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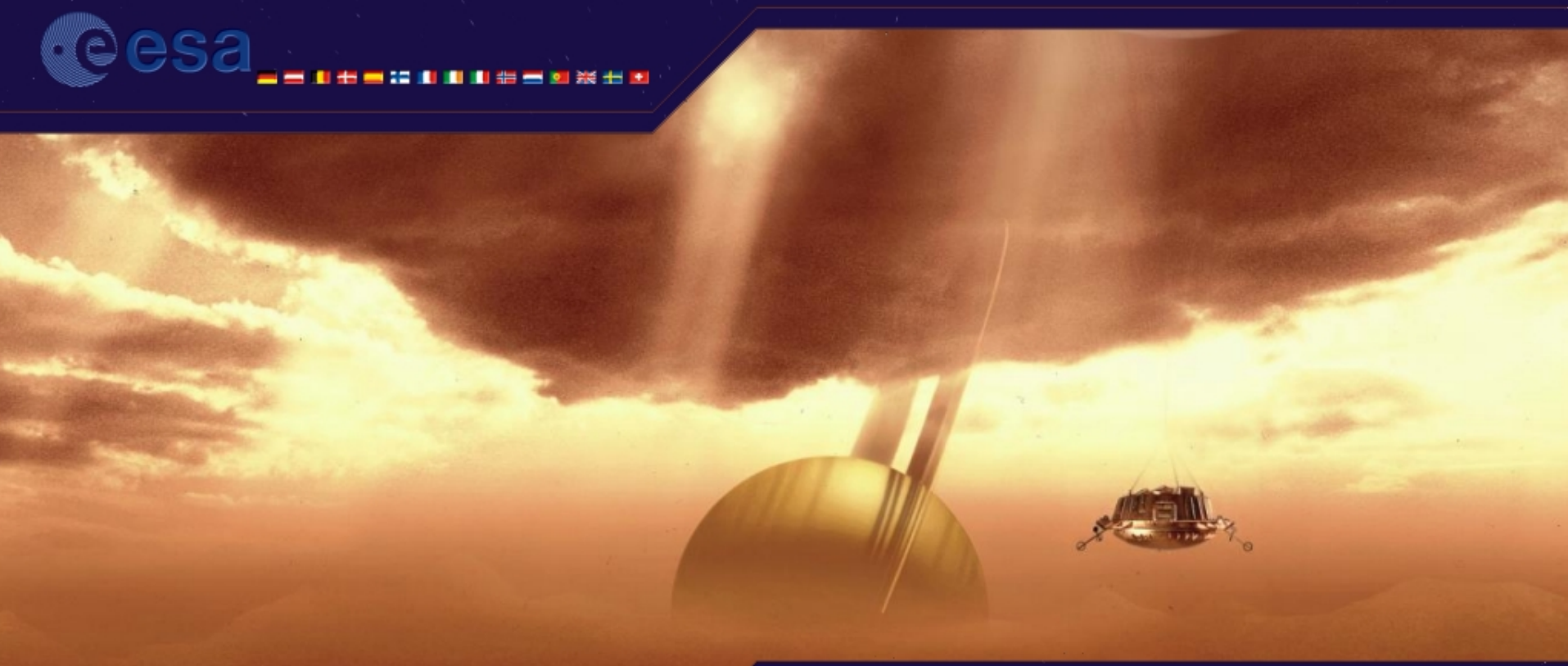

CASSINI-HUYGENS

THE UNIVERSITY OF TEXAS AT DALLAS
SCHOOL OF MANAGEMENT

"The European Space Agency and Space Challenges after the Success of the Cassini-Huygens Mission"

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Dr. Alain Bensoussan

LECTURE OUTLINE

1. The Cassini-Huygens Mission
2. The European Space Agency
3. ESA Strategic Issues
4. Space Strategic Issues

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“In two short hours, one small unmanned probe changed my direct experience of our solar system in ways that I never imagined. “..

Dr. Lawrence M. Krauss

Director of the Center for Education and Research in Cosmology and Astrophysics at Case Western Reserve University

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An Impressive Success

- The Cassini-Huygens Mission is the most ambitious effort in Planetary Space Exploration ever mounted.
- It is the first time that a probe lands on such a remote object of the solar system, a remarkable feat for Europe.
- It is a Model of International cooperation
- A remarkably well managed program of 19 years duration.
- More than 250 Scientific teams worldwide will study the Data Collected

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A Long Journey

- Oct 15, 1997: Launch of Orbiter by Titan-IV Centaur, the most powerful available launcher
- Jul 21, 2004: Orbit positioning of Cassini around Saturn
- Dec 25, 2004: Separation of Huygens probe from Cassini to begin its 21 day journey to Titan
- Jan 15, 2005: Arrival of Huygens on Titan
  - 2 h 30 min descent through Titan's atmosphere
  - Huygens survived and functioned for 2 hrs after landing (Although expectation was only ½ an hour)
- Jul 2008: For 4 more years Cassini will orbit around Saturn, its moons and rings

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What Does It Cost and What For?

- Total Budget: $3.4 Billion ,Europe's Share: $660 Million

- Space Craft:
  - Cassini Orbiter Weight is 4,685 lb
    - ❖ There are 12 Scientific Instruments on Cassini to:
      - Take pictures in visible, near ultraviolet, near infrared light
      - Map the surface of Titan
      - Study atmosphere, rings and gravity of Saturn and its moons
      - Study the neutral and charged particles near Titan
      - Identify and study Chemical composition and temperature of surface
      - Analyze ice and dust grains in the Saturn system
      - Explore plasma orbiting Saturn
      - Study Saturn's magnetic field and its interactions with the rings and moons

  - Huygens Probe Weight is 705 lb
    - ❖ There are 6 Scientific Instruments on Huygens to:
      - Take pictures and measure temperature of particles in Titan's atmosphere and on its Surface
      - Explore the structure, the physical properties and chemical composition of Titan's atmosphere
      - Examine the clouds and suspended particles in Titan's atmosphere
      - Study the winds and investigate physical properties of Titan's surface

A Complex Technological Object

- Electric Power Provided by RTG (Radioisotope Thermoelectric Generators)

- A perfect 3.5 Billion Km flight. Complex path aided by “Gravity-Assisted” Swing-bys around Venus, Earth and Jupiter

- Carries several technical innovations that hold great promise for use on Earth:
  - o New Solid State Recorder
  - o New family of High-Speed Integrated Electronic Chips
  - o Innovative Solid-State Power Switches which significantly improve component life time

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Scientific Interest of the Planet Saturn

- The sixth planet from the Sun and the second largest in our Solar system behind Jupiter.
- Saturn is made mostly of Hydrogen and Helium with a solid core.
- Being a gaseous planet, Saturn has no surface on which to Land.
- Saturn is 9 ½ times farther from the Sun than Earth, 750 Million miles from Earth.
- In Volume Saturn is 750* Earths but in Mass only 95 times. It is the only planet with a density less than that of water
- High speed winds (near the equator approx. 1,100 miles per hour).

