NEOMI (New EO Mission Ideas) – 250 k€ scientific studies initiated end of 2022 ; New Call in 2024

Continuous flow for creating new mission concepts (with SRL =3) ➔ to become candidate mission concepts for Earth Explorer Calls

PoSARA: UCL (UK) with Univ. Manitoba (CA), Univ. Northumbria (UK), Leeds University (UK).
- study of polarised altimeter echoes to simultaneously retrieve elevations of the upper and lower interface between snow and sea ice and land ice.

SLAINTE (Sub-daily Land Atmosphere INTEractions) - led by TU Delft (NL) with sub-co: TU Wien (AT), Univ. Edinburgh (UK), Ghent University (BE), CNR-IRPI (IT), and MPI-BGC (DE).
- exploitation of sub-daily land-atmosphere interactions based on a microwave SAR (C-band) in a MEO or LEO orbit.
- **Already proposed for EE-12**

Nightwatch - led by GFZ Potsdam (DE) with sub-co from Cégep de Sherbrooke (CA), IGB (DE), Stars4All (ES) and University of Twente (NL).
- exploiting the connection between artificial night light and societal and environmental issues based on a Hi-Res multi-channel optical sensor.
- **EE-12 EULE was derived from this NEOMI Activity**

Technology developments within System Studies

Phase 0/A System studies are co-funded:
FutureEO + Preparatory (part of DPTD Basic Activities)

EE-11 phase 0/A : significant increase for Technology
- well above average (< 40 %) of System Studies

On-going in 2022:
- 6 missions in Phase 0
- 5 missions in Phase A/B1

Much more than one decade ago.

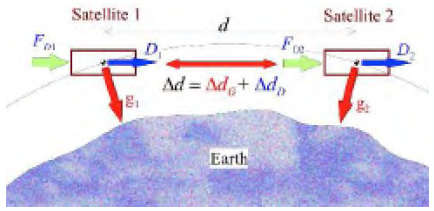
	Phase	M€ per study (2 parallel studies)	Technology part M€	Technology part %
EE-9 (Skim, Forum)	A	3.5	1.5	43%
	B1	4.5	1.5	33%
EE-10 (Harmony, Hydroterra, Daedalus)	0	1	0.4	40%
	A	3.5	1.5	43%
EE-11 CAIRT, WIVERN, Ph.0/A Nitrosat, SEASTAR : Ph.0 only	0	1.3	0.4	30%
	A	4.5 + 1	2.5 + 1	63% ~~(55%)~~
EE-12	0/A			
CO2M, CRISTAL, CMIR, ROSE-L	A/B1	5	1.8	36%
LSTM, CHIME	A/B1	6	2	33%
NGGM	A	4.5	Next slide	
S1-NG	A/B1	5.5	1.6	29%
S2-NG	A/B1	6 + 0.5	2.5 + 0.5	45% ~~(41%)~~
S3-NG Opt.	A/B1	6 + 1.5	2.5 + 0.5	53% ~~(41%)~~
S3 Topo-NG PhA/B1 + S6 NG Ph.A	A/B1	6	1.6	27%
Aeolus-2	A2/B1	2	Next slide	

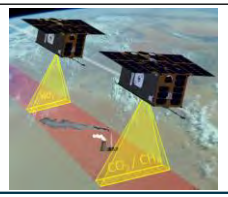
ESA acknowledges the importance of technology
Increase : increase of 1 to 1.5 M€ per study in recent Ph.A studies

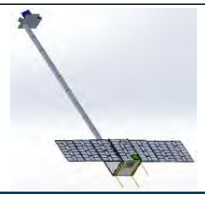
Increasing % in technology (> 40%, up to 63%)

Additional technology developments (by FutureEO)

Some mission concepts have additional technology pre-developments

	Phase	M€ per study	Additional technology activities
 **NGGM – MAGIC** Next Gen. **Gravity** Mission Mission of Opportunity (MoO) with NASA	A	4.5 M€	15.5 M€ Laser Tracking instrument, Propulsion, accelerometer
Wind  **Aeolus-2**	A2/B1	2 M€ (not incl. P/L)	21.8 M€ UV Lidar Instrument consolidation, 2x Transmitter Laser, Detector Emission Beam Expander Beam Steering Mechanism Double Field compensated Michelson Interferometer
Not selected Scout-1 – recently selected as **Scout-2** **TANGO** + **NanoMagSat**)			8.9 M€ * Risk Retirement Activities (RRA)





