HydroGNSS will help to monitor Earth's vital signs

Surrey Satellite Technology Ltd (SSTL) has built a pair of 72kg small satellites for a mission called HydroGNSS to measure climate change variables relating to Earth's water cycle.

HydroGNSS will measure key hydrological climate variables, including soil moisture, freeze thaw state over permafrost, inundation or wetlands, and above ground biomass, using a technique called GNSS-R (Global Navigation Satellite System Reflectometry).

It uses existing signals from Global Navigation Satellites, such as GPS and Galileo, as radar signal sources. These signals are reflected off the land, ice and ocean and can be collected by a low power receiver on a small satellite in low Earth orbit. They can be used to yield important geophysical measurements.

The novel HydroGNSS microsatellite mission is part of the Scout framework which is a new component of the European Space Agency's (ESA) Earth Observation FutureEO Programme.

HydroGNSS consists of two satellites and it paves the way for an affordable future constellation that can offer measurements with a temporal-spatial resolution not accessible to traditional remote sensing satellites, thus offering new capacity to monitor very dynamic phenomena and helping to fill the gaps in our monitoring of the Earth's vital signs for the future.

Several innovations in measurement enable HydroGNSS to innovate the products to access improved resolution on the ground, sensing of inundated locations and separation of roughness and vegetation effects from soil moisture.

The HydroGNSS mission will assist with the fight against climate change by providing valuable measurements using space technology.

HydroGNSS is based on earlier SSTL endeavours in GNSS-R that prompted other nations around the world to embark on their own GNSS-R constellations.

HydroGNSS Principal Investigator Martin Unwin with UKSA representatives

The journey to HydroGNSS

The Centre for Earth Observation Instrumentation (CEOI) first supported SSTL in 2011 when it provided funding for developing product development systems which SSTL flew on TechDemoSat-1 (TDS-1). Following this mission, SSTL's Space GNSS Receiver Remote Sensing Instrument (SGR-ReSI) was selected as the primary payload for NASA's Cyclone Global Navigation Satellite System (CYGNSS) constellation and the organisation received funding from the European Space Agency.

SSTL went on to win the bid to provide a satellite for HydroGNSS and applied to CEOI for further funding so it could add extra capabilities to the payload it was developing for the mission.

"The work we did on TechDemoSat-1 (TDS-1) and for NASA's Cyclone Global Navigation Satellite System (CYGNSS) constellation was revolutionary. There is a large community of people who have been using data from TDS and CYGNSS for all kinds of applications. It really stirred things up and there are other missions from other countries now – all this stems from our work that was funded by CEOI."

- Martin Unwin
HydroGNSS Principal Investigator

About HydroGNSS

HydroGNSS went into orbit on November 28, 2025 and uses L-band satellite navigation signals to monitor Earth's water systems and gather measurements linked to Essential Climate Variables (ECVs) that critically contribute to the characterisation of the Earth's climate, as defined by the Global Climate Observing System (GCOS) set up by the World Meteorological Organization (WMO) and the United Nations.

It will collect information about soil moisture, inundation or wetlands, freeze/thaw state over permafrost and above-ground biomass and will measure wind speed over the ocean. The information it collects will support researchers and organisations involved in climate monitoring, agriculture, meteorology and mitigation planning for floods and drought.

It will complement ESA's existing Soil Moisture and Ocean Salinity (SMOS) mission measuring soil moisture and ESA's Biomass mission which provides information about the state of our forests, how they are changing and the role they play in the carbon cycle.

As a secondary product HydroGNSS's ability to measure the sea state has weather and climate uses and may also have commercial applications as the intelligence it can provide could help shipping companies to more efficiently route their ships.

SSTL is managing to do this with a relatively low-cost satellite. NASA's SMAP (Soil Moisture Active Passive) satellite cost over $900 million when it was launched over a decade ago. In comparison, SSTL had a budget of €30 million for its two HydroGNSS satellites.

GNSS-R is a form of radar that doesn't need a transmitter because it uses signals being transmitted between existing Global Navigation Satellites and Earth. The signals are collected by a low power receiver on a small satellite in low Earth orbit as they return from the Earth and the geophysical imprint of the signals are then measured. The fact the satellite only needs the receiver element of the process means HydroGNSS is a relatively small satellite.

The HydroGNSS mission consists of two satellites but the team at SSTL believe many new applications will be developed from the data and hope it will pave the way for a larger constellation of satellites to provide even more frequent global measurements in the future.

