COSMIC VISION – PRESENTATION TO NASA ASTROPHYSICS SUBCOMMITTEE

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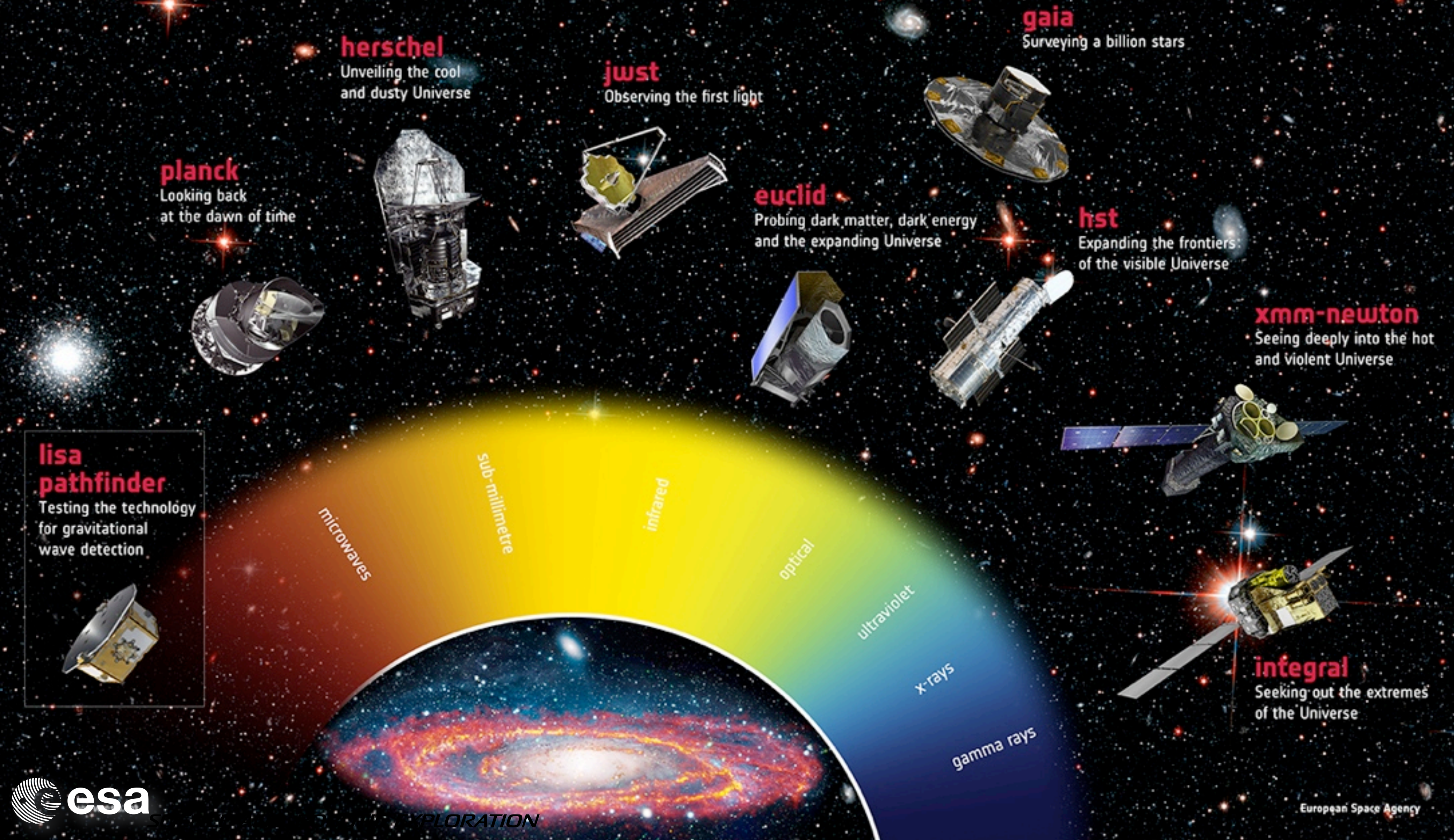
→ ESA'S FLEET ACROSS THE SPECTRUM