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Scientific Interest of the Planet Saturn

Saturn's Rings

- The best telescopes on Earth show three nested main rings about Saturn, but in fact the ring system is a collection of thousands of ringlets .
- The rings are not solid, but made up of countless unconnected particles of ice, dust and rock
- Other planets have rings too. Saturn's rings are the only ones that are visible from Earth.

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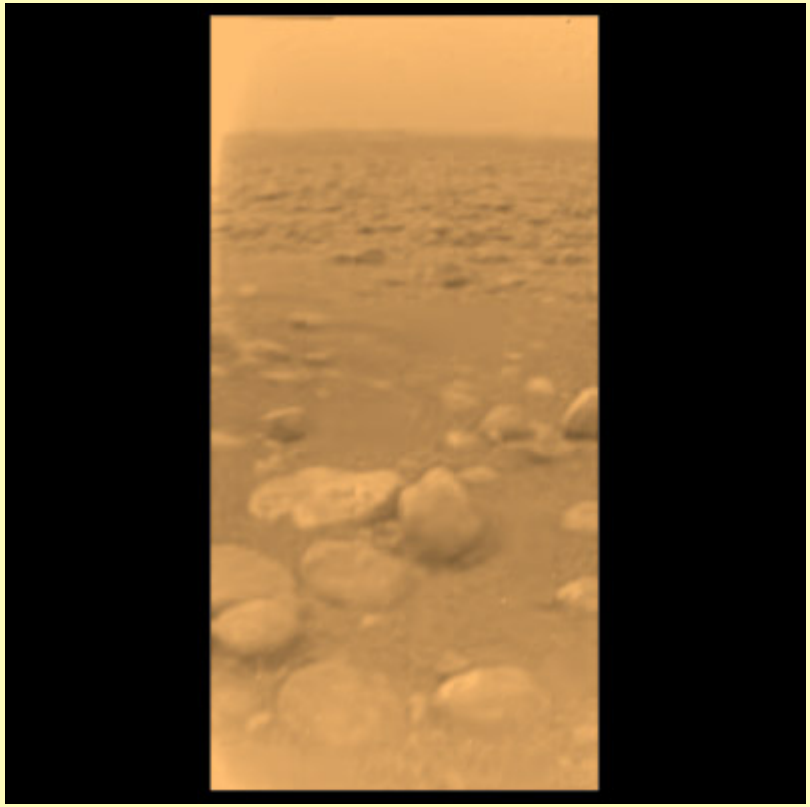
Scientific Interest Of Titan



Pebbles on Titan

- Titan has an atmosphere 50 percent denser than Earth's.
- Titan has two major components of Earth's atmosphere-nitrogen and oxygen, but oxygen is frozen as water ice within the body.
- If Titan received more sunlight, its atmosphere might more resemble that of primitive Earth.
- Titan's atmosphere contains also methane and many other organic compounds, giving the orange hue

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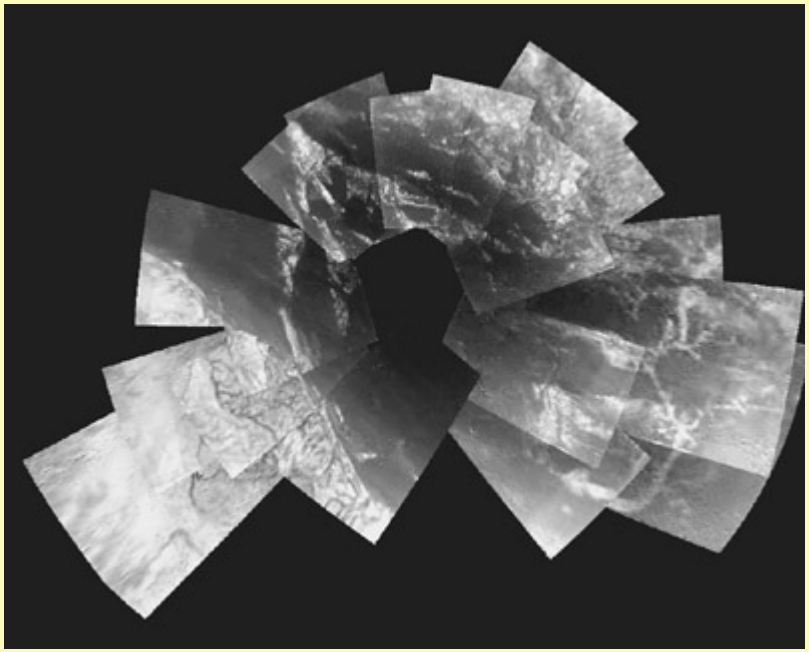
Scientific Interest Of Titan



Titan View From Ten Kilometers High

350 pictures of Titan collected during the descent of the Huygens probe revealed:

- A landscape apparently modeled by erosion
- Drain channels which could be lakes of hydrocarbons, presumably Methane or Ethane.
- Analysis of the atmosphere at altitudes of 160 kilometers from the ground revealed:
  - Uniform mix of methane with nitrogen in the stratosphere
  - Methane concentration increase in the troposphere
  - Clouds of methane at 20 kilometers altitude and methane (or ethane) fog near the surface

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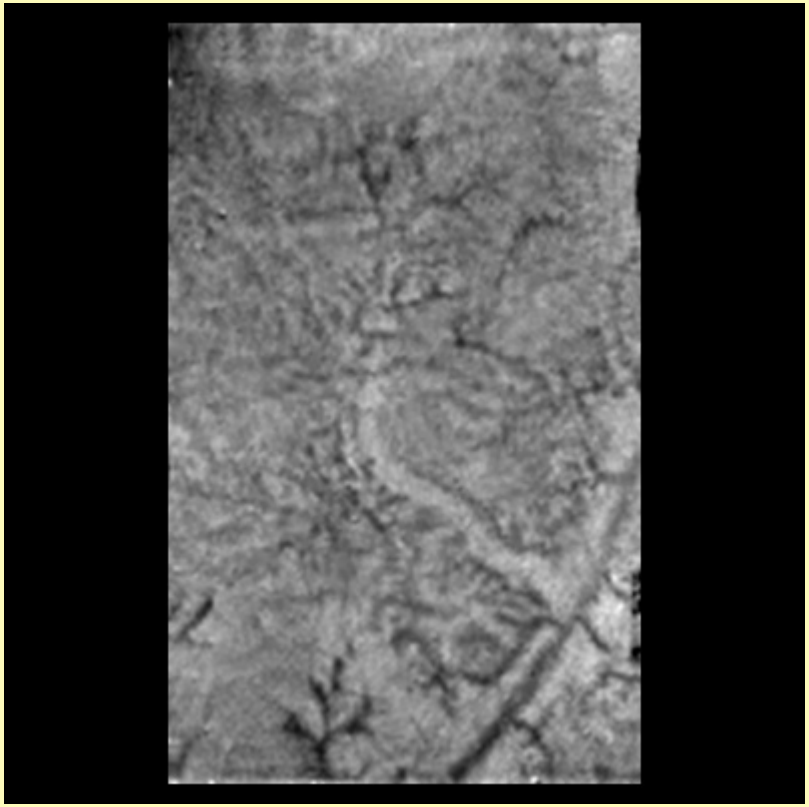
Scientific Interest Of Titan



- The area where the probe landed looks like wet sand or soft clay composed by a mix of dirty water ice and hydrocarbon ice.
- The temperature measured at ground level was -176 Celsius= - 285 Fahrenheit

Two new Titan features - water ice and methane springs:

A bright linear feature suggests an area where water ice may have been extruded onto the surface. Also visible are short, stubby dark channels that may have been formed by 'springs' of liquid methane rather than methane 'rain'.

