Update on the EO science strategy (and how to involve the CCI community)

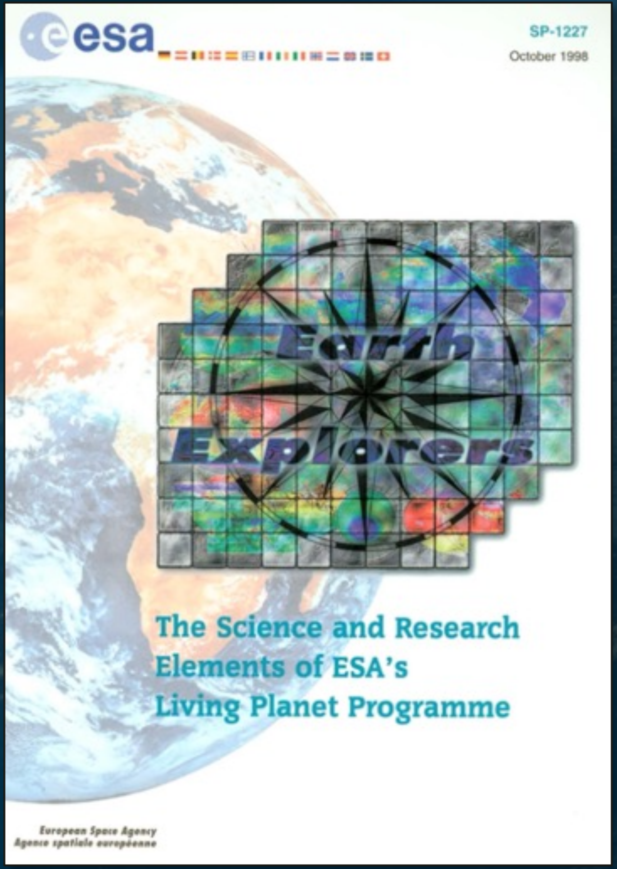
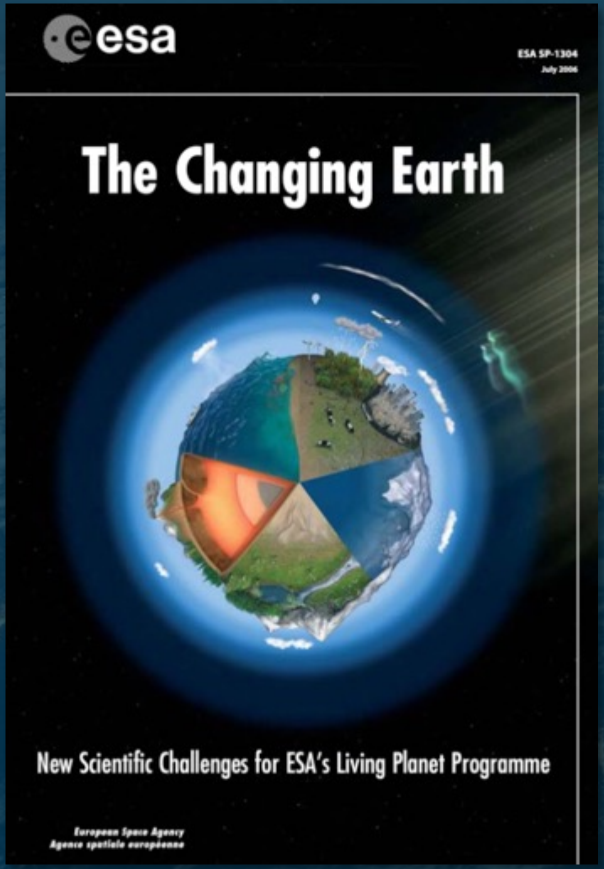
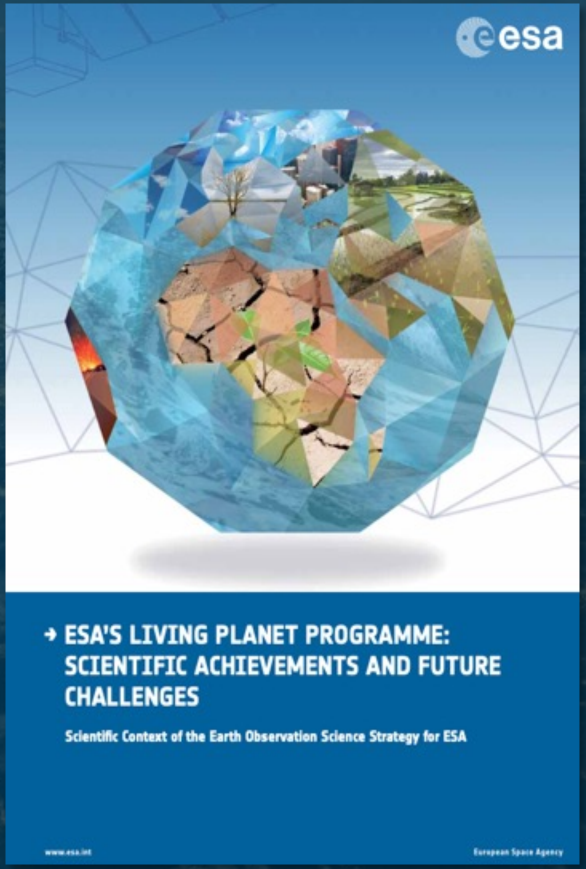
M. Davidson, M. Drinkwater, R. Floberghagen
Climate Action, Sustainability and Science Department
Earth Observation Programmes
07/11/2023

What is the ESA's EO Science Strategy?

esa

- ESA's EO Science Strategy expresses ESA's science vision. It presents cross-cutting priorities and accompanying strategies that reflect the user communities shared values and which are responsive to both scientific and societal challenges.
- It identifies the areas of science that ESA needs to be responsive to across the value chain from innovative missions through excellent science to societal benefits.
- It involves innovation, strong partnerships with other organisations, national programmes and funding agencies.
- These priorities and strategies are intended to focus attention on those areas where ESA's EO Programmes can have the greatest impact , and where its activities can address the scientific challenges
- Previous ESA EO Science Strategy published in 2015
- Updated EO Science Strategy Recommended in 2021 Independent Science Review (ISR) of the FutureEO programme
    - Also recommends more frequent review of scientific challenges (or core science questions driving the programme) every 5-6 years

EO Science Strategy documents

1998	2006	2015	2024
			
ESAC	ESAC + writing team (15 persons)	ESAC + writing team (13 persons)	EO Foundation Study + EO Science Strategy Workshop + ACEO + writing teams

