FIRE | European Forum for Earth Observation

D2.2 Sectorial Cards

WP2 – Building the Community

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Executive Summary

FIRE is helping decision makers and stakeholders shape the Research and Innovation Strategy for Earth Observation (EO) solutions in Europe. It aims to establish a user community across different sectors, starting with agriculture, energy, raw materials, infrastructure, marine, and urban development. To achieve that, FIRE will focus on fostering the development of current and new markets and supporting capacity building activities to realise the EO-enabled benefits. Open dialogue with the demand side will guide the development, delivery, and uptake of EO services in Europe.

As a means to describe the current state of play in the targeted sectors as well as EO capabilities in support of these, but also to get interaction with stakeholders in these sectors started, a Sectorial Card has been created for each of these sectors. This deliverable presents the concept of these cards and the methodology of their development, as well as the results of the performed task.

1 Introduction

Before defining future steps for Research and Innovation activities in the European Earth Observation sector, it has to be established where it currently stands today. Thus, as part of task "T2.2 Mapping of Key Market Sectors", a comprehensive picture of the current state-of-play vis-à-vis the uptake of Earth Observation solutions in each of the six sectors – Agriculture, Energy, Raw Materials, Marine, Infrastructure, and Urban Development – has been built.

The above-mentioned sectors had been proposed both due to their economic and strategic importance, as well as the potential EO has to support these sectors:

Agriculture: Production and processing of food is one of the basic pillars of the EU economy, accounting for a turnover of €1T and employing 16% of the EU's workforce. The industry is set to grow, as the world must boost food production by 70% by 2050 to accommodate population growth and greater economic prosperity. The EU has the largest share of the global food and drinks market, but its share has dropped from 20% in 2001 to 16% in 2012. As noted by the EC, slow growth in labour productivity and added-value have decreased the competitiveness of the EU's food producers. These issues should be addressed in the context of a growing interest in the link between food and health, which has changed mainstream consumption patterns by valorising quality aspects related to good health. One of the EU's primary research and innovation missions is to restore soil health and function to help grow food, textiles and wood more sustainably and mitigate the effects of climate change. In this regard, EO, GNSS and deeptech have a large potential role to play in helping to reach the goals of this mission. Food production is a complex input-output problem, for which EO and GNSS offer a large and cost-effective source of information while deeptech capabilities can enhance strategic and tactical decisions that increase quality and/or quantity of yields while lowering costs and environmental footprints through e.g. generation of heterogenous fertilisation maps and automated fertilisation application, remote disease detection and warnings, fruit harvest scheduling to maximise fruit/wine quality, monitoring soil erosion, crop classification, or land usage information.

Energy: The global demand for is expected to continue to rise into the middle- and long-term, fuelled by a growing world population and increasing per-capita energy use (despite savings from growing energy efficiency). Renewable energy sources (RES) are already marking the fastest rates of growth amongst the world's fuel mix, with this growth trend expected to continue for all mature renewables, including solar, wind and biofuels. EO data is a crucial resource for both planning and management of RES projects. EO data can be used to scout for high-potential locations for RES projects and provide highly accurate estimates of energy generation potential and thus return to investment. EO data is also useful for disaster risk management applications, to support emergency services, effectively monitor infrastructure conditions, and inform high-performant energy infrastructure projects. As such, it is recognised in the sector that EO can contribute to the optimisation of renewable energy systems for power production and optimal integration of traditional and renewable energy supply systems into electric power grids. As such, the estimated Total Addressable Market for EO downstream services in the RES Electricity sector amounts to approximately € 73 M and is key to achieving the EU 32% renewable energy target 2030.

Raw Materials: In the EU, this sector has an added value of around €1,000bn and provides employment for some 30 million people. It represents crucial input to various industries. Reliance on important resources outside of the EU, but also scarcity, safety hazards, and the environmental impact associated with the extraction of raw materials require means for optimising exploration and extraction.

Marine/Maritime: Oceans are a source of life to our planet. They hold a huge reserve of healthy food, contributing 16% of the animal protein we eat. They are the planet's largest carbon sink, helping to regulate our climate and in total have absorbed 26% of anthropogenic carbon dioxide emissions since the beginning of the Industrial Revolution. Moreover, they are home to the richest biodiversity on our planet. Oceans also offer a great potential for boosting growth, jobs and innovation, and a large share of our economy already depends on the sea. The EU's blue economy represents roughly 5.4 million jobs and generates a gross added value of almost €500 billion a year. Yet the ocean's health and its capacity to provide these services are put in danger by pollution, ocean warming and the over-exploitation of marine and maritime resources. A research and innovation mission area for the EU is to raise awareness of the importance of healthy oceans, seas, coastal and inland waters. When it comes to stimulating innovation in the blue economy, EO and GNSS are quite uniquely positioned in their abilities to monitor movements, ecological impacts, resource usage and economic productivity over vast geographic regions with tremendous accuracy. Leveraging these incredible data sources with deeptech solutions will drive forward our practices and understanding of what is possible in the maritime sector, e.g. monitoring of illegal fishing and shipping, measurement and modelling of water pollution and its dispersion, precision open-sea fish farming, or maritime ecosystem and biodiversity monitoring.

Infrastructure: Physical networks of roads and railway including bridges and tunnels are an important backbone of industry and society, as they enable mobility of citizens and transportation of goods. They are thus contributing to economic growth and employment (the transport industry in Europe employs 1om people and accounts for 5% of the GDP) as well as to quality of life. The European single market demands such infrastructure for free movement of goods, integrating all regions. The EU28 counts a combined 218k km length of railway lines (2018), 77k km of motorways (2017), all roads combined 4.85mn km (2013). Not only building these has been a massive investment over time, also their maintenance – crucial for safety and availability. Transport infrastructure investment across EU28 countries in 2018 exceeded €100bn, maintenance on overage €25bn per year during 2010-2014. It is in particular in planning and maintenance where Earth Observation – remote sensing or in situ measurements – already plays an important role. Beyond transportation infrastructure, pipelines are critical infrastructure that need surveying and monitoring throughout planning, construction, and service life. They may be used for long-distance transportation of e.g. oil or gas, but also inside cities for e.g. gas, water, or sewage. Maintenance of these large and often difficult to access structures is a major effort and crucial to reduce downtime, which can have significant impact on economy and quality of life.

Urban Development: Currently, ca. 75% of the European Union's population lives in urban areas. 68% of the world population is projected to so by 2050. More than 80% of global GDP is generated in cities. Thus, their contribution to the world's economy is crucial. Yet, constant growth exposes these areas to more risks coming from e.g. natural disasters, pandemics, or the effects of unsustainable sprawl, energy usage, or waste production. Urbanisation brings with it challenges as regards e.g. availability of suitable services and infrastructure, health and wellbeing of citizens, environmental degradation, availability and quality of housing, provision of suitable means of mobility, or social inequalities. With these challenges comes the demand for new solutions to plan, develop, and operate urban areas efficiently and sustainably. City planners are in need of solutions that allow monitoring of assets and conditions as well as forecasting possible future developments and impacts. The transition towards Smart Cities could provide such solutions through the use of (big) data and ICT. EO solutions could provide both various types of data as well as means to process data and to integrate resulting information in applications for monitoring, decision-making, or policy-enforcement.

