esa

SPACE SOLUTIONS

# GREEN DOSSIER


→ THE EUROPEAN SPACE AGENCY

# ABOUT THIS REPORT

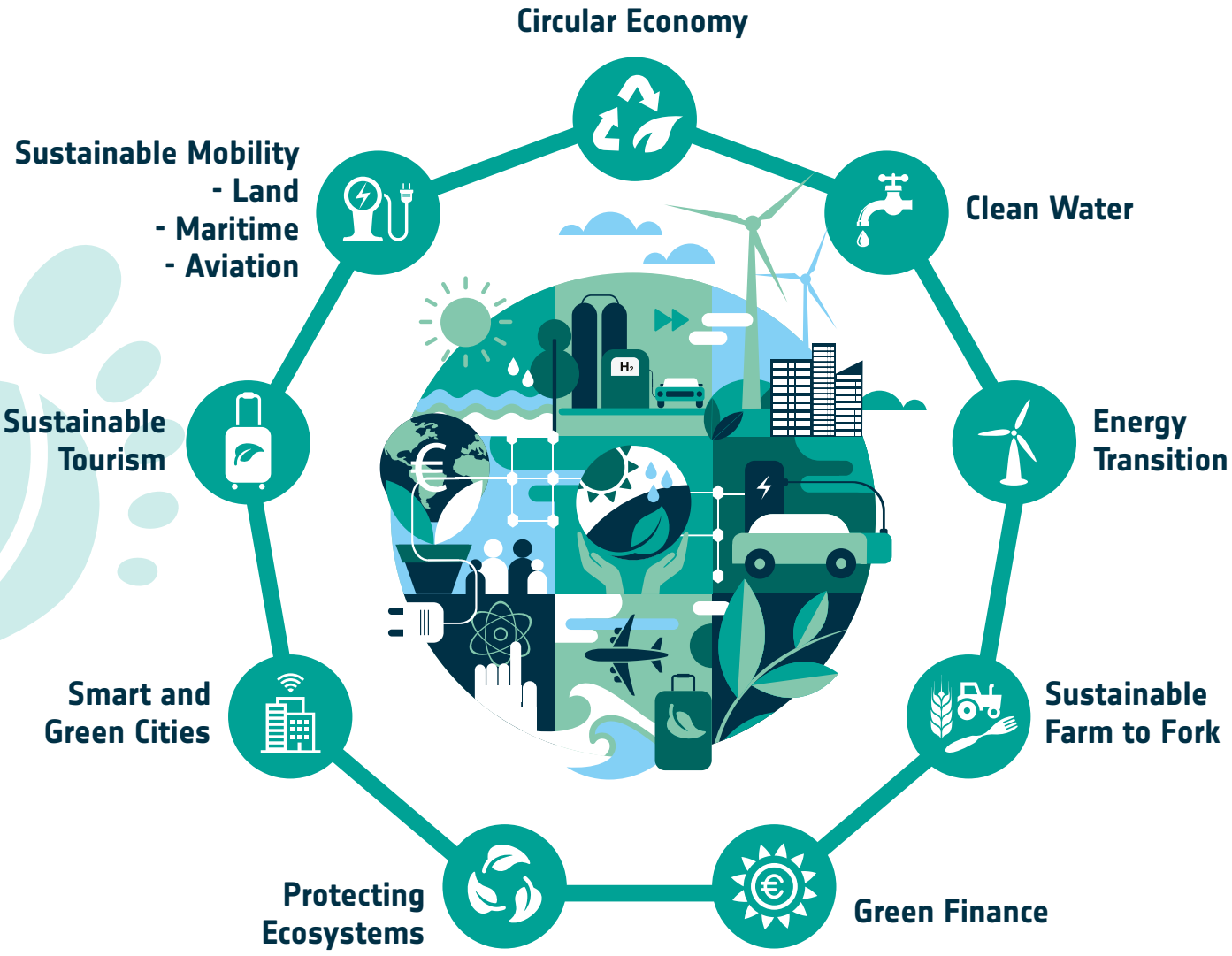
Climate change is one of the most urgent and complex challenges of our time. It affects every aspect of life on Earth and requires fundamental transformations in our society and economy. To achieve a more sustainable and resilient future, we need to harness the power of innovation and technology, and to collaborate across sectors and borders.

Tackling climate change through sustainable development is a priority for the European Space Agency (ESA); space-based solutions have a vital role to play in the transition to a net-zero world. At the same time, the space sector itself has a responsibility to advance in a sustainable way.

This report presents the ways in which sustainable space and satellite applications have contributed to green objectives through ESA's Business Applications and Space Solutions (BASS) programme since 2010 and looks at the path ahead.

# GREEN TOPICS IN THIS REPORT

This report organises the activities based on the following topics:



# CONTENTS

# SPACE FOR A GREEN TRANSITION

## Green Space-Based Applications

Satellite applications help tackle environmental challenges and support sustainable development across every industrial sector. The green transition now drives almost half of all ESA BASS activities, with over 183 million EUR invested (103 million EUR from ESA and 80 million EUR from industry) into more than 300 green activities since 2010. This report draws upon data from those green space-based application activities (studies and projects) that were supported by BASS and that have delivered tangible environmental benefits.

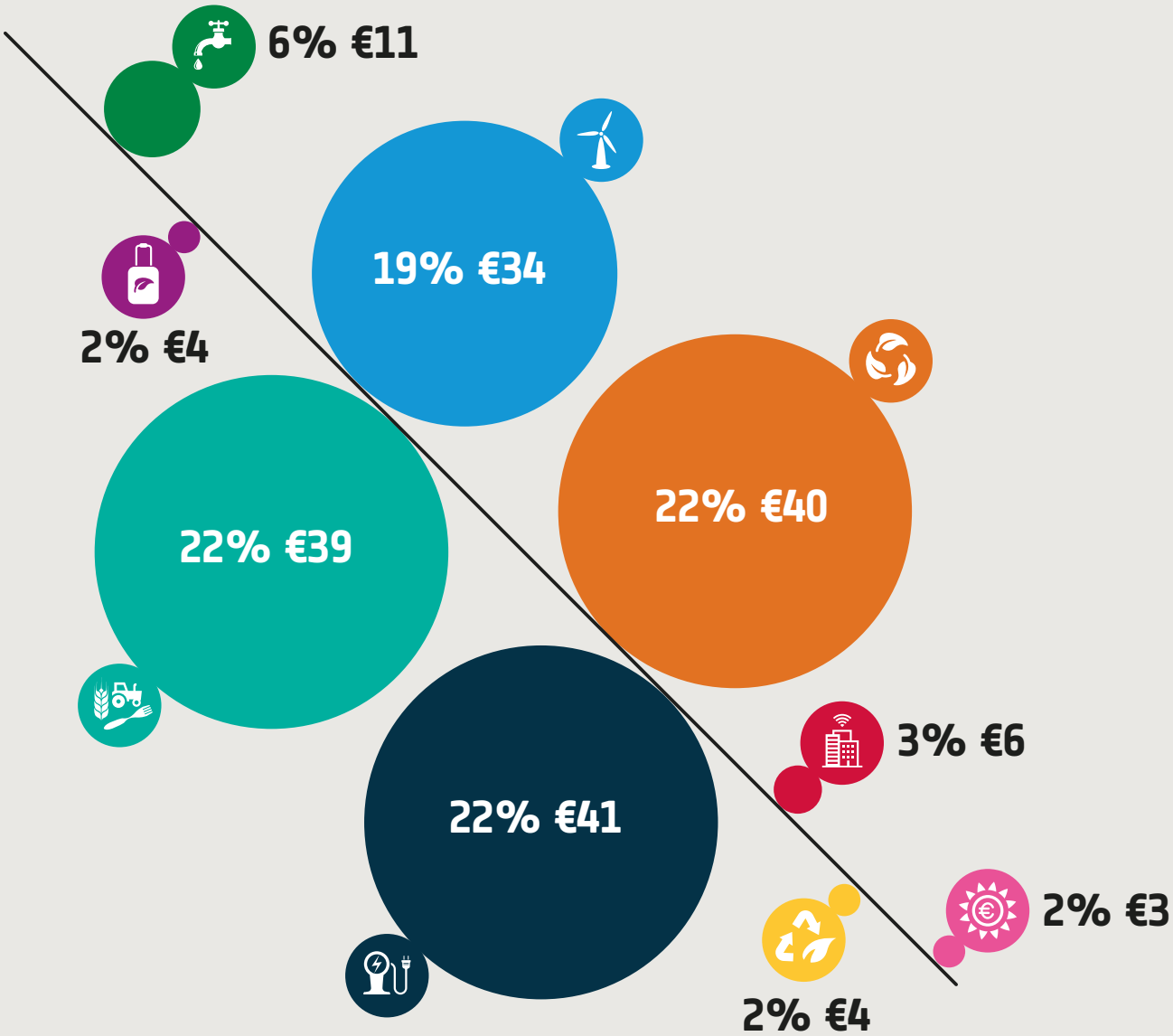
## Investment in Green Activities

With the use of space-based services, ESA, Member States and industry are working together to develop solutions that help us live and work more sustainably and enabling market sectors such as energy and mobility to accelerate their path towards carbon neutrality.

