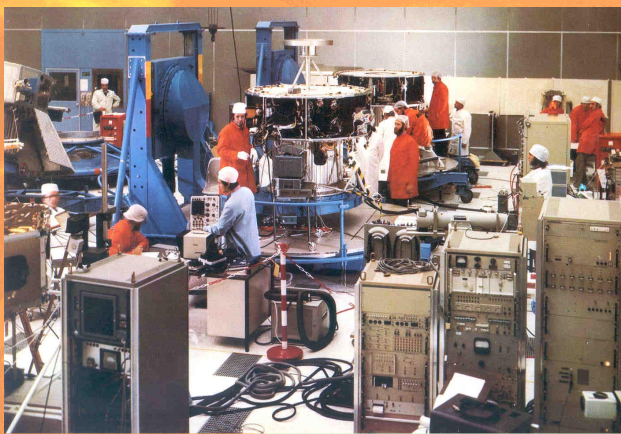
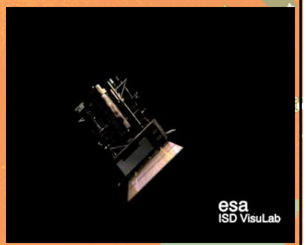
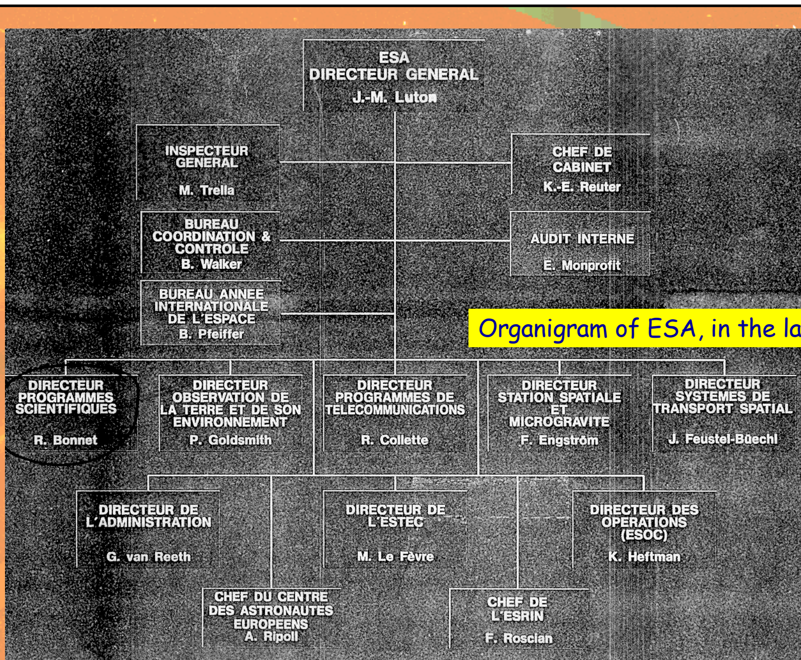
Space Instrumentation (13)

Lectures for the IMPRS June 23 to June 27 at MPAe Lindau
Compiled/organized by Rainer Schwenn, MPAe,
supported by Drs. Curdt, Gandorfer, Hilchenbach, Hoekzema, Richter, Schühle

Fri, 27.6., 15:00 How to do experimental research in space (RS)