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What's Next for the Mission

The main objective is to understand better the chemical reactions in Titan's atmosphere, in particular the source of methane and the complex organic compounds.

On Earth sunlight destroys methane and organic compounds are created. Biological sources continuously supply destroyed Methane. What is the analogue on Titan, since the conditions are two cold for life?

How does the surface looks like, are there Oceans?

By learning about Titan, we'll learn about our planet, and the chemistry which took place on the early Earth- and possibly how we came to be...

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What's Next for the Mission

- Cassini is designed to shed light on many mysteries :
  - Saturn produces 87 per cent more energy than the planet absorbs from sunlight? The Energy balance is a mystery. There must be a source of heat inside Saturn to produce the excess energy.
  - What is the origin of Saturn's rings? There may represent partial models for the disk of gas and dust from which all the planets formed about the early sun.
  - Where do the subtle colors in the rings come from? Are there electrically charged particles ? What explains the spacing and width of the ringlets?
  - There are 31 moons confirmed in orbit at Saturn, including 13 discovered since the launch. Are there any more moons?
  - Why has the moon Enceladus such an abnormally smooth surface?
  - What is the origin of the dark organic material covering one side of the moon Iapetus? On the other side, it is one of the brightest objects of the solar system. The dividing line between the two sides is inexplicably sharp.

EUROPE IN SPACE

ESA’s mission and its programmes

ESA – facts and figures:

30 years of experience

15 Member States (plus Greece and Luxembourg as of 2005)

5 establishments

2000 staff

2.7 billion euro per year

60 satellites developed

15 scientific satellites in operation

5 launchers developed

160 launches performed

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ESA's Main Activity Fields

Enabling activities:

Access to space

Competitive Technologies

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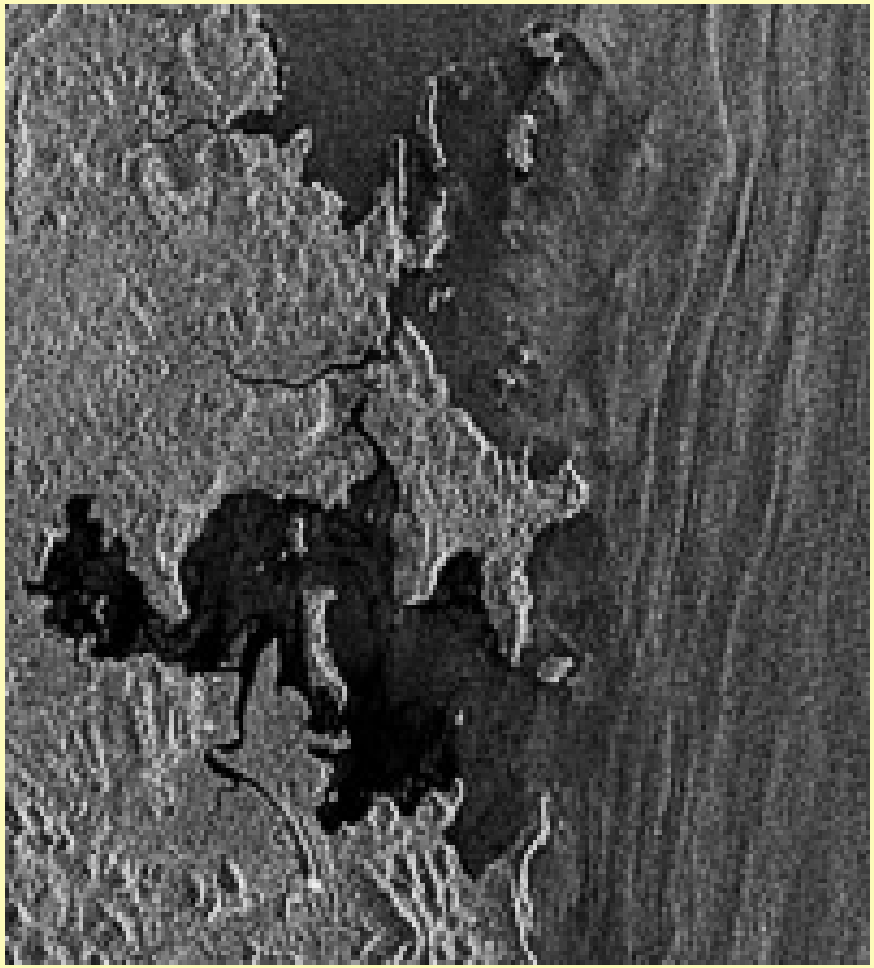

ESA's main activity fields

Utilitarian activities:

