Senior Science Committee Recommendations for Voyage 2050

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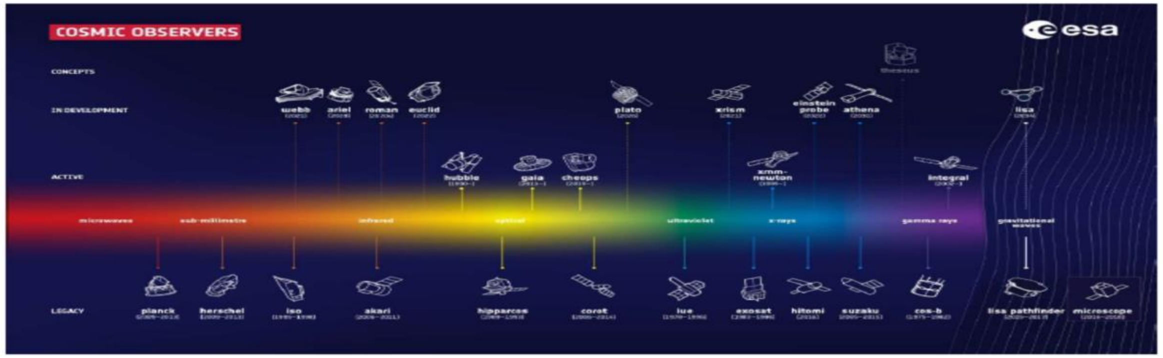
Prologue



- ESA has a very high quality science programme and its strategic planning includes, about every 20 years, the appointment of an **independent** panel of scientists, the "Senior Science Committee" to chart a path forward.
- This process started in 2019 to prepare a plan for the period 2030 to 2050.
- It involved significant community interaction in terms of providing new science ideas and community members to work in topical teams.
- However, this is <u>my</u> view of that work and the report that resulted.
- <u>I am not speaking for ESA.</u>

ESA Basics

- The whole programme at ESA is funded by 22 member states by way of subscriptions , related to GDP, plus other contributions to "optional programmes" that interest an individual country.
- The subscription pays for Administration and the Science Programme.
- For this reason the Science Programme budget is protected and only subject to (smallish) revision by the Council of (Space) Ministers every three years.
- ESA is divided into operational Directorates:
  - Science, Human and Robotic Exploration, Earth Observation, Navigation, Technology, Launchers, Telecomms

ESA Science Projects

- The ESA annual budget is about 6 Bn Euros with a spend of about 550 M Euros on science.
- The science programme is made up of Large (L), Medium (M) and Small (S) missions
- The ~500 M Euro budget for an M class mission will be spent by ESA on
    - Project management
    - Specific technical developments, if needed
    - Procurement and testing of the spacecraft
    - Procurement of the Launcher- and Launch
    - Capture of and dissemination of data
    - Operation in orbit of spacecraft.
- Consortia from member states can propose instruments to fly on L class or M class missions and **the cost of the instrument(s) will be borne by the space science agencies in the member states** comprising the winning consortium.