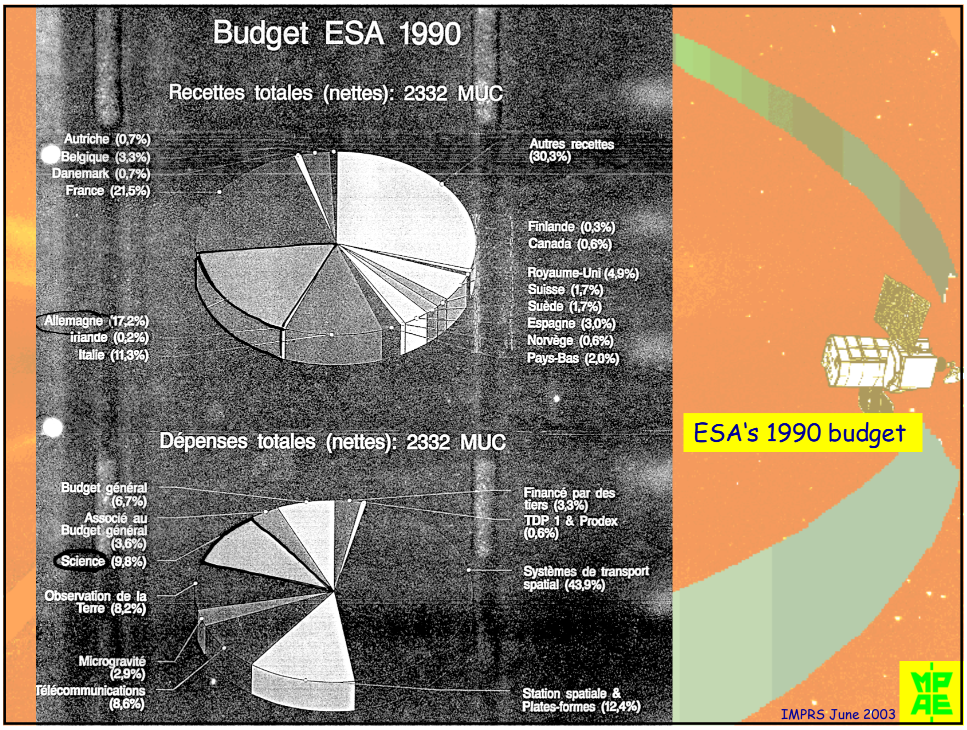






Organigram of ESA, in the late 1980s

http://www.esa.int/export/esaCP/GGGZM2D3KCC_index_0.html



Répartition géographique des contrats

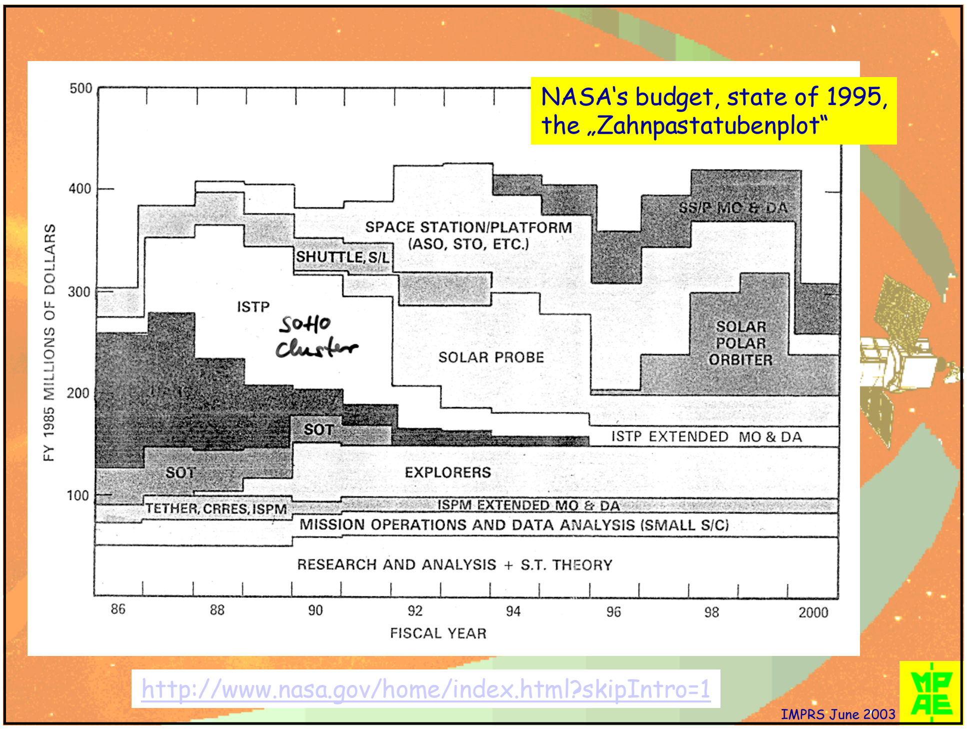
Coefficients de retour global (en milliers d'unités de compte)

