

## **Socio-economic benefits from ESA Technology Transfers**

A report for **eesa** 



CASE STUDY: Optimising Image Processing Algorithms



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## A new perspective: satellite image processing algorithms to improve lives on Earth

Since 1978, humans have monitored the colour of our oceans from space<sup>1</sup>. Ocean colour can reveal the makeup of the water underneath, informing scientists of everything from phytoplankton

biomass to levels of suspended sediment near to the shore. These measurements collected from satellites are not just of interest to marine biologists but have wider ramifications for climate science, providing clues as to the effects of climate change on our oceans.

eesa European IT specialists Cloudlfight are experts in processing satellite imagery, developing algorithms to extract these vital insights from complex data streams received from satellites. The firm is now transferring this expertise to terrestrial applications with the support of ESA, such as helping UK company GiveVision to develop their visual aid technology, SightPlus, with the aim to improve the lives of visually impaired people on Earth.

## A new generation of satellites

ESA's ENVISAT (ENVIronmental SATellite) provided satellite imagery of our oceans from **2002-2012**, as the first imaging spectrometer mission with the primary objective to carry out the remote sensing of the colour of our oceans and coastal waters. The satellite carried MERIS (Medium Resolution Imaging Spectrometer), a programmable spectrometer operating in the solar reflective spectral range, predominantly intended for ocean colour observations. MERIS made major contributions to scientific study, helping researchers to understand the role of the oceans in our climate system and thus improving our ability to predict climate change.

ENVISAT was finally retired in 2012, having operated for more than twice its planned lifetime. The Copernicus Sentinel-3 earth observation satellite now provides satellite imagery of our oceans and land, observing oceans through OLCI (Ocean and Land Colour Instrument). OLCI is a pushbroom imaging spectrometer based on the design of MERIS, but with an improved specification. The OLCI instrument covers 21 spectral bands, compared to MERIS's 15, has improved coverage of the ocean and mitigates sun glint contamination of images, among other technical improvements. Despite these technical improvements however, it was also vital to design OLCI in a way to ensure continuity of data collection between the two instruments.

In this context, ESA's CAWA (Advanced Clouds, Aerosols and WAter vapour products for Sentinel-3/OLCI) project was initiated to **improve the atmospheric retrieval algorithms** developed for MERIS, extending these to OLCI and allowing for the full exploitation of the data collected since **2002**. ESA contracted European IT specialists Cloudflight to lead the consortium developing these algorithms.

# Cloudflight is a leading full-service provider in the field of **industrial digital transformation** in Europe, providing end-to-end services from

consulting to custom software across a number

of industrial sectors, including the space industry. Cloudflight has over 20 years of experience in digital technologies and has successfully carried out more than 1,000 projects around the world.

On the CAWA project, Cloudflight successfully developed the Generalized Retrieval of Aerosol and Surface Properties (GRASP) algorithm, for the retrieval of aerosols and surface properties, a



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<sup>&</sup>lt;sup>1</sup> ESA, n.d. Sentinel Online. Available at: <u>https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci/overview/heritage</u>

water vapour algorithm, and a cloud top-pressure procedure. These three algorithms have all been applied to the **full MERIS dataset and the OLCI data collected** since the launch of Sentinel-3. During the course of this project, TRL5 was reached.

## A terrestrial challenge

This space technology has since found use on Earth, through the **ESA technology transfer programme**, which put Cloudflight in contact with UK firm GiveVision, to help **develop the software behind their visual aid technology SightPlus.** 



GiveVision was founded in 2014 with the ambition to empower partially-sighted people through technology. The UK-based firm is developing a device called SightPlus, which aims to improve the vision of those with untreatable sight loss, using Augmented Reality (AR).

