ESA/NASA Scientific Collaborative Programmes

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1. ESA

esa

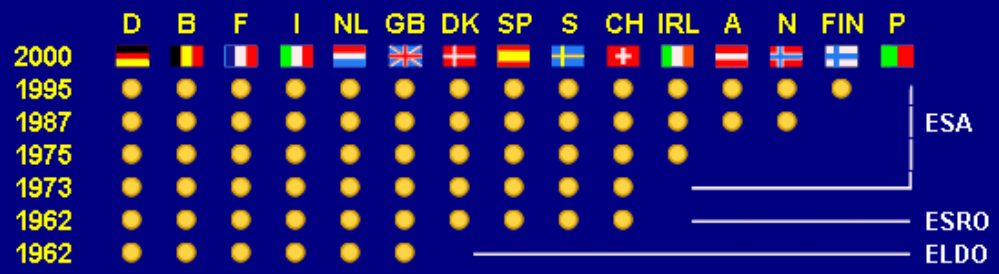
The European Space Agency

- The idea of an independent European space organisation began in the early 1960s.
- ESA was formed in 1975, replacing the ESRO satellite and ELDO launcher organisations. It has 15 Member States.

ESA Member States

ESA has 15 Member States:

- Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Norway, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom
- Canada takes part in some projects under a cooperation agreement



- **Nota: Most member states also belong to the European Union, but some do not. Conversely, some members of the EU do not yet belong to ESA. EU and ESA interact constructively in evolving Space policies for Europe.**

The purpose of ESA

An inter-governmental organisation with a mission to provide and promote - for exclusively peaceful purposes - the exploitation of:

- Space science, research & technology
- Space applications

ESA achieves this through:

- Space activities and programmes
- Long-term space policy
- A specific industrial policy
- Coordinating European with national space programmes

ESA programmes

- All Member States participate in activities related to space science and in a common set of programmes (mandatory programmes).
- In addition, members choose their level of participation in the following optional programmes:
  - Earth observation
  - Telecommunications
  - Navigation
  - Launcher development
  - Manned space flight
  - Microgravity research

ESA headquarters and establishments

Staff on posts at 30/11/2000, total: 1723

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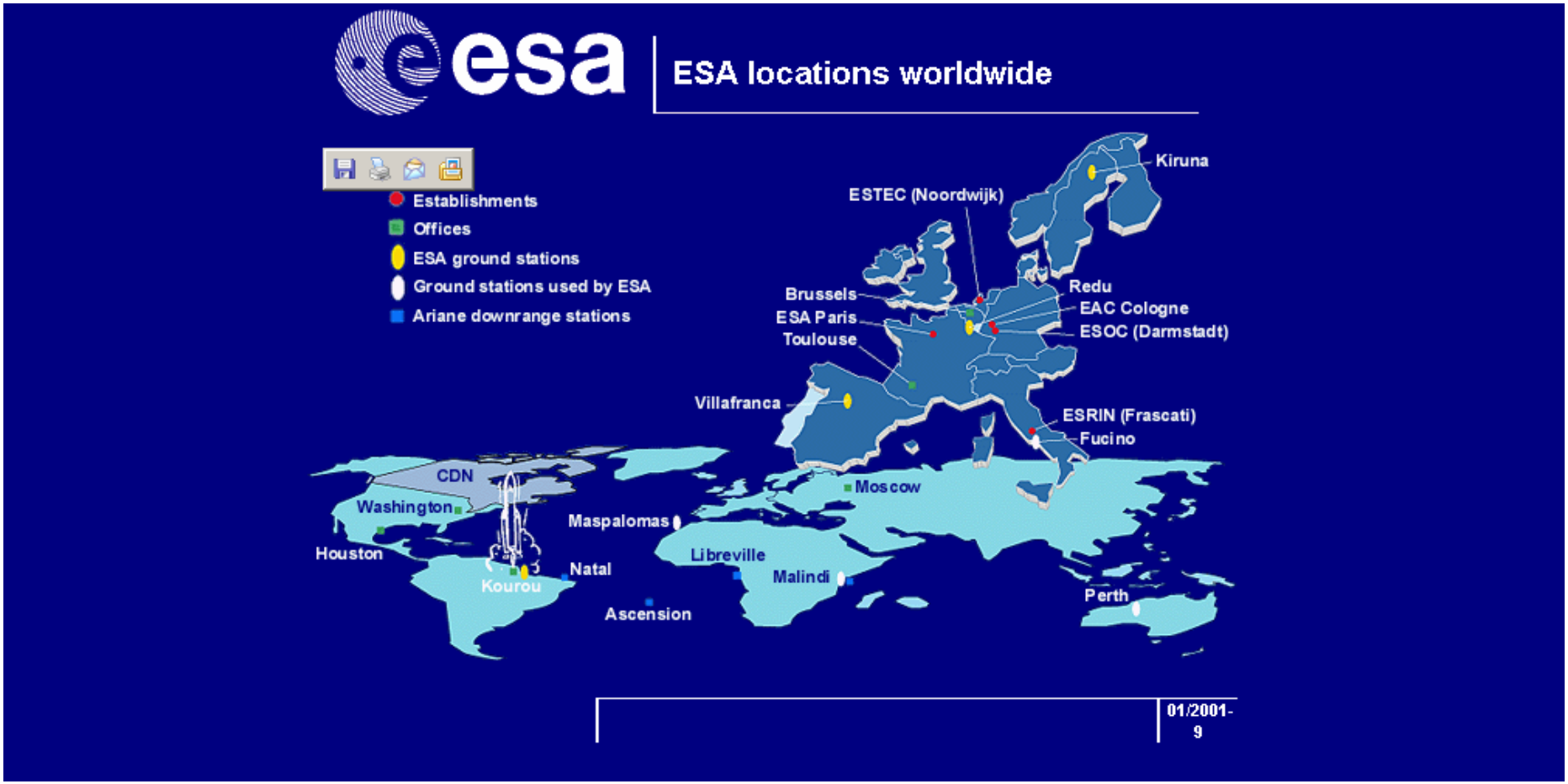
esa
ESA locations worldwide
Establishments
Offices
ESA ground stations
Ground stations used by ESA
Ariane downrange stations
Kiruna
ESTEC (Noordwijk)
Redu
EAC Cologne
ESOC (Darmstadt)
Brussels
ESA Paris
Toulouse
Villafranca
ESRIN (Frascati)
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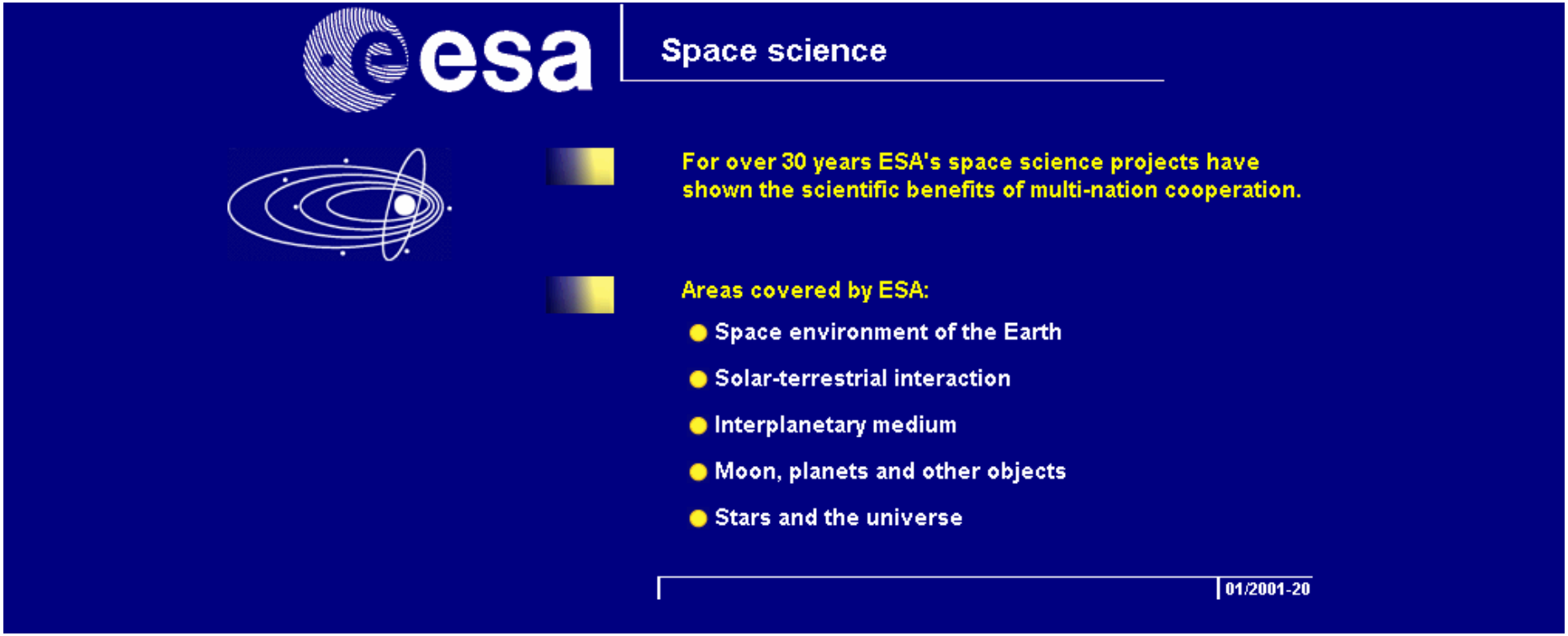


