Ambitious missions in support of Frontier Science and building a long-term (towards 2040+) EO ecosystem perspective

Splinter 1 – Summary of Splinter and Plenary discussion

ESA EO Science Strategy Workshop 2024
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General feedback (focusing on the implementation)

Transition period between the old and the new strategy:

- When will the new EO Science Strategy be applicable? A transition period between the old and new strategy is recommended. The Strategy should also consider the link to the past and what has already been done and accomplished.

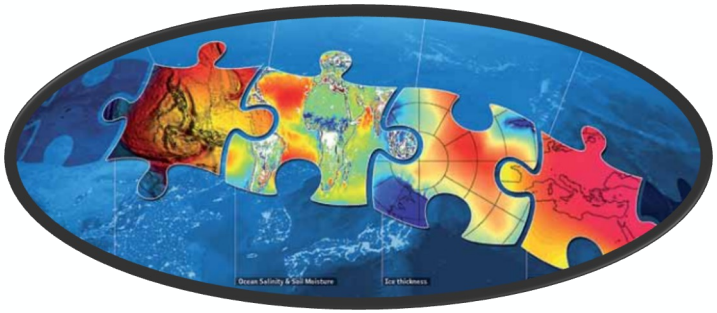
Applicability:

- A clarification is needed with respect to the applicability of renewed science strategy. To which elements of the ESA Earth Observation Programmes is the new EO Science applicable and how. (E.g. Earth Explorer Calls, Mission Extension Reviews, Independent Science Reviews, Applications in FutureEO Block 4,….)
- A clarification is needed to which elements the new EO Science Strategy is not applicable (E.g. Earth Explorer originating from past calls)

Other elements:

- The EO Science Strategy needs to be open for further review and in-depth assessment by ACEO as the Advisory Committee for Earth Observation.

Observation Gaps and Long-term planning



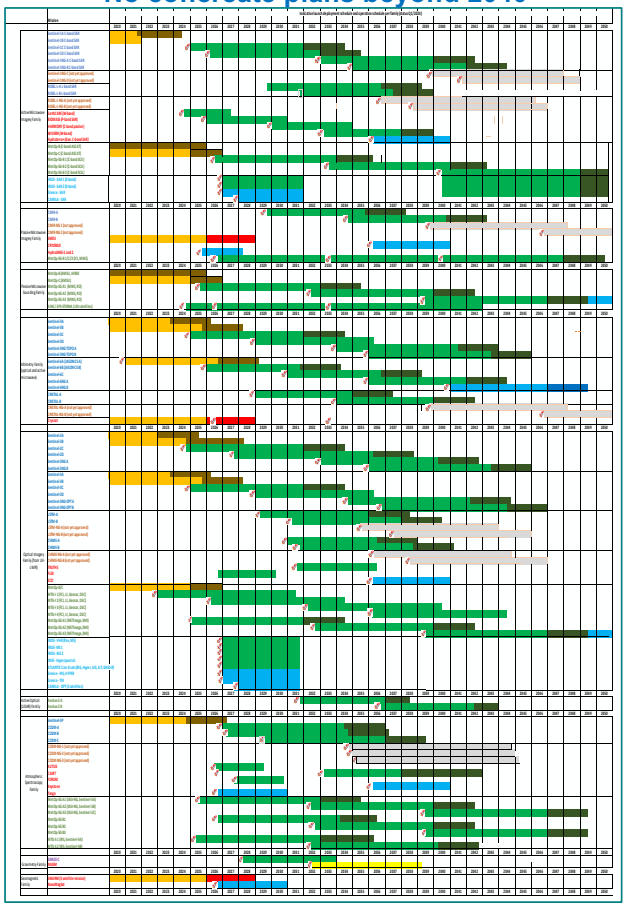
From science priorities to a living future EO architecture for a living planet