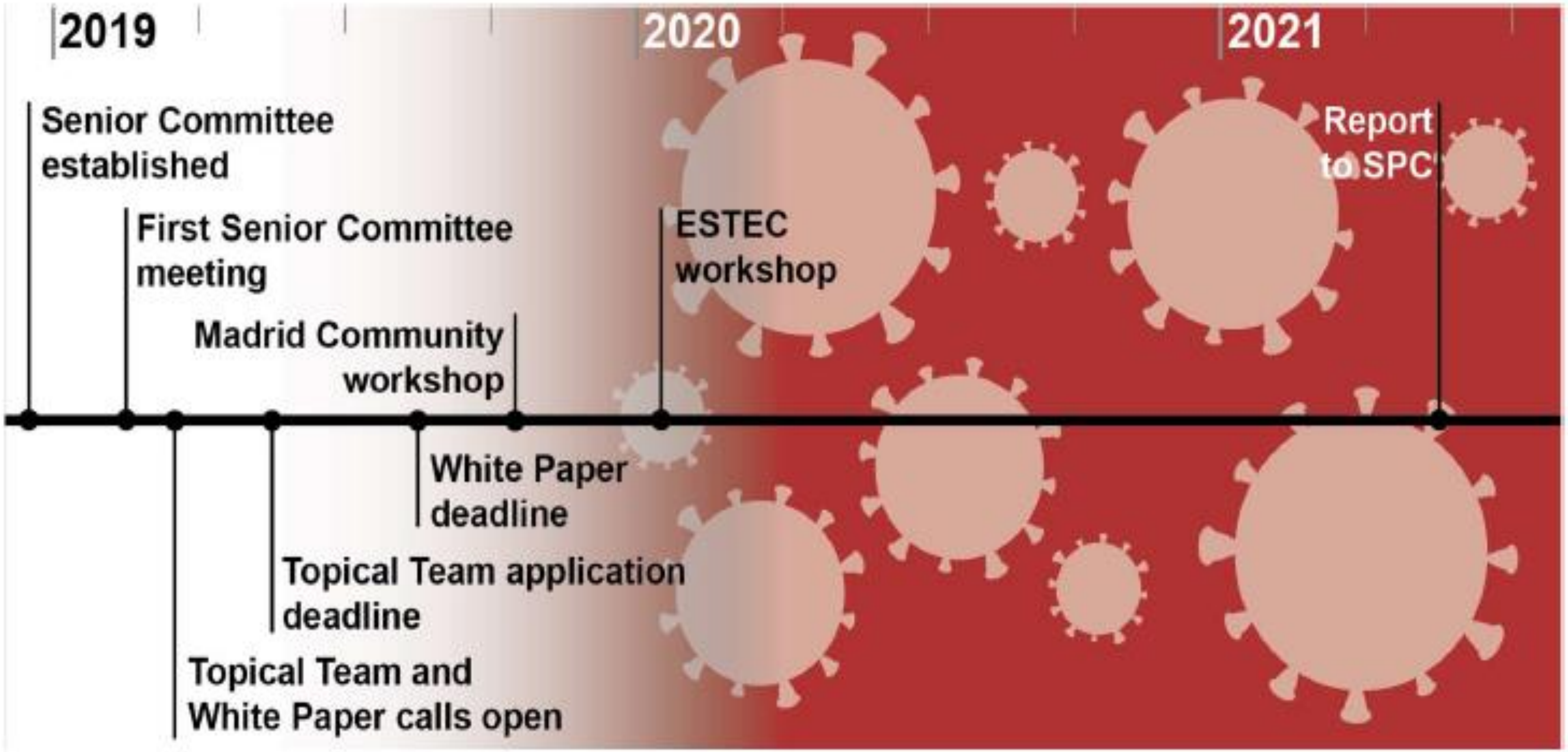
The Science Programme

- In past decades the ESA science programme has developed a science plan covering a 20 year time frame including the following elements :
  - 3 Large (L class) missions each costing about 1bn Euro,
  - ~10 Medium (M class) missions each costing about 500-550 M Euro
  - A few –two or three- Small missions
  - A technology development programme
- The Voyage 2050 plan is the latest of these science plans and there are some (good) implications for the development of Cold Atom technology for space.
- This plan was a **recommendation** to the SPC –the decision making body formed of member states.

Plan Content

- To recommend to the Science Programme Committee:
  - **Three science objectives** suitable for Large missions in the period 2030-2050.
  - **A list of Medium mission science objectives** in order to justify the medium mission budget provision without prejudicing mission choices every few years during the operation of the plan.
  - **Areas of technology development** that should be undertaken to enable the science missions of the future.

