DLR

esa

living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

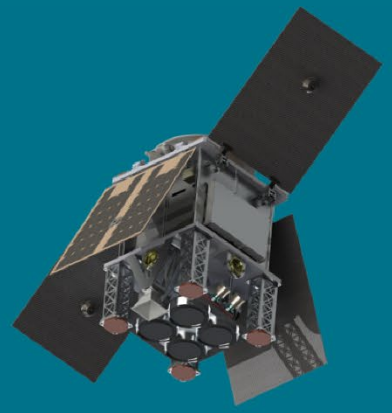
The New Space Scout Mission - HydroGNSS

Dr. Peter Garner, SSTL

24th May 2022

ESA Living Planet Symposium

23-27th May 2022, Bonn



The New Space Scout Mission – HydroGNSS

Dr Peter Garner, SSTL – Project Manager for HydroGNSS

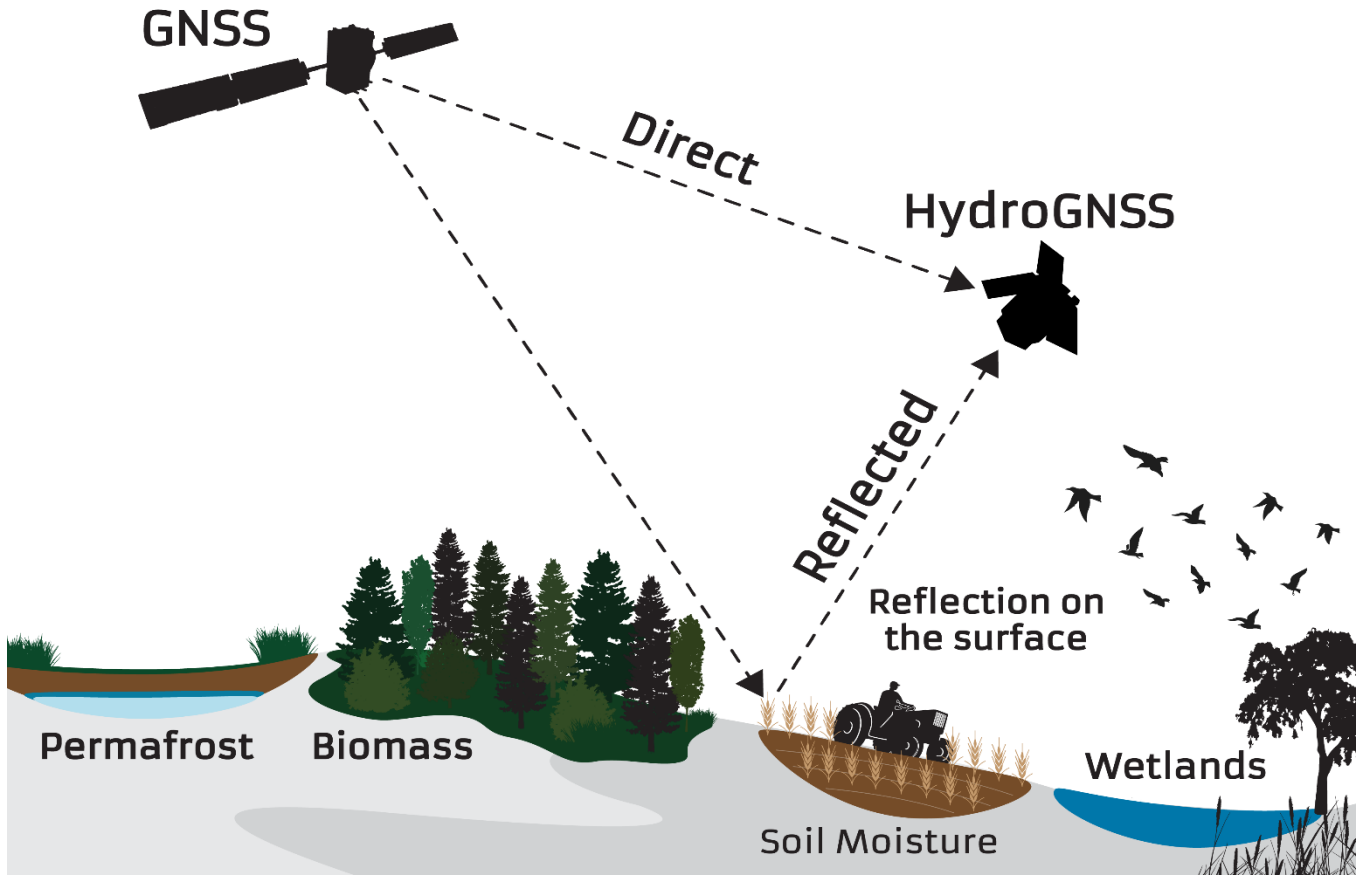
SSTL is supported by a team of Science partners, comprising:

ESA Scout Missions

- New initiative from ESA's Earth Observation directorate
- Small satellite missions, demonstrating science with small budget and rapid schedule
- Missions fully funded by ESA, characterised by an agile and low-cost development process to prove new concepts for future ESA endeavours
- Aiming to tap into New Space approach to achieve a launch within 36 months after KO, budget < €30m
  - Accepting higher risks, use of COTS components, reuse of existing designs
- Free, full and open data, delivered using service-based approach
- **HydroGNSS** selected as one of first two Scout missions in Feb 2021

What is HydroGNSS?

- HydroGNSS targets land parameters linked to Essential Climate Variables (ECVs)
- Global Climate Observing System (GCOS) specifies 54 ECVs for observation of climate, of which 60% can be addressed by satellite data



- **Soil Moisture**, **Biomass** and **Permafrost** are key ECVs.
- **Wetlands** a primary source of greenhouse gases
- Mission uses GNSS-Reflectometry
  - Addresses shortage in L-band measurements
- For details on the Mission & Science Objectives of HydroGNSS, see SSTL talk:
  - *Wednesday 25th 8:30AM - Garden Room*
  - ***B7.01 Scout:** ESA New Space Science Missions*

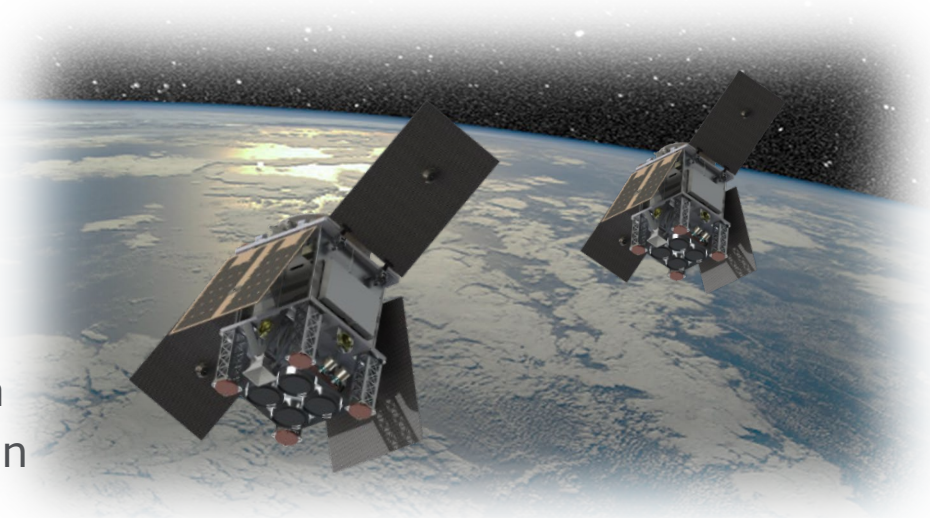
HydroGNSS Service Delivery

Payload

- New GNSS-R Instrument based on those flown on TDS-1 and CYGNSS missions
- Nadir antenna ~13 dBi dual polarised, dual frequency
- Instrument compatible with Galileo & GPS, reconfigurable in orbit, supporting new GNSS-R measurements

Platform

- 65 kg SSTL-Microsatellite, dual redundant core avionics
- 2.5 year operational life plus 2 year extension
- Agile star tracker attitude, Xenon propulsion
- Dual redundant X-band 200Mbps downlink



Ground Segment

- Payload Data Ground Segment (PDGS) in Guildford, UK
- Based upon www.merrbys.org disseminating Level 1, Level 2 data
- End-to-End Simulator demonstration informs the payload design
- SSTL prime, supported by science team members
- Operations & all scientific data product Service Delivery will be conducted by SSTL from Guildford

Launch & Constellation

- SSTL procure Launch and manage Launch campaign
- Option for an identical second satellite to enhance the scientific return from the programme, particularly benefitting the dynamic geophysical processes.
- Future HydroGNSS satellites could be added to the constellation at low re-build cost