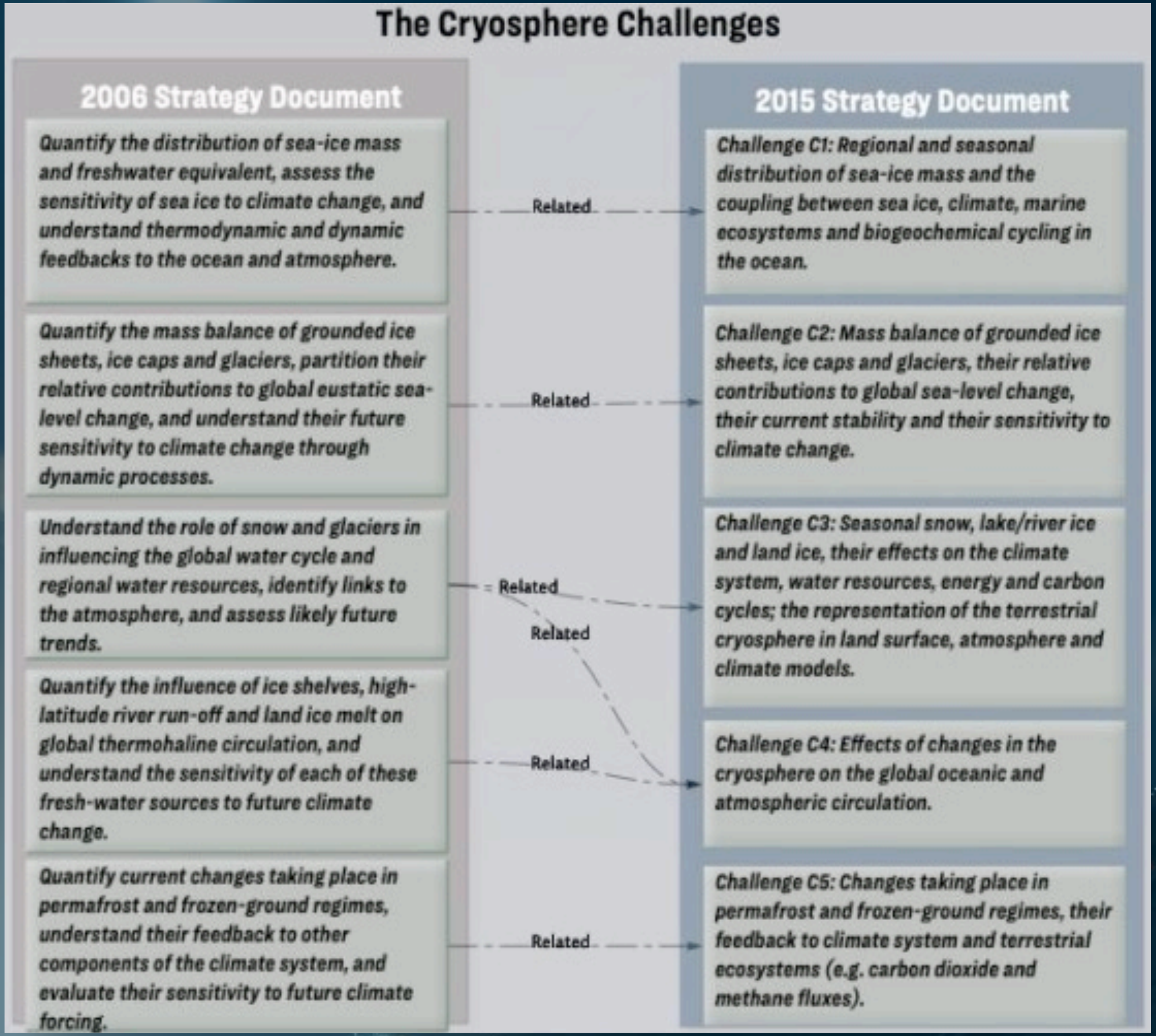
NEW
Earth Observation
Science Strategy for
ESA

NB: Document layout and title TBC

ESAC (prev) and ACEO are the external science advisory groups to the Director of Earth Observatipn Programmes

Perceived issues / areas for improvement

- Need for a stronger link between outcomes of the ESA programme and delivery of societal benefits
- Better appreciation of the need for inter-disciplinary approach
- More explicit focus on the different timescales over which actions resulting from the strategy would be undertaken (and deliver results)
- Desire for a smaller number of challenges in the strategy to allow for more targeted actions
- More frequent update of science strategy recommended



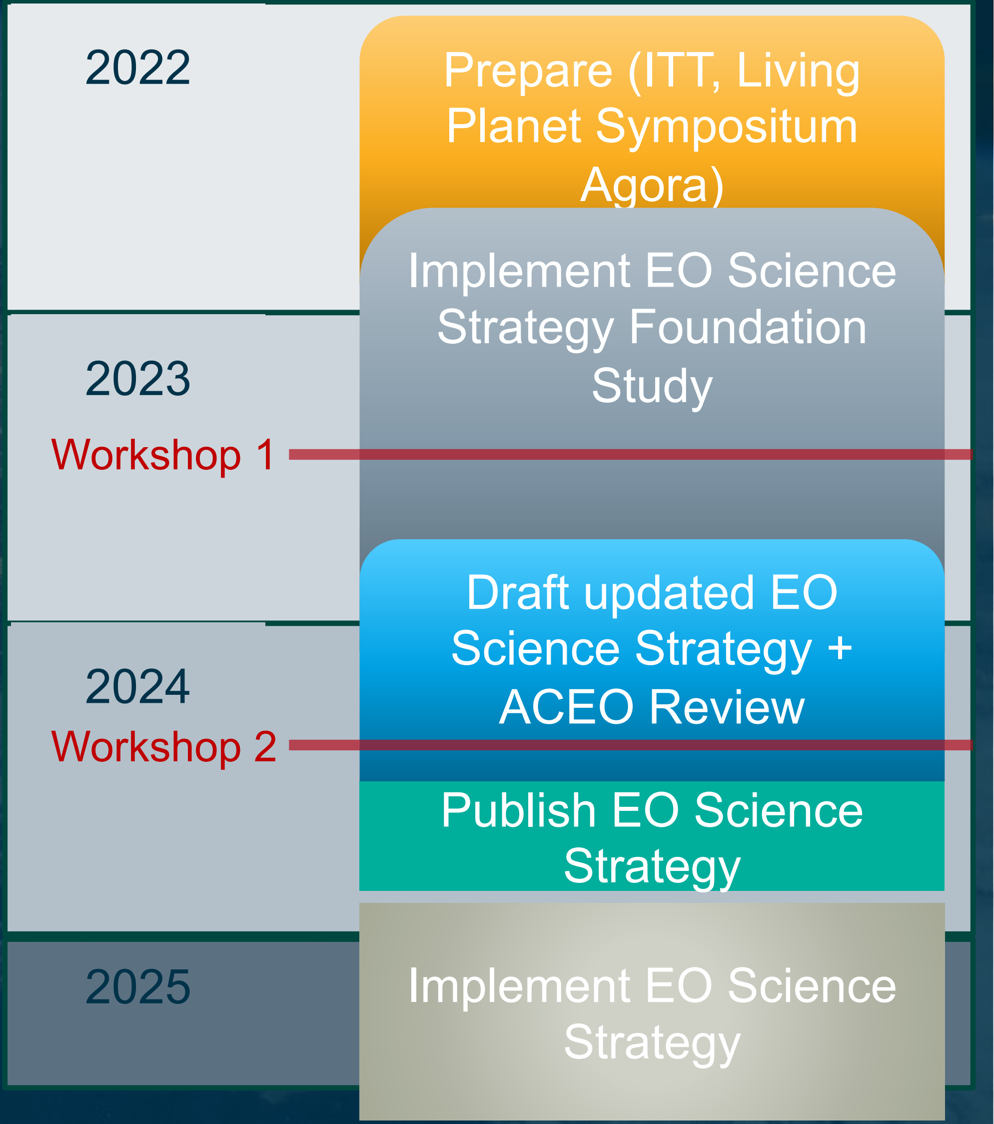
New approach in developing the 2025-2030 EO Science strategy (1)