2 Methodology

Development of the six Sectorial Cards has built upon:

- Desk research;
- Results from task "T2.3 Analysis of EO emerging trends";
- Results from deliverable "D3.1 Focus Group Activity Summary 1".

Research included market analyses for each of the sectors, confirming the importance of the selected sectors for (European) economy and citizens and indicating challenges these sectors are facing. Studies and statistics from international organisations such as OECD, World Bank, UN, and the European institutions have been consulted as well as flagship publications of the Earth Observation sector (including e.g. Copernicus Market Report, EARSC Industry Survey, ESA SeBS) to identify those aspects that could benefit most from existing or future Earth Observation solutions.

Further, key policies and initiatives have been identified for each sector that create demand for Earth Observation solutions either for implementation of these or for verification of their performance.

Results from task "T2.3 Analysis of EO emerging trends have been complemented by further example projects showcasing research and innovation activities at the intersection with Earth Observation solutions. These highlight both the demand for solutions in specific application fields as well as the shift towards data-driven solutions.

Examples of Earth Observation applications and enabling technologies have been described to demonstrate applicability to the identified challenges and potential needs.

A simple scale (low, medium, high) has been added to indicate the "Relative EO adoption" in the respective sector, i.e. as compared to each of the other sector. EO revenues from sales and services in the sectors have been the basis for the benchmark.

3 Results and next steps

The analysis and mapping activity resulted in a four-page document for each sector that presents

- Characteristics
- Key policies and initiatives
- Key challenges
- Research and innovation activities applying Earth Observation to address challenges and implications of policies and initiatives
- Example applications of Earth Observation
- Enabling technologies.

Chosen examples served as inspiration for actors across value chains of the selected sectors, raising among them awareness for Earth Observation capabilities and serving as a starting point for discussing needs and shortcomings of solutions from an industry perspective. The identified challenges and needs have been verified and extended through Focus Group discussions under task "T3.1 Focus Group Event Organisation". Findings from these discussions have been reflected in an update of the initial version of the Sectorial Cards.

The Sectorial Cards will be further facilitated in the outreach to the sectors, e.g. serving as material for EO Evangelists briefing and activities, during interaction with communities built from Focus Group discussions, dedicated FIRE Forum events, as well as general communication activities. Further, they will be direct input to the sector-specific action plans developed under task "T4.1", and through these to the Sector development roadmap (D4.3).

The Sectorial Cards will be living documents that will benefit from updates through interaction with sector stakeholders throughout the lifetime of the project and will be adapted for specific audiences where needed.

4 Annex – Sectorial Cards

Sectorial Cards for each strategic sector are available as individual documents. They are visualised below in the following order:

1. Agriculture
2. Energy (Wind)
3. Infrastructure
4. Marine
5. Raw Materials
6. Urban Development

Relative EO adoption in sector

		high

Sectorial Card – Agriculture

Characterisation of the industry

The European Union has a population of almost 450 million, all of which require a reliable supply of healthy food at affordable prices. The agricultural sector therefore has the enormous responsibility of ensuring these needs are met, day in, day out without fail. The vital role the agricultural sector plays in all of our lives cements its standing as a perpetual economic powerhouse, meeting all of our daily needs while also supporting the livelihoods of millions. Given its position, the never-ending pressures and challenges it faces are immense and the economic environment it currently faces is set to remain uncertain for some time to come. Globalisation, financial crises, climate change and the volatile costs of inputs are only a few of the threats it must grapple with on a constant basis.

The agricultural sector contributed €176.9 billion towards the EU's overall GDP in 2018. The value of everything that the EU's agricultural industry produced in 2018 was an estimated €434.3 billion; this includes the value of crops, of animals, of agricultural services as well as of some goods and services.

About one half (51.8%) of the value of the total output of the EU's agricultural industry in 2018 came from crops (€224.9 billion), within which vegetables, horticultural plants and cereals contributed the most. A further two fifths (39.6%) came from animals and animal products (€172.0 billion), a majority coming from just milk and pigs. Agricultural services (€20.8 billion) and inseparable non-agricultural activities (€16.6 billion) contributed the rest (8.6%).

Key policies & Initiatives with industry implications

The following policies and initiatives describe the overarching framework and direction in which the agricultural sector is being guided through international and governmental regulation.

Policy / Initiative	Description
United Nations Sustainable Development Goals (SDGs)	EU agriculture makes a two-fold contribution to Sustainable Development Goal 2: • The common agricultural policy guarantees the availability of safe, nutritious and sustainably produced food for all Europeans. • EU food exports contribute to food security in third countries, while granting developing regions extremely favourable terms of trade, thereby advancing the growth of their domestic agricultural industries.
Common Agricultural Policy (CAP)	• The CAP is the overarching and most prominent policy in the EU agricultural sector. • It has 9 key objectives: to ensure a fair income to farmers; to increase competitiveness; to rebalance the power in the food chain; climate change action; environmental care; to preserve landscapes and biodiversity; to support generational renewal; vibrant rural areas; to protect food and health quality.
COP 21 – Paris Agreement	• In 2015 parties to the UN Framework Convention on Climate Change agreed to intensify the actions and investments needed for a sustainable low carbon future.

	• The agricultural sector has considerable responsibility to help support climate mitigation and adaptation by influencing how individual farmers choose to manage their land, crops and livestock and how they use inputs, including energy, fertilisers and water.
European Agricultural Fund for Rural Development (EAFRD)	• Within the CAP the EAFRD is the funding instrument that supports rural development strategies and projects. • The EAFRD aims to improve competitiveness for farming, protect the environment and the countryside, improve the quality of life and diversification of the rural economy, and support locally based approaches to rural development.
European Innovation Partnership for Agricultural Productivity & Sustainability (EIP AGRI)	• In 2012 EIP AGRI was launched to contribute to the EU's strategy for smart, sustainable and inclusive growth. EIP-AGRI brings together innovation actors (farmers, advisers, researchers, businesses, NGOs etc.) in agriculture. • Its aim is to strengthen research and innovation to foster competitive and sustainable farming.

Research & Innovation at the intersection with Earth Observation

- **EO4AGRI:** EO4AGRI's main target is the preparation of the European capacity for improving operational agriculture monitoring from local to global levels based on information derived from Copernicus satellite observation data and through exploitation of associated geospatial and socio-economic information services.
- **DIONE:** The DIONE project offers a unique fusion of innovative technologies that improves the workflow of agricultural monitoring. DIONE is developing a direct payment controlling toolbox for paying agencies to abide by the modernised CAP.
- **RE.CAP:** The RE.CAP project aims to develop an improved remote monitoring of CAP obligations and to supplement the in-field inspections procedures.
- **e-shape:** The e-shape project is the largest coordinated effort to highlight operational services in the field of Earth Observation research in Europe. Various pilots within e-shape are demonstrating agricultural applications.
- **GRACE:** The GRACE project is demonstrating the large-scale production of novel miscanthus hybrid crops and hemp crop varieties on marginal and contaminated land as well as the use of the biomass in creating a wide range of products.
- **DIVERSIFOOD:** DIVERSIFOOD will evaluate and enrich the diversity of cultivated plants within diverse agroecosystems so as to increase their performance, resilience, quality and use through a multi-actor approach.
- **FERTINNOWA:** The main objective of the FERTINNOWA project is to create a meta-knowledge database on innovative technologies and practices for fertigation of horticultural crops.

