health professionals and public health actors.

European Public Health Association (EUPHA): The EUPHA is an umbrella organisation for public health associations and institutes in Europe. Their vision is to improve health and well-being and narrowing health inequalities across the continent. They seek to support their members to improve health in Europe,

---

[8] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:12008E006:EN:HTML
[9]https://eur-lex.europa.eu/EN/legal-content/glossary/public-health.html#:~:text=Under%20Article%20168%20of%20the%20Treaty%20on%20the,between%20the%20European%20Union%20and%20its%20Member%20States.
[10]https://commission.europa.eu/about-european-commission/departments-and-executive-agencies/health-and-food-safety_en
[11] https://www.ema.europa.eu/
[12] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:12008E004
[13] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:12008E006:EN:HTML
[14] https://eur-lex.europa.eu/EN/legal-content/glossary/public-health.html#:~:text=Under%20Article%20168%20of%20the%20Treaty%20on%20the,between%20the%20European%20Union%20and%20its%20Member%20States.
[15] https://www.hma.eu/

adding value to the efforts of stakeholders in regions and states, in national and international organisations and individual public health professionals.

BioMed Alliance: The alliance is the result of a unique initiative of leading European medical societies that together include more than 400,000 researchers and health professionals. Their goal is to promote excellence in European biomedical research, strengthen the representation of researchers, advocate for increased funding and improve the health and well-being of all citizens of Europe.

EuroHealthNet: a not-for-profit partnership that includes organisations, institutes and authorities working on public health, disease prevention, promoting health and wellbeing and reducing inequalities. Their mission is to help build a sustainable, fair and inclusive Europe through healthier communities and to tackle health inequalities within and between European member states.

European Federation of Pharmaceutical Industries and Associations (EFPIA): Representative body of the biopharmaceutical industrie operating in Europe. Through its direct membership of 37 national associations, 40 leading pharmaceutical companies and a growing number of small and medium-sized enterprises (SMEs), EFPIA's mission is to create a collaborative environment that enables our members to innovate, discover, develop and deliver new therapies and vaccines for people across Europe, as well as contribute to the European economy.

European Federation of Biotechnology (EFB): The EFB is a non-for-profit federation of national biotechnology associations, learned societies, universities, scientific institutes, biotechnology companies and individual biotechnologists working to promote biotechnology throughout Europe. The EFB promotes the safe, sustainable and beneficial use of fundamental research and innovation in life sciences, to provide a forum for interdisciplinary and international cooperation, to improve scientific education and to facilitate an informed dialogue between scientists, the biotechnology industries and the public.

R&I related platforms

European medicines regulatory network: The Agency operates as a partnership among EMA, the European Commission and representatives of more than fifty national competent authorities (NCA) for human and veterinary medicines. The network promotes the exchange of best practices and cooperation on statutory and voluntary regulatory activities [16].

GEO Health Community of Practice: The GEO Health Community of Practice is a global network of governments, organisations, and observers. Its mission is to promote the use of environmental observations data to improve decision-making concerning healthcare at the international, regional, country, and district levels.[17]

GEO Aqua Watch: The Aqua Watch Initiative aims at improving the use, coordination, and delivery of water quality EO data for the benefit of society[18]. Among other topics, Aqua Watch focuses also on the monitoring and forecasting of water quality to detect issues related to drinkable water and water-borne diseases. Additionally, the organisation promotes partnerships and exchanges of EO data best practices among its members.

EuroHealthNet's Research Platform: The EuroHealthNet's Research Platform is a collaborative initiative aimed at enhancing public health and wellbeing across Europe. It brings together a diverse network of organizations, institutes, and authorities working on public health, disease prevention, health promotion, and the reduction of health inequalities. The platform facilitates the exchange of knowledge, best practices, and innovative solutions among its members, fostering a collaborative environment to address public health challenges.

---

[16] https://www.ema.europa.eu/en/about-us/how-we-work/european-medicines-regulatory-network
[17] https://www.geohealthcop.org/
[18] https://www.geoaquawatch.org/

Other relevant organisations

National governments: Within national governments, ministries of health are responsible for the regulation of healthcare practices at Member State (MS) level and the transposition of health-related EU Directives.

International Association of Medical Regulatory Authorities: is a membership organization whose purpose is to promote effective medical regulation worldwide by supporting best practice, innovation, collaboration, and knowledge sharing in the interest of public safety and in support of the medical profession.

International Federation of Pharmaceutical Manufacturers & Associations (IFPMA): is a global, non-profit organization that represents the research-based pharmaceutical industry. Founded in 1968, IFPMA's mission is to promote and support the development of innovative, safe, and effective medicines and vaccines that improve global health outcomes.

Global Health Council (GHC): The GHC is a leading membership-based organization dedicated to improving global health through advocacy, policy development, and collaboration. Established in 1972, GHC serves as a platform for a diverse network of organizations, including non-governmental organizations (NGOs), academic institutions, foundations, and private sector entities, all committed to advancing global health initiatives.

International Federation of Red Cross and Red Crescent Societies (IFRC): is the world's largest humanitarian network, providing assistance without discrimination to those in need. Established in 1919, the IFRC coordinates and supports the activities of 192 National Red Cross and Red Crescent Societies, working together to respond to disasters, promote health and wellbeing, and uphold human dignity.

2.3.2 Selection of applicable regulations

EU legislation

PSI Directive: This directive encourages the re-use of public sector data, including space borne data, by removing barriers and setting common legal and practical frameworks. This can facilitate the development of innovative healthcare applications that utilize space borne data.

General Data Protection Regulation (GDPR): a comprehensive data protection law that applies to all sectors, including healthcare. It sets strict requirements for the processing of personal & patient data, which would include health data communicated through means of SATCOM. Organizations that transfer patient data through satellites must ensure compliance with GDPR provisions.

EHDS (EU) 2024: the directive concerns the European Health Data Space and its specific rules, common standard and practices, infrastructure and governance framework.

Bathing Waters Directive (EU) 2006/7: the Directive concerning the management of bathing water quality exemplifies the connection between healthcare and other areas of EU competence[19].

EU-Public Health (Article 168): Provides the EU with the authority to implement actions to improve public health, prevent human illness and diseases, and obliviate sources of danger to physical and mental health. The EU's role is to complement national policies and to encourage cooperation between member states.

EU-Single Market (Article 114): Relates to the harmonization of laws to ensure the establishment and functioning of the internal market. This can include harmonizing regulations for products and services

[19] https://www.europarl.europa.eu/factsheets/en/sheet/126/tourism/

related to healthcare to ensure they can move freely within the EU while maintaining a high level of health protection.

EU-Social Policy (Article 153): Provides a basis for the EU to support and complement the activities of member states in the field of social policy, including aspects related to health and safety at work, working conditions, and social security and protection of workers.

EU-Charter of Fundamental Rights (Article 35): Recognizes and respects access to preventive healthcare and the right to benefit from medical treatment under the conditions established by national laws and practices.

Climate ADAPT: Initiative by European Agency (EEA) and the European Commission to support member states in adapting to climate change. It provides information on expected climate change in Europe, current and future vulnerability of regions and sectors, national and transnational adaptation strategies and case studies on adaptation measures.

European Heat Health Action Plans: Some EU countries have developed Heat Health Action Plans (HHAPs) that include monitoring and response systems for heat waves. These plans are often developed in accordance with guidelines from the World Health Organization (WHO) and are tailored to the specific needs of each country.

2.3.3 Other (standards, practices, guidelines, ...)

2.3.3.1 Relevant Standards for EO

EO techniques present a lack of consistency between sensors and their calibration, in data formats and structures, in accuracies and terminology, and structures. Uptake of some EO techniques has been slow and there have been challenges in ensuring interpretability. International standards would help address these issues, and these guidelines aimto go some way towards improving the accessibility of EO data products and technologies.

There are currently very few standards or regulatory documents in EO, either in data quality or in processing or products. The internationally adopted standards in data formats and metadata associated with digital spatial data were provided by ISO, IEEE, OGC, GRSS and SEOAH:

- The International Organization for Standardization (ISO):
  - ISO/TR19121:2000 concerning Geographic information, imagery, and gridded data
  - ISO 19115:2014 Geographic Information - Metadata
- The Open Geospatial Consortium (OGC) provides Standards and Schemas (XSD, JSON Schema, etc) for the geospatial information interoperability and implementation used by international organizations.
- EO product metadata: OGC's GML Application Schema for EO Products
- Collection and service discovery: OGC's Cataloguing of ISO Metadata using the ebRIM profile of CS-W.
- Catalogue Service: OGC's Catalogue Services Specification 2.0 Extension Package for ebRIM Application Profile: EO Products.
- Order: OGC's Ordering Services for EO Products
- Feasibility Analysis: OGC's Sensor Planning Service Application Profile for EO Sensors
- Online Data Access: OGC's WMS EO Extension
- Identity (User) Management: OGC's User Management Interfaces for EO Services.
- Geoscience and Remote Sensing Society (GRSS) created the Standards in Earth Observations (GSEO) Technical Committee to support the development and promotion of technical standards

related to the generation, distribution, and utilization of interoperable data products from remote sensing systems.

- The Standards in Earth Observations Ad Hoc Committee (SEOAH) is the managing organizational unit within GRSS to handle standards development within the IEEE.

Additionally, the relevant EO standards in the field of Healthcare & Wellbeing can be divided into different classes:

- **Standards for Air Quality**

The Ambient Air Quality Directives establish air quality standards for 12 pollutants, including sulfur dioxide, nitrogen oxides, particle matter (PM10 and PM2.5), ozone and several toxic substances. The objective of the directive is to define a common method to monitor, assess and inform air quality across the European Union. In addition to that, they establish for ambient air quality to avoid, prevent or reduce harmful effects on human health and the environment.