Earth Observation

Meteorology

Telecommunications

Navigation

ENVISAT Image

28 December 2004 (2 days afterTsumani hit Asia)

Indian Andaman Islands and the Ritches Archipelago

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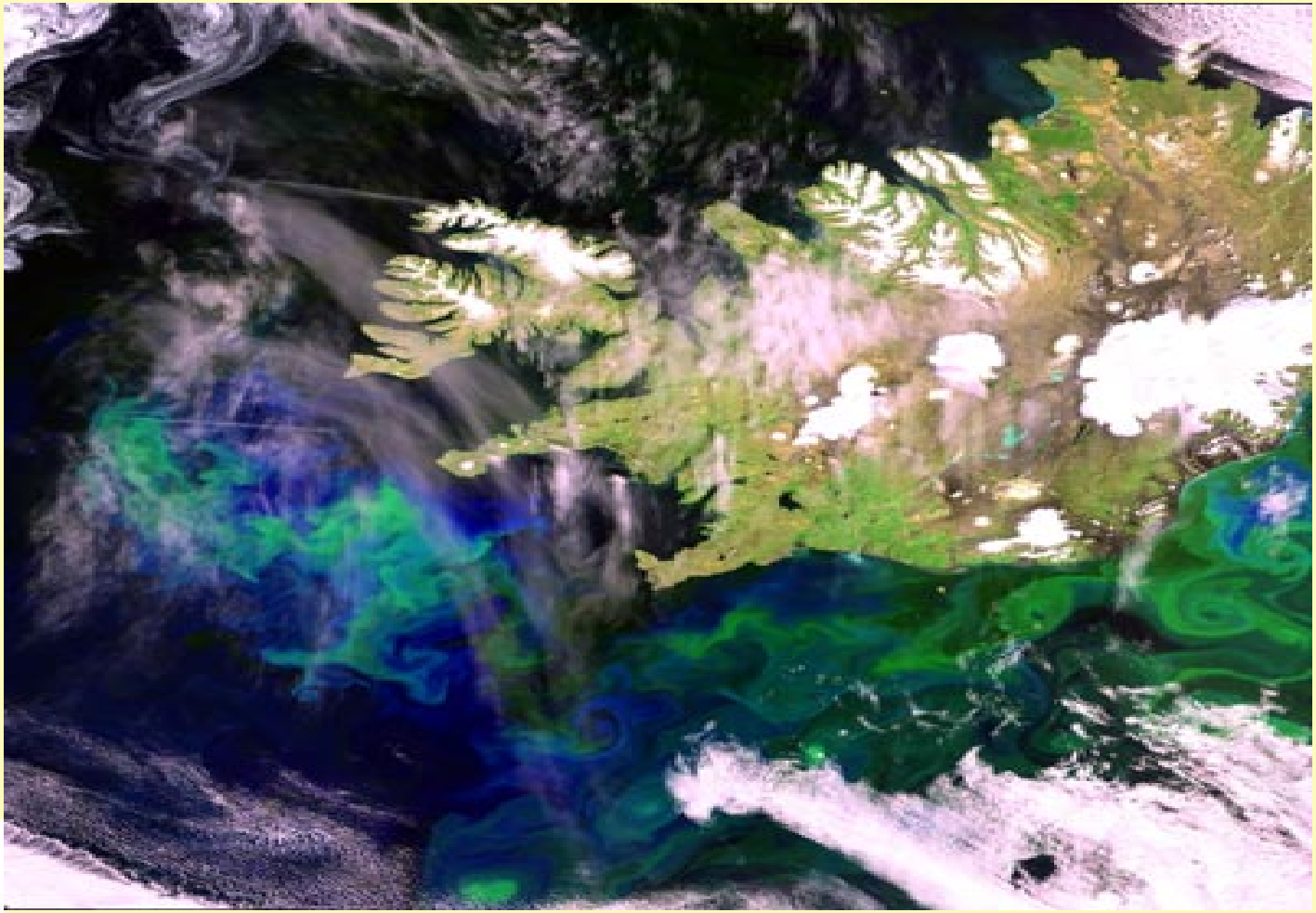
Iceland and Denmark Strait taken by ENVISAT June 2004



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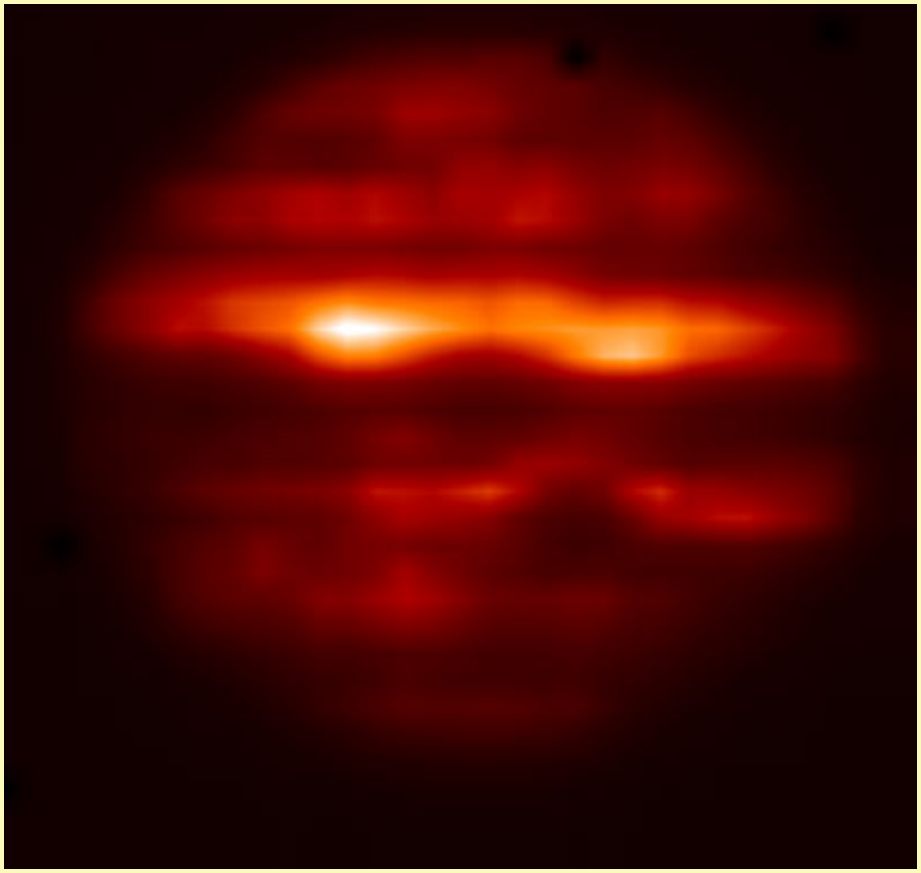

Jupiter as seen by ISO

ESA's main activity fields

Inspirational activities:

Space Science

Earth Science

Microgravity Science

Human Exploration

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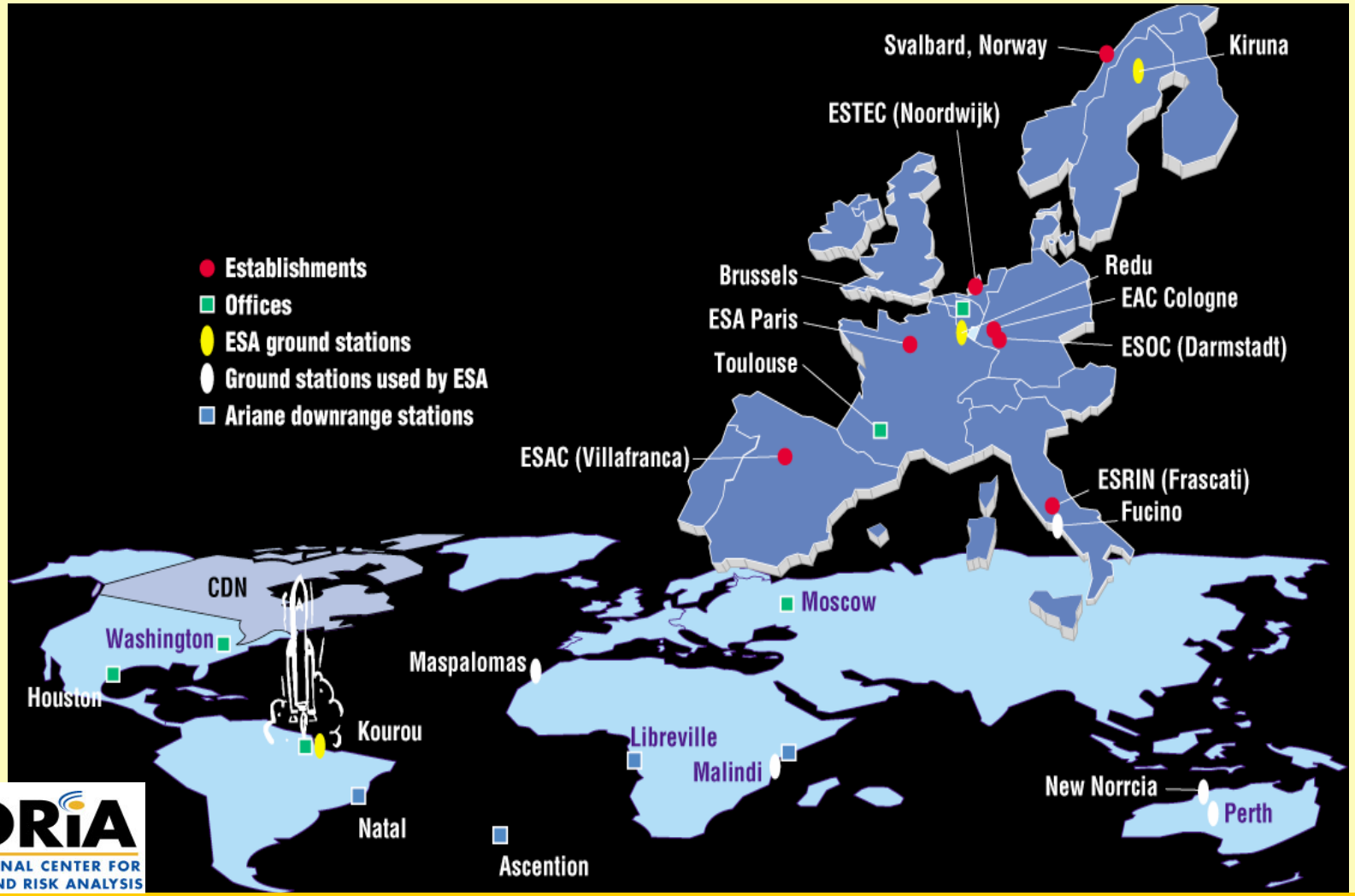
ESA Locations:



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Europe Ambition in Space Exploration

- Mars Exploration: (following Mars Express June 2003) with Landers similar to Spirit and Opportunity

- Europe, Satellite of Jupiter, with a Lander comparable to Huygens
- Mercury : in 2012 mission BepiColombo

- Rosetta : With Lander Philae
  - Launched in March 2004 and expected arrival on the comet Cheryumov-Gerasimenko in 2014.

- Venus Express: similar to Mars Express.
  - Launch will be Nov. 2005 and expected arrival April 2006

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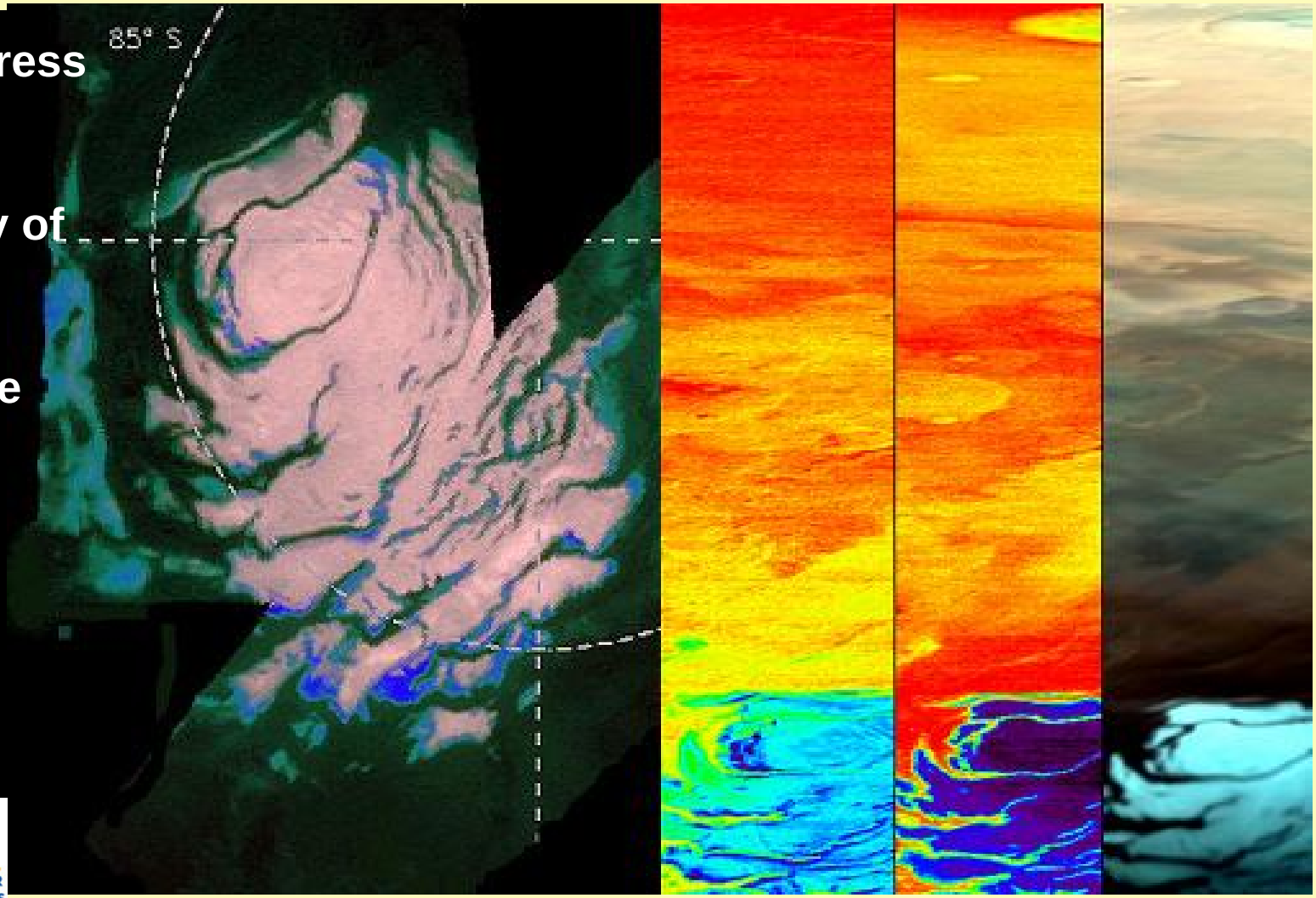
Mars Express