- ESA has several cooperative ventures with other nations such as the United States, Russia, Canada, Japan, and China.

- The Space Science Programmes in collaboration with NASA have been and are still a very important factor of the Scientific Directorate.

2. ESA Scientific Programmes

- Space Science Programmes are funded by all member states according to their GNP.
- Their respective contributions are to go back to them in the form of contracts awarded to their own industry.
- This geographical return rule is strictly enforced on scientific projects and leads to the selection of a prime contractor and dozen of sub-contractors all over Europe.
- As a consequence, the ESA Programme Management is based on inter-European collaboration.

ESA/NASA Collaborative Programmes
General

- Scientific instruments flown on European Spacecrafts have always been subject to announcements of opportunity (AO) open to US and European PIs.
- As a consequence the scientific payloads have mainly been developed as collaborative ESA/NASA programmes through US/European PIs and COIs
- A large number of scientific spacecrafts still in operations were developed, launched, and operated as ESA/NASA collaborative projects: Hubble/Ulysses/SOHO/Cassini-Huygens/Clusters.
- The main characteristics of these programs are an independent agency funding and no exchange of funds between ESA and NASA.
- Common objectives and respective responsibilities and contributions are agreed in the memorandum of understanding prior to start of the programme (MOU issued by ESA/NASA HQ).

Selected ESA/NASA Projects

- Hubble Space Telescope
  - 1977 - 1990 Launch – In operation through 2010
- Cassini/Huygens
  - 1990 – 1997 Launch – In operation through 2008
- SOHO
  - 1989 – 1995 Launch – In operation through 2007

- Similarities
  - Three programmes are governed by top level documents
    - MOU – Project Plan – IRD - ICD
  - Long duration programme in three phases
    - Development phase
    - Launch and Commissioning phase
    - Scientific Operational phase

Hubble Space Telescope

Hubble Space Telescope

- ESA is NASA's partner for the Hubble Space Telescope (MOU 1977)
- ESA Contributions
  - Faint Object Camera (FOC)
    - Optical and ultraviolet camera able to count individual photons as they arrive: equipped with two complete detector systems (f/48, f/96).
      - Dimensions: 1 x 1 x 2.2 m
      - Mass: 320 kg
      - Wavelengths: 1220 – 5500 Angstroms
  - Solar Panels that power the spacecraft
    - Fully deployable in orbit
      - Size: 3 x 12 m
      - Power: 3 KW

HST (con't)

- ESA Contribution (Con't)
  - A European team of 15 Space scientists (astronomers) and engineers at the Space Telescope Science Institute in Baltimore (STSCI) for the duration of the operational phase.
  - In Return, 15% of the telescope's observing time is reserved for projects and research devised by European astronomers from ESA's member states (as long as their proposal is approved by the Scientific STSCI committee).