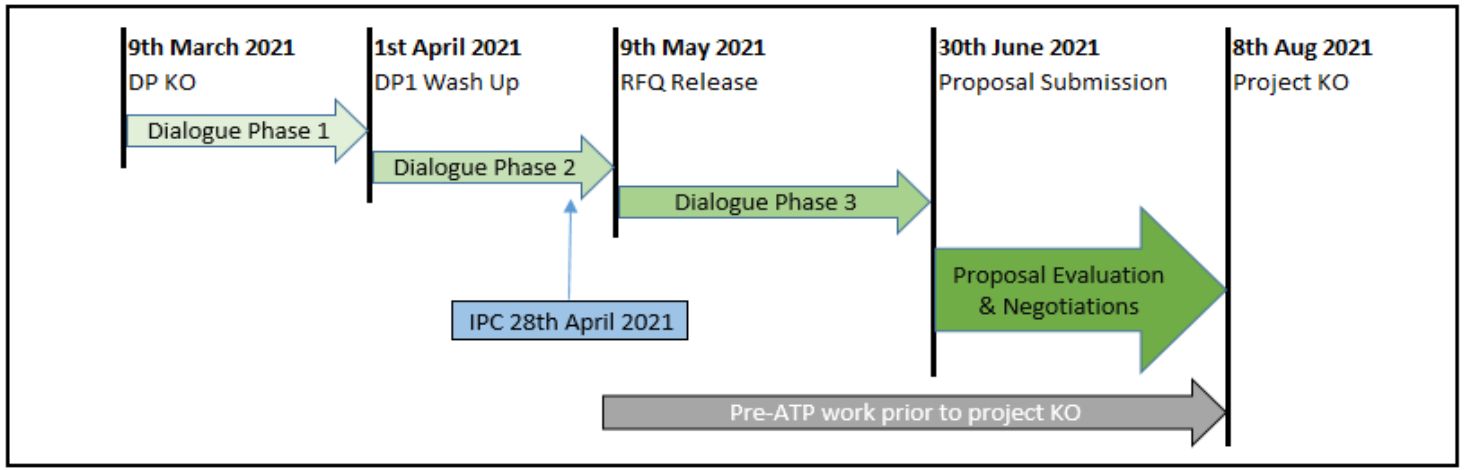
HydroGNSS Path to Selection

- ESA solicits Scout bids 2019
  - First HydroGNSS concept and team discussions at GNSS+R conference, Italy, Benevento May 2019
  - 16-17 proposals received by ESA, August 2019
- Consolidation Study Award Nov 2019
  - Four Scout concepts down-selected
  - Study Jan 2020-Aug 2020
  - Presentation to ACEO, Oct 2020
- ESA Scout Awards
  - Scout-1 announced, Dec 2020
  - Scout-2 announced, Feb 2021
    - **HydroGNSS selected as Scout-2**

HydroGNSS Study Team Members pre-lockdown (Feb 2020)

