Space for sustainability

Using space-based Earth Observation
to help build a sustainable future

CGI

Contents

1. Space and sustainability

Space was once regarded as the last great frontier, but today it's the perfect vantage point from which to observe the earth and collect data that can help drive a sustainable future.

Building sustainability with space data

As the planet warms and the climate changes at an ever-increasing pace, it's vital that we effectively monitor, understand and pre-empt how this will impact living conditions across the globe. Space can help us drive a wide variety of ingenious sustainable initiatives, from reducing the energy requirements of greenhouses to opening up more eco-friendly forestry management solutions.

It's also increasingly providing the information we need to keep people safe from the effects of climate change. From real-time weather monitoring to help first responders tackle wildfires, to longer-term strategic information about the design of coastal barrages, new ways that space can help us to manage our changing environment are emerging all the time.

Observe, assess, remediate

Space-based Earth Observation technologies are a core part of monitoring and assessing the natural and manmade environment. Earth Observation provides a global level of trusted data quality that cannot be achieved by terrestrial approaches.

Armed with remote sensing technologies and imaging devices placed on strategic satellites that orbit the earth continuously, Earth Observation missions gather information about the earth's physical, chemical and biological systems. These assessments can then be used to inform our climate knowledge, science, monitoring and early warning systems, guiding policy change and practical action.

Earth Observation is an efficient and cost-effective way to assess where climate change is creating vulnerabilities for communities and to measure the success of remediation strategies.

2. CGI's place in space

At CGI, we have more than 40 years' heritage of involvement in the space industry and a deep commitment to supporting global efforts to reduce and mitigate climate change.

## Space systems that monitor our climate

Working alongside organisations like the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and the UK Space Agency (UKSA) we deliver secure, mission-critical space systems, including data processing, satellite communications, modelling and simulations to support climate missions. The technologies we create enable scientists to monitor Essential Climate Variables (ECVs). These ECVs are physical, chemical or biological variables that make critical contributions to the formulation of earth's climate, for example, sea surface and land temperatures. Monitoring ECVs gives us a better understanding of climate drivers and how they interact, as well as fluxes in energy, water and carbon.

Monitoring ECVs effectively requires high-quality datasets, based on accurate, comprehensive observations. The technology we provide does just that, turning huge quantities of data into usable, timely and relevant information. With this information, scientists can better understand how climate change impacts our planet, and policy makers can effectively model the implications their decisions have on the environment.

Internationally trusted technology solutions

Our technology is at the heart of the fight for a sustainable future, and our commitment to creating world-leading technology solutions means we are a recognised thought leader in space security and space applications.

As well as helping our clients to get the most value from their space assets, we are also part of The United Nations Framework Convention on Climate Change, which leads international efforts to restrict global temperature rises to less than 1.5°C above pre-industrial times. Plus, we're a founder member of Space4Climate, an organisation chaired by the UKSA that brings together expertise from government, industry and academia about the development of satellites, analysis and exploitation of the data they gather, and the production of quality assured global data and climate services.
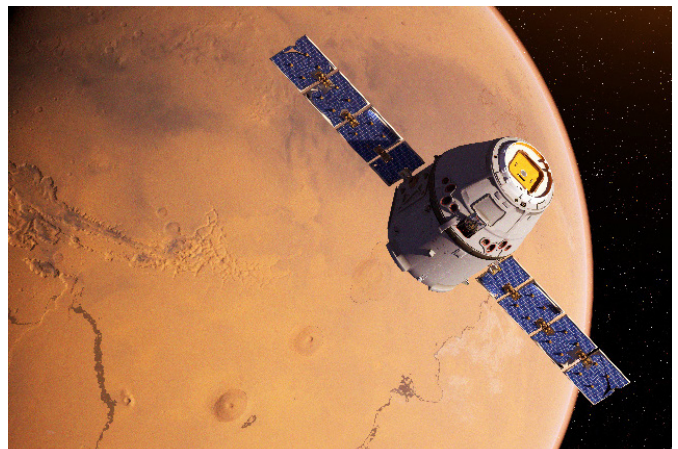
3. Data underpins sustainability

In the sphere of space, the focus is often on the satellites and the sensors they carry. Yet, in reality, it's the data they capture that's critical to developing sustainable solutions here on earth.