esa

- Emphasise **<u>EO science questions that cross-cut different science domains</u>**, taking the place of domain specific Living Planet Challenges at the heart of the future EO science strategy
- Trace and document connection between updated EO science questions to
  - **geophysical information gaps** addressed through new mission development activities or use of space assets available from 2025-2030
  - **impact for societal benefits** and how these related to international policies and agendas
- Deepen integration and alignment of strategy with EO solutions focusing on
  - EO data use (R & D in science and climate, Green solutions, Commercial EO)
  - new technical developments and opportunities (e.g. Digital Innovation and Open Science)
- Ensure that progress is measurable over the shorter strategic timeframe (e.g. 2025-2030) taking into account the different timescales (e.g. EO mission development vs activities focused on data use)

New approach in developing the 2025-2030 EO Science strategy (2)

- Integrate larger EO Science Community views in EO strategy development process
  - EO Science Strategy Foundation Study
    - Selected via ITT with specific tender conditions (multi-disciplinary team, science lead for science integrity)
    - Identify, justify, document candidate EO Science Questions (CSQs) as input s to Science Strategy
  - Two EO Science Strategy Workshops to consult EO Science Community on their views on future EO science priorities
  - ACEO review of draft EO science strategy and endorse of final strategy document



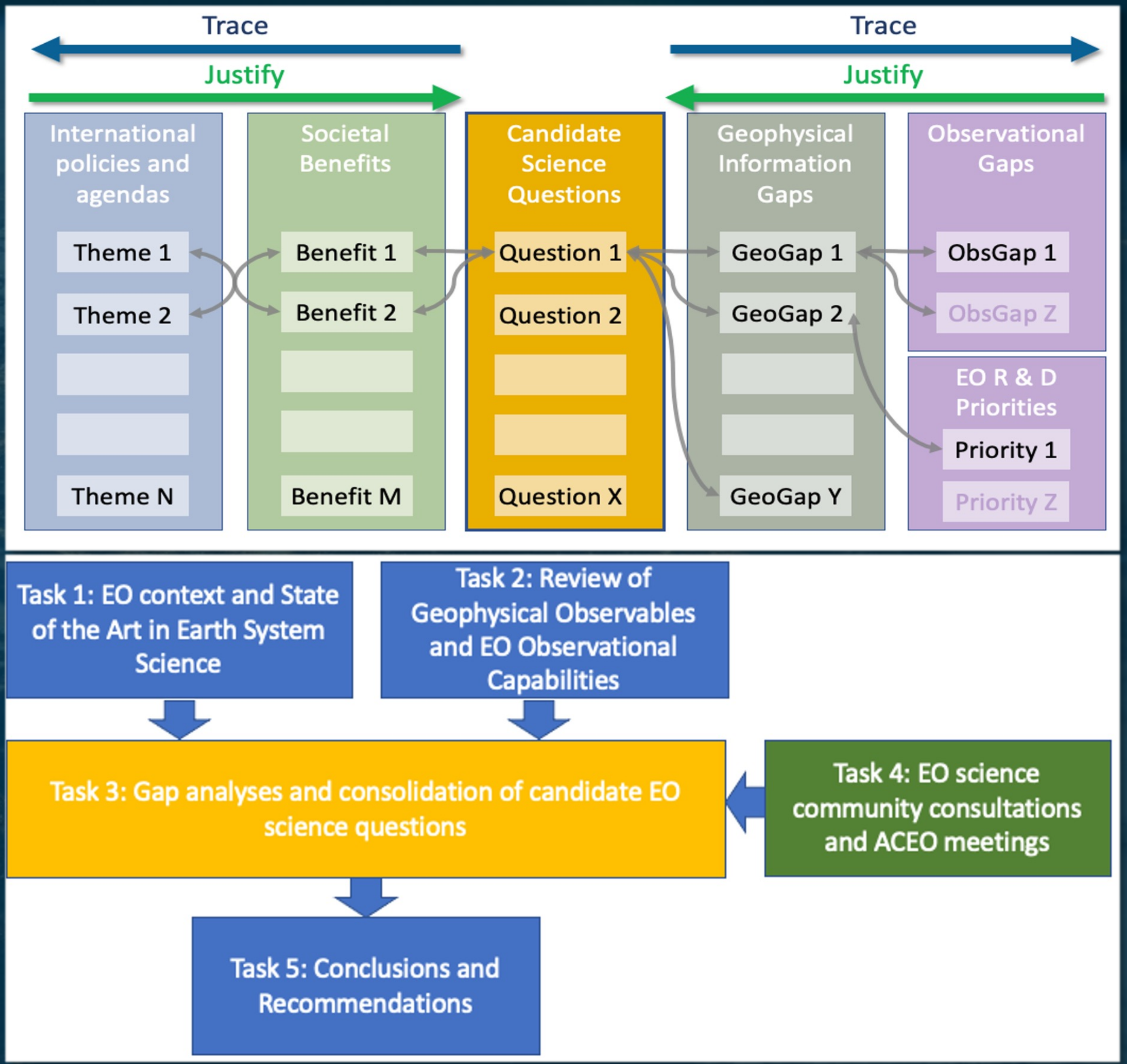
EO Science Strategy Foundation Study - Overview