Before GiveVision developed SightPlus, the only devices available to the 191 million people suffering from untreatable sight loss globally<sup>2</sup> were small handheld devices, essentially comprising a camera and a tiny screen. These devices are rudimentary, only allowing users to magnify objects up close (e.g., for reading). SightPlus offered a substantial improvement on these devices, capable of aiding vision at any distance, so **people with untreatable sight loss could engage in activities previously inaccessible to them**, such as watching TV or playing an instrument. This device has a huge potential user base, with **30 million blind and partially sighted persons** living in geographical Europe alone (1 in 30 Europeans experience sight loss)<sup>3</sup>.

The device could be analogised to a **hearing aid for vision**. It comprises a virtual-reality-style headset, attached to a smartphone, which beams light into the healthy part of the eye. This enables users to make full use of their residual vision, whilst not interfering with normal perception.

The device offers enhancements tailored to different sight conditions and users can alter their field of view according to what they are doing, for example zooming in on a TV.



Image: ESA

## Space technology brought down to Earth ...

GiveVision had developed their code in-house, producing a functioning first-generation device, **but the technology needed improvement**: the device was heavy, heated up quickly and there were small lags between the images shown to users and reality, making the device impractical for some uses/users. These issues stemmed from the **enormous amount of code** needed for the device to function.

To overcome these challenges, GiveVision approached the UK technology transfer broker STFC, who shared GiveVision's request with the Europe-wide network of ESA brokers. Austrian broker Brimatech responded by putting GiveVision in contact with Cloudflight, building a beneficial partnership.

<sup>&</sup>lt;sup>2</sup> Rupert R A Bourne, Gretchen A Stevens, Richard A White, Jennifer L Smith, Seth R Flaxman, Holly Price, Jost B Jonas, Jill Keeffe, Janet Leasher, Kovin Naidoo, Konrad Pesudovs, Serge Resnikoff, Hugh R Taylor, 2013. Causes of vision loss worldwide, 1990-2010: a systematic analysis. *The Lancet Global Health*. 1, no.6, 339-349. https://www.sciencedirect.com/science/article/pii/S2214109X1370113X

<sup>&</sup>lt;sup>3</sup> EBU, n.d. *About Blindness and Partial Sight: Facts and Figures*. Available at: <u>Facts and figures | European Blind Union</u> (euroblind.org)

## As part of an ESA transfer demonstrator project, Cloudflight optimised GiveVision's code, moving computationally intensive tasks from the main processing units to chipsets on the target

platform that are specialised in graphical processing. Cloudflight was able to extract the core application from GiveVision's code, removing irrelevant functionality such as diagnostics and subsequently **reducing the volume of code from approximately 14,000 to 4,000 lines**. This massively cut down the processing time per frame from around 300ms to 50ms, in turn reducing image latency.

## Potential for significant socio-economic benefits

Cloudflight's expertise developed within the space sector has the potential to be applied to a **wide range of terrestrial industries**, with the company already working across aerospace, manufacturing, mobility, transportation and logistics, as well as in the public sector. Although GiveVision have not yet commercialised their SightPlus device, **the technology transfer from Cloudflight to GiveVision was successful and demonstrates the broader potential of Cloudflight's knowledge**.

In the following section, we focus on the benefits associated with this transfer, as an exploration of the types of benefits which can be achieved through the application of Cloudflight's technology and optimisation approach. We also consider the wider potential benefits which could be realised through future terrestrial applications of Cloudflight's expertise developed within the framework of ESA projects.

## **Opening new commercial opportunities**

#### A tangible success for Cloudflight

As an IT company, the majority of Cloudflight's work and demonstrable successes are intangible. This can make marketing difficult for the company, when **potential customers struggle to grasp what they are selling**, never mind appreciating the potential benefits from a partnership with the company. Pictures of lines of code or computers can only go so far in inspiring an audience.

A key benefit of the project to Cloudflight was to give the company a **clear tangible example of the potential of custom code**, showcasing their capabilities. For Cloudflight, visibility is key; the company still uses SightPlus in their marketing today, several years after the technology was successfully transferred.