- **Standards UV Monitoring**

Ambient Air Quality Directive (2008/50/EC) focuses primarily on the monitoring and management of air pollutants, it also has implication for UV radiation because certain air pollutants can affect the amount of UV radiation that reaches the Earth's surface.

- **Water Framework Directive**

The Water Framework Directive focuses on ensuring good qualitative and quantitative health, i.e. on reducing and removing pollution and on ensuring that there is enough water to support wildlife at the same time as human needs.

2.3.3.2 Relevant Standards for GNSS

CEN/CENELEC:

- EN 16803 series: These standards, developed by CEN, provide guidelines for the testing and performance of GNSS. They cover various aspects of space systems and operations, including the use of GNSS-based positioning for road transport (e.g. ambulances or telemedicine)
- EN 303 413: This standard specifies technical characteristics and methods of measurements for GNSS equipment, including receivers and transmitters for satellite navigation services I the road transport.

ISO Standards:

1. ISO 17123 series: this set of standard specifies field procedures to be adopted when determining and evaluating the precision (repeatability and reproducibility) of GNSS field measurement systems in real-time.
2. ISO 11664 series: These standards are related to colorimetry, including the measurement of spectral radiance and irradiance, which can be relevant for GNSS applications that involve optical tracking or remote sensing.
3. ISO 19689 series: This series provides minimum performance requirements and testing procedures for GNSS equipment intended for critical applications, such as emergency responses, telemedicine or any operations where human safety & wellbeing is involved.

2.3.3.3 Relevant Standards for SATCOM

In commercial SATCOM, there are two main sets of rules and regulations that guide the process of data transmission between two or more points in space, also referred as protocols, 5G and DVB-2X.

Additionally, RCS2 and the 3rd Generation Partnership Project (3GPP) have significant roles in enhancing return link capabilities and setting industry standards for advanced mobile communications, respectively.

DVB-2X

DVB-S2x is currently the main protocol for commercial SATCOM. It is the latest iteration of the Digital Video Broadcasting - Satellite (DVB-S) series of protocols, designed to provide more efficient, robust, and versatile satellite transmission for television, radio, data, and interactive services. DVB-S2X supports higher transmission rates, better channel bonding, finer granularity, and a variety of modulation and coding schemes, enabling greater spectral efficiency and enhanced performance, thereby maximizing the satellite system's throughput, and reducing operational costs. However, it could be expected that, over the long term, it will be substituted by the upcoming non-terrestrial 5G as this will have the added value of also benefiting from the 5G terrestrial ecosystem.

5G

Refers to the application and integration of 5G technology into satellite communication systems. Emerging standards, such as the 3rd Generation Partnership Project (see below), are focusing on including satellite networks in their 5G network specifications. This would allow seamless interoperability between terrestrial 5G networks and satellite systems.

RCS2

While DVB-S2X is the standard on forward link. On return link, some manufacturers are implementing RCS2 which includes innovations that support services with QoS-based protocols for enhanced return link capabilities.

3GPP

A collaboration between seven global telecommunications standard development organisations aiming to set industry standards for advanced mobile communications.

Since 2017, they have focused on the support of non-terrestrial networks (NTN) with 3GPP defined radio interfaces as part of the Release 15, i.e., adding the capability to support NTN in existing 3GPP technical specifications.

Harmonisation activities are on-going to include the above standards in the V2X and IoT application roadmap considering interoperability between terrestrial and NTN networks (See also chapter 5.3).

2.4 User Needs and Requirements

This chapter provides a summary of user needs and requirements pertaining to Healthcare & Wellbeing applications, describing the current user needs related to EO, GNSS and SATCOM and, ultimately, identifying the corresponding requirements from a user perspective.

The table below presents the primary applications of EO/GNSS/SATCOM technologies in the field of Healthcare & Wellbeing, indicating whether each application is covered within the scope of this report's analysis. This list is not exhaustive and will likely expand and adapt as space technologies are adopted and innovations emerge in the coming years. While all applications discussed can benefit from satellite technologies, not all are covered in detail due to varying levels of maturity and uptake of EO/GNSS/SATCOM.

Table 2. Primary applications of EO/GNSS/SATCOM technologies in Healthcare & Wellbeing

Sub-segments	Applications	Space Technology (GNSS, EO, SATCOM)	Covered in the 2024 Analysis
Environmental Health & Safety Monitoring	Air quality monitoring (pollen & pollution)	EO	YES
	Water quality monitoring (drinkable water quality, vector / water-borne disease)	EO	YES
	UV monitoring	EO	YES
	Heatwave monitoring	EO	YES
Assistive Technologies and Precision Tracking	Visually impaired support	GNSS	YES
	Internet of Things – Performance monitoring	GNSS	YES
Digital Healthcare	Telemedicine	SATCOM + GNSS	YES

2.4.1 Segment applications and current EO/GNSS/SATCOM needs and requirements

2.4.1.1 Air Quality Monitoring

EO enables air quality applications which measure the presence of harmful substances and particulate matter in the air (e.g., sulphur dioxide and PM 2.5). Measurements of air quality are used to provide data insight to provide recommendations to users.

Currently, EO-based air quality monitoring in healthcare applications is considered a nice-to-have supplementary source of information. However, it is anticipated that in the near future, this method will become increasingly prominent and regarded as essential, as discussed during the panel discussion[RD4].

A significant driver for the adoption of EO data will be the legal obligations imposed on private companies to monitor and report on air quality. While there is currently a perceived competition between in-situ and EO data, the focus should shift towards leveraging the potential synergies between the two. This approach will enhance data uptake and utility, leading to more comprehensive data validation via temporal and spatial analysis and ultimately, more accurate air quality assessments [RD4].

This chapter will focus on two distinct groups of atmospheric particulates: pollution & pollen.

2.4.1.1.1 Pollution

Air pollution is responsible for about 350,000 premature deaths in Europe each year[20]. It is a major environmental health risk, particularly affecting the respiratory and cardiovascular systems. It involves various pollutants and varies significantly over time and location.

For citizens, especially those vulnerable to air pollution and allergies, it is important to have information on air quality for outdoor activities such as walking, sporting, and cycling. This information should be provided at the correct location (current position) and in real-time. This is particularly relevant in areas with high traffic or air-polluting industries. Based on the individual's location (provided via GNSS), easy-to-understand information should be available to the user group, for example, in the form of textual recommendations or coloured maps.

Air quality information is valuable to various policy makers, including local authorities as well as city and traffic planners. High-quality modelled air data is essential for informing policy decisions on the planning of new buildings, traffic flow management, congestion control or revegetation efforts to improve air quality in urban areas. Much of urban development, especially in emerging countries, lacks proper planning. This results in less liveable cities, which particularly impacts Europe where 70% of the population resides in urban areas[21]. EO data from Copernicus satellites, combined with local sources, can support evidence-based decision making for urban developers, contributing to safer, more resilient, and sustainable cities.

In the real estate market, clear indicators of air quality status can serve as compelling sales arguments. Proximity to green areas is often desirable and can positively influence physical and mental health in urban areas.

Air quality information can be incorporated into the automation of ventilation systems in buildings. Smart ventilation systems are capable of using real-time pollutant monitoring to adjust airflow dynamically, resulting in a more efficient and occupant-friendly method of controlling indoor air quality (e.g., project Aircheckr). Indoor air quality (IAQ) is closely linked to outdoor air quality (OAQ) since outdoor air often enters buildings through ventilation systems, windows, and doors. Pollutants from traffic, industry, and

---

20 Title: Harm to human health from air pollution in Europe: burden of disease 2023
EN HTML: TH-AM-23-026-EN-Q - ISBN: 978-92-9480-614-7 - ISSN: 2467-3196 - doi: 10.2800/721439

21 https://www.euspa.europa.eu/newsroom-events/news/evidence-based-urban-planning-starts-eo

natural sources can affect both OAQ and IAQ. By monitoring real-time air quality both indoors and outdoors, smart ventilation systems can reduce outdoor air intake when OAQ is poor and increase it when OAQ is good, ensuring a healthier indoor environment and enhancing energy efficiency.

Medical insurance organizations can use both large-scale and local data to estimate the risk of lung or respiratory diseases for citizens, based on geographical area and air quality. This enables them to conduct extensive risk assessments and pricing exercises, tailoring their services to specific regions. Additionally, it allows these organizations to implement health promotion initiatives, anticipate claims, and customize insurance policies to meet customer needs (e.g., AIR-Portal).

Air quality is significantly impacted by events like wildfires, war, or volcanic eruptions, and the assessment of such large-scale events can be effectively conducted using satellite data. Asthma, affecting 30 million Europeans and 300 million people globally, may worsen due to climate change, which increases air pollution risks, including ozone and particle pollution. Rising temperatures contribute to ground-level ozone formation, a key smog component that can trigger asthma attacks. Additionally, hotter temperatures and droughts lead to more frequent and intense wildfires, generating smoke that deteriorates air quality and exacerbates asthma. According to the European Federation of Asthma and Allergy Associations, global asthma prevalence could rise to 400 million by 2025. A 2021 Eurostat report highlighted Finland, Germany, and France as having the highest asthma rates in Europe, while Romania and Bulgaria reported the lowest [RD7] .

2.4.1.1.2 Pollen

The systematic observation of airborne pollen concentrations, commonly referred to as pollen monitoring, is a critical component of public health surveillance. About a quarter of the European population experiences pollen allergies[22] that effect their energy levels and work capacity during pollen season. Individuals who suffer from pollen-induced allergic reactions represent one of the primary beneficiaries of pollen monitoring. Access to real-time and predicted pollen counts enables them to pre-emptively manage their allergic symptoms by making informed decisions about outdoor exposure and medication intake.

