

Astronomy

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for the **Astronomy Working Group**

Answers to the call for ideas

Illustration of the strong expectation of the community from the ESA Science Programme:

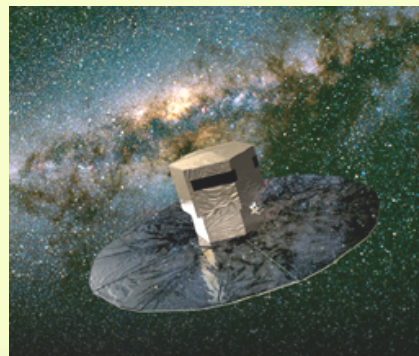
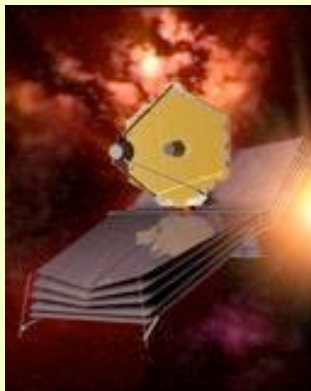
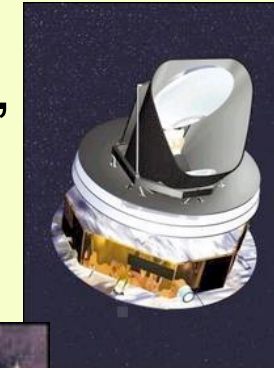
In astronomy

1983: Horizon 2000	29 answers
1993: Horizon 2000+	28 answers
2004: Cosmic Vision 2015-2025	47 answers

Context, ESA satellites



- In operation: HST, XMM-Newton, Integral
- In development: Herschel, Planck
- In preparation: GAIA, JWST (with NASA), Corot (with CNES), Astro-F (with JAXA)

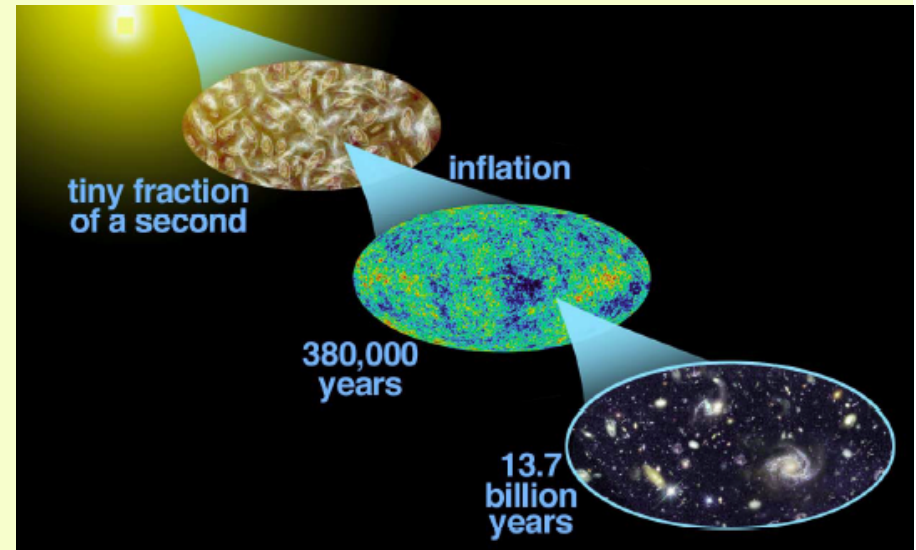
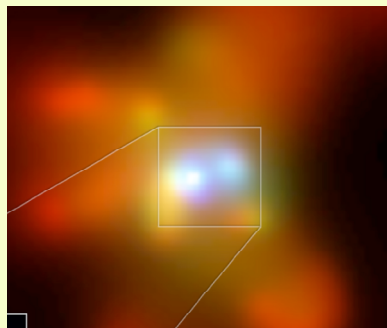


Context, science



- discovery of 134 exo-planets (118 systems), down to $\sim 15 M_{\text{Earth}}$
- very different from the planets in the Solar System
- high diversity

- observations at higher and higher redshifts
- new cosmological parameters, more and more accurate
- dark energy dominates the Universe, now