Discovery of water ice at the south pole



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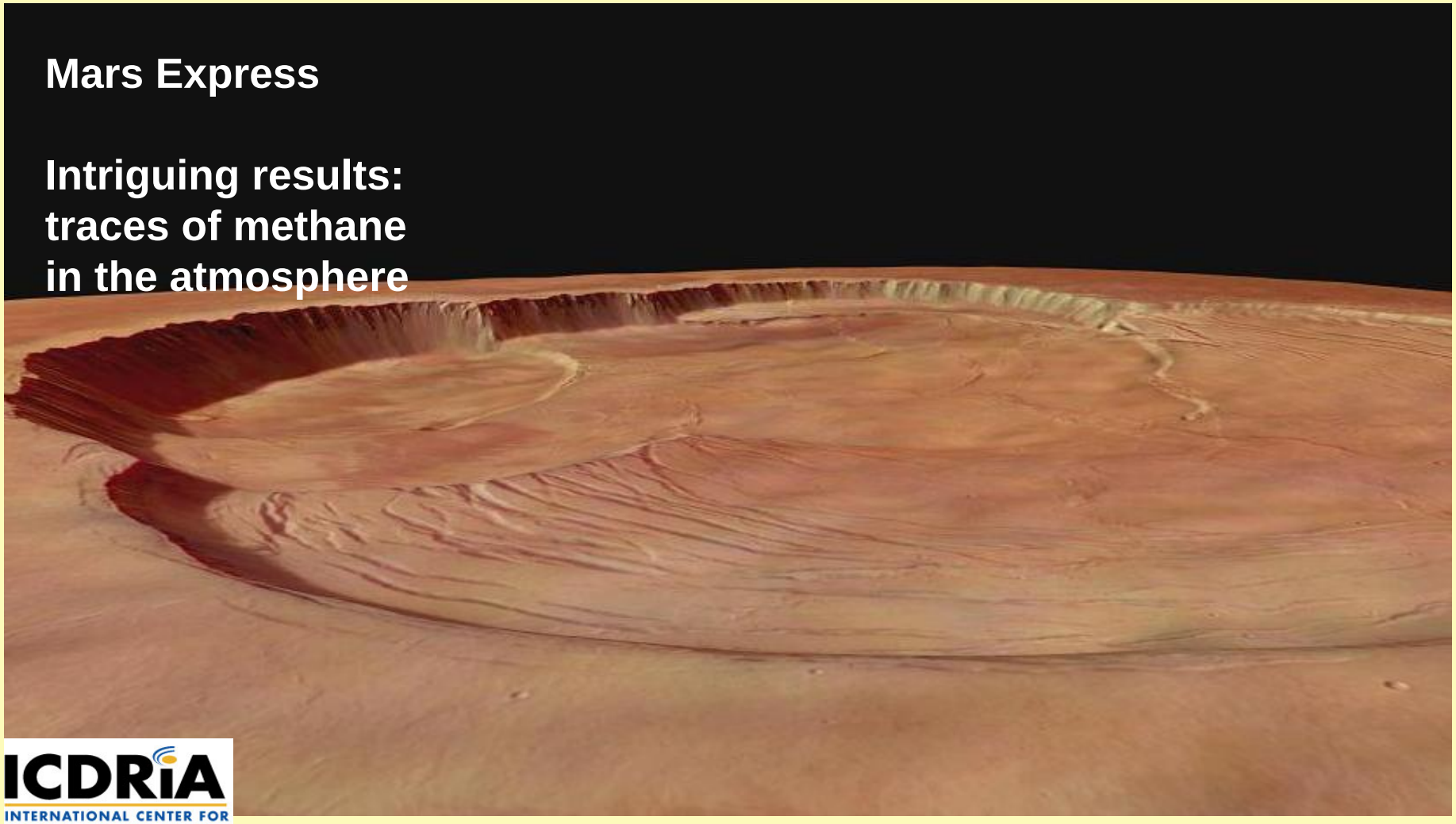
Mars Express

Intriguing results: traces of methane in the atmosphere



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Strategic Issues For ESA

- **The initial concept was implementing "Complementarities ideas"**
  - ESA was created in 1973 as an intergovernmental agency realizing programs out of reach of a single nation.
  - The launcher Ariane was an essential motivation
  - CNES (the French Space Agency) convinced other European nations to join forces.
  - The Science Program illustrates complementarities. For a mission, the Platform is common and each Nation is responsible for its own instruments.
  - ESA's concept is a very flexible one: A limited mandatory program based on Science and many optional programs managed by Participating Member States (Ariane is an optional program)
- **Some Evolution: "New Partners", "Customers"**
  - Application of space technologies to Meteorology motivated some evolution.
  - The European organization EUMETSAT appears as a **customer** , operating satellites designed with the help of ESA. EUTELSAT is a spin off of ESA.
  - New sources of funding arise this way.

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Strategic Issues For ESA

- **The Major Change: "The European Union"**
  - In an intergovernmental agreement, European Nations **do not** transfer their sovereignty.
  - For the fields of competence of the European Union, The European Nations transfer their sovereignty to the European Union.
    - More and more domains of sovereignty are transferred to the EU
    - Most economic affairs are already transferred
    - A major debate concerns the stepwise transfer of political affairs like Foreign Affairs, Security and eventually Defense
  - This is in particular the objective of the **European Constitution** , to be adopted in the coming months. Europe will appear as a political power, and not just an economic power.
  - Space, like Defense, is not a domain of competence of the European Union. The European Constitution changes partly this situation.
  - Space is mentioned as a domain of shared competence.

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Strategic Issues For ESA

- **Why is this matter Essential?**
  - The role of ESA will be completely different if the European Union takes full competence for space matters
  - It's budget will come from the European Union and the decisions will be taken by the European Union and no more by the ESA council.
    - Under the shared competence concept, part of the budget will go on as now and part will come from the European Union.
  - If space is a political and strategic issue for Europe, as it is for the US, Russia, China, and India, then funding based on political (not economic) reasons has to be provided. It must come from the European Union.
  - This is the only way to increase the European Budget for space.

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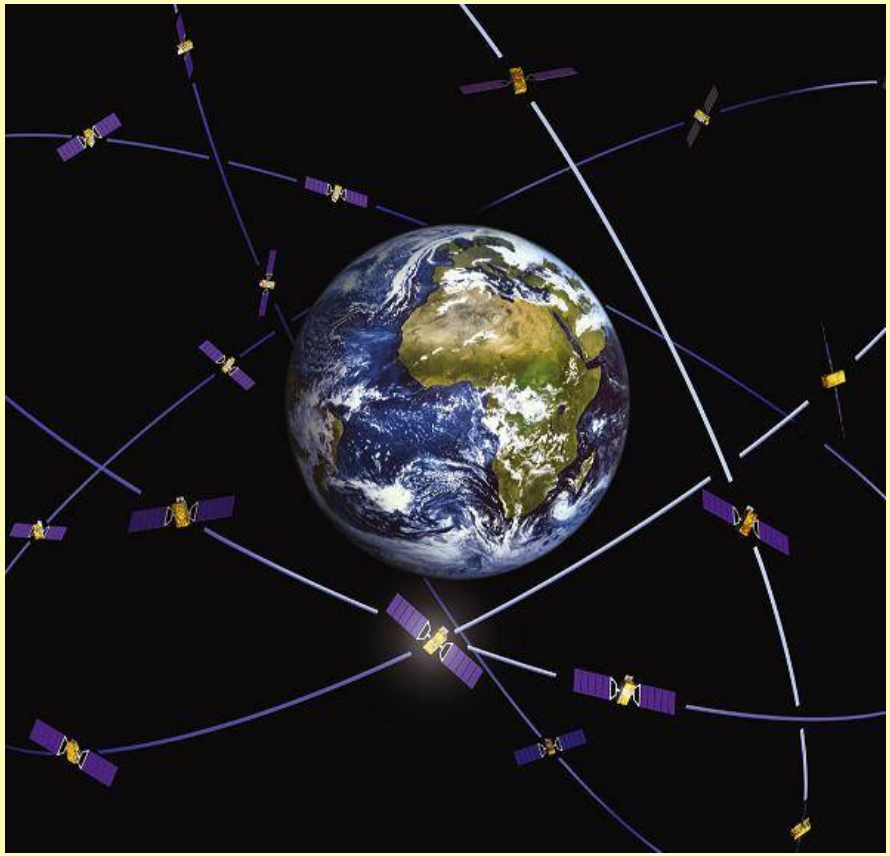
Strategic Issues For ESA



Two Major Examples

- Autonomous Access to Space: it is a matter of Independence
  - No Launcher can survive today without public subsidies.
  - Political reasons prevail everywhere, otherwise everybody will rely on Russian launchers, and later on Chinese and Indian launchers.