Delivering the complete picture

This data from space is rarely used in isolation, which adds a further layer of complexity. In order to provide an accurate overview of the state of our planet, it needs to be combined and calibrated with a broad range of terrestrial data. We specialise in data processing and developing data-enabled services. This means we have the expertise to take huge quantities of raw satellite and terrestrial data and make it available to the researchers, businesses and governments that can turn it into actionable intelligence.

Data that drives innovation

We believe that if you put the right information into the right hands, innovation will follow. We also recognise that, as a planet, we have to come up with solutions to environmental challenges rapidly.

It's time for a change of thinking and a change of pace. Perhaps we don't need to wait for a new satellite to be designed and commissioned to capture the insights we need. Perhaps the insights are already accessible in the data we have today.

We make data from space available every day. Data that curious people can explore and find new uses for, merging data sources in ways that generate fresh thinking and new possibilities.

This brochure outlines effective ways space data is being used today, from monitoring de-forestation and melting glaciers to helping insurers determine the storm risks associated with major new building projects.

This is just the beginning. Start imagining your tomorrow.

Monitoring the sustainable use of the earth and its resources is critical.

The unique characteristics of space deliver the global monitoring we need cost effectively, with a level of coverage and data quality that no other approach can provide.

4. Explore how data from space can make a difference

In this brochure, we'll look at the challenges our planet faces as global temperatures increase, and the innovative solutions that are creating a more sustainable future.

Traceable Underpinning Terrestrial and Helio Studies - improving accuracy of EO radiations date for climate modelling

Forestry and Food Security Thematic Exploitation Platform - monitor health of vegetation or crops

AI4EO Fire monitoring - combines EO, AI and cloud computing to track devastating wildfires

CGI GeoData360 - data processing platform for geospatial and satellite imagery

EO4SD Lab - cloud platform to enable sustainable development sector to efficiently use space based data

Project Seagrass - Using EO and CGI Geodata360 to identify the healthy seagrass meadows and raise awareness of its benefit to reduce the UK's Carbon Footprint

Greenhouse Early Warning System - EO to track performance and energy loss from greenhouses

Digital Twin Earth Precursor - visualise and monitor activity on Earth

Wind Storm Information Service - understanding and mitigating impact of windstorms

CGI GeoApp - tools to take advantage of location based data and intelligence

eSurge - forecasting damaging coastal surges

AIAdvance - using artificial intelligence to speed up critical climate insights

Defra's EODS - reducing cost of analysis ready data

PASSES - continuously monitoring peatlands health and land-use

CGI - Space sustainability

Maintaining peatland's ability to store carbon

Encompassing 3% of the earth's surface, peatlands are among the most valuable ecosystems on earth. They help preserve global biodiversity, provide safe drinking water, and minimise flooding risks. Plus, they store around 42% of all soil carbon[1], more than any other vegetation type.

But as global temperatures increase, and land is excessively drained through intensive farming, peat can dry out, releasing vast amounts of CO2 into the atmosphere. Restoration projects are key to curtailing these carbon emissions, but they can be difficult to initiate on the ground.

Peatlands encompass

3%

of the earth's surface

Peatlands store around

42%

of all soil carbon

Damaged peatlands contribute around 10% of greenhouse gas emissions from the land use sector[1].

PASSES: preserving peatland

Our project, PASSES, operates throughout Malaysia and Indonesia and aims to preserve peatland. Working with our partner organisation, Terra Motion, we used PeatMotion monitoring via Sentinel satellites to continuously measure peat levels over several years. With this data, we determined areas of shrinkage and created accurate, up-to-date maps of vast agricultural areas.