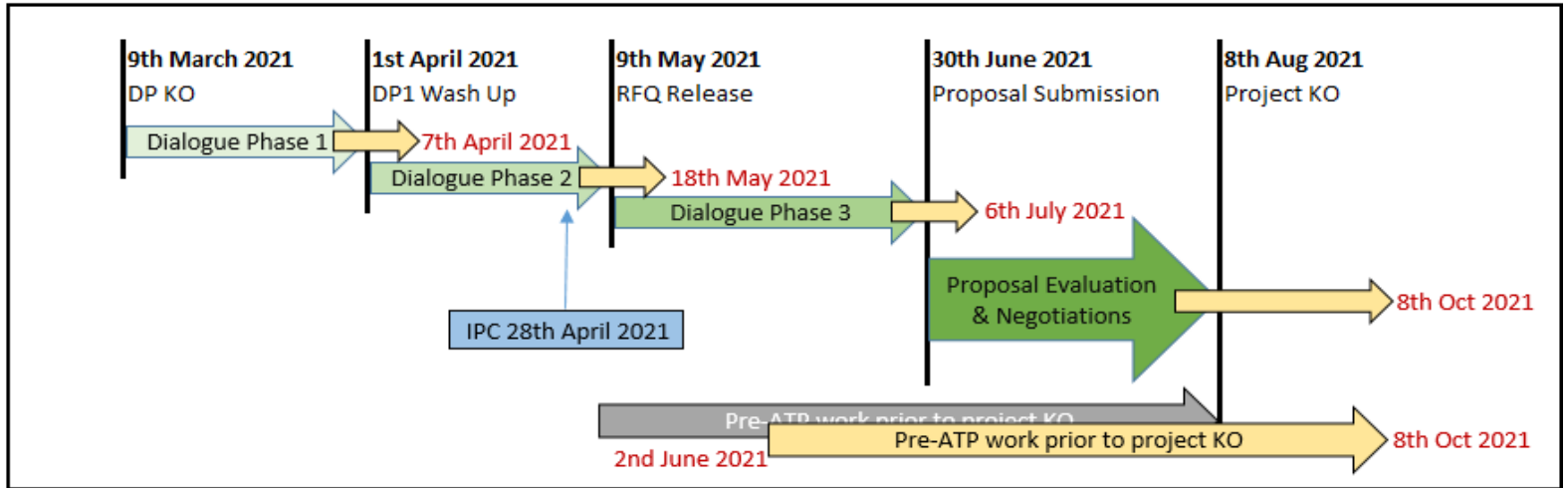
Pre-Contract Discussions

- After selection, ESA outlined the three specific dialogue phases expected prior to any proposal evaluation, negotiations and project KO
  - **Dialogue Phase 1** (March 2021):
    - Final evaluation to confirm the mission can go forward to Implementation, ROM refresh of costs ahead of the April IPC
  - **Dialogue Phase 2** (April-early May 2021):
    - Detailed discussion about technical and programmatic areas of the service delivery requirements, RFQ preparation and scope of pre-Contract work to advance key technologies
  - **Dialogue Phase 3** (early May-June 2021):
    - Contractual focus prior to final proposal submission, start pre-Contract work ahead of project KO
- Very challenging schedule set to get to project KO in 5 months



Pre-Contract Discussions

- SSTL has taken a very positive experience from the Pre-Contract interactions
  - Ability to clearly explain SSTLs pioneering approach has been encouraged regularly by ESA
  - Constant interaction has lead to team building & understanding between project teams
  - Refinement of project SOW using Statement of Compliance and tailoring the PARD & ECSS to enable the best scientific scope within the available budget and required schedule
  - The benefits taken have not come for free due to the efforts required, but it costs much less than preparing for a typical ESA science mission, future participation encouraged
  - The desire to get the best from discussions lead to a delay through the phases that meant proposal evaluation & negotiations clashed with August holiday period extending this phase
  - **Concluded with SSTL signing contracts on the first ESA Scout Mission in Oct 2021**