- Galileo: The European Positioning System
  - Today everybody relies on the GPS system under the control of the DOD
  - Russia has its own system, GLONASS, inherited from the Soviet Union and has decided to renovate it to keep its autonomy
  - The European Union has claimed that an autonomous European system, Galileo, fully compatible with GPS and in partnership with the US should exist.
  - Even before the transfer of competence, the European Union has put aside a budget for Galileo
  - A complex organization ESA-EU is managing the program

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Strategic Issues For ESA

The Case of Space Exploration

- Jan 14th, 2004 : President Bush announced a space exploration program based on the nation's scientific, security and economic interests.
- Is it strategic? Is it a political issue to go to the Moon? To go to Mars and beyond?
  - In the US obviously the answer is **YES**
  - China has decided a manned Space Program based on political reasons.
  - Europe so far has been a timid player. Unlike the US, Russia and now China, Europe has no autonomous transport capability for astronauts.

- Europe participates at a level of 8% to the ISS
- Science cannot suffice to justify space exploration by humans
- Europe is confronted here by a serious political decision.

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Strategic Issues For ESA

Security and Defense Matters

- ESA is a strictly civilian Agency. Defense is not a domain of competence of the European Union.
- However Security has clearly become a strategic and political issue. The EU has acquired competence in this area, on the European territory, and the Constitution will increase its competences. In the mean time a European Defense Agency has been created
- In view of the importance of Space for Defense and of the importance of Defense for Space, ESA cannot be out of this evolution.
- Therefore, a major issue is the possibility for ESA to manage space programs for the European Defense Agency or carry programs related to security on behalf of the European Union
  - GMES: Global Monitoring for Environment and Security
    - This program has been launched jointly by the European Union and ESA.
    - The word security is interpreted in the sense of Protection Against National Disasters
    - But there is no big difference between the space technology used for civilian or military security

The evolution of this program in Europe and in relation with similar programs in the US, Japan, or else where is an extremely important issue.

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GMES

Independent capability for global monitoring

Vital information on the global environment

Supporting Europe's needs for security including defence aspects

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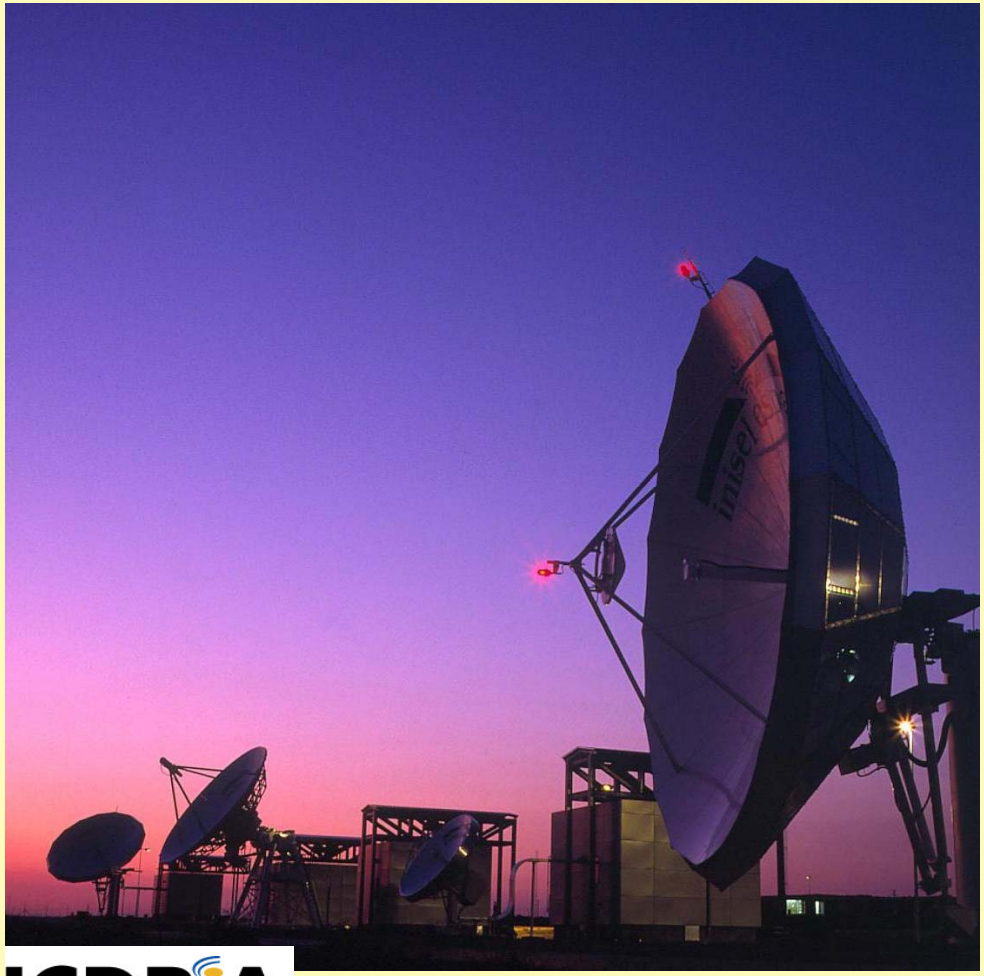

Bridging the Digital Divide

High-speed access to the Internet – Europe-wide

Supporting Europe as "knowledge-based society"

Increasingly important through the EU enlargement

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Strategic Issues For ESA

An Organizational Challenge For ESA

- Under the subsidiarity principle, Nations have preserved national space programs and maintained public technical competences.
- As a result, the staff of ESA is limited to 2000 people which is clearly insufficient for an ambitious European Space Program.
- It is thus is important for ESA to make use of the national competences, at a time when the national programs decline in favor of the European programs.
- The concept of Union of technical centers has been launched. Some progress has been made to give flesh to it. It remains to transform it into an completely operational tool.

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Strategic Issues For Space

Why invest in Space?

1. First Objective: Science

- A success like Cassini-Huygens is a remarkable boost for space
- The exploration of the Universe is very limited from Earth
- Only space missions will permit great progress in our understanding of the Universe.
- Ultimately it will lead to a better understanding of our origins and our future.

Budget Realities:

- Space science will be compared to other fields like Health, Energy, Information Technology, Transport, etc…
- Although supported by public opinion, it cant be considered a top priority
- Space Science budget is 1/6 of NASA's or ESA's budget

- However Space Science carries a very convincing symbolic image which helps getting government subsidies .
- It is also a domain of fruitful international cooperation.