The driver – the science questions

CSQ	Short Title	Atmosphere	Land	Ocean	Solid Earth	Cryosphere
CSQ-1	Anthropogenic influences on the	x	x			
CSQ-2	Land biosphere response to CC	x	x			
CSQ-3	Ocean carbon cycle responses to	x		x		
CSQ-5	Sea level change in the coastal ocean		x	x		
CSQ-7	Coastal interfaces with land	x	x	x		
CSQ-8	Coastal climate change feedbacks		x	x		
CSQ-20	Ice mass balance			x	x	x
CSQ-21	Sea Ice thermodynamics					x
CSQ-24	Polar change and climate variability	x		x		x
CSQ-25	Cryosphere and Polar ecosystems		x	x		x
CSQ-33	Ice sheets and rheology				x	x
CSQ-35	Erosion and sedimentation		x	x	x	
CSQ-36	Plate boundary deformation dynamics				x	
CSQ-39	Crust and internal dynamics interactions				x	
CSQ-43	Coupling between energy water and	x	x	x		
CSQ-44	Anthropogenic influences on the water	x	x			
CSQ-45	internal energy flux estimates	x	x	x		x
CSQ-46	Earth energy imbalance	x	x	x		x
CSQ-48	Regional planetary heat exchange	x	x	x		
CSQ-51	Lithosphere-atmosphere-ionosphere	x			x	
CSQ-55	State of Land ecosystems		x			
CSQ-56	Land ecosystem critical transitions		x			

ESA Missions Planning: Now-2050

No concreate plans beyond 2040



Observatory gaps current and future

EO Architecture

With **short-term** (2030), **medium-term** (2040) and **long-term** (2050) vision

Observation Gaps – Summary (1)

- In the (draft) new EO Science Strategy, are the observation gaps from space well captured? Are there any additional gaps?
- Which candidate science questions require a longer-term perspective (to advance frontier science & fill gaps in observational capacity) and why?

- **Some gaps and needed observables are not yet known** and may only be unravelled in the future (e.g. . figuring out the importance of measuring Partial CO2 pressure (at the surface) required a 2 year study).
- There may be **observables which cannot be identified now**. We may have a question, but not yet know or fully understand the observables. Also, new observables and questions can originate from current/planned instruments e.g., in unexploited spectral bands.
- We should keep **an open perspective on what is not yet identified** and could be discovered during the mission. **The draft strategy fosters new discoveries**, in the process of defining how to measure/address a quantity, and that may lead to new scientific questions (and even domains, such as for example fluorescence, looking back at the EE7 call and FLEX).
- The **discovery – blue-sky element in the strategy needs to be strengthened**.

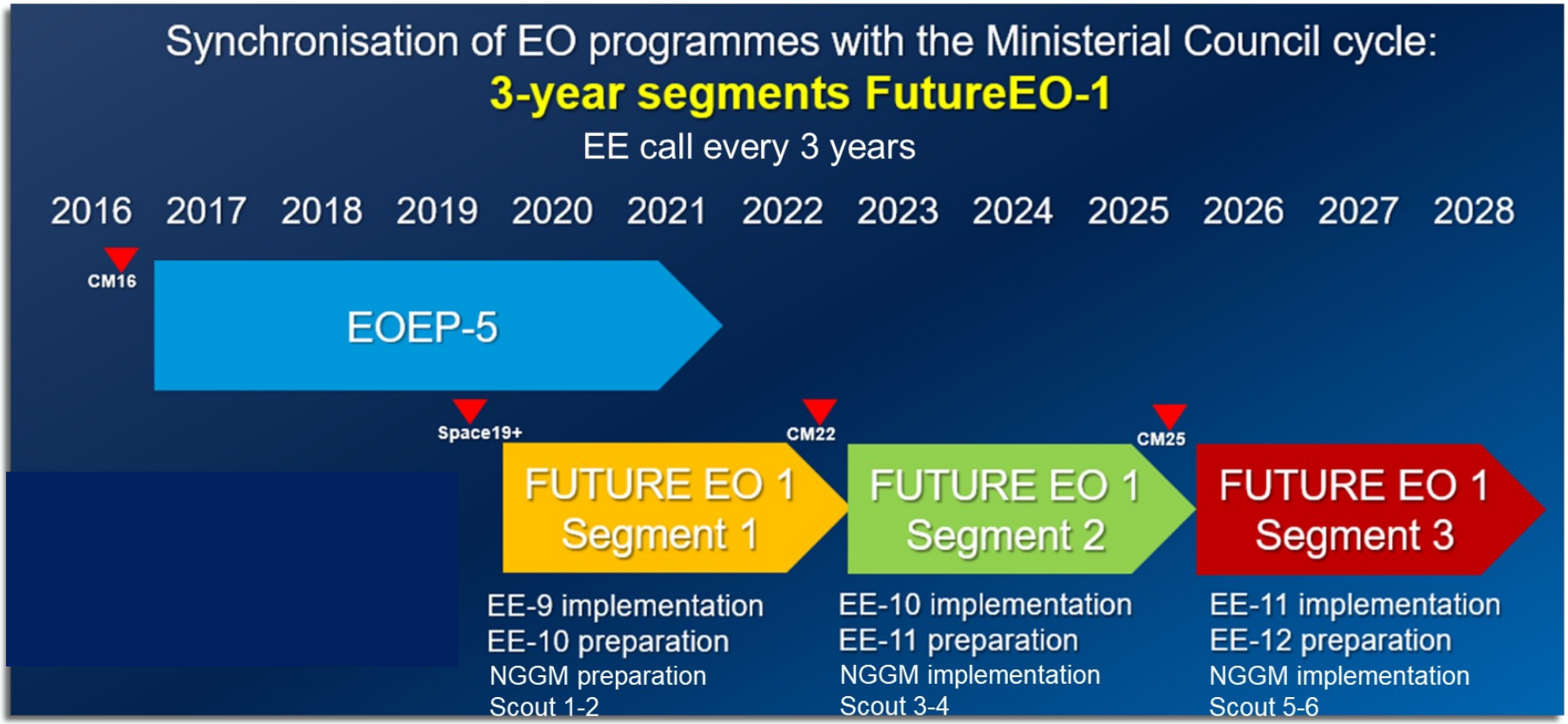
Observation Gaps – Summary (2)