Process timeline



Process

- A “Senior Science” committee was set up in 2019 by the Executive including a Chair, a Deputy Chair and 11 members.
- The Community was invited to send in “White Papers, (WP)” on **science topics** suitable for L class missions. 97 were received.
- The Community was invited to apply to be members of the Topical Teams (TT) advising the Senior Committee.
- Membership of the Topical Teams was decided by the Senior Committee.
- A workshop was held in Madrid including as speakers some authors of WP’s and as audience the Topical Teams and Senior Committee.

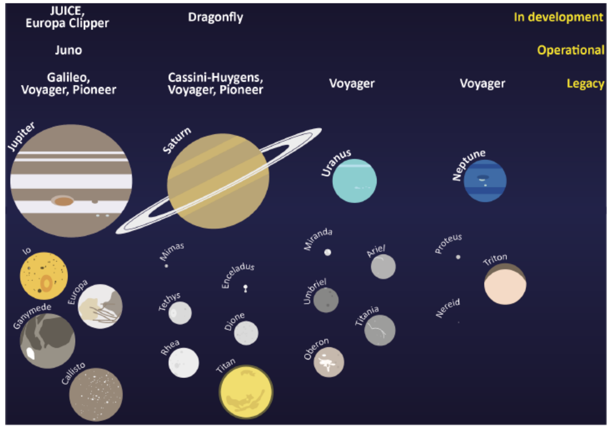
Process cont’d

- The Topical Teams, structured following analysis of the White Papers were:
  - Solar and Space Plasma Physics
  - Planetary Science
  - Galaxy, Star and Planetary Evolution (including the ISM and Astrochemistry)
  - The Extreme Universe including Gravitational Waves, Black Holes and Compact Objects
  - Cosmology, Astroparticle Physics and Fundamental Physics
- The Topical Teams reviewed the White Papers in their discipline and in any overlapping areas and reported on the L class science cases.

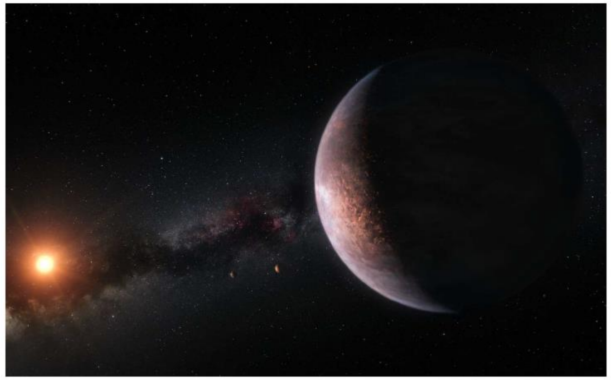
The Senior Committee activities

- Senior Committee members with relevant expertise presented a report on the White Paper analysis by the Topical Teams.
- Senior Committee members **without** relevant expertise presented a report on the White Paper analysis by the Topical Teams!
- The White Papers were analysed by the Senior Committee and a set of twelve potential L class science objectives were selected for further discussion.
- These twelve were gradually down-selected to the final three.

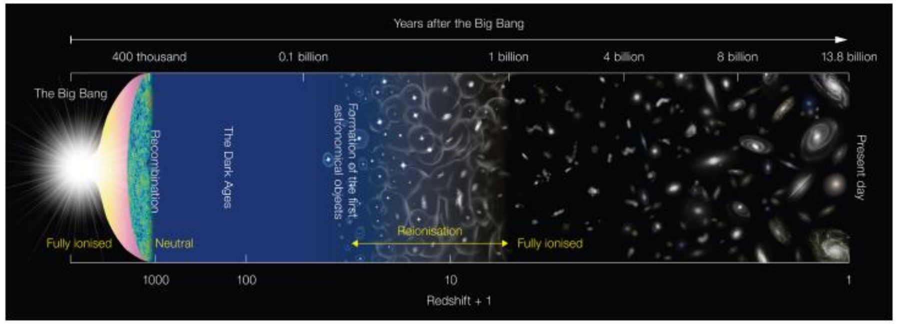
L Class Science selection



- Moons of the Giant Planets
  - Exploring the frozen worlds
  - Europa or Enceladus
- From Temperate Exoplanets to the Milky Way
  - Characterising the spectrum of temperate Exoplanets
  - GAIA infra-red to probe the centre of our Galaxy