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Strategic Issues For Space

2. Second Objective: Human Exploration:

- It has always been the dream of Man to explore new territories
- Space represents the new dimension
- The impact of landing on the moon has been tremendous but since then hard realities prevailed. Mars was expected as the next step but it didn't materialize
- Space is an extremely hostile environment for Man
- Reproducing safe conditions for life outside Earth is a formidable and extremely expensive challenge
- What has been done since Apollo remains limited, though costly:
  - Efforts amount to the International Space Station (400km to Earth), after the Russian MIR
  - Record of duration for man in space of roughly one year
  - Total budget of ISS is close to $100 Billion

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Strategic Issues For Space

2. Second Objective: Human Exploration:

- President Bush has fixed the objective of human return to the Moon by the year 2020, in preparation for the human exploration of Mars.
- Mars is certainly the single most realistic target within the next 40 years
  - Yet this objective (already mentioned 30 years ago) requires major changes in the propulsion system and depends on major unknowns related to human capabilities
- Undoubtedly, Human exploration is the manifestation of the ***dream of adventure*** which has always been a driving force for Mankind.
- Yet, a strong debate remains on the value of such effort. The challenge maybe too big and the cost simply too high.
- Technological challenges and Breakthroughs can be achieved with automated Exploration, not necessarily related to Manned flights.
- Human exploration represents more than %40 of NASA budget

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- Europe has experienced some disappointments with the ISS.
  - **A new momentum has to be found**

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Strategic Issues For Space

3. Third Objective: Strategic Aspects, Defense

- Defense today represents the major booster for space development
- The US under the concept of "**Space dominance**" have expressed will to achieve full supremacy on space for Defense purposes.
- Satellites provide the possibility of military operations anywhere in the world with full real time control from US soil
- Consequently, US puts considerable effort on space for Defense with a DOD budget for space higher than that of NASA
- Although growing, the European effort is very limited in comparison with a ratio of 1 to 16

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Strategic Issues For Space

Strategic Aspects Beyond Defense:

- There are programs which contribute to the independence and are thus strategic while not necessarily military oriented; examples include:
  - Atlas V , Delta IV , GPS
- They are covered by DOD budget
- The Corresponding European programs ,covered by civilian budget (ESA-EU), are:
  - Ariane , Vega and Galileo
- This reduces the gap US-Europe to 1 to 6

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Strategic Issues For Space

4. Fourth Objective: Protection against Natural Disasters and Environmental Issues

- The recent Earth quakes and Tsunami disasters in Asia have emphasized the need for efficient alert systems.
  Example: SPOT View & Quick Bird view of Banda Aceh

- This requires both **Forecasting capabilities** and **Fast Communication systems**

- Satellites can provide both and should play an essential role for all these problems

- Satellites have the unique property of accessing any point on Earth whatever be the conditions.

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Strategic Issues For Space

4. Fourth Objective: Protection against Natural Disasters and Environmental Issues

- Combining weather prediction, imagery, positioning and communication facilities of satellites one can design an efficient early warning system which could be valid worldwide and combined with in situ facilities

- This domain is progressing fast and Europe wants to play a leading role within a well organized international effort

  - Europe has realized ENVISAT, launched in 2002, which is the biggest space craft dedicated to Environment
  - ESA and EU have started the program GMES, Global Monitoring for Environment and Security.

- This domain is leading to a strong international cooperation for the benefit of Mankind.

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Strategic Issues For Space

5. Fifth Objective: Commercial Market Applications

- This sector has raised hope which ended in disappointments
- The failures of IRIDIUM (MOTOROLA) and GLOBALSTAR (LORAL) in Mobile telephony have stressed that space technologies cannot replace ground technologies in Telecommunications at large
- However, telecommunication satellites are very useful to complete ground technologies to reach any point on the globe
- As TV Satellites have shown, space technologies are also extremely successful for broadcasting massive data.

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Strategic Issues For Space

5. Fifth Objective: Commercial Market Applications

- Satellites can play a strong role for Broadband Internet
- GPS has shown the large potential of commercial applications arising from the positioning function obtained by satellites
- GPS III and Galileo (The European System) can together boost a large market of new services.
- Commercial market difficulties are apparent when looking at the number of launches in 2004:
  - The total number is 54 with 4 failures, and only 12 commercial flights
  - Launch Transport is too costly for Commercial Development

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Strategic Issues For Space

5. Fifth Objective: Commercial Market Applications

- In this gloomy landscape, the European company Arianespace is the leader with half of the commercial market
- The other half is split between Boeing marketing the Russian rocket **ZENIT** and Lockheed Martin (ILS) marketing the Russian rocket **PROTON**
- Number of Launches in the past 15 years
- Sub-orbital space tourism had a boost when the first flights of Space ship-one vehicle occurred with the test pilot Mike Melvill reaching an altitude of100 km in a privately funded vehicle.
- The vehicle has attracted interest from Virgin Atlantic CEO Sir Richard Bronson who set up an off shoot “Space Line” Virgin Galactic with plans to offer space tourism flights

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Year	No. Orbital Launches	No. Launchers Related Failures*	Launcher Related Failure Rate (%)
1990	121	9	7.4
1991	92	6	6.5
1992	97	3	3.1
1993	64	7	8.3
1994	93	5	5.4
1995	80	8	10.0
1996	77	8	10.4
1997	89	8	9.0
1998	82	8	9.8
1999	78	9	11.5
2000	85	6	8.7
2001	59	3	5.1
2002	65	4	6.2
2003	63	3	4.8
2004	54	4	7.4

•If one or more payloads is lost or does not achieve planned orbit due to a launcher related failure.

Food For Thought

•Internet Entrepreneur **Musk**, one of the richest people in America, is pouring significant portion of his personal fortune into building rockets that are both reliable and inexpensive

•The bargain- basement pricing is a direct attack on the high cost of space launch

•Musk aims to capture a share of commercial industry that generates an estimated $4 Billion in annual revenue

•Whether he rocks aerospace giants like Lockheed Martin and Boeing remains to be seen.

•The success rate of past space launch start-ups is dismal

Elon Musk's Falcon rocket will cost customers about $6 million. Its closest competitor, Orbital Sciences' Pegasus rocket, costs about $25 million.

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Conclusion

- A dominating actor: USA ($32 Billion government budget)
- Europe is the second actor($6 Billion government budget) with strong points in Launchers, in Science, in Earth Observation and in Navigation. Russia is a particular case in view of the past efforts of the Soviet Union
- New space powers with impressive expansion
  - China, India
  - Japan remains strong while facing difficulties
- A sector of huge potential for international cooperation: Science, Exploration of the Universe, Environment and Positioning

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Conclusion

Today and for the near future, the space sector is characterized as follows:

- The Dream and the excitement of the public remain quite strong: Science, Human and Robotic Exploration of the Universe
- Space Infrastructure correspond to important applications of public nature: Meteorology, Environment, Protection against National Disasters, Security and Defense
- The Commercial Market applications exist but cannot represent the main driving forces: TV, Broadband Internet, Positioning and niche activities

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SPOT views of Banda Aceh (Before and After Tsunami)

Quick Bird views of Banda Aceh

BEFORE

AFTER

THE END

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