These maps provided various organisations throughout Southeast Asia with cost-effective access to the information they needed to prevent further decline. With the right data, organisations can alert farmers in vulnerable areas and encourage them to stop draining peat. While in other areas, the process of rewetting can be coordinated to prevent additional drying.

Tackling the worldwide advance of wildfires

The advance of climate change means that wildfires globally are becoming more intense and unpredictable, with areas like the UK's Dartmoor National Park experiencing previously unheard-of winter wildfires[2].

As fire season severity is set to increase over the coming decades, every continent except Antarctica faces the significant challenge of regenerating vast areas of fire-ravaged land. When battling these wildfires, first responders need accurate information about the landscape and weather conditions in order to effectively coordinate containment and suppression efforts. And, once the wildfire is under control and has passed, it's vital that local and governmental organisations have a comprehensive overview of the devastated area, so remediation efforts can be optimised.

The global mean fire weather season has increased by 19% between 1979 and 2013[3].
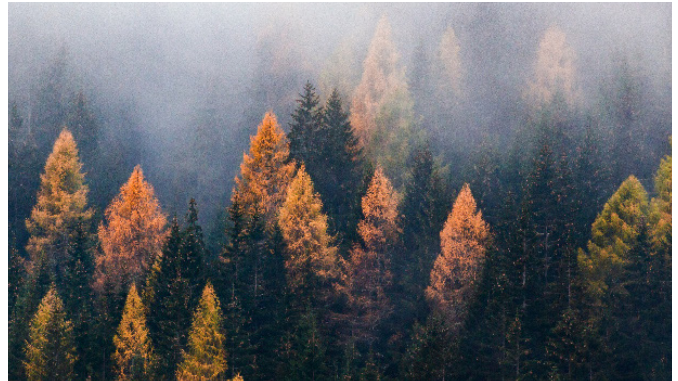
AI4EO Fire Monitoring: using AI to battle and rebuild

Alongside the University of Leicester, we are currently working on AI4EO Wildfires, a project that combines Earth Observation, AI and cloud computing to tackle devastating fires. AI4EO Wildfires allows our pilot users such as Geoscience Australia and ONF France, to monitor and track wildfires, as well as help with the remediation of burnt areas. The AI-enabled wildfire mapping service is also available to the wider environmental community through our EO4SD Lab portal, giving free access to a range of EO data, tools and services.

Our complex, mission-critical space software systems provide better monitoring and analysis of burnt areas and they help to improve future land management so that the impact of wildfires can be better contained. AI4EO Wildfires is also developing predictive technology, to provide insight into where wildfires will likely occur in the future. This information is invaluable, giving local and national organisations warning so that resources can be effectively shared, and fires brought under control faster.

Helping greenhouses to feed the planet

By 2050 the world needs to feed two billion more people[4], putting greenhouse horticulture growers under even greater pressure to produce high-quality crops efficiently and on a large scale. The scale of these operations is one of the reasons owners need to be innovative about how they protect and maintain their businesses.

With greenhouses spanning areas as large as four hectares, it's possible for ground subsidence, flooding and broken glass to go unnoticed for weeks, leading to damaged crops, a rise in heating costs, and ineffective watering systems — any of which can impact crop yield and have a negative effect on profit margins and carbon emissions.

The global Greenhouse Horticulture Market is expected to grow at a compound annual growth rate of 10% from 2019 to 2027[5].

The Greenhouse Early Warning Service

In an effort to keep the world's greenhouses efficient and productive, we developed the Greenhouse Early Warning Service. The service relies on our Earth Observation technology, using space data from satellites to monitor greenhouses in a consistent way. Capturing infrared and radar signals from the earth's surface, these images provide insights into the performance of various greenhouse components such as temperature levels.

This information is then combined with leading algorithm technology, to effectively monitor greenhouse performance. As a result, there's less need for physical inspections, saving growers time and money. This means that changes in greenhouse conditions can be detected early, so that resulting damage can be prevented and the effect of uncontrollable events, limited.

Managing coastal surge defences

Coastal surges occur when low pressure, high winds and extreme tidal conditions push waves towards the coast, creating high water levels. Surges can lead to devastating flooding, putting lives and property at significant risk.