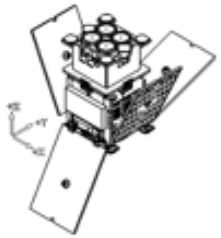


Implementation – Key Delivery Points

Oct-21
Project KO

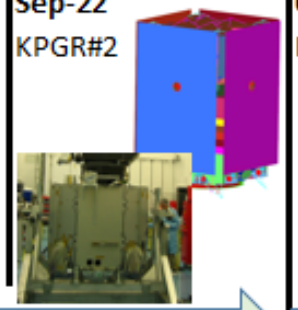
SRR Phase Inc. TRL5

Jan-22
KPGR#1



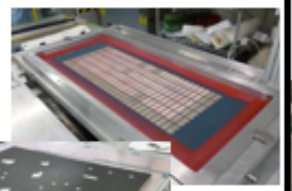
PDR Phase Inc. TRL6

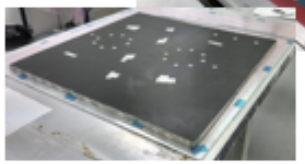
Sep-22
KPGR#2



CDR Phase

Oct-22
KPGR#3

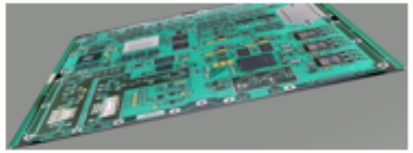




Structure Manufacture

Feb-23
KPGR#3a

Avionics Manufacture & Test and prepare for AIT Start

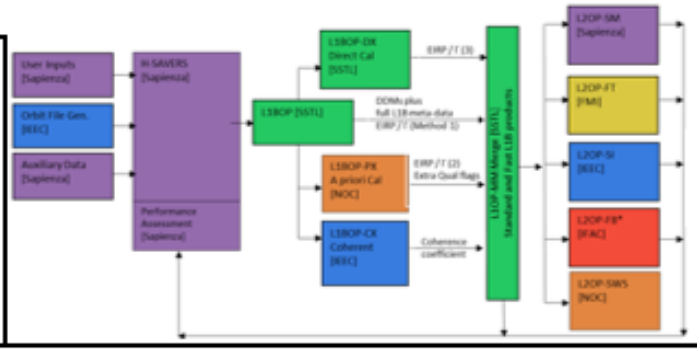


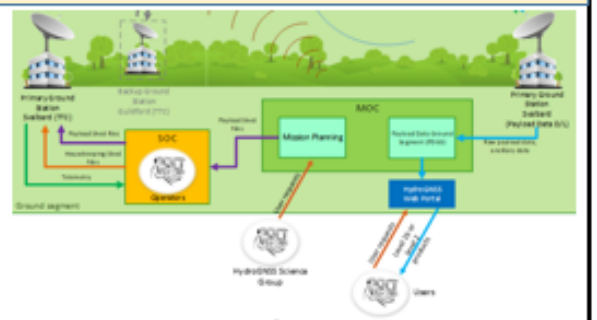
AIT Commences...

End to End Simulator (SRL5)

End to End Simulator (2nd Order)

Ground Segment (including PDGS) Development...

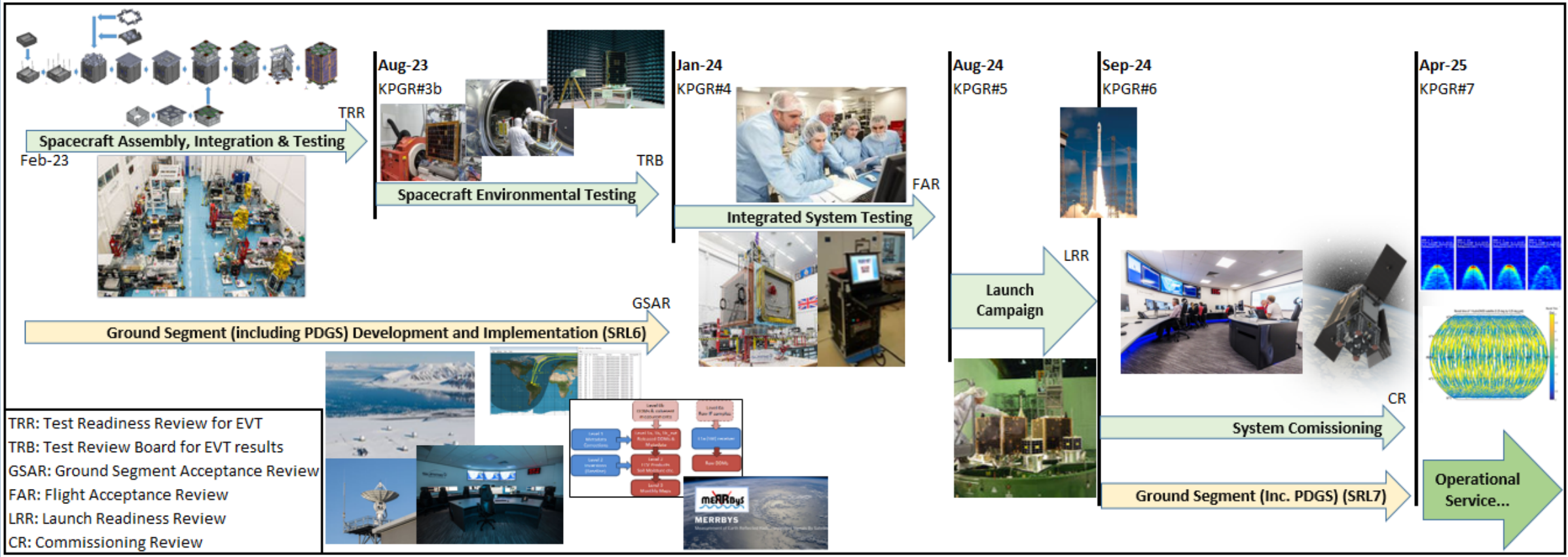




SRR: System Requirements Review
PDR: Preliminary Design Review
SRL: Scientific Readiness Level
TRL: Technology Readiness Level
CDR: Critical Design Review
AIT: Assembly, Integration & Test
KPGR: Key Performance Gate Review

SAPIENZA UNIVERSITÀ DI ROMA
TOR VERGATA
Institute of Space Sciences CSIC IEEC
IFAC
National Oceanography Centre
University of Nottingham

