



# Socio-economic benefits from ESA Technology Transfers

A report for esa

CASE STUDY: Optical and RF Constellation  
on Airplanes (ORCA)

**know.space**

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## The missing layer: how aircraft constellations could provide a new perspective on our planet

Earth observation (EO) is the gathering of information about Earth's physical, chemical and biological systems. EO satellites are constantly orbiting Earth at altitudes of 200-2,000km, providing us with detailed information on our planet, vital to climate change monitoring, emergency and disaster response, forestry, precision agriculture, weather forecasting and many other applications.

Drones are increasingly used to monitor Earth also, flying at low altitudes of around 100m and providing detailed coverage of land, free from the obstruction of clouds, but lacking the broad coverage of satellite images. Yet between these two altitudes, **there exists a gap in earth observation, a range of altitudes currently unexploited**, which could offer a compromise between the broad coverage of satellites and the detailed coverage of drones.



### Space technology brought down to Earth ...

In this context, **SkyfloX, an ESA spin-off company, has developed the ORCA concept (Optical and RF Constellation on Airplanes). ORCA uses commercial aeroplanes as a piggyback platform to carry smallsat-like payloads, forming aircraft constellations and delivering satellite-like earth observation services.** Crucially, ORCA does not require additional planes to be flown. Instead, it capitalises on the 30,000 commercial flights across European airspace every day<sup>1</sup>. SkyfloX's modelling and simulation demonstrates the strong ground coverage which could be achieved, even with only a fraction of these planes carrying ORCA payloads. At a typical cruising altitude, a commercial plane 'covers' an area of around 711km diameter for radiofrequency applications and up to around 55km diameter for imaging applications. This coverage, combined with the sheer number of commercial flights every day, enables a high revisit time. The same areas could be observed a hundred times a day.

**SkyfloX describes ORCA as the 'missing layer': we observe Earth from satellites above the Earth and drones at far lower altitudes, but this type of observation to-date has not been utilised, despite the significant potential benefits.** ORCA fills this gap, complementing existing capabilities.

The technology consists of a small payload, weighing less than a traveller's luggage, which attaches to the underside of a plane. The payload will hold optical and thermal cameras (at present, it is the only system doing so) and is compatible with a range of camera types, allowing for regular technology updates. ORCA is a standalone and self-contained plug-and-play system, with no operational interference to the aircraft.

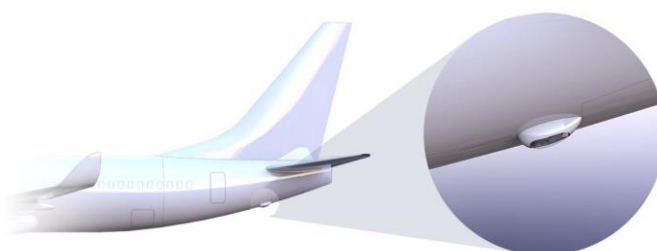


Image: SkyFloX

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<sup>1</sup> ESA, n.d. *Commercial aviation platform for Earth observation applications*. Available at: [https://www.esa.int/Enabling\\_Support/Space\\_Engineering\\_Technology/Commercial\\_aviation\\_platform\\_for\\_Earth\\_observation\\_applications](https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Commercial_aviation_platform_for_Earth_observation_applications)



SkyfloX was founded in 2016 as a spin-off from ESA BIC Noordwijk, before establishing its base in Luxembourg in 2018 to benefit from the country's dynamic space programme. SkyfloX is licensed by ESA to develop and commercialise ORCA.

The concept, patented by ESA, has potential in both telecommunications and earth observation activities, though SkyfloX is currently focused on several potential EO applications, including **environmental monitoring** (e.g. forest fire detection or CO2 emissions measurement), **resource monitoring** (e.g. asset monitoring or agricultural applications), **maritime applications** (e.g. oil spill detection or coastal management) and **disaster relief** such as aiding response units by rapidly assessing the evolution and impacts of forest fires.

