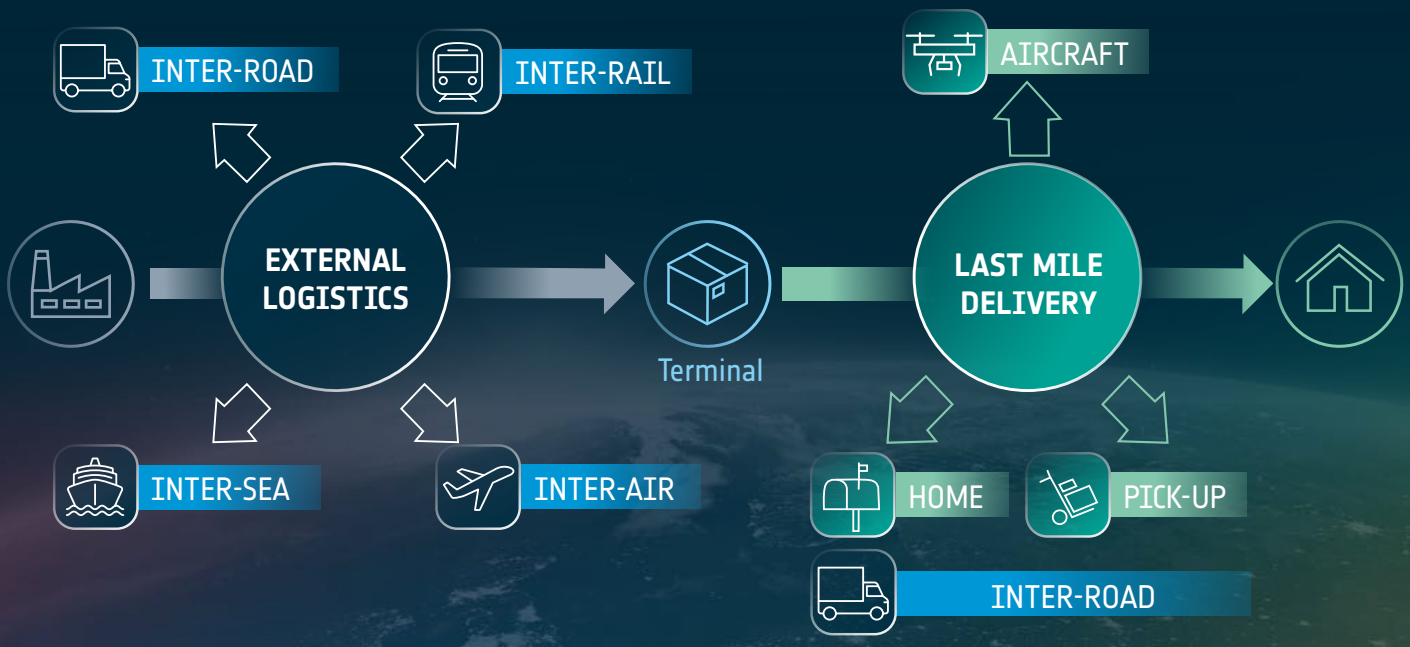
Space-Based Green Logistics Solutions: Commercial Opportunities Trends

Introduction to green logistics

The aim of logistics is to optimise all work processes so that products can be delivered from suppliers to customers as quickly as possible, without delay and at the lowest possible cost. However, with freight transportation making up 8% of global greenhouse gas emissions, or as much as 11% if warehouses and ports are included[1], this objective often conflicts with the need for sustainable practices and emission reductions that has intensified in the wake of the Paris Agreement and subsequent legislation.

The green logistics industry is therefore seeking to integrate the goals and responsibilities of traditional logistics with environmentally responsible practices and strategies. Achieving this balance involves implementing innovative strategies and technologies to minimise carbon emissions, energy use, waste and other environmental impacts within the supply chain and logistics operations. Key strategies include intermodal switching, optimising transportation efficiency, enhancing supply chain management, improving packaging practices, using cleaner fuels and reducing energy consumption.