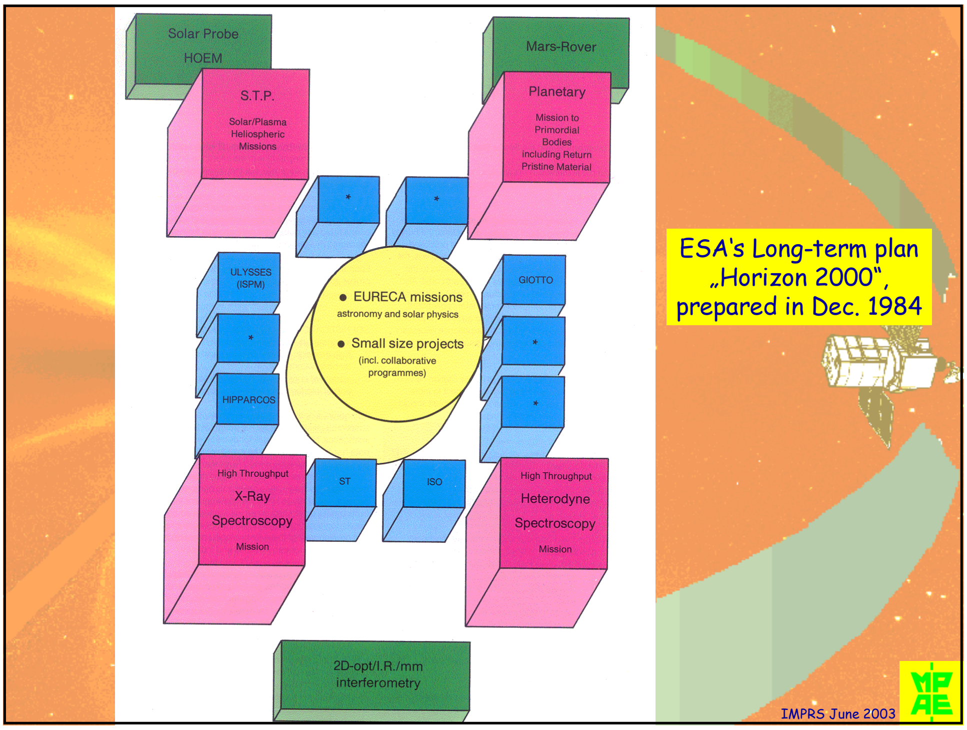
Return of funds to ESA countries by industry contracts etc