Study work centred on 5 blocks (1 main – 4 traceability)

- Research and propose candidate cross-cutting Earth system science questions to orient the future EO science strategy (main block)
- Trace candidate questions to gaps in geophysical information from EO and future R & D priorities
- Trace and document links between candidate questions and societal benefits, international policies and agendas

Study to explicitly build on other initiatives and work

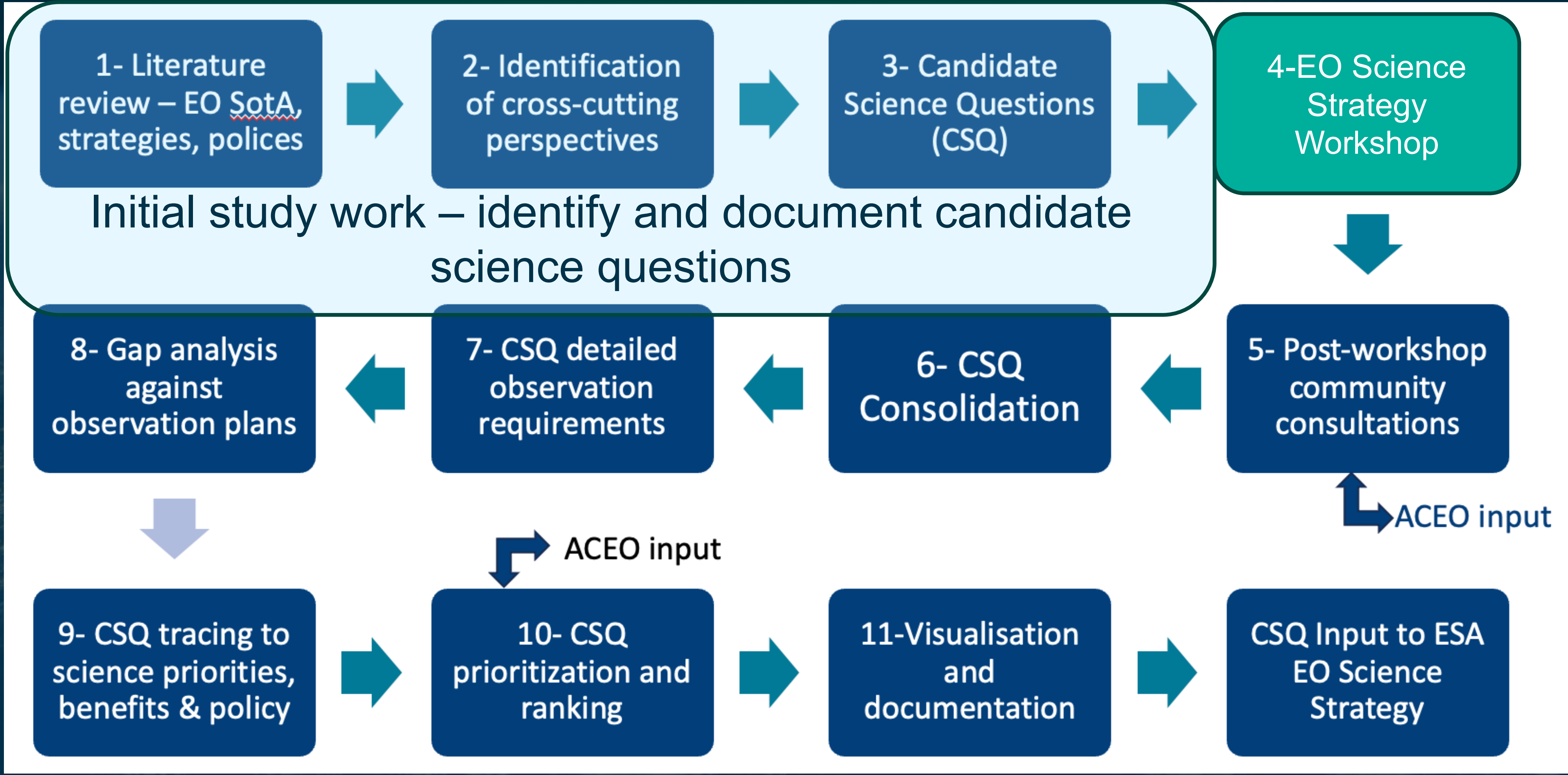
- Previous ESA EO Science Strategy (2015)
- 2021 Independent Science Review Report (ISR)
- Earth Science and EO strategies elaborated by relevant national, international organisations including space agencies and the EC
- Gap analyses of geophysical observables and observations from other missions
- State of the art and R & D trends in the use of EO data and addressing Earth Science Questions



EO Science Strategy Foundation Study – Consortium

Name	Company	Role
Jon Styles	ASSIMILA, UK	Prime
Stephen Briggs	Steeple International Consulting Ltd, UK	Science lead and core science team
Johnny Johannessen	Nansen Environment & Remote Sensing Center, NO	Core science team
George Dyke	SYMBIOS SPAZIO Ltd, UK	Core science team (database)
Han Dolman	NIOZ, NL	Science Team
David Crisp	ex:JPL	Science Team
Anna Hogg	Univ. Leeds, UK	Science Team
Ana Bastos	MPI:BGC, DE	Science Team
Christine Gommenginger	NOC, UK	Science Team
Martin Herold	GFZ, DE	Science Team
Peter Thorne	NUI. Maynooth, IRL	Science Team
Michael Sideris	Univ. Calgary, CAN	Science Team
Bob Su	Univ. Twente, NL	Science Team
Karina von Schuckmann	Mercator, FR	Science Team
Maria Fabrizia Buongiorno	INGV, IT	Science Team
Alain Hauchecorne	LATMOS, FR	Science Team
Johanna Tamminen	FMI, FI	Science Team
Jose Moreno	Univ. Valencia, ES	Science Team
Isabelle Panet	IPGP, FR	Science Team