HST - Organisation

- ESA
  - Project office at ESTEC – The Nertherlands
  - FOC Prime Contractor* – Dornier, Germany
  - Solar Array Prime Contractor – BAE, UK
- NASA
  - Project office – MSFC Huntsville (AL)
  - Project office (Instrument and operations) – GSFC, Greenbelt (MD)
  - Optical telescope assembly (OTA) Perkin Elmer – Danburry, CT
  - HST Prime contractor - Lockheed (LMSC) Mountain View (CA)
  - STSCI Johns Hopkins Baltimore (MD)

*The FOC was provided by ESA as a facility instrument under the FOC science team requirements.

HST – Working Relationship

- Very large programme with several interfaces
  - Industry to Industry
  - Agency to Agency
- Multiple reviews, meetings, working groups to be attended on a regular basis by several parties on both sides of the Atlantic.
- Weekly telecons (regular and ad-hoc)
- Marshal quarterly progress meeting during the full duration of the development programme.
- Permanent ESA resident team at GSFC for the development phase (1978 – 1989)
- Permanent ESA/Industry resident team at Lockheed for AIT activities and KSC for the launch campaign.
- ESA team attendance at GSFC and KSC for all servicing missions.

HST – Main Issues

- **Issues**
  - Interface with two NASA centers and 3 major Primes in the US.
    - Time consuming/duplication of effort.
  - Several NASA project manager changes during the development phase
    - 3 at GSFC
    - 4 at MSFC
  - NASA annual funding under constant scrutiny.
    - Uncertain future/funding crisis.
  - High number of project reviews, quarterly meetings, working group meetings.
  - Very long duration program with several launch date slips.

- **Measures Taken**
  - Resident in place at GSFC from day 1 through end of programme.
  - Need to rebuild relationship with new PM (ESA management fortunately kept stable)
  - Share the problem with partner.
  - Have ESA/NASA/Industry representatives attending all meetings in the US/Europe.
  - Extend the ESA and Industrial support by contract riders.

HST – Issues (con't)

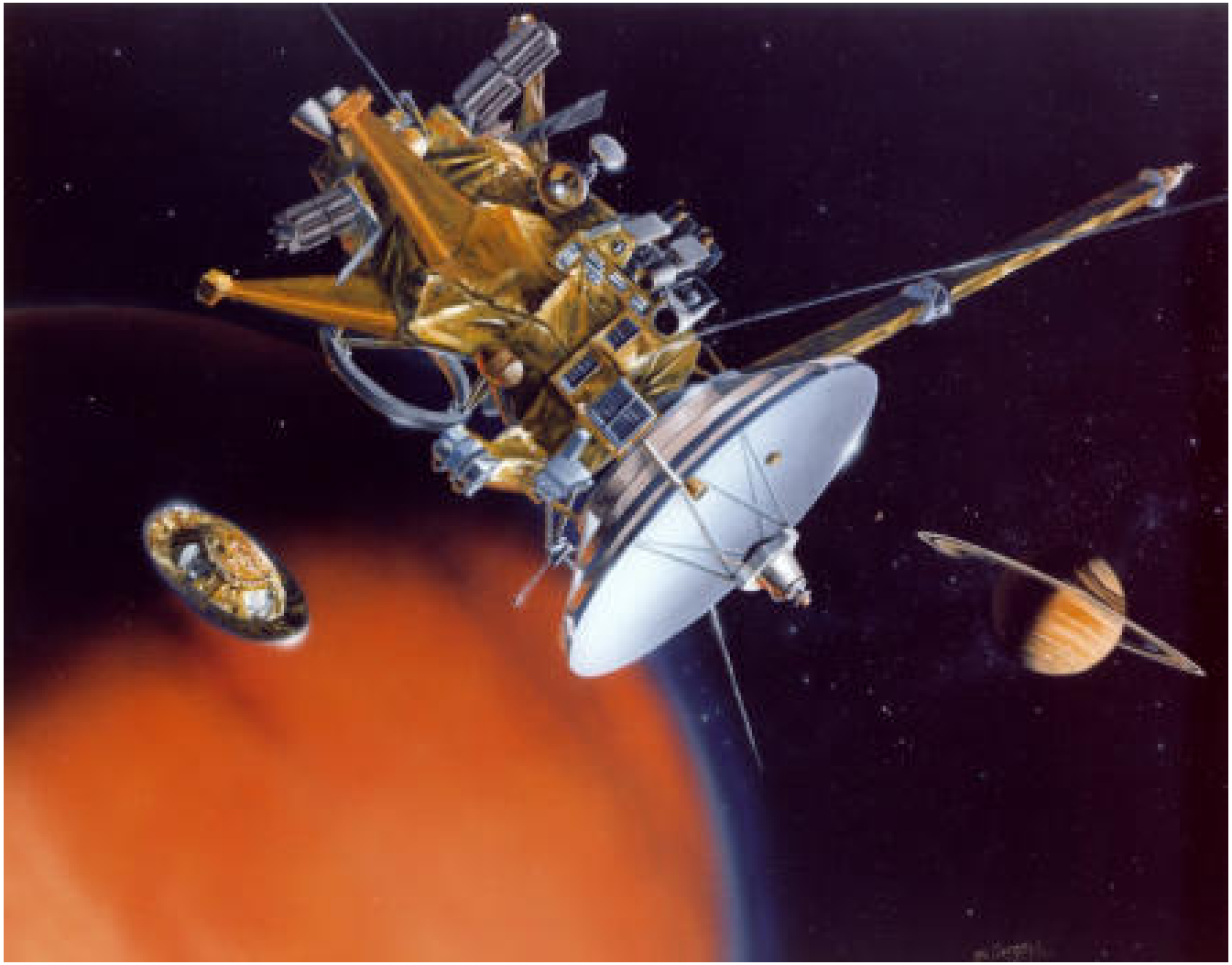
- **Issues**
  - **Several interface issues between European and US contractors during development phase could not be resolved at contractor level.**
  - **Original set of solar panels was oversensitive to temperature variations during Hubble's orbit which led to pointing accuracy problems (Discovered in orbit after April 1990 launch).**