Thanks to cutting edge technology, astronomy is unveiling a new world around us. With ESA's fleet of spacecraft, we can explore the full spectrum of light and probe the fundamental physics that underlies our entire Universe. From cool and dusty star formation revealed only at infrared wavelengths, to hot and violent high-energy phenomena, ESA missions are charting our cosmos and even looking back to the dawn of time to discover more about our place in space.

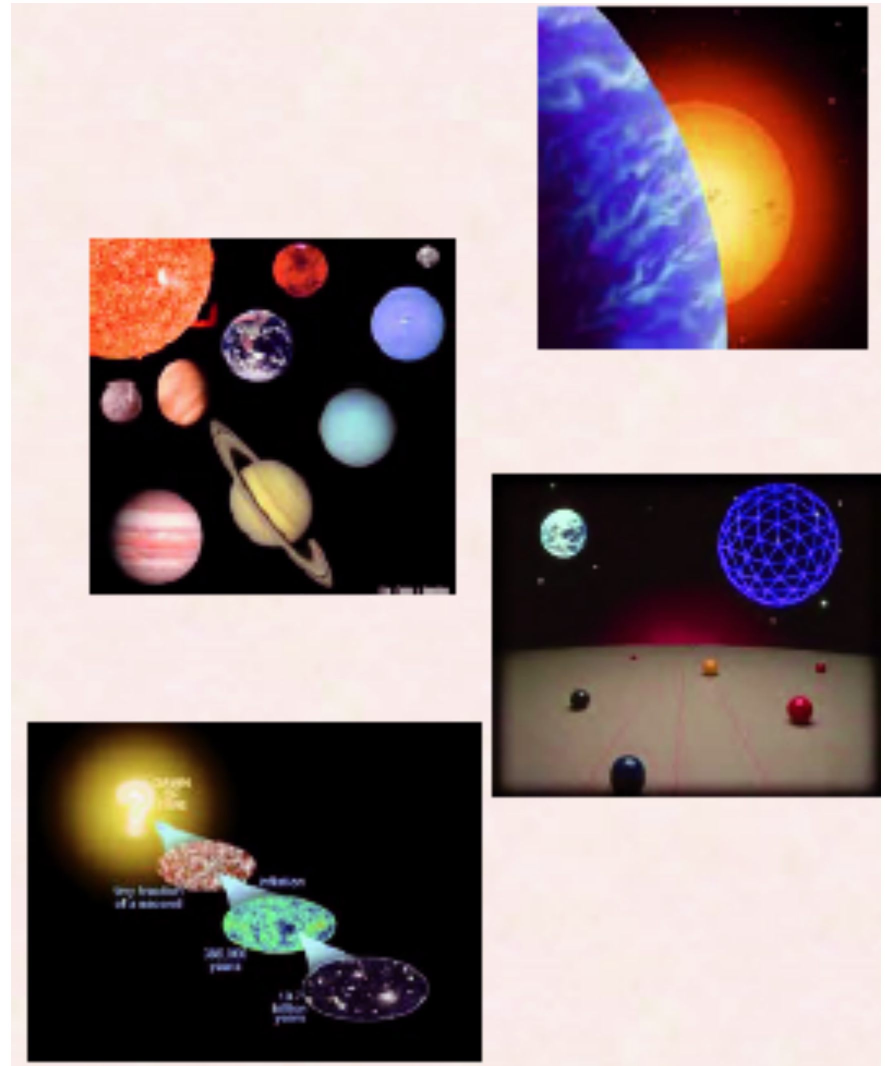


European Space Agency

COSMIC VISION "GRAND THEMES"

In 2005 the Cosmic Vision plan was announced covering the Science Programme in the 2015-2025 decade. Four questions were posed:

1. What are the conditions for planetary formation and the emergence of life ?
2. How does the Solar System work?
3. What are the physical fundamental laws of the Universe?
4. How did the Universe originate and what is it made of?