A **valuable marketing tool** for both companies, with Cloudflight still using SightPlus to demonstrate their capabilities today

#### Showcasing SightPlus

The project didn't just provide a boost to Cloudflight's marketing, but also **gave GiveVision increased visibility and reach**. As part of the project, GiveVision's SightPlus product was presented on stage to a live audience, enhancing in the company's profile.

In addition, an article showcasing the technology transfer was published on ESA's website, gaining traction via Facebook and LinkedIn, and bringing GiveVision's technology to a new, international audience. The association with the European Space Agency and the space sector in general gave the company a new, interesting angle through which to advertise.

#### New market segments and partnerships

Whilst Cloudflight's services can address a wide range of different solutions and market segments, the company's predominant focus is in the areas of: aerospace, manufacturing, mobility, the public

sector, and transportation & logistics. Through its contribution to the SightPlus technology, Cloudflight was able to highlight capabilities within a new market segment with support for visual aids/the medical sector. Additionally, it created a new partnership with a UK-based start-up.

#### Technological advancement

For GiveVision, the key benefit of the project was to develop their technology further, improving the end user experience and hence widening their customer base. Cloudflight had sophisticated capabilities in optimising code, which GiveVision did not, and provided a crucial steppingstone for GiveVision to develop a user-friendly, commercial product.

Optimising the code was crucial to addressing the key problems with the technology identified in prototype user trials, which were creating barriers for end users to make best use of the technology. The specific advancements made possible by this partnership are explored below.

## Facilitating a practical solution for end users

#### Enabling real-time vision

Cloudflight reduced GiveVision's code from **14,000 to 4,000 lines**, increasing the speed of image processing from **300ms to 50ms per frame**.

**With limited processing power, the more code, the slower a piece of software**. By reducing the volume of GiveVision's code from 14,000 to 4,000 lines<sup>4</sup>, Cloudflight increased the speed of image processing, from around 300ms to 50ms per frame. This in turn greatly reduced image latency (the delay between something moving in real life and the image moving on the screen), which is a crucial determinant of users' experience; high image latency can induce nausea and makes activities such as watching TV infeasible, as images on the TV fail to align with the audio. This laid the foundations for GiveVision to develop a usable device.

#### A comfortable, wearable device

Although the results of GiveVision's user trials were broadly positive, **some users felt that the SightPlus device was too bulky or awkward to use**. The virtual-reality style prototype was heavy and protruded a long way from the face to accommodate a large smartphone to perform the image processing work.

Cloudflight's success in reducing the volume of code necessary for the device to function helped to overcome this problem, since GiveVision could then use **more compact hardware and a lighter battery**, paving the way for a far smaller second-generation device, which was designed to resemble a normal pair of glasses.

#### Facilitating greater independence

By helping GiveVision to overcome two of the crucial usability issues associated with the prototype device, **Cloudflight helped GiveVision to lay the foundations for a well-functioning, commercialised device**, which is practical for people to use in their everyday lives. Low latency makes it possible to walk around with the device on, without experiencing nausea, and hence greatly increasing the range of activities those with uncurable sight loss can take part in independently.

<sup>&</sup>lt;sup>4</sup> Verhaert, 2019. Technology Transfer Demonstrators Report.

Furthermore, Cloudflight's work was critical in enabling GiveVision to design a device which could be worn throughout the day. As mentioned previously, the lower processing requirements allowed for a **smaller, more comfortable second-generation device** to be designed, which could feasibly be worn for longer. Secondly, by reducing the demands on the CPU, **battery drain was reduced, allowing for greater use time**.

## With wide-ranging potential applications and benefits...

#### Already in use across a range of industries

Cloudflight's expertise in optimising code can be widely applied to custom image processing software across a wide range of industries. Cloudflight have already taken the knowledge developed in the space sector and on this project forwards, applying these code optimisation skills to a range of both space-related and terrestrial applications.