- **Measures Taken**
  - **All issues were resolved by ESA/NASA project managers as part of normal work with the respective industry counterpart. Time consuming effort but ESA/NASA involvement mandatory.**
  - **A second set of Solar Panels were installed during the first servicing mission (December 1993). The second set was modified and had a more advanced system of springs to reduce vibration induced by temperature variations (Bright side of the orbit to dark side and vice versa). After installation vibrations were reduced dramatically.**

Cassini/Huygens

- **Purpose**
  - A joint ESA/NASA mission to explore the Saturnian system including Saturn's atmosphere, rings and magnetosphere and some of its moons – Titan and the icy satellites.
  - The spacecraft comprise NASA's Cassini orbiter and ESA's Huygens probe. The Italian Space Agency (ASI) is a major partner through a bilateral NASA/ASI agreement. ASI provided the Cassini telecommunication equipment.
- **Launch of Cassini-Huygens**
  - Launched 15 October, 1997 aboard a Titan IVB/Centaur.
- **Mass of the Orbiter + Huygens**
  - 5.82 tons
- **Swingbys**
  - To reach Saturn, Cassini had to use a series of gravity-assist manoeuvres, with the following swingbys:
    - Venus 26 April 1998
    - Venus 24 June 1999
    - Earth 18 August 1999
    - Jupiter 30 December 200
- **Arival at Saturn**
  - Saturn orbit assertion (SOI) 1 July 2004
- **Cassini Orbiter Mission Duration at Saturn**
  - 4 Years (nominal mission ends July 2008)

Cassini/Huygens



Cassini/Huygens

- The Huygens probe after separation from the orbiter will descend through the atmosphere of Titan taking in situ samples, measuring the physical and chemical properties of the atmosphere and making images of the clouds and the surface.
  - Huygens probe: 319 kg (44 kg payload – 6 Instruments including 2 US funded)
  - Associated Equipment (Receiver) on Board Orbiter: 30 kg
  - Cruise phase: 22 days after orbiter release.
  - Descent phase: 150 minutes.
  - Operation on Surface: 3 – 30 minutes.

Cassini/Huygens

- ESA Contribution
  - Huygens probe
  - Probe support equipment
  - Probe operation responsibility during probe check-outs and Probe relay activities
- ESA / NASA Organization
  - ESA project office ESTEC (The Netherlands)
  - Industrial prime contractor: Aerospatiale Cannes, FRANCE
  - NASA project office JPL
- Interface with JPL
  - Project reviews attendance (probe and orbiter)
  - Quarterly reviews alternatively in Europe and US.
  - Weekly telecons
  - US resident at DASA/MBB Munich for probe system AIT
  - European residents at JPL for EM probe/Cassini AIT
  - European team at KSC for launch campaign
- Development Phase
  - 1990 to launch in October 1997
- Operational Phase
  - 1997 through 2008

Cassini/Huyens – Main Issues

- **Issues**
  - Spacecraft Model Policy
    - JPL protoflight model
    - ESA classical model philosophy
      - Structural thermal model
      - Engineering model
      - Flight model
  - Engineering Model Build Standard
    - ESA EM limited to electrical and software test
    - JPL EM able to withstand environmental tests
  - Radio Isotope Heaters Unit (RHU)
    - US/DOE equipment not deliverable to Europe
  - Additional Independent Audit
    - NASA HQ request one year before launch

- **Measures Taken**
  - Probe STPM and EM delivered to JPL to be integrated with Cassini PFM.

    FM support equipt. delivered to JPL.

    FM probe directly to KSC.
  - Need to realign some tests with the requested models: EM STPM swaps at JPL.
  - Heater simulators used during thermal testing in Europe.

    RHU integrated at KSC under DOE surveillance.
  - ESA agreed reluctantly at first but review conducted very professionally and final recommendations appreciated.

