Royal Aeronautical Society
TOULOUSE BRANCH

15th April 2014

Sixth A|D|S Lecture
Aerospace|Defence|Security

“Mars Express,
The First European Interplanetary Mission –
An industrial challenge”

Vincent POINSIGNON,

Head of European Science Projects, Airbus Defence & Space

Please sign the Attendance Sheet
& include your email address if changed from our records

Royal Aeronautical Society
From 1866

- **The Society's Prime Aim remains to Share Knowledge**

  In the Toulouse Branch –
  Especially between Airbus employees and Students

- **Tonight's audience of 99 contains -**
  - **20 Airbus employees up to Senior Manager level**
  - **42 Students from French aerospace universities**
  - **37 others – with many years' experience in the industry**

- **We hope you can all take the opportunity to network together before and after lectures – to share your passion for aeronautics and help to learn how the industry works.**

  DON'T BE SHY

Vincent POINSIGNON

Born : 5th December 1958

1982 Ecole Nationale Supérieure de l'Aéronautique et de l'Espace

1983 Joined Airbus Defence & Space (Astrium)

1999   Head of Mars Express project

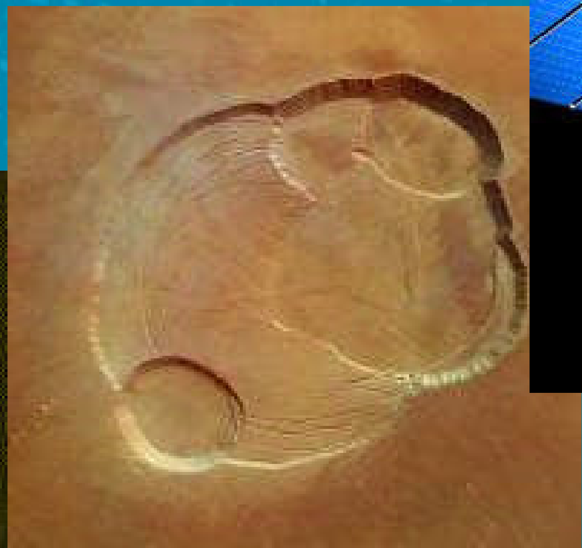
2006   Head of the Gaia Scientific project

2011   Responsable for European Scientific Projects

Vincent POINSIGNON

“Mars Express,
The First European Interplanetary Mission –
An industrial challenge”

Mars Express
The First European Interplanetary Mission



Toulouse, April, 15th 2014

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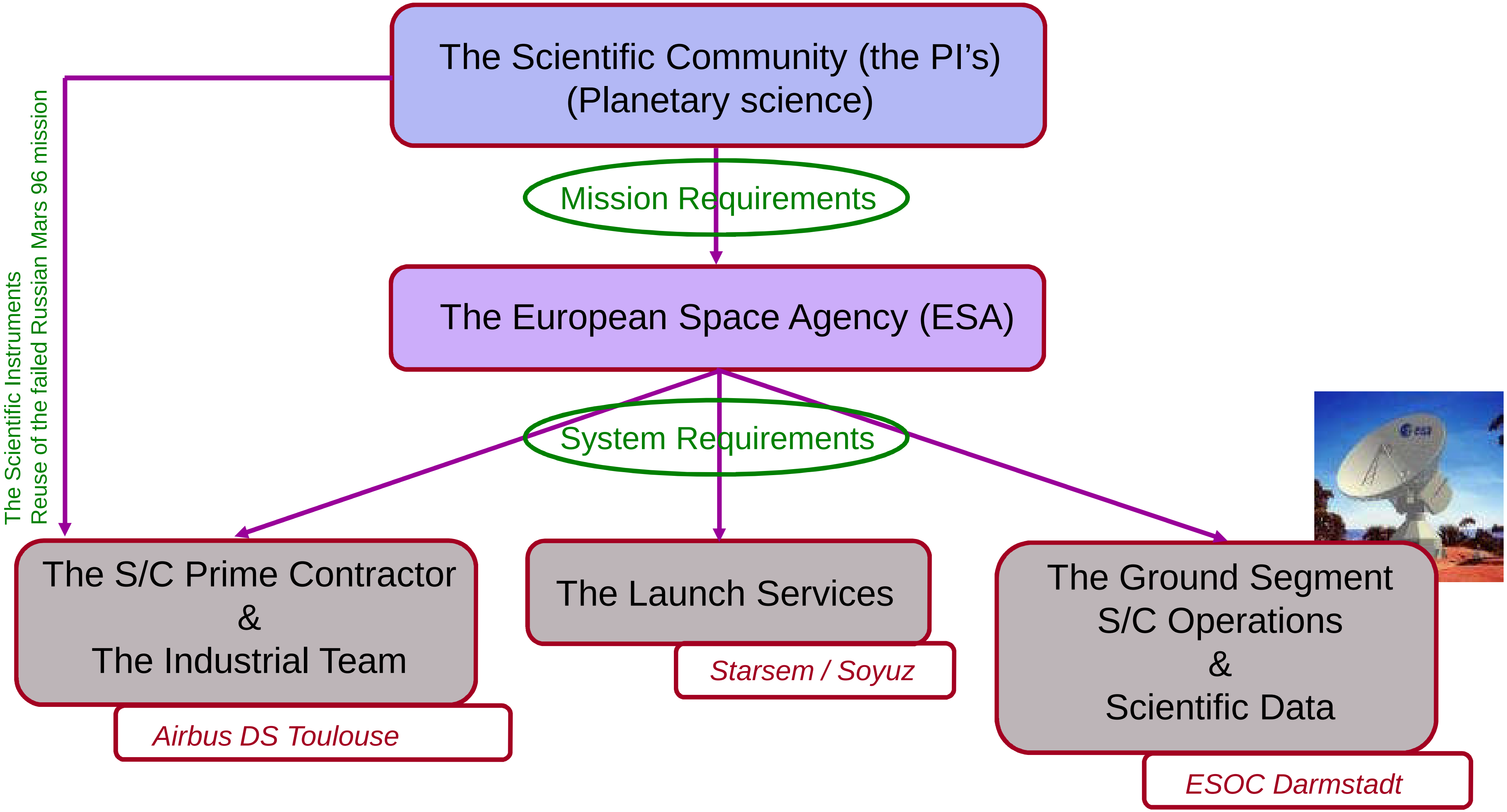
1. Mars Express : Mission & Design

The Programme implementation



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Mars Express and Beagle 2 : a Dual Mission

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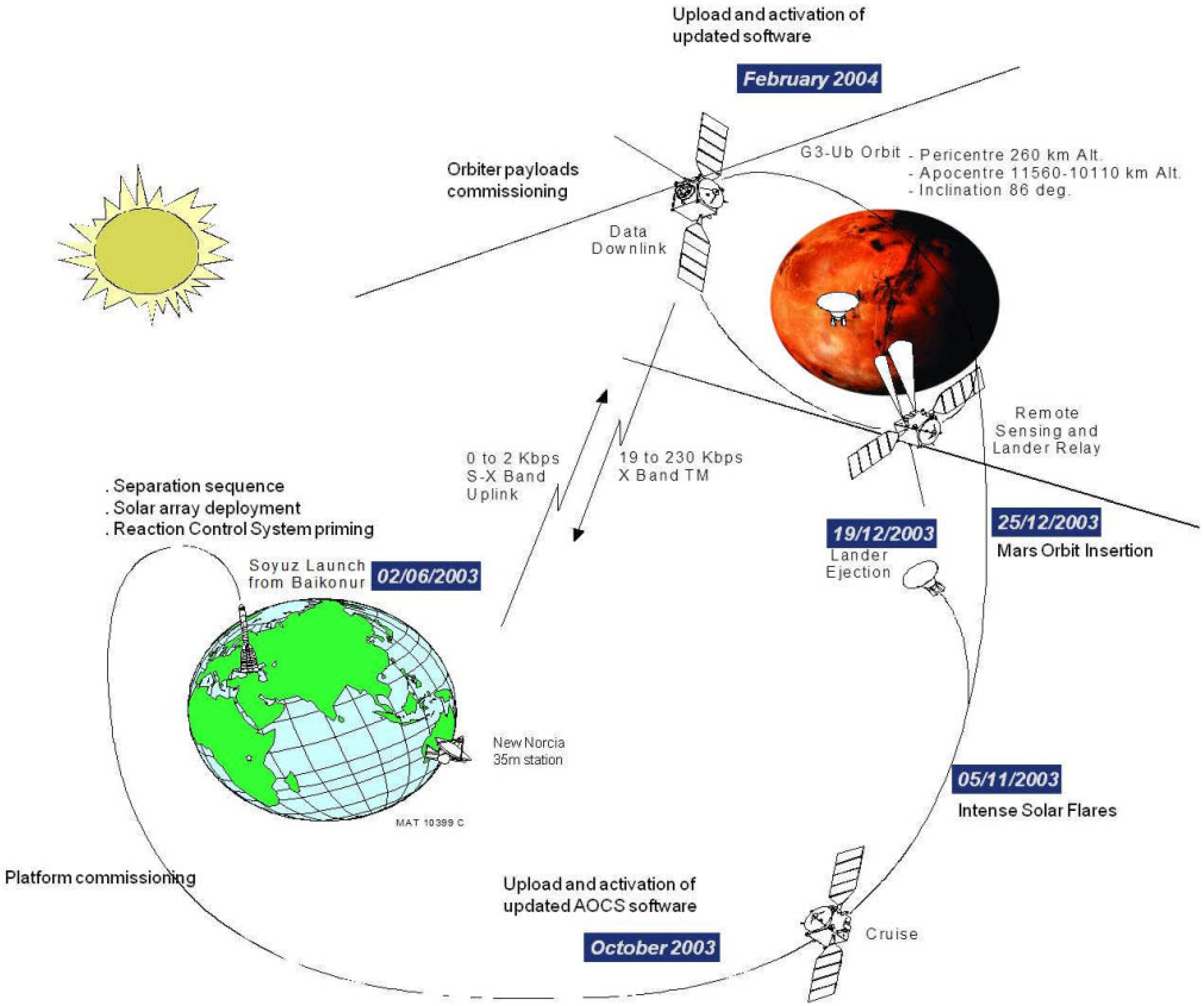
Mission overview