SCIENCE PROGRAMME

- The Science Programme has an annual income of around 500 M€. In addition, Member States normally directly fund the payloads and parts of the science ground segments.

- The selection of missions in Cosmic Vision is “bottoms up”. Working Groups (including AWG), recommend to the Space Science Advisory Committee (SSAC) who make a consolidated recommendation to the Science Programme Committee (SPC) who are responsible for the content of the programme.

- The building blocks of the programme include L, M, S and O missions.

SCIENCE PROGRAMME ELEMENTS

- L-missions (1/2):
  - Large European-led flagship missions with a cost to ESA of around 2 annual budgets with one opportunity every 7-8 years
  - L-missions are open to international participation of any element. Any such contributions will have to have potential European replacements and their total envelope will be limited to ~20% of the total mission cost.
  - L1 is JUICE – a mission to the Jupiter system scheduled for a 2022 launch. JUICE is in Phase B1.
  - The L2 (2028) science theme was selected at the end of 2013 to be the “hot and energetic Universe”. 32 science themes were proposed.

SCIENCE PROGRAMME ELEMENTS

- L-missions (2/2):
  - L2 call for mission concepts to fulfil the science goals defined above closes on 15 April 2014. Proposers are welcome to suggest possible schemes for international collaboration in the proposals.
  - Based on the stated interest of NASA and ISAS/JAXA to participate in the mission, ESA intends to include US and Japanese scientists in the Study Team.
  - AO for payload and science ground segment elements will likely be released in early 2015 with Phase A completing at the end of 2016.
  - Mission adoption (final approval) is expected around the end of 2018
  - The L3 science theme (2034) is “the gravitational Universe”. ESA intends to invite NASA involvement in the technology assessment studies to be started later this year.

SCIENCE PROGRAMME ELEMENTS

- M-missions (1/2):
  - Provide the programme with flexibility.
  - ESA led or implemented through international collaboration.
  - Cost to ESA of around one annual budget, one every 3-4 years.
  - In 2011, the SPC selected M1 to be Solar Orbiter (2017) and M2 to be Euclid (2020). Both missions have substantial US involvement and have been subsequently “adopted” by the SPC
  - In 2010 the Call for M3 was issued. 47 proposals received of which 4 were recommended for further study (EChO, LOFT, MarcoPolo-R and STE-QUEST) to which PLATO, left over from M1/M2, was later added.

SCIENCE PROGRAMME ELEMENTS

- M-missions (2/2):
  - PLATO was selected as M3 in 2014. Exo-planet transits and stellar oscillations. Will detect hundreds of low-mass planets in the habitable zones of bright solar-like stars for which accurate radii, masses, densities, and ages can be derived.
  - 34 white light cameras, each with four passively cooled CCD detectors. Survey of ~2250 deg^2 continuously. Two regions will be observed for ~2 years each, with 2 years of step-and-stare.
  - Prime product will be a large sample of high precision stellar light curves over months to years with a >95% duty cycle.
  - Preliminary schedule:
    - Mission adoption in Feb 2016
    - Camera delivery by Q4 2021
    - Launch Q1 2024 using a Soyuz-Fregat from Kourou

SCIENCE PROGRAMME ELEMENTS

- S-missions:
  - New concept allowing national agencies to play a leading role in missions, 0.1 annual budgets, one every 4 years, potentially.
  - S1 is CHEOPS which will study transits of known exo-planets. It will allow the determination of the masses and radii of super-Earths and Neptunes orbiting bright stars.
  - Small (280 kg) mission in partnership with a consortium led by Switzerland.
  - CHEOPS will observe exoplanet transits on V = 9 stars with a photometric precision of 150 ppm in one minute. This precision allows the detection of an Earth-size planet transiting a star slightly smaller than the Sun (0.9 Solar radius) with a 50 day period, detected with a signal-to-noise ratio >5 (100 ppm transit depth).

