ESA's Cosmic Vision Plan and Outer Planets

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CESR, Toulouse, France

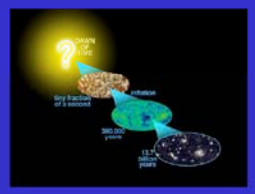
OPAG meeting, Boston, may 1st -2nd, 2007

Cosmic Vision process

- ✓ Cosmic Vision 2015 –2025 process launched on 2 April 04 with call for Science themes
- ✓ In excess of 150 responses received ! (Horizon 2000 + consultation received less than 100 responses) including many proposals for Outer Planets
- ✓ July 04: Analysis of responses by the ESA Science advisory bodies (AWG, SSWG, FPAG, SSAC)
- ✓ 15-16 September 04: Workshop in Paris (~400 participants)
- ✓ Spring 05: presentation of Cosmic Vision 2015-2025 to community :
  ESLAB symposium with a summary article on Outer Planets exploration (Blanc et al.) including many U.S. authors
- ✓ Oct. 05: Final Cosmic Vision document

Grand themes

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



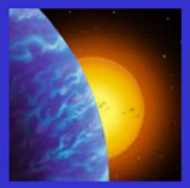
1. What are the conditions for life and planetary formation?

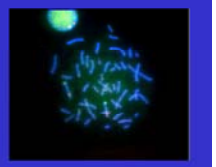
Place the Solar System into the overall context of planetary formation, aiming at comparative planetology

1.1 From gas and dust to stars and planets.

1.2 From exo-planets to bio-markers.

1.3 Life and habitability in the Solar System.



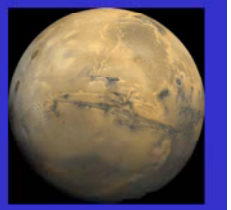


1.3 Life and habitability in the Solar System

Explore 'in situ' the surface and subsurface of the solid bodies in the Solar System more likely to host –or have hosted- life.

Appearance and evolution of life depends on environmental conditions (geological processes, water presence, climatic and atmospheric conditions, Solar magnetic and radiation environment)

Mars is ideally suited to address key scientific questions of habitability. Europa is the other priority for study of internal structure, composition of ocean and icy crust and radiation environment around Jupiter.



2. How does the Solar System work ?

2.1 From the Sun to the edge of the Solar System

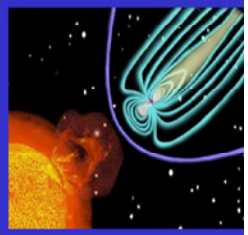
2.2 Gaseous Giants and their Moons

2.3 The Building Blocks of the Solar System: Asteroids and Small Bodies

2.1 From the Sun to the edge of the Solar System

Study the plasma and magnetic field environment around the Earth, the Jovian system –as a mini Solar System-, the Solar poles and the heliopause where the Solar influence area meets the interstellar medium.

The structure of the magnetic field at the solar surface requires observations from above the poles to understand the field's origin.



The Solar System pervaded by the solar plasma and magnetic field provides a range of laboratories to study the interactions of planets (Jupiter) with the solar wind

In-situ observation of the heliopause would provide ground truth measurements of the interstellar medium .

Tools: Solar Polar Orbiter, Earth magnetospheric swarm, Jupiter Probe, Interstellar Helio-Pause Probe.