## Environmental Sustainability Impact

Ensuring that ESA-backed projects and activities are sustainable and have a positive impact on the environment is essential. Around 50% of all projects carried out under the Business Applications and Space Solutions (BASS) programme are driven by the green transition and this figure continues to rise. The positive impact of space on Earth spans multiple fields, including biodiversity, air and water quality and global decarbonisation, to name but a few.

## INVESTMENT IN GREEN ACTIVITIES SINCE 2010




- Energy Transition
- Circular Economy
- Smart and Green Cities
- Sustainable Mobility
- Sustainable Farm to Fork
- Clean Water
- Protecting Ecosystems
- Green Finance
- Sustainable Tourism

# CIRCULAR ECONOMY

A linear economy is based on mass production and disposable products where society extracts resources, manufactures products, uses them and then throws them away. In a circular economy on the other hand, resources are circulated for as long as possible; they are used, reused, repaired, re-purposed, and recycled, with minimal waste generation.

## KEY CHALLENGES

**Too Much Waste**
The growing world population currently generates over two billion tonnes of waste per year, which is more than society can properly process or recycle, (worldbank.org).

**Poor Waste Management**
At least one third of generated waste is handled in an environmentally-unsafe way, leading to environmental tragedies such as ocean pollution, and geopolitical tensions as wealthier nations ship waste overseas to developing countries (worldbank.org).

**Unsustainable Consumption**
Since so much is wasted, society extracts unsustainable quantities of natural resources to keep pace with growing consumption.

## SPACE FOR A GREEN TRANSITION

**Satcom** enables communication between central hubs and isolated locations, where little or no terrestrial network is available; this is key for supply chain operations and in the collection and processing of materials in remote places.

**Satnav** can track and trace goods along the supply chain, helping optimise efficiency and match supply to demand more accurately. This minimises the risk of goods such as food and pharmaceutical items expiring. Satnav can enable lifetime monitoring of a product from manufacture to disassembly, ensuring that re-usable and recyclable elements are not wasted. Improved mapping and tracking services could improve household waste collection systems to maximise recycling.

**SatEO** monitors environmental changes, which can help reduce the amount of water and chemicals used in the production of certain goods (e.g. in the agriculture and textiles industries).

## SHOWCASE

### EYES ON PLASTIC

Eyes on Plastic is a project aimed at providing information to waste collectors that will help them remove up to 60 tonnes of plastic per day from bodies of water.

The project models and geo-localises waste slicks to determine their drift using Earth observations data. The service is being developed by EOMAP in Germany and will be trialled in Brazil, Indonesia and Italy, in collaboration with environmental agency One Earth – One Ocean, energy company ENEL, the municipality of Genoa and The SeaCleaners

## WHAT'S NEXT?

ESA is exploring different options for using space-based data and other novel technologies to facilitate the re-use of resources and the minimisation of waste. Various initiatives have recently been launched including the Kick-start Waste to Energy call, aimed at developing services to support the production of heat and electricity starting from non-reusable and non-recycling waste. Proposed services will target waste identification services, digitisation of waste (IoT), routing services & landfill monitoring.

Further initiatives include Space for Sustainable Pharma, a funding opportunity looking at potential products and services that will reduce the impact of the pharmaceutical industry on the environment, from the manufacturing process through to waste disposal. Also in the pipeline is the Space for Sustainable Textiles initiative, where ESA has been working with major players in the retail and environment sectors to identify areas for new applications around protecting water sources, traceability and ecosystem protection to ensure a sustainable textile supply chain.

## PARTNERSHIPS

**Power for Planet (PFP)**

PFP is a consulting company that extracts power from waste projects to deliver green power. A Non-Disclosure Agreement (NDA) has been signed between ESA and PFP. The information exchanges between ESA and PFP have supported the definition of the use cases captured in the "Waste to Energy" thematic Kick-Start call for proposals.

# CLEAN WATER

Substantial progress has been made in increasing access to clean drinking water and sanitation, but continued improvement is necessary: billions of people worldwide, mostly in rural areas, do not have access to these basic services. Clean water is not only essential for life and the environment, but also for industry, which uses around 19% of all freshwater worldwide[1], with all industries relying on water in some way.

The facts surrounding clean water are shocking. Over 80% of human wastewater is discharged into rivers and seas without pollution removal.[2] Water scarcity affects more than 40% of the global population, and an ever-increasing world population could push society towards a global water crisis.

Good-quality and well-managed water resources and water supply services, as well as disaster mitigation practices, are essential for providing safe and secure water. Solutions are especially needed to progress conventional water and wastewater systems into instrumented, interconnected and intelligent systems.

## KEY CHALLENGES

**Industry**
Any change to clean water availability has an impact on supply chains in four key areas: access to raw materials, supply, direct operations and product use.

**Monitoring**
In order to fully understand the situation and make informed decisions about water, constant monitoring of water basins, water quality and water pollution is necessary to provide accurate, up-to-date information. Challenges in monitoring water have previously led to incomplete, inconsistent, dispersed, or outdated data.

**Emergency Management**
Drought and flood prediction and management systems play a crucial role in ensuring prompt responses to extreme weather events and natural disasters.

[1] mckinsey.com
[2] Wastewater Pollution: Turning a Critical Problem into Opportunity (nature.org)

## SPACE FOR A GREEN TRANSITION

**Satcom** connects data captured in water basins to decision-makers more efficiently. 5G-Satcom connectivity and nanosat networks could enable IoT water monitoring applications. Additionally, Satcom could be used as a primary or reserve means for operating autonomous vehicles Beyond Visual Line of Sight.

5G-Satcom connectivity and nanosat networks could extend the IoT water monitoring capacity at greater distances from existing water stations. It could also increase its monitoring capacity beyond locations that are already monitored such as weirs, providing real time data which could help prevent floods or other sudden events.

**SatEO**. Environmental and weather data provide deeper insights on water quality and the concentration of pollutants within water. SatEO data, including next generation nanosatellite and CubeSat networks, have the potential to monitor water security and the resilience of water basins.

**Satnav** offers precise positioning, navigation and timing information for in-situ data. Satnav is also key in the navigation and tracking of autonomous vehicles, which can assist in marine data collection.

## SHOWCASE

### MATEREOSPACE


The Undersee service provided by Portuguese company Matereospace improves water quality monitoring in marine environments. With the use of Sentinel-2 and Sentinel-3 datasets, Undersee supports environmental agencies and aquacultural producers in accessing water data and forecasts, such as temperature and chlorophyll-a concentrations. Undersee can alert service users when thresholds are reached or anticipated risks are foreseen. These alerts helped aquaculture producers take preventive actions, reducing stock losses by up to 270k EUR/year.

# PARTNERSHIPS

**CEO Water Mandate**

ESA and the UN Global Compact CEO Water Mandate have signed a Memorandum of Intent to address global water challenges by promoting the development of space-enabled applications for purposeful innovation. The CEO Water Mandate heads the CEO-led, industry-driven Water Resilience Coalition (WRC) initiative, which includes companies such as the Cola-Cola Company, HEINEKEN, Levi Strauss & Co., Bayer, Colgate, 3M, Gap Inc and Microsoft. Together, the CEO-Water Mandate and WRC are investing in new technologies related to water conservation, waste-water treatment and sanitation.

# WHAT'S NEXT?

ESA launched the Digitising Water Resilience fixed call for proposals in partnership with the CEO Water Resilience and WRC to address the global water crisis in its three dimensions: availability, quality, and accessibility. The call is part of a long-term plan to roll out water resilience services that will improve the impact of the sustainability actions carried out by high-profile companies collaborating in the initiative and improve the status of 100 priority water-stressed basins by 2030.

# ENERGY

The energy sector is the world's biggest contributor to greenhouse gas emissions[3]. Several countries have begun decarbonising the energy sector, a process that requires a huge transformation in the methods of energy production, transportation and usage. The traditional centralised organisation of the energy system is now facing a paradigm shift to distributed and renewable energy.

The most effective way to facilitate the transition to green energy is to replace carbon-based fuels with renewable resources such as solar, wind and hydro power.

[3] Facts and Figures | United Nations

## KEY CHALLENGES

**Fossil Fuel Reliance**
Countries around the world continue to rely heavily on fossil fuels. Decarbonisation not only means replacing fossil fuels, but also requires the development of new scalable, dependable, ecologically viable and affordable ways to meet increasing demand for electricity.

**Logistics**
Renewables require significant investment, innovation, and planning. Logistical challenges and insufficient infrastructure can impede the development of a renewable-powered economy.