Earth Explorer 11 Candidates

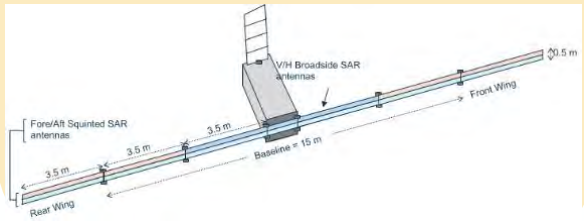
Ph. 0 + Ph.A

Done up to Ph.0

SEASTAR

Air–sea interactions using 2-antenna along-track interferometric radar

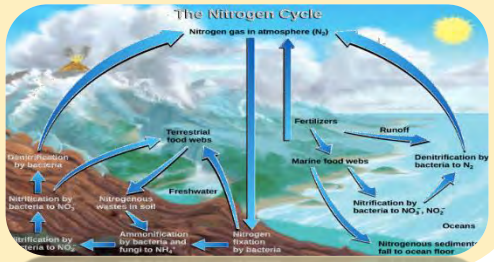
1 km res. **ocean** surface current & wind vectors for coastal ocean, shelf seas and sea ice marginal ice zones



Nitrosat

Links between **climate change** and **carbon** and **nitrogen** cycles

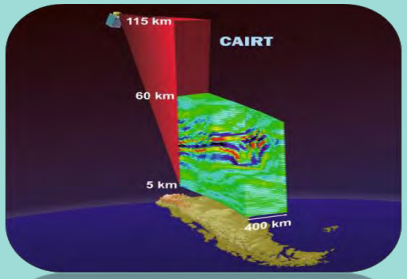
Measures key reactive **atmospheric** NO2 compounds and NH3 with IR spectrometers



CAIRT

Atmospheric composition, structure and dynamics from 5 to 115 km

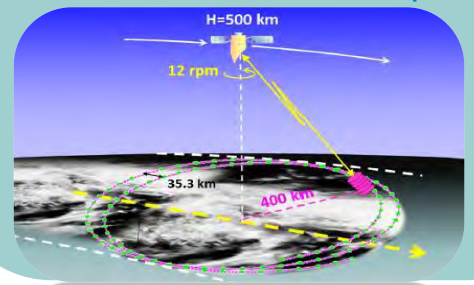
IR limb emission imaging with FT - IR technology in space



WIVERN

Improving the prediction of high-impact weather and hazard warnings

Dual-Pol, conically scanning 94 GHz Doppler radar for measuring **wind in clouds**; and **rain**, snow, ice water profiles



today

15 Mission Ideas

Call / Selection
May-2020
to Q1-2021

Procurement
Q2-2021
Q1-2022

4 Mission Concepts

4x Ph.0
Q2-2022
Q3-2023
14 months

2 parallel contracts per Mission Idea (in Ph.0/A/B1)

UCM / ACEO recommend
10-14 Oct-2023

PB-EO endorsement

2 Mission Concepts

2x Ph.A
Q4-2023
Q2-2025
14 months

UCM / ACEO recommend
July-2025

PB-EO endorsement +
+ CMIN-25 new budgets

1 Mission Concept

Phase-B1
early 2026

Phase-B2/C/D
~5 years

~2032

UCM: User Consultation Meeting
ACEO: Advisory Committee to EO

Ph. B1 to E1 : 450 M€ (in Blk.2)

Incl. 250 M€ for Space Segment + Ground Processor Proto. (GPP)