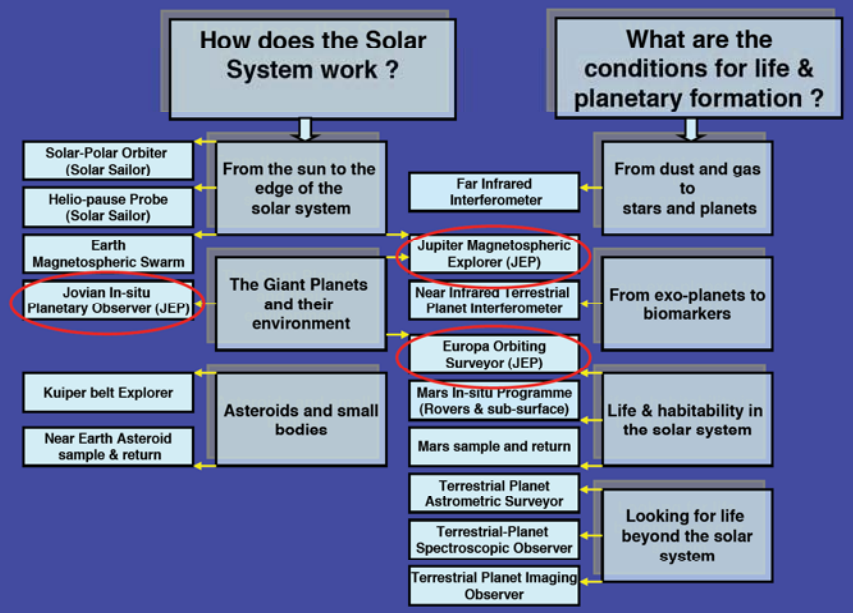
2.2 Gaseous Giants and their Moons

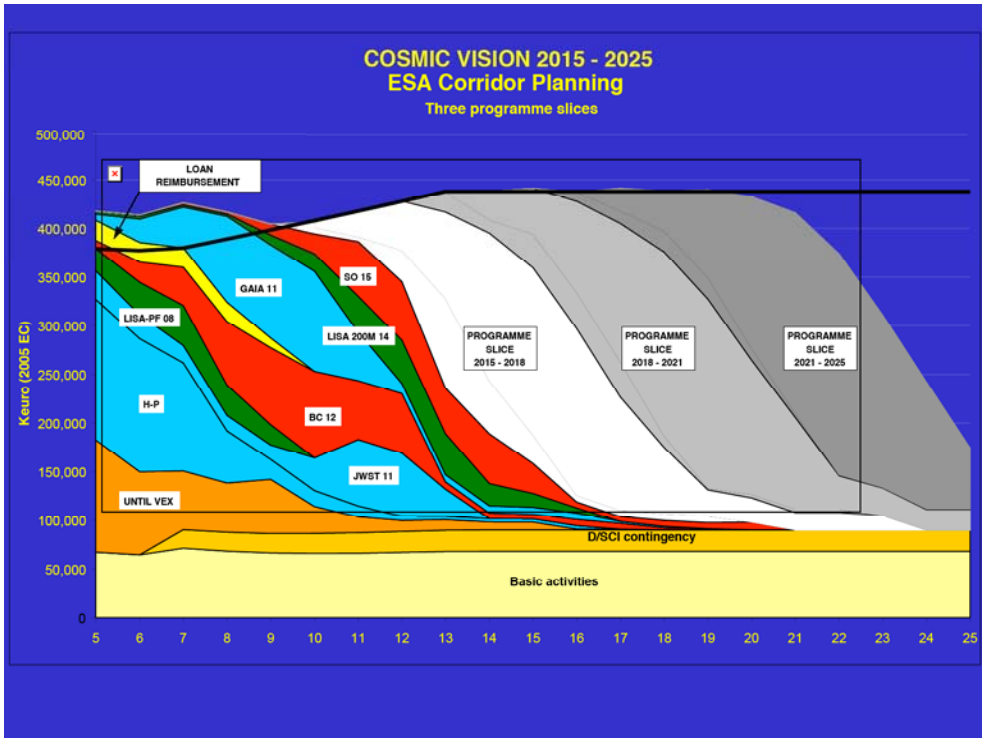
Study Jupiter In-situ , its atmosphere and internal structure.

Giant planets with their rings,diverse satellites and complex environments, constitute systems which play a key role in the evolution of planetary systems.