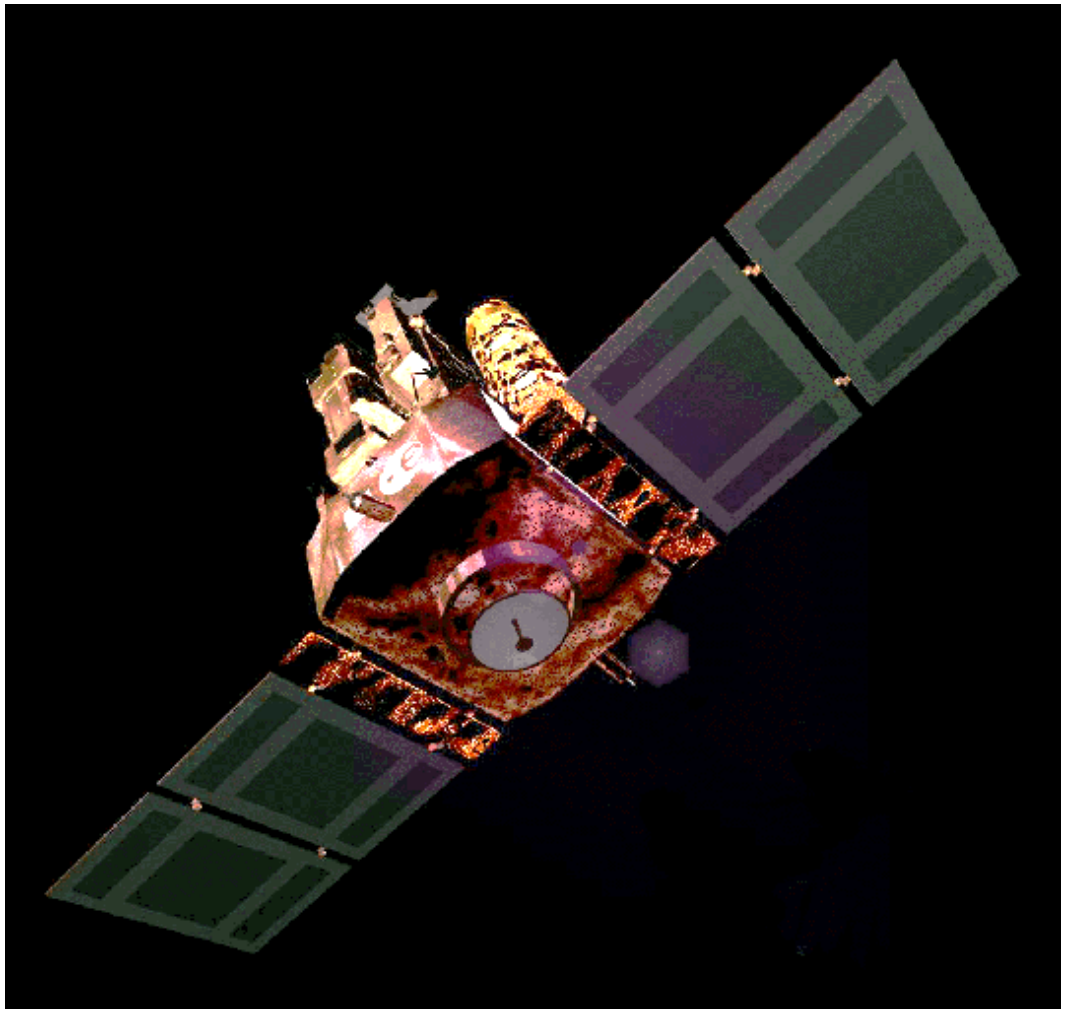
Cassini/Huygens – Main Issues (con't)

- **Issues**
  - Comet Rendez-Vous Asteroid fly-by cancellation
    - CRAF spacecraft cancellation by NASA due to budget constraints led to ESA NASA interface changes (Late 1990)
    - CRAF supposed to be a sister ship to Cassini with propulsion system delivered by German Space Agency
  - Probe cooling on launch pad
    - Too strong an Airflow on launch pad caused potential damage inside probe module
  - Probe receiver anomaly
    - Anomaly discovered during the first in-flight test in February 2000 of the probe relay link. Investigation team confirmed the flaw in the European built receiver

- **Measures Taken**
  - JPL took over the propulsion module responsibility.

    Budget constraints led to cancellation of the JPL provided dedicated probe relay antennae. Decision to use The High Gain Antennae. New interface worked out satisfactorily
  - Disassembling of probe and repair of damaged thermal foam isolation. Two weeks delay on launch date. Inquiry board traced the problem to ICD misinterpretation
  - Joint JPL/ESA recovery task force analyzed the receiver failure mode and devised scenario to recover the mission. Currently under implementation. ESA personnel resident at JPL to this effect.