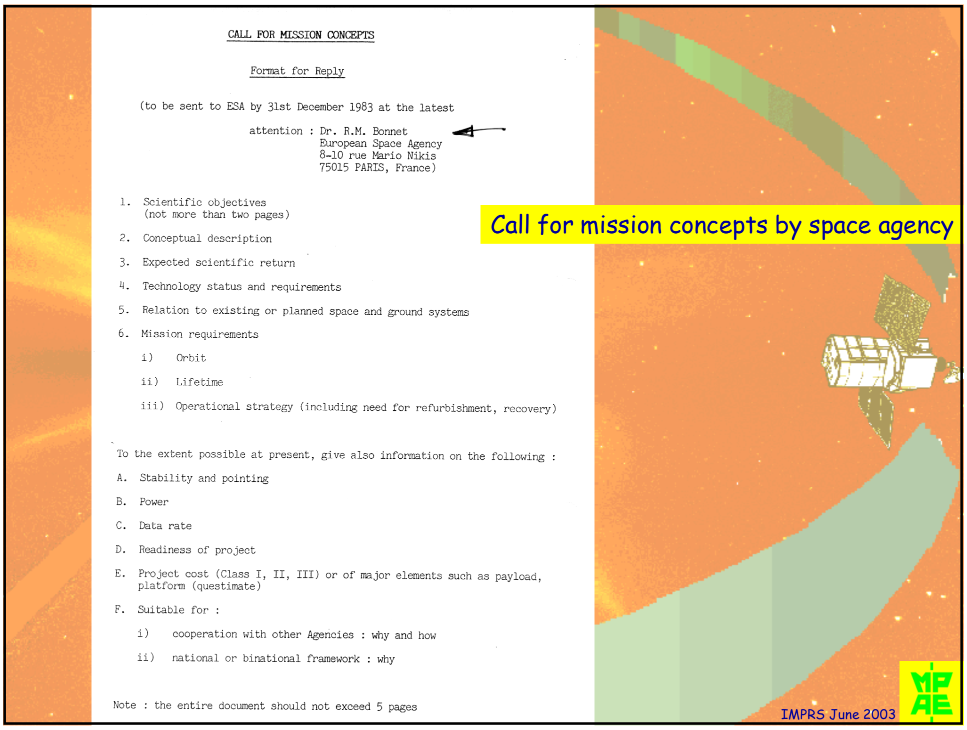
Du 1er janvier 1972 au 31 décembre 1990

	Montant des contrats		Contributions %	Montant idéal	Coefficient de retour	Excédent/ Déficit
Etats membres	Non pondéré	Pondéré				
Allemagne	3120,438	2826,085	24,29	2716,987	1,04	109,098
Autriche	56,246	49,961	0,51	57,170	0,87	– 7,209
Belgique	582,835	481,391	4,61	516,396	0,93	– 35,005
Danemark	150,439	121,465	1,05	117,253	1,04	4,212
Espagne	410,852	339,466	3,21	358,746	0,95	– 19,280
ance	4552,286	3900,749	34,99	3913,929	1,00	– 13,180
rlande	25,097	21,967	0,15	16,739	1,31	5,228
Italie	1675,015	1536,983	13,94	1559,509	0,99	– 22,526
Norvège	49,433	48,544	0,48	54,010	0,90	– 5,466
Pays-Bas	474,769	324,824	2,78	310,924	1,04	13,900
Royaume-Uni	1246,721	1012,552	8,72	975,307	1,04	37,245
Suède	271,474	231,443	2,27	253,629	0,91	– 22,186
Suisse	253,998	226,692	2,00	223,865	1,01	2,827
Sous-total	12 869,603	11 122,122	99,00	11 074,464		
Etats associés						
Canada	102,631	101,939	0,92	103,499	0,98	– 1,560
Finlande	2,752	2,630	0,08	8,652	0,30	– 6,022
Sous-total	105,383	104,569	1,00	112,151		
ESA total	**12 974,986**	**11 226,691**	**100,00**	**11 186,615**		
Autres Etats						
pon	277	8				
Autres	15,165	3,689				
Etats-Unis	223,764	165,120				
Sous-total	**239,206**	**168,817**				
Total général	**13 214,192**	**11 395,508**				

IMPRS June 2003


NASA's budget, state of 1995,
the „Zahnpastatubenplot"
FY 1985 MILLIONS OF DOLLARS
500
400
300
200
100
SPACE STATION/PLATFORM (ASO, STO, ETC.)
SHUTTLE, S/L
SS/P MO & DA
ISTP
SoHo
Cluster
SOLAR PROBE
SOLAR POLAR ORBITER
SOT
ISTP EXTENDED MO & DA
SOT
EXPLORERS
TETHER, CRRES, ISPM
ISPM EXTENDED MO & DA
MISSION OPERATIONS AND DATA ANALYSIS (SMALL S/C)
RESEARCH AND ANALYSIS + S.T. THEORY
86
88
90
92
94
96
98
2000
FISCAL YEAR
http://www.nasa.gov/home/index.html?skipIntro=1
IMPRS June 2003