Pollen monitoring applications are typically delivered through mobile apps (e.g., Airmine) that provide pollen risk information down to street level in hyperlocal, interactive maps. The services provided may include pollen risk forecasts, which are derived from a combination of vegetation mapping using satellite data, weather data, topography, and local measurements. The necessary data encompasses temperature, precipitation, local topography, season, and vegetation type in the area. Earth Observation data is particularly useful in mapping local vegetation, which can be further refined through image recognition technology to identify specific plant species.

Table 3. Applications, users and current needs and requirements in Air Quality Monitoring

ID	EUSPA-EO-UR-HW-0001, EUSPA-EO-UR-HW-0002
Application	Air Quality Monitoring
Users	Engaging Stakeholders: • Citizens • Urban mobility planning • City planners • Real estate market • Automation of ventilation systems • Policy makers • Government authorities • Medical service providers • Medtech companies • Insurance

[22] https://atmosphere.copernicus.eu/live-discussion-how-copernicus-pollen-forecasts-help-allergy-prevention

Operational scenario	• Personal advice for people living in locations and environments prone to air pollution • Personal advice for people prone to pollen-induced allergies for pre-emptive informed decision-making regarding outdoor exposure and medication intake • Information for policy creation and decision making (especially in urban areas) • Parameters in automation technology systems (e.g. ventilation systems)
Size of area of interest	• Various areas of interest, from a few square kilometres (up to 1000 km^2 for megacities), from a specific location within the city up to the size of a whole city • Maps of an entire region, state, province, or country can be valuable
Frequency of information needed	Hourly
Type of service (continuous, forecasting, one-off?)	Most providers established a continuous service that offer heatmaps of pollution levels. EO-Data is often used to complement in-situ measurements
Satellite EO Data Requirements	
Spatial resolution	• Minimum: 100 meters
Temporal resolution	Hourly, daily, monthly
Spectral resolution	Multispectral: • VIS (400-800 nm) • VNIR (400-1400nm) • SWIR (1400-3000 nm)
Other requirements (if applicable)	• Availability of relevant data (EO, ground) with sufficient spatial and temporal resolution is key for most applications • Current output is on pollution level (PM10, PM2.5 & OZONE). Ideally, the components of PM are measured, to study the toxicity of particulate matter (mixture of solid and liquid components, e.g. sulphate, dust, nitrate, carbon, metals, etc.) • Currently, there are many companies trying to include small air quality stations into their smart city products or even downscale the sensors to a human wearable item. The data gathered in this way could be shared and used to refine the satellite models to achieve higher-resolution products
Technology used	• Sentinel-2, Sentinel-5P (e.g., air pollutants, ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide, formaldehyde and methane) • Sentinel-3 (e.g., fire detection) • GNSS/Galileo (e.g., geolocalisation of local sensor networks, determination of user position)
Data supplements	• Meteo data (MSG, METOP, etc.) provide low resolution information on air pollutants and on the local meteorological situation (e.g. air quality after rainfall improves significantly, as the pollutants are washed out) • Copernicus Atmosphere Monitoring Service (CAMS) delivering valuable air quality data at European scale such as CO_2, CH_4 and N_20 • Air quality data from ground-based sensor networks or drones (the most accurate and high spatial resolution data) • VDC (ESA Atmospheric Validation Data Centre)

	• Sensors for measuring black carbon (e.g. Aerosol.si) which allow a very accurate correlation between sources of pollution and level of pollution • Land cover maps produced from EO imagery, such as the Copernicus Urban Atlas, providing pan-European comparable land use and land cover data for Large Urban Zones with more than 100.000 inhabitants • MAIAC (NASA) which includes large time-series

Case Study / User Story

AIR-PORTAL - High resolution insights into air quality problems

As urbanization intensifies, so does the exposure of populations to air pollution, with over 80% of the urban population living in areas that exceed WHO air quality limits, impacting health and eco-systems. Addressing the critical environmental challenge, the KNMI (Dutch weather authorities) have developed AIR-PORTAL, an innovative air quality dashboard tailored for urban areas. AIR-PORTAL integrates satellite and local data into a model, providing high-resolution air quality forecasts. This service offers global-scale pollution tracking with street-level precision, empowering policymakers, and informing the public.

Airmine – Pollen risk forecast

Airmine is an innovative mobile application that leverages several data points, including complex Earth observation data to provide end-users with personalized pollen risk assessments and actionable health recommendations. They provide real-time pollen levels and predicts fluctuations based on vegetation activity, weather patterns and historical data. This way the company improves the daily lives of allergy sufferers and showcases a prime example of how EO data can be transformed into valuable, user-centric health solutions.

2.4.1.2 Water Quality Monitoring

EO data can help assess water quality and detect pollution, supporting the management of vector-borne diseases and ensuring the provision of potable water. Data on variables like chlorophyll concentration, water cloudiness, and surface temperatures from satellite observations can indicate events such as algal blooms and suspended sediments.

The use of EO can significantly enhance traditional methods of water quality assessment, which typically involve labour-intensive fieldwork and laboratory analysis limited in both scope and frequency. EO technologies offer a revolutionary approach to monitoring water bodies on a much larger scale, providing timely, comprehensive and cost-effective insights into various water quality parameters. The main advantage of EO in water quality monitoring is the combination of data frequency, continuous observation and historical data. Traditional methods use periodic samples that miss changes in water quality between tests. EO data can fill this gap and enhance in-situ measurements for better water quality management. This is especially useful for recreational waters in summer.

The relevance of EO data in monitoring water quality extends beyond environmental stewardship, it is a matter of public health and wellbeing. Clean water is fundamental to human life, not only for consumption but also for agriculture and recreation. Contaminated water sources can lead to the spread of waterborne diseases and impact food security through the irrigation of crops. By providing early warning signs of water contamination, EO can enable swift action to mitigate risks and protect public health.

The critical role of oceans in human wellbeing cannot be overstated [RD4]. Oceans are vital for regulating the Earth's climate, providing food, and supporting biodiversity. To ensure the health of our oceans, the collection of marine data is essential. This data provides critical information about the historical conditions of the ocean, its current state in near real-time, and offers forecasts for future conditions. Such information is crucial for making informed decisions that enhance our capacity to interact with the marine environment in a safe and sustainable manner. Applications of this data include tracking ocean plastics and ensuring sustainable aquaculture by providing information about adverse conditions within the system, such as low salinity.

Additionally, there is a high demand for nutrient monitoring from space, which can be effectively addressed through EO data [RD4]. Nutrient levels, such as nitrogen and phosphorus, are critical indicators of water quality and can influence the occurrence of harmful algal blooms and other water quality issues. EO data can provide valuable insights into nutrient concentrations over large areas and over time, helping to identify trends and potential problem areas. This capability is particularly beneficial for managing agricultural runoff and other sources of nutrient pollution, which can have significant impacts on water bodies.

Furthermore, in the context of climate change, where extreme weather events and rising temperatures are altering water cycles and quality, EO becomes an important tool for adaptation. It allows for the tracking of long-term trends and the development of models to predict future scenarios, ensuring the water management strategies are informed and proactive.

Service providers often supplement EO data with locally measured data to enhance the accuracy and applicability of water quality monitoring. EO data provides extensive spatial coverage and the ability to monitor large and inaccessible areas with relative ease. However, the resolution of EO data may be insufficient for detailed analyses, and certain parameters critical to water quality assessment, such as specific chemical concentrations or microbial counts, cannot be directly observed from space. Moreover, EO is subject to temporal limitations and may be compromised by atmospheric conditions such as cloud cover, which can introduce data gaps.

Therefore, locally measured data are an essential supplement. Local measurement devices may be equipped with SATCOM to allow installation in remote locations where conventional data transfer means are unavailable. These devices are expected to become more widely used as the costs of data transactions over SATCOM become more accessible for smaller commercial entities.

A regulatory limitation of using EO data exclusively for water quality monitoring is the lack of standardized (EU) data quality certifications, such as those from the International Organization for Standardization (ISO). Although EO data provide extensive coverage and enable observation of water bodies in diverse and remote regions, the absence of certifications that validate the data or comparable credentials can create challenges for regulatory acceptance and compliance.

One additional challenges in adopting EO data for water quality monitoring is the lack of trust among users in new methods. Traditional methods have been in use for decades and are well-understood and trusted by regulatory bodies and stakeholders. Introducing innovative methods like EO into established protocols requires not only demonstrating their reliability and accuracy but also overcoming scepticism and resistance to change.

These last two challenges could be addressed by engaging public authorities in the standardization effort needed for regulatory acceptance and compliance [RD4]. This collaborative approach can facilitate the creation of new regulations that incorporate EO data, providing a framework for its acceptance and use in water quality monitoring. Engaging public authorities can also help in building trust among users, as regulatory endorsement can serve as a powerful validation of the new methods.

The synergistic role of EO data in water quality monitoring can be fully realized through collaboration between service providers, users, and public authorities. Such partnerships are crucial for improving service offerings and enhancing the understanding of EO data's potential [RD4]. By working together, these stakeholders can develop more robust and comprehensive monitoring systems, ultimately leading to better water quality management and protection of public health.