The threat of coastal flooding is increasing, propelled by factors such as population growth, coastal infrastructure, subsidence, and rising sea levels. This can render previously adequate surge barriers ineffective. In the UK, for example, the Thames barrier has been operational since 1982, but in 2014 alone, it closed more times than in every previous year combined[6], highlighting the strain modern defences now face.

Across the world's 136 largest coastal cities, average coastal flood losses are estimated to cost approximatively $6 billion[7].
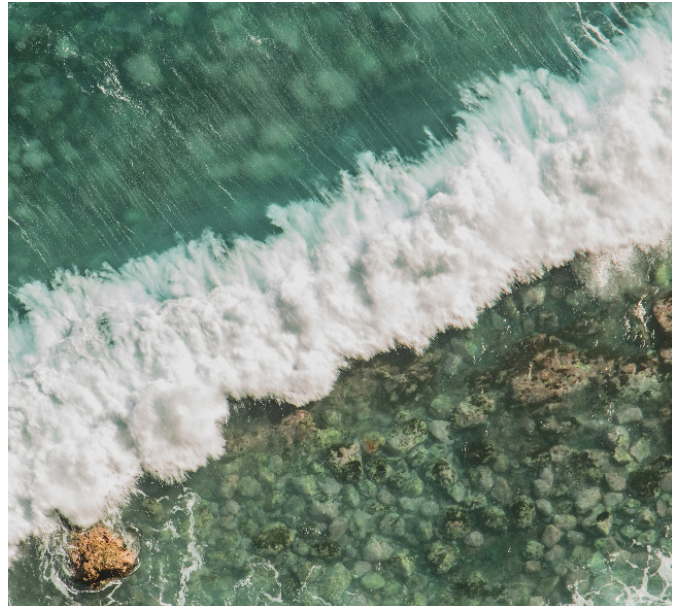
eSurge: helping communities turn back the tide

eSurge aimed to mitigate the damage these surges can cause by improving coastal surge predictions and helping to create more effective early warning systems. We led the delivery of this ESA project, making Earth Observation data, modelling and forecasting tools more widely available to storm surge experts and organisations.

Creating accurate surge maps, sharing forecasting insights and making sure all coastal areas have access to accurate data means organisations are able to mobilise more efficiently to protect people and property in the days before a coastal surge. It also means more effective long-term flood defence systems can be designed, helping to mitigate the devastating human and financial toll these weather events can have.

Mitigating windstorms and unexpected weather

High-impact and low-probability extreme weather events like hurricanes are notoriously difficult to predict. But as climate change warms the earth's atmosphere, increased precipitation and cloud formation are fuelling these devastating windstorms.

Detailed, advanced and accurate warning can help governments and other organisations to mitigate the devastating impact these storms can have on communities and infrastructure. With accurate data sets and modelling, the worst affected areas can be properly protected, and people evacuated and assisted early. An advanced warning system is also the best way to protect underdeveloped areas which can be crippled by the cost of rebuilding.

Between 2008 and 2018, there were 27 major Northeast winter storms in America, four times more than any year since the 1950s[8].

WISC: mitigating weather risks

We work with KNMI, the Netherlands National Meteorological Institute, to deliver WISC, the Wind Storm Information Service, to bridge the gap between those who gather climate data and the modellers and decision-makers who use it. We use cost-effective open-source tools and data sources, to combine historical data on windstorms with projections. It makes high-quality windstorm data sets available to policy and private-sector decision makers and presents the results in a way that can be used in risk modelling.

An important tool for the energy, transport and civil engineering sectors, WISC also supports catastrophic assessment models used in the insurance industry. With access to reliable data, major projects requiring decadal insurance can be costed more accurately.

Monitoring and managing forests

Forests are vital to life on earth, regulating ecosystems, protecting biodiversity and sitting at the heart of sustainable growth. Spanning vast areas of the globe, forests contain 80% of all terrestrial biodiversity[9].