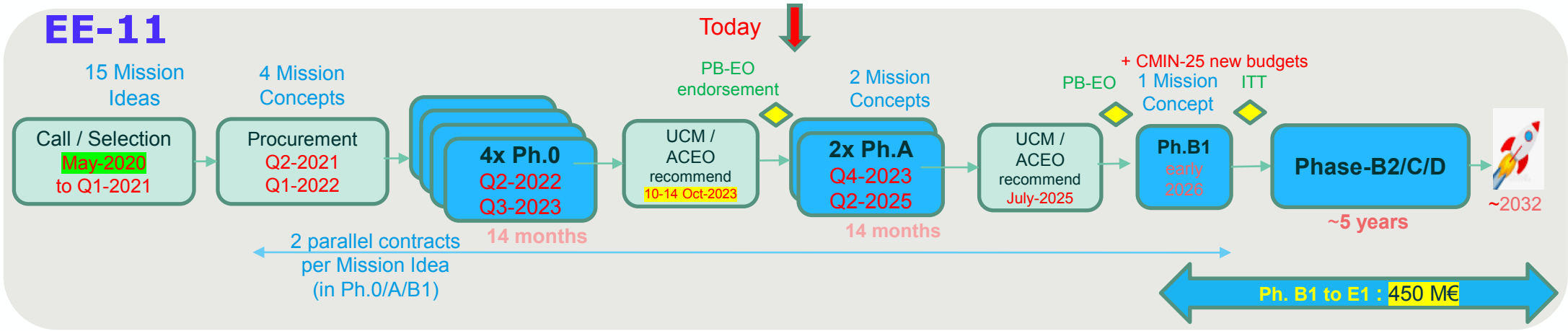
Earth Explorer 11 – Mission Concepts

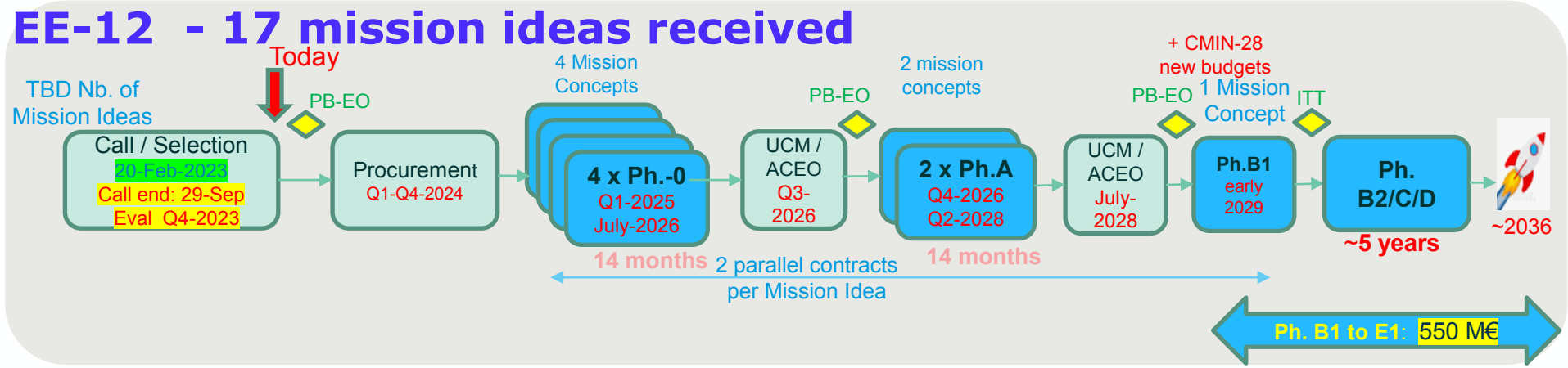
		Previous Calls	Title	RF - Optical	Instrument	Freq.	Preliminary Techno needs	Application
Recommended Ph.0/A/B1	WIVERN	EE-10	A 'WInd VElocity Radar Nephoscope'	RF	Conical scanning radar (3 m diam., 12 rpm)	94 GHz	- Rotating Antenna and free space Rotary joint - HPA: isolator, ferrite switch	Atmos Phys
	CAIRT	EE7 Premier EE10 CAIROS	The Changing-Atmosphere IR Tomography Explorer	Optical	Limb sounder Fourier Transform	IR (4.5 to 14 um)	- Detector - ROIC - Fast FE Electronic - Dichroic optics - Back optics	Atmos comp
	SEASTAR	EE-8, EE-9, EE-10	Submesoscale dynamics and small-scale atmosphere-ocean processes in coastal, shelf and polar seas.	RF	InSAR	Ku band (13.5 GHz)	- Antenna radiators - Klystron HPA - COATS metrology sys	Ocean
	Nitrosat	EE-8, EE-9, EE-10	Mapping reactive nitrogen at the landscape scale	Optical	- Imaging FT (Hyper) Spectrometer (IFTS) - Imaging pushbroom spectrometer	- 900 - 1000 cm-1 for NH3 - 350 to 700 nm for NO2	- Imaging Motion compensation mirror - LWIR Detector	Atmos comp
Commended Maturation only	KEYSTONE	EE-9, EE-10 (as LOCUS)	Chemical and thermal structure of the upper atmosphere (50-250 km).	Optical	- THz heterodyne radiom. - IR radiometer - UV/VIS spectrometer (limb sounding)	0.8, …, 4.7 THz, 4.27 -15.2 um, UV/VIS (new)	- Quantum Cascade Laser - THz Schottky mixers	Atmos comp
	STREAM	Extended SKIM (EE-9)	Surface TRansport, ocean Energy, Air-sea fluxes and Mixing	RF /Optical	- STREAM-R: connical scan Ka radar (3 m diam., >25 rpm) -STREAM-O hi-res Optical	-Ka band (37.75 GHz) ~ as S2	- OB processing - Rotating antenna - LNA - STREAM-O: µ-vibrations, pointing knowled	Ocean
	CRYORAD	EE-10	Low freq. wideband radiometer - study of the cryosphere	RF	nadir Ultra Wideband spectro-radiometer (12 m antenna)	- 0.4 to 2 GHz (RFI critical)	- Digital Beamforming - RFI detection & mitigation - LNA - Large Deployable Reflector - Ultra Wideband feed	Cryosphere
	STRATUS	EE9, EE-10	SaTellite RAdar sounder for earTh sUbsurface Sensing (1 sat Tx + 4 sats Rx)	RF	Sounder	- VHF (40-50 MHz)	- High Power Amplifier - Matching network & antenna - Formation Ctrl techno	Cryosphere