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The Interplanetary Cruise

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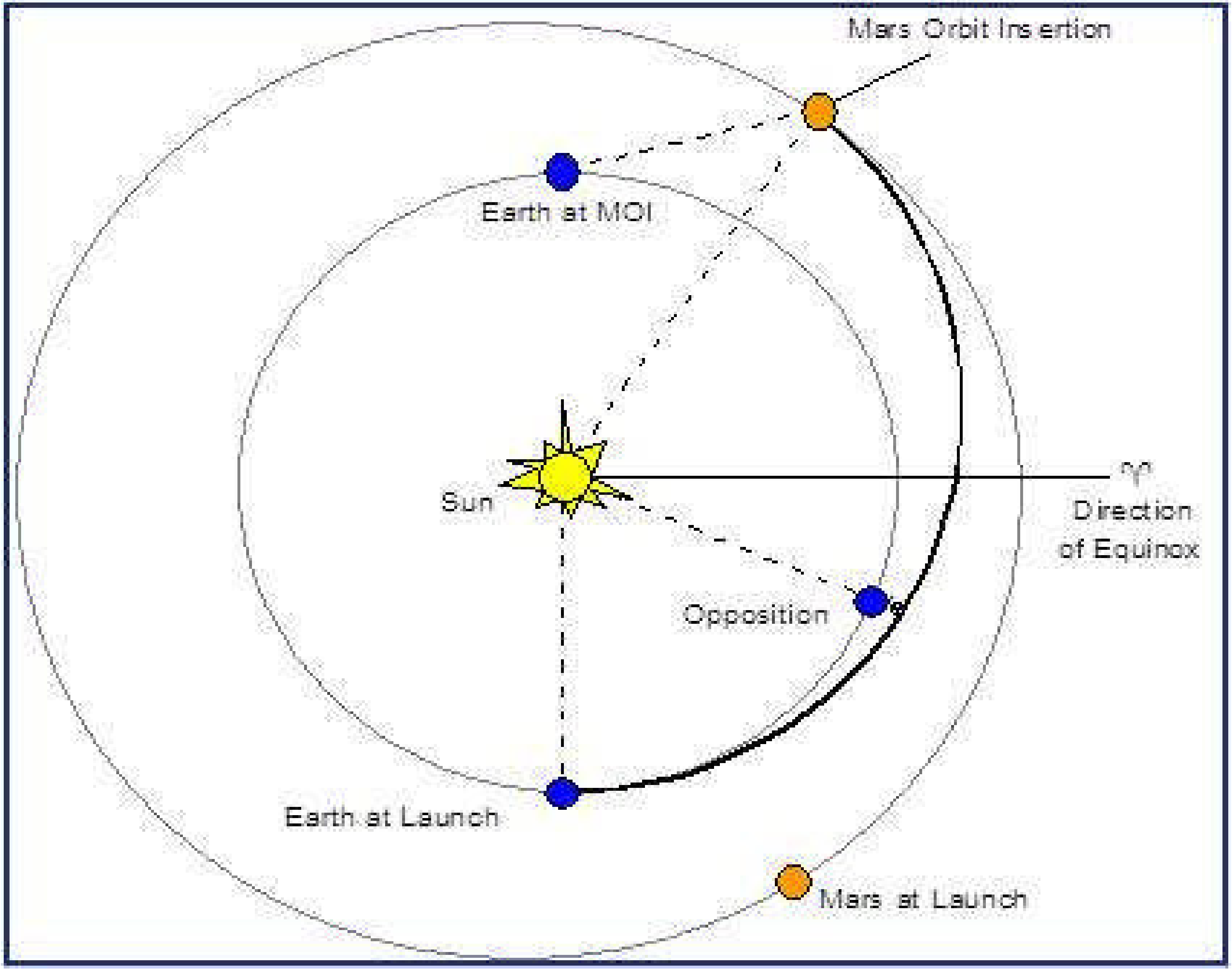

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Mission animation - video available separately on website www.dibley.eu.com

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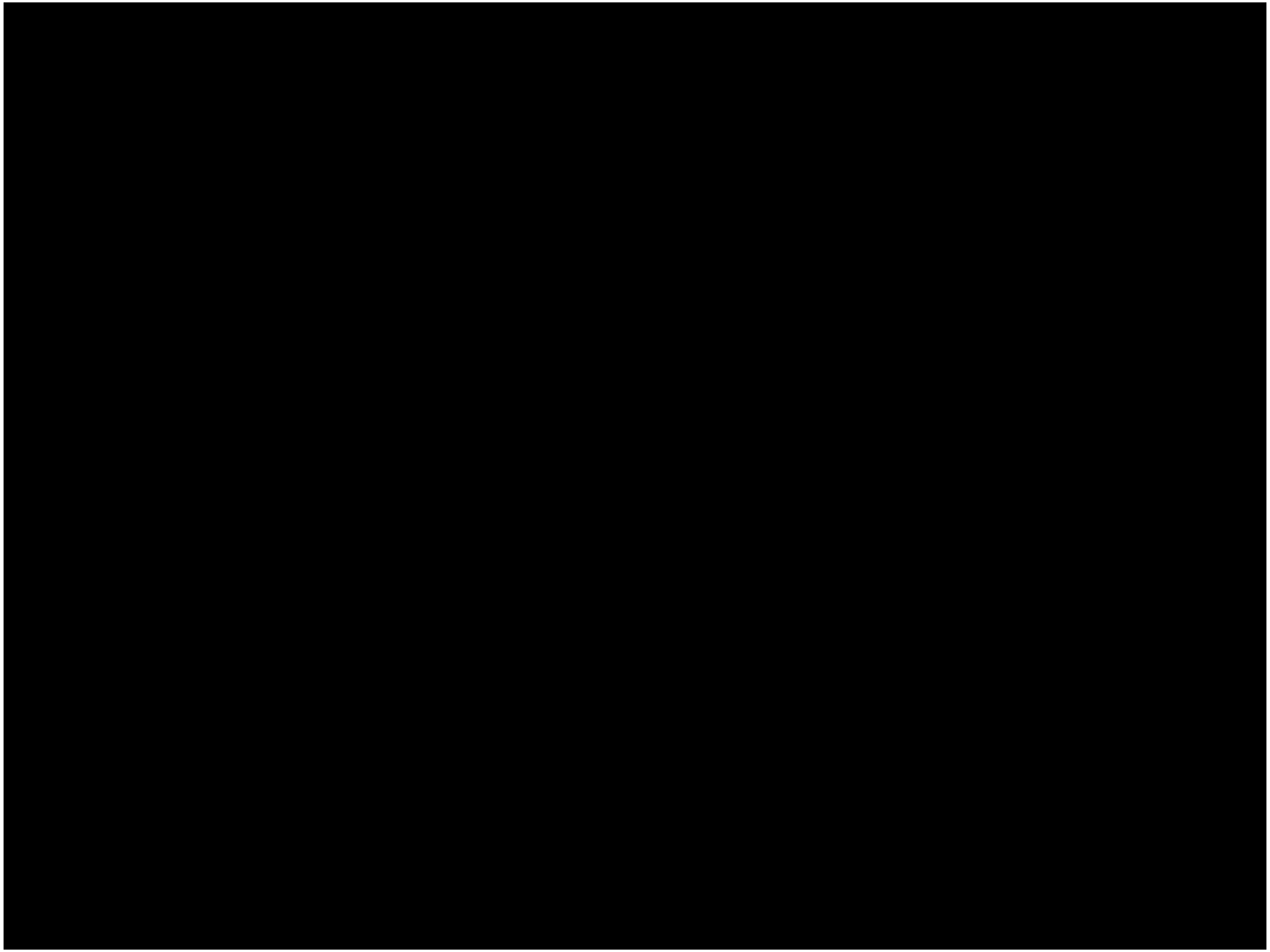
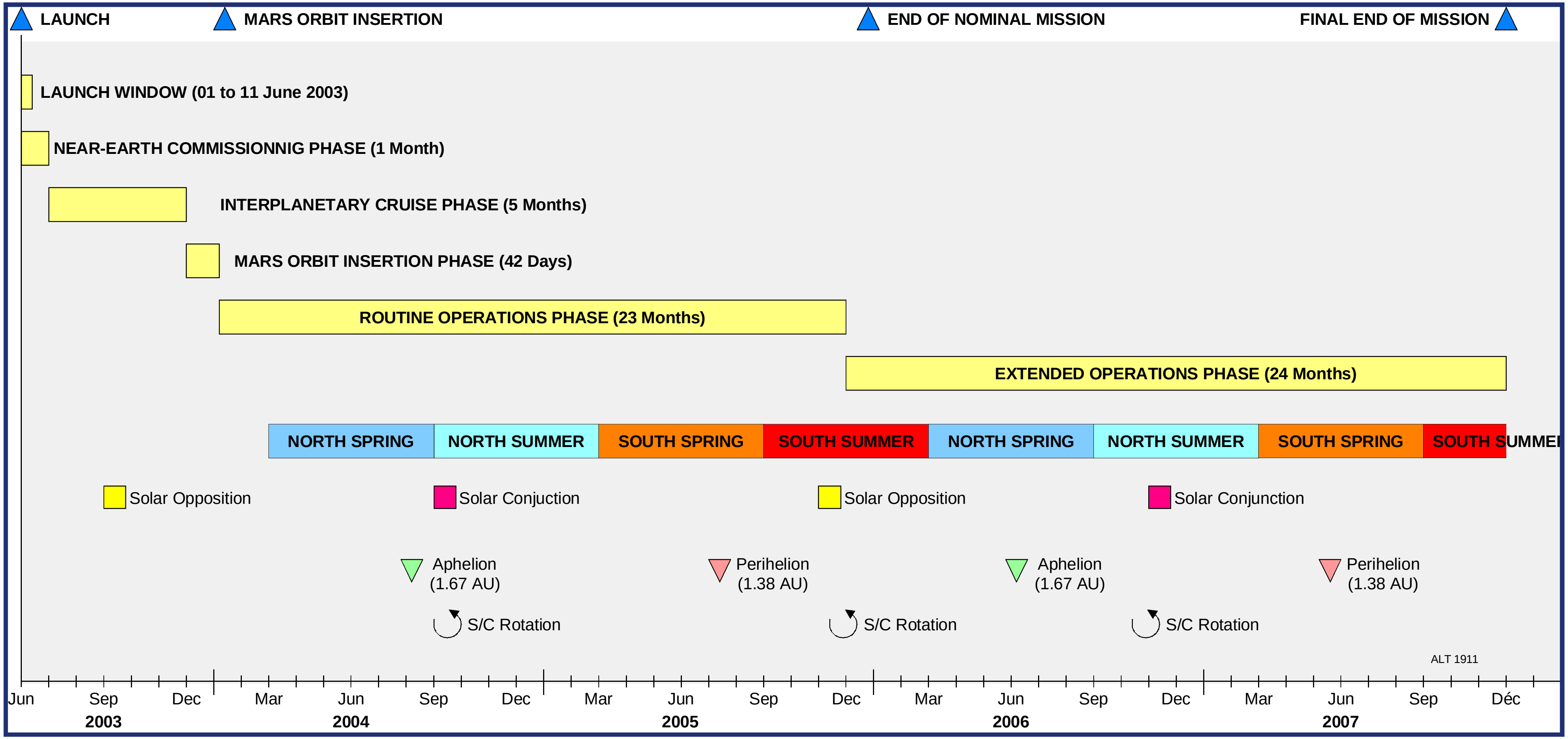