Table 4. Applications, users and current needs and requirements in Water Quality Monitoring

ID	EUSPA-EO-UR-HW-0003
Application	Water Quality Monitoring
Users	Engaging Stakeholders: • Citizens • Public authorities and policy makers
End Users Application Needs	
Operational scenario	• Personal advice for people that are planning to swim or fish • Information for policy creation and enforcement / monitoring • Parameters in automation technology systems (e.g. water purification installation) • Detection of matter components or development of algae • Detection of matter components in and around construction projects • European member states that are required to report on the ecological water quality (e.g., Integrated Water Policy)
Size of area of interest	Usually at a minimum of 3.000km^2, but can fluctuate significantly based on the end-user needs and requirements
Frequency of information needed	Daily is what is used in the service offering of many EO-firms. However, they need to supplement this with locally measured datapoints as some pollutants develop extraordinary fast (<1h), meaning the temporal resolution of 1 day is not sufficient
Type of service (continuous, forecasting, one-off?)	Service provided is mostly continuous to end-users (swimmers / fishers) or public customers that review drinking water basins or have a warning system in place. Some forecasting systems are in development, including the use of Artificial Intelligence
Satellite EO Data Requirements	
Spatial resolution	• 30cm (to monitor ditches), 5-20 meters, 300-1000m (sea / oceanic applications)
Temporal resolution	• Daily
Spectral resolution	• Multispectral (400 – 2200 nm), specific spectral bands for monitoring chlorophyll-a and phycocyanin
Data Sources	• Sentinel 2 & 3, commercial satellites for high resolution
Data supplements	• In-situ data-collection devices to calibrate the atmospheric correction of the satellites and complement EO-limitations due to atmospheric condition such as cloud formations and the inability to measure some key chemicals. Monitoring data from the user to validate and show the user the data quality

Case Study / User Story

WaterInsight – Enhancing Water Quality in the Netherlands through EO

The Netherlands have been reclaiming land for years from the sea and other water bodies. This new land is very fertile and often used for agricultural purposes. The combination of high population density, intensive agriculture and shallow bodies of water greatly affects water quality throughout the country.

The Dutch SME "WaterInsight" mainly uses Copernicus Sentinel observations to analyse and conclude on water quality for various water bodies. The Dutch public water authorities, a user of their service offering, receives periodical results that allow them to take corrective measures to improve water quality through e.g. limit the use of nutrients in agricultural areas. In addition to that, the company offers the possibility to go back in time, to analyse the evolution of algal bloom. This not only helps users to prevent algal blooms from happening but is also used extensively by policy makers when it comes to the overall Dutch water quality.

EOMAP – Supporting the bathing water directive execution

The monitoring of cyanobacteria blooms (also known as blue-green algae) is one important legal aspect of the EU Bathing water directive, as they are able to form toxins potentially harmful to humans and animals. The directive is nationalized in regulations applied in the individual states, but other than in the EU water framework directive (EU-WFD) and its related regulations, the methodology is not defined in detail, only that an "appropriate monitoring shall be carried out to enable timely identification of health risks".

Harmful Algal Bloom indicators, chlorophyll concentrations and visibility calculations derived from high temporal and spatial resolution optical satellite sensors such as the Copernicus Sentinel missions, enables earth observation to support the directive execution in addition to the employment of traditional in-situ measuring methods for blue green algae such as fluorescence signal detection with optical probes, HPLC techniques or absorption spectroscopy. EOMAP partners with several authorities in Germany (Landesamt für Umwelt, Rheinland-Pfalz & Mecklenburg Vorpommern) using Sentinel-2 and Planet-SuperDove Data for near real time detection of harmful algae bloom events. This includes the synoptical detection of critical events in warning- and alert dashboards, where individual thresholds can be set in a parameter- and site-specific fashion (see demonstration data in region "Massower See" on aqua.eoapp.de). The authorities use the data to fill data gaps of their in-situ measurement time series, to obtain full system understanding of algal bloom development - particularly for larger water bodies-, to extend their surveillance programmes also to rivers and non-official bathing sites and to plan their deployment of field resources properly.

EOMAP - Algal Bloom in the Oder River

The Sentinel 2 satellite's optical sensor has been used to monitor the Oder River, detecting changes in watercolour to identify high concentrations of algae through chlorophyll levels. Data collected from July to August revealed medium chlorophyll levels in the river during the second half of July, with higher levels near Opole, Poland. In early August, a significant increase in chlorophyll has been observed near Wroclaw, Poland, followed by a rapid spread of the algal bloom across the river within a week. By the end of August, chlorophyll levels returned to early July averages. The satellite data, combined with ecological monitoring and water samples, is useful for understanding the Odra disaster, particularly the origin and spread of the toxic prymnesium algal bloom, with ongoing analysis expected to provide further insights.

2.4.1.3 UV Monitoring

UV radiation can lead to a range of health disorders and diseases, including sunburn, skin cancer, and cataracts, and alter the immune response of the human body. The incidence of skin cancer has significantly increased since the 1970s, which is strongly correlated with personal habits regarding UV radiation exposure, as well as the societal preference for tans. The UV Index (UVI) varies significantly over time and across different locations, due to factors such as sun elevation, ozone levels, cloud cover, aerosols, ground reflection, and altitude. Although there are approximately 160 stations across 25 European countries that monitor the UVI, these sites are not evenly distributed. As a result, a portion of the European population remains uninformed about UV radiation and the associated health risks. Additionally, obtaining information about the UVI for a specific region or country can be challenging for individuals planning their holiday destinations. To enhance UVI information accessibility, satellite and ground-based measurements can be combined to offer both forecasts and UV index climatology.

To enhance UVI information accessibility, satellite and ground-based measurements can be combined to offer both forecasts and UV index climatology. Earth Observation can be used to operationally estimate and continuously monitor the ultraviolet index in Europe[23]. EO data are used in consumer UV monitoring applications to provide UV exposure measurements for specific geolocations, to inform users about safe levels of UV exposure and to make recommendations for user behavior (e.g. to remain indoors when the UV index is very high). Nonetheless, a challenge remains in the limited high-resolution data for comprehensive ground and building mapping on a global scale.

A decision support system, such as a "Sunlight Healthcare Assistant" (UVI classes: low, moderate, high, very high, extreme), could be provided for end-users. This system would deliver geolocalized, personalized, and actionable daily information about solar radiation exposure and allow for personal dosimetry control. The system can be integrated as an app in smartphones or wearable devices that measure other relevant parameters. Tourists can be a higher risk group since they often do not have the same innate knowledge on how to correctly deal with the UV radiation of the visiting destinations and are spending a lot of time outside. It is important that they have the correct knowledge on the current dangers of UV radiation and how to protect themselves from it.

It is acknowledged, however, that citizen-led UV monitoring utilizing EO technologies remains in its infancy stages. Awareness campaigns could enhance sensitivity and encourage broader adoption [RD4].

Table 5. Applications, users and current needs and requirements in UV Monitoring

ID	EUSPA-EO-UR-HW-0004
Application	UV Monitoring
Users	Engaging Stakeholders: • Citizens • Public authorities and policy makers • Individuals with specific health requirements
End Users Application Needs	
Operational scenario	• Provision of localised, personalized, and actionable information daily about solar radiation exposure • Creation of historical UVI information, at local and regional level, to provide tailored recommendations and products for local and regional organisations and businesses
Size of area of interest	• Area of interest is the whole globe, with information to be broken down for individual locations • Minimum: single spots for outdoor activities (individual beaches, hotel resorts or entire city regions) • High interest on areas with increased UV radiations, like desert areas, water areas, mountain areas, areas in the range of reduced ozone layers (e.g. Australia)
Frequency of information needed	• Near-real time information is needed for some applications • Hourly is important for detailed studies and correlations • Daily or weekly UV indexes results are good enough for the overall evaluation, however peaks are more important than the average value • Low temporal resolution UV data (daily, weekly, monthly) can be analysed and used in assessment and planning with information about the expected UV over different regions

[23] Kosmopoulos, P. G., Kazadzis, S., Schmalwieser, A. W., Raptis, P. I., Papachristopoulou, K., Fountoulakis, I., Masoom, A., Bais, A. F., Bilbao, J., Blumthaler, M., Kreuter, A., Siani, A. M., Eleftheratos, K., Topaloglou, C., Gröbner, J., Johnsen, B., Svendby, T. M., Vilaplana, J. M., Doppler, L., Webb, A. R., Khazova, M., De Backer, H., Heikkilä, A., Lakkala, K., Jaroslawski, J., Meleti, C., Diémoz, H., Hülsen, G., Klotz, B., Rimmer, J., and Kontoes, C.: Real-time UV index retrieval in Europe using Earth observation-based techniques: system description and quality assessment, Atmos. Meas. Tech., 14, 5657–5699, https://doi.org/10.5194/amt-14-5657-2021, 2021.

Type of service (continuous, forecasting, one-off?)	To continuously measure UV-Exposure, EO data needs to be complemented with input parameters such as precise location of the end-user and skin-type. Therefore, the continuous service offering commonly includes a wearable (watch, wristband, skin patch, etc.) that combines satellite data (GNSS) to determine the exact location and the relevant UV-Exposure (EO) to advice the end-user on UV-exposure
Satellite EO Data Requirements	
Spatial resolution	• 100 meters but not yet achieved today
Temporal resolution	• Satellite data are mainly used for forecasting models (like weather models, e.g. MetOffice). As the processing requires time, the temporal resolution requirement depends on the capabilities of the models. In current weather models, data are provided on 6-hourly basis which then can generate hourly forecasts. Therefore, it is assumed that a similar temporal resolution is sufficient. EUMETSAT Meteorological satellites (e.g. MSG), which are geostationary satellites, are used to model UV radiation and they provide information every 10 minutes[24]. On the contrary, the revisit time of LEO satellites carrying relevant instruments for UV monitoring is in the range of days rather than hours
Spectral resolution	• UV (100-400 nm) • VNIR (400-1400 nm)
Data Sources	• Copernicus Land Monitoring Service • Copernicus Atmosphere Monitoring Service • Sentinel-2 (e.g. land cover, vegetation) • Sentinel-3 (e.g. cloud cover, aerosols and water vapour, other atmospheric parameters) • Sentinel-5P (e.g. solar irradiance) • Meteosat
Data supplements	• MetServices (e.g. ECMWF) and Satellite Application Facility on Ozone Monitoring (EUMETSAT O3M SAF) (global UV index forecasts for clear sky and clouded weather forecasts updated daily) • EUMETSAT CM-SAF (Satellite Application Facility for Climate Monitoring): it provides continuous climate data records containing the Surface Incoming Solar radiation (SIS) • Surface incoming Direct Irradiation (SDI), spectrally resolved irradiation (SRI) and the effective cloud albedo (CAL) • Tropospheric Emission Monitoring Internet Service (TEMIS; temis.nl) for initial clear-sky UVIs (hosted by the Royal Netherlands Meteorological Institute (KNMI)) • UV index forecast by the Copernicus CAMS service • Other air quality parameters (aerosols, clouds, total ozone, etc.) • Digital elevation models, as well as vegetation and surface maps