Also positive feedback by ACEO for others: e.g. SnowCube, 2 Lidars (QSAT, ATLAS), N8, Scadi, Min2OS

Earth Explorers (EE-11, EE-12) candidate missions

Continuous flow



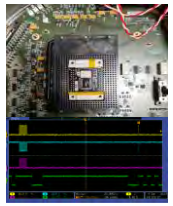


3 year cycles
- Missions
- Budgets in CMIN

UCM: User Consultation Meeting
ACEO: Advisory Committee for EO

Optical Instruments & technologies

Snapshot of optical activities (UK-perspective)



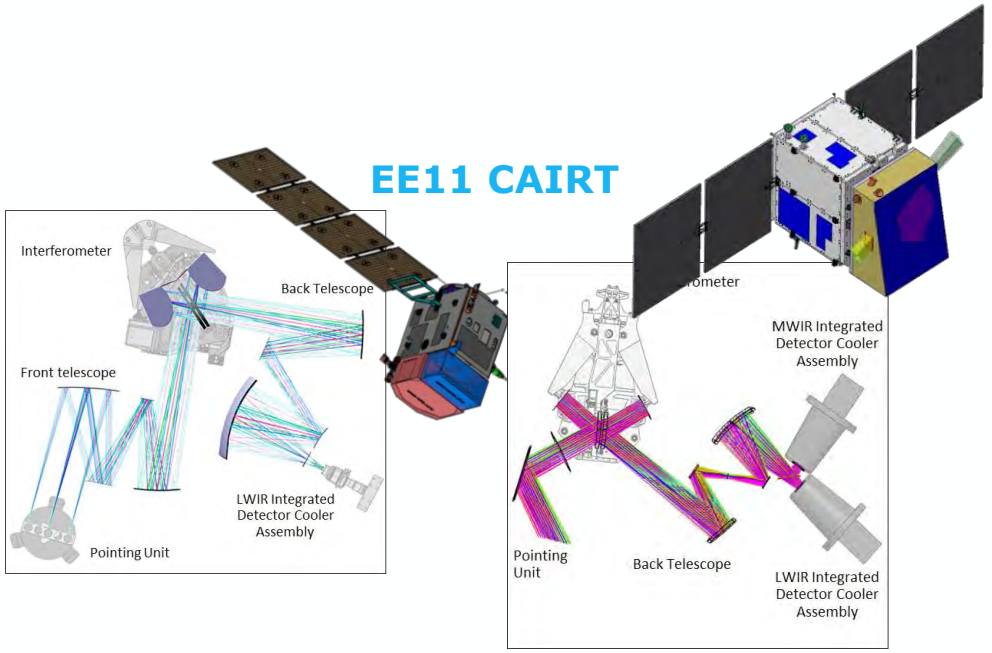
Aeolus-2 detector pre-development
Front face device on test board (courtesy TE2V)

- **AEOLUS-2 Ph. A/B1 (UV Lidar for wind)**
  - Ph. A/B1 System Studies (ADS-UK, TAS-UK)
  - Improved detector capability (TE2V)
  - New instrument pre-developments of Spectrometer, Beam expander and steering mechanism are about to be initiate

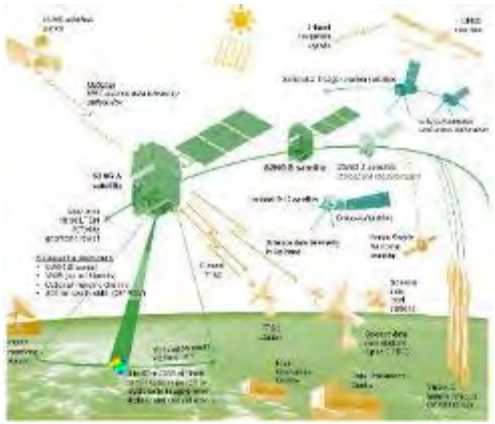
- **EE11 CAIRT Ph. A (IR Limb Sounder)**
  - Key subcontractors and suppliers Ph.0: Leonardo-UK – Detector
  - Potential additional pre-developments in Ph.A on IR Coatings, Dichroic filters