Challenges

Some of the overarching challenges facing the agricultural sector are listed below.

- **Population growth:** With the world's population set to grow from 7.8 billion in 2020 to 10 billion in 2050, major increases in demand for nutritious food will be a huge challenge for our farmers.
- **Climate change:** Climate change is altering the way farmers must conduct their activities by changing the ecosystem balances and affecting harvests.
- **Environmental footprint:** Many agricultural practices have damaging environmental impacts with more and more policies demanding sustainable practices & technologies in farming.
- **Price stability:** Agricultural commodities face constant fluctuations in price for many reasons, such as economic crashes and climactic weather events. Maintaining business throughout this is a major issue for farmers and agri-food companies.

- **Globalisation:** Competitive pressures from globalised markets, stringent regulations and innovation can render some farmers' operations economically unviable.
- **Perceived technological barriers:** Although a positive in many ways, given the aging demographics farmers in many regions, the rapid development of precision agriculture technologies can be seen as impermeable and challenging to many "would be" adopters.

Example Earth Observation applications in the agricultural value chain

Crop monitoring

EO solutions are well established and extremely useful when it comes to the classification and monitoring of crops. Through the computation of vegetation indices from satellite data, the health, growth rate and projected yields of crops can be understood which can help decision making, and in particular, help to optimise resource utilisation, such as fertilizer application, irrigation or weed spraying.

Regulatory compliance monitoring

When applied in agriculture, EO can be used by competent authorities to ensure policies, laws and regulation are being adhered to. This can reduce the need for compliance checks to be performed manually.

Environmental impact monitoring

Agriculture can produce many types of pollution and detrimental environmental impacts, from water pollution, soil erosion to greenhouse gas emissions. Many of these impacts can be detected using available high or very-high resolution satellite imagery.

Commodity monitoring

Companies are using satellites to try to shed light on the sometimes tightly held secrets in the commodity trading world, from corn to barley to oranges. EO can help monitor the regional and international and trade of many agricultural commodities.

Insurance and risk monitoring

EO can allow many agricultural stakeholders, particularly insurance companies to understand the risks associated with the loss of yields and provide accurate insurance coverage and investigations.

Security planning

EO can also be used to help public bodies understand the state-of-play within regions with regards to food security and agricultural reserves, helping to ensure effective mitigation plans can be put in place.

Examples of enabling technologies

Multispectral / Hyperspectral imagery

Multispectral imaging (MSI) and hyperspectral imaging (HSI) allow significant opportunities for entrepreneurs seeking to bring new value-added services onto the market across a large amount of applications. Through the use of MSI/HSI imagery the likes of vegetation growth, moisture and fertilizer application rates can all be monitored and subsequently controlled, meaning input costs can be reduced and harvest times planned efficiently.

SAR / InSAR

SAR and InSAR are very well-established technologies which have proven to be extremely reliable and precise in its application. Again, crop monitoring can be conducted through the use of SAR while InSAR can provide insights to displacement and changes in elevation of the earth's surface, allowing the impact of agricultural practices on ground stability to be monitored.

In situ observation

In situ instruments can serve as validation and calibration of satellite-borne data, and also as observation instruments in their own right for multiple agricultural related functions, including precise local weather monitoring, as well as soil moisture and mineral content monitoring.

Atmospheric monitoring

Monitoring of greenhouse gas emissions related to agricultural practices is of high importance due

Drones / HAPS

Drones are increasingly used as a source of information that complements data provided by

Small satellites

Large numbers of smaller satellites ("smallsats") have been launched in recent years. Being cheaper, to the large amount of methane released from biological sources and carbon from the likes of farm machinery. The likes of Copernicus' Sentinel 5p, with its tropospheric measuring instrument (TROPOMI) is just one example of the possibilities in atmospheric monitoring.

satellite-based remote sensing. In agricultural applications drones can provide high spatial resolution crop monitoring services such as weed scouting, crop health monitoring and harvest readiness information.

smallsats come with a shorter lifetime (around 3 years) – but this is actually a hidden benefit: the capabilities of the constellation as a whole can be upgraded relatively fast. Smallsats can help drive forward the capabilities of agricultural related earth observation technologies, providing higher and higher spatial and temporal resolution data.

Relative EO adoption in sector

low		

Sectorial Card – Wind Energy

Characterisation of the industry

The European Union has been an early mover on renewable energy and is committed to becoming the global leader in renewables. Wind power provides already 15% of Europe's electricity. It employs over 350,000 people, represents more than €25bn of new investments, and exports €8bn of goods and services every year. Especially prominent is the dominance of European companies in the manufacturing of wind turbines, where they produce an impressive 90% of the offshore global market.

The development and installation of wind energy has been growing over the last years, with 15.4 GW of new wind power capacity in 2019 in Europe (27% higher than 2018, but 10% less than the record in 2017).

Onshore wind continues to be the main form and still makes up 89% of the overall wind capacity. Nonetheless, in 2019, 3.6 GW new offshore wind energy capacity has been installed in Europe. Additionally, the EU currently has the largest floating wind energy capacity in the world - about 70% of the total.

Wind power is one of the most prominent forms of renewable energy, known to be a corner stone of the European Green Deal and a fundamental element towards the aim for climate neutrality.

Key policies & Initiatives with industry implications

While the wind energy profile of a country greatly depends on elements such as the energy portfolio of the region, robustness of the electrical grid, or available energy in neighbouring countries, onshore or offshore deployment, there are some common policies applicable throughout Europe. These energy-related policies and initiatives are considered below.