- In the (draft) new EO Science Strategy, are the observation gaps from space well captured? Are there any additional gaps?
- Which candidate science questions require a longer-term perspective (to advance frontier science & fill gaps in observational capacity) and why?

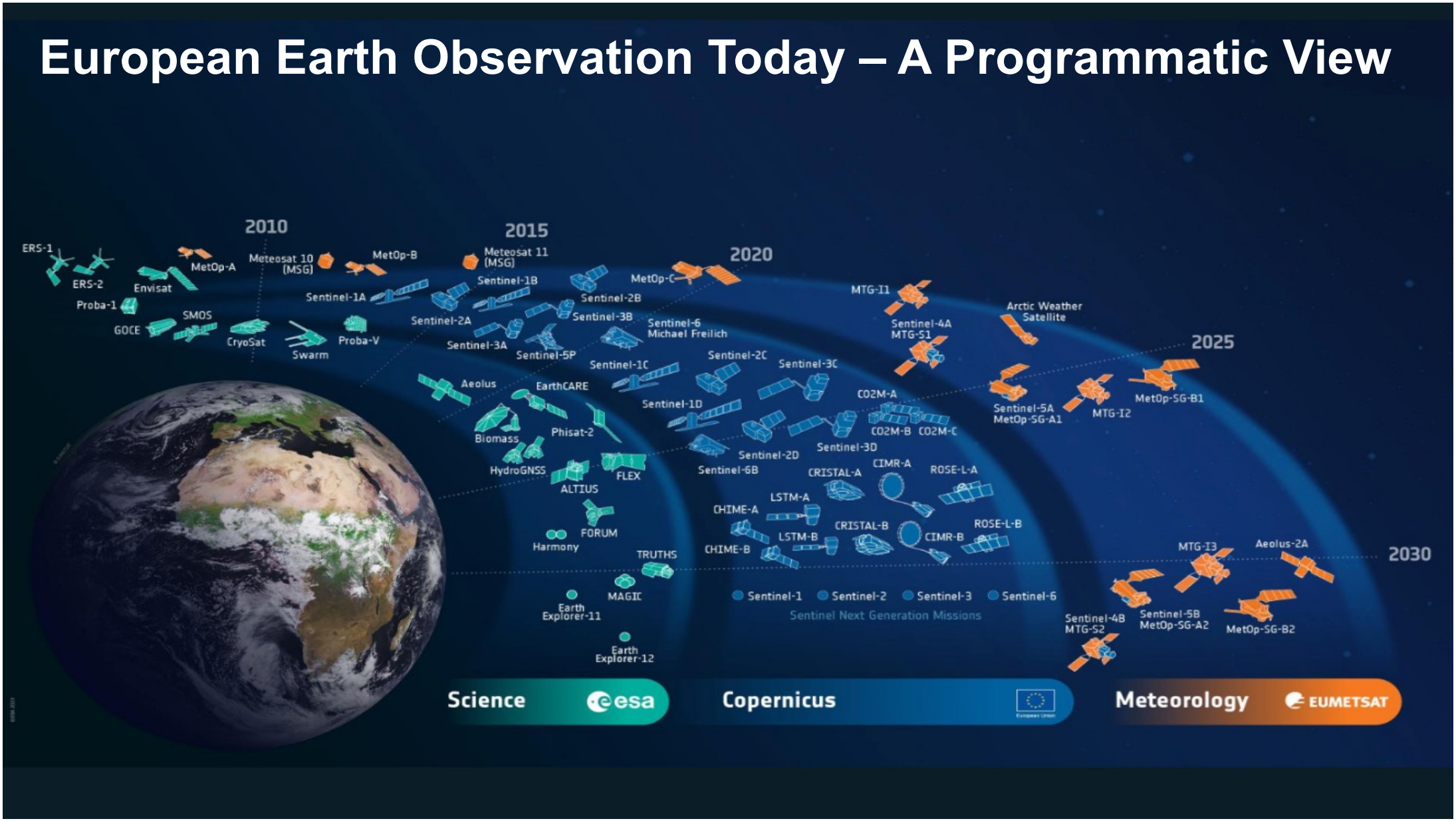
- The **gap analysis is recognised to be an enormous and ambitious exercise**. Having a fully comprehensive and in-depth exercise is seen as a challenge and it requires scientific intelligence!
- The gap analysis is one element of the strategy. It informs on what is already here and starts to answer the question of what could be missing with respect to known needs. It provides a **starting point** that can be complemented by science feedback.
- The current methodology for gap analysis seems to be more of a quantitative nature – it misses out a qualitative assessment e.g. when a parameter is available in the database but not yet at the required accuracy/resolution/coverage. The observable is than still a potential gap, as the requirements are not yet met. A weighing factor could be introduced and a link to evolving requirements.
- Gaps may arise when missions end (continuity of missions is an element to consider). Continuity is a European topic, EUMETSAT and the EU play a key role.
- It's important to look not just at scientific gaps, but at **domains to focus on a strategic point of view, building on strengths, leadership and interest** and where the money should go to position Europe in 2040/2050 on the EO side. The **gap analysis should be just a background information**.