Overall mission timeline (baseline plan)



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Spacecraft Design Overview

Orbiter Design : overview

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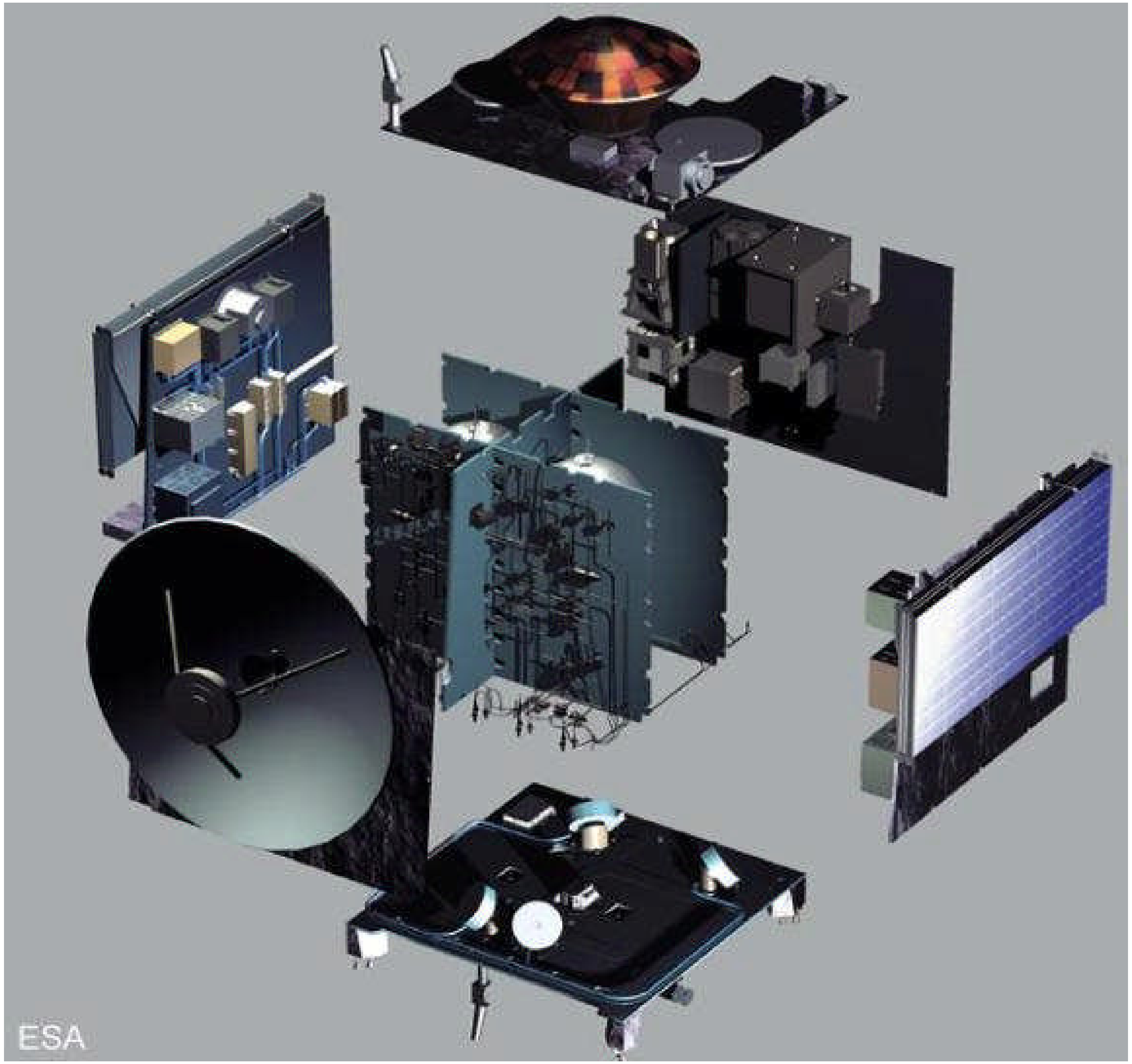

Launch mass : 1200 kg
(propellant mass : 460 kg)

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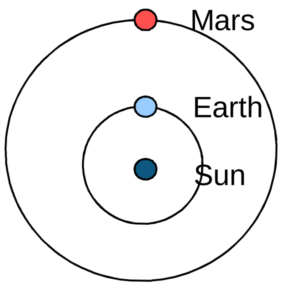
A Specific requirement : high level of autonomy

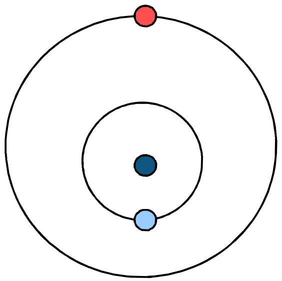
- Distances between the spacecraft and the Earth can reach up to 2.5 times the distance between the Earth and the Sun.
  - The one way propagation time can reach up to ***20 minutes***.
  - The spacecraft configuration can change between the sending and the reception of a telecommand.

→ The spacecraft continuously manages its configuration & own resources.

- The spacecraft should remain operational even during the « opposition » and « conjunction » phases with the Sun
  - During conjunctions : one week without any telecommand.
  - During oppositions : one month without telecommand & telemeasure.



Conjunction



Opposition

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The Scientific payload
6 ‘orbiter’ instruments + 1 lander

A true scientific rationale : search for traces of water

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The «Surface» Package Payload

- **HRSC (DLR, Germany)**
  2D/3D global and accurate photogeology at 15 m ground
  resolution + higher resolution mode

- **OMEGA (IAS/Orsay, France)**
  2D global mineralogical spectro-imaging
  at 100 meter resolution

- **MARSIS (ASI/JPL, Italy-US)**
  Surface LW radar altimetry and sounding
  down to permafrost at 1 km resolution

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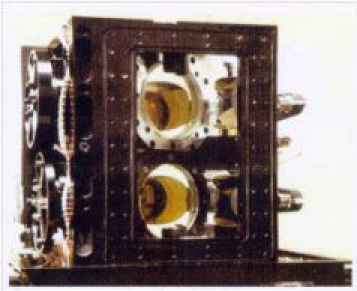
The «Atmospheric» Package Payload



- **PFS (ASI/CNR, Italy)**
  IR spectral sounding of the martian atmosphere; 10 km ground resolution

- **ASPERA (IFSI, Sweden)**
  Plasma (electrons / ions) and neutral gas energy / mass measurements

- **SPICAM (S. A. / Verrières, France)**
  UV and IR spectral limb sounding at 2 to 3 km vertical resolution

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2. Mars Express : the Management Approach

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The Programme challenges

- A very ambitious scientific mission, within a stringent cost cap (the overall cost is one third of the cost of previous scientific missions) and an unusually quick development schedule to meet a ***fixed*** and narrow launch window in June 2003.
- The mission requirements were specific and unprecedented in Europe.
- Mars Express has pioneered a more economic way of building space science missions.
- Moreover, Mars Express is a high visibility mission.

→ ***« failure was not an option ».***

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The Management Principles

- Low budget and fixed launch date : the main drivers for the spacecraft development.
- They have been achieved thanks to
  - A larger responsibility delegated to the Industrial Prime contractor: management of the technical interface with the launcher and the scientific instruments (ESA responsibility in standard approach).
  - A maximum re-use of proven design and technology, such as the Rosetta avionics or Satcoms propulsion system.