Policy / Initiative	Description
The Renewable Energy Directive (Directive 2009/28/EC)	• Established a European framework to promote renewable energy by setting mandatory national targets in order to achieve at least a 20% renewable energy share in final energy by 2020.
The revised Renewable Energy Directive (Directive 2018/2001/EU)	• Was adopted as part of the Clean energy for all Europeans package and includes a new binding renewable energy target of at least 32% for 2030, with a clause for a possible upwards revision by 2023, thereby helping the EU to meet its emissions reduction commitments under the Paris Agreement. The directive needs to be transposed into national law by Member States by 30 June 2021, when the original renewables directive will be repealed. • Includes provisions that simplify permitting processes while accounting for legitimate concerns of citizens and respecting environmental standards – especially problematic in the case of wind energy.
Regulation on the Governance of the Energy Union and Climate Action (Regulation (EU) 2018/1999)	• EU countries are required to draft national energy and climate plans (NECPs) for 2021-2030, outlining how they will meet the new 2030 targets for renewable energy and for energy efficiency.
Clean energy for EU islands initiative	• The initiative dates back to 2017. In 2020, the European Commission and the participating 14 EU countries signed a Memorandum of

	Understanding establishing a long-term framework for cooperation to advance the energy transition for European islands.
European Green Deal	• Aiming at making Europe climate neutral by 2050, boosting the economy through green technology, creating sustainable industry and transport, cutting pollution. • The decarbonisation strategy requires Europe to multiply its wind energy capacity no less than five times by 2050 in order to achieve 30% of the future electricity demand.
Next Generation EU	• EU's COVID-19 recovery package leads the way out of the crisis and lays foundations for a modern and more sustainable Europe through a resilient, inclusive, and green recovery, and towards a low-carbon future.
United Nations Sustainable Development Goals (SDGs)	• Goal 7 aims at ensuring access to affordable, reliable, sustainable, and modern energy for all and calls for, among others, stepping up the efforts in the realm of renewable energy.
EIT InnoEnergy	• The initiative of the European Institute of Innovation and Technology supports the development of new products, solutions, and services contributing to a sustainable energy sector.

Research & Innovation at the intersection with Earth Observation

- **e-shape (2019-2023):** Pilot 3.3 provides a unique product from existing EO data. It shall improve offshore wind resource estimates, thus helping wind farm planning and development. The new product can be further customised upon request from the offshore industry.
- **SUMO (2015-2017):** Service for planning and monitoring of marine operations for offshore wind farms. The service supports these activities by integrating diverse information to allow the monitoring and forecasting of metoceanic conditions and tracking of the locations of vessels and personnel involved.

Challenges

Numerous are the challenges standing before the wind energy sector, and so are the ways of confronting them. This sector has been using the oldest form of EO data since long, namely meteorological data. Other data is still mostly to be integrated. Some of the areas which may benefit from EO are considered below.

- Forecasting and optimising wind energy output
- Siting wind farms (including the assessments of demand profile, infrastructure, environmental conditions, social acceptance, co-existence and permitting)
- Building wind farms and installing wind turbines
- Monitoring and assessing wind turbine conditions
- Optimizing wind farm operations and maintenance
- Predicting extreme weather events

Example Earth Observation applications in the wind energy value chain

Onshore site planning and operations monitoring

EO can provide data on the assessments of demand profile, infrastructure, environmental conditions, social acceptance, co-existence and permitting of the

Offshore site planning and operations monitoring

Offshore wites, who are exposed to severe environmental conditions, make construction, operations, and maintenance more difficult compared to onshore installations. EO data can provide imagery on

wind plants, as well as serve for monitoring purposes.
Data on land use, for instance acquired through radar imagery, can provide data on surface topography and roughness in order to forecast wind and to improve the accuracy of regional wind atlases, which are essential for onshore wind installations.

environmental impact assessment and minimise HSE risks for personnel, by helping establish optimal site maintenance weather windows and help foresee or determine/monitor possible weather effects on the blades. Moreover, satellite-based scatterometers provide invaluable meteorological information for offshore platforms positioned in coastal zones.

Examples of enabling technologies

SAR / InSAR

SAR data can provide wind maps with 1km resolution and imagery down to 25cm, and has proved to be more accurate than meteorological data and mesoscale model results. Satellite observations from SAR and scatterometer provide data on wind, wave, terrain roughness and orography. Radar altimeters can provide ocean data relevant for offshore wind farms, such as wave height and wind speed.

Multispectral / Hyperspectral imagery

EO-derived normalised difference vegetation index (NDVI) products can be used for vegetation monitoring for overhead transmission line management.

In situ observation

In situ instruments can serve as validation and calibration of satellite-borne data, and also as indispensable observation instruments in their own right for multiple functions, such as collecting meteorological data.

Meteorology and metocean data

Satellites provide accurate data on a few parameters related to metocean conditions, such as winds, waves, and sea surface height – even very closely to a coastline.
Moreover, satellites can offer complementary data used for forecasting applications and predict extreme weather events.

Drones / HAPS

Drones are increasingly used as a source of information that complements data provided by satellite-based remote sensing. Similar benefits of flexibility and connectedness are also attributed to a lesser-known market trend, the “stratosphere drone” or High-Altitude Pseudo-Satellite (HAPS).
Drones are an appropriate tool for inspections of onshore and offshore wind farms.

Small satellites

Large numbers of smaller satellites (“smallsats”) have been launched in recent years. Being cheaper, smallsats come with a shorter lifetime – but this is a hidden benefit: the capabilities of the constellation as a whole can be upgraded relatively fast.

Relative EO adoption in sector

	medium	

Sectorial Card – Infrastructure

Characterisation of the industry

Physical networks of roads and railway including bridges and tunnels are an important backbone of industry and society, as they enable mobility of citizens and transportation of goods. They are thus contributing to economic growth and employment (the transport industry in Europe employs 1om people and accounts for 5% of the GDP) as well as to quality of life. The European single market demands such infrastructure for free movement of goods, integrating all regions. The EU28 counts a combined 218k km length of railway lines (2018), 77k km of motorways (2017), all roads combined 4.85mn km (2013). Not only building these has been a massive investment over time, also their maintenance – crucial for safety and availability. Transport infrastructure investment across EU28 countries in 2018 exceeded €100bn, maintenance on overage €25bn per year during 2010-2014. It is in particular in planning and maintenance where Earth Observation – remote sensing or in situ measurements – already plays an important role.

Beyond transportation infrastructure, pipelines are critical infrastructure that need surveying and monitoring throughout planning, construction, and service life. They may be used for long-distance transportation of e.g. oil or gas, but also inside cities for e.g. gas, water, or sewage. Maintenance of these large and often difficult to access structures is a major effort and crucial to reduce downtime, which can have significant impact on economy and quality of life.

Key policies & Initiatives with industry implications

The following policies and initiatives are examples that describe the overarching framework and direction in which the Infrastructure sector is being guided through international, European, and governmental regulation.

Policy / Initiative	Description
United Nations Sustainable Development Goals (SDGs)	• **SDG9: Industry, innovation and infrastructure:** infrastructure contributing to an economic environment that generates employment and income • **SDG11: Sustainable cities and communities:** roads and transport systems as one crucial factor for quality of life and environmental sustainability; protection of and safeguarding the world's cultural (and natural) heritage is a further target
Directive 2004/54/EC on minimum safety requirements for tunnels in the Trans-European Road Network	• Proposed actions to guarantee a high, uniform, and constant level of security, service, and comfort on the Trans-European Road Network
Directive 2008/96/EC on road infrastructure safety management	• Member States are required to perform road safety audits • Safety inspections are required for verification of characteristics and defects that require maintenance work for reasons of safety
Roadmap to a Single European Transport Area	• 2011 White Paper on Transport published by the European Commission • Strategies and initiatives for sustainability of infrastructure both in terms of meeting growing demand as well as climate goals

EU Road Safety Policy Framework 2021-2030 - Next steps towards "Vision Zero"	• The Safe System includes demands for safer and improved infrastructure • Properly maintained roads are believed to reduce the probability of road traffic accidents
European Heritage Alliance Manifesto	• Initiated by Europa Nostra, a relay between civil society and EU institutions that aims to raise awareness for European cultural heritage and to securing it through policies and funding.