Implementation – Key Delivery Points



The Equation of Success

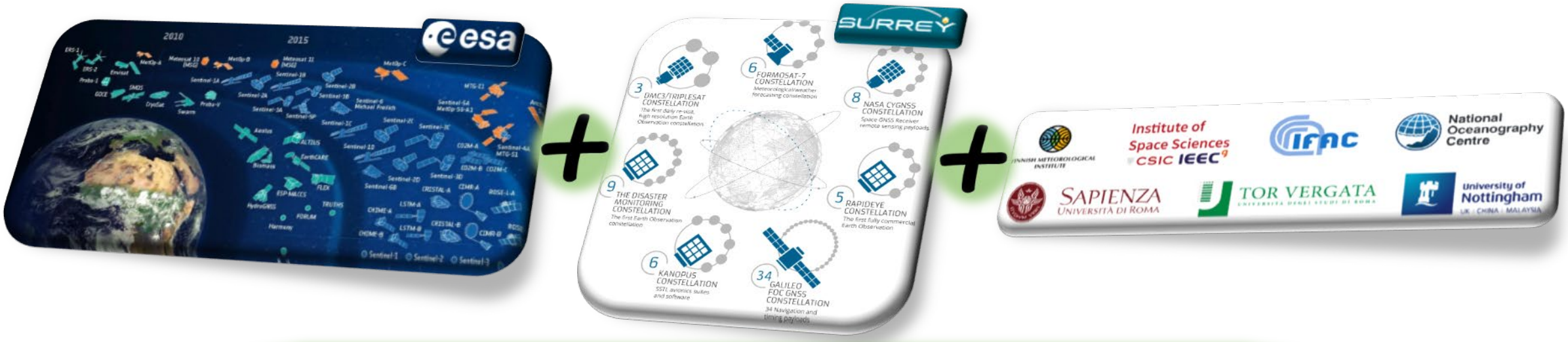
- The Scout Missions are an experiment by ESA…..

- SSTL are New Space, with the advantage of 37 years experience doing it
- Combined with ESAs science knowledge and a pragmatic ESA project team
- Plus a motivated team of highly capable Science Partners

The Equation of Success

- The Scout Missions are an experiment by ESA…..

- SSTL <u>are</u> New Space, with the advantage of 37 years experience doing it
- Combined with ESAs science knowledge and a pragmatic ESA project team
- Plus a motivated team of highly capable Science Partners



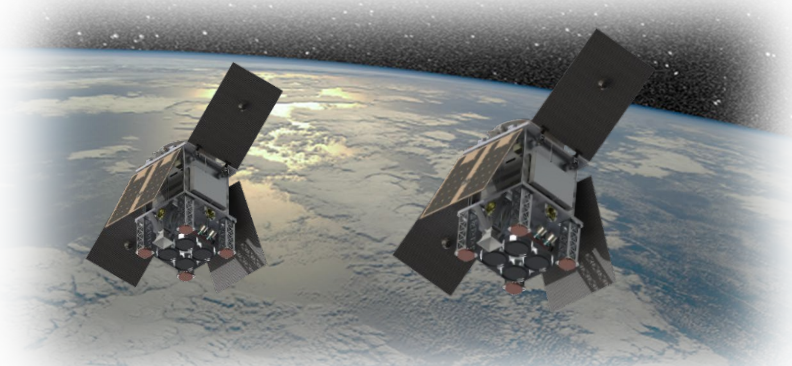
= Successful Scout Mission

Pressing Need for Soil Moisture

- Scientists, meteorologists and others increasingly using global soil moisture measurements from space
  - Accurate weather forecast depends on soil moisture measurements
  - Also needed for flood warning services, agriculture, subsidence, permafrost sensing, climate modelling
- ESA SMOS and NASA SMAP provide soil moisture through passive L-band radiometry, most widely used for soil moisture measurement
  - But both satellites are past end of design life, no immediate replacements
  - Large satellites (SMAP had 6 metre antenna, cost $1B) hard to sustain
  - Urgent need recognised for continuity of services
- COP26 ‘Space Enabled Net-Zero’ targets would benefit from monitoring soil moisture in support of fighting climate change using Space–enabled technology in line with the Ten Point Plan in the UK National Space Strategy