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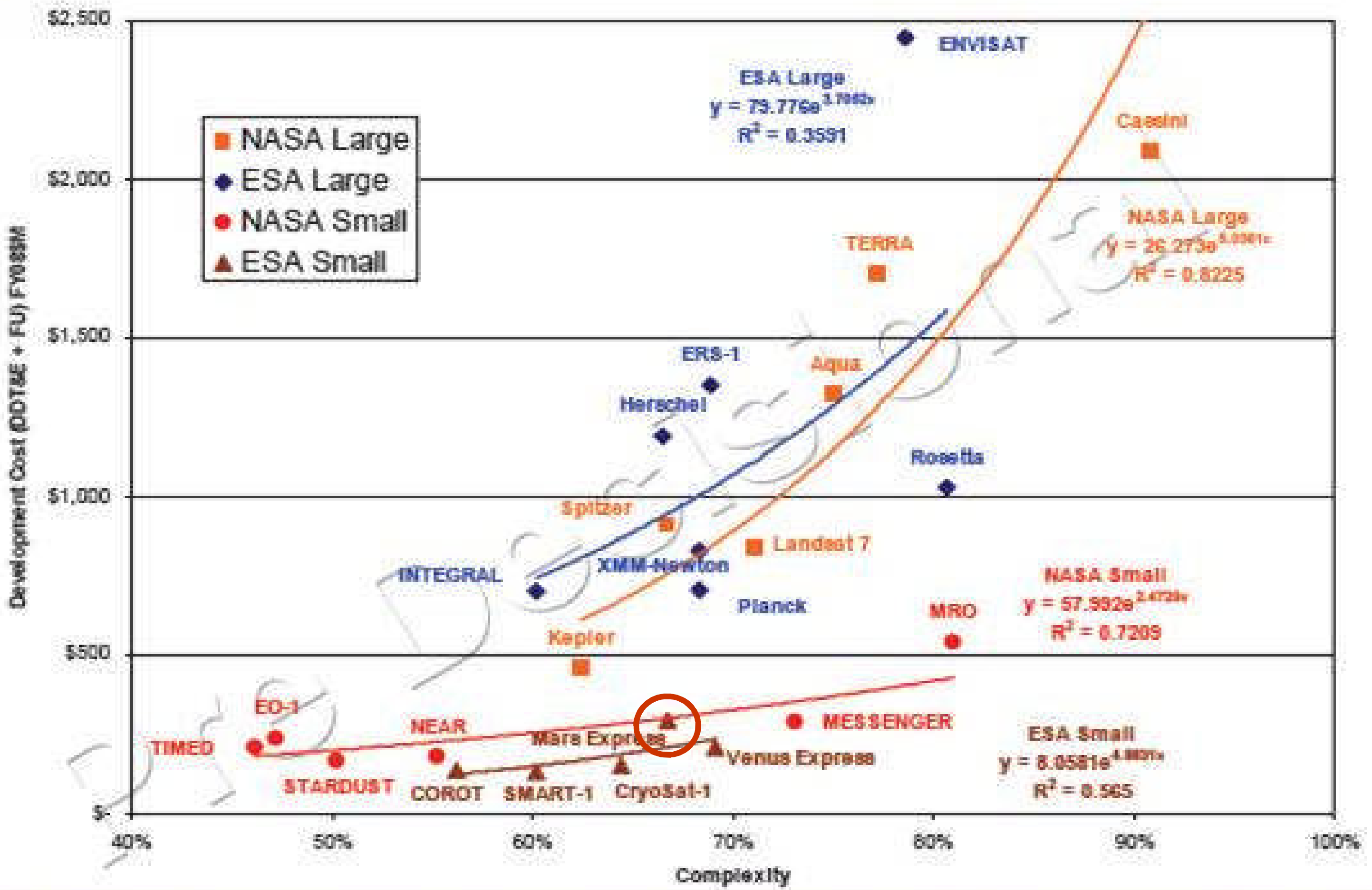
Relative Cost vs. Complexity of NASA & ESA Missions



NASA & ESA Comparable, although ESA Smaller Missions are More Efficient

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The Industrial Consortium
- Meeting the ESA geo-return requirements -

- Airbus DS Prime Contractor
- More than 20 industrial subcontractors over Europe and the US
  - Norway : Kongsberg (Solar Array Drive Mechanism)
  - Ireland : Captec (Software independant validation)
  - UK : AEA / Quinetic (Batteries / Lander Communications System)
  - Germany : Teldix (Reaction Wheels)
  - France : Intespace / Starsem / Thales (Tests / Launcher / TWTA)
  - Spain : Casa / Alcatel (Electronics)
  - Finland : Patria (Power distribution unit)
  - Sweden : Saab Ericson Space (On-board Computer)
  - Denmark : Terma (Power unit)
  - The Netherlands : TNO (Sun Sensors)
  - Belgium : Nexans (Harness)
  - Austria : Austrian Aerospace (Thermal Control Hardware)
  - Switzerland : Oerlikon (Spacecraft Structure)
  - Italy : Galileo Avionica (Star sensors)
  - US : Honeywell (Gyros)

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3. Mars Express : The Development approach

Overall Programme Planning

- 1 year for the design studies
- 4 years for the detailed design and development phase
  - 1999 : Definition and Design phase
  - 2000 : Units (Experiments and Bus Equipment) manufacturing
  - 2001 : Start of S/C integration
  - 2002 : S/C integration Testing
  - 2003 : Launch in June, Mars Orbit Insertion in december

  - 2004 / 2005 : Operational routine phase
  - 2006 -> : Extended routine phase

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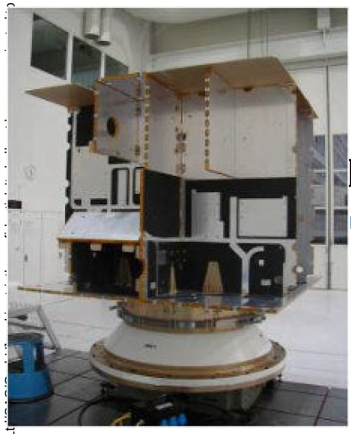
Overall Development logic

Electrical and Functional Integration : H/W - S/W validation

(Airbus DS Toulouse)



Mechanical Bus integration and tests (Structure + Propulsion)

(Airbus DS Stevenage)

S/C integration and tests

(TAS Torino)

Launch

Payload development and manufacturing (6 Experiments)

(European Scientific Laboratories)

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Spacecraft integration and tests

Thermal environment tests

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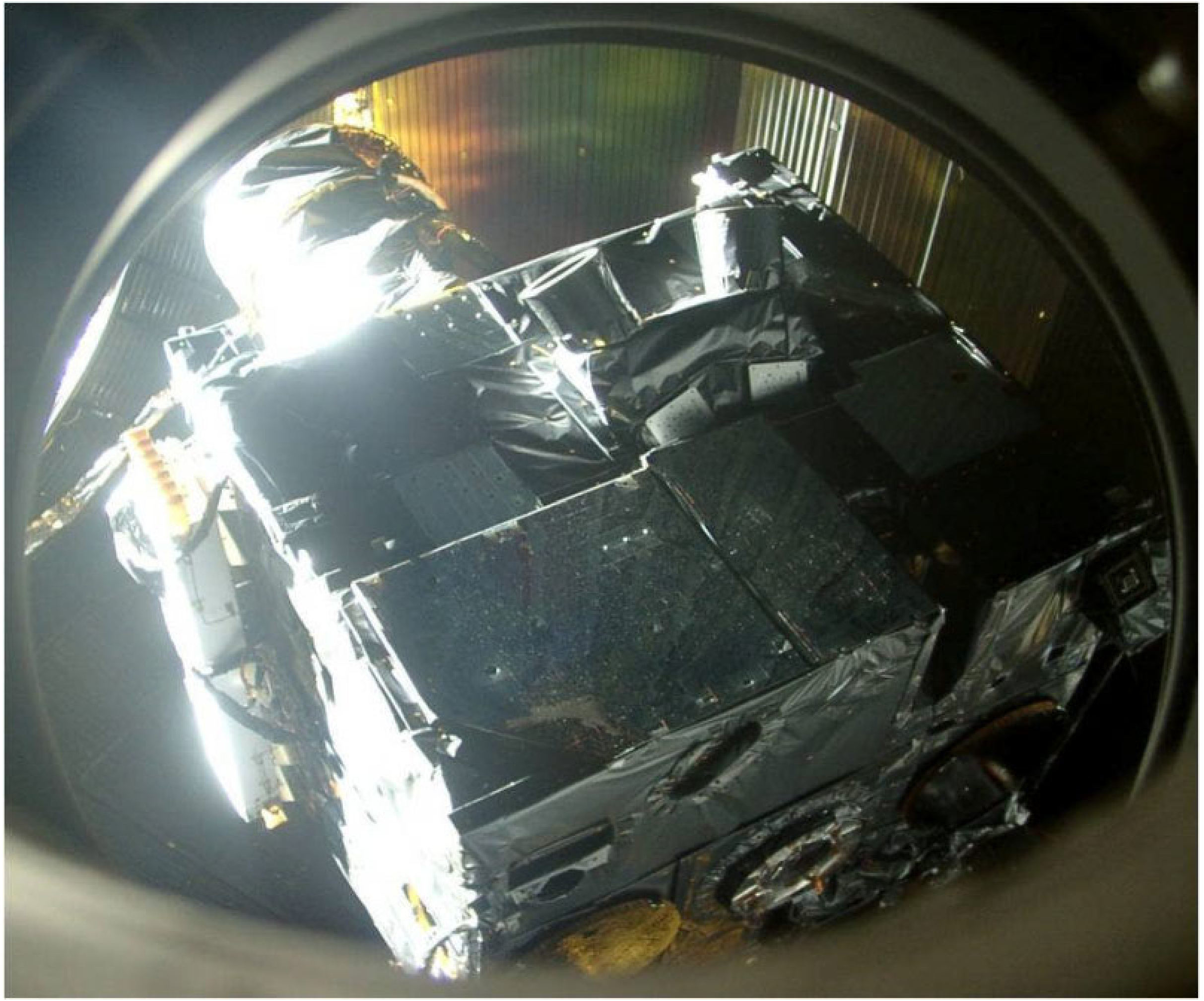
Thermal vacuum test
Intespace, Oct 2002