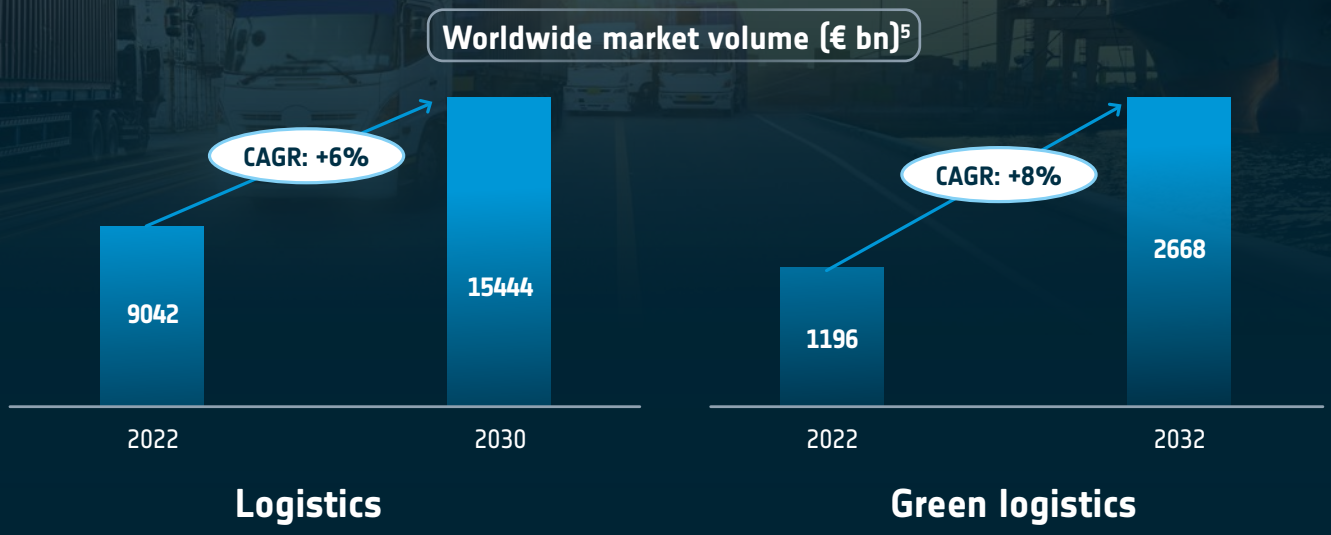


These strategies can be applied to all global transportation modes:

- **Ocean freight,** which carries more than two thirds of global traded goods[2].
- **Rail transport**, which is usually associated with domestic freight, but can also be an economical alternative to cross-border air freight.
- **Air freight**, which is the fastest mode and makes up just 1% of the total volume of global trade but 35% of the value of goods shipped[3].
- **Trucking services**, which can be a very economical option for cross-border shipments within a region.

1.CO2 Emissions from Fuel Combustion (2018), International Energy Agency
2.Ocean shipping and shipbuilding - OECD
3.Value of air cargo – Air transport and global value chains , IATA

By adopting green logistics practices, companies can reconcile **operational efficiency with environmental sustainability**, thereby aligning with corporate social responsibility and sustainability goals that promote "people, planet and profit" principles. As a result, the green logistics market is experiencing even stronger growth than the overall logistics market[4].