- **KEYSTONE – EE11 Commended Mission / EE12 Mission Idea**
  - THz & IR Limb sounding radiometry (PI: RAL Space)
  - Technology needs: Quantum Cascade Laser & THz Schottky mixers

- **Incubed: MANTIS & SAT4EO**
  - MANTIS: VIS-NIR (3m GSD), 4-Band Dual Telescope w/ on-board super resolutions & cloud detection (Open Cosmos). Launched Q1 2024
  - SAT4EO: VHR (0.6m GSD), Super Res. (0.3m GSD)Compact VIS-NIR Telescope (Deimos, SSTL). Using the detector developed by E2V under UK-CEOI



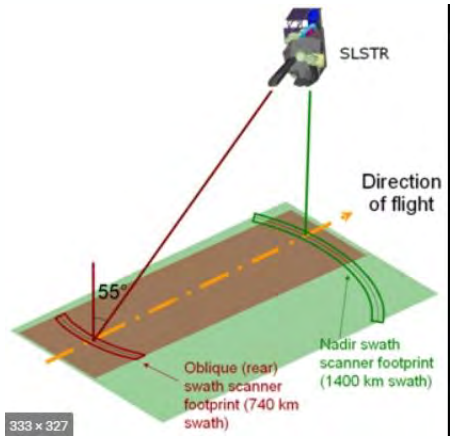
Copernicus: Sentinel-2 NG and Sentinel-3 optical NG



Sentinel-2 NG mission objectives: LAND driven

Provide enhance capabilities with respect to Sentinel 2 by

- Improve revisit time to 3 days
- Improve spatial sampling distance by a factor of 2 along and across track
- Potential additional spectral bands to meet new/emerging user needs

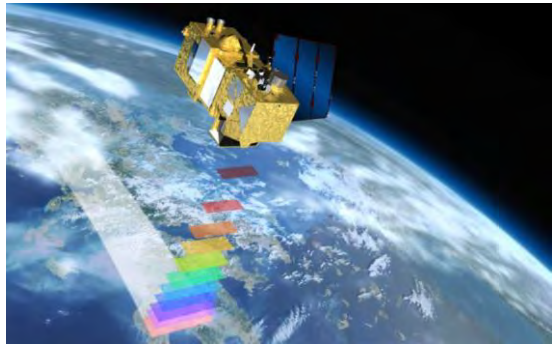


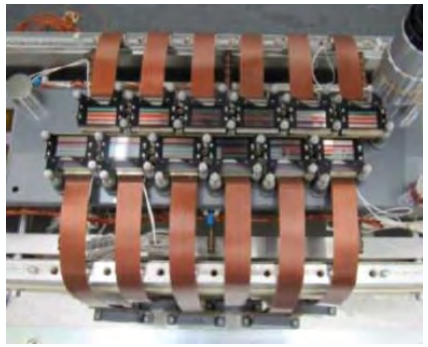
Sentinel-3 optical NG mission objectives: OCEAN driven

Provide enhance capabilities with respect to Sentinel 3 by

- OLCI: increase the spatial resolution instrument to 150 m
- OLCI: increased number of spectral bands
- SLSTR: Spatial resolution to 500 m for all bands and additional spectral bands