Tools: Jupiter Exploration Programme/JEP

From themes to proto-missions





IMPLEMENTATION AND SELECTION PROCESS

Call for two mission classes, M (<300 M€) and L (<650 M€)

- Over 60 LOI's submitted, april 2007, ~ 25 in Solar System
- Full proposals due, june 29, 2007- mission concepts only, 36 pages total – means « zero dollar » studies !
- International collaboration encouraged, requires letters from partner agencies.
- At least 3 proposals expected for Outer planets:
  Jupiter-Europa, TANDEM, Kronos
- Shows STRONG and BROAD interest from european space sciences community for outer planets: from space plasmas to astrobiology through geosciences and planetary formation (= astronomy….)

Next steps: class M (<300 M€)

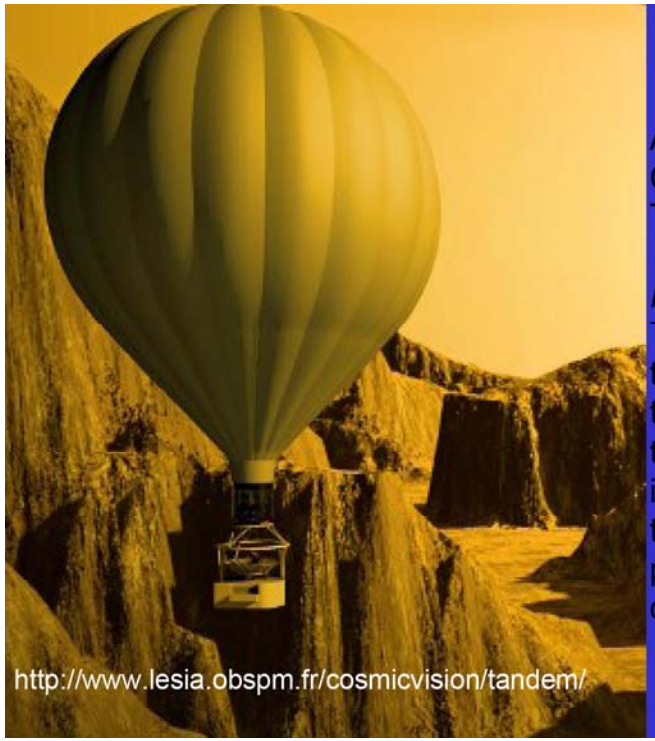
Activity	Date
ESA Internal Assessment Phase	November 2007 - end May 2008
Industrial Assessment Phase (emphasis on payload, cost and risk)	June 2008 - August 2009
Open presentation of study results & Working Group recommendation for Definition Study Phase	September - October 2009
SSAC down selection to 2 missions for Definition Phase	October 2009
SPC confirmation of 2 missions for Definition Phase	November 2009
2 missions in competitive Definition Phase	April 2010 - September 2011
Working group/SSAC evaluation and recommendation for adoption of one mission	September 2011-October 2011
SPC Confirmation of one mission for ITT release *	November 2011
SPC mission adoption (CaC and Payload Formal Agreement)	July 2012
Mission enters Implementation Phase	September 2012
Mission Launch	mid 2017

Next steps: class M (<300 M€)

Activity	Date
Internal Assessment Phase, focused on identification of key technology areas (up to 3 proposals)	November 2007 to May 2008
Industrial Assessment Phase and definition of TDP (3 proposals)	June 2008 - June 2009
Working group evaluation and recommendation for down-selection from 3 to 2 Class L concepts to compete with LISA for Definition Phase	July 2009 – September 2009
From 2L concepts + LISA, SSAC recommendations for two missions to enter Definition Phase. TDPs activated (or continued if LISA) for the two missions entering Definition Phase as well as for the remaining (third) mission concept	October 2009
Two missions confirmed by SPC for entering Definition Phase	November 2009
Two missions in competitive Definition Phase	January 2010 – June 2011
Working group/SSAC evaluation and prioritisation	July 2011 – October 2011
Confirmation by SPC of first mission for ITT release *	November 2011
SPC mission adoption (CaC and Payload Formal Agreement)	July 2012
Start of industrial Implementation Phase	September 2012
Mission Launch	October 2018

A new journey to Saturn's system to study in depth the new worlds revealed by Cassini-Huygens :
Titan & Enceladus in particular

Athena Coustenis et al.
http://www.lesia.obspm.fr/cosmicvision/tandem/



TANDEM :

A combined Post-Cassini exploration of Titan & Enceladus.