Different Mission Classes

Initial statement: *ESA EO programmes are already driven by long-term assumptions. The current main drivers are originating from "mechanical" or "financial" considerations.*



European Earth Observation Today – A Programmatic View



Mission Classes – Summary (1)

- Would you suggest less frequent-large science missions vs more frequent smaller-higher cadence (less ambitious) missions?

- The current funding envelope for Earth Explorers is insufficient to answer certain high priority science questions – due to the technology being too expensive/complex/not yet available. (i.e. Lidar - active measurement techniques are the only way to decouple the surface from lower-most atmospheric return.
    - It is important to decide where strategic technological leadership is needed. If we can't decide or the implementation is not feasible due to programmatic constrains, we should raise the flag.
- One of the recommendations of the Independent Science Review in 2021 was that more ambitious missions are needed occasionally. This can only be done together, which is a key ESA mandate.
- **One approach is to invest early in advancing the technology to make mission feasible and more affordable.**
- **Faster time to launch.** This would imply taking more risks. Nevertheless **Ph0 and PhA are crucial** !
- We are not exploiting all available data yet, and also need to be prepared that tighter policies (i.e. on CO2) may require better details/quality. **Where are the limits for the current datasets and where are new large science missions required?**

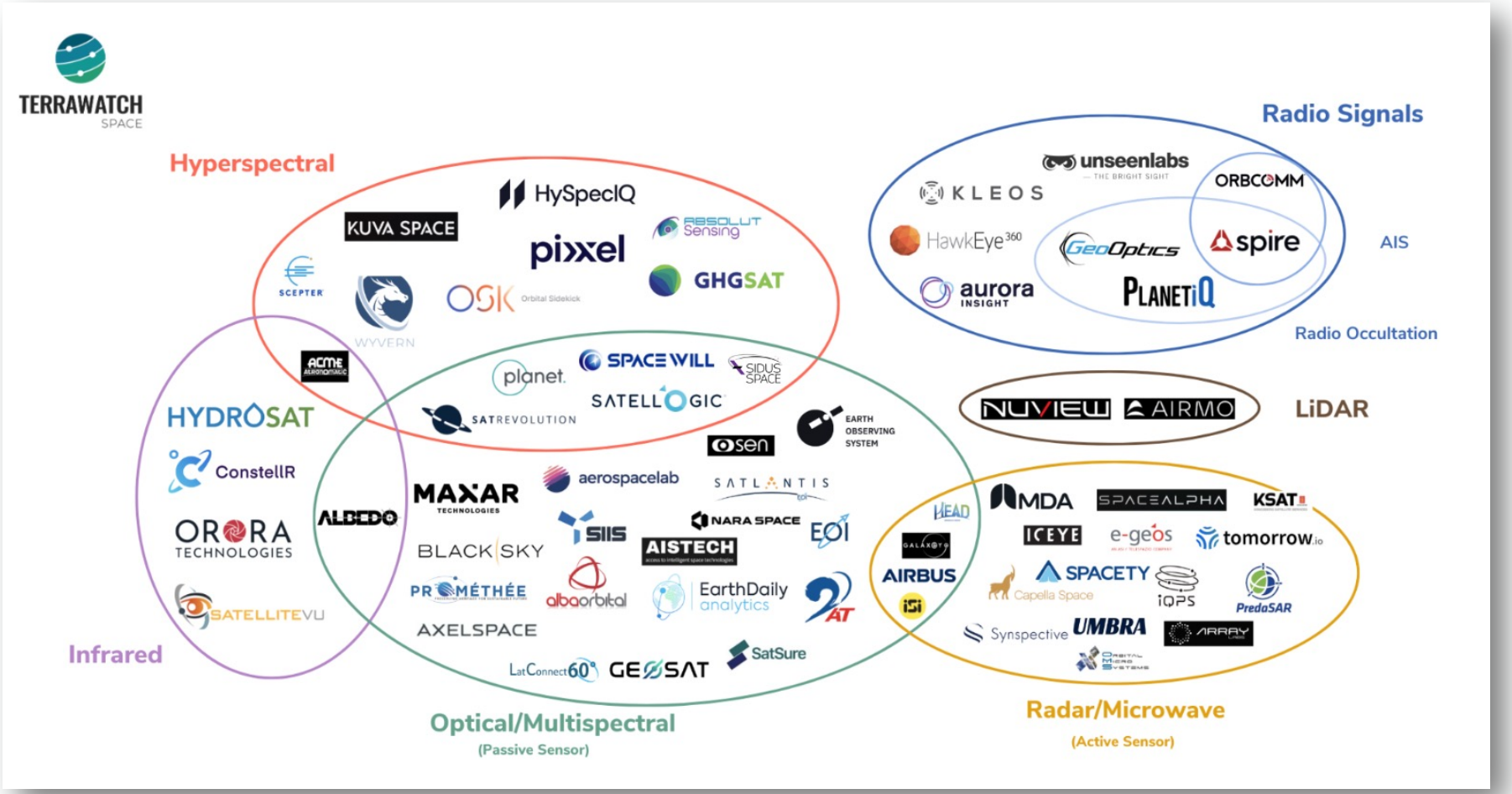
Mission Classes – Summary (2)

- Would you suggest less frequent-large science missions vs more frequent smaller-higher cadence (less ambitious) missions?

- When deciding on the next science missions, consider:
  - **We need to identify which science questions require missions beyond the current frame to be answered.**