They also represent up to $100 billion per year in goods and services such as clean water and healthy soil, supporting the livelihoods of almost 25% of the world's population[9].

What's more, forests are at the core of mitigating climate change, absorbing up to a third of the CO2 released from burning fossil fuels every year. However, mismanagement and unsustainable deforestation increases the amount of carbon in the atmosphere and takes away the immense power that forests have to absorb CO2. Despite this, there's an area the size of South America, two billion hectares, of degraded land around the world that could be regenerated and, if properly managed, provide part of the solution to climate change[9].

The role of space in forest management

F-TEP, the Forestry Thematic Exploitation Programme, run in conjunction with our project partner, VTT, the Finnish Research Institute, uses Earth Observation data to support forest management and carbon sequestration. It translates data into the spectral bands of colour used to monitor the health of the forest and identify areas of vulnerability.

FS-TEP, the Food Security Thematic Exploitation Platform delivered in partnership with VISTA and VITO, can monitor and focus on the health and vulnerability of crops. It's a space-based monitoring system that can help to balance the conflict between deforestation and the necessity to grow crops for human consumption - a huge step towards a more sustainable future.

CGI also supports Forestry England through developing the eTimber platform and the Forrestry Commission via our GeoApp platform enabling sustainable usage of natural resources and the responsible preservation of woodlands across England. Space data allows us to support sustainable forest management worldwide.

Over 12% of global CO2 emissions come from deforestation and the degradation of forests[9].

Balancing the radiation budget

The energy entering, reflected, absorbed, and emitted by earth is all part of the planet's radiation budget. This represents the balance between incoming, largely solar, radiation and outgoing radiation, a mixture of both reflected solar radiation and emissions from earth itself.

Getting this balance wrong in models can increase or decrease temperatures so, accurately, thoroughly, and continuously measuring the amount of radiation that earth absorbs and emits is vital to our measurement and attribution of climate change, and our continued effort to combat it. In-flight calibration of Earth Observation satellites can drive this accuracy, improving confidence in Earth Observation data and the critical forecasts it informs.

Earth's energy imbalance approximately doubled during the 14-year period from 2005 to 2019[10].

TRUTHS: accurate data to measure climate change

TRUTHS (Traceable Underpinning Terrestrial and Helio-Studies) is an important climate mission involving CGI, the UKSA, Airbus UK and the ESA, which aims to ensure more accurate radiation monitoring.

We're working closely with the National Physical Laboratory to make this project a reality and it will enable high-quality climate predictions that will assist with climate change interventions. The accuracy of the data will not only help scientists to understand the impact of climate change but will also ensure the accuracy of critical forecasts driven by this data.

TRUTHS will allow the performance of current satellite missions to be assessed and will perform the calibration upgrades needed by many climate studies. It aims to enhance our accuracy of measurements by an order-of-magnitude and, in turn, to increase our ability to estimate the Earth Radiation Budget through direct measurements of incoming and outgoing energy.

This mission, seen as a flagship mission for the UK, will foster the development of capabilities within the UK, and is an opportunity to help train the next generation for the space sector.

Our core technologies underpin
all these uses and also embody
sustainability, being reusable
in many different contexts.

The technology is ready.
How will you apply it?

5. Our sustainability solutions

All the examples we cover are based on our core solutions, and we're confident these reusable solutions will spark many more vital examples in the future.

How could you use the data these solutions provide in new ways to manage our changing environment and drive a more sustainable approach?

CGI GeoData360

CGI GeoData360 is our state-of-the-art data processing platform for geospatial data and satellite imagery.

For scientists, environmental organisations, and various other sectors, this data is an invaluable source of information, providing the basis for climate change remediation. Achieving remediation, however, requires efficient and reliable processing of large volumes of data using complex workflows and algorithms.