In situ study of the Titan atmosphere, the surfaces, the interiors, the magnetospheric interactions and the Astrobiological potentials of both satellites

Preferred mission scenario

A combination of

- Orbiters (Titan+Enceladus)
- Probes and Balloon(s) on Titan and/or Landers with surface package
- Penetrators/Landers for Enceladus

Balloon on Titan floating within a few km above the surface

Surface package

KRONOS :

ESA contribution to a NASA-led New Frontiers mission.

In situ studies of the Saturnian atmosphere

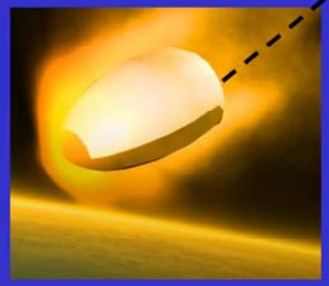
Lead: B. Marty
Co-leads : T. Guillot
A. Coustenis

http://www.lesia.obspm.fr/cosmicvision/kronos/

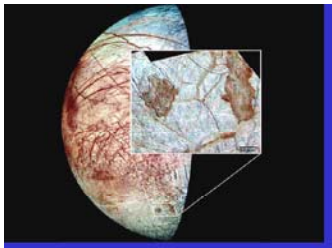
Preferred mission scenario

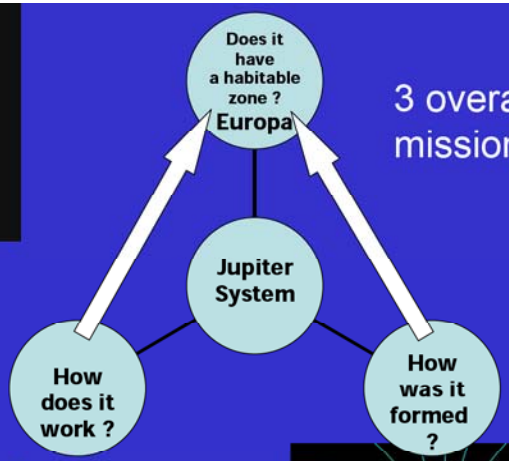
A combination of

- **Orbiter (?) or solar-powered carrier**
- **2 probes into Saturn's atmosphere**
- **Microsats for ring science**



Microwave probe entering Saturn's atmosphere

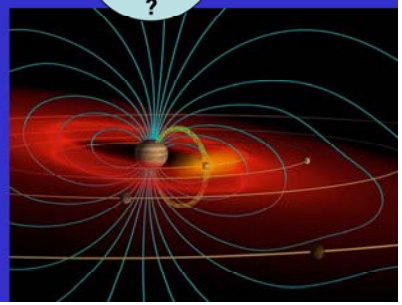




3 overarching mission goals

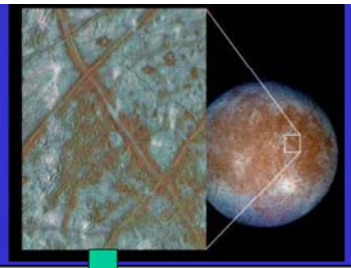
Mission to Europa and the Jupiter System