Foundation study process and initial study work



Example: Candidate Science Question – Carbon Cycle

Carbon Cycle

Question	Knowledge Advancement Objectives	Observables	Measurement Specifications	Tools & Models	Policies / Benefits
What anthropogenic and natural processes are driving the global carbon cycle?	Quantify CO_2 and CH_4 emissions from both anthropogenic and natural sources and CO_2 removals from natural sinks on spatial scales from individual facilities or field plots to regional and global scales on seasonal time scales.	• Column-averaged atmospheric CO_2 and CH_4 dry air mole fractions (XCO_2, XCH_4) and their gradients.	• High-spectral-resolution imaging spectroscopy of CO_2, CH_4 and O_2 bands at 1-10 km spatial resolution with 0.1 to 0.5% accuracies.	• Atmospheric CO_2 and CH_4 retrieval algorithms • Atmospheric flux inverse models	Integrated constraint on net emissions and removals of CO_2 and CH_4 for climate change (CC) mitigation and adaptation policy Climate finance. Monitor the efficacy of decarbonization policies and CO_2 removal strategies
	Distinguish intense anthropogenic CO_2 and CH_4 point source emissions associated with fossil fuel extraction, transport and use and land use change from wildfires and weak, spatially-extensive sources (wetlands, permafrost melting, agriculture).	• High spatial and temporal resolution measurements to detect CO_2 and CH_4 emission plumes • Observations of co-emitted species (NO_2, CO) to discriminate combustion sources • Fire radiative power	• High-spectral-resolution imaging spectroscopy of NO_2 and CO at 1-10 km spatial resolution • High-spatial resolution (< 30m) multi-spectral and hyperspectral imaging	• Atmospheric GHG retrieval algorithms • Atmospheric assimilation systems • Discrete plume models	
	Quantify emissions and removals (fluxes) of CO_2 by the land biosphere on sub-seasonal time scales with the accuracy needed to quantify and distinguish long-term (decadal) changes from climate perturbations and disturbances (e.g., drought, floods, wildfire) and human activities (e.g., deforestation, intense agriculture).	• XCO_2 and XCH_4 and their gradients at 0.1 to 10 km resolution • Solar induced chlorophyll fluorescence (SIF) • Land use and land use change (LULUC)	• High-spectral-resolution imaging spectroscopy of CO_2 and Sif at 1-10 km spatial resolution • high spatial resolution NDVI, NIRv, Fire radiative power	• SIF retrievals • Empirical light Use Efficiency and Machine learning models	

+ written narrative for each Candidate Science Question providing context, detailing state of the art and justifying why it was selected

1st ESA EO Science Strategy Workshop – 19-20 June 2023

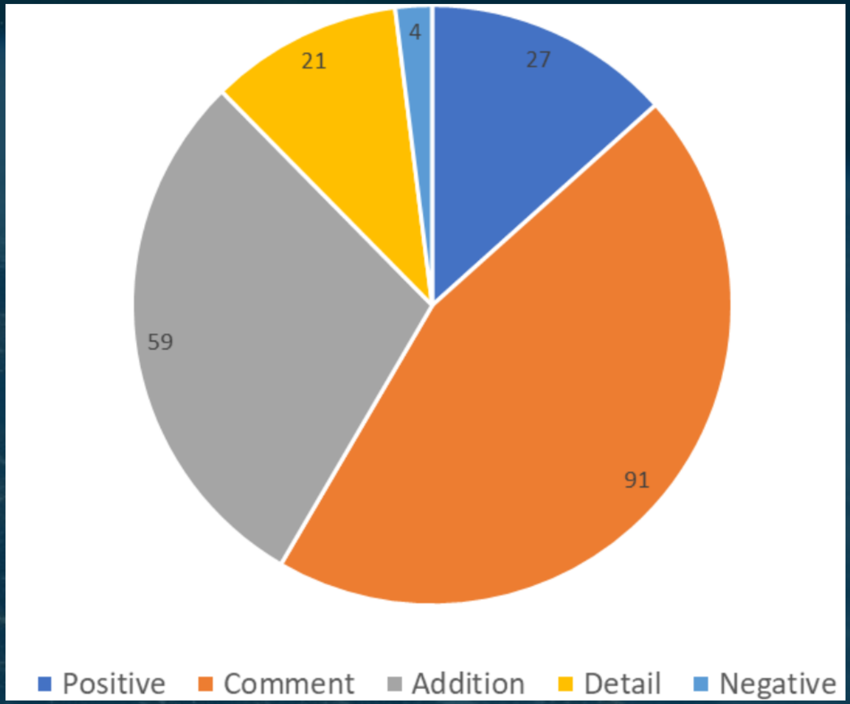
- Objectives:
  - Consult EO stakeholder community on priorities for the future EO Science Strategy
  - Communicate the role that the future ESA EO Science Strategy will play in ESA EO Programmes
  - Communicate and review candidate science questions developed by EO Science Strategy Foundation Study and collect community feedback
  - Collected feedback on EO strategy building blocks (e.g. Digital Innovation, Open Science, Policy driven R & D)
- June 19-20 June in Bruges, Belgium
- 220 Registered Workshop Participants
- Workshop widely communicated via available channels

Workshop Programme

- Workshop Programme based on 4 main blocks
  1. Presentation on EO Science Strategy update process and the role of strategy in guiding future EO programmes starting in 2025
  2. Presentation on the EO Science Strategy Foundation study results and draft 59 Candidate Science Questions (CSQs)
  3. Interative splinter sessions addressing future EO strategy building blocks
     - Community feedback on CSQs
     - Open Science and Digital Innovation
     - Use of Commercial Space for EO
     - Panel discussion co-chaired with EC on Earth systems science and applied research for societal benefits
  4. Presentation of outcome of splinters during final plenary
- Participants invited prior to the workshop to comment and select CSQs to be tabled in splinters (Web form)
- Participants invited prior and for 1 month after the workshop to comment and propose edits (Web form)