Case Study / User Story

siHealth

Designed for personal use, the siHealth app is a certified medical device dedicated to managing sun exposure through UV monitoring using satellite data. The app is particularly beneficial for individuals

[24] https://publications.jrc.ec.europa.eu/repository/handle/JRC32976

with photosensitive skin, outdoor workers, and those at risk of vitamin D deficiency or Actinic Keratosis. It utilizes EO data from Meteosat MSG and Sentinel-5B to calculate and measure solar radiation exposure in various bands (UV, VIS, IR) and employs GNSS to monitor individual exposure levels. The app provides real-time solar radiation measurements, focusing on avoiding sunburn and reducing skin cancer risk. Users can access personalized recommendations and historical UVI data at local and regional levels to support tailored health advice. siHealth is working on AI tools to estimate user location based on GNSS signals and seeks access to raw GNSS/GPS data to improve accuracy. The app is involved in corporate partnerships for sunscreen and vitamin D supplements, supports skin cancer treatment, and provides a web portal for dermatologists and an app for patients. Clinical studies have demonstrated the app's effectiveness in modifying sun exposure behaviour and increasing vitamin D synthesis.

This use case was presented by siHealth during the UCP event, showcasing the application of EO and GNSS technology for UV monitoring [RD4].

2.4.1.4 Heatwave Monitoring

The increasing incidence and intensity of heatwaves represent a significant challenge to global public health and well-being. These extreme temperature events are not only more frequent, but also more severe and impact particularly the elderly[25] and individuals with pre-existing health conditions[26]. These groups face heightened risks of heat-related conditions such as heat cramps, heat exhaustion and heat stroke.

Public health measures are crucial in mitigating the impact of heatwaves. The European Centre for Disease Prevention and Control (ECDC)[27] recommends implementing heat-health action plans, which include early warning systems, public awareness campaigns, and providing cool spaces for vulnerable populations (ECDC, n.d.). By understanding the increasing risks associated with heatwaves and implementing effective public health strategies, we can better protect vulnerable populations and improve overall community resilience to extreme heat events.

In this context, Earth Observation has become an even greater asset in public health management, particularly in mitigating the impacts of heatwaves. The advanced remote sensing capabilities of EO technology offer good insights by capturing detailed spatial and temporal patterns. EO data facilitates the early detection of heatwaves, which is essential for mobilizing an effective health response but also facilitates predictive analytics by providing historical time-series that can be used by urban designers to create future-proof cities. Health authorities can implement early warning systems, providing critical public alerts that can save lives and reduce the burden on healthcare systems. These systems can trigger public health advisories, encourage the activation of heat health warning systems, and inform the deployment of emergency services and resources.

The integration of EO data with existing datasets enhances its practical utility. For instance, when EO-derived temperature maps are overlaid with demographic and health data, a more nuanced understanding of heatwave impacts emerges. This integrated approach allows for the identification of urban heat islands and vulnerable neighbourhoods, enabling healthcare providers and urban designers to direct their efforts where they are needed most. The availability of this health data however is not always easily accessible

[25] Kenney WL, Craighead DH, Alexander LM. Heat waves, aging, and human cardiovascular health. Med Sci Sports Exerc. 2014 Oct;46(10):1891-9. doi: 10.1249/MSS.0000000000000325. PMID: 24598696; PMCID: PMC4155032.

[26] Arsad FS, Hod R, Ahmad N, Ismail R, Mohamed N, Baharom M, Osman Y, Radi MFM, Tangang F. The Impact of Heatwaves on Mortality and Morbidity and the Associated Vulnerability Factors: A Systematic Review. Int J Environ Res Public Health. 2022 Dec 6;19(23):16356. doi: 10.3390/ijerph192316356. PMID: 36498428; PMCID: PMC9738283.

[27] European Centre for Disease Prevention and Control, 2023, Homepage | European Centre for Disease Prevention and Control

or present depending on the EU-member state. In addition to that, when looking at healthcare data, the location of those patients is usually not captured, which is key in combination with the heatmaps.

By combining EO data with socio-economic and health statistics, we can develop targeted interventions that not only address immediate risks, but also contribute to building long-term resilience against heat-related health issues. Such interventions may include the creation of cooling centres in high-risk areas, the distribution of hydration kits to at-risk individuals, and the development of urban planning strategies that incorporate green spaces and heat-reflective materials to mitigate the heat island effect.

Table 6. Applications, users and current needs and requirements in Heatwave Monitoring

ID	EUSPA-EO-UR-CSO-0008
Application	Heatwave Monitoring
Users	Engaging Stakeholders: • Citizens and public users • Elderly • Individuals with pre-existing health issues (e.g. cardiovascular or respiratory disease)
End Users Application Needs	
Operational scenario	• To supply localized, personalized, and actionable information daily about upcoming and current heatwave development • Creation of historical heatwave data, at local and regional level to provide tailored recommendations for policy makers • Predictive models to help prepare citizens and / or public bodies prepare for potential upcoming heatwaves
Size of area of interest	• Global interest, data needs to be disaggregated to a local / regional level to provide actionable recommendations • Minimum: Urban regions and / or cities (min 12km radius)
Frequency of information needed	Depending on the service offering: • Hourly information for current heatwave monitoring • Daily or weekly are sufficient for predictive models
Type of service (continuous, forecasting, one-off?)	Both continuous and forecasting services are being marketed
Satellite EO Data Requirements	
Spatial resolution	300 meters
Temporal resolution	3 hours and minimum 3 datapoints per day, supplemented by local ground measurements as temperatures fluctuate strongly and continuously. The lack of continuous data points from an EO perspective alone is commonly mitigated by using predictive models.
Spectral resolution	• VNIR (400-1400 nm) • SWIR (1400 - 3000 nm)
Data Sources	Sentinel 2
Data supplements	Local ground data is usually introduced to provide recommendations daily. For predictive models, EO data alone usually suffices.

Case Study / User Story

DT-HEAT+: Integrated heat Resilience for Tomorrow's Cities

To prepare for the future, the DT-HEAT+ researchers have proposed the use of digital twin technology to create comprehensive insights that transform urban centers into resilient environments capable of withstanding extreme heat conditions. The concept is designed to serve a large range of stakeholders, including local governments, urban planners, emergency services, and NGO's by enhancing emergency responses, improving urban ecosystems and empowering vulnerable populations. EO data and expertise are central to the development of the DT-HEAT+ service, which collects comprehensive data that is used to monitor urban heat island and heat waves on cities.

The deliverable is a heatmap of an in-scope city or region that can be multi-purposed to improve public health and wellbeing.

The idea is to incorporate a dual timescale approach, offering both long-term urban planning solutions and a next-day heatwave management tool. The technical side is particularly advanced as it employs machine learning to predict heat-related mortality rates and integrating a wide array of environmental and urban data.

2.4.1.5 Visually impaired support

GNSS technology can be utilized to offer turn-by-turn navigation based on precise positioning, aiding visually impaired individuals in navigating their surroundings more effectively. Various portable devices, along with their associated mobility services tailored for visually impaired users, have emerged in the market. However, standalone GNSS solutions fall short in delivering the required level of positioning accuracy and integrity essential for efficiently assisting visually impaired individuals in their mobility. The acquisition time is often too lengthy, and users lack confidence in the reliability of the information provided. Typically, dedicated portable devices are used to enable this application.

Table 7. GNSS user requirements for Visually Impaired Support

GNSS user requirements for Visually Impaired Support		
Accuracy	Horizontal	High
	Vertical	3-4 meters
Availability	Urban canyon	Yes
	Natural canyon	Yes
	Canopy	Yes
	Indoor	Yes
	Better than 95%	High
	Better than 99%	High
Robustness	Susceptibility to interference	Yes
	Susceptibility to spoofing	Yes
Integrity and reliability	Risk	Yes
Size, weight, autonomy (when smartphone or handheld based)	Relevance	Yes
	Time a device can run	>8h
TTFaF	In hot start	<15 seconds
Service area	Geographical coverage	Global

2.4.1.6 IoT

The diversity of IoT applications presented at previous UCP-events, leads to significant disparities in terms of performance requirements. A single table of requirements for this application category cannot represent accurately all applications. To accurately transmit the requirements this section will provide a detailed table of requirements per application.

❖ **Sport tracker (sport/athlete tracking)**

GNSS enabled sports trackers revolutionized the world of sports and fitness by providing precise location tracking capabilities. These trackers leverage GNSS signals to measure athlete's speed, distance travelled and changes in elevation during activities like running, cycling, hiking and swimming. By providing real-time data and post exercise analysis, GNSS-enabled sport trackers help athletes to set goals, track progress and improve their training regimens.

For this use-case to grow even further, the comfort, efficiency and pricing of the devices have the highest impact on consumer adoption. Those drivers push for lower-end sport devices with smaller size, cheaper price and higher accuracy. Additionally, long-range connectivity brings added value to sport trackers by adding social interaction such as position sharing.