How CEOI supported HydroGNSS

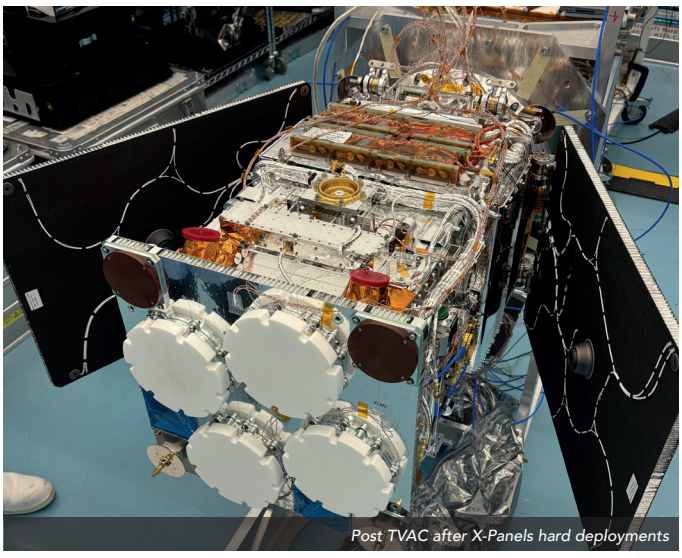
Since 2011, the CEOI has provided SSTL with £691,000 of funding. Its first grant enabled SSTL to develop an earlier instrument which demonstrated a new way of remote sensing. The organisation credits CEOI's funding with enabling it to develop this technology and get it into space and this quickly led to SSTL being selected for NASA's Cyclone Global Navigation Satellite System (CYGNSS) mission.

When the concept for HydroGNSS technology was originally advanced there were initially reservations about it because of the low strength of the signals it was proposing to use. However, the earlier work SSTL had done, which had been supported by CEOI, gave people the confidence that it could be done.

The latest grant from CEOI enabled SSTL to invest extra time in developing a number of HydroGNSS' peripheral capabilities. As a result, HydroGNSS' instruments are more capable in orbit thanks to CEOI's funding. In particular, the technology's dual frequency – utilising Galileo and GPS signals – is more enhanced.

SSTL also says CEOI played a pivotal role in it developing one of its key partnerships. When the SSTL team bid for CEOI funding, the CEOI encouraged it to work with other scientific and academic partners which led to it beginning a partnership with the National Oceanography Centre. It is a research centre committed to gaining a deeper knowledge of the complexity of the oceans, the Earth system and biosphere and the organisation's work includes measuring the oceans and modelling how oceans behave.

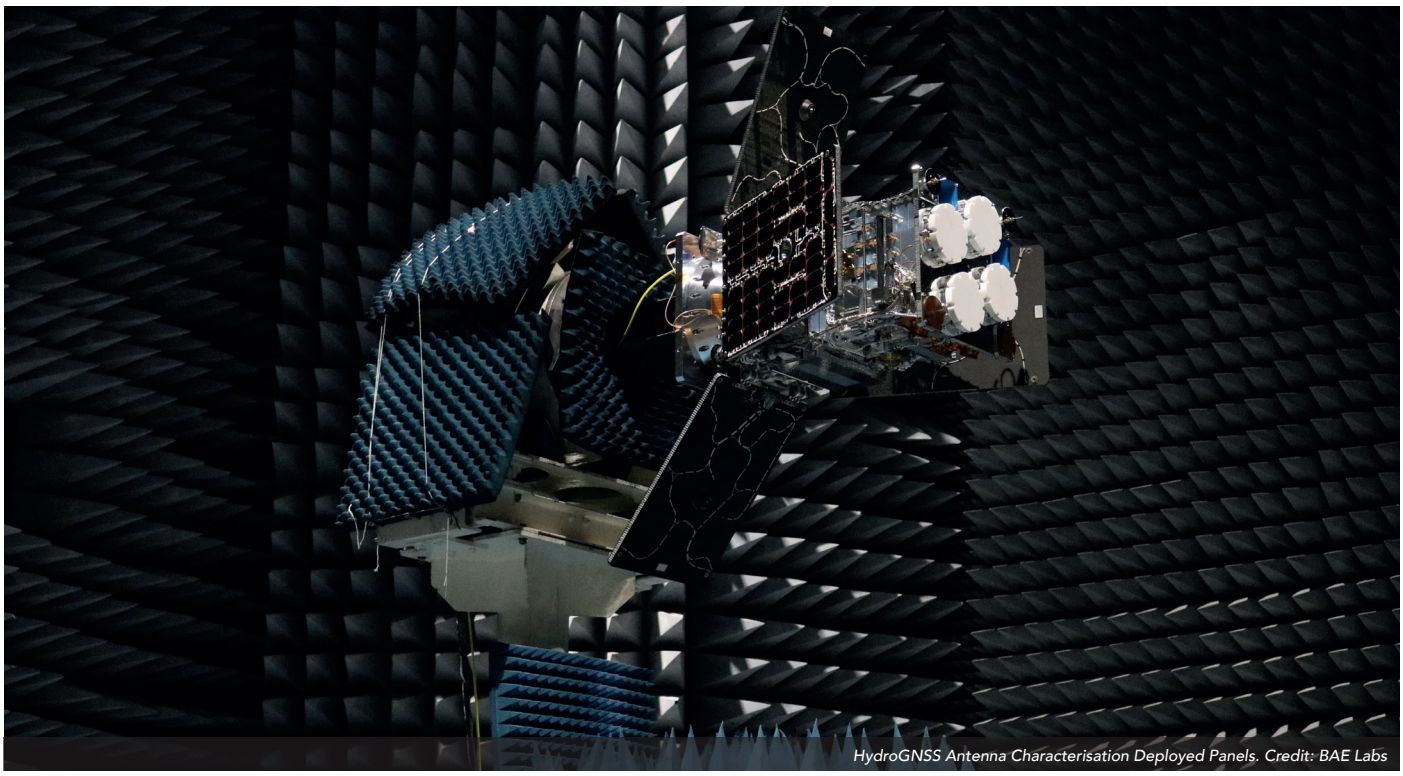
GNSS-R can measure the differences between a calm ocean that is flat and without winds and a rough ocean with strong winds and big waves, including areas of the deep ocean which are not currently well measured. The information provided by HydroGNSS will support the National Oceanography Centre with its research and its efforts to model how oceans behave and how climate affects them.