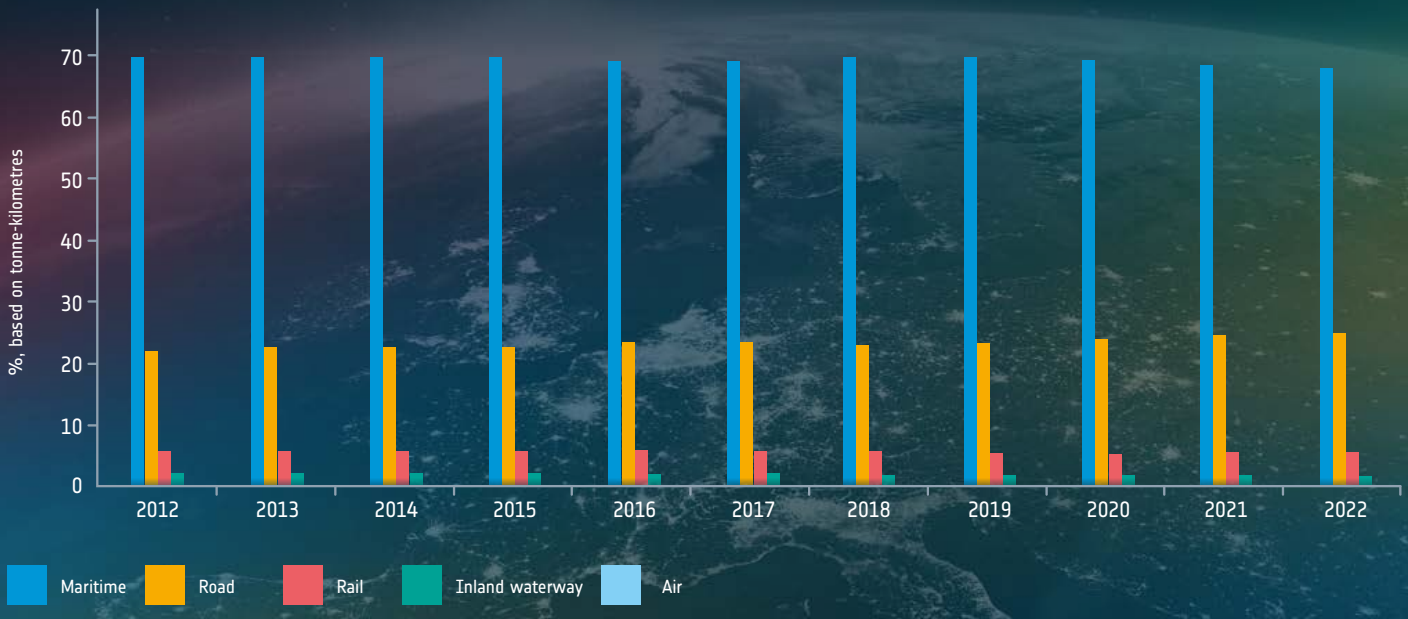


Zoom on Europe

In the European Union, freight transport, and especially maritime transport which accounts for more than two-thirds of freight transport, plays a vital role. It supports the single market and ensures the continuous supply of goods to supermarkets, factories and pharmacies while facilitating cross-border trade for European businesses.

With the EU economy projected to expand, emissions from freight are expected to increase significantly unless decisive decarbonisation measures are implemented. Addressing this challenge is crucial to managing emissions growth while sustaining the essential functions of freight logistics in the EU economy.

To meet the **European Green Deal's** target of a 90% reduction of transport-related greenhouse gas (GHG) emissions by 2050, the European Union is focusing on optimising rail capacity, incentivising low-emission lorries and establishing a common approach for emissions reporting[6]. It is investing in many different projects and compiling new regulations for the market.



Modal split of freight transport, EU, 2012-2022 *(source: Eurostat)*

4.Green logistics Market (2023), Allied Market Research
5.Green Logistics and Transportation Market (2023), Allied Market Research
6.Green Deal: Greening freight for more economic gain with less environmental impact (2023), European Commission

Most relevant needs and use cases

Some green logistics-related needs, such as infrastructure harmonisation or regulations, require a nationwide or even an EU-wide approach. Other needs, however, can be addressed by businesses.

Alternative fuels

The green logistics-related need with the biggest impact on GHG emissions is the need for alternative drive technologies. Depending on the transportation mode, this need can be addressed by **alternative and sustainable fuels**, such as hydrogen, or the **electrification of fleets and aircraft** (EVTOLs). Of all the transportation modes, sea transport faces the greatest hurdles: the average age of ships stands at 22.2 years and the adoption of alternative fuels is in the early stages, with 98.8% of the fleet still sailing on fossil fuels[7]. Shifting to zero-emission alternatives, even if available, would require considerable investment.

Intermodality, fleet management and routing

In many cases, becoming more sustainable means becoming more efficient to optimise lead times and cargo capacity. **Tracking** is therefore growing in importance for all modes of transport and is essential for implementing route optimisation technologies that minimise travel distances and fuel consumption. In addition, **digital coupling** enables real-time communication between vehicles and enhances transportation efficiency by optimising fleet driving and reducing fuel consumption.