Solar Probe
HOEM
S.T.P.
Solar/Plasma Heliospheric Missions
Mars-Rover
Planetary
Mission to Primordial Bodies including Return Pristine Material
ULYSSES (ISPM)
HIPPARCOS
GIOTTO
EURECA missions
astronomy and solar physics
Small size projects
(incl. collaborative programmes)
ST
ISO
High Throughput X-Ray Spectroscopy Mission
High Throughput Heterodyne Spectroscopy Mission
2D-opt/I.R./mm interferometry
ESA's Long-term plan „Horizon 2000", prepared in Dec. 1984
IMPRS June 2003



CALL FOR MISSION CONCEPTS

Format for Reply

(to be sent to ESA by 31st December 1983 at the latest

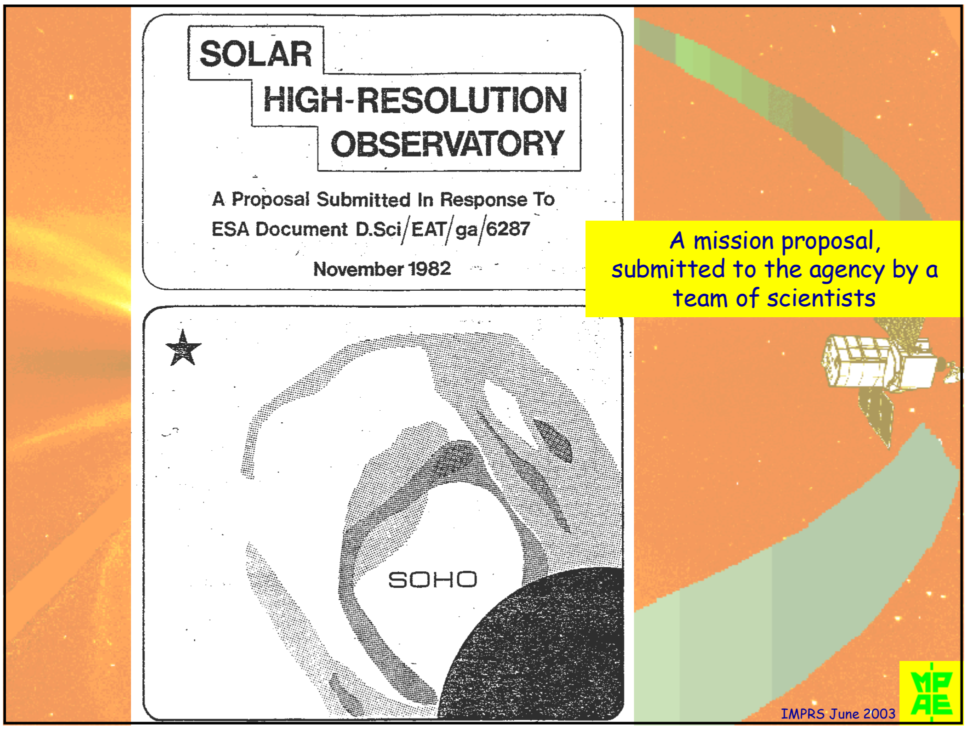
attention : Dr. R.M. Bonnet
European Space Agency
8-10 rue Mario Nikis
75015 PARIS, France)