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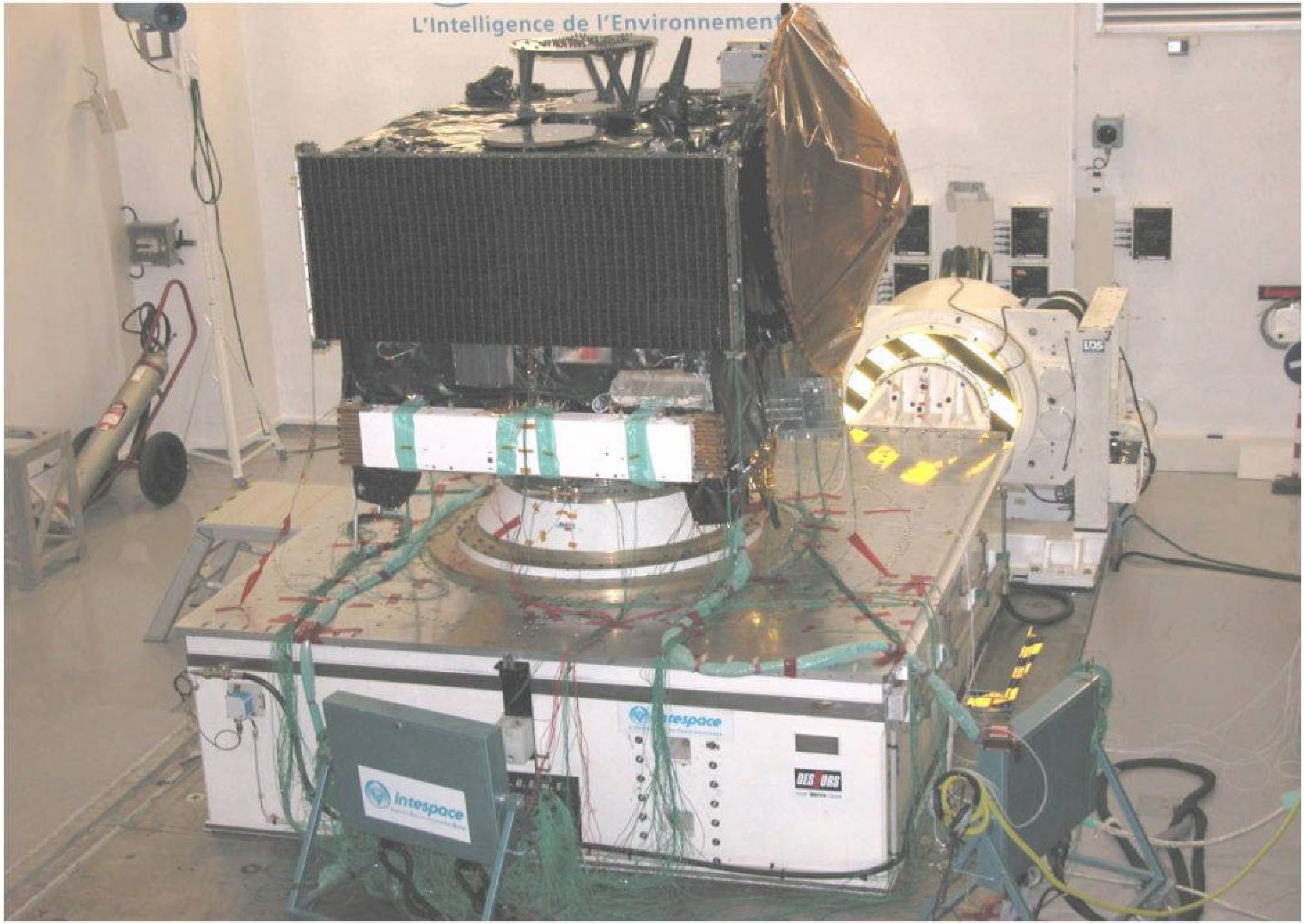
Mechanical environment tests



Sine and acoustic test
Intespace, Dec 2002

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Mechanisms deployment test

Beagle 2 * ejection test
Intespace, Dec 2002
* Simulator

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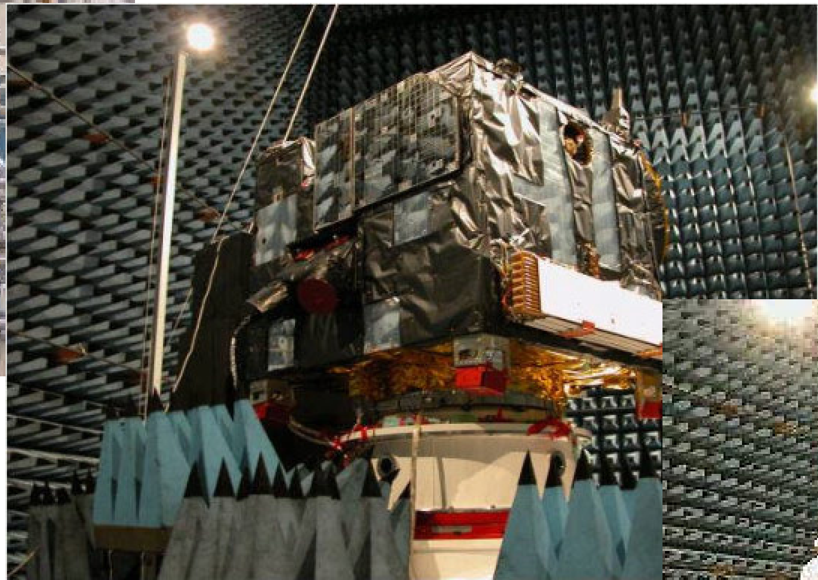
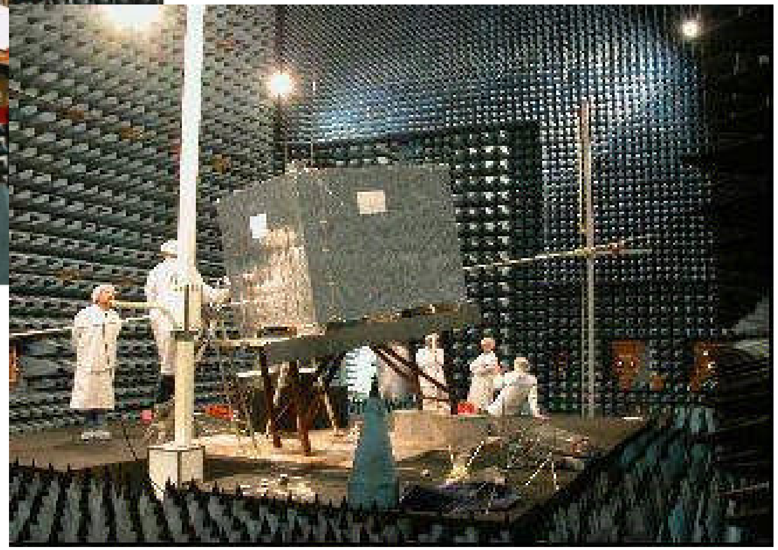
EMC environment test

Conducted EMC test,
Torino, Aug. 2002



Radiated EMC test
Intespace, Jan 2003



MARSIS characterization,
Intespace, November 2002

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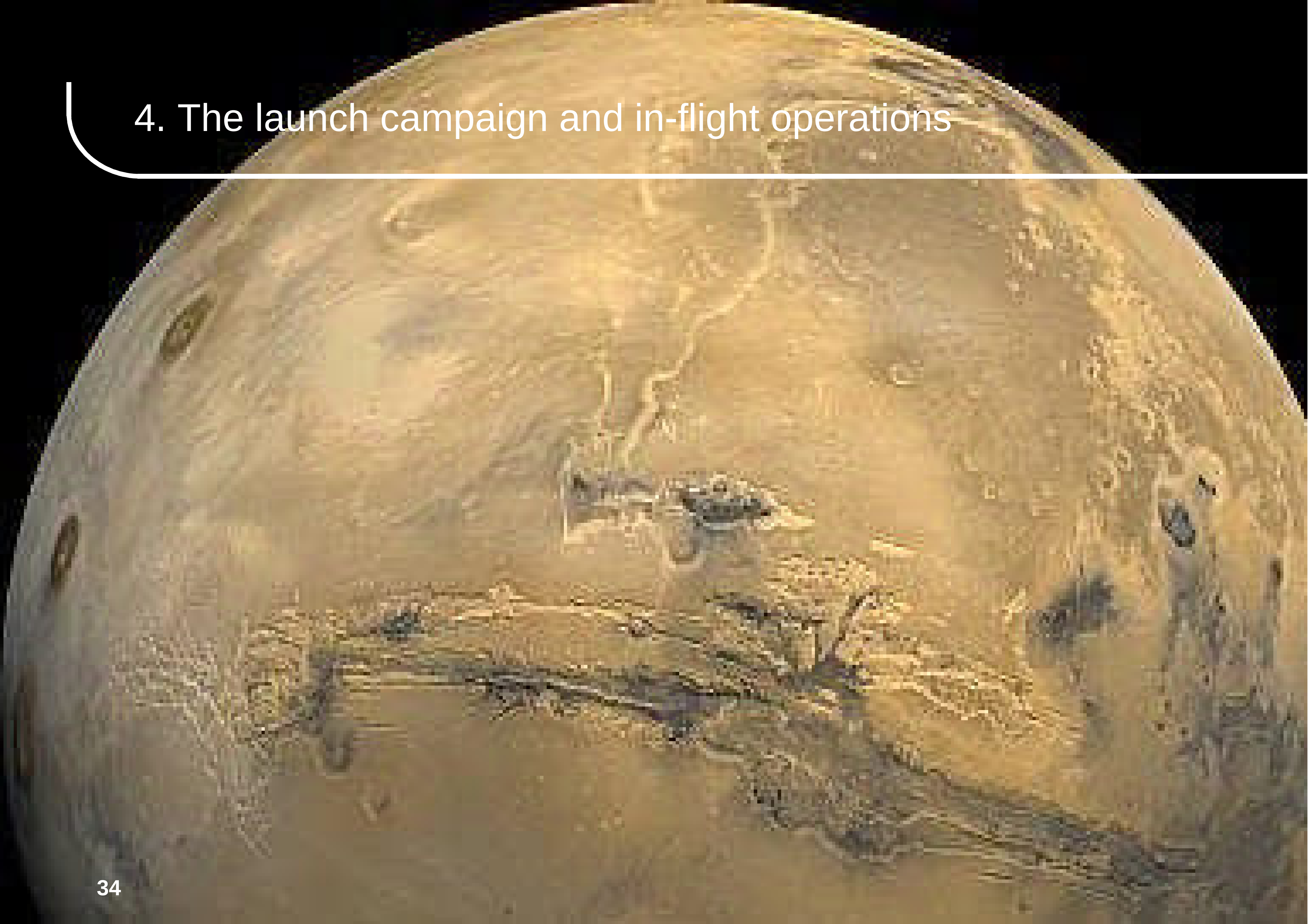
Mass CoG and inertia measurements

Intespace, Jan. 2003

4. The launch campaign and in-flight operations



Departure from Toulouse to Baikonur

Loading onboard an Antonov Cargo
Blagnac, March 2003

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The Launch campaign starts

Launch pad preparation
Baikonur, March 2003

Spacecraft final preparation and Fuelling

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Spacecraft integration onto Launcher upper stage

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Spacecraft encapsulation

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Launcher integration (in parallel)

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Composite transfer to the launch pad

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Babysitting

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Successful launch !