Table 8. GNSS user requirements for Visually Impaired Support

GNSS user requirements for Sport Trackers		
Accuracy	*Horizontal*	*2 meters*
	Vertical	*2.5-3 meters*
Availability	*Urban canyon*	*Yes*
	Natural canyon	*Yes*
	Canopy	*Yes*
	Indoor	*Yes*
	Better than 95%	*High*
	Better than 99%	*High*
Robustness	*Susceptibility to interference*	*Yes*
	Susceptibility to spoofing	*Yes*
Integrity and reliability	*Risk*	*Yes*
Size, weight, autonomy (when smartphone or handheld based)	*Relevance*	*Yes*
	Time a device can run	*>8h*
TTFaF	*In hot start*	*<15 seconds*
Service area	*Geographical coverage*	*Global*

2.4.1.7 Telemedicine

The concept of satellite-assisted remote patient monitoring and treatment involves leveraging satellite communication technologies to facilitate the instantaneous transfer of health data and provision of medical services to patients in remote or difficult-to-access regions. In Telemedicine, satellite communication facilitates real-time video consultations, allowing patients to receive medical advice, diagnoses and treatment plans from healthcare providers without the need for travel. This not only saves time and resources but also ensures that expert medical care can reach those in need promptly regardless of location. Additionally, satellite communication supports the secure transmission of patient data, including electronic health records, diagnostic images and test results, enabling healthcare professionals to make informed decisions quickly.

Although the benefits of telemedicine over satellite communication are numerous, the same technology does face challenges. One of the primary concerns is the latency associated with satellite communication, particularly when real-time interactions are necessary. However, advances in satellite technology are continually reducing latency times, making satellite communication more viable for a broader range of telemedicine applications. Furthermore, there is the need for training and technical support for healthcare providers and patients to effectively use telemedicine services. Satellite communication can facilitate remote training and support but ensuring that users are comfortable and proficient with the technology is essential for the success of telemedicine programs.

Table 9. SATCOM User Requirements for Telemedicine

SATCOM User Requirements for Telemedicine	
○ **Link Type**: the type of communication for voice or data	▪ Bi-directional voice: user-to-user communication
○ **Availability**: a qualitative indication of the availability required of the communications system when the application is in use exceeding a certain quality of service.	▪ High
○ **Latency**: The delay between action and reaction.	▪ Low: immediate (<600 ms)
○ **Bandwidth (bit rate)**: a qualitative indication of the anticipated rate of data transfer when using the application.	▪ Medium : 512 kbps – 1 Mbps
○ **Coverage**: an indication of geographical area which can be reached by the service.	▪ Regional (Europe) & Global (initiatives in development to serve remote areas of Africa)
○ **Symmetry Up/Down**: The ratio between the uplink traffic and the downlink traffic.	For example: ▪ 50/50 for bi-directional voice ▪ 100/0 for uni-directional voice ▪ 80/20 for internet use
○ **Distribution**:	▪ Multi-user, where a user can be a human or a system
○ **Setup**: a qualitative indication of the time to establish a voice or data communication session with the application that would be acceptable to a user and is sufficient to perform the railway operation.	▪ Immediate (hours)
○ **Speed**: the speed that a user is travelling in, maximum value:	▪ Low ≤40 Km/h, including stationary users
○ **Security protection**	▪ Confidentiality: must be considered for distributed data storage and distributed access to personal data

Case Study / User Case

Colibri : Telemedicine in areas with limited or no internet connectivity

The Colibri service was designed to enhance healthcare access for rural populations in France, particularly targeting areas with limited internet connectivity and a shortage of medical professionals. Its objectives were to enable medical teleconsultations for those in remote areas, provide consistent follow-up for chronically ill patients through telemonitoring stations and the Consultobus while utilizing broadband satellite communication for a range of telemedicine services. This proved especially valuable in the wake of the Covid-19 crisis.

Upon its conclusion in 2024, the Colibri project had made significant strides in transforming rural healthcare through the use of Satellite Communication. It successfully deployed telemedical stations and secured additional funding for more mobile units. Colibri’s integration of space assets for internet and communication services was pivotal in its success and is now positioned for commercialization and expansion across Europe and Lebanon, offering a new model for rural healthcare delivery.

2.5 User Requirements Specification

The chapter provides a synthesis of the requirements described on GNSS in section 2.5.1, on EO in section 2.5.2 and on SATCOM in section 2.5.3. The content of this section will be updated, completed, and expanded by EUSPA in the next releases of the RUR based on the results of further investigations discussed and validated in the frame of the UCP.

2.5.1 Synthesis of Requirements Relevant to GNSS

Table 10. Synthesis of Requirements Relevant to GNSS

ID	Description	Type	Source
EUSPA-GN-UR-LBS-0790	The PNT solution shall provide the user position with a horizontal accuracy better than 1 meter with a 95% confidence level	Performance	
EUSPA-GN-UR-LBS-0800	The PNT solution shall provide the user position with a vertical accuracy within 1-5 meters with a 95% confidence level	Performance	
EUSPA-GN-UR-LBS-0810	The geographical coverage of the PNT solution shall be global.	Functional	
EUSPA-GN-UR-LBS-0820	The PNT solution shall be available in urban canyons with a 95% confidence level	Functional	
EUSPA-GN-UR-HW-XXXX	The PNT solution shall be available in natural canyons with a 95% confidence level	Functional	[RD4]
EUSPA-GN-UR-LBS-0830	The PNT solution shall be available under canopy with a 95% confidence level	Functional	
EUSPA-GN-UR-LBS-0840	The PNT solution shall be available indoors.	Performance	
EUSPA-GN-UR-LBS-0850	The PNT solution shall provide a TTFF (hot start) of less than 15 seconds.	Performance	
EUSPA-GN-UR-LBS-0860	The PNT solution shall provide continuous positioning once the operation has started.	Functional	
EUSPA-GN-UR-LBS-0880	The PNT solution shall provide robustness against interference.	Functional	
EUSPA-GN-UR-LBS-0890	The PNT solution shall provide robustness against GNSS spoofing threats.	Functional	
EUSPA-GN-UR-LBS-0891	The PNT solution shall be able to provide timely warnings to the user when data provided by the solution should not be used.	Functional	
EUSPA-GN-UR-LBS-9000	The PNT solution shall provide the user position with a horizontal accuracy of 2 meters.	Performance	
EUSPA-GN-UR-LBS-9010	The PNT solution shall provide the user position with a horizontal accuracy within a range of 2.5 to 10m.	Performance	
EUSPA-GN-UR-LBS-9090	The PNT solution shall provide the user position with a vertical accuracy of 2.5 meters.	Performance	
EUSPA-GN-UR-LBS-9150	The geographical coverage of the PNT solution shall be global.	Functional	
EUSPA-GN-UR-LBS-9200	The PNT solution shall be available in urban canyons.	Performance	
EUSPA-GN-UR-LBS-9300	The PNT solution shall be available under canopy.	Performance	

ID	Description	Type	Source
EUSPA-GN-UR-LBS-9400	The PNT solution shall be available indoor.	Performance	
EUSPA-GN-UR-LBS-9500	The PNT solution shall provide robustness against interference.	Functional	
EUSPA-GN-UR-LBS-9600	The PNT solution shall provide continuous positioning once the operation has started. The update rate shall be 10 Hz.	Performance	
EUSPA-GN-UR-LBS-9610	The PNT solution shall provide continuous positioning once the operation has started. The update rate shall be less than 5 minutes.	Performance	
EUSPA-GN-UR-LBS-9700	The PNT solution shall provide a TTFF (hot start) of less than 2 seconds.	TTFF	

2.5.2 Synthesis of Requirements Relevant to EO

Table 11. Synthesis of Requirements Relevant to EO

ID	Application	Abstract of the Need & Requirement	Size of the area of interest	Frequency of information needed	Spatial resolution	Temporal resolution	Type of EO data
EUSPA-EO-UR-HW-0001	Air Quality Monitoring	• Personal advice for people living in locations and environments prone to air pollution • Information for policy creation and decision making (especially in urban areas) • Parameters in automation technology systems (e.g. ventilation systems)	$10m^2$ – $1000km^2$	Hourly	min. 100m	Hourly, daily, monthly	• Sentinel-2, Sentinel-5P (e.g., air pollutants, ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide, formaldehyde and methane) • Sentinel-3 (e.g., fire detection)
EUSPA-EO-UR-HW-0002	Air Quality Monitoring	Personal advice for people prone to pollen-induced allergies	$10m^2$ – $1000km^2$	Hourly	min. 100m	Hourly, daily, monthly	• Sentinel-2, Sentinel-5P (e.g., air pollutants, ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide, formaldehyde and methane) • Sentinel-3 (e.g., fire detection)
EUSPA-EO-UR-HW-0003	Water Quality Monitoring	• Personal advice for people that are planning to swim or fish • Information for policy creation and enforcement • Parameters in automation technology systems (e.g. water purification installation) • Detection of matter components or development of algae • Detection of matter components in and around construction projects • EU reporting (integrated water policy)	min. $3000km^2$	Daily currently but not sufficient as some pollutants develop extraordinary fast (<1h)	• 30cm (to monitor ditches) • 5-20 meters • 300-1000m (sea / oceanic applications)	Daily	Sentinel 2 & 3
EUSPA-EO-UR-HW-0004	UV Monitoring	• Provision of localised, personalized, and actionable information daily about solar radiation exposure • Creation of historical UVI information, at local and regional level, to provide tailored recommendations and products for local and regional organisations and businesses	$200km^2$	• Near-real time for some applications • Hourly for detailed studies and correlations • Daily or weekly for overall evaluation, but peaks are more important than average value • Daily, weekly, monthly can be analysed and used in assessment and planning expected UV over different regions	100m	6-hourly basis based on current weather models	• Copernicus Land Monitoring Service • Copernicus Atmosphere Monitoring Service • Sentinel-2 (e.g. land cover, vegetation) • Sentinel-3 (e.g. cloud cover, aerosols and water vapour, other atmospheric parameters) • Sentinel-5P (e.g. solar irradiance) • Meteosat
EUSPA-EO-UR-HW-0005	Heatwave Monitoring	• Localized, personalized and actionable information on a day-to-day basis about upcoming and ongoing heatwaves • Creation of historical heatwave data at local and regional level for policy makers • Predictive models to help citizens and public bodies prepare	$200km^2$	• Hourly information for current heatwave monitoring • Daily or weekly for predictive models	300m	3 hours and min. 3 datapoints per day	Sentinel 2