Sentinel-2 NG & Sentinel-3 NG Optical





SENTINEL - 2 NG

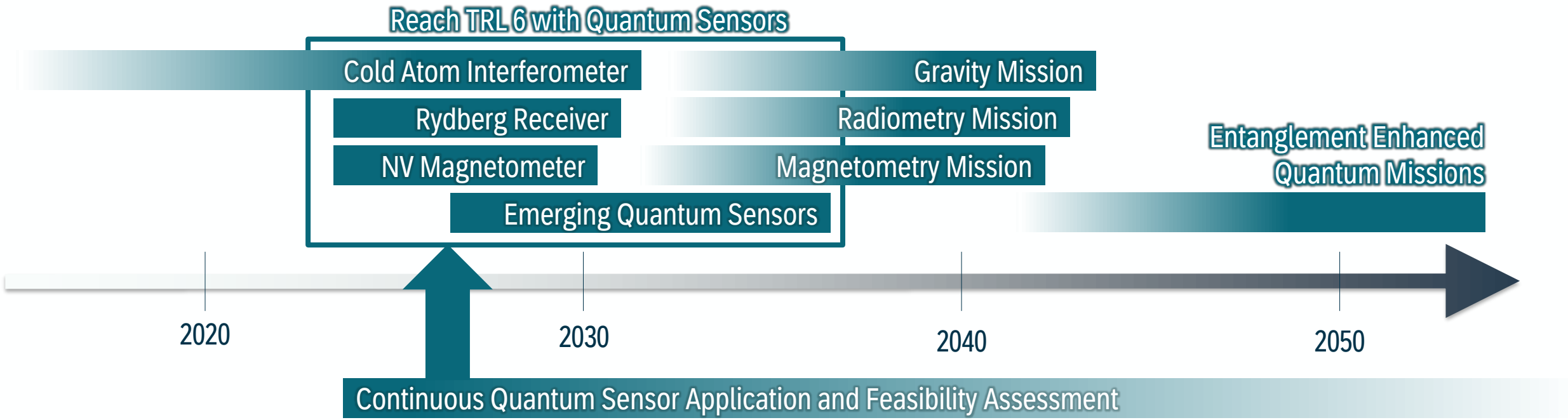
- **Application**: Agriculture, forestry, inland waters and wetlands, land cover, land use, biodiversity, coastal marine zones
- Up to **17 spectral bands** (goal) from ca. 443 to 2190 nm, spectral widths 15 to 90 (180) nm
  → **Ground sampling: 5 to 30 m** (goal) @ ca. **300 km swath**
  → large image field
  - large telecentric telescope
  - large number of detectors, staggered assembly
  → large number of pixels → high datarate
- **Significant increase in requirements** from Sentinel-2, especially wrt. min. **spatial resolution from 10 m to 5 m**

- **Phase** A/B1 to be started shortly (under EOP-P)
- Pre-developments as part of phase A/B1 studies (VIS detector, filters, dichroic)
- Pre-development SWIR detector: ESA ITT to be issued

SENTINEL-3 NG Optical

- **Application:** ocean
- **2 instruments**
  → Advanced Ocean and Land Colour Instrument (**AOLCI**)
  → Advanced Sea and Land Surface Temperature Radiometer (**ASLSTR**)
- **Enhanced continuity** wrt OLCI and SLSTR from Sentinel-3
  → 2x better spatial resolution
  → More spectral channels
  → Better SNR
- **Phase 0 activities completed** with TAS/Leonardo and OHB/ADS
- **ITT phase A/B1 (*2) issued: this includes pre-developments with expected focus on;** Detectors (VIS, SWIR, MWIR/TIR), Grating (VIS), Filters (IR)

Quantum Sensing for Earth Observation



Rydberg receiver : ITT 1-11974 - Under evaluation

Nitrogen Vacancy (NV) centre study: ITT 1-11973 - Under evaluation

Raman combiner (for Quantum inertial sensors): ITT 1-11858 - Evaluation done

Emerging Quantum Sensors: planned Call in 2024 under http://ideas.esa.int (OSIP)

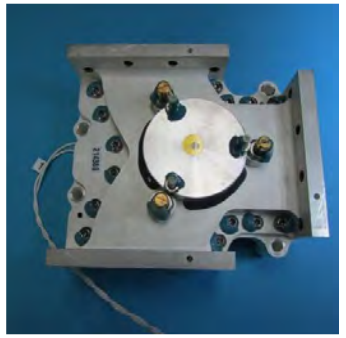
Microwave Instruments & technologies

Snapshot of microwave activities (UK-perspective)

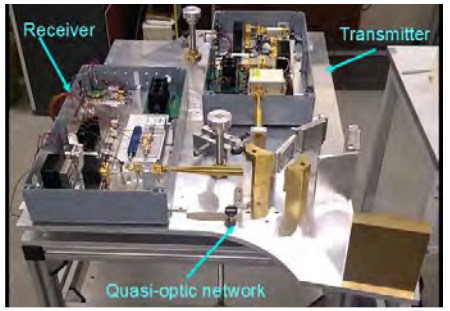
- **STRATUS**
  - 1 breadboard of a VHF Deployable Antenna and RF matching network and documentation (target TRL 4)
  - Contract: EOSOL [ES] as prime, and COMET [ES], Open Cosmos [UK], AeroXess [DE], UPV [ES] as subcontractors

- **C-Band Switches and circulators**
  - Future Scatter meters and Synthetic Aperture Radars missions operating at C-band e..g, Hydroterra (EE-10 Ph.0)
  - 2 parallel contracts awarded to COMDEV [UK] and HARP [FI], TRT [FR]

- **G-Band Radar – atmospheric missions**
  - G-band radar to provide a better characterization of cloud and precipitation vertical structure
  - Contracts: : STFC RAL Space [UK], Politecnico di Torino [IT],



METOP SG C-band Ferrite switch (image credit: COMDEV International)



GRACE G-Band Radar for Cloud Evaluation (image credit: STFC RAL Space)