Intermodality is also essential for achieving greener freight transport across all transportation modes. To facilitate seamless switches between transportation modes, terminals have to be modernised and upgraded. Harmonisation initiatives also promote **standardised processes and regulations across supply chains**, enhancing coordination between different stakeholders and reducing inefficiency. However, several obstacles must be overcome to enable effective intermodal operations:

- Technical – **Inadequate infrastructure and compatibility issues** due to varying size and weight restrictions across transportation modes pose massive challenges.
- Operational – A lack of coordination often results in **safety and time concerns** when transitioning between transportation modes. Security concerns also arise when security protocols change across transportation modes.
- Economic – Intermodal transport can be **slower and less reliable** due to delays, and intermodal intelligence is required for optimised efficiency and sustainability in freight transport.

Resilient and circular logistics

The need for environmental resilience can mainly be tackled through two avenues. The first is **circular logistics** which focuses on reducing waste and promoting resource efficiency by implementing reverse logistics systems that facilitate product reuse, refurbishment or recycling. This approach contributes to a circular economy model, minimising environmental impact throughout the supply chain. The second consists of **sustainable packaging initiatives** that minimise the environmental footprint of logistics operations by utilising eco-friendly materials and optimising packaging designs to reduce waste and emissions. In addition, the use of **reusable containers and packaging** not only reduces waste but also lowers the environmental impact of transportation by minimising single-use packaging materials.

Automation

Autonomous cars and trucks are promising solutions for last-mile delivery and long-haul transport, potentially reducing reliance on traditional vehicles and improving road safety and efficiency. **Warehouse automation** streamlines operations, minimises energy use and optimises inventory management, leading to reduced emissions. Another important use case concerns **micro-fulfilment centres** that leverage automation and proximity to consumers to optimise inventory management and shorten delivery distances, enhancing coordination in last-mile logistics.

Space's added value

With an increasing focus on sustainability and environmental responsibility, logistics businesses are seeking innovative solutions to reduce their carbon footprint and enhance efficiency. In this context, the integration of satellite-derived data is poised to redefine the traditional logistical processes, enabling enterprises to systematically optimise transportation routes, as well as internal and external operations.

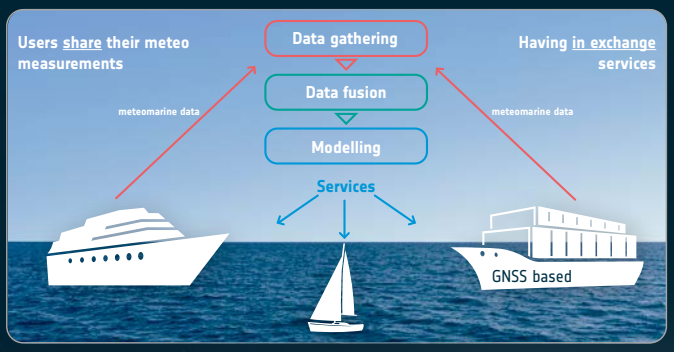
In recent years, the European Space Agency (ESA), most notably through its **Business Incubator Centres (BICs)**[8] and programmes such as **Business Application and Space Solutions** (BASS)[9] and **Incubed**[10], has provided technical and financial support for several projects to develop solutions that cater to these use cases and market needs.

7.Review of Maritime Transport 2023, UNCTAD
8.ESA BUSINESS INCUBATION CENTRES - ESA Commercialisation Gateway
9.ESA Space Solutions
10.InCubed (esa.int)

Alternative fuels

Space technologies can significantly enhance the adoption of alternative fuels in the green logistics sector. Earth observation (EO) can monitor environmental conditions by providing real-time data on weather patterns, sea states and air quality, which helps in planning optimal routes and schedules for hydrogen- and electric-powered vehicles, thereby reducing energy consumption. EO can also track fuel usage by observing emissions and identifying inefficiencies in current logistics operations. Navigation satellites enable precise route planning for electric- and hydrogen-powered fleets, optimising energy use and reducing greenhouse gas emissions. Communication satellites facilitate real-time data sharing and coordination, essential for managing the transition to alternative drive technologies. These space-based solutions collectively promote a more sustainable and efficient logistics system, accelerating the move towards zero-emission alternatives.