Research & Innovation at the intersection with Earth Observation

- PLIMM: developed a set of ground and structural motion monitoring services, which can utilise both space and terrestrial technologies and offer both wide area and site-specific analysis.
- SaTEllyte: applied SAR interferometry to model dam stability, to monitor dam structural health, and to timely provide preliminary hints about the stress-strain status of the dam.
- ASSETS4RAIL: is exploring, adapting, and testing cutting-edge technologies for railway asset monitoring and maintenance, including bridges and tunnels, as well as track geometry.
- CAMEO: developed and performed demonstrations of EO data in combination with ground data and data processing and analytics techniques for improved infrastructure monitoring insights, demonstrating benefits to asset managers of pipeline and energy transmission corridors.
- PANOPTIS: uses high-resolution modelling data, weather forecasts, multi-sensor UAV- and satellite-based observations, and other datasets to increase resilience of road infrastructures and ensure reliable network availability under unfavourable conditions, such as extreme weather, landslides, or earthquakes.
- ATHENA: aimed to establish a Center of Excellence in the field of Remote Sensing for Cultural Heritage, facilitating remote sensing techniques for applications in archelogy and protection of cultural heritage.

Challenges

Some of the overarching challenges facing the Infrastructure sector are listed below.

- **Environmental footprint** created by construction and use of infrastructure
- Increasing **interconnection and interdependence** of infrastructure systems
- **Capacity** limits due to growing population and economy
- Lack of detailed **data** on location and condition of legacy infrastructure
- **Availability of land** and space for new infrastructure
- **Maintenance** of large networks, including in remote areas

Example Earth Observation applications in the Infrastructure value chain

Vegetation management

Vegetation can have negative impacts in particular on electrified railway lines, where power lines can be affected. Drone inspections can measure distances of vegetation, identify vegetation type, and provide data that can be used to predict growth, define pruning priorities, and monitor pruning works of contractors.

Pipeline monitoring

Pipelines need surveying and monitoring throughout planning, construction, and service life. Exposed to different environmental forces, natural disasters, soil movement, but also third-party interference. Impacts on integrity could lead to damages and leaks. Satellite observations can support identification of such impacts, but also of ground movement, allowing for targeted maintenance.

Construction monitoring

Detecting ground movements on the Earth's surface can reveal deformation associated with tunnel and underground space excavation and construction. Where placing sensors along a dense network has its limits, time series of satellite imagery can reveal damages for large areas.

Mapping of transportation networks

Remote sensing can be applied to map overground road networks, including a classification of road type and surface material. At the same time, characteristics associated with ageing of specific materials can be detected, revealing or even predicting damages in the surface. Radar is applied to detect anomalies such as ground movement and change detection, e.g. displacement of bridges or rails can be performed based on historical data, enabling action before failure.

Examples of enabling technologies

SAR / InSAR

SAR and InSAR are very well-established technologies which have proven to be extremely reliable and precise in their application. SAR/InSAR can be used to help measure ground instability issues either prior to construction or for monitoring of e.g. roads, tunnels, or pipelines.

Multispectral / Hyperspectral imagery

Through the use of Multispectral imaging (MSI) and hyperspectral imaging (HSI) a variety of plants can be classified, allowing for efficient and geographically widespread vegetation management.

In situ observation

In situ instruments can serve as primary source or for validation and calibration of satellite-borne data. Sensors built into transport infrastructure can measure both intensity of use as well as conditions and structural damages building up.

Drones

Drones are increasingly used as a source of information that complements data provided by satellite-based remote sensing. They can be a low-cost alternative to helicopters for inspection of e.g. bridges or roads, also in remote areas. Beyond Visual Line of Sight (BVLOS) approaches – AI-enabled obstacle avoidance – allow for close inspections in difficult-to-reach areas such as under bridges or in tunnels.

Small satellites

Large numbers of smaller satellites (“smallsats”) have been launched in recent years. Being cheaper, smallsats come with a shorter lifetime (around 3 years) – but this is actually a hidden benefit: the capabilities of the constellation as a whole can be upgraded relatively fast. Smallsats can help drive forward the capabilities of Earth Observation, providing higher and higher spatial and temporal resolution data.

Relative EO adoption in sector

low		

Sectorial Card – Marine

Characterisation of the industry

Seas and oceans cover about 70% of the Earth's surface. They are a primary source of biodiversity, crucial in mitigating the effects of climate change and play a major role in the global economy and its various sectors. The main ocean activities' contribution to economy are valued at USD 24 billion, and the expectations point at overpassing USD 3 trillion for overall marine and maritime activities by 2030.

Traditionally, the industry is considered to operate in four key areas: naval, commercial, leisure, and offshore renewable energy. For the purposes of FIRE, we shall exclude the last one from consideration, as within its framework, Energy is addressed as a sector of its own (as is Raw Materials where marine mining shall be considered).

In view of the possible application of Earth Observation (EO) in the sector, FIRE focuses on the following:

- Fishing & aquaculture
- Shipping & ice navigation
- Offshore assets monitoring
- Water quality & marine ecosystems
- Coastal management

Key policies & Initiatives with industry implications

Due to its primary importance and complex structure, the marine sector is a subject of a multitude of matter-specific and overarching policies, which vary from national and regional, to international level. Some of the policies and initiatives where EO is potentially relevant are considered below.

Policy / Initiative	Description
Blue economy	• Encompasses ocean and coastal activities. It registered a turnover of €750bn in 2018 solely within the EU. • The impact of Covid-19 on the sector (e.g. on coastal and marine tourism, fisheries) is severe and still to be assessed.
Water Framework Directive (WFD)	• Focuses on water quality of inland and territorial coastal waters, and mandates EU Member States to perform regular monitoring and reporting of a series of ecological and chemical parameters relevant for assigning and maintaining the "good" status of a waterbody.
Marine Strategy Framework Directive (MSFD)	• The MSFD embraces a wholistic ecosystem approach to the management of human activities impacting the marine environment, through environmental protection and sustainable use. • Aims at protecting the marine biodiversity, by stimulating the achievement of a good environmental status. • The Marine Strategies must be kept up-to-date and reviewed every 6 years, with the third cycle beginning in 2024.