The CGI GeoData360 platform addresses this and supports the complex processing of large volumes of Earth Observation and Geospatial Data. It achieves this by containerising processing algorithm steps and decoupling them from the underlying infrastructure. This allows for dynamic, secure, efficient and automatic scalable processing; allocating ICT resources and storage to meet demand. It can also be deployed locally and within different cloud environments, giving organisations complete control, while also offering big data production capabilities based on imagery and/or other geospatial data, for example, climate and meteorological data.
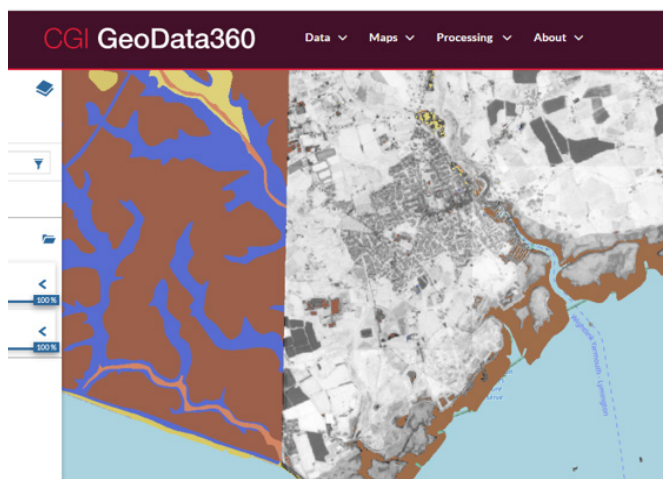
CGI GeoData360 provides an easy-to-use application that hides the complexity of the processing and offers:

- The flexibility to draw-in data from different types of feed or archive

- The ability to tailor workflows to your particular use case

- Easy configuration for efficient, automated data production

- At-a-glance monitoring of system performance via graphical feedback dashboards

- Visualisation and analytical tools to make geospatial data outputs accessible to a wider audience.

CGI GeoApp

CGI GeoApp delivers all of the essential tools an organisation needs to successfully take advantage of location-based data and intelligence. It's easy to deploy and use and is built on open standards, providing a single, supported, out-of-the box solution.

CGI GeoApp unlocks the 'power of where' for your organisation and automates geospatial tasks that free up specialists' time, offering intuitive self-service options.

A core set of modules give access to a wide range of functionality:

- Integration with existing internal and external geospatial data holdings

- Easy management, discovery, viewing and downloading of data

- Straightforward sharing and federation of data via OGC-compliant services

- The ability to create and run geo-enabled business applications

- Connected/disconnected access to data and applications in the field

- The option to integrate and build custom dashboards and reports.

The EO4SD Lab

The EO4SD Lab is our cloud-based platform that allows those in the sustainable development sector to experiment and operationalise with space-based data.

In response to the vast amounts of Earth Observation data currently being generated, the EO4SD Lab, sponsored by the ESA, offers an Infrastructure as a Service (IaaS) approach to provide a scalable, low cost, collaborative framework, through which professionals can access Earth Observation mission data. It also allows for the immediate exploitation, analysis, sharing, mining and visualisation of this data.

Importantly, the EO4SD Lab is designed to make data accessible to a wide range of users. By reducing the threshold of data expertise required, the platform supports increased awareness and use of Earth Observation data across various disciplines. By lowering the barrier to understanding and making the data available more broadly, project design, urban planning, environmental policy and many other disciplines are able to capitalise on Earth Observation technology. As such, the EO4SD Lab promotes sustainable development by integrating space-based insights across numerous sectors.

The EO4SD Lab is designed to help bridge the gap between the idealised solution and what's currently achievable. It offers:

- Efficient data workflows because it holds data and services in the same working environment

- A scalable infrastructure that opens access to computing resources not affordable by an organisation working alone

- An easy user experience with defined entry points tailored to different levels of expertise

- A collaborative community that promotes information exchange and awareness raising so you stay up to date with the latest possibilities

- Access to unique third-party data sources and solutions so you can add processing functions and data to the platform.

Watch this space…

Alongside our CGI GeoData360, CGI GeoApp and the EO4SD Lab, we also have a number of innovative projects in development phases. Once complete, these will join the fight to combat climate change. Here's how we're inventing the future.