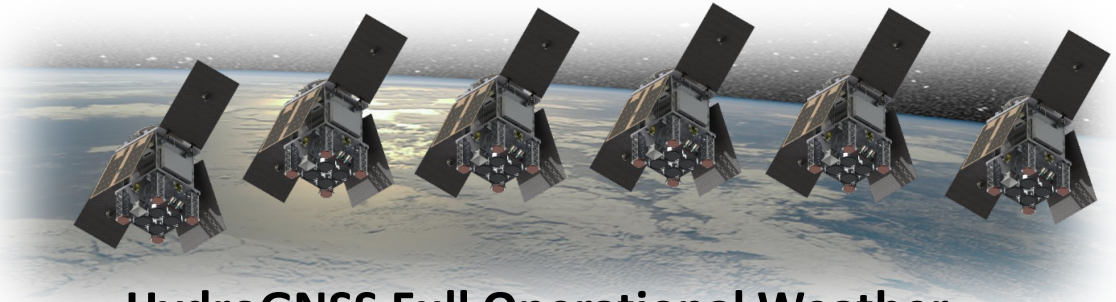
Need for HydroGNSS Constellation

- ESA Scout Mission proves the technology & delivery of the science
- Follow on operational constellation would provide global temporal coverage as SMOS (~3 days), at improved spatial resolution (<25 km)



ESA Scout HydroGNSS x 2

Augmented By:



HydroGNSS Full Operational Weather Satellite Constellation x 6

- HydroGNSS Workshop (Feb 2022) with participation by Users
  - Met Office, ECMWF / C3V, ESA CCI
  - Identified HydroGNSS would be filling valuable role as a continuity source of Soil Moisture Measurements from SMOS, SMAP, and offering new forward scatter measurements valuable for Essential Climate Variables
  - Importance of fast delivery of data for weather forecast and flood sensing was highlighted
  - Lower cost robust technology, sustainable approach to address future soil moisture needs