The Maritime Spatial Planning Directive (MSPD)	• Aims at ensuring that human activities at sea take place in an efficient, safe, and sustainable way. The directive focuses on reducing conflicts and encouraging investments, all while preserving the environment.
Integrated Maritime Policy	• An umbrella concept aiming at a more coherent approach to maritime issues through enhanced coordination between overarching different policy areas. • It coordinates existing policies in the sector of blue growth, marine data and knowledge, maritime spatial planning, integrated maritime surveillance, and sea basin strategies.
United Nations Convention on the Law of the Sea's (UNCLOS)	• A convention to which almost the entirety of countries globally adheres. Part XII of UNCLOS deals with protection and preservation of the marine environment.
International Convention for the Prevention of Pollution from Ships (MARPOL)	• Focuses on different types of pollution from ships such as by oil, harmful substances, sewage, garbage, as well as air pollution.
EU Directives on ship source pollution (Directive 2005/35/EC as amended by Directive 2009/123/EC)	• Provide that any intentional or seriously negligent infringement of those standards, whether in EU coastal waters or on the high seas, should even be regarded as criminal offence.
EU Biodiversity Strategy for 2030	• This initiative outlines the EU's ambition for the post-2020 global biodiversity framework to be adopted in October 2020 at the UN Biodiversity Conference in Kunming, China. • It commits the EU to curtailing biodiversity loss and to preserving and restoring the ecosystems.
Habitats directive and Natura 2000	• Concern the protection of flora and fauna to whom seas, oceans, and coastal zones are home.
Illegal, unreported, and unregulated fishing (IUU)	• Various legal frameworks exist, such as the common fisheries policy and measures regarding sustainable management of fishing fleets.
United Nations Sustainable Development Goals (SDGs)	• The SDGs have numerous implications for the marine sector, including e.g. the goals of Zero Hunger, Clean Water and Sanitation, Climate Action, or Life Below Water.
European Institute of Innovation & Technology (EIT)	• Climate KIC, EIT Food and EIT InnoEnergy are all related to the marine sector. • The creation or EIT Marine is among the potential future thematic EIT areas under the 2021-2027 agenda.

Research & Innovation at the intersection with Earth Observation

- **4DANTARCTICA:** Development of state-of-the-art ice-sheet and hydrology models and techniques and algorithms for surface and basal ice melt detection, in order to better understand the Antarctic Ice Sheet's supra and sub-glacial hydrology, its evolution, and its role within the broader ice sheet and ocean systems.
- **Arctic+Salinity:** This ESA project will contribute to reduce the knowledge gap in the characterization of the freshwater flux changes in the Arctic using high-resolution satellite data.
- **BathySent:** Developing a Sentinel-2 based automated method for mapping coastal bathymetry.

- **C-TEP:** Web-based service providing forecast on marine macro litter drift.
- **CERTO:** Harmonised water quality observation service for oceans, lakes, transitional waters.
- **CoastObs:** To develop a service platform for coastal water monitoring with validated products derived from EO.
- **Coastal Bathymetry Mapping (EO4SD):** Uses optical satellite data to estimate water depth.
- **EOMORES:** Operational inland and coastal ecological water quality monitoring, by integrating satellite and in-situ sensors data with cutting-edge numerical modelling.
- **FORCOAST:** Providing information services for high resolution water quality and met-ocean indicators in coastal and nearshore areas.
- **HiSea:** Information services providing high resolution data of water quality at sea.
- **IMMERSE:** Aims at ensuring access to world-class numerical marine modelling tools for the next generation systems of the Copernicus Marine Environment Monitoring Service.
- **IMPRESSIVE:** Developing a platform for real-time management of marine pollution events in the wider area of EU harbours and their vicinities.

Challenges

Numerous are the challenges standing before the Marine sector, and so are the ways of confronting them. For many instances, EO proposes suitable solutions to enhance or substitute, and anyways improve the efficiency of the currently employed methods. Some of the areas which may benefit from EO are considered below.

- Security (maritime piracy and terrorism, border control)
- Environmental concerns and regulations
- Biodiversity (IUU fishing, pollution)
- Food safety (IUU fishing, pollution)
- Traffic (monitoring routes, pollution, oil spills)
- Pandemics and unforeseen global events (impact on many sectors: commerce, tourism, food safety)

Example Earth Observation applications in the marine/maritime value chain

Water quality and algal blooms

Some parameters influencing coastal and inland water quality, such as turbidity and Chlorophyll-a, are easily accessible through EO - alone or in combination with in situ data. An important application is the monitoring and prediction of the spread of harmful algal blooms who can have serious negative consequences on aquaculture, desalination, fishing, and human health.

Vessel detection

EO can be used to detect vessels, when their AIS systems have been disabled. This has many applications, related to pollution from ships, IUU fishing and others. Satellite data, detecting incoming inhospitable objects in near-real-time, combined with other anti-encounter measures taken on the ships, this can greatly increase security against maritime piracy as well.

Oil spills

Satellite data can be used for monitoring oil spills and help assess the damage and prepare at best for taking the appropriate measures. Moreover, by combining information on oil spills and their position relative to vessels, it is possible to find the polluter.

Safe navigation

EO can improve the efficiency and safety *en route*, by, for instance, providing data for rerouting, loss of track, information on ice accumulation on ship route, or on changes in ocean currents. Very high-resolution data can contribute to the localisation of ship debris.

Altimetry

Satellite altimetry data is that it is not dependent on weather conditions. It is always available, making it continuous. Applications like maritime safety, shipping or coastal management require very high-resolution ocean forecasts. Having this level of resolution is only possible with at least 3

Climate/meteorological forecasting

The technical feasibility of using EO data in this domain is for most applications unproven at this point. Estimating spatially detailed characteristics about the high seas requires high resolution data and possibly the integration of in-situ complementary satellite altimeter missions. EO Satellite altimetry data is incapable of getting altimetry data in coastal regions.

sensor data from ships and other vessels.

Examples of enabling technologies

SAR / InSAR

SAR and InSAR are very well-established technologies which have proven to be extremely reliable and precise in its application. They are also fast becoming a technology that more and more huge industrial sectors are relying upon to improve their products and services. SAR is used for detection of oil spills.

Multispectral / Hyperspectral imagery

Multispectral imaging (MSI) and hyperspectral imaging (HSI) allow significant opportunities for entrepreneurs seeking to bring new value-added services onto the market across a large amount of applications, particularly in ocean and coastal monitoring.

In situ observation

In situ instruments can serve as validation and calibration of satellite-borne data, and also as indispensable observation instruments in their own right for multiple water and marine-related functions, such as monitoring water quality parameters, and taking probes around oil spills.

Atmospheric monitoring

Monitoring of emissions and atmospheric constituents is of high importance in today's sustainability focused markets. The likes of Copernicus' Sentinel 5p, with its tropospheric measuring instrument (TROPOMI) is just one example of the possibilities in atmospheric monitoring.

Drones / HAPS

Drones are increasingly used as a source of information that complements data provided by satellite-based remote sensing. Similar benefits of flexibility and connectedness are also attributed to a lesser-known market trend, the "stratosphere drone" or High-Altitude Pseudo-Satellite (HAPS).

Small satellites

Large numbers of smaller satellites ("smallsats") have been launched in recent years. Being cheaper, smallsats come with a shorter lifetime (around 3 years) – but this is a hidden benefit: the capabilities of the constellation as a whole can be upgraded relatively fast.

Relative EO adoption in sector

	medium	

Sectorial Card – Raw Materials

Characterisation of the industry

Raw Materials, in this context, refer to the materials or substances used in the primary production or manufacturing of goods. It primarily encompasses the industry of mining or extracting “non-energy” commodities such as minerals, rock, or metals, and excludes the extraction of oil & gas as well as the management of forestry for wood.