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Early Operations at ESOC - June 2003 -

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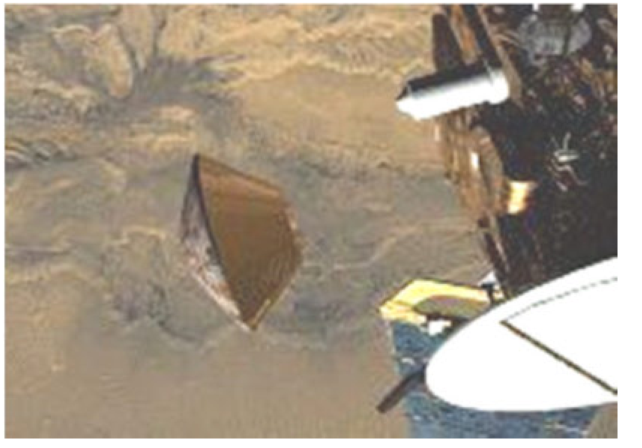
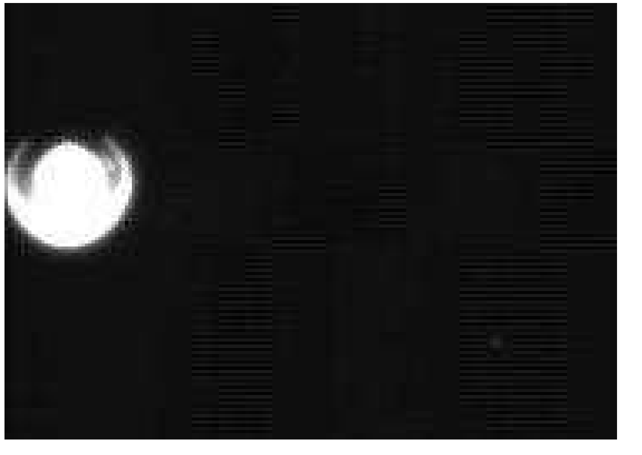
Beagle 2 Lander Ejection - December 2004 -

- Beagle 2 was ejected on 19.12.03, 6 days before the Orbiter capture
- Separation confirmed through
  - Doppler measures (2 cm/s)
  - Reaction wheels kinetic momentum profile
  - Pyro current profile
  - Video Camera picture
- Following separation, the orbiter is redirected towards the insertion point around Mars.
- No more contact from Beagle 2 since then.
- Beagle 2 declared lost on February, 6th 2004.



Artist's view of the Lander ejection



Last picture of Beagle 2

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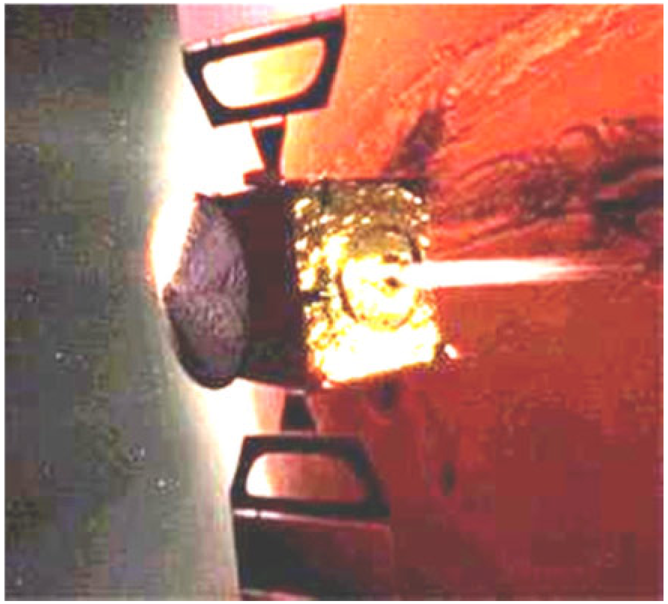
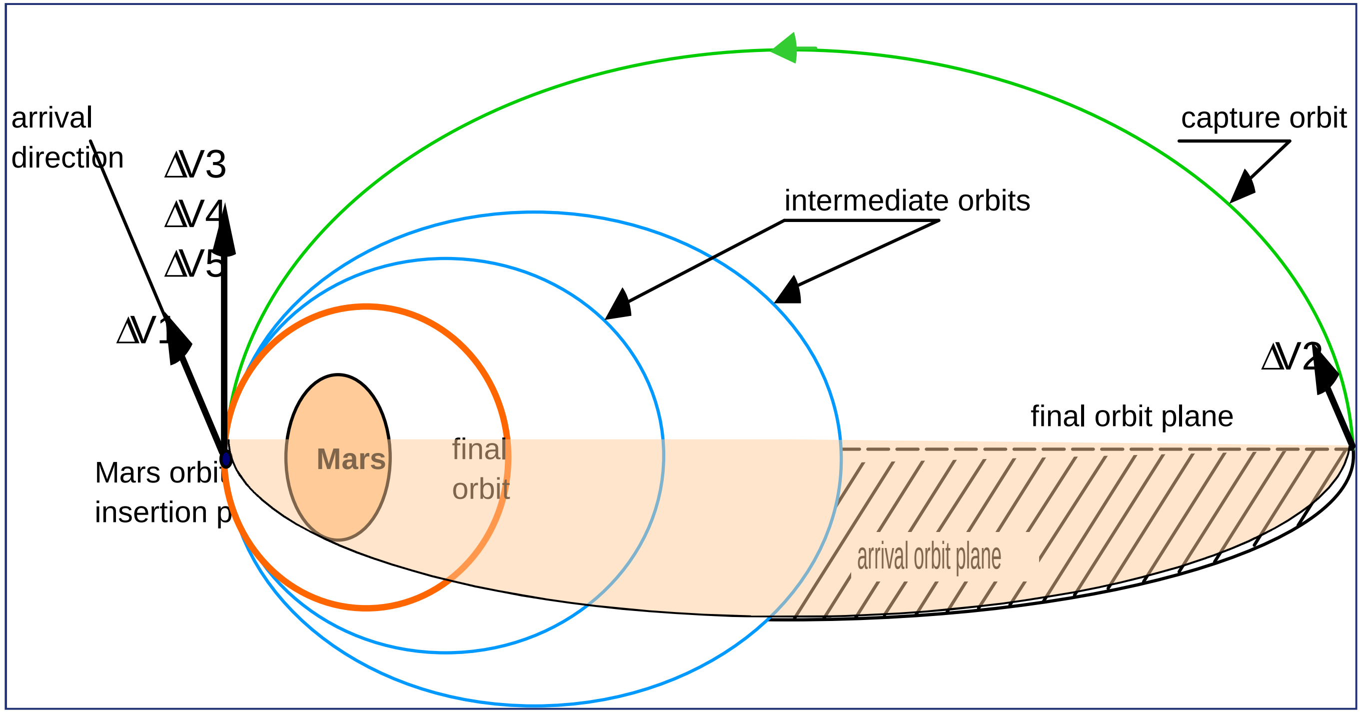
The Mars Orbit Insertion - December 2003 -





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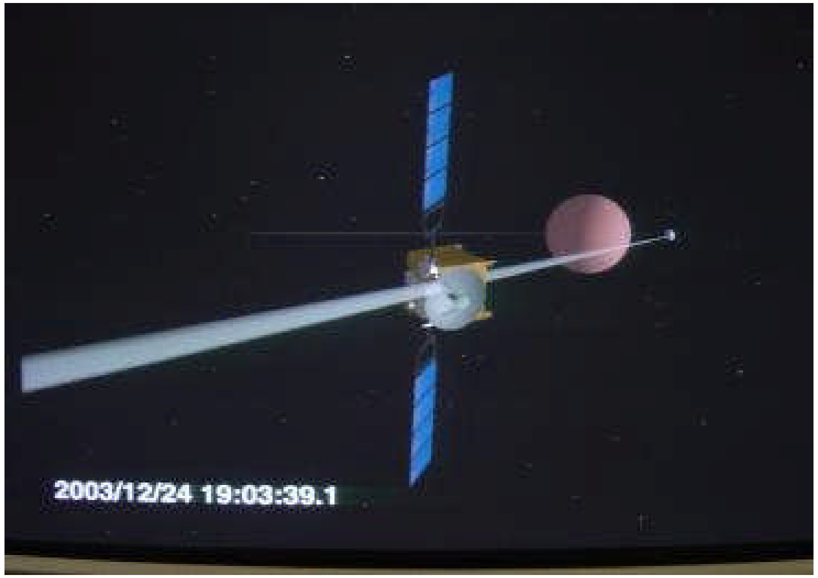
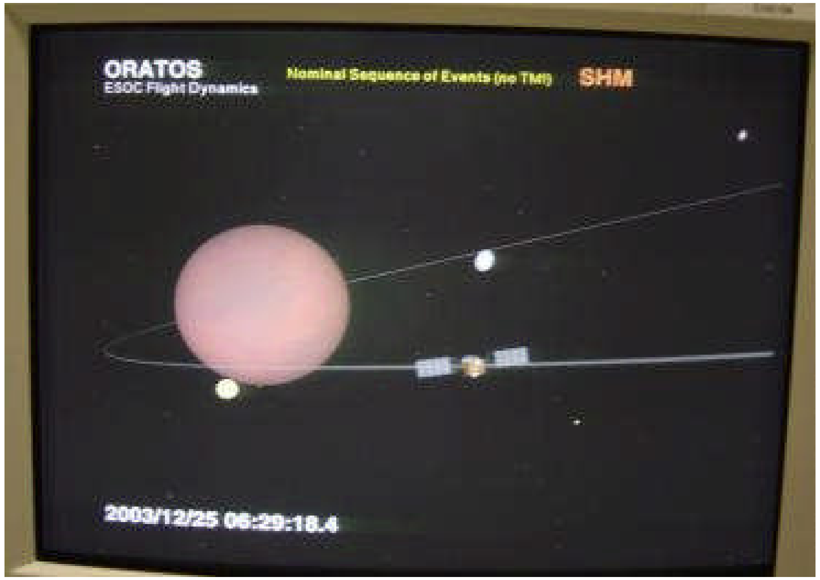
The Mars Orbit Insertion - Christmas 2003 -