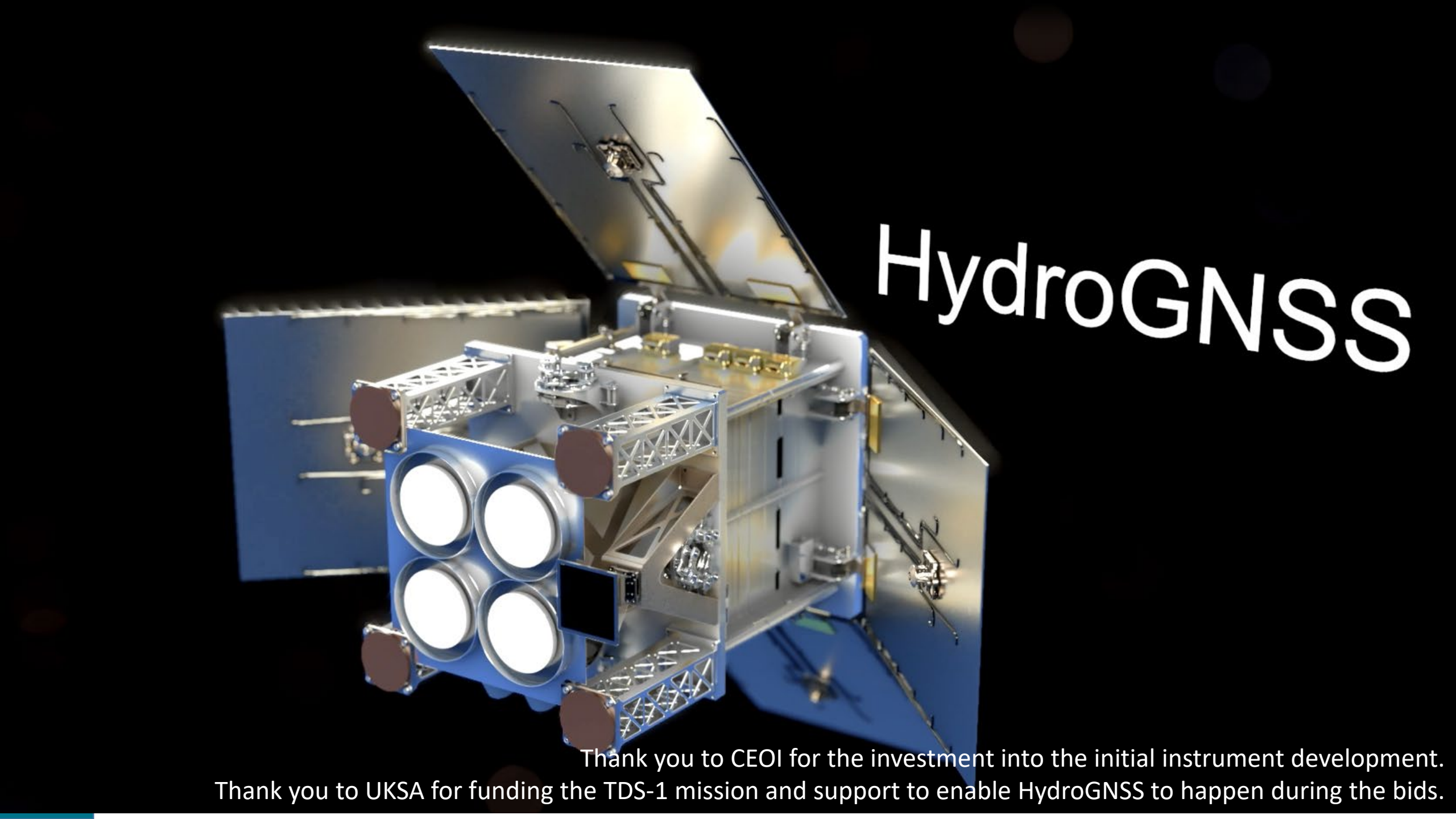
Second ESA Scout HydroGNSS Satellite

- Original science approval from ACEO in 2020 was for two HydroGNSS Satellites
- Single HydroGNSS satellite enables GNSS-R for land sensing
  - Single satellite demonstrates all GNSS-R innovations (dual polarisation, dual frequency, coherent channel), shows recovery of ECVs from GNSS-R measurements,
  - Adequate for capturing slow dynamic hydrological & biomass processes especially at high latitudes
- Two HydroGNSS satellites offer significant advantages
  - Sets framework for constellation – enabling cross-satellite normalisation
  - Coverage increase – second satellite improves global coverage from 30 days to 15 days
    - Mean revisit time at a location improves from 3.8 days to 2.9 days
  - Temporal monitoring resolution of dynamic processes improves significantly
    - Soil Moisture, inundation, Freeze/thaw transition in permafrost, forest disturbances & ice
    - All better sampled with two satellites to improve scientific return
- Option for the second HydroGNSS satellite – within Scout envelope (€30m)
  - Efficient build of two satellites, launched together, commissioned together
  - Improving scientific return, benefitting Earth Science for Society

HydroGNSS Summary

- Great opportunity to exploit small satellites to advance Earth Observation science
- At €20-30m, Scout Missions sit somewhere between Earth Explorers (budgets ~€200m+) and typical New Space missions (<€10m)
- Accelerated schedule (36 months KO to launch)
- Strong science element
  - Scientific Advisory Group called to oversee mission
  - Scientific Readiness Levels (SRL) must be met according to SRL Handbook
- Technology Maturity
  - Technology Readiness Levels (TRL) to be demonstrated for new technologies throughout
- Product Assurance
  - New Space PA approach can be used, tailored from ECSS baseline to suit the strengths of the supplier
- Opportunity to add a second satellite at CM22 within the Scout envelope (€30m) to improve scientific return, benefitting Earth Science for Society

- **HydroGNSS has been optimised to deliver the best scientific return within the available schedule and budget**



Thank you to CEOI for the investment into the initial instrument development.
Thank you to UKSA for funding the TDS-1 mission and support to enable HydroGNSS to happen during the bids.

Export Information

UK Export Control	**This document and any hardware referred to within has been UK Export Control Rated as:**	
Hardware UK Export Rating Number:	Not Controlled	**Date of rating:** 22/05/22
Information UK Export Rating Number:	Not Controlled	
I confirm I am an approved SSTL Export Rater and this rating is correct as of the date above:		Peter Garner
US Export Control	No US Origin Content	
ITAR	**The information contained herein is controlled under US ITAR and is authorised for export under the provision of TAA/DSP: Not Controlled**	
EAR	**The information contained herein is controlled under US EAR and has been classified as ECCN: Not Controlled**	
ITAR EAR	**The following statement is only applicable for documents containing ITAR/EAR classified information. This document contains information controlled by the U.S. government and authorized for export only to the country of ultimate destination for use by the ultimate consignee or end-user(s) herein identified. It may not be resold, transferred, or otherwise disposed of, to any other country or to any person other than the authorized ultimate consignee or end-user(s), either in its original form or after being incorporated into other items, without first obtaining approval from the U.S. government or as otherwise authorized by U.S. law and regulations.**	