Michel Blanc et al.
http://jupiter-europa.cesr.fr/

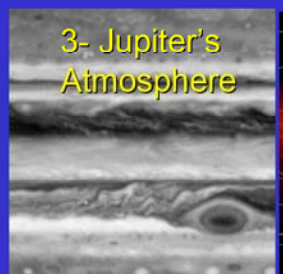


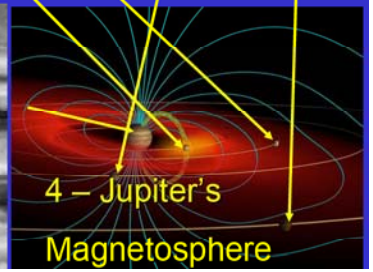
- Four Mission Targets:

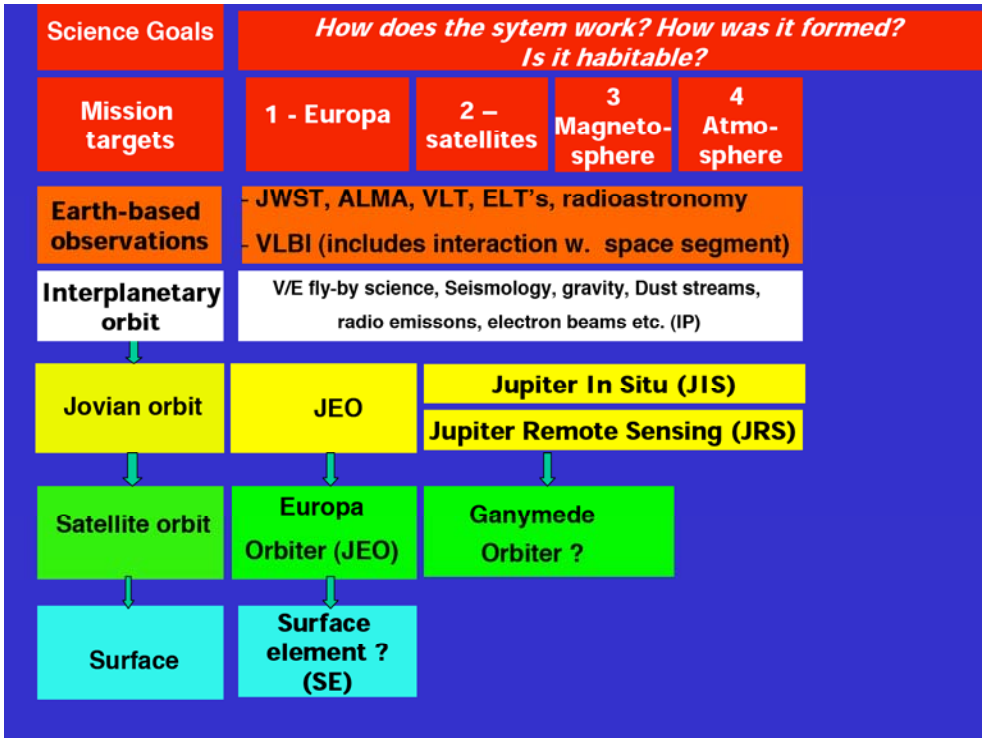
1 - EUROPA



2 – Jovian Satellites

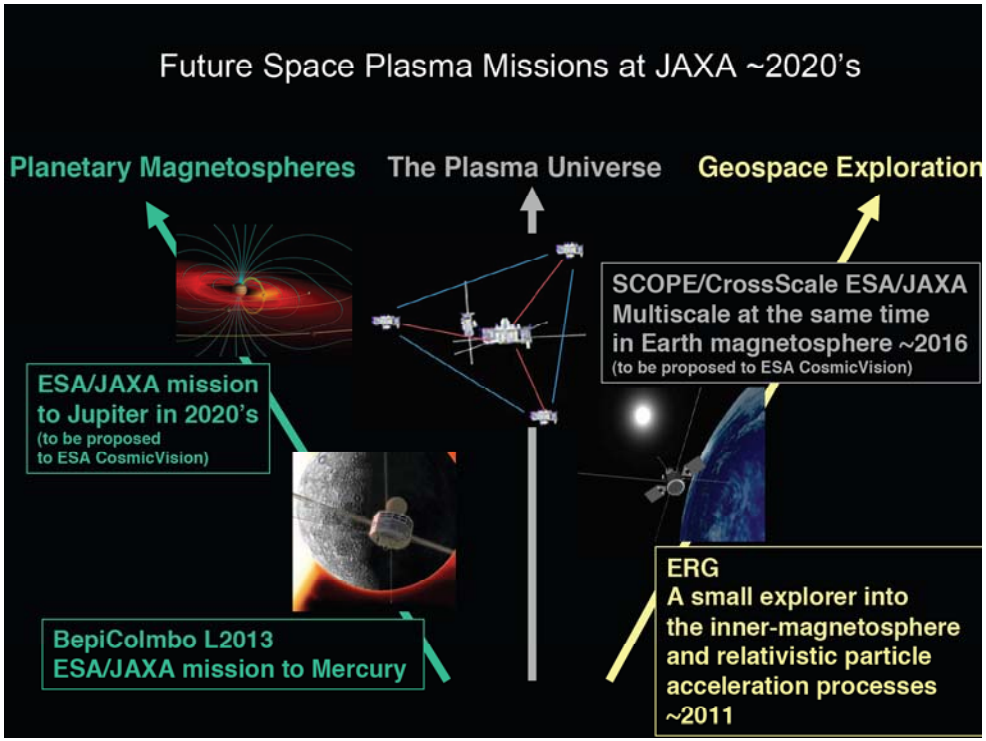