Raw materials encapsulate a large array of primary input materials which play important roles in many sectors such as construction, chemicals, automotive, aerospace, machinery, pharmacy, equipment, renewable energy devices, and defence. In the EU, these sectors have a combined added-value of around €1,000bn and provide employment for some 30 million people. There are many stages and sub-branches along and within the raw materials value chain, from exploration, to extraction, to treatment, to transport and trade. Each of these segments brings with them roles and processes which can be examined and improved through technological developments.

Key policies & Initiatives with industry implications

The following policies and initiatives describe the overarching framework and direction in which the Raw Materials sector is being guided through international and governmental regulation.

Policy / Initiative	Description
United Nations Sustainable Development Goals (SDGs)	A 2016 report named “Mapping Mining to the Sustainable Development Goals” described how mining can help achieve several SDGs by: • Providing opportunities for employment • Creating of new business enterprises • Increasing fiscal revenues • Increase transport infrastructure development Moreover, it described how many of the minerals produced by mining are essential building blocks for technological components, infrastructure, energy, and agriculture.
Raw Materials Initiative (RMI)	In 2008 the EC adopted the RMI which set out a strategy for tackling the issue of access to raw materials in the EU. The strategy has 3 pillars which aim to ensure: • Fair and sustainable supply of raw materials from global markets • Sustainable supply of raw materials within the EU • Resource efficiency and supply of 'secondary raw materials' through recycling
European Innovation Partnership on Raw Materials (EIP)	• In 2008, the RMI stakeholder platform was initiated. • It brings together EU countries, companies, researchers, and NGOs to promote innovation in the raw materials sector. Its primary objective is to help to raise the Raw Materials industry contribution to the EU’s GDP by securing its access to raw materials.

	• Its secondary objective is to play an important role in meeting the objectives of the Commission's flagship initiatives "Innovation Union" and "Resource Efficient Europe" by ensuring the sustainable supply of raw materials to the European economy whilst also increasing benefits for society as a whole.
EIT Raw Materials	• EIT Raw Materials is the largest consortium in the raw materials sector worldwide. • Its mission is to enable sustainable competitiveness of the European minerals, metals, and materials sector along the value chain by driving innovation, education, and entrepreneurship. • It unites more than 120 core and associate partners and 180+ project partners from leading industry, universities, and research institutions.
Action Plan on Critical Raw Materials	• The EC has created a list of critical raw materials (CRMs) which is subject to a regular review and update. • CRMs combine raw materials of high importance to the EU economy and of high risk associated with their supply. • The 2020 list contains 30 materials and charts out a plan towards greater security and sustainability of their supply.

Research & Innovation at the intersection with Earth Observation

- EO4RM **(2019-2020):** The Earth Observation Best Practice for the mining of Raw Materials (EO4RM) project brings together experts from both the Mining and the Earth Observation sector to identify key challenges of the mining sector and suitable solutions drawing from modern and future Earth Observation capabilities.
- RawMatCop **(ongoing):** The RawMatCop Programme from EIT Raw Materials aims to develop skills, expertise, and applications of Copernicus data to the raw materials sector. It is funded in major part by a series of grants from the European Commission (DG GROW).
- Automated Transportation Mining Monitoring **(2020):** ATMM intends to enhance the transparency of local and global coal flows, the service will show the logistic activities and coal volumetric changes in coal harbour areas using satellite-derived observations.
- Goldeneye **(2020-2023):** The project develops an EO and GNSS data acquisition and processing platform for safe, sustainable and cost-efficient mining operations. Data from drones, satellites, and in situ sensors, after processing, will be converted into actionable intelligence to be used for safety, environmental observation, more efficient exploitation and increased extraction.

Challenges

Some of the overarching challenges facing the raw materials sector are listed below.

- **Environmental footprint:** Mining activities can have large carbon and environmental footprints. Reducing these impacts is of vital importance for the sustainability of the sector. Moreover, most of the raw materials we expend today are still less than 1% recyclable, meaning sustainability is a major challenge for the sector.
- **Security of supply**: Many imported raw materials are vulnerable to supply shocks as a result of natural disasters or geo-political tensions.
- **Price volatility:** Market commodity prices constantly fluctuate, meaning trade flows and jobs can be put at risk.
- **Health and safety:** Mining is a dangerous job, ensuring people remain safe is a constant challenge in the sector.

- **Access to energy:** Many mines are forced to operate in more and more remote locations. Connecting to a power grid is a major issue for many operators.
- **Perceived technological barriers:** Within the mining and raw materials sector, the use of cutting-edge technologies can sometimes be seen as only relevant for larger companies who can afford them.

Example Earth Observation applications in the Raw Materials value chain

Exploration

EO can help find new opportunities at abandoned mine sites and map minerals that can be exploited in an economical way. In surface mine operations, drones equipped with hyperspectral cameras can collect images from exposed orebody, helping mine planners update mineable reserves.

Safety monitoring

When applied in mineral extraction, EO can be used to monitor the movement of slopes in open pits, or more complex subsidence patterns can be analysed for deeper operations as it is essential to assure service continuity.

Activity monitoring

Companies are using satellites to try to shed light on activity in the commodity trading world, from coal mine productivity to global copper trading. While doubts remain around the accuracy and consistency of the data, there could come a day when traders can track supply and demand of raw materials, the operations of producers and consumers and even the output of entire economies in near-real time.

Environmental impact monitoring

Mining of metal ores and non-metallic minerals fragments and degrades natural habitats and is often characterised by high levels of water pollution and mining waste production which can extend far beyond the actual boundary of a mining area. Many of these impacts can be detected using available high or very-high resolution satellite imagery.

Illegal mining detection

Detection and monitoring of illegal mining activities is something EO can lend itself to thanks to the all-encompassing nature of the data and the relatively high temporal resolution.

Permitting, licensing and regulatory compliance

Using EO to map land use over large areas as well as the controlling and monitoring of land use permits is seen as a very relevant application. EO can contribute to replacing some of the traditional mapping techniques when it comes to permitting and regulatory compliance monitoring, such as on-site visits.

Examples of enabling technologies

SAR / InSAR

SAR and InSAR are very well-established technologies which have proven to be extremely reliable and precise in their application. SAR/InSAR can be used to help measure ground displacement in proximity to mines for safety monitoring purposes.

Multispectral / Hyperspectral imagery

Through the use of Multispectral imaging (MSI) and hyperspectral imaging (HSI) a variety of minerals present in the earth's crust can be detected, allowing for efficient and geographically widespread mineral exploration.

In situ observation

In situ instruments can serve as validation and calibration of satellite-borne data, and also as observation instruments in their own right for multiple raw materials related functions, including exploration as well as deformation and safety monitoring.