- cosmological nature of γ ray bursts
- diagnostics of strong field gravity
- discovery of binary black holes

Proposals received

Classified by theme, not by wavelength

Among the 20 best:

- detection, imaging of exo-planets, exo-Earths
- atmosphere of exo-planets, biomarkers, life on habitable planets
- star and planetary system formation, stellar evolution (asteroseismology)
- early phases of the Universe: inflation, dark energy
- formation and evolution of galaxies
- intra-cluster medium, intergalactic medium
- the evolution of the hot Universe
- compact objects, matter under extreme conditions
- birth of black holes

Strong connections with

- **Solar System Working Group**
 - ★ what are the conditions for formation and evolution of planetary systems ?
 - ★ what are the conditions for life ?
 - ★ which life forms ?

- **Fundamental Physics Advisory Group**
 - laws of physics under extreme conditions
 - possible imprints of the very early Universe
 - properties of Dark Energy

Evaluation criteria

- * what is new ?
- * how crucial is it for our general understanding of the subject ?
 - what is the likely impact in the domain ?
- * what is the expected range of application ?
- * what is the risk (discovery versus deepening of a subject) ?
 - what is the likely general impact on science ?
- * what is the added value of space ?
- * short (around 2015), medium (2020), long (2025) or very long (> 2025) term ?

Still a lot of work to be done to focus the priorities.

Three main themes identified

1. Other worlds and life in the Universe
Placing the Solar System into context
 - Formation of stars and planetary systems
 - Detection, census and characterization of exo-planets
 - Search for extraterrestrial life
2. The Early Universe
 - Probing inflation
 - Investigating Dark Energy
 - The observable Universe taking shape
3. The evolving violent Universe
 - Black holes and galaxy evolution
 - Matter under extreme conditions
 - Supernovae and the life cycle of matter

Theme 1: Other worlds and life in the Universe

Placing the Solar System into context

- ➔ Formation of stars and planetary systems
- ➔ Detection, census and characterization of exo-planets
- ➔ Search for extraterrestrial life

➤ Stars are forming: why ? how ? where ?

Planets are forming: why ? how ? where ?

IR, mm, X-rays, UV, radio

➤ Exo-planets exist: learn more about them !

Detect and characterize (spectroscopy) all possible types of exo-planets

Find planets in the habitable zone

Make a census of terrestrial planets in the solar neighbourhood

Image exo-planets

optical, IR, UV

➤ Find life outside the solar system. Detect biomarkers

What are the conditions for life ?

IR, optical

Theme 2: The early Universe

- Probing inflation
 - Investigating Dark Energy
 - The observable Universe taking shape
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- What happened in the early phases of the Universe ?
What are the imprints of the period of inflation ?
sub-mm to mm, CMB polarisation, gravitational waves

 - Less than 5 % of the content of the Universe has been identified.
What makes up the remaining 95 % ?
optical, IR, X-rays

 - How did the very first stars form ?
How did the first structures take shape ?
How did the first super-massive black holes form ?
IR, X-rays, UV

Theme 3: The evolving violent Universe

- Matter under extreme conditions
 - Black holes and galaxy evolution
 - Supernovae and the life cycle of matter
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- Strong gravity, ultradense matter, accretion/ejection flows X-rays
 - How and when did the first black holes form ?
How do they grow ? What happens when they merge ?
 - What is the relation between galaxy and black hole evolution ?
X-rays, gravitational waves, IR, γ -rays
 - What is the origin of γ -ray bursts ?
 - What is the role of supernovae in the life cycle of matter ?
 - Image a black hole X-rays, γ -rays, IR

From themes to the programme

The proposals illustrate different kinds of missions and underline the importance to have a balanced programme with

- big missions based on European leadership
 - major impact in their main scientific domain
 - wide range of scientific objectives serving a broad community
 - involve long term technology developments
- medium-sized missions
 - medium-term missions with more focussed scientific goals
- and missions of opportunity for flexibility
 - possibility to participate in missions led by other agencies

Today's presentations

For each theme

- ♥ a review of the theme
- ◆ two examples, chosen from amongst the 20 best proposals, presented by the coordinators of the proposals
- ♥ a proposed roadmap, resulting from initial discussions of the AWG, presented by a member of the AWG