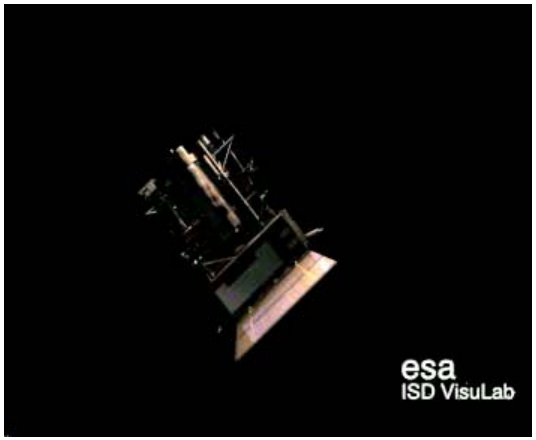
SOHO
Solar and Heliospheric Observatory

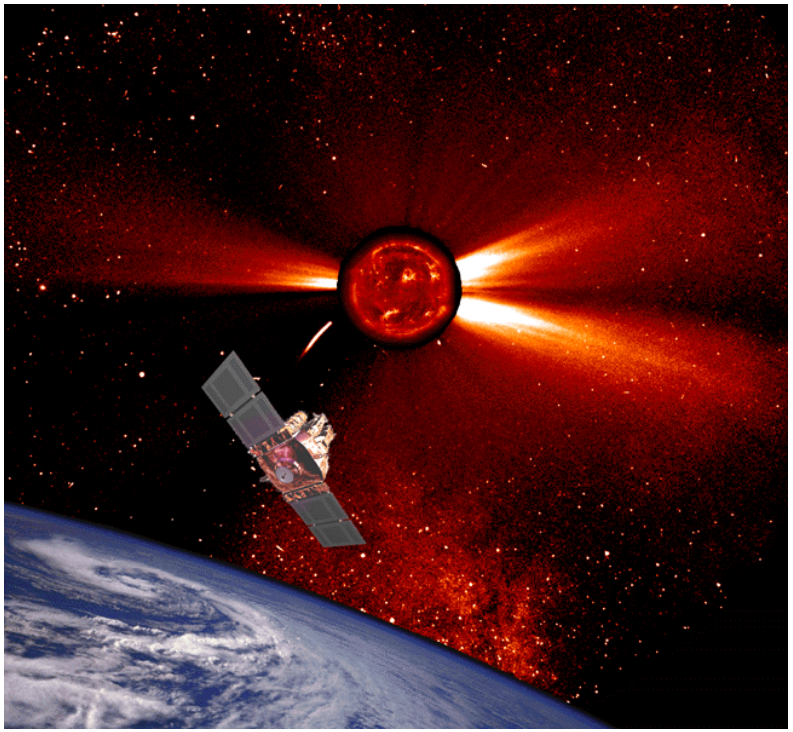


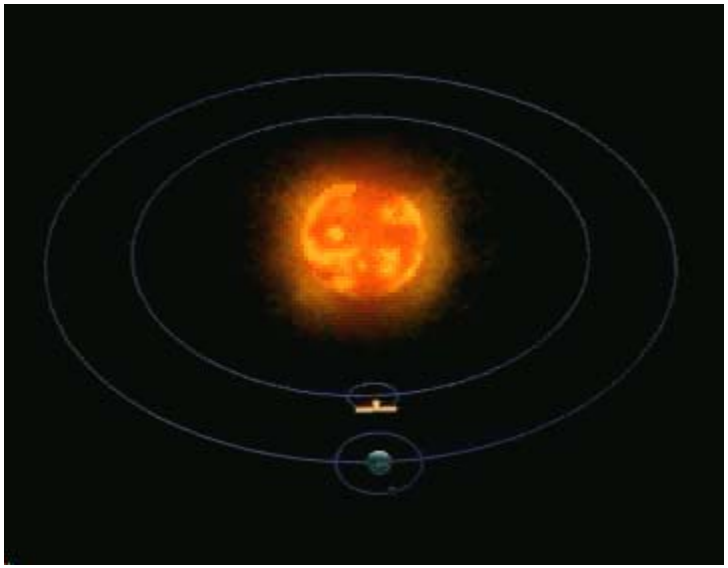
- SOHO is a joint ESA/NASA project in which ESA is a senior partner. It is also a contribution to the International Solar Terrestrial Physics program including ESA/NASA and the space agencies of Japan, Russia, Sweden, and Denmark.
- SOHO is stationed at 1.5 million km out on the sunward side of the earth (Lagrange point #1)
- SOHO studies the Sun 24 hours a day.

Science Objectives

- Solar Interior: What are its structure and dynamics?
- Corona: Why does it exist and how is it heated?
- Solar Wind: Where is it accelerated and how?