Atmospheric monitoring

Monitoring of emissions and atmospheric constituents is of high importance in today's sustainability focused markets. The likes of Copernicus' Sentinel 5p, with its

Drones

Drones are increasingly used as a source of information that complements data provided by satellite-based remote sensing. Drones in particular can be used as

Small satellites

Large numbers of smaller satellites ("smallsats") have been launched in recent years. Being cheaper, smallsats come with a shorter lifetime (around 3 years) – but this tropospheric measuring instrument (TROPOMI) is just one example of an instrument which can help mining companies in monitoring any potential releases of greenhouse gases associated with their activities.

a low-cost alternative to helicopters for high resolution mine activity and safety morning as well as in exploration activities.

is actually a hidden benefit: the capabilities of the constellation as a whole can be upgraded relatively fast. Smallsats can help drive forward the capabilities of mining related earth observation technologies, providing higher and higher spatial and temporal resolution data.

Relative EO adoption in sector

Sectorial Card – Urban Development

Characterisation of the industry

Currently, ca. 75% of the European Union's population lives in urban areas. 68% of the world population is projected to so by 2050. More than 80% of global GDP is generated in cities. Thus, their contribution to the world's economy is crucial. Yet, constant growth exposes these areas to more risks coming from e.g. natural disasters, pandemics, or the effects of unsustainable sprawl, energy usage, or waste production. Urbanisation brings with it challenges as regards e.g. availability of suitable services and infrastructure, health and wellbeing of citizens, environmental degradation, availability and quality of housing, provision of suitable means of mobility, or social inequalities. With these challenges comes the demand for new solutions to plan, develop, and operate urban areas efficiently and sustainably. City planners are in need of solutions that allow monitoring of assets and conditions as well as forecasting possible future developments and impacts. The transition towards Smart Cities could provide such solutions through the use of (big) data and ICT. EO solutions could provide both various types of data as well as means to process data and to integrate resulting information in applications for monitoring, decision-making, or policy-enforcement.

Key policies & Initiatives with industry implications

The following policies and initiatives are examples that describe the overarching framework and direction in which the Urban Development sector is being guided through international, European, and governmental regulation.

Policy / Initiative	Description
United Nations Sustainable Development Goals (SDGs)	• **SDG3: Good Health and Well-being:** living conditions in urban areas, including e.g. air quality or availability of green spaces, have a significant impact on citizens' health and well-being • **SDG11: Sustainable cities and communities:** access to public transport, open spaces, and quality of air are some of the crucial factors for quality of life and environmental sustainability in urban areas
OECD Principles on Urban Policy	• Aiming at adaptation of a coherent, integrated and effective strategy to build smart, sustainable and inclusive cities • Co-developed with international organisations, development banks, networks of cities and local governments, research institutes and academia, and private sector actors • Implementation supported through the Athens Pledge
Regional Development and Cohesion Policy 2021-2027	• Supports locally-led development strategies and sustainable urban development across the EU • 6% of the European Regional Development Fund is dedicated to sustainable urban development • The new European Urban Initiative further supports the urban dimension as a new networking and capacity-building programme for urban authorities

Urban agenda for the EU	• Supports development of action plans (e.g. on legislation, funding programmes, best practice sharing) through partnerships between the Commission, EU organisations, national governments, local authorities, and NGOs • Priority themes include air quality, circular economy, climate adaptation, culture and heritage, digital transition, energy transition, housing, inclusion, public procurement jobs and skills, sustainable use of land and nature-based solutions, urban mobility, and poverty

Research & Innovation at the intersection with Earth Observation

- **EO4SD-Urban:** aimed at deriving key geo-information products from Earth Observation data in support of urban development programmes, implemented by a Consortium of EO Service Providers and Research Organisations
- **LandSense:** aggregates innovative EO technologies, mobile devices, community-based environmental monitoring, data collection, interpretation and information delivery systems to empower communities to monitor and report on their environment
- **So2Sat:** fuses remote sensing data from diverse sensors incl. EO satellites with massive data from GIS and social media to map 3D urban infrastructures and their evolution over time, i.e. 4D, in high resolution and on a global scale
- **SMURBS:** aims to increase urban resilience targeting challenges with respect to air quality, urban growth, natural/manmade disasters and relevant impacts and more entangled issues such as the migrant crisis and the health implications of such environmental pressures via means of Earth Observation
- **CURE:** is developing cross-cutting applications among Copernicus Core Services to address urban resilience, coping with the required scale through the exploitation of third-party data, in-situ observations and modelling, as appropriate
- **AI4SmartCities:** generates professional solutions for very high resolution geospatial and social–economic indicators for smart city planning and management by extending AI algorithms and big Earth Observation data management properties to very high resolution data for smart city solutions

Challenges

Some of the overarching challenges facing the Urban Development sector are listed below.

- **Growing population** in urban areas
- **Climate change** affecting urban **resilience** and **health** of citizens
- Increasing **digitalisation** as a requirement for a transition towards **smart cities**
- Functioning **urban mobility** providing efficient, affordable, and sustainable access to transportation

Example Earth Observation applications in the Urban Development value chain

Air quality monitoring

Satellite observations combined with non-satellite observations can be utilised for monitoring air quality (e.g. pollutants or particles such as NO_2, CO, CO_2, PM2.5), enabling e.g. citizens, municipalities, or health authorities to act upon the provided information. Such information can be integrated in consumer solutions as well as in urban planning

Urban Heat Islands

Due to human activities, urban heat islands can occur that are significantly warmer than surrounding urban areas. EO can support mapping temperatures and temperature variations across urban areas, e.g. as a means to alert citizens or health authorities of related risks for specific demographic groups.

Urban modelling & Digital Twins

EO data can be facilitated to create detailed 3D maps of urban areas, ultimately – through fusion with other data – enabling the creation of Digital Twins of e.g. whole cities. These can be utilised to perform high-precision simulations on a number of aspects (mobility, pollution, civil protection, etc.), e.g. for improved planning, predictions, applications. Citizens can be involved in the measuring efforts, acting as citizen scientists equipped with in situ sensors.

Urban Greening

Green spaces in urban areas contribute to local climate, air quality, and wellbeing of citizens. EO can map urban green, e.g. to promote its use, to monitor its conditions, or to support planning ensuring proximity to the population.

or contributing to policy-making and implementation.

Examples of enabling technologies

SAR / InSAR

SAR and InSAR are very well-established technologies which have proven to be extremely reliable and precise in their application. SAR/InSAR can be used to help measure ground instability issues either prior to construction or for monitoring of e.g. roads, tunnels, or pipelines.

Multispectral / Hyperspectral imagery

Through the use of Multispectral imaging (MSI) and hyperspectral imaging (HSI) a variety of plants can be classified, allowing for efficient and geographically widespread vegetation management.

In situ observation

In situ instruments can serve as primary source or for validation and calibration of satellite-borne data. Sensors in urban areas could measure e.g. temperature, air quality, or the intensity of use and condition of urban infrastructure.

Drones

Drones are increasingly used as a source of information that complements data provided by satellite-based remote sensing. They can be a low-cost alternative to helicopters for inspection of urban assets. Beyond Visual Line of Sight (BVLOS) approaches – AI-enabled obstacle avoidance – allow for close inspections in difficult-to-reach areas such as under bridges or in tunnels.

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