Creating Earth's Digital Twin

A digital twin is the digital replication of a system, so Digital Twin Earths will enable us to visualise, monitor and forecast natural and human activity on the planet. It will allow modelling to perform simulations of earth's interconnected systems with human behaviour, giving numerous industries and sectors a better understanding of how policies, actions and projects will impact the planet.

We're working on the Digital Twin Earth Precursor project, alongside ESA, Oxford University, Trillium and IIASA to develop a Food Systems Digital Twin, focused on the biosphere, atmosphere and hydrosphere systems. The project will incorporate socio-economic as well as physical measurements to help create more accurate predictions and modelling for those creating policies that deal with the climate, food production and sustainability. One important data source for DTE will be new low-cost 5G and SatCom-enabled IOT sensors which provide a new level of in-situ data which can be combined with other data sources to produce higher quality information.

The benefits of a successful model include better seasonal monitoring and improved policy development, for example sustainable solutions to crop shortages caused by weather extremes.

We partner with and sponsor Project Seagrass. Using our technical expertise in Earth Observation and CGI Geodata360 we support Project Seagrass to identify healthy seagrass meadows and raise awareness of its benefit to reduce the UK's carbon footprint.

AIAdvance:
fast-tracking AI

AIAdvance is our AI platform built to assist and add value to every stage of the AI journey across numerous industries. It enables Machine Learning development, deployment and monitoring, so it helps to ensure both efficacy and best practice.

The first step of any AIAdvance project is the discovery phase. This allows us to pinpoint client objectives, as well as assess the current condition of any industrialisation platforms. From here, we move to proof of concept, the first iteration of a data-driven solution to meet the client objective. The next phase is deployment, where the AI model is integrated with current live systems to automate workflows. Then, it's important to upskill the client's team so that they can autonomously run their AIAdvance solution.

AIAdvance is currently being used to experiment with various sources of climate data. By combining industry-leading open-source technologies with AIAdvance, it's possible to deliver critical climate insights to tighter timeframes and budgets. AIAdvance also offers scalability, portability, and agnosticism, so it's a solution which has far-reaching uses across the sustainability sector. An area ripe for innovation, the coming years are set to involve significant developments in the use of AI for climate sustainability solutions.

Defra's EODS solution

The UK's Department for Environment Food and Rural Affairs (Defra) is responsible for safeguarding the country's natural environment, rural economy and food and farming industry.

To do this, it needs 'Analysis Ready Data' (ARD) for everything from simple visualisations to complex machine learning algorithms. A significant source of this data is the ESA Sentinel satellite system, but over 70% of the cost of using this resource was tied to processing raw data in order to make it useable.

To mitigate this, we are partnering with Defra's central Data Programme to build a facility that would automatically generate ARD and store it cost-effectively, reducing storage costs by over 90%.

We have created a single, flexible source of ARD in just three months, making it easily accessible to a wide audience through the use of the open architecture and cloud-based systems. This facility processes raw Sentinel data using a solution developed by Aberystwyth University which addresses complex tasks like correcting atmospheric and meteorological issues. Defra now has an intelligent, cost-effective solution to harness the crucial Sentinel data and process, produce and disseminate ARD.

Defra is using this ARD solution to support a number of important projects, including illegal forest felling detection and assessing water pollution and quality due to road run-offs, houses or farmland. It is also playing a major part in the UK and Overseas Territory (OT) Governments' Blue Belt Programme which aims to protect over four million square kilometres of marine environment across the UK OTs.

Project Seagrass: promoting carbon capture

Project Seagrass is committed to the conservation of seagrass ecosystems, one of the UK's most promising carbon sinks.

The UN hailed seagrass as a "secret weapon in the fight against global heating" after research identified that seagrass ecosystems globally can consume carbon up to 35 times faster than rainforests[11]. However, seagrass is under threat from coastal development, pollution and damage from human activity in the marine environment.