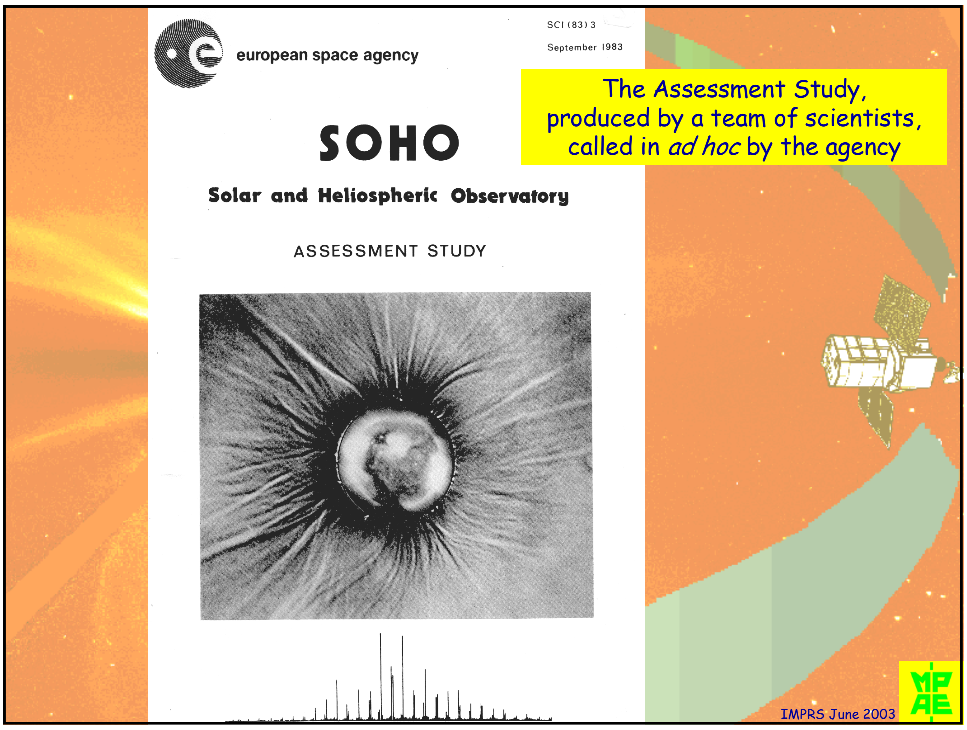
1. Scientific objectives
(not more than two pages)
2. Conceptual description
3. Expected scientific return
4. Technology status and requirements
5. Relation to existing or planned space and ground systems
6. Mission requirements
   i) Orbit
   ii) Lifetime
   iii) Operational strategy (including need for refurbishment, recovery)

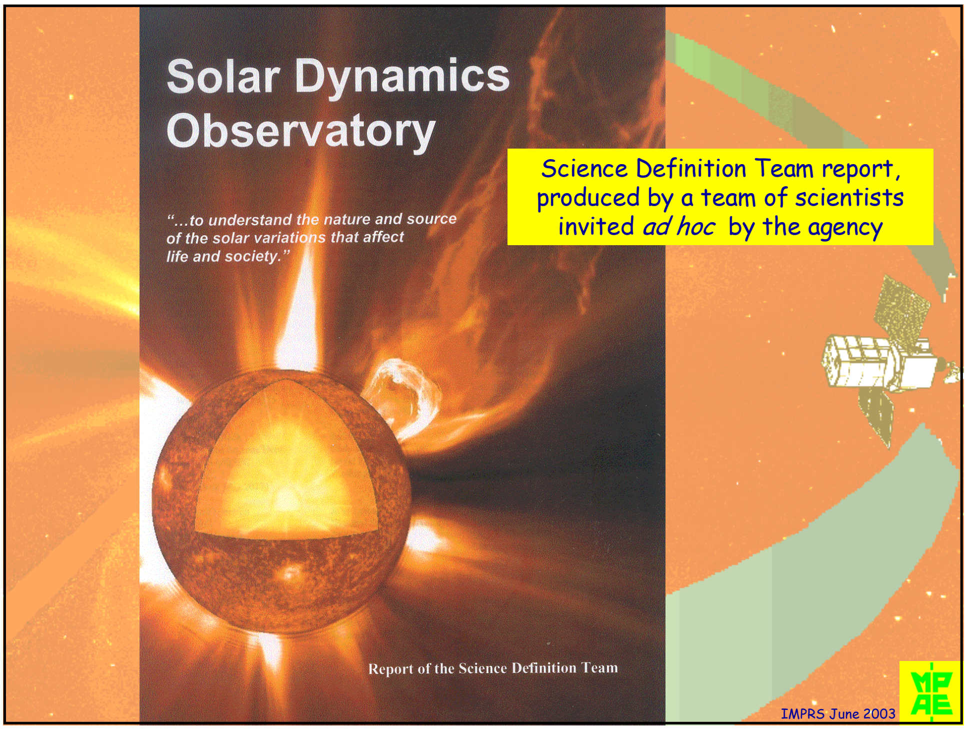
To the extent possible at present, give also information on the following :