Workshop – selected results and community feedback

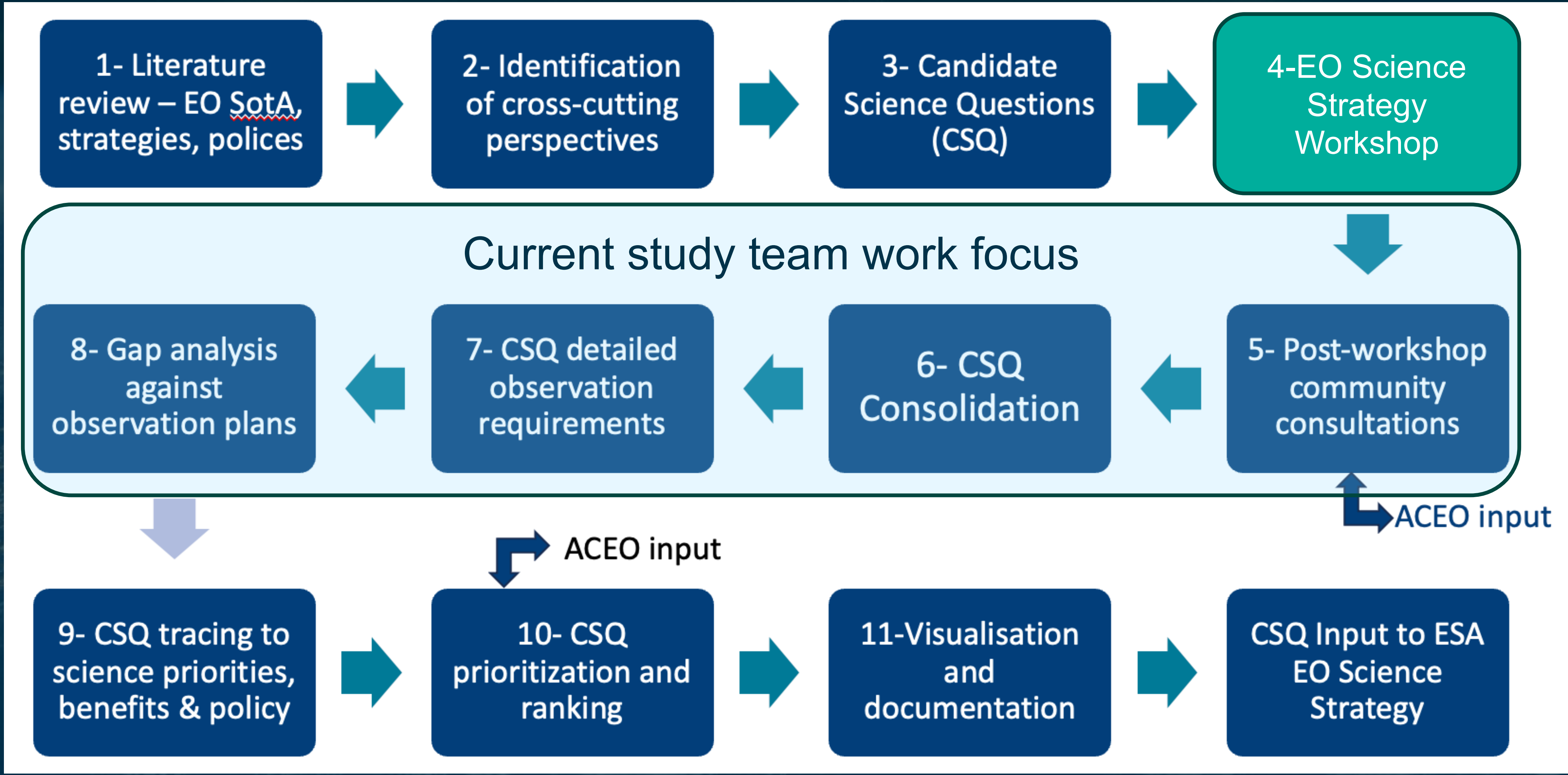
- Important to distinguish between science questions addressing our understanding of Earth System and methodological or cross cutting aspects (e.g. calval, field experiments, continuity)
- Extreme events/tipping points of high interest but should be considered in terms of underlying processes and their understanding
- Some gaps in CSQs addressed through new or updated CSQs or associated Knowledge Advancement Objectives (KOA)s
- Need to consider both policy/societal benefit perspective in future EO strategy in addition to discovery science
- Uptake of Commercial Space requires reliability, sustainability and continuity of data provision
- On-line feedback - 202 substantive comments received and processed with outcome of comments documented
- Splinter session summaries available on workshop website