  - **Urgency** (to be reflected in the strategy)
  - **Uniqueness of ESA as vehicle for science missions identification, preparation and implementation**
  - Ability of science community to agree on one urgent science question, which we could address with an ambitious science mission. Can the science community accept the impact of other missions being deferred/not implemented?
- For more ambitious missions:
  - We need to choose very wisely!
  - The "very obvious" science questions and "easier missions" are in preparation and in operations → next ones may be much more challenging
  - ESA needs a framework for larger missions
  - Priority science questions in strategy address cross-cutting topics / are not domain specific. Addressing those questions has stronger potential to engage a larger and wider science community.

Commercial Space & Science

Commercial EO satellite players



Commercial Space – Summary

- Where can Commercial Space best deliver complementary science?
- If joint Commercial + Institutional missions: Which scientific use cases do you see?
- What are the requirements to leverage commercial (+institutional) constellation to answer scientific questions?

- From a science perspective it does not matter if the data are coming from commercial or institutional providers. What is delivered needs to be **reliable data** from either sources**.**
  - Standards for quality assurance, characterisation, calibration, validation
  - Transparency
  - Accessibility and availability. Commercial providers usually **limit the use and distribution of data.** This is a limit for the science community.
  - Cost factor for using them + quality assurance.
- From a commercial provider point of view science users represent one customer domain when it comes to data exploitation. We need to exploit potential partnership models where commercial can rely on science community for their expertise, e.g. by providing “quality stamps”.

Trust and quality matter!