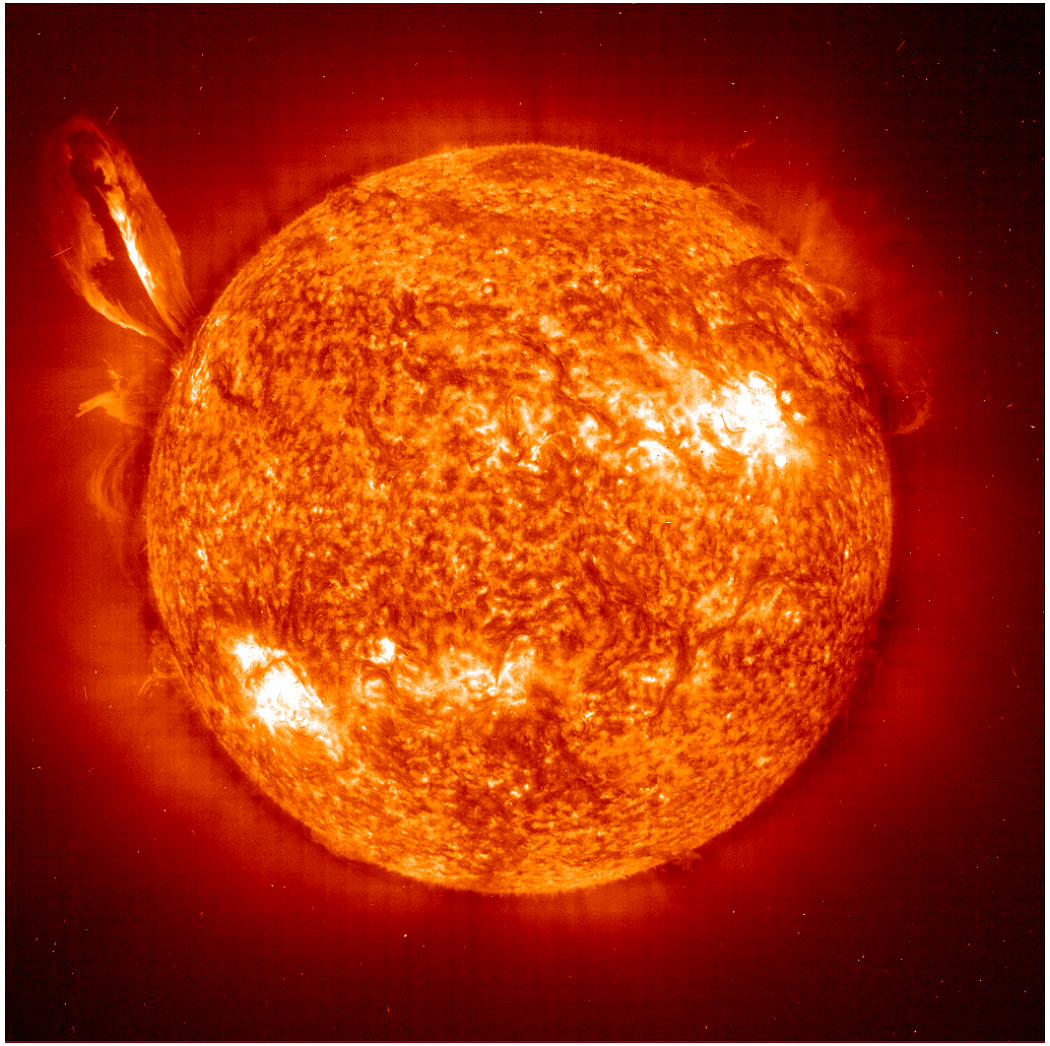






The Beauty of the Sun

EIT He II 304 Å 27 July 1999



SOHO

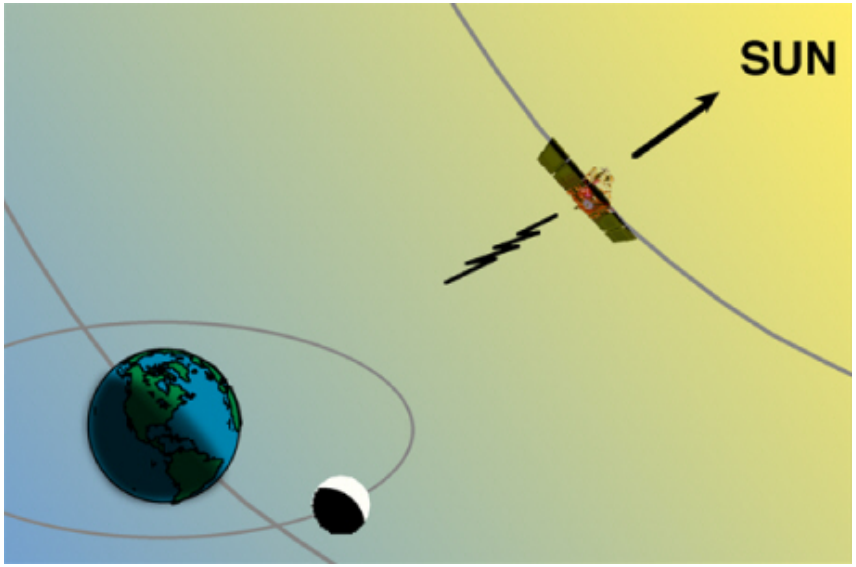
- **ESA Contribution**
  - SOHO was built for ESA by industrial companies in 14 European countries, led by Matra Marconi. The service module, with solar panels, thrusters, attitude control systems, communications and housekeeping functions, was prepared in Toulouse, France. The payload module carrying the 12 scientific instruments was assembled in Portsmouth, UK, and mated with the service module in Toulouse, France.
  - The total mass of the spacecraft at launch was 1 850 kg (payload 655kg). Its overall length along the sun-pointing axis is 4.3 metres, and the span of the extended solar panels is 9.5 metres.

- **NASA Contribution**
  - Two US instruments
  - Launcher Atlas II AS
  - Mission operation from GSFC (Command, telemetry data, flight dynamic support and orbit determination)
  - DSN stations

SOHO Organization

- **Development Phase**
  - **ESA**
    - **Project office at ESTEC (The Netherlands)**
    - **Prime contractor: Matra: Toulouse, FRANCE**
  - **NASA**
    - **Project office at GSFC**
    - **Responsible for operation preparation/spacecraft simulator/US instruments**
  - **Nominal Interface**
    - **Quarterly progress meeting GSFC/ESTEC**
    - **Formal project reviews attendance**
- **Operational Phase**
  - **ESA management and technical resident team at GSFC (Full integration with NASA operational team)**
  - **ESA scientific team at GSFC (Full integration with NASA SOHO Project scientists)**
  - **Respective responsibilities of ESA and NASA clearly established and approved by the Mission Management Plan**

SOHO Operations



- Mission control for SOHO is at NASA's Goddard Space Flight Centre near Washington DC. Communication with the spacecraft goes via big radio dishes of NASA's Deep Space Network, located near Goldstone (California), Canberra (Australia) and Madrid (Spain). The main tasks of the controllers are to keep SOHO pointing at the Sun and to maintain its halo orbit that takes it around Lagrange Point No. 1 roughly every six months. SOHO has an Emergency Sun Reaquisition routine to point it automatically at the Sun in the event of mishaps.
- Also based at Goddard is a scientific team led by ESA and NASA's project scientists, which plans and executes daily programmes of observations with SOHO's 12 sets of instruments. The principal investigators responsible for the instruments are in continual touch via the Internet, and attend periodic meetings of the Science Working Team. Some of the instrumental teams have permanent representatives at Goddard.

SOHO – Main Issues
Development Phase

- **Issues**
  - **According to the draft MOU, AIT activities were to be performed at GSFC.**

    Based on facilities available at the time at GSFC and in Europe (Solar simulation thermal vacuum chamber) The decision was made by ESA not to come to the US.

- **Measure Taken**
  - **Initial "quid pro quo" was revised - shift of financial share between ESA and NASA was renegotiated.**

    NASA saving was converted to goods and/or services to be provided by NASA after agreement of both project managers