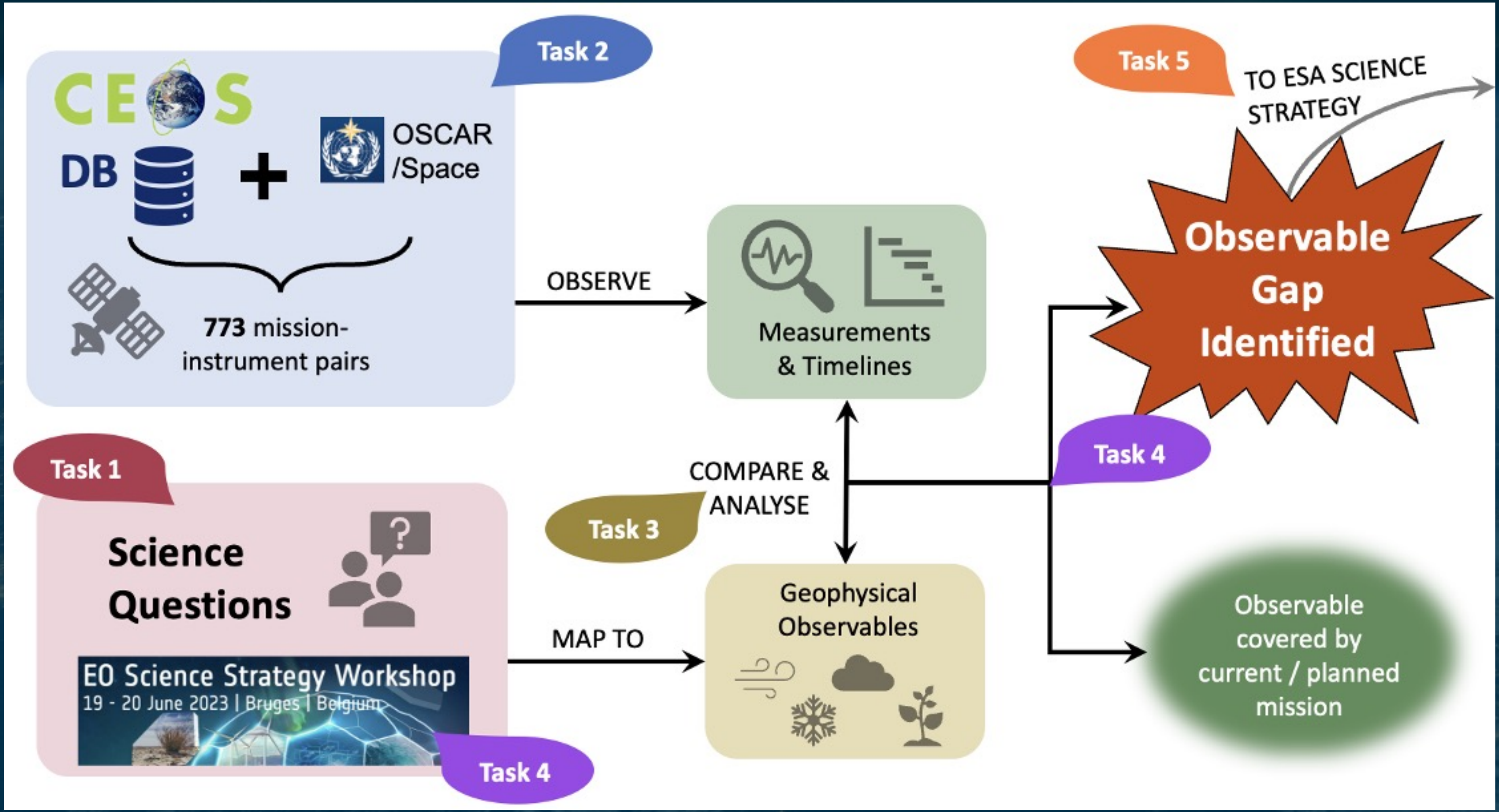
Categories of 202 online comments

https://atpi.eventsair.com/science-strategy-workshop-2023/workshop-programme

Foundation study process and current status

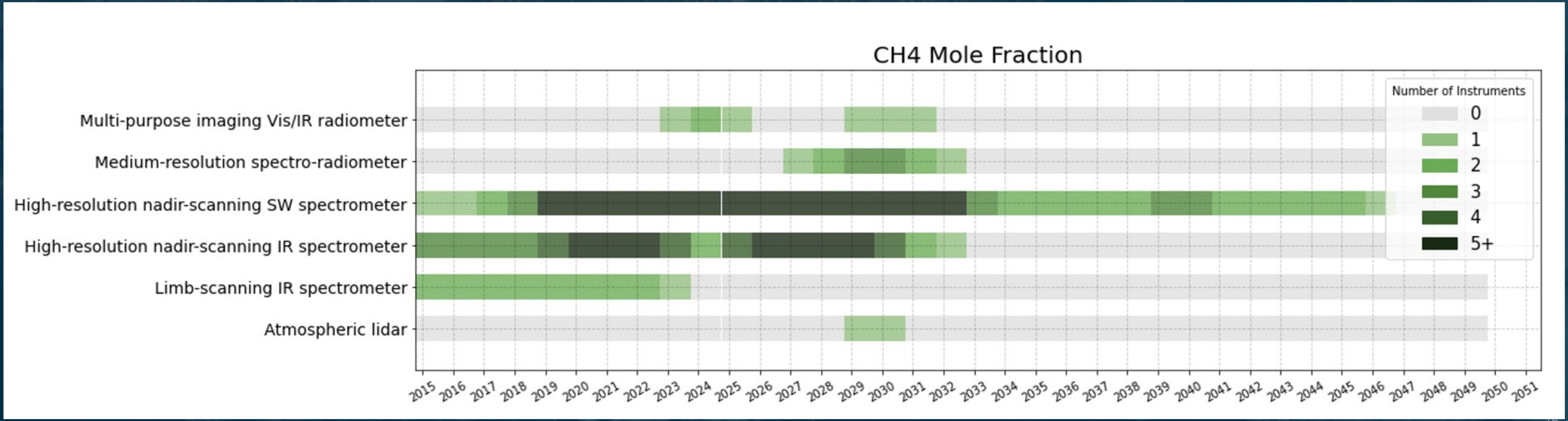


Gap Analyses – the role of a fit-for-purpose database

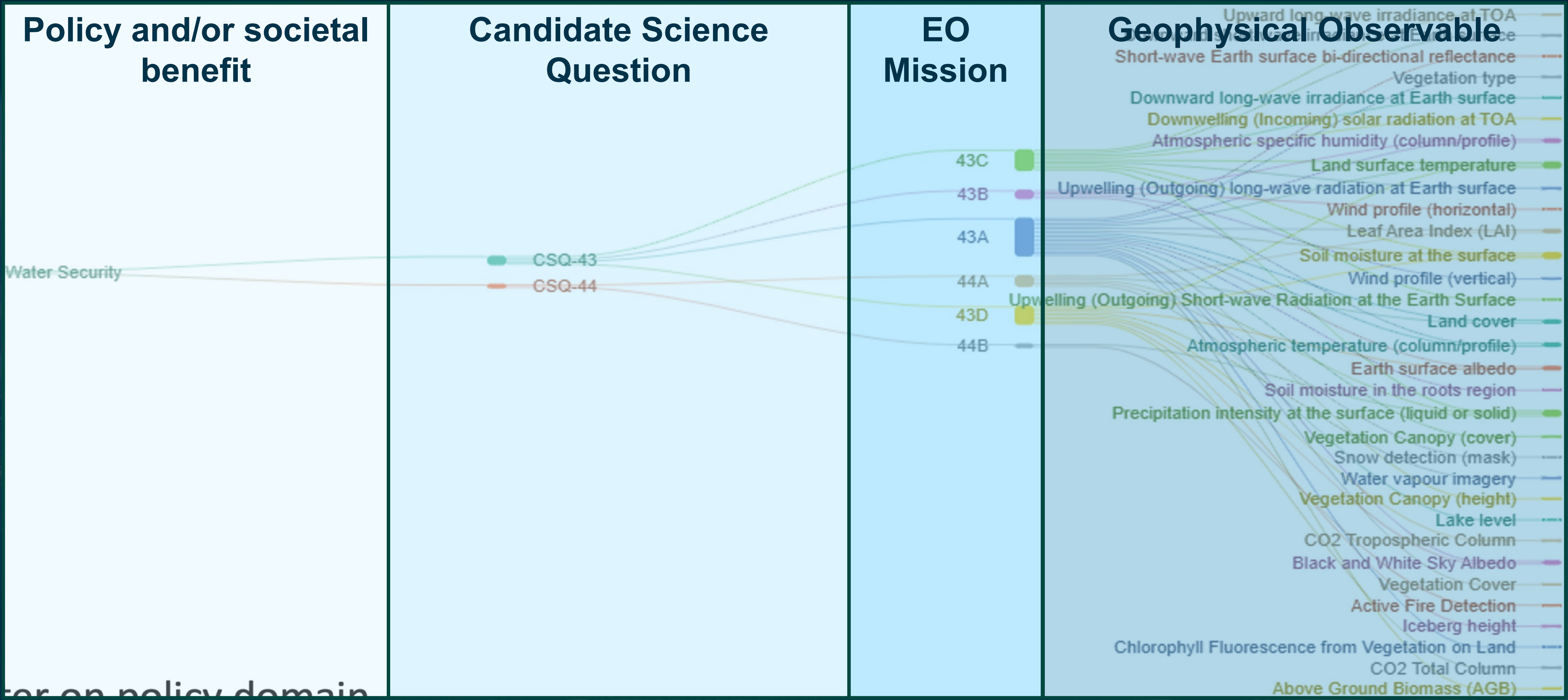


Example: Observation gap analyses – atmospheric methane

- In support of the observational gap analyses the study has developed a database summarising geophysical and observational capabilities of current and planned EO assets at national and international level
- Database includes 773 mission-instrument pairs, with 336 unique missions, and 425 unique payloads
- Payloads provide information on 168 geophysical parameters across all domains: land, ocean, atmosphere, ice & snow, and gravity & magnetic fields



Example study output: traceability for water security



EO Science Strategy - Next steps

(EO Science Strategy Foundation Study)

- Finalise version 2 of the CSQs taking into account workshop and community feedback
- Complete gap analyses between CSQs and EO observational capabilities using mission database developed in the study
- Recommend criteria to categorise and trade-off science priorities depending on programmatic priorities
- Document and deliver all study outputs by February 2024