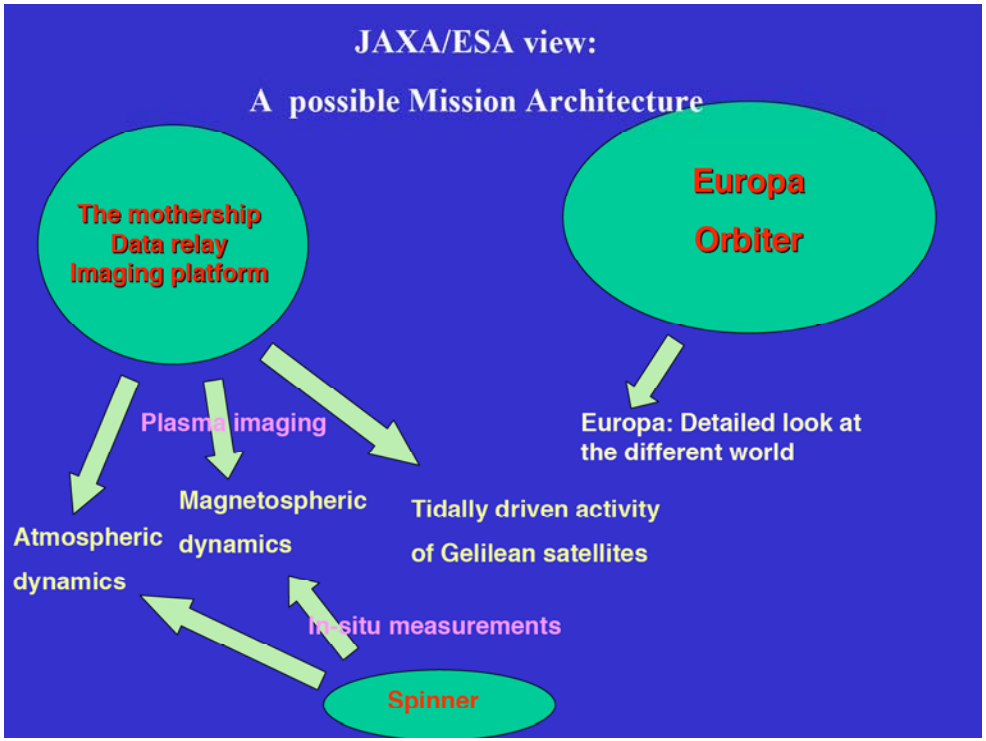




International collaboration

	NASA	ESA	JAXA
Flagship missions:			
	Europa JSO	Jupiter-Europa Proposal	Jupiter-Europa with Magnetospheric Orbiter
	Titan Enceladus	Tandem Proposal	
New Frontiers			
	Saturn Probe	KRONOS proposal	