Mapping seagrass ecosystems is critical to this project's work. Working on a pro bono basis as a sponsor and partner, we are supporting Project Seagrass with our technical expertise in Earth Observation and our CGI Geodata360 platform to deliver the data they need for education, influence and research.

We are using Earth Observation data to develop a seagrass identification algorithm that can locate and quantify seagrass meadows across the UK. This automated mapping tool will be able to survey the entire UK in minutes, replacing time-consuming work that previously could only be accomplished by boat or drone. In addition, the algorithm includes correlation with data collected by CGI volunteers and their families, including those taking part in a CGI-organised STEM project, helping to improve the accuracy in the dataset.

Project Seagrass will use this data source to aid conservation and local activities to preserve and restore this valuable carbon sink resource, and to increase CO_2 consumption through improving the health and volume of the UK's coastal seagrass.

Start using space-based data to build a sustainable future

The technology is ready and waiting to give you a picture of how the earth is changing – a picture that's only available if we use space as a vantage point.

Space-based data opens up new horizons for sustainable activity, horizons that are only going to expand as researchers and businesses take inspiration from what's possible today to imagine more for tomorrow.

Get in touch to find out how space-based data can support your business towards a sustainable future.
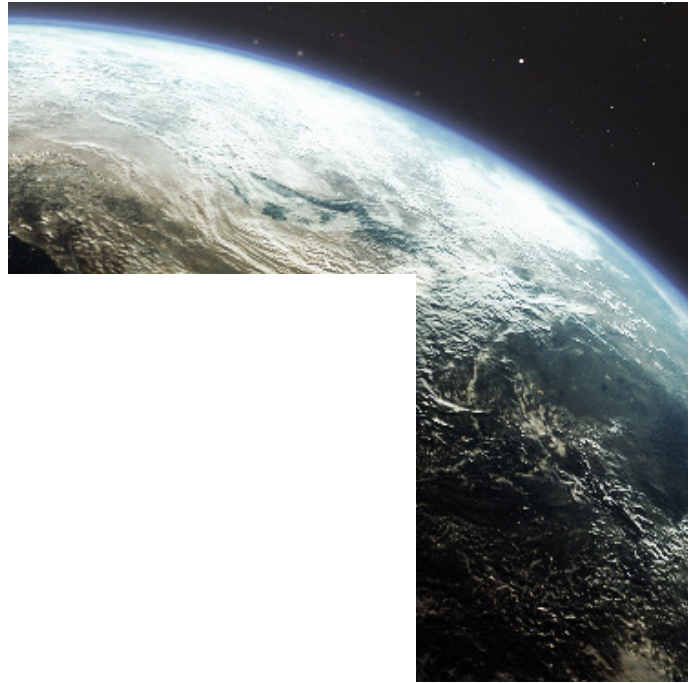
About CGI

Founded in 1976, CGI is among the largest IT and business consulting services firms in the world.

We are insights-driven and outcomes-based to help accelerate returns on your investments. Across 17 industries in 400 locations worldwide, our 76,000 professionals provide comprehensive, scalable and sustainable IT and business consulting services that are informed globally and delivered locally.

cgi.com/uk/space

References

[1] IUCN, Peatlands and Climate Change, 2017

[2] BBC, Huge fire breaks out across Dartmoor near Tavistock, 2021

[3] Nature Communications, Climate-induced variations in global wildfire danger from 1979 to 2013, 2015

[4] National Geographic, Feeding the World, 2014

[5] GlobeNewswire, Global Greenhouse Horticulture Market Size Projected to Reach USD 40 Billion by 2026: Facts & Factors, 2021

[6] Gov.uk, The Thames Barrier, 2014

[7] Floods Direct, 12 - Coastal Surges, 2017

[8] The New York Times, How climate change is affecting winter storms, 2020

[9] IUCN, Forests and Climate Change, 2021

[10] Earth Observatory, Earth's Radiation Budget Is Out Of Balance, 2021

[11] UN Environment Programme, Seagrass - secret weapon in the fight against global heating, 2019