The **Profumo**[11] initiative by **Telespazio BE**[12] is a BASS project that leverages EO data to empower maritime professionals by providing them with tailored weather routing that helps them optimise fuel consumption, particularly in challenging marine weather conditions.



Intermodality, fleet management and routing

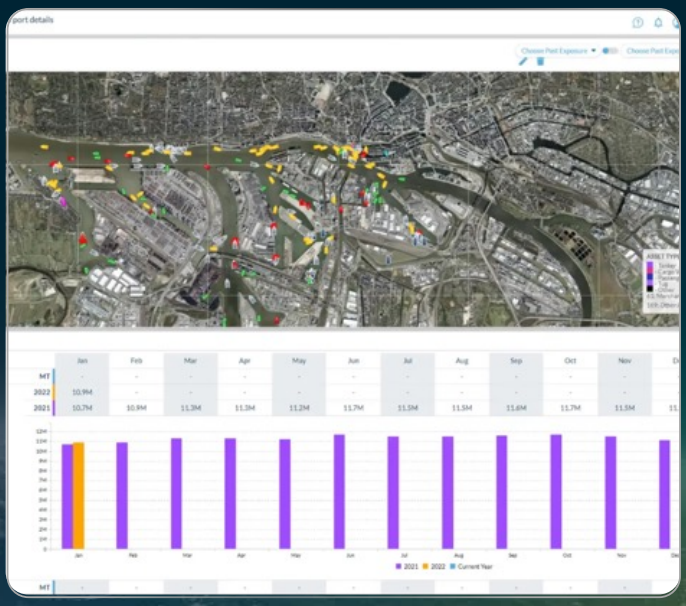
Integrating space-based solutions can help logistics companies to achieve more sustainable, cost-effective and reliable route planning and fleet management. Satellite navigation and EO can be instrumental in creating dynamic, **interactive maps.** EO can also provide accurate weather forecasts, facilitating proactive **route adjustments** that minimise delays. Additionally, satellite communication and satellite-based automatic identification systems (AID) can enable precise **shipment tracking**, ensuring real-time visibility and efficient logistics coordination. Satellite communication also facilitates **robust data-sharing platforms**, promoting seamless integration across various transport modes and improving overall logistics efficiency.

ESA BASS is currently supporting the **TEMIS**[13] demonstration project from **Ternwaves**[14], incubated from 2021-2022 in **ESA BIC Sud France**[15]. The project aims to transform route optimisation with an IoT satellite system delivering end-to-end location services in challenging environments, ensuring operational reliability even without GNSS coverage and resilience to interference.

Resilient and circular logistics

Space-based advancements can help promote a more resilient and circular approach to logistics, reducing its environmental risk and impact and supporting a closed-loop economy. Coupled with satellite navigation, satellite communication can, for example, facilitate comprehensive **supply chain monitoring**, enabling precise tracking of materials and products throughout their lifecycle. In addition, Earth observation can be used to provide an accurate **risk exposure picture** of the supply chain. It can also be used to optimise **waste management** by providing detailed data on waste generation patterns.

The **Cargo Port Analysis**[16] project contracted by Skytek[17] is part of the **InCubed** portfolio. It supports the analysis of the risk of cargo accumulation at ports. Leveraging satellite data and modern image analysis combined with machine learning techniques makes it possible to assess current levels of cargo both onshore and on docked vessels. This approach has produced a fully automated solution for calculating risk exposure which can be used for the major cargo ports worldwide. Skytek has also received support from ESA under the ARTES Core Competitiveness Programme for the development of geospatial information networking techniques for maritime awareness services[18].



Skytek's SAAS for risk aggregation in ports

Two more BASS-supported projects are further examples of the instrumental role played by EO data and GNSS capabilities in monitoring the location of goods throughout their lifecycle, thereby contributing to more transparent and accountable management.