**Geopolitical challenges**
Western countries have become increasingly reliant on imported energy, making them vulnerable to geopolitical emergencies. The need to accelerate self-sufficiency could also drive the transition to more ecologically-viable power systems that depend on a less globalised network.

# SPACE FOR A GREEN TRANSITION

In order to increase sustainability in the energy sector, data is key. Combining datasets from Earth and satellites, offers greater potential to make informed, environmentally-friendly decisions.

**Satcom** can accelerate grid modernisation towards smart(er) grids by helping to implement real-time monitoring and control of the grid and its nodes, which are often in remote locations.

**SatEO** data and non-space data can provide comprehensive, accurate and actionable information to decision makers for decarbonisation. This enables enhanced insights based on next generation “what-if” analyses on both a global and local scale.

**SatNav** can be used to locate emissions measurements and to pinpoint sources of greatest emission generation. Positioning information also provides geo-tagging services for data collection.

# SHOWCASE

## SNOW POWER

SnowPower, a service developed by German company EOMAP GmbH and supported by ENEL, combines Earth observation satellite data and algorithms to deliver detailed information on snow depth and snow water equivalent (the volume of water packed into a snow layer). Both types of data are important for snow modelling, a key factor in hydropower operation. SnowPower is poised to transform the management of hydropower plants in hard-to-reach mountain regions, converting satellite data into actionable snow-related information in a simple and effective format.

The commercial promise shown by SnowPower's innovative space-based solution is coupled with socio-economic and sustainability returns: the project will improve the efficiency of hydro energy production, while minimising the impact of floods through improved forecasting, and reducing the carbon footprint through the development of affordable and clean energy.

# WHAT'S NEXT?

The Task Force for Innovation in Energy Through Space Energy Task Force was the first Task Force to be established as part of the ESA BASS programme. It is delivering concrete actions with contributions to inform calls for proposals, including Space for Infrastructure. New initiatives such as the commercial application of space-enabled robotics, new opportunities around green hydrogen and other novel projects are also taking shape.

# PARTNERSHIPS

### The Task Force for Innovation in Energy Through Space (Energy Task Force)

Inspired by the success of ESA BASS initiatives in the energy sector, the Task Force for Innovation in Energy Through Space (Energy Task Force) was launched in October 2022 in collaboration with eight international energy organisations. The Energy Task Force will use space assets and data to develop innovative services that foster a clean, green energy ecosystem.

**Energy Task Force**

These founding members have been recently joined by DENA, E.ON, Elia Group, ENEL and Friends of Sustainable Grids with more in the pipeline.

# SUSTAINABLE FARM TO FORK

Food scarcity and farming challenges continue to increase with a growing global population and shifting weather patterns resulting from climate change. The situation is complex – agriculture is extremely vulnerable to shifts in the climate but is also a major contributor to the climate problem.

Nitrogen is an essential element for plant growth and reproduction. However, the application of organic or synthetic nitrogen-rich fertilisers leads to the emission of nitrous oxide, $N_2O$, which has a global warming potential roughly 300 times more potent than $CO_2$[4] and currently generates 19-29% of greenhouse gas emissions, (unep.org). Soil, on the other hand, plays a fundamental part in carbon sequestration, which is the process of gathering and storing carbon dioxide from the Earth's atmosphere. There is no one-size-fits-all solution; farming practices, needs and vulnerabilities vary according to the ecosystem and geographical area.

## KEY CHALLENGES

**Reduced Production**

In many parts of the world, crop yields are levelling off. Declining ocean health and a reduction in natural resources – including soil, water, and biodiversity – make it harder to increase food production.

**Contributing Factors**

Many factors are contributing to a reduction in crop yields. These include rising temperatures, weather variability and increasingly frequent extreme weather events, shifting agro-ecosystem boundaries and invasive crops and pests.

# SPACE FOR A GREEN TRANSITION

Space-based solutions have proven to be instrumental in improving how we use our natural resources. The combination of data collected from satellites and technology here on Earth helps to reduce the use of pesticides and to protect biodiversity, water bodies and soil conditions.

At the same time, space-based solutions help farmers reduce their operational costs without decreasing the quantity and quality of their yield. In some cases, by optimising their nitrogen fertiliser usage, the farmers have been able to increase their yield.

[4] Four reasons why the world needs to limit nitrogen pollution (unep.org)

**SatEO** helps monitoring carbon sequestration, forecast food supply availability and manage water scarcity on farms.

**Satnav** can track herd and flock movement, navigate autonomous harvesting machines and improve the performance of delicate tasks such as fruit harvesting.

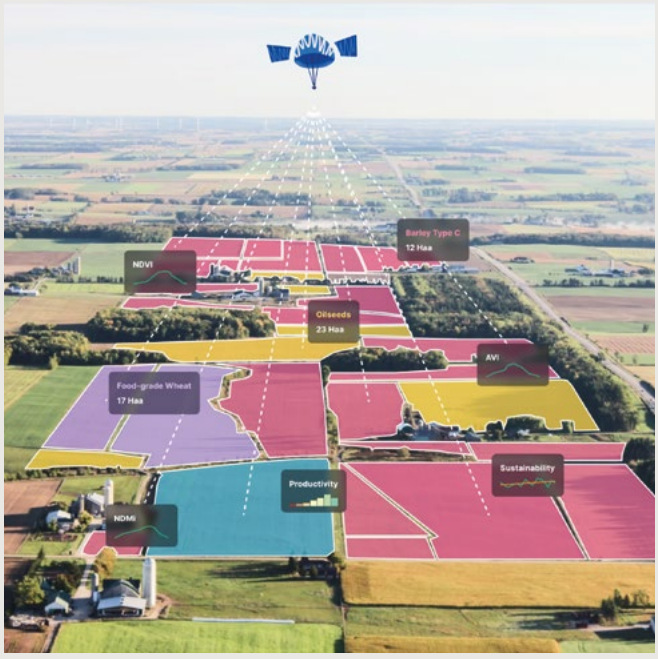
The role of narrowband data collection from local sensors, known as Satellite IoT, is well recognised in the food production industry, especially for remote fields. It is expected to grow significantly due to increasing needs from precision agriculture and the availability of new satellite-based services.

Unlike narrowband IoT, the use of broadband satellite communications within food production remains limited. In some areas, it is the only way to provide access to farming applications such as farm management systems and specialised online services.

## SHOWCASE

### CROPCLOUD

Norwegian agritech company DigiFarm created CropCloud, a programme that supplies highly accurate crop-field analyses. CropCloud uses artificial intelligence (AI) and satellite imagery from the ESA-developed Copernicus Sentinel-2 mission to provide accurate information on field boundaries and seeded acres. This in-season crop-field analysis reduced farmers' costs by 15% and increased their yield by up to 10%.



# WHAT'S NEXT?

ESA BASS is bringing key players together to form the Bioeconomy Task Force, which will focus on facilitating the sustainable use of natural resources. By developing economically and environmentally sustainable applications, this new Task Force aims to help Europe accelerate progress towards a circular and low carbon economy. The focus will be on implementing initiatives around sustainable forestry and sustainable textiles, as well as agriculture, fisheries and waste management

# PARTNERSHIPS

**Copa Cogeca**

Copa Cogeca are the united voice of farmers and agri-cooperatives in the EU. They ensure that EU agriculture is sustainable, innovative and competitive, while guaranteeing food security for 500 million people throughout Europe. Copa represents over 22 million farmers and their family members whilst Cogeca represents the interests of 22,000 agri-cooperatives. They work to deliver the type of agricultural products that European citizens expect and demand, with a market-oriented agriculture model that provides the highest level of food safety, sustainability, welfare standards and plant and animal health.

Copa Cogeca and ESA have signed a Memorandum of Intent to support the sustainable transformation of farms and the agri-food sectors through the usage of space technology.

Initiatives supporting the development of services focused on optimising agricultural practices that minimise negative environmental impacts are already being explored. These services will decrease soil degradation, water depletion and contamination, inefficient energy use and loss of biodiversity. Information about current Open Calls can be found here.

# GREEN FINANCE

The consideration of environmental, social and governance factors when companies make financial investment decisions is known as green finance, or sustainable finance.[5] Finance is recognised as part of the solution in the transition to a low carbon, more resource-efficient and sustainable economy.[6]

Companies, particularly those in the energy, utilities, agriculture or food sectors, must consider the impact of climate change on their businesses. Supply chains and assets, such as properties or equipment, can be negatively impacted by harsh or unexpected weather conditions. Financial institutions that support these companies, such as banks, investors, asset managers or insurers are becoming more aware of the increased risk exposure to their assets from climate change.

[5] Finance – European Commission (europa.eu)
[6] https://unfccc.int/process-and-meetings/the-paris-agreement/the-glasgow-climate-pact/cop26-outcomes-finance-for-climate-adaptation

## KEY CHALLENGES

**Securing Funding**
Industries need sufficient funding to transition to more sustainable business models, and more resilient asset bases and supply chains. Solutions prioritising internal investment needs, efficient planning, progress and impact reporting are essential for companies, investors and stakeholders.