2.5.3 Synthesis of Requirements Relevant to SATCOM

Table 12. Synthesis of Requirements Relevant to SATCOM

ID	Application	Operational Scenario	Link type	Availability	Coverage	Setup	Security protection	Speed	Latency	Bandwidth (bit rate)	Symmetry up/down	Distribution
EUSPA-SAT-UR-CSO-0001	Telemedicine	Remote patient monitoring	Bi-directional voice: user-to-user communication	High	Regional (Europe) & Global (initiatives in development to serve remote areas of Africa)	Immediate (hours)	Confidentiality: must be considered for distributed data storage and distributed access to personal data	Low ≤40 Km/h, including stationary users	Low: immediate (<600 ms)	Medium : 512 kbps – 1 Mbps	• 50/50 for bi-directional voice • 100/0 for uni-directional voice • 80/20 for internet use	Multi-User: between multiple users, where a user can be a human or a system

2.5.4 Sources for the requirements

As this document is mostly based on interviews, the requirements come from the feedback from experts and various UCP participants. The sources vary with the specific application. The majority of input came from the persons listed in Annex A1.6 while the community participated as well via the UCP.

3 ANNEXES

A.1 Definition of key EO performance parameters

This annex provides a definition of the most used EO performance parameters and includes additional details which are relevant for Road and Automotive community.

Spatial resolution refers to the level of detail and clarity in the images, specifically the size of the smallest discernible ground features. It is determined by the pixel size, which is the smallest unit in the image that represents a spatial area on the Earth's surface. Spatial resolution is usually measured in terms of meters per pixel. Thus, a spatial resolution of 1 meter means that each pixel represents a 1 by 1 meter area on the ground.

Spectral resolution refers to the ability of a sensor to differentiate electromagnetic radiation of different wavelengths. In other words, it refers to the number and “size” of wavelength intervals that the sensor is able to measure. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band. In remote sensing, features (e.g. water, vegetation) can be characterised by comparing their “response” in different spectral bands.

Radiometric resolution expresses the sensitivity of the sensor, that is to say its ability to differentiate between different magnitudes of the electromagnetic energy. The finer the radiometric resolution, the more sensitive it is to small differences in the energy emitted or reflected by an object. The radiometric resolution is generally expressed in bit, e.g. an 8-bit image has a scale of 2^8=256 nuances.

Temporal resolution relates to the time elapsed between two consecutive observations of the same area on the ground. The higher the temporal resolution, the shorter the time between the acquisitions of two consecutive observations of the same area. In absolute terms, the temporal resolution of a remote sensing system corresponds to the time elapsed between two consecutive passes of the satellite over the exact same point on the ground (generally referred to as “revisit time” or “orbit cycle”). However, several parameters like the overlap between the swaths of adjacent passes, the agility of the satellites and in case of a constellation, the number of satellites mean that some areas of the Earth can be reimaged more frequently. For a given system, the temporal resolution can therefore be better than the revisit time of the satellite(s).

Geolocation accuracy refers to the ability of an EO remote sensing platform to assign an accurate geographic position on the ground to the features captured in a scene. An accurate geolocation makes easier the combination of several images (e.g. combination of a Synthetic Aperture Radar image with a cadastral map and a vegetation map).

Spectral range refers to the wavelength range of a particular channel or band over in which remote sensing data must be collected.

Latency is the difference between the reference time of the satellite measurement and the time the final product is made available to the user (here the service provider).

A.2 Additional EO definitions

Ground deformation monitoring is the process which consists in tracking the vertical and horizontal movements of the land surface and their dynamics, whatever these movements are caused by natural phenomena (e.g. volcanic activity) or by human activities (e.g. aquifer exploitation).

Change detection is the process which aims at identifying difference in the state of "objects" (e.g. bridges, constructions, urban areas) or of a phenomenon (e.g. deforestation, soil sealing) by comparing snapshots of the situation at different times. In Earth Observation, change detection is extensively based on satellite imagery obtained through a wide variety of sensors (e.g. optical, radar, infrared, microwave, etc.

Geodesy (see [RD3]) is the earth science of accurately measuring and understanding three of Earth's fundamental properties: its geometric shape, orientation in space, and gravitational field. The field also studies of how these properties change over time. Today, geodesy goes beyond that, being the geoscience that deals among other with the monitoring the solid Earth (which includes the monitoring of displacement, subsidence or deformation of the ground and structures due to tectonic, volcanic, and other natural phenomena as well as human activity.

Interferometric Synthetic Aperture Radar (InSAR) is a technique enabling to generate surface deformation maps based on the processing of SAR images captured at different moments in time. The processing uses the fact that if the ground has moved between the times of two SAR images of the same area, a slightly different portion of the wavelength is reflected to the satellite resulting in a measurable phase shift that is proportional to displacement. The processing therefore consists in obtaining information about the vertical movements of the ground surface by calculating the phase difference between the emitted radar signal and the signal backscattered by the surface for successive images. InSAR can potentially measure deformations of millimetre-scale during periods ranging from days to years.

Near-Real-Time (NRT) refers, when used in the context of EO applications, to applications/services/products for which the time delay between the occurrence of a given event and the availability of the outcomes of the processing of the Earth observation data corresponding to that event is considered as being not significant from a user perspective. The notion of "near real-time" is therefore depending on user requirements. For Earth observation, the corresponding time delays may range from a few hours to a few days depending on the application/service/product.

A.3 Definition of key GNSS performance parameters

This annex provides a definition of the most commonly used GNSS performance parameters, taken from [RD2] and includes additional details which are relevant for Road and Automotive community.

Availability: the percentage of time the position, navigation or timing solution can be computed by the user. Values vary greatly according to the specific application and services used, but typically range from 95-99.9%. There are two classes of availability:

- System availability: the percentage of time the system allows the user to compute a position - this is what GNSS Interface Control Documents (ICDs) refer to.
- Overall availability: considers the receiver performance and the user's environment. Values vary greatly according to the specific use cases and services used.

Accuracy is the difference between true and computed solution (position or time). This is expressed as the value within which a specified proportion – usually 95% – of samples would fall if measured. This report refers to positioning accuracy using the following convention: centimetre-level: 0-10cm; decimetre level: 10-100cm; metre-level: 1-10 metres.

Continuity is the ability of a system to perform its function (deliver PNT services with the required performance levels) without interruption once the operation has started. It is usually expressed as the risk of discontinuity and depends entirely on the timeframe of the application. A typical value is around 1*10-4 over the course of the procedure where the system is in use.

Indoor penetration is the ability of a signal to penetrate inside buildings (e.g. through windows). Indoor penetration does not have an agreed or typical means for expression. In GNSS this parameter is dictated by the sensitivity of the receiver, whereas for other positioning technologies there are vastly different factors that determine performance (for example, availability of Wi-Fi base stations for Wi-Fi-based positioning).

Integrity is a term used to express the ability of the system to provide warnings to users when it should not be used. It is the probability of a user being exposed to an error larger than the alert limits without timely warning. The way integrity is ensured and assessed, and the means of delivering integrity-related information to users are highly application dependent. Throughout this report, the "integrity concept" is to be understood at large, i.e. not restricted to safety-critical or civil aviation definitions but also encompassing concepts of quality assurance/quality control as used in other applications and sectors.

Latency is the difference between the reference time of the solution and the time this solution is made available to the end user or application (i.e. including all delays). Latency is typically accounted for in a receiver but presents a potential problem for integration (fusion) of multiple positioning solutions, or for high dynamics mobile devices.

Robustness relates to spoofing and jamming and how the system can cope with these issues. It is a more qualitative than quantitative parameter and depends on the type of attack or interference the receiver is capable of mitigating. Robustness can be improved by authentication information and services.

Authentication gives a level of assurance that the data provided by a positioning system has been derived from real signals. Radio frequency spoofing may affect the positioning system, resulting in false data as output of the system itself.

Power consumption is the amount of power a device uses to provide a position. It will vary depending on the available signals and data. For example, GNSS chips will use more power when scanning to identify signals (cold start) than when computing a position. Typical values are in the order of tens of milliwatts (for smartphone chipsets).

Probability of false alarm refers to the likelihood of the receiver to indicate the presence of a signal when no signal is present.

Probability of detection refers to the likelihood of a receiver to detect the presence of a GNSS signal when a signal is indeed present.

Time To First Fix (TTFF) is a measure of time between activation of a receiver and the availability of a solution, including any power on self-test, acquisition of satellite signals and navigation data and computation of the solution. It mainly depends on data that the receiver has access to before activation: cold start (the receiver has no knowledge of the current situation and must thus systematically search for and identify signals before processing them – a process that can take up to several minutes.); warm start (the receiver has estimates of the current situation – typically taking tens of seconds) or hot start (the receiver understands the current situation – typically taking a few seconds).

Time To First accurate Fix (TTFaF) is a measure of a receiver's/solution's performance covering the time between activation and output of a position within the required accuracy bounds.

A.4 Definition of key SATCOM performance parameters

Link type refers to the type of communication link used for transmitting voice or data.