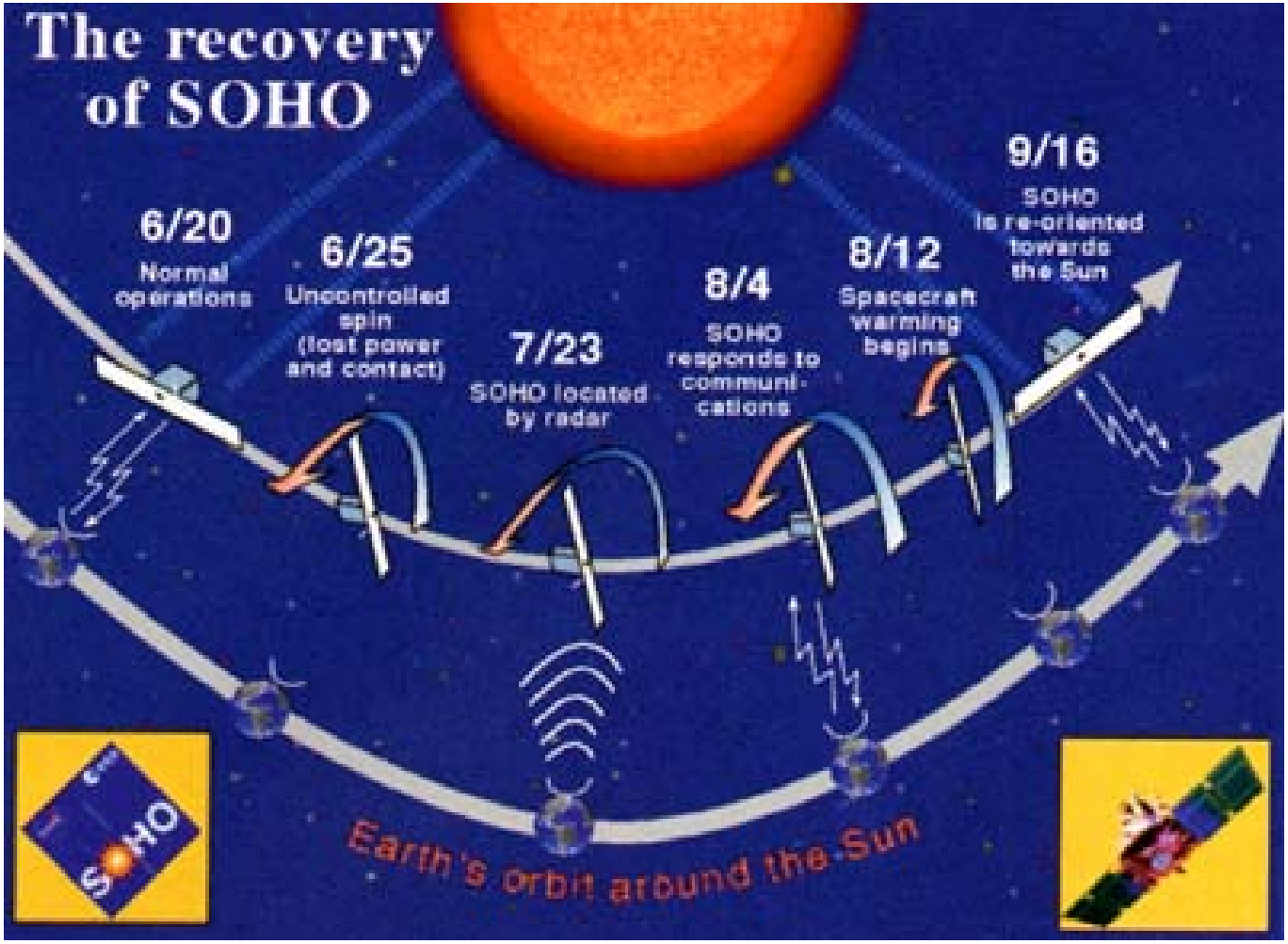
SOHO – Main Issues
Operational Phase

- **Issue**
  - **Spacecraft Contact Lost**
    - **Contact with spacecraft was lost on June 25, 1998 during a planned manoeuver**
  - **Gyro Failure**
    - **Two gyros out of three were found dead after recovery. Last gyro failed in December 1998**

- **Measures Taken**
  - **Very quick reaction**
  - **A joint ESA/NASA engineering team planned and executed a successful recovery effort from GSFC in the following six months. By December 1998 the spacecraft was fully operational with only one working gyro.**

    In parallel to recovery effort an ESA/NASA inquiry board made recommendations to avoid the repeat of the spacecraft loss. All board recommendations are now fully implemented at GSFC.
    - **ESA/NASA operational team reinforced**
    - **Spacecraft simulator upgraded**
    - **Operational risk continuously evaluated**
    - **Strict configuration control in place**
  - **Gyroless software was developed and tested in Europe and uploaded to the spacecraft in October 1999**

SOHO Recovery



SOHO
Operational Phase

- SOHO has been fully operational since January 1999 in a transitional mode and since October 1999 in the new gyroless mode.
- The ESA / NASA fully integrated operational team in place since January 1999.
- The first extension of the programme to March 2003 is almost completed.
- A second extension of 4 years through 2007 has been approved and funded by ESA and NASA

3. Conclusion – Lessons Learned

- **ESA / NASA Collaboration**
  - **Scientific collaborative program are motivated by:**
    - **Common scientific interest with similar objectives of European and US scientific community**
    - **Available ESA or NASA funding at the time of the programme decision (resource sharing)**
    - **Political motivation**
    - **Technology availabilty**
  - **Most difficult phase is the negotiation preceding the programme decision**

    Who is doing what? Respective contribution agreement
    - **Interface should be minimized as much as possible. A complicated technical interface or management organization will always create problems during the development phase.**

Conclusion (Con't)
Lessons Learned

- ESA/NASA collaborative programs were always successful. In spite of different culture and/or background, no major issued were encountered
- All the issues were solved at project level. There was no need to involve our respective HQ during development phase
- How to improve our working relationship
  - ESA: be aware of the different partner's center culture/background; I.e. GSFC, MSFC, JPL, KSC
  - NASA: ESA establishment, background, and working attitude are rather similar; I.e. ESOC, ESTEC

    Be aware of the different prime contractor culture and sensitivity
  - Pay considerable attention to interface definition:
    - IRD – ICD should be under configuration control as soon as possible
  - Define very early on the protocol to deal with interface changes. Change request procedure to be agreed by both parties
  - Do not under estimate the amount of information and date exchange
    - "Open Books" project attitude
    - Attendance of all partner's formal reviews
    - Hold weekly telecons
    - Have direct project manager to project manager involvement (In order to build mutual trust)
    - Consider resident team early on

Conclusion (Con't)
Lessons Learned

- Understand your partner's objectives and his constraints
- Define clearly your own objectives and constraints
- Industry to Industry interface could be accepted and authorized at working technical level but ESA and NASA project approval are mandatory in case of any changes.
- Remember that no exchange of funds is to take place during the programme duration and that project budget approval are different in Europe and US
- Be aware of vocabulary differences (Same name but different meaning)
  - Engineering model - different build standard
  - Major project review – same name but different schedule and objectives
- Do not blame your partner in case of difficulty but help him in solving it (team effort)
- Build an integrated team with the same objectives
- Do not fight the system but find acceptable work around
- Create a working atmosphere of mutual trust.