**Developing Services**
Cultivating the growing interest in environmental, social and governance products relies on funding and developing applicable services. Corporate disclosure of climate-related information, for example, has made green finance relevant to a much wider market.

**Access to Data**
For investors such as asset managers or banks, understanding and avoiding physical risk exposure is an important challenge. This can relate to property values, non-performing loans and credit losses, or the volatility of financial instruments. Physical risk assessments require data around counterparty assets location, resiliency plans, expected impacts, regional weather, vulnerability to physical risks, granular forecasting maps for flood, hurricane and wildfire risks, and vulnerability to droughts.

# SPACE FOR A GREEN TRANSITION

**SatEO.** The use of Earth observation data can help to solve the most complex challenges, such as monitoring greenhouse gas emissions, understanding the extent of oil spills, deforestation and flooding.

**Satcom.** Widespread connectivity from integrated terrestrial and satellite communications makes it possible to relay data collected by in-situ sensors in remote areas. 5G integrated satellite and terrestrial communication networks can connect local sensors and weather stations to the data analysis servers.

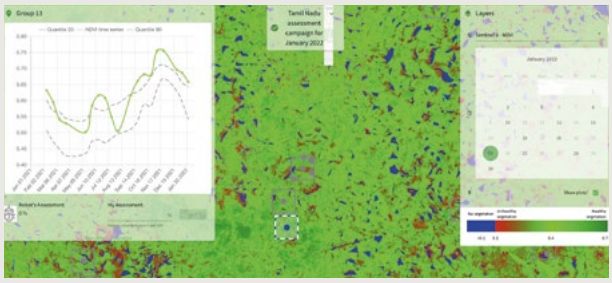
**Satnav.** Global navigation satellite systems can provide precise positioning and timing information, e.g., to locate assets, geo-tag data collected by in-situ sensors such as IoT devices, or to timestamp information. Geo-located information collected from IoT sensors measuring levels of pollutants in the air is processed through data analytics allowing the identification of the source of the emissions.

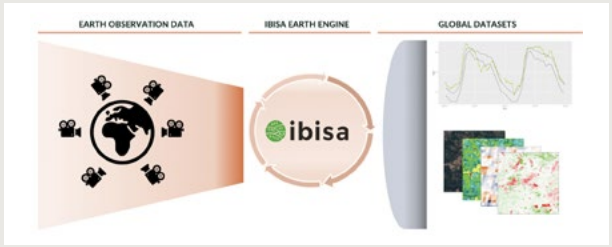
# SHOWCASE

## IBISA

Despite producing 70% of the world's food supply, more than 500 million farmers lack access to insurance for their fields, leaving them completely exposed to weather risks.[7], Traditionally, insurance companies have avoided the agricultural micro-insurance market because of prohibitive costs and complexity in distribution, administration and claims handling.

Lithuanian company IBISA developed the IBISA platform, which uses satellite data to enable mutuals and insurers to define, distribute, and manage parametric insurance products for agriculture. Their service provides insurance to more than 200,000 policy holders in India, Senegal and the Philippines, with the aim of expanding to other countries in the future.






[7] Smallholder market support | World Food Programme (wfp.org)

## PARTNERSHIPS

ESA is in partnership with the Centre for Greening Finance and Investment (CGFI), further emphasising the increasing importance of green finance in broader decarbonisation and sustainability efforts. Companies across various industries require financial support to transition to more sustainable business models and achieve net-zero targets. Simultaneously, the growing allocation of financial resources towards sustainable initiatives necessitates a thorough understanding of the environmental impact and performance of various projects. As a result, financial institutions are seeking to integrate sustainability considerations into their decision-making processes.

CGFI, a research and innovation centre funded by the Natural Research Council in the UK, aims to integrate the financial risks associated with climate and environmental change into mainstream financial decision-making. Comprising a consortium of research organisations led by the Oxford Sustainable Finance Group at the University of Oxford, CGFI provides comprehensive support to organisations that seek to effectively manage climate risks and optimise their environmental impact.

## WHAT'S NEXT?

Stakeholders from the financial sector (e.g. banks and investors) will be part of the Bioeconomy Task Force, providing early access to innovative and sustainable solutions. The Task Force will facilitate the involvement and financial support of stakeholders at different stages of project concept maturity, either at the seed ideas or (pre) operational services stages.

# PROTECTING ECOSYSTEMS

Biodiversity – the variety of ecosystems, species and genes in the world or in a particular habitat – is essential to the well-being of all life and intrinsically linked to water resources[8]. Biodiversity is crucial for ecosystem services – services that nature supplies – such as pollination, climate regulation, flood protection, soil fertility and the production of food, fuel, fibre and medicines. Biodiversity also delivers services that sustain our economies and societies. A lack of water causes stress on species which eventually leads to biodiversity loss. This means protecting water resources is not only vital for life but is also an effective way of conserving biodiversity.

## KEY CHALLENGES

**Agriculture**

Improper agricultural practices are the largest contributor to biodiversity loss and the biggest driver of deforestation. The impacts of poor farming practices are compounded by an ever-increasing global population. These practices can destroy biodiversity by converting natural habitats to intensely managed systems, and releasing pollutants, including greenhouses gases.[9]

**Overfishing**

Technological developments over the past few decades have enabled humans to fish more than ever before. This has led to overfishing, when fish are removed from the ocean on a massive scale. Overfishing, by-catch and ghost fishing and habitat destruction are all key causes of ecosystem collapse in many aquatic systems. This has led to the loss of valuable ecosystem services provided by coral reefs, such as coastal protection and revenue through tourism.

**Transportation Infrastructure**

Transportation networks can also harm biodiversity. Mountainous regions, coastal zones and seas can be particularly vulnerable to pollution from transport. Transport corridors through Alpine valleys are essential for the European economy, but also exert pressure on unique ecosystems. Certain pollutants, such as ground-level ozone from vehicle emissions, are known to lower crop yields, affect tree growth and cause acidification in lakes.

[8] eea.europa.eu

[9] 5 key drivers of the nature crisis (unep.org)

# SPACE FOR A GREEN TRANSITION

Depending on the crop, the application of space-based services to maximise efficiency in the use of water bodies has already reduced the amount of water used by 11-20%.

**Satcom** offers reliable connectivity to remote farms, open ocean, and other regions with insufficient terrestrial coverage.

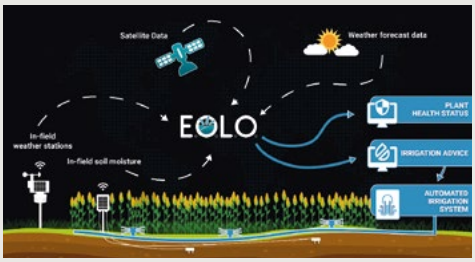
Satcom remote sensors can be used in water to detect pollution levels and also used in soil, where they can determine the soil carbon status through the collection of real-time data. Data can also be collected on biophysical and biochemical vegetation, covering large geographical areas over long periods of time. This can support more sustainable natural capital management practices.

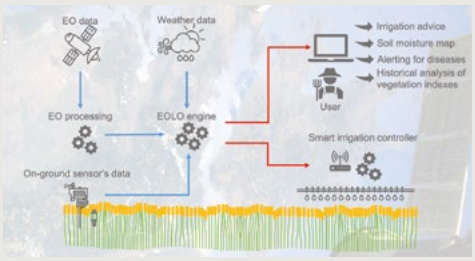
**SatEO** provides valuable insights for water management and crop monitoring, enabling farmers to optimise irrigation practices and conserve water resources. This data also helps to identify suitable locations for land development, while tracking changes in plant diversity and land cover disturbances.

**Satnav** helps track livestock movement and behaviour and route vehicles and ships along green corridors. It also provides better geophysical and hydrographic survey data for monitoring bodies of water, simultaneously reducing the associated carbon footprint of the surveying process.

## SHOWCASE

### EOLO




EOLO, a project carried out by Italian company Bluetentacles, is an automated irrigation service powered by Earth observation data and local soil samples to reduce the amount of water used for crop cultivation.

EOLO provides soil moisture maps and vegetation index maps to help farmers gain a better understanding of how much water their field needs. EOLO irrigation management has led to 16% water savings on average, compared to traditional irrigation, while maintaining the yield.