## Pioneering technically and legally...

**The project has overcome significant regulatory challenges to fly payloads on commercial planes across Europe.** The first challenge was to certify the safety of the payload; plane modifications require stringent safety measures and only approved organisations can apply. This led SkyfloX to partner with SAFRAN Engineering Services who assisted in the successful payload design and certification process. The second regulatory challenge was to gain approval to take images from planes across Europe. This involved pioneering work in regulation, both technically and legally, since there is no Europe-wide regulation pertaining to imagery and flying camera payloads. Every country has its own legal framework regarding taking imagery, and SkyfloX had to gain permission from each individual civil aviation authority in Europe. In this effort, SkyfloX had support from the Ministry of Foreign Affairs of Luxembourg and from the European Aviation Safety Agency (EASA). This process is ongoing, with overflight permission gained in a majority of European countries and imaging permission in the countries where the initial targeted markets are located.

## Potential for significant socio-economic benefits

The Optical and RF Constellation on Airplanes (ORCA) concept is **still under development** and SkyfloX aims to test its payloads on flights in 2022. In the meantime, some initial socio-economic benefits have begun to emerge, with the promise of many larger, wide-reaching benefits to come through its successful commercialisation, including for the business involved, for the European industrial landscape, and for broader society and the environment.

## Bringing a cost-effective service to new market segments

### *Commercial opportunities*

Founded in 2016, SkyfloX is an SME that was spun-out from ESA, going through the 2-year incubation at ESA BIC in Noordwijk and receiving extensive support from the ESA Technology Transfer and Patent office, for the purpose of bringing a new innovative technological solution to the market. Its creation established **a new company** in the European space industry landscape, and although small in terms of FTEs currently, it seeks to grow in the near future as it develops along its commercial roadmap, offering potential further job creation.

Its solution is also unique to the EO market segment, proposing a method by which to carry cameras on aircraft. Through the design and development of this service, it is bringing additional contracts and potential revenue streams to a wider variety of companies – both in terms of the system design and manufacturing, as well as through the end data provided that will enable EO application developments.

**EO revenues in data and services are forecast to double** from around €2.8 billion to more than €5.5 billion by 2031.<sup>2</sup>

Total revenue for EO data in 2021 amassed to €536 million across all market segments, and is expected to enjoy strong growth over the next decade – potentially up to a 3.5% Compound Annual Growth Rate (CAGR). Furthermore, the EO value-added services market, which is considerably larger, accumulated a total of €2.2 billion in 2021, with a forecast growth leading to €4.7 billion total revenues by 2031.<sup>3</sup>

These forecasts highlight the **strength of the market** in which SkyfloX's ORCA service will enter, indicating the potential for significant revenues for the company as a complementary data provider source for both commercial and governmental actors.

### New market segments

The ORCA system establishes a platform that can provide **data to address both commercial/industrial and governmental applications**, with the current first-generation payload already able to serve applications such as insurance/infrastructure monitoring, resource monitoring, insurance risk management, early forest fire detection and emergency management.

In the future, SkyfloX also aims to address pollution and air quality, through mounting additional sensors for measuring pollution in the atmosphere and monitoring debris within oceans – for example, plastic litter. Additionally, from 2026 onwards, the company wants to provide **telecommunication payloads** on planes as well.

In 2021, over half of global revenue was generated by five market segments for EO data: Urban Development and Cultural Heritage, Agriculture, Climate Services, Energy and Raw Materials, and Infrastructure, with a forecast that Insurance and Finance will become an increasingly significant contributor to EO revenues by 2031.<sup>4</sup> SkyfloX's ORCA service is well-positioned to address these markets.

The service offering also **opens up markets** where firms have struggled to afford or find a suitable service for their needs with the existing market solutions, where data performance and cost do not match the monitoring needs of the customer. For example, to monitor pipelines, a single order from a satellite service may take weeks, can be expensive, and often does not provide available data across the whole infrastructure. Conversely, when using drones it can be difficult to monitor the extensive network of pipelines – requiring too many drones and operators to cover the entire infrastructure, but also facing regulatory barriers about obtaining permission to fly. The current solution is therefore to fly helicopters and monitor the network with humans instead. ORCA meanwhile could provide daily monitoring of the pipeline network, covering the full network of pipes, unlike drones, but at lower cost than satellites.

### Cost effectiveness

SkyfloX's ORCA service avoids expensive launch requirements, and enjoys **low capital and operational costs**, especially in comparison with satellite constellations.

Whilst SkyfloX do have to pay for installation and rental costs, which will be paid to the airline companies carrying the payloads, it enjoys significantly lower costs elsewhere in its business model, especially in comparison to satellites constellations that could provide similar data coverage.

<sup>2</sup> European Union Agency for the Space Programme, 2022. *EUSPA EO and GNSS market report*.

<sup>3</sup> European Union Agency for the Space Programme, 2022. *EUSPA EO and GNSS market report*.

<sup>4</sup> European Union Agency for the Space Programme, 2022. *EUSPA EO and GNSS market report*.

For example, ORCA does not have to rely on launchers to place its payload into the correct environment, thereby **avoiding the cost of launch** – even a relatively inexpensive rideshare by SpaceX can cost around \$1.1m (just over €1m) for the launch of one small 200kg satellite, with recent pricing adjustments in 2022 to account for rising levels of inflation.<sup>5</sup>

Beyond launch, the ORCA service also has lower costs thanks to the use of the existing infrastructure of the aircraft operated by airlines. Moreover, unlike satellites, aircraft constellations are easy to service because of the ease of regular access to the payloads. Furthermore, ORCA does not have a dedicated communication ground segment, as it uses the existing mobile telephone network for transmitting the images, and this has led to low CAPEX and OPEX.

### *New collaborations*

SkyfloX is the prime contractor within a large network of stakeholders, **bringing together a wide-ranging consortium of companies** in order to implement the ORCA system.

Whilst SkyfloX oversees the system architecture and design, regulatory aspects, and go-to-market and financing activities, it has required support for production, integration, software and more for ORCA.

For example, SAFRAN Engineering Services has overseen the payload design and certification, whilst Spacemetric has managed the ground and on-board software for data processing, including cloud infrastructure for storage. There are stakeholders involved in the payload engineering and manufacturing, as well as developing the regulatory and legal framework in which such a novel system will function. Airlines have been included in the consortium in order to provide access to their fleets and allow for payload installations and upcoming test flights for the payload. There are also consortium members overseeing the integration of the payload onto the aircraft.

Furthermore, Letters of Intent (LOIs) have been signed with a variety of end users also, including Value-Added Resellers and EO application developers.

Therefore, **the development of the ORCA system has built new collaborations/networks between European industry actors**, including those which may not have a strong connection with the space sector, particularly aviation industries, including airlines and airline equipment developers and manufacturers. This brings opportunities from a technological perspective, introducing new expertise and knowledge across the wider industry.

## **A powerful, yet simple and versatile, technology**

### *High quality data*

The ORCA system can provide data that has **high resolution, high revisit time and good geographical coverage**, at a lower cost than competitor services.

Thanks to images being captured from aircraft rather than satellite-mounted cameras, the ORCA system can provide data that is metre-class resolution. Despite using commercial 'off the shelf' components for the payload, it can capture the **images at a higher resolution than a satellite system** using a similar payload, since it operates at 10km only. Alternatively, drones can operate at lower altitude, but do not have the same geographical coverage as the ORCA system would provide, as their cruising altitude is limited by commercial air space.

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<sup>5</sup> Wall, M., 2022. SpaceX raises launch and Starlink prices, citing inflation. Available at: <https://www.space.com/spacex-raises-prices-launch-starlink-inflation>

As with any optical payload, the ORCA system has limitations when there is cloud coverage, similar to satellites; however, since it will fly over the same areas multiple times a day, there are more opportunities to capture imagery of a specific location, decreasing this risk. SkyfloX has carried out simulations of coverage using flightpaths of specific airlines and cloud statistics, and initial findings indicate the ORCA system would provide better coverage than a satellite system.

Providing a new source of **high-quality, low-cost imagery** means that SkyfloX is offering more accessible data to the market, supporting the democratisation of EO applications.

### *Simplified solution*

As mentioned, the ORCA system utilises the existing infrastructure of aircraft, **avoiding the complexity of having to schedule a launch in advance**, as would be the case in a satellite constellation. It also does not have to face potentially costly delays of launch due to weather, issues with primary launch payloads in a rideshare, issues with the launcher or a myriad of other causes of delays. Furthermore, ORCA does not need a dedicated ground segment as it uses the existing mobile network for its connectivity needs.

From a payload perspective, ORCA has additional technological advantages since it does not require specifications that must survive the space environment. A lot of technology has to be more robust and further tested in order to function well within space; by avoiding this, ORCA can provide payloads at a lower cost. Furthermore, **maintenance of the payload is far simpler**, as the payload is regularly accessible, and equipment can be easily replaced and upgraded.

Moreover, since satellites have to survive for decades in space without maintenance, they are built with redundancy, using expensive materials and design in case of failure. The easily accessible nature of the ORCA system overcomes this issue and allows for less expensive design and production, generating considerable cost savings.

### *Payload versatility*

The ORCA system uses both optical and thermal cameras and is the only system which can offer such a combination; to date, **there are no satellites which provide a similar payload set-up**.

Since the maintenance and access to the payload is far easier for the ORCA system, mounted on an aircraft, rather than a satellite for example, it is also easier to change the payload itself when required, with the main limitations being simply cost and logistics. In the future, SkyfloX is considering providing multispectral cameras, and from 2026 onwards hopes to expand its focus to providing telecommunication payloads on the aircraft also.

## **Impacts on wider industry economic activities and corporate social responsibilities**

### *Corporate Social Responsibility for airlines*

As contributors to climate change, the aviation industry can help balance its carbon footprint by playing a role in the development of **environment and climate monitoring solutions**

The aviation industry is a contributor to climate change, burning fossil fuel that releases CO<sub>2</sub> emissions but which also has strong warming non-CO<sub>2</sub> effects thanks to the nitrogen oxides and vapour trails created by the altitude of the aircraft. These non-CO<sub>2</sub> effects can contribute twice as

much to global warming as the aircraft CO<sub>2</sub> itself, and emissions from aviation are growing faster than any other mode of transport.<sup>6</sup>

With the increasing focus on sustainability and the need to tackle climate change within Europe, **airlines are looking for additional solutions to minimise their carbon footprint** and bolster their Corporate Social Responsibility (CSR). Whilst actions are also being taken around their actual operations, other options could be through supporting environmental and climate monitoring solutions.

Thanks to ORCA providing high quality complementary data for monitoring services, airliners can offer a service of broad societal benefit that would otherwise be extremely expensive to deploy using alternative means. Hence they can differentiate their company brand by how they are contributing towards services such as monitoring forest fires and pollution or supporting emergency management.

### *Pioneers in regulation*

As noted previously, SkyfloX has had to be a pioneer in the face of legal and regulatory activities, because this is the first time a company has tried to use commercial aircraft as a platform for EO. In order to achieve their goal, they have worked extensively within the aviation industry, ensuring agreement with EASA for the certification of the payload to be placed on an aircraft.

Furthermore, there is no Europe-wide regulation pertaining to imagery and flying camera payloads, with each country having their own rules about taking images. SkyfloX has so far received regulatory clearance from 34 countries in and around Europe, working closely with all civil aviation authorities and other relevant authorities. Whilst this work has been time consuming and somewhat challenging, it has also **created new discussions on legal frameworks**, and could have potential impact on the wider industry if utilising aircrafts for payloads becomes simpler to achieve.

### *Increased ancillary revenues for airlines*

By nature of ORCA's business structure, **airlines will be paid to carry the ORCA payload** onboard their aircraft, generating an additional revenue stream for companies.

The solution is a standalone plug-and-play payload, and thanks to the small size of the equipment, it should cause no more than a **negligible impact on aircraft aerodynamics**. Maintaining the ORCA system will be the responsibility of SkyfloX. Therefore, it is a simple service from the standpoint of the airline company, who: will not have to invest in the technology; will not see negative impacts to their aircraft or be concerned with the hassle of maintenance; and will receive financial contributions to carry the payload. Therefore, by installing this turnkey ORCA solution, the airline company can increase their ancillary revenues.

### *Increased economic opportunities for European industry*

With the introduction of a service that is both innovative and new to certain market segments, as well as one which is contributing high quality data, SkyfloX's ORCA is providing new opportunities for other commercial actors. For example, it has created a **new market for equipment manufacturers** who build and integrate the payloads.

The quality and low cost of its data means that it can also contribute to applications and services which may otherwise not be possible due to the required data performance, contributing key imagery in terms of resolution and revisit time for EO application developers. Value-Added Resellers can also benefit.

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<sup>6</sup> European Federation for Transport and Environment, 2022. *Airplane pollution*. Available at: <https://www.transportenvironment.org/challenges/planes/airplane-pollution/>

The ORCA solution also creates **synergies between Civil Aviation and Space Industries**, which is a key European Commission objective.

## Solutions contributing to sustainable environments in space and on Earth

### *Contributing to a sustainable space environment*

The ORCA service **avoids contributing to space debris** and the use of sought-after satellite orbits, thereby **supporting a sustainable space environment**

The European Commission outlined in its 'Action Plan on Synergies between civil, defence and space industries' that a focus should be on including Space Traffic Management (STM) as one of its flagship projects, acknowledging the importance of ensuring the security of space-based assets and infrastructures that are crucial for the functioning of modern societies. The dangers to spacecraft from debris impacts can range from small surface pits all the way to mission-critical damage for debris larger than 1cm, whilst any impact of an object of 10cm or larger will most likely cause a catastrophic disintegration of the spacecraft, thanks to the high velocity of collision within the space environment.<sup>7</sup>

By utilising commercial airliner fleets as the platforms on which to carry the payloads, ORCA provides a solution whereby **high-resolution imagery can be captured without adding to the proliferation of satellites and overall space debris**.

### *Supporting EU Climate Actions*

SkyfloX's ORCA solution aims to be a **complementary data source for European satellite services that supports EU climate action and environmental policies**, especially thanks to the fact it can provide metre-class resolution imagery with multiple daily revisits, and excellent potential geographical coverage. For example, it aims to be a valuable data source for Copernicus in its environment and climate monitoring services, acting as a third-party contributor.

Amongst its solutions, ORCA can contribute towards:

- Optical-thermal imaging for daily Land Surface temperature, where the derived evapotranspiration can be a key variable for climate variability;
- Management of water resources for agriculture;
- Prediction of droughts;
- Addressing land degradation and natural hazards such as forest fires;
- Coastal and inland water management;
- Urban heat island issues and monitoring heat distribution of human-made structures.

Its monitoring parameters could support the EU-Emission Trading System, which is a large greenhouse gas emissions trading scheme used to fight global warming and is a pillar of the EU energy policy, as well as the European Green Deal, which aims to make the EU climate neutral by 2050.

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<sup>7</sup> ESA, 2022. *Hypervelocity impacts and protecting spacecraft*. Available at: [https://www.esa.int/Safety\\_Security/Space\\_Debris/Hypervelocity\\_impacts\\_and\\_protecting\\_spacecraft](https://www.esa.int/Safety_Security/Space_Debris/Hypervelocity_impacts_and_protecting_spacecraft)



Additionally, it can support LULUCF (Land Use, Land-Use Change and Forestry) activities and REDD+, an international framework for reducing emissions from deforestation and forest degradation.

### Tackling forest fires

ORCA has been awarded a **European Seal of Excellence for its solution on forest fires**, where it could provide support to fight fires in all phases – before, during and after.

This assistance is supplied in a variety of ways:<sup>8</sup>

- Thermal and optical imaging with multiple daily revisits for fire risk mapping and monitoring of forest fires;
- Thermal imaging and on-board algorithms can identify active fires at outbreak;
- Fire coordinates are transmitted in real time through satellite communications to authorities;
- During fire suppression, ORCA can provide imaging of extent, size and hot spots of the fire, as well as supply information on access roads and sensitive infrastructure;
- After fire suppression, ORCA can provide information on burned surfaces, infrastructure damage and more, to help decision-makers in their response to the disaster;
- Assistance in investigating the onset of the fire can be provided through reviewing archived images.

The implementation and use of this solution may also be a valuable tool for rescEU, the reserve of resources for providing citizen protection in Europe, integrated into the EU Civil Protection Mechanism.

As estimated by SkyfloX using Copernicus data, if ORCA-equipped airlines could rapidly detect/reduce the spread of only 5% of South-European forest fires, it could lead to the **prevention of around 1 million tonnes of CO<sub>2</sub> entering the atmosphere annually**, a major aviation carbon offsetting action.

## Would these benefits have been realised without ESA?



**ESA have played a vital role** in this project from its conception. The ORCA concept was invented and proposed to ESA by staff member Emmanuel Rammos in 2015. ESA then **patented** the ORCA concept and now **license** the idea to the ESA spin-off company, SkyfloX, founded by Rammos in 2016 with ESA's support. SkyfloX participated in a two-year ESA incubation programme at the ESA BIC in Noordwijk, where ESA played a strong role in the technological development of ORCA. Since then, SkyfloX has run two further ESA programmes as prime contractor, Demonstration of ORCA Constellation Services Phase 1 (DOCS-1), from 2017-2018, and DOCS-2, from 2019-2022. The DOCS-1 contract involved business, technical, and regulatory evaluations of the potential to use commercial planes for telecommunications and EO. During DOCS-1, a first flight test campaign was conducted over the Netherlands. After successful completion of DOCS-1, SkyfloX secured a multi-million-euro DOCS-2 contract, to fly the first payload on a Boeing 737-800 in 2022.

'Without the support provided by ESA, this project would not have begun.'

*Emmanuel Rammos, Founder and CEO of SkyfloX*

<sup>8</sup> SkyfloX, 2022. *Commercial airlines joining the fight against forest fires and climate change*

## ... with further development and benefits to come

SkyfloX are coming to the end of the pilot phase of the project, culminating in conducting real tests on commercial passenger planes. The company is confident that **the technical challenges of the project have been overcome - what remains is overcoming all regulatory barriers**, with a few countries yet to grant SkyfloX permission to use ORCA in their airspace. SkyfloX are also investigating potential end-users, both commercial (e.g., pipeline monitoring or insurance) and governmental, for example, selling data to Copernicus. The company already has partnerships with TUI, Transavia and Luxair as part of the ESA demonstration activities and is currently in discussions with airlines about future steps. Initially the company will focus on EO applications. From 2022-23, SkyfloX plans to obtain series A financing to deploy ORCA on 30 planes in the EU, before raising series B financing in 2024 to expand the fleet to 200 EU planes and 100 North American planes. Finally, in 2026 the firm will branch out into telecommunications and EO, with the aim of using Series C financing to deploy **more than 1,000 aircraft with ORCA technology from 2030 in Europe and North America**.