VHF Deployable Antenna

EE11 Commended mission pre-developments

Activity Title (with 500+ k€ each)	Potential applications	Companies
L-band internal calibration subsystem for wide band radiometers	CRYORAD	Sener + ADS [ES]
Wideband L-band integrated LNA	CRYORAD	TAS [IT]
VHF High-Power SSPA	STRATUS	TTI [ES]
Very Wideband VHF Deployable Antenna and RF matching network	STRATUS	EOSOL [ES]
Ku- and Ka-band GaN LNA	STREAM, SKADI, SEASTAR, SnowCube	TAS [FR]
Ku- and Ka-band high power low loss ferrite switches and circulators	STREAM, SKADI, SEASTAR	HARP [FI]
C-band very high-power low loss ferrite switches and circulators	Hydroterra, METOP NG SCA	Honeywell [UK]

WIVERN

Principal Investigator: Univ. of Reading
Mission Advisory Group(MAG)

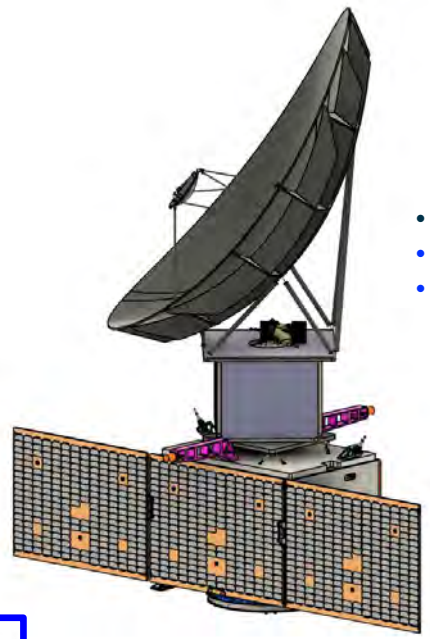
ECMWF

esa

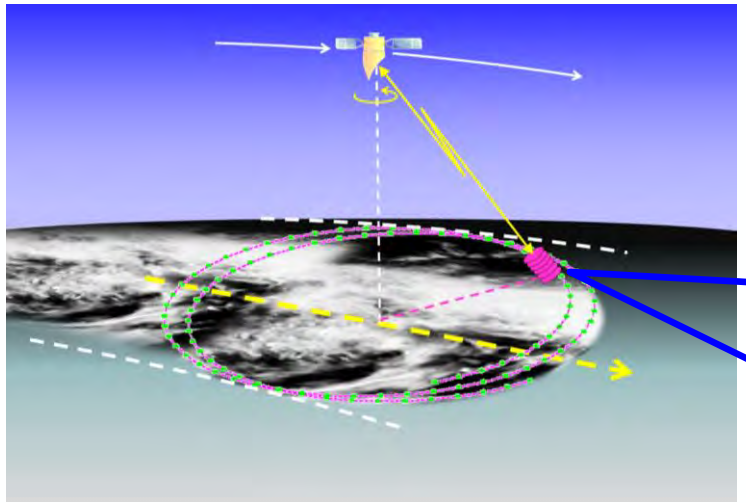
EE11 Ph. 0 & Ph. A: In-cloud wind products and Cloud & Precipitation products

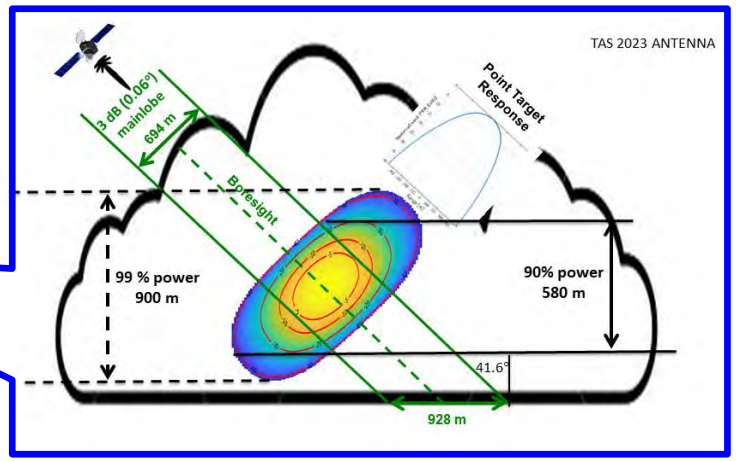
(Rain/snow rates, Liquid Water Path, Ice Water Content) (Rain/snow rates, Liquid Water Path, Ice Water Content)