## WHAT'S NEXT?

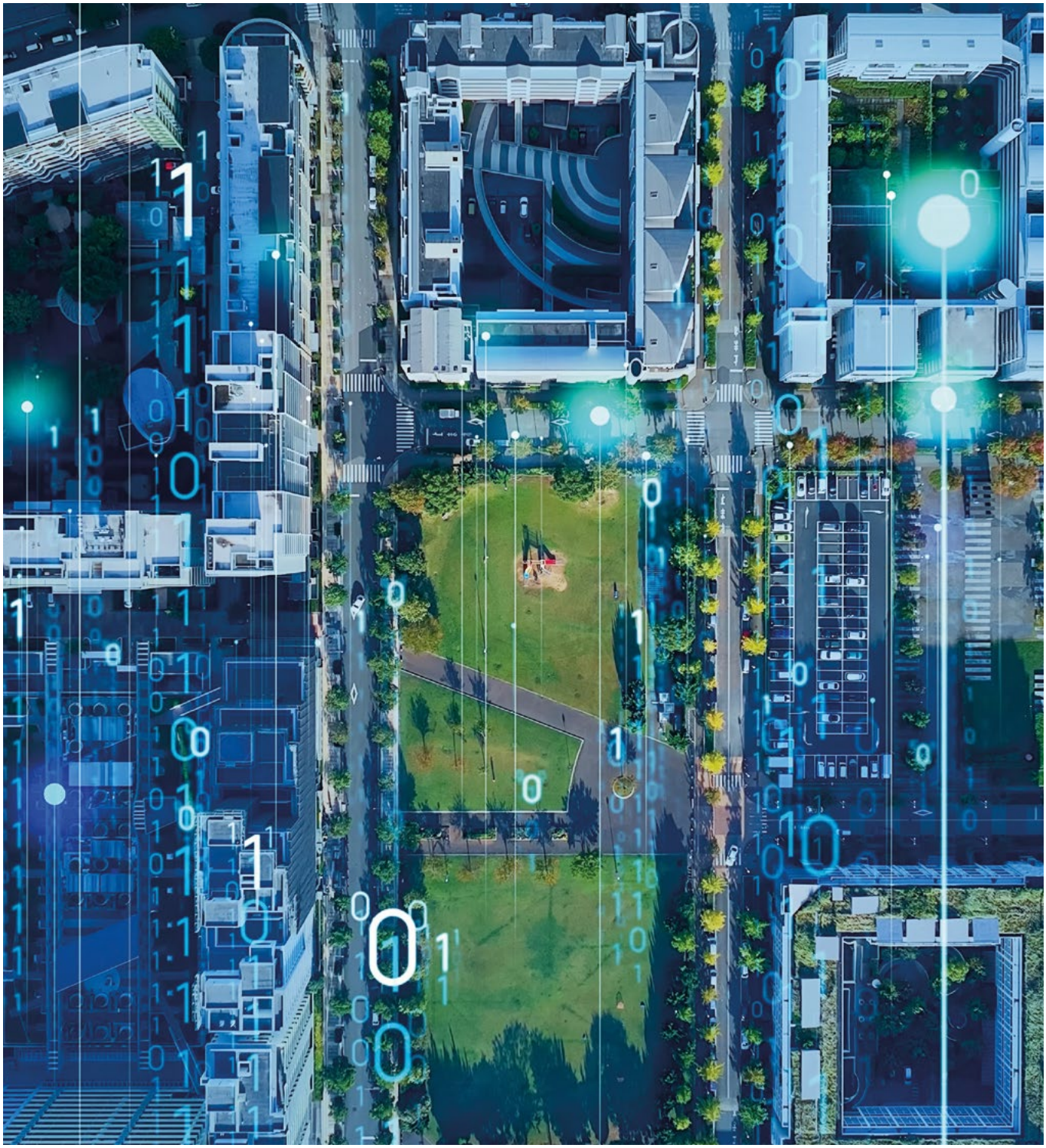
The ESA BASS Blue Capital call for proposals focuses on three use cases:

- Monitoring coastlines and marine ecosystems
- Developing sustainable aquaculture and fisheries
- Creating financial mechanisms to support sustainable blue ecosystems

BASS is exploring new methods to promote innovation, accelerate business growth and support businesses in scaling up and expanding their portfolios. ESA is collaborating with accelerators such as Plug & Play and VeniSIA to develop sustainable solutions for the Blue Economy. Italian accelerator Faros and BASS, promoted by Venture Capital SGR, are successfully supporting companies wanting to develop innovative sustainable solutions for the Blue Economy.

These accelerators provide support to startups through incubation, helping them to develop business models and implement minimum viable services. Startups can apply for BASS funding to demonstrate their solutions in a pre-operational environment. This collaboration also benefits from the support of important stakeholders in the maritime sector, such as the Port Authority of the Ionian Sea and the Port of Taranto.

# SMART AND GREEN CITIES



Smart and green cities prioritise environmental impact reduction and the green economy to create and maintain healthier, more sustainable places to live and work. Urban planners struggle with the challenges of offering sufficient housing to a growing population while ensuring that new development projects are sustainable in terms of air quality, water and sanitation.

## KEY CHALLENGES

**Sustainability During Expansion**

Around the world, urban areas are expanding across agricultural and semi-natural areas. As a result, emissions, air and noise pollution, energy, water and material consumption all increase. Cities face additional challenges such as land scarcity, waste management, road congestion and habitat and biodiversity loss.

**Poor Air Quality**

Despite air pollutant emissions declining in recent years, approximately 20% of the EU's urban population live in regions where air pollutant concentrations exceed at least one EU air quality standard.[10]

**$CO_2$ Emissions**

Urban areas are also responsible for at least 70% of global carbon emissions.[11] Cities are currently a core contributor to future environmental challenges. European cities must shift towards a more integrated approach to addressing persistent, systemic environmental challenges.

[10] SR 23/2018: Air pollution Our health still insufficiently protected (europa.eu)

[11] Effects of changing population xor density on urban carbon dioxide emissions | Nature Communications

# SPACE FOR A GREEN TRANSITION

**Satcom** enables IoT-like smart grid applications, which can help to reduce energy consumption in buildings and cities. Satcom and terrestrial 5G infrastructure are considered essential for smart cities where IoT and sensors are connected to vehicles, power grids, hospitals, tunnels, roads, water systems, buildings, gas and oil pipelines to provide seamless uninterrupted information and monitoring services.

**Satnav** provides geo-tagging services for data collected by smartphones and IoT sensors, such as those measuring pollutants in the air. This can be harnessed to locate emission measurements and pinpoint emission sources. Satellite navigation allows transport operators within cities to plan, reroute and avoid traffic jams and offers a clearer picture of infrastructure use for city planners.

**SatEO** provides information on geological, hydrological, ecological and anthropological characteristics of a region prior to developing new services or infrastructure, and during the life of a building. It can monitor and manage natural resources to assist in the site selection, design and operation of green buildings. Examples include mapping vulnerabilities such as land deformation and landslides, identifying brownfield sites to build on and positioning buildings to maximise natural ventilation. SatEO can map thermally-inefficient buildings for renovation, monitor air quality in neighbourhoods and forecast energy production of renewable sources. SatEO data are also used by insurers to validate claims.

## SHOWCASE

### BELMAP


ESA BASS supported Belgian company GIM to develop Belmap, a 3D digital twin of all buildings and addresses within Belgium and its neighbouring countries.

Leveraging Earth observation satellite data, EO4Belmap has a multitude of linked data variables to help users switch to renewable and clean energy resources by identifying new solar panel locations and sites for geothermal energy installation, as well as supporting the design of urban heat networks and energy communities.

## WHAT'S NEXT?

Stakeholders from both the Task Force for Smart and Green Cities and the Energy Task Force are working with key players from the automotive industry to explore innovative services using space technologies along the full value chain of electromobility deployment, with the aim of setting up trials globally.

# SUSTAINABLE TOURISM

Tourism is a significant contributor to many national and local economies. Prior to 2020, the tourism industry directly contributed, on average, 4.4% of GDP and 21.5% of service exports in OECD countries.[12] However, tourism can also have a negative impact on the environment but analysing the different elements of tourism and its impact on the environment is challenging, with difficulties assessing the role of travel and accommodation, and ascertaining whether local tourism is contributing to soil erosion or natural habitat loss.

## KEY CHALLENGES

**Local Land Stress**
Tourism often puts enormous stress on local land use. A high number of visitors can lead to soil erosion, increased pollution, natural habitat loss, and additional pressure on endangered species. These effects can gradually destroy the environmental resources on which tourism itself depends, especially when travellers visit an environmental attraction.

**Diversity**
When, how and why people travel to a particular location varies drastically.
To address the diverse nature of tourism, the industry ranges from large enterprises to microbusinesses, meaning any resources and solutions implemented must remain flexible.

**Support Sustainable Tourism**
New technological and digital services are essential in creating sustainable tourism that respects and protects the environment while supporting the economic growth of the tourism industry.

# SPACE FOR A GREEN TRANSITION

**Satcom** ensures the continuation of communication networks on Earth, especially in remote areas where terrestrial solutions are absent or unreliable.

**SatEO.** Monitoring land cover, rivers, and wildlife habitats is made easier with Earth observation satellite data. SatEO can monitor urban expansion. Whilst growing cities often allow for a larger tourist capacity, this can create other challenges such as the need for sustainable public transportation networks, touristic infrastructure and logistics.

**Satnav** enables visitor flow-monitoring, geo-fencing and time-fencing features, which can manage and mitigate the impact of visitors. Satnav receivers and sensors installed at tourist sites act as complementary ground surface deformation measurement points for more accurate environmental impact assessment.