SCIENCE PROGRAMME ELEMENTS

- O-missions:
  - which are "missions of opportunity", led by other agencies, with small contributions from ESA. Examples include:
    - AKARI – contributions to ISAS/JAXA IR sky-survey mission
    - Microscope – ESA is providing the micro-propulsion system for this CNES led mission to test the Equivalence Principle.
    - ASTRO-H, where ESA is providing HV power supplies, loop heat pipes, a European science centre, a scientist at ISAS etc
  - New initiative:
    - Collaboration with Chinese Academy of Sciences on a joint-call for a small mission to be launched in 2021. A first workshop involving the scientific communities from both Europe and China took place in Chengdu on February 25-26. Follow-up workshop in Europe in 24-26 September 2014.

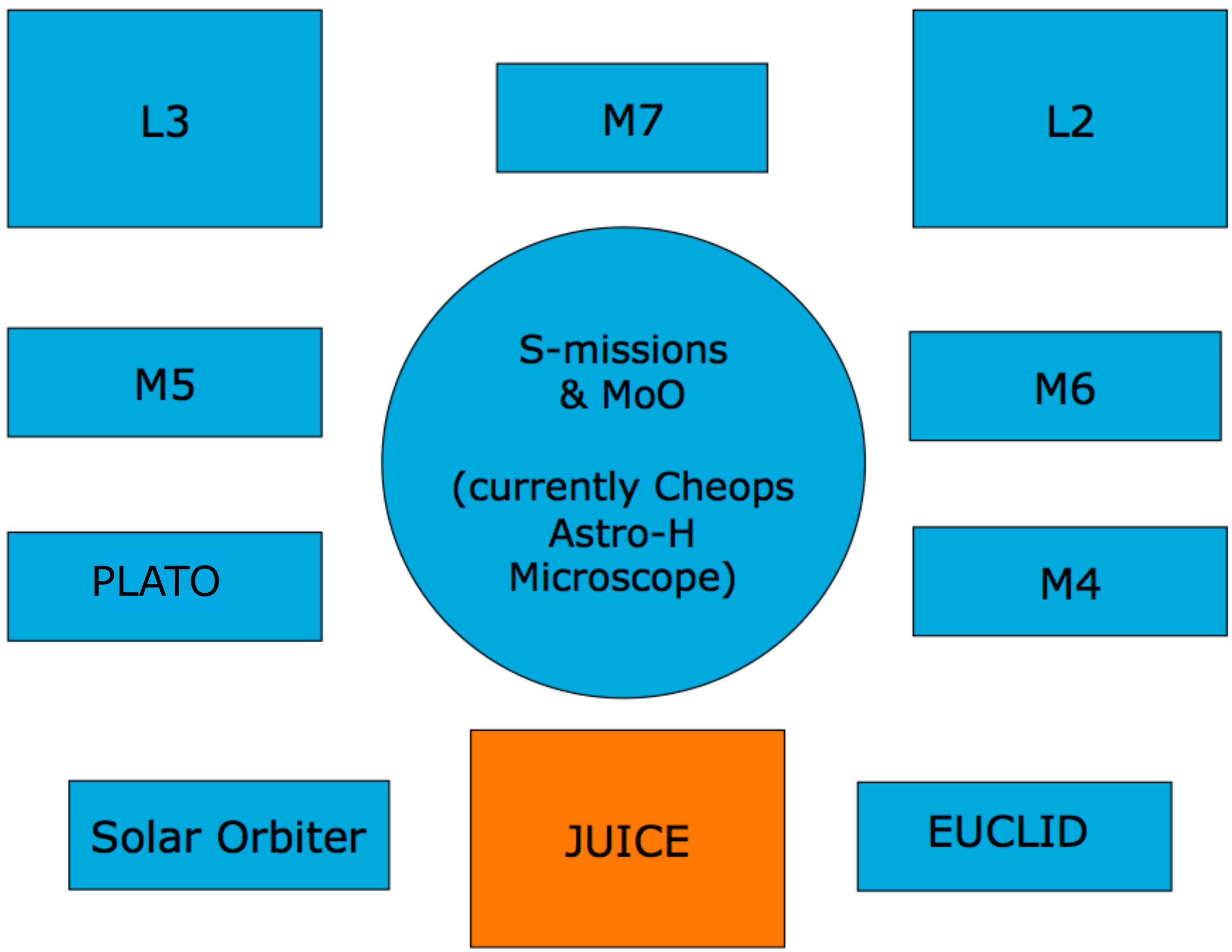
LONG TERM PLANNING

- The aim of D/SRE is to implement a regular series of M and L mission, interspersed with S and O missions, if/when applicable.
- Assumes constant spending power from 2015 and:
  - Strong cost capping on operations, basic activities, and expenditure on S and O missions.
  - Strict cost control of on-going and new projects together with prudent risk and contingency management

- Assume costs of M and L missions are 0.5 and 1.0 B€ for planning purposes (1 and 2 annual budgets)
- Until 2035, it is assumed that there are funds for 5 M and 2 L missions.

COSMIC VISION (2016-2035)

COSMIC VISION (2016-2035)



PLANNING CYCLE

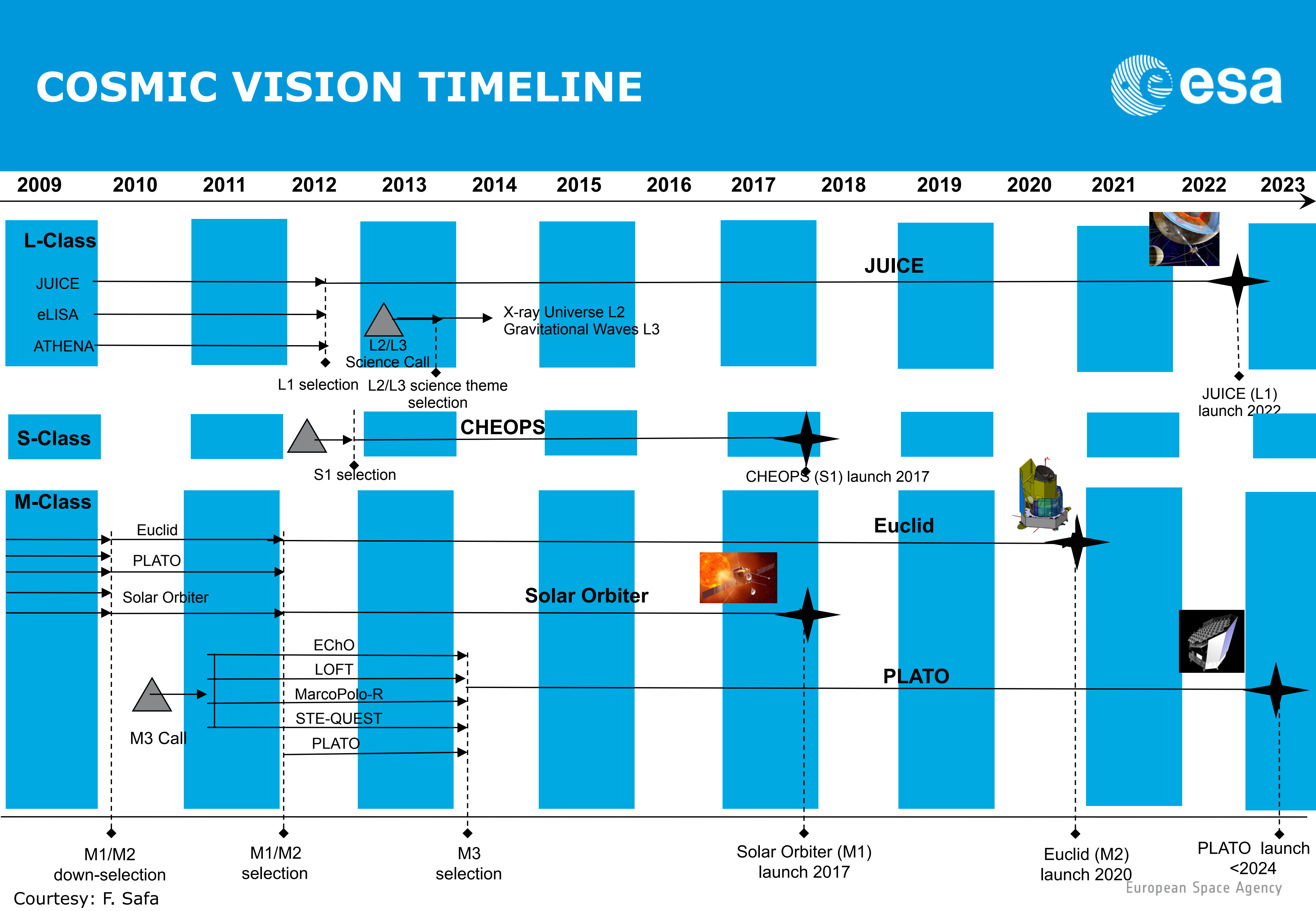
Tentative planning for mission calls:

a.	M1, M2, L1	done, done, done
b.	M3, M4, L2	done, 2014, 2014
c.	M5, M6, L3	2018, 2020, 2020
d.	M7	2022

Tentative planning for mission launches:

a.	M1, M2, L1	2017, 2020, 2022
b.	M3, M4, L2	2024, 2026, 2028
c.	M5, M6, L3	2030, 2032, 2034
d.	M7	2035

BACKGROUND INFORMATION


COSMIC VISION TIMELINE
esa
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
L-Class
JUICE
eLISA
ATHENA
JUICE
L2/L3
Science Call
X-ray Universe L2
Gravitational Waves L3
L1 selection
L2/L3 science theme selection
JUICE (L1) launch 2022
S-Class
CHEOPS
S1 selection
CHEOPS (S1) launch 2017
M-Class
Euclid
PLATO
Solar Orbiter
Euclid
Solar Orbiter
EChO
LOFT
MarcoPolo-R
STE-QUEST
PLATO
PLATO
M3 Call
M1/M2 down-selection
M1/M2 selection
M3 selection
Solar Orbiter (M1) launch 2017
Euclid (M2) launch 2020
PLATO launch <2024
Courtesy: F. Safa
European Space Agency

STUDY PROCESS TO FINAL SELECTION

esa

1. Issue of AO for new missions
2. Selection by Advisory Structure of n missions concepts for study
3. CDF studies in ESTEC
4. Parallel industrial studies with support of payload consortia
5. Selection of one mission by Advisory Structure/ SPC
6. Definition Study leading to Mission Adoption

Phases	Phase 0	Phase A	Phase B1
Phases	Assessment		Definition
Reviews		PRR	SRR
ISO TRL Required			≥6

TYPICAL M MISSION DURATIONS AND ACTIVITIES

Phase	Typical Duration (years)	Activities
0	1	Early concept studies: define mission goals, study multiple approaches
A	1	Preliminary Mission Analysis and System Trade Studies: define functional requirements, choose an approach, analyse alternatives
B1	2	Definition Study: define system requirements, complete a preliminary system design allocating functions and defining interfaces
B2/C/D	8	Design, Development, Test and Evaluation: complete detailed system design, fabricate, integrate and test. Prepare for launch and operations.
E/F		Launch, Operations and Disposal (F)
Total	**12**	This is the nominal schedule assuming that each phase is successful with a smooth transfer to the next.