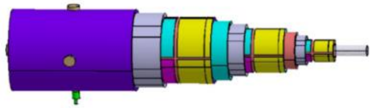


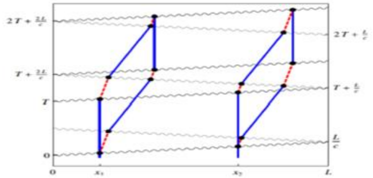
- New Physical Probes of the Early Universe
  - Spectral distortion of the CMB, or
  - DeciHertz/microHertz Gravitational Waves

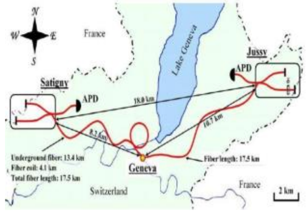


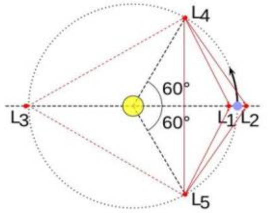
M Class missions

- These are selected by open call every few years, but the range of attractive missions fully justifies the allocation of budget to M Class projects.
- Potential Science:
    - Magnetospheric systems
    - Plasma cross scale coupling
    - Solar Magnetic fields
    - Solar Polar imaging
    - High precision Astrometry
    - High precision Asteroseismology
    - ISM Studies
    - Space radio interferometry of Black Holes
    - Mapping Cosmic Structure in Baryons and Dark Matter
    - X Ray absorption mapping of the IGM
    - General Relativity and Quantum Mechanics
- **We were not selecting these missions**









Technology Development for Science

- **Cold Atom technology**
- X-Ray interferometry
- Power sources for Planetary missions
- Sample return technology for Planetary missions
- Propulsion for high Heliographic latitudes

- **These were suggestions to the Executive for necessary developments to prepare for future missions**

Voyage 2050 : Cold Atom Technology Development

- Technology needs to be at TRL 5/6 (Technological Readiness Level 5/6) for mission selection.
- This means a component or model demonstrating “critical function in a relevant environment”.
- The Voyage 2050 report suggested a process:
    - Choose atomic species at outset
    - Choose application in which CA technology is superior (Atomic Clock?)
    - Carry out a system design of payload followed by technology audit
    - Develop necessary subsystems to TRL 6
    - Respond to Science Directorate call for proposals (M missions or smaller)

Executive's Response: Voyage 2050

- The Voyage 2050 report's recommendations were accepted by the SPC.
- On Cold Atom Technology the comments from the Executive were :

  - Feasibility of CA missions driven by lack of mature technology.
  - Difficult to identify individuals who would commit time and resources to mature and develop viable payloads.
  - It would be necessary to mature and develop viable space payloads from the very performing but complex, and fragile ,laboratory experiments.

  - "The Executive plans nevertheless on the basis of this recommendation to consult again with the Community, as well as with Member States, to define a possible concrete plan for progress in this field."

- **Let us hope that this workshop is the start of that consultation.**

Personal remarks (AMCruise)

- **In My Opinion:**
- No Cold Atom mission will be selected in the ESA Science programme unless the technology can be shown to offer seriously improved performance over current, classical instrumentation.
- Cold Atom technology must be demonstrated at the required performance level both in the lab and in a relevant environment (vibration, temperature, vacuum, EMC).
- The science objectives selected must be of the highest timeliness, international quality and broad scientific implications.
- There must be a coherent scientific plan supported by the Quantum Technology community and led by committed project leaders.
- **I hope this has been helpful**

The Senior Science Committee being thanked by the Community