- W-band (94 GHz, 3 mm, sensitivity to clouds)
- **Big** >3 m **antenna** ($\theta_{3dB} \approx 0.07^o$) (vert. res. 600 m, hor.res. < 1km),
- ~12 rev./min - Conically scanning at 42^o (830 km swath)
- Doppler capability (polarization diversity) for measuring large line-of-sight (LoS) horizontal winds
- Radiometric mode with km-scale resolution and **~2 K** relative accuracy



- **W-band (94 GHz)**
- **>3 m antenna**
- **~12 rev./min**





Next SCOUTS (current plan)

Under development for launch end 2024

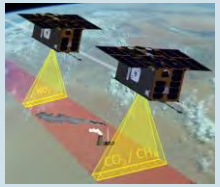
SSTL

In Feb.2024 PB-EO approved

NanoMagSat & TANGO

to go for implementation (Ph. B/C/D/E1)

OpenCosmos



New Mission Concepts → New Feasibility studies before CM25

TBD Nb. of Mission Ideas

Procurement ITT Q2-2024

today

4 Mission Concepts

≤ 4 Feasbilitiy Q4-2024 July-2025

months

ACEO recommends Q3-2025

CMIN-25 new budgets + PB-EO

≤ 2 Phase-B/C/D/ E1

< 3 years to launch

30-35 M€ (in Blk.2)

Incl. Space Segment + Science+ Launcher + GPP

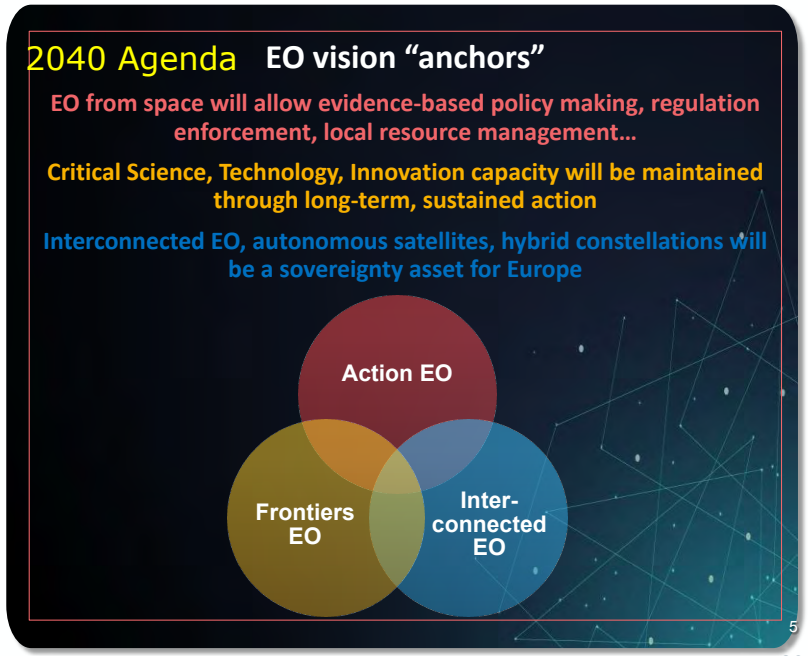
For each Mission Idea:

- 750 k€ (TBC) - from Blk1
- NO parallel contract
- Starting at TRL=4 & SRL=4

CMIN25 vision

Long Term (2040) Vision : Many more missions to come
→ Technology is the key enabler to push the FRONTIERS of EO
→ Promote data uptake: interconnection and action-able EO data

Programmatic Simplification :
→ Merging programmes: FutureEO , incl. Digital Twin , …
→ Copernicus
→InCubed



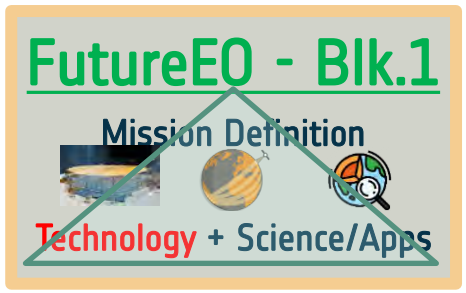
Take away(s)

EOP Technology needs (incl. European independence)

- New + higher performance (EO instruments) + Higher efficiency (incl. platform / operations)

Market pull (User driven: EE, Copernicus, Meteo) **+ Techno push** (enabler for new **Mission Calls**)

- Driven by **institutional** (**Large Satellites**), but **Instruments** for **Small Sats** too (Scouts, commercial)



FutureEO Programme

- Unique synergizer to build the **whole range of ESA EO missions**
- EO architecture grows

The **EO Technology needs** keep **growing fast** (more than the resources)

- ➔ Science new strategy → opportunity to **focus the technology** too
- ➔ Continuous flow + New Frontiers → more EO missions and technology to come
- ➔ UK substantial involvement and input into ESA EO Technology

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