11.Profumo | ESA Space Solutions
12.Telespazio BE
13.TEMIS | ESA Space Solutions
14.Ternwaves
15.ESA BIC Sud France
16.Cargo Port Analysis – InsureTech | InCubed
17.Skytek
18.Skytek | ESA ARTES

The **HGR**[19] kick-start activity supported by BASS and overseen by **Origosat**[20] underscores ESA's commitment to supporting the development of space-based solutions for the advancement of secure and reliable positioning technologies, which are crucial for transparency within circular economy practices. The project's concept is to acquire the same signals from different sites by means of collaborative receivers and/or reference receivers managed by the service owner, and compare them with the GNSS-derived position to protect against spoofing. This is vital for verifying the authenticity of the positioning data. Four transport and logistics companies are expected to be involved in the project.

Similarly, the **WASTE IAP**[21] feasibility study, led by **Telespazio VEGA UK**[22], aims to leverage EO data to identify illegal waste sites and monitor legal ones. This initiative harnesses the capabilities of GNSS technology to track transporting vehicles through the destination of high-value waste.

The project's significance lies in its potential to bolster the transparency and accountability of waste management entities by furnishing evidence of compliance with operational regulations and providing governments with actionable data to prosecute offenders.

The WASTE IAP project supports several Sustainable Development Goals defined by the United Nations[23]:

- **SDG9 Industry, Innovation and Infrastructure**
- **SDG11 Sustainable cities and communities**
- **SDG12 Responsible consumption and production**
- **SDG16 Peace, Justice and Strong Institutions**

Automation

Space technologies can greatly enhance the efficiency, sustainability and reliability of automated logistics systems. In warehousing, they facilitate **process automation**, enabling more efficient **inventory management** and reducing energy consumption. For **autonomous vehicles**, satellite-based navigation and communication provide precise positioning, ensuring accurate and safe navigation. Additionally, EO offers real-time environmental monitoring, aiding in the planning and execution of **last-mile delivery automation** by identifying optimal routes and adjusting to real-time conditions.

TeleRetail[24], a startup incubated in **ESA BIC Switzerland**[25], has completed a demonstration project with ESA BASS for its **TeleRetail Delivery Robot**[26], an autonomous courier robot that leverages space technologies for urban and suburban deliveries.

1. Satellite Navigation (DGNSS)

DGNSS in an enhancement to a primary GNSS system using an accurately-surveyed position know as the reference station.

2. Satellite Asset Tracking

Use of satellites to receive signals from the transporters. This enable global coverage and allows seamless tracking to maximize security and to avois theft.

2. Nanosatellite Imagery

Use of satellites for mapping. The resulting close to real time maps can be used as a source of information for navigation.

Another promising BASS project is the **STAP ULD-Watcher system**[27], developed by **STAP GmbH**[28] and incubated in **ESA BIC Austria**[29] from 2018 to 2020. Using global satellite communication and navigation services, it addresses challenges in monitoring and tracking unit load devices (ULDs) used in air cargo operations. Traditionally, ULDs rely on outdated labels, leading to frequent misguidance issues. This system offers comprehensive monitoring and tracking of the entire aircraft loading process, ensuring compliance with IATA and ICAO regulations. Accurate, real-time data is essential for ground handlers, air cargo companies, airlines and ULD manufacturers to make informed decisions and execute precise actions without human intervention.

Green logistics is essential for improving the efficiency of the supply chain and reducing its environmental impact. Space-based solutions involving satellite Earth observation, communication and navigation enable intermodal transportation, optimise routing, support circular logistics and enhance automation. ESA supports companies developing these innovative solutions through its commercialisation initiatives and programmes, providing financial and technical assistance.

START YOUR ESA JOURNEY WITH THE ESA COMMERCIALISATION GATEWAY

19.HGR | ESA Space Solutions
20.Origosat
21.WASTE IAP | ESA Space Solutions
22.Telespazio UK T
23.Waste-IAP | SDG (esa.int)
24.Teleretail
25.ESA BIC Switzerland | Start-ups – AP Swiss
26.TeleRetail Delivery Robot | ESA Space Solutions
27.STAP-ULD | ESA Space Solutions
28.Stap
29.ESA BIC Austria- Space Tech Incubation