[12] OECD Tourism Trends and Policies 2020 | OECD Tourism Trends and Policies | OECD iLibrary (oecd-ilibrary.org)

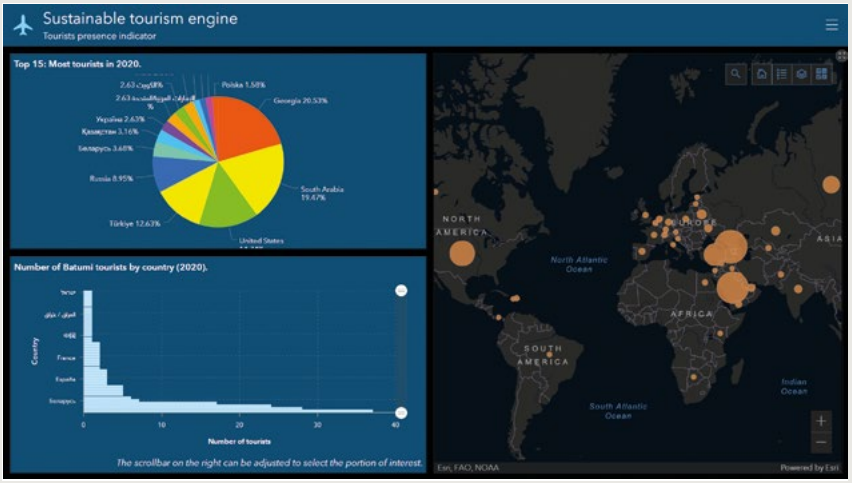
# SHOWCASE

## MURMURATION

Sustainable Tourism Indicators, a service developed by French company Murmuration, supplies environmental monitoring and forecasting data for the tourism sector. This service supports decision makers who need to understand, monitor and report on the impact of tourism on the environment, as well as the impact of the environment on tourism.

Murmuration's algorithm joins Earth observation satellite data, statistics and economic indicators to provide people with the information they require to make informed decisions. Several environmental inputs are used, including data from water, land, air, biodiversity and human activity.

Murmuration has the potential to help governments preserve economic activity and jobs linked to tourism, support environmental preservation projects, and foster sustainable tourism practices. The service can support private entities, such as hotels, by providing data on the environmental conditions of their geographical areas.



## WHAT'S NEXT?

The Space for Olympic Games call continues to support a range of sustainable projects which help improve the experience and impact of major international tournaments.

## PARTNERSHIPS

The ESA BASS programme initiated the Space for Tourism initiative, which is actively supported by a consortium of stakeholders recognising sustainability as a critical area for space-based solutions. This collaboration includes the city of Florence, WWF, Mirpuri Foundation, Andermatt Swiss Alps, Visit Flanders, Global Himalayan Expedition, Pari&Co, and the World Tourism Forum of Lucerne. Each stakeholder has identified specific use cases, ranging from urban planning and development initiatives that integrate environmental considerations to remote destination tourism operators seeking to engage travellers and businesses in climate-positive approaches. These include monitoring natural resources and conserving water usage.

# SUSTAINABLE MOBILITY – LAND

Countries around the world are trying to find ways to improve road transport by reducing congestion, commuting times, traffic accidents and pollution. Passenger cars and vans account for around 12% and 2.5% respectively of the EU's total $CO_2$ emissions. Heavy-duty vehicles, such as trucks and buses, are responsible for about a quarter of $CO_2$ emissions in the EU from road transport, and for about 5% of total EU emissions.[13]

The decarbonisation of road transport is an essential element of the green transition. Space-based services are particularly effective at minimising $CO_2$ emissions. For example, they can optimise driving techniques, ease the adoption of vehicle sharing schemes, and support the [uptake] of electric vehicles or vehicles with hydrogen batteries. Satellites can significantly reduce fuel consumption and $CO_2$ emissions, with a 10% average reduction recorded.

Space-based assets can also improve the sustainability of the rail networks across Europe, with a number of projects contributing to improved efficiency and service levels for trains and tracks.

## KEY CHALLENGES

**Road**

To reduce the environmental impacts of road transportation, continued innovation is required. A variety of methods can assist in environmental improvement, such as an increased uptake in electric vehicles, alternative fuels, traffic flow management solutions, smart charging schemes and new mobility options such as e-scooter sharing.

**Rail**

While rail is more environmentally friendly than many other transportation methods, heavy regulatory frameworks and lengthy innovation cycles means a slow evolution.

[13] $CO_2$ emission performance standards for cars and vans - European Commission (europa.eu)

## SPACE FOR A GREEN TRANSITION

**Satcom** ensures the resilience of communication networks, which are essential for autonomous vehicles and other road transportation services. The availability and reliability of these communication networks supports the development of future railway mobile communication systems.

**SatEO**. The planning of transportation and railway infrastructure is made easier by using Earth observation satellite data: infrastructure can be implemented sustainably and with respect to the environment and biodiversity. Satellite imagery provides the necessary maps and data for traffic management and provides key data for monitoring and forecasting parameters such as air pollution.

**Satnav**. Accurate tracking and tracing capabilities assist automated vehicles, car sharing applications and parking assistance. Such navigational data helps reduce rail infrastructure through innovative signalling applications.

## SHOWCASE

### AITO

German company TeleRetail GmbH developed AITO to optimise the so-called last mile in supply chain operations. The last mile refers to the distance from a logistics facility to the final recipient. AITO developed a self-driving electrical vehicle to transport goods. This 24/7 on-demand transport service has the potential to reduce transport costs by up to 90%.

Global Navigation Satellite Systems (GNSS) and Earth observation satellite imagery are critical for precise localisation and navigation, and enable the vehicle to navigate in the most environmentally friendly manner possible.

## WHAT'S NEXT?

The continuous Open Call for Proposals on Space for Rail addresses use cases geared towards improving railway attractiveness, which is considered a crucial objective in carbon footprint reduction for the entire transportation sector.

Converting a passenger from a two-person car to a mainline diesel train would save about 84 grams of $CO_2e$ (expressed in carbon dioxide equivalent) per kilometre. Shifting one-tonne kilometres of freight from heavy truck to diesel bulk rail would save approximately 55 grams $CO_2e$.

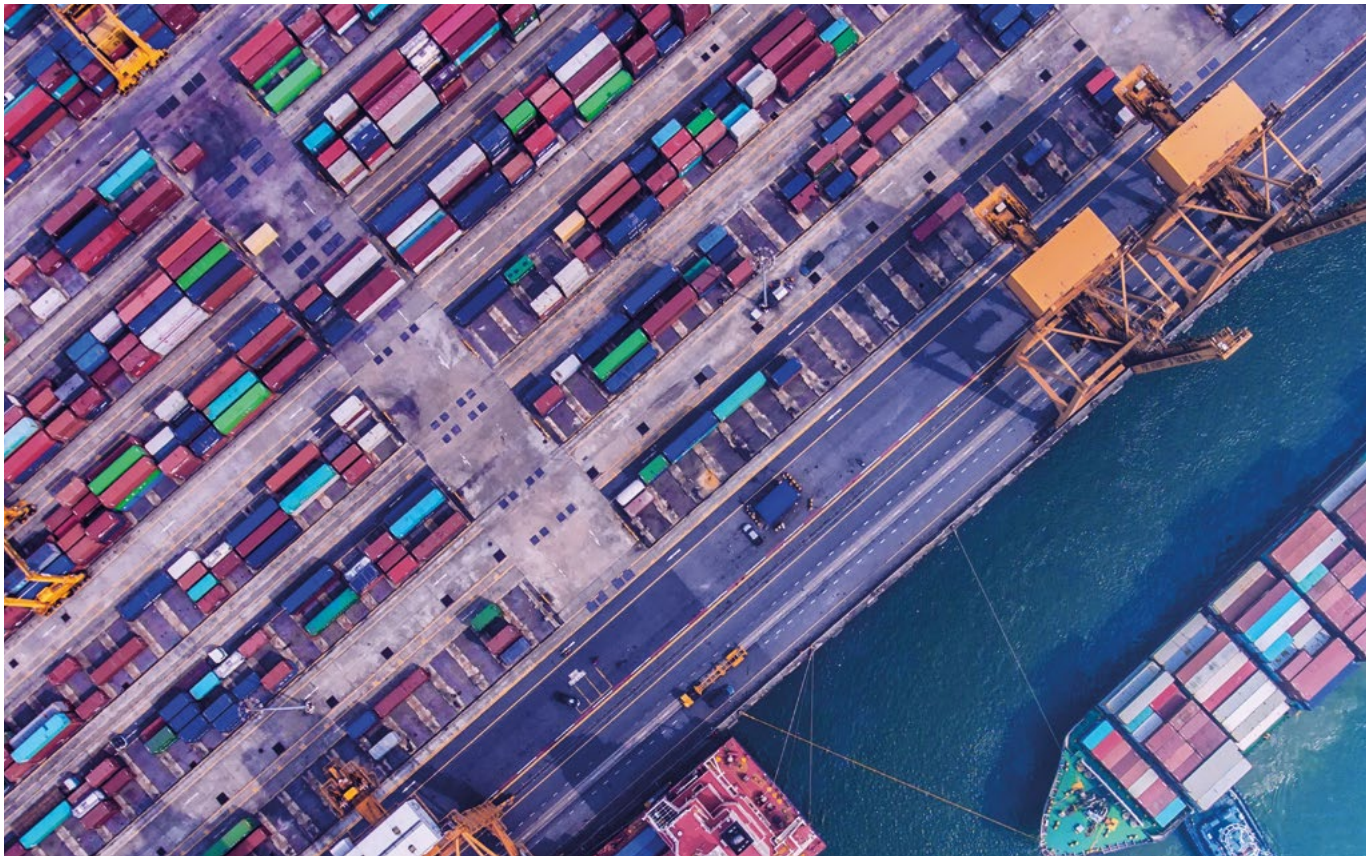
ESA's BASS programme spoke with several European stakeholders who identified the key improvement areas needed to expand the use of the railway sector for both passenger and freight transport. These include, but are not limited to:

- Improvement in wagon freight and cargo tracking and tracing
- Digitilisation of paperwork for freight
- Detection of unusual environmental conditions for wagons, boxes, and cargo
- Innovative integrated ticketing before and during transport

## PARTNERSHIPS

BASS is collecting use cases from different stakeholders to shape new initiatives on intermodal transport. These will tackle the issues faced by the community in both the road and maritime sector. The Space for the Sports Car Sector – Efficiency, Safety and Sustainability call, supported by Ferrari, supports the development of sustainable space-based services and applications addressing challenges related to the sports car sector.

# SUSTAINABLE MOBILITY – MARITIME



Maritime transport is considered to be the most fuel-efficient method of transportation. It accounts for the movement of approximately 90% of global trade and less than 3% of global anthropogenic $CO_2$ emissions[14]. Thanks to developments in autonomous and automated navigation, the decarbonisation of the maritime sector has become a viable possibility. Vessels can respond almost in real-time to changes (e.g. weather conditions, port delays), increasing productivity and fuel efficiency. Autonomous shipping reduces vessel speed and minimises queueing times at ports, which has the potential to decrease carbon dioxide emissions by 30%[15]. Maritime accidents such as collisions or oil spills, which seriously impact the environment, are reduced with constant monitoring of vessel positions, helping ships maintain a safe distance from each other.

ESA's Maritime Sustainability Task Force, launched in 2024, is developing initiatives to decarbonise the maritime sector.

[14] IMO's work to cut GHG emissions from ships

[15] The Maritime Exective

# KEY CHALLENGES

**Port decarbonisation**

Optimising and digitising port operations to improve vessel, energy and operational efficiency, meet new regulations and accelerate the green transition is a key priority for the sector.

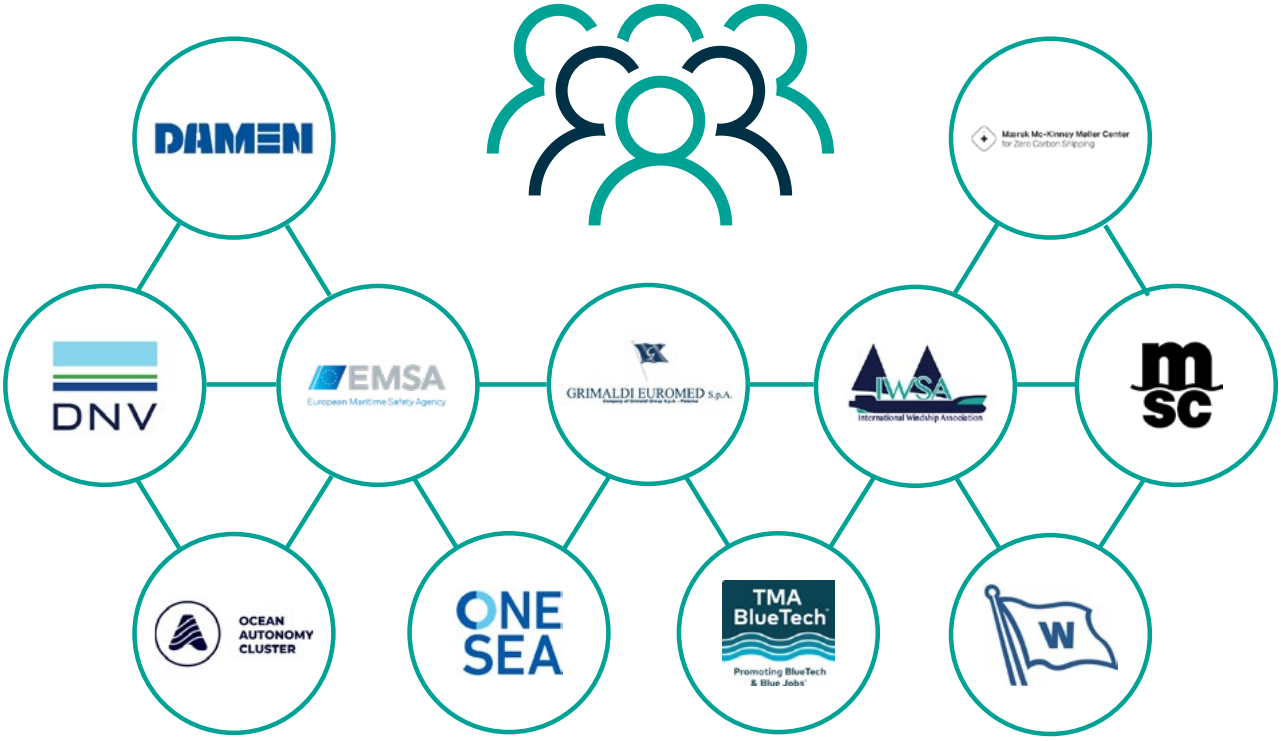
**Pollution**

Reducing the high emissions levels of the maritime sector is paramount. The impact of an oil spill or vessel collision at sea or in port is environmentally catastrophic.

**Protecting marine life**

Protecting our marine ecosystems from man-made and environmental threats including climate change, underwater noise pollution, biofouling and antifouling is essential.

**Maritime Sustainability Task Force**



## SPACE FOR A GREEN TRANSITION

**Satcom**. 5G integrated Satcom networks provide connectivity to vessels at sea and continued connectivity in the event of terrestrial communication network failure.

**Satnav**. Advanced positioning, navigation and timing technologies provide location, routing and tracking capabilities to machinery in ports, as well as vessels and cargo. As a result, ships can sail on greener routes which reduce $CO_2$ emissions as well as improving air quality for coastal towns. Wait times at ports are also diminished.

**SatEO**. Earth observation satellites detect and monitor environmental impacts, such as coastal erosion, the effects of dredging and water quality. SatEO data enables the monitoring of protected areas.

## SHOWCASE

### SEA-KIT

Uncrewed Trans-Atlantic Survey (UTAS) is a service provided by British company SEA-KIT. UTAS offers highly accurate and precise information about the ocean floor with a 12 metre remotely controlled Uncrewed Surface Vessel.

Retrieving data from the ocean floor is rare due to the challenges and costs of trying to reach remote locations. Satellite technology enables SEA-KIT to deliver unprecedented amounts of ocean data from space to the ocean floor.

## WHAT'S NEXT?

The Maritime Decarbonisation call is focused on innovation around maritime decarbonisation and seeks to help the maritime sector adapt to and comply with new international regulatory frameworks. The Call has four main focus areas: decarbonisation through digitalisation and logistics optimisation, decarbonisation through maritime autonomy, port decarbonisation and green propulsion.

# SUSTAINABLE MOBILITY – AVIATION

[16] ScaleX Invest

[17] IPCC report 2022

Key innovations are needed to make aviation greener and help aircrafts use less fuel and emit fewer greenhouse gases. Innovations such as hybrid propulsion, electric engines, vertical take-off and landing and alternative fuels (such as hydrogen, algae or animal fats) could all help reduce air travel emissions significantly[16]. Simulation software, digital twins, 3D printing and connected, geotagged sensors could improve new aircraft designs and help visualise their impact on the environment.

In aviation, space technologies can help to optimise routes and flight paths, via accurate weather forecasting and use of Iris. They can also help to implement autonomous airside operations, such as maintenance robots, for greener airports and monitoring the environments surrounding airports.

## SHOWCASE

### SATAVIA

The aviation industry is actively pursuing strategies to minimise both direct ($CO_2$-related) and indirect (non-$CO_2$ related) effects. One of the indirect effects arises from 'condensation trails' or 'contrails', the clouds that aircraft produce, which increase surface warming by reflecting longwave radiation towards the Earth's surface. Contrail clouds contribute to about 35% of the aviation sector's global warming impact, (IPCC 2022)[17].