The strength of International Collaboration

- We need an international Science and Technology Road Map to outer planets to be able to fly at least one mission every decade
- Broad scientific scope, mission complexity, technological challenges and cost REQUIRE international collaboration
- In return, outer planets exploration is a fantastic platform for international collaboration
- Let us use it to follow and broaden the examples of Cassini-Huygens and Bepi-Colombo
- The next flagship-class misssions to the outer planets require innovative approaches to mission design and development:
  - Optimize science return,
  - Use each partner's specific interests and know-how,
  - Minimize total and per partner costs vs. Science return

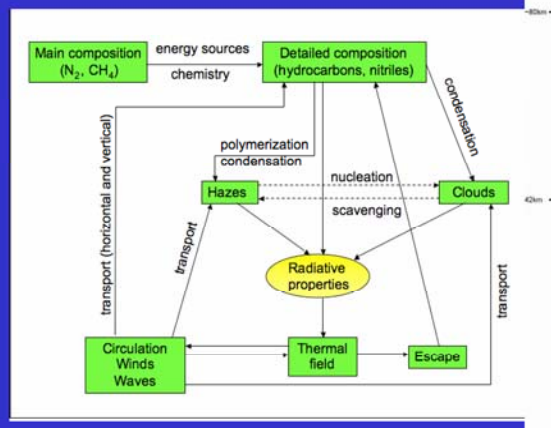
We need to define the best methodology to work together, starting from an open « tree » of mission scenario options

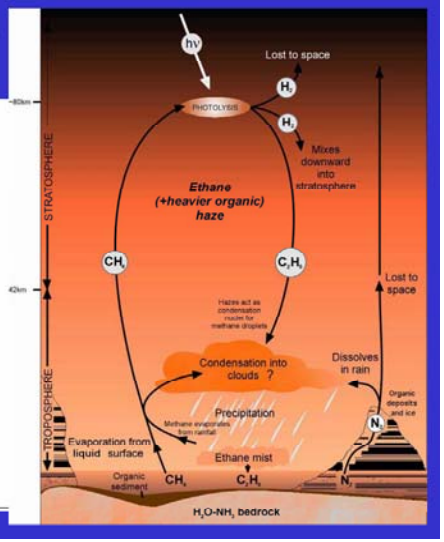
(See example of « Billion $ study » methodology shown yesterday)

Additional slides

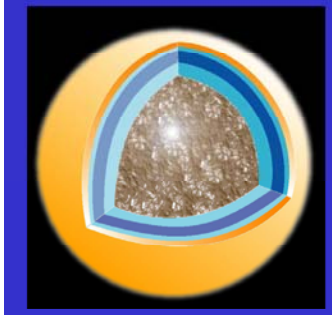
Scientific objectives for Titan's atmosphere

- Dynamics, meteorology and radiative transfer
- Titan's chemistry and the chemistry of the evolution
- Titan's climate and methane cycle





TANDEM Scientific Objectives: Interiors



Why is Titan different from Callisto and Ganymede ?
What lies in the interior of Enceladus and causes the jets?

Structure and composition of the interior ?
Magnetic field, internal ocean ?
Reservoir of volatiles ?
Evolution and outgassing mechanismes ?

Science questions that will remain after an extended and successful Cassini-Huygens mission.

1) What is the small-scale geological structure of the surface and how does it correlate with surface forming processes.