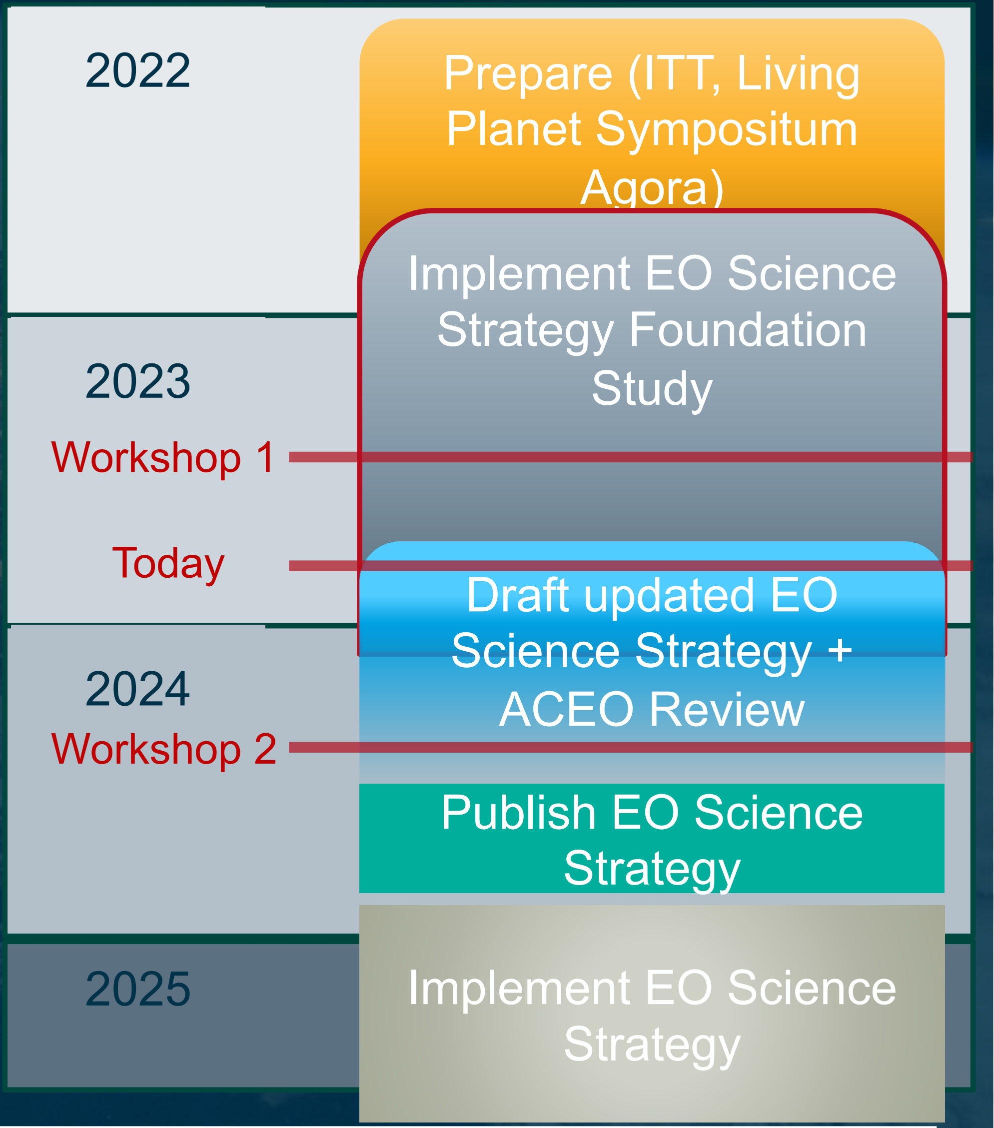
(ESA) Lead drafting of EO science strategy – December to April 2024

- ACEO to review of draft EO science strategy and make recommendations

(All) 2nd User Workshop planned for early May 2024 with dates TBC

- Review draft EO science strategy and final recommendations

Publish EO Science Strategy – June 2023



Conclusions and how to involve CCI community

- ✓ Outlined the role of the ESA EO Science Strategy in guiding implementation of ESA EO Programmes
- ✓ Communicated the process and steps leading to the new EO Science Strategy in 2024
- ✓ Presented results achieved through the EO Science Strategy Foundation Study
- ✓ Outlined next steps leading to the publication of the EOP Science Strategy in mid-2024
- CCI community already involved (e.g. workshop participation, study members)
- Welcome further engagement from the CCI community in the process. Some ideas include:
  - Review version 2.0 of Candidate Science Questions (Jan 2024) which includes results of feedback from the EO community from the 2023 Science Strategy workshop
  - Reflect on role and priorities of Candidate Science Questions within current and future CCI activities
  - Review of ESA draft EO strategy document when published
  - Participate and table your views/feedback at the 2nd science strategy workshop in May 2024