SATAVIA, a company from the UK, developed DECISIONX:NETZERO, a service for aircraft operators to quantify and mitigate their contrail impact. The service uses advanced numerical weather prediction modelling to forecast contrail forming regions, modify flight plans for avoidance and precisely calculate climate impact (including impact avoidance) post-flight.

Multiple Earth observation satellites such as the ESA-developed Meteosat and ESA-developed and operated Sentinel satellites contribute to the data SATAVIA uses for accurate global climate models and numerical weather prediction models.

# BASS GREEN STARS

## SHOWCASES

### BASS – GREEN STARS

Among the many green projects delivered by BASS, a number of companies have successfully developed and demonstrated a service that delivers a positive environmental impact, and have expanded beyond the initial customer base. Expansion into the wider market not only boosts commercial profit but increases the green impact of these services. These projects also show potential for broader adoption and scale by a larger customer community through deployment in other countries and by establishing novel industrial partnerships, extending their environmental reach and some examples of these can be found below:

### BASS GREEN STAR KAYRROS

Kayrros (FR) – Methane Watch Demonstration Project

Kayrros' Methane Watch project has developed and deployed a platform capable of identifying and quantifying methane sources, aiding leak detection and supporting the decarbonisation of the energy industry. Combining data from Sentinel 5P, Sentinel 2, and Sentinel 1, as well as other satellite data sources, this platform effectively detects and monitors methane emissions.

Kayrros' ESA-backed Methane Watch project played a significant role in the Global Methane Pledge, where 150 countries committed to reducing their methane footprint by at least 30% by 2030. Building upon this success, the UN Environment Programme has implemented a Methane Alert and Response System based on Kayrros technology, and the EU is poised to follow suit. The International Energy Agency uses Kayrros insights to assess global emissions, while US regulators are also exploring the use of Methane Watch.

The company's work has garnered recognition through awards and widespread media coverage, highlighting its breakthrough approach to methane gas monitoring and its contribution to driving political momentum for climate action. Kayrros has recently partnered with Bloomberg to assist in their environmental journalism investigations.

In June 2023, Kayrros joined the portfolio of NewSpace Capital, a leading private equity firm in the space sector. The company envisions a fully-fledged platform for digital monitoring, reporting and verification (MRV), spanning all aspects of Greenhouse Gas emissions, from accurate biomass and carbon stock estimates to plume detection.

## MOBILITY

## BASS GREEN STAR VALERANN

Valerann (UK) – ITS Equant Demonstration Project

Valerann, an intelligent transportation system (ITS) provider, has developed and implemented its AI-powered solution in several countries, including Chile, UK, Spain, Israel, and the US. The solution uses real-time traffic analytics to optimise traffic flow, reduce congestion and minimise accidents. It aggregates data from various sources, including CCTV cameras, vehicle telematics, social media, mobile apps, legacy sensors, and satellite positioning data. Satellite communication ensures seamless data transmission. Road operators adopting Valerann's ATMS service have reported a 20% reduction in congestion and a 35% decrease in accidents.

Valerann's service was successfully deployed during the UEFA Women's Euro 2022 tournament in the UK, positively impacting traffic flow and safety. This achievement has boosted the company's profile and fuelled its growth. Valerann has secured USD 25 million in funding, doubled its UK workforce, and expanded its customer base across Europe, South and Central America, and the US.

Future plans include developing a digital twin of the road for "what-if" scenario analysis, enabling simulations to assess the impact of decisions like lane closures or dynamic speed limits. This digital replica will be instrumental in optimising traffic and preparing for the integration of connected automated vehicles (CAVs). Valerann's commitment to innovation and traffic management excellence positions it as a key player in shaping the future of transportation.

## BASS GREEN STAR DARWIN

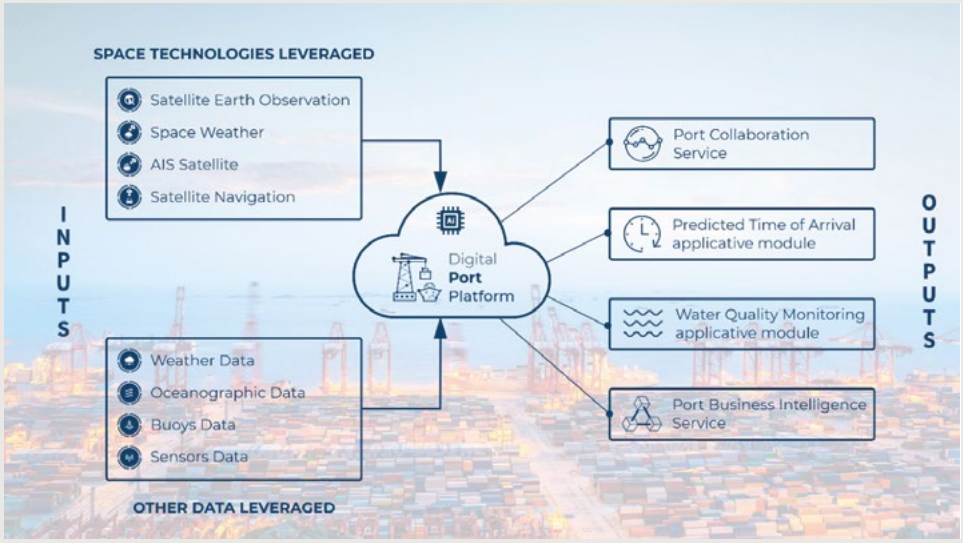
Darwin Innovation Group (UK) – Darwin Shuttle Demonstration Project

Darwin Innovation Group, a UK-based company pioneer, has successfully deployed a new connected and autonomous vehicle (CAV) service. The electric shuttle, which harnesses the power of 5G terrestrial and satellite networks, as well as satellite positioning to support continuous tracking of the shuttle, enhances vehicle sharing options on the road. Darwin's innovative technology is contributing to the green transformation of road transportation.

Darwin's successful deployment at the Harwell Campus, spanning 8,174 service hours, 7,418 miles covered, and 1,431 satisfied customers, cements its position as the UK's longest-running CAV service. Darwin hopes to expand across Europe and other regions in the years to come, with the goal of reducing CAV service deployment time so more customers have access to CAVs soon.

## BASS GREEN STAR SINAY

Sinay (FR) – Digital Port Platform Demonstration Project




French company Sinay has developed a cloud-based Digital Port Platform (DPP) designed to increase port performance and reduce environmental footprint. The DPP, which provides data to customers such as port operators and shipping companies, uses space assets and advanced AI technologies to gather and transform data, providing insights into vessel arrival times, optimal shipping routes, water quality changes and potential pollution events.

This comprehensive data enables port operators to make informed decisions to increase berth ratio use, crew efficiency and crane productivity. Additionally, the DPP facilitates proactive water pollution management by tracking environmental impacts, anticipating pollution events and ensuring regulatory compliance.

The DPP will be piloted in ports across France and Central America, with plans for wider deployment in Northern European and Asiatic markets. Sinay has secured partnerships with accelerators and business partners such as Zebox in France, Betatron in Hong-Kong and Singapore, Impact USA and the Sustainable Ocean Alliance in the USA to support its expansion efforts. Sinay benefits from valuable support of the European Network of Maritime Clusters (ENMC), which promotes the cooperation between European maritime cluster associations.

# CONCLUSION

The effects of climate change are already being seen on Earth, with more frequent extreme weather events, often leading to natural disasters and national and international emergencies. Widespread and innovative actions are urgently needed to decarbonise and reduce our dependence on fossil fuels, transforming the ways we live and work to mitigate climate impacts. The scale and complexity of these challenges necessitate global cooperation and collaboration across all sectors and industries.

**The role of space applications in the green transition**

Space applications have a key role to play in this and are essential for the development of green services. When integrated with other products and technologies, satellite datasets address environmental and climate-related challenges across every industrial sector. Green services not only drive the green transformation of industries, but also contribute significantly to the economic growth within those industries. Activities that demonstrate a strong economic performance hold great potential for scalability, multiplying their impact on both the environment and revenue generation. Forging partnerships and initiating specialist task forces is a fundamental element of BASS support for companies, strengthening their products and services, improving their environmental impact and driving innovation.

**The BASS portfolio of services**

The BASS portfolio of services which deliver a positive impact towards the environment continues to grow steadily, thanks to the support of BASS Participating States. Their investment, together with the significant contribution committed by industry, has steadily increased over recent years. Today, almost half of all the new activities supported by BASS are environmentally driven. As part of the BASS programme ESA launches several green initiatives every year, offering European companies the opportunity for funding and support to develop new green services, technologies, and products as part of the solution to the unprecedented challenges climate change presents.

**Find out more**

Discover more about these initiatives on ESA's Business website, or apply to these opportunities here.

To keep up-to-date with the latest news and opportunities from ESA BASS, sign up to our monthly newsletter.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