Post TVAC after X-Panels hard deployments

Current status of the mission

SSTL's two HydroGNSS satellites went into orbit on SpaceX Transporter-15 in November 2025 as part of a European Space Agency (ESA) Mission.
The data from HydroGNSS will be owned by ESA and SSTL will make it available to users on an open and free basis. The SSTL team will support users with the data for their research and it is expected that this mission will lead to the discovery of further promising applications for this novel technology.



HydroGNSS Antenna Characterisation Deployed Panels. Credit: BAE Labs

In the words of Martin Unwin
HydroGNSS Principal Investigator

"Our first instrument demonstrated a new way of remote sensing. CEOI allowed us to develop this in preparation for use in space on TDS-1 and that very quickly led to us being selected to be part of NASA's Cyclone Global Navigation Satellite System (CYGNSS) mission. The work we did on TDS-1 and CYGNSS showed that the signals that were being picked up over the land contained valuable information and by processing them in the right way it was possible to recover useful measurements of soil moisture and other hydrological parameters and this inspired HydroGNSS. The most recent support we've received from CEOI enabled us to spend more time on HydroGNSS's peripheral capabilities. The instruments are more capable in orbit thanks to CEOI – in particular, the dual frequency capability is better."

At a glance

- CEOI has provided **£691,000** in funding towards GNSS-R projects since 2011
- The HydroGNSS mission was designed and built in Guildford
- HydroGNSS consists of **2** satellites in Low Earth Orbit
- Both satellites carry a GNSS-R instrument and are at a nominal orbit altitude of **500km – 600km** and at an inclination of 98°, phased apart by 180 degrees
- Reflected signals will be used to reveal valuable information about the land water cycle and more
- GNSS reflectometry is a growth market, with strong potential for commercial applications and new international partnerships
- The core team working on the satellite project consists of **25** people
- Around **250** people have been involved in the project – three-quarters of SSTL's workforce
- The project has **8** European science partners
- It provided internships for **2** PhD students and a further **2** PhD students based at SSTL contributed towards the project

Members of the HydroGNSS team

"When you bid for CEOI funding, it really encourages you to work with scientific and academic partners and it's through working with other people that you often find a user. In our case we found that the National Oceanography Centre wanted measurements over the ocean and we had a way of developing technology to support their needs."

- Martin Unwin
HydroGNSS Principal Investigator

"HydroGNSS is incredibly novel and there is such a scientific need for it. Other nations are now planning their own constellations but this is really the first European endeavour in GNSS-R focused on using this technique for land sensing."

- Peter Garner
SSTL Senior Project Manager