Mars capture timeline of main events
(December 25th 2003)

01:31	Start of attitude slew
01:36	X-TX switch off
02:01	End of slew
02:41	Start of Main Engine Boost mode
02:41	Start of Burn Initialisation phase
02:45	Start of Liquid Settling phase
02:47	Start of burn
03:19	End of burn, switch to Sun Acquisition mode
03:20	Start of occultation by the planet
03:58	End of occultation
03:23	Switch to Safe Hold Mode (Earth pointing)
04:11	Lock on Goldstone DSN
04:12	Retrieve of S-band signal
08:35	Switch ON X-TX, retrieve of telemetry
09:03	First command sent to the S/C

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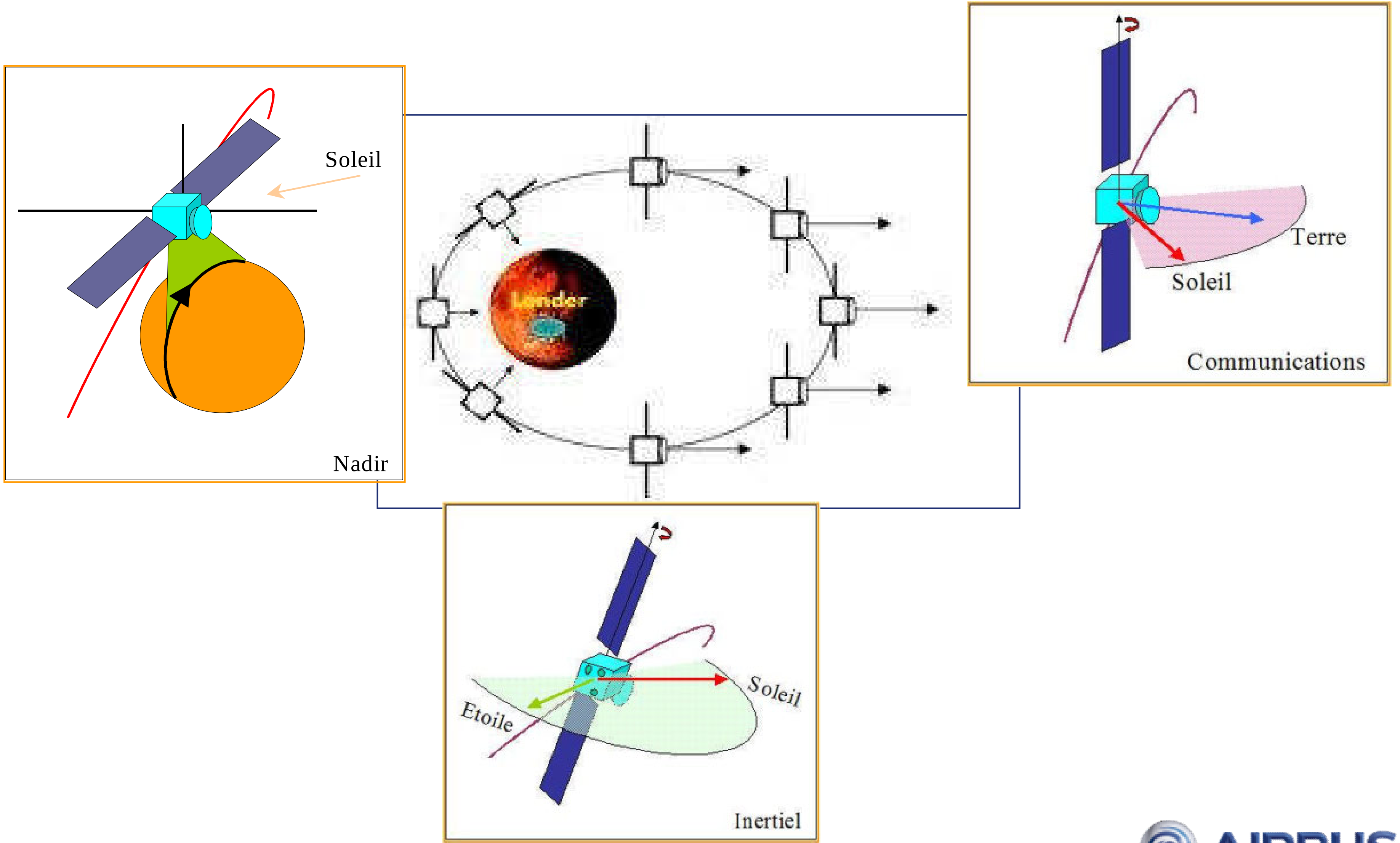
Spacecraft around Mars



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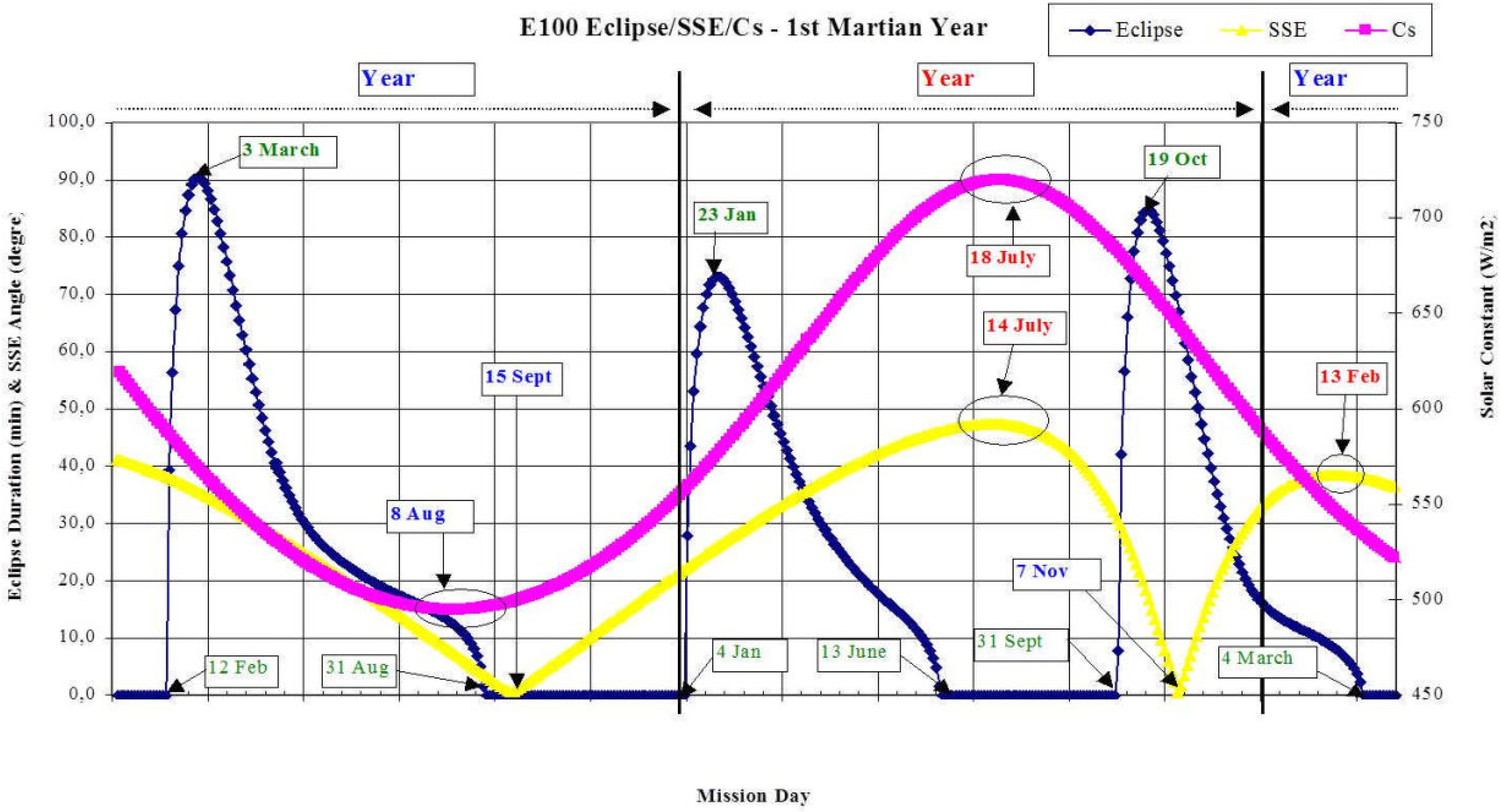
Orbit characteristics



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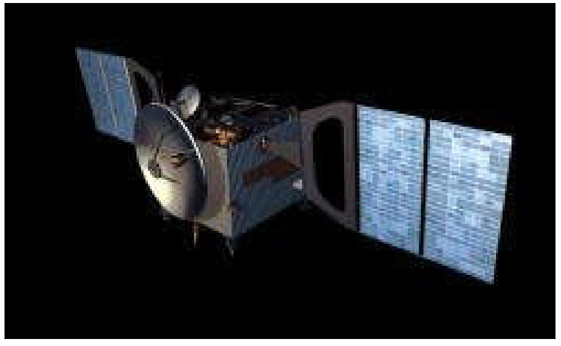
Beyond Mars Express - The interplanetary Programme at Airbus DS -

- Mars Express has paved the way for further interplanetary programmes
  - ***Rosetta***, the Comet Chaser, launched in February 2004

  - ***Venus Express***, the Venus explorer, launched in November 2005



- These 2 programmes make intensive use of a common avionics architecture, derived from the flight proven Mars Express.