Availability is qualitative indication of the reliability and uptime of the communications system. It refers to the percentage of time the communication system is operational and meets the required quality of service when the application is in use.

Latency refers to the delay between the transmission of a signal and the reception of the response. This is the time it takes for a signal to travel from the sender to the receiver and back.

Bandwidth (bit rate) is a qualitative indication of the anticipated rate of data transfer when using the application. It is the amount of data that can be transmitted over the communication link in a given amount of time, usually measured in bits per second (bps).

Coverage is an indication of the geographical area that can be reached by the service. It defines the regions where the satellite signal is available and can provide communication services.

Symmetry Up/Down is the ratio between the uplink traffic (data sent from the ground to the satellite) and the downlink traffic (data sent from the satellite to the ground). This ratio indicates whether the communication link is symmetric (equal uplink and downlink capacity) or asymmetric (different uplink and downlink capacities).

Distribution refers to the method and extent to which the communication service is distributed across different regions or users. It can include the distribution of signal strength, service availability, and user access.

Setup refers to a qualitative indication of the time required to establish a voice or data communication session with the application. It refers to the acceptable duration for setting up a communication link that is sufficient to perform the intended operation, such as railway operations.

Speed: the speed at which a user is traveling, with a maximum value specified. In satellite communication, this can affect the ability to maintain a stable communication link, especially for mobile users.

Security protection refers to the measures and protocols implemented to ensure the security of the communication link. This includes protecting the data from unauthorized access, interception, and ensuring the integrity and confidentiality of the transmitted information

A.5 Other performance parameters

EO

Agility corresponds to the ability of a satellite to modify its attitude and to point rapidly in any direction to observe areas of interest outside its ground trace. High agility can improve the temporal resolution compared with the revisit time of the satellite.

Swath corresponds to width of the portion of the ground that the satellite "sees" at each pass. The larger the swath, the bigger the observed area at each pass.

Off-nadir angle corresponds to the angle at which images are acquired compared with the "nadir", i.e. looking straight down at the target. In practice, objects located directly below the sensor only have their tops visible, thus making it impossible to represent the three-dimensional surface of the Earth. High resolution images are therefore generally not collected at nadir but at an angle. A large off-nadir angle enables a wider ground coverage at each pass and the identification of features not visible at nadir, but it reduces the spatial resolution. For optical imagery, typical off-nadir angles are in the range of 25-30 degrees.

Sun-elevation angle corresponds to the angle of the sun above the horizon at the time an image is collected. High elevation angles can lead to bright spots on the imagery while low elevation angles lead to darker images and longer shadows. The most appropriate angle depends on the type of application: a high sun elevation is appropriate for spectral analysis since the objects to be observed are well illuminated while a lower elevation angle is better suited to interpretation of surface morphology (e.g. the projected shadows can enable a better image interpretation).

GNSS

Size, weight, autonomy, and power consumption. Power consumption and size are not strictly GNSS performance parameters, however they are also considered in this analysis, especially for GIS and Mapping-related applications.

- **Autonomy**. Power consumption is the amount of power a device uses to provide a position. The power consumption of the positioning technology will vary depending on the available signals and data. For example, GNSS chips will use more power when scanning to identify signals (cold start) than when computing a position. Typical values are in the order of tens of mW (for smartphone chipsets). GNSS is considered one of the heaviest drains on smartphones batteries
- **Size, weight**. Most GIS devices used by NGOs are handheld or rugged tablets/phones, which implies that they must remain small and lightweight.

Resiliency is the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions; including the ability to recover from deliberate attacks, accidents, or naturally occurring threats or incidents. A resilient system will change its way of operations while continuing to function under stress, while a robust (but non-resilient) system will reach a failure state at the end, without being able to recover.

Connectivity refers to the need for a communication and/or connectivity link of an application to be able to receive and communicate data to third parties. Connectivity relies on the integration with both satellite and terrestrial networks, such as 5G, LEO satellites, or LPWANs.

Interoperability refers to the characteristic of a product or system, whose interfaces are completely understood, to work with other products or systems, in either implementation or access, without any restrictions (e.g. ability of GNSS devices to be combined with other technologies and the possibility to merge the GNSS output with the output coming from different sources).

Traceability is the ability to relate a measurement to national or international standards using an unbroken chain of measurements, each of which has a stated uncertainty. For Finance applications, knowledge of the traceability of the time signal to UTC is essential to ensure regulatory compliance of the timestamp.

A.6 List of Acronyms

Acronym	Definition
AI	Artificial Intelligence
CAMS	Copernicus Atmosphere Monitoring Service
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
DG SANTE	Directorate General for Health and Food Safety
DVB	Digital Video Broadcasting
EC	European Commission
EFB	European Federation of Biotechnology
EFPIA	European Federation of Pharmaceutical Industries and Associations
EGNOS	European Geostationary Navigation Overlay Service
EGNSS	European Global Navigation Satellite System
EMA	European Medicines Agency
EO	Earth Observation
EPHA	European Public Health Alliance
ESA	European Space Agency
EU	European Union
EUPHA	European Public Health Association
EUSPA	European Agency for the Space Programme
EU-WFD	European Union Water Framework Directive
GEO	Group on Earth Observations
GOVSATCOM	GOVermental SATellite COMmunication
GNSS	Global Navigation Satellite System
GRSS	Geoscience and Remote Sensing Society
GSEO	Geoscience Standards for Earth Observations
HMA	Heads of Medicines Agencies
IAQ	Indoor Air Quality
IFPMA	International Federation of Pharmaceutical Manufacturers and Associations
IFRC	International Federation of Red Cross and Red Crescent Societies
InSAR	Interferometric Synthetic Aperture Radar

Acronym	Definition
IoT	Internet-of-Things
IPCC	Intergovernmental Panel on Climate Change
IRIS	Infrastructure for Resilience, Interconnectivity and Security by Satellite
ISO	International Organization for Standardization
LEO	Low-Earth Orbit
MAIAC	Multi-Angle Implementation of Atmospheric Correction
MEP	Member of European Parliament
MR	Market Report
MSG	Meteosat Second Generation
NCA	National Competent Authorities
NGO	Non-Governmental Organization
NTN	Non-Terrestrial Networks
OAQ	Outdoor Air Quality
OGC	Open Geospatial Consortium
PNT	Positioning, Navigation and Timing
PSI	Public Sector Information
R&I	Research and Innovation
RCS2	Return Channel via Satellite 2
RUR	Report on User needs and Requirements
SAR	Synthetic Aperture Radar
SATCOM	Satellite communications
SDI	Surface Direct Irradiation
SIS	Surface Incoming Solar radiation
SME	Small and Medium-sized Enterprise
SWIR	Short-Wave Infrared
TEMIS	Tropospheric Emission Monitoring Internet Service
TFUE	Treaty on the Functioning of the European Union
TTFF	Time to First Fix
UCP	User Consultation Platform
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UVI	Ultraviolet Index
UV	Ultraviolet

Acronym	Definition
VDC	Validation Data Centre
VIS	Visible Spectrum
VLEO	Very Low Earth Orbit
VNIR	Visible and Near-Infrared
WFID	Workflow Identifier
WHO	World Health Organisation

A.7 Reference Documents

Id.	Reference	Title	Date
[RD1]	EUSPA Market Report	EUSPA EO and GNSS Market Report (Issue 2)	2024
[RD2]	GNSS Technology Report	GSA GNSS Technology Report (Issue 3)	2020
[RD3]	SAR and Optical Satellite Images for Advanced Asset Monitoring	https://spottitt.com/industry-news/sar-and-optical-satellite-images-for-advanced-asset-monitoring/	2023
[RD4]	UCP 2024 Minutes of Meeting	UCP 2024 Minutes of Meeting of the Health & Wellbeing market segment panel	2024
[RD5]	Expression of User Needs for the Copernicus Programme	Commission Staff Working Document Expression of User Needs for the Copernicus Programme	2019
[RD6]	EU Space Programme Regulation	Regulation (EU) 2021/696 of the European Parliament and of the Council of 28 April 2021	2021
[RD7]	EU space programme	Copernicus services supports Global Pharmaceuticals | EU Agency for the Space Programme	2023

EUSPA Mission Statement

The mission of the European Union Agency for the Space Programme (EUSPA) is defined by the EU Space Programme Regulation. EUSPA's mission is to be the user-oriented operational Agency of the EU Space Programme, contributing to sustainable growth, security and safety of the EU. In the execution of its mission, EUSPA counts on strong partnerships with the European Commission, European Parliament, Member States, European Space Agency, and private actors across the EU.

The EU Agency for the Space Programme:

- Provides state-of-the-art, safe and secure positioning, navigation and timing services based on Galileo and EGNOS, cost-effective satellite communications services for GOVSATCOM and soon IRIS², and Front Desk services of the EU Space Surveillance Tracking whilst ensuring the systems' service continuity and robustness;
- Promotes and maximises the use of data and services offered by Galileo, EGNOS, Copernicus, GOVSATCOM and soon IRIS² across a broad range of domains;
- Fosters the development of a vibrant European space ecosystem by providing market intelligence, and technical know-how to innovators, academia, start-ups, and SMEs. The agency leverages Horizon Europe, other EU funding, and innovative procurement mechanisms;
- Implements and monitors the security of the EU Space Programme components in space and on the ground with the aim to enhance the security of the Union and its Member States. To do so, EUSPA operates the Galileo Security Monitoring Centre (GSMC).

The EU Space Programme Security Accreditation Board is established within the Agency, representing the security accreditation authority for all of the EU Space Programme's components.

The European Union Agency for the Space Programme: linking space to user needs.

www.euspa.europa.eu

EUSPA

@space4eu

EUSPA

#EUSpace

European Union Agency for the Space Programme