2) What is the composition, distribution and physical state of materials on and beneath Titan's surface and how is it related to geology?

Scientific Objectives

Upper atmosphere/Magnetospheric interaction

*** Highlights: not covered by the very successful Cassini mission or only in a limited way !**

- "Agnostosphere"(~400 km – 950 km)

  Recent observations(negative ions,evidence for aerosols…) point to Titan's atmosphere as a chemical reactor of 1000km depth

- Magnetotail/Wake at high altitudes

  This complex region of Titan's induced magnetosphere warrants careful 3D-studies

- Magnetospheric Variability

  Influence of Saturn's magnetospheric dynamics on Titan's induced magnetosphere out to ~ 10 RT

- Internal magnetic field (permanent or induced)

  EM sounding of electrolytic ocean, core characteristics

Example of science vs payload for interiors

Scientific objectives	Measurements	Instruments
1) Present-day interior structure: rocky core and liquid water/ice shells	Spatial and temporal variations of topography, gravity field and magnetic field on global and local scales.	**On a polar (?) orbiter:** Radio science experiement, Radar or Laser altimeter, Magnetometer, HR Near-Mid-IR Multispectral + Radar Imaging
2) Seismic and cryovolcanic activities	Seismic survey	**On an aerial platform:** Gradiometer, Accelerometer, Radar altimeter, Magnetometer, Ground Penetrating Radar, GCMS, HR Spectroscopy.
3) Internal reservoirs of volatiles and outgassing processes	Subsurface sounding Near-surface thermal gradient and thermophysical properties	
4) Early Titan: internal evolution, crust and atmosphere formation	Composition of surface materials, and of cryovolcanic magma and gases Noble gases abundances and isotopic ratios in major species.	**On a lander**: Geophysical surface package (including seismometer & magnetometer), Ground penetrating radar, Surface sampling analysis package, GCMS

ESLAB symposium inputs April 2005

Definition of a Road Map to the origins of the solar system

TRACING THE ORIGINS OF THE SOLAR SYSTEM

M. Blanc[1], D. Moura[2], Y. Alibert[3], N. André[1], S. K. Atreya[4], I. Baraffe[5], M. Barthelemy[6], A. Barucci[7], R. Beebe[8], W. Benz[3], B. Bézard[7], D. Bockelée-Morvan[7], S. J. Bolton[9,10], R. H. Brown[11], G. Chanteur[12], L. Colangeli[13], A. Coradini[14], A. Doressoundiram[7], M. Dougherty[15], P. Drossart[7], M. Festou[16], E. Flamini[17], M. Fulchignoni[7], M. Galand[15], D. Gautier[7], T. Gombosi[4], E. Gruen[18,19], T. Guillot[20], R. Kallenbach[21], S. Kempf[18], T. Krimigis[22], N. Krupp[23], W. Kurth[24], P. Lamy[25], Y. Langevin[26], J.-P. Lebreton[27], A. Leger[26], P. Louarn[1], J. Lunine[28,14], D. Matson[10], A. Morbidelli[20], T. Owen[29], R. Prangé[7], F. Raulin[30], C. Sotin[31], R. Srama[18], D. F. Strobel[32], N. Thomas[3], H. Waite[4], O. Witasse[27], P. Zarka[7], and J. Zarnecki[33]

Key missions	Comets	TNO's	Jupiter	Saturn	Uranus	Neptune
Low periapsis polar orbiter			X JUNO (NASA)	Cassini		
Entry probe			Galileo (?)	X	X	X
Satellite orbiter	X		X			X
Satellite in situ probe	X		X	x		
Magneto-spheric explorers			X	Cassini		x
Mission Concepts	Post-Rosetta Sample return	Earth Observations first	Europa Orbiter + Magnetosphere Explorer	Post Cassini Titan/ Saturn mission	Uranus Orbiter and probe	Neptune Orbiter and Probe