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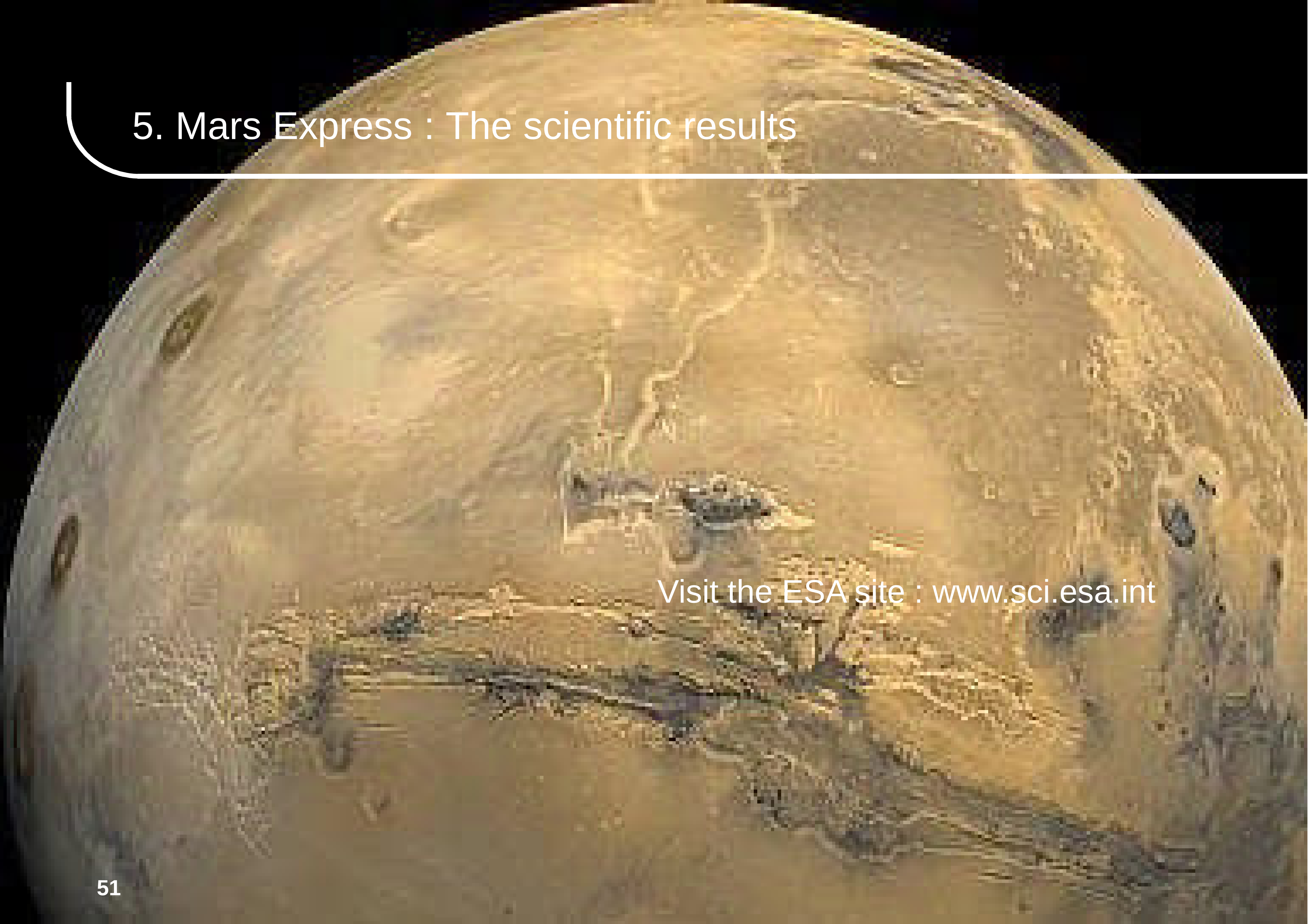
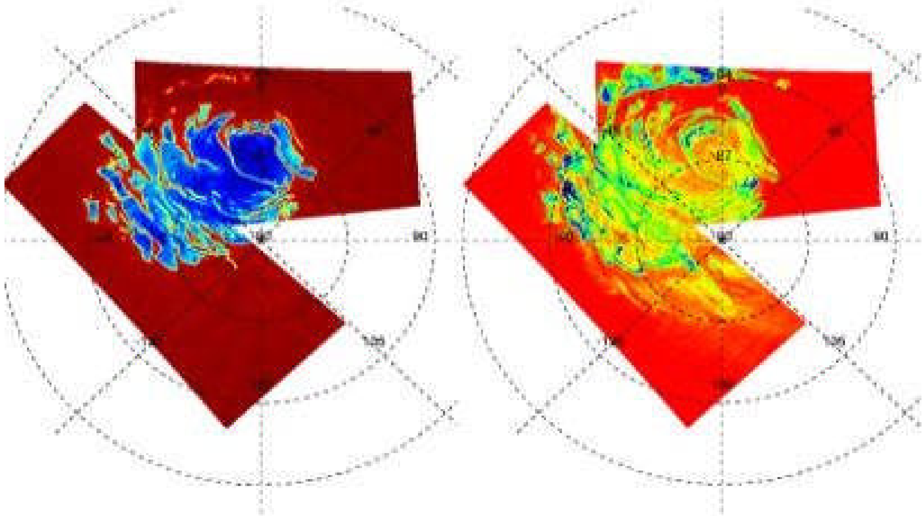


5. Mars Express : The scientific results

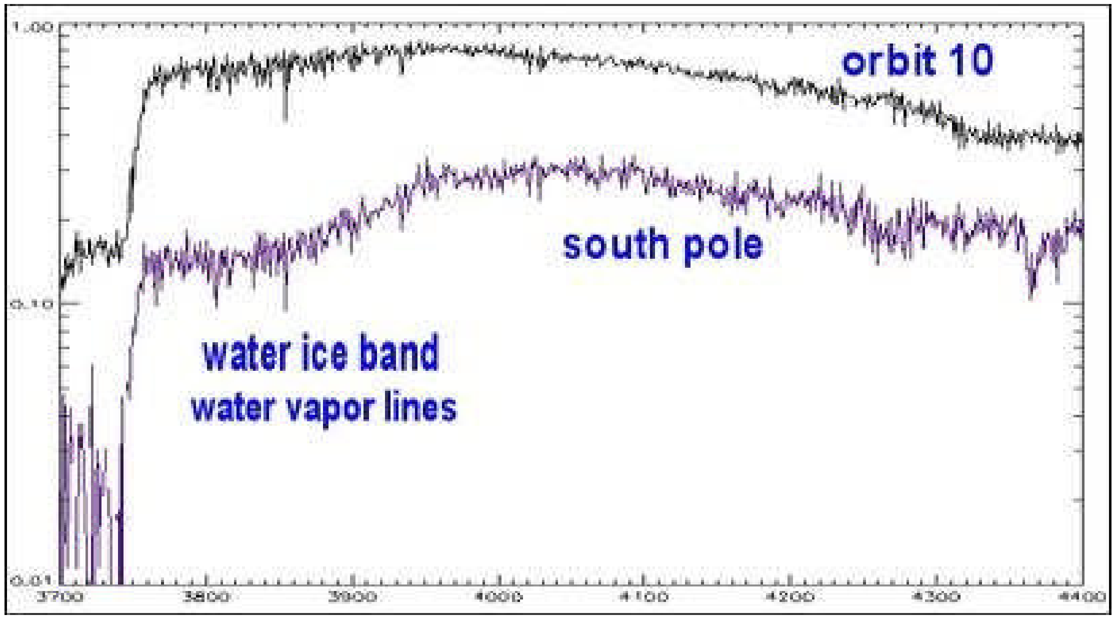
Visit the ESA site : www.sci.esa.int

First scientific results - Start of the operational phase

- PFS and OMEGA found water in the southern polar cap.
- PFS indicated that methane is present in the Martian atmosphere.
- SPICAM detected ozone, water vapour and carbon dioxide.



South pole of Mars - the blue color indicates the presence of CO_2 (left hand side) and ice (right hand side) (credits ESA/IAS J.P. Bibring)



PFS spectrum over south polar cap (credits ESA/CNR - V. Formisano)

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First scientific results - routine phase

Spectacular colour pictures of the surface of Mars taken by HRSC (credits ESA/DLR/FU – G. Neukum).

Archeron fossae

Hellas basin

Valles Marineris

Mangala Valles

Melas Chasma

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Conclusion

- Mars Express deemed as a great success for the science community, the ESA interplanetary programme and Airbus DS.
- The orbiter has reached stable and well-understood operational conditions in 2004.
- First major findings at the beginning of the mission
  - evidence of water ice in the southern polar cap,
  - unprecedent large size images of the Martian surface in high resolution, 3D and in colour,
  - unexpected elements of the composition of the Martian atmosphere.
- This exciting mission continues : extremely valuable scientific data are made available daily to the international science community.
- Airbus DS remain present in the maintenance phase and support ESA (ESOC – Darmstadt) in the daily operations.

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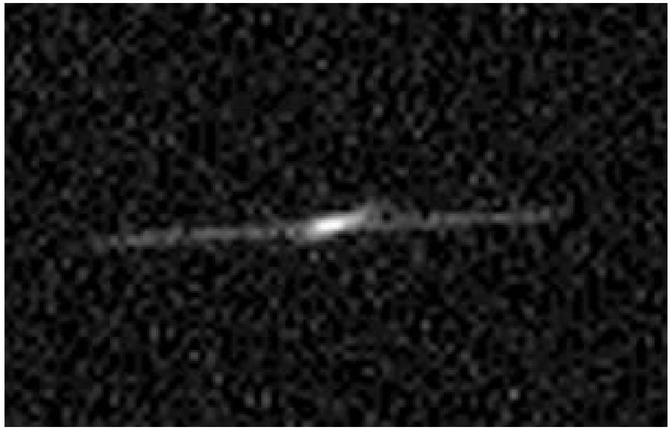
NASA / ESA cooperation in space

Mars Reconnaissance Orbiter / Mars Express encounter (Feb. 06)

- **MRO imaged the Mars Express spacecraft on February 10, 03:45:32 SCET UTC. The attempt was mostly successful.**
- **For the detected crossing, Mars Express was at a distance of roughly *122 KM***
- **The solar arrays are evident in the image and appear to be edge-on, which corresponds with an expected sun position mostly overhead. The body of the spacecraft is seen with much more detail than the previous attempt. The MARSIS booms are not apparent in the image. This was expected, since the booms are small (a few inches in diameter) and have little light reflection due to their dark color.**



Mars Express, 10 February 2006

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