The firm have since optimised image processing code for a number of international private sector clients working in the space sector, from a large satellite company to a number of start-ups working on NewSpace projects. In addition, this expertise developed in conjunction with ESA has been applied terrestrially to several applications in the travel industry. Cloudflight are using their image processing expertise in toll collection, using very similar methods to those used on the GiveVision project, as well as applying these techniques to automatic baggage detection for airports, allowing airlines to identify the type of bag someone is handling.

#### Occupying a market niche

In the time that Cloudflight has been optimising code commercially, they have not seen other firms offering the same services - only universities assigning code optimisation tasks to students. The firm's **background in the space sector puts them in a strong position to offer terrestrial code optimisation services**; satellites produce enormous volumes of data, through non-stop recording, which must be analysed quickly, requiring efficient code. The criticality of efficient image processing for satellite applications meant that Cloudflight developed deep expertise in this area, so are now in a strong position to transfer their skills to commercial space and terrestrial applications.

#### With energy saving potential

## Globally, data centres were estimated to account for **1% of final electricity demand** in 2020<sup>5</sup>.

Optimising GiveVision's code did not in itself generate energy savings, since the computer processing taking place was minimal and within the device itself. However, **applying these same techniques to other applications has huge energy saving potential**.

Where devices are linked to the cloud, they rely on the services of enormous data service centres, which store and process our data. Although estimates vary, globally these data centres are estimated to account for around 1% of final electricity demand a year<sup>6</sup>. Of this, around 43% of electricity use is associated with servers, the processing element of data centres<sup>7</sup>. Moreover, the electricity used by these devices ultimately converts to heat, which must be removed using cooling

<sup>&</sup>lt;sup>5</sup> IEA, 2021. Data Centres and Data Transmission Networks. Available at: <u>https://www.iea.org/reports/data-centres-and-data-transmission-networks</u>

<sup>&</sup>lt;sup>6</sup> IEA, 2021. Data Centres and Data Transmission Networks. Available at: <u>https://www.iea.org/reports/data-centres-and-data-transmission-networks</u>

<sup>&</sup>lt;sup>7</sup> Shehabi, Arman, Et Al. (2016). *United States Data Center Energy Usage Report*. No. LBNL-1005775. Lawrence Berkeley National Lab.(LBNL), Berkeley, CA (United States).

devices that use yet more electricity. This alone accounts for nearly half the electricity used at data centres.

By reducing the volume of code which computers must enact, Cloudflight can potentially reduce the strain on servers at data service centres, in turn reducing the electricity demands and emissions of these centres. Cloudflight have noticed a significant uptick in interest surrounding the environmental impact of computer usage over the last two years, as climate change awareness grows.

### Would these benefits have been realised without ESA?



**ESA played a crucial role throughout this technology transfer**. Cloudflight developed their code optimisation techniques across a number of ESA-funded projects, notably the CAWA project, improving the algorithms associated with MERIS and extending these to OLCI. ESA was also key to the transfer itself:

GiveVision used the Europe-wide ESA broker network to have their technology need matched with Cloudflight's code optimisation capabilities through their respective technology brokers. Once the potential for a successful transfer was established, ESA remained key to its success, by providing **transfer demonstrator funding**. This enabled Cloudflight's time-consuming work, optimising 14,000 lines of code over 6 months and laying the foundations for substantial future benefits to both companies and wider society.

"The ESA study in 2012/13 was the **cornerstone of these activities**...The tech transfer [ESA TTPO] gave GiveVision the funding and in that regard helped them... it was a **clear win-win** for them."

Michael Aspetsberger, Industrial Leader, Aerospace and HPC at Cloudflight

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

**Cloudflight have enjoyed continued commercial success with their code optimisation capabilities**, employing these skills both in the commercial space sector and in a variety of terrestrial applications. Given the generalised nature of their expertise, Cloudflight could work with firms in virtually any sector, opening a huge pool of potential commercial opportunities. They have already applied their expertise to several different sectors and uses, including toll collection and luggage screening at airports. The firm has noted increased interest in the environmental benefits associated with code optimisation, boosting interest in their services. Cloudflight remain on Brimatech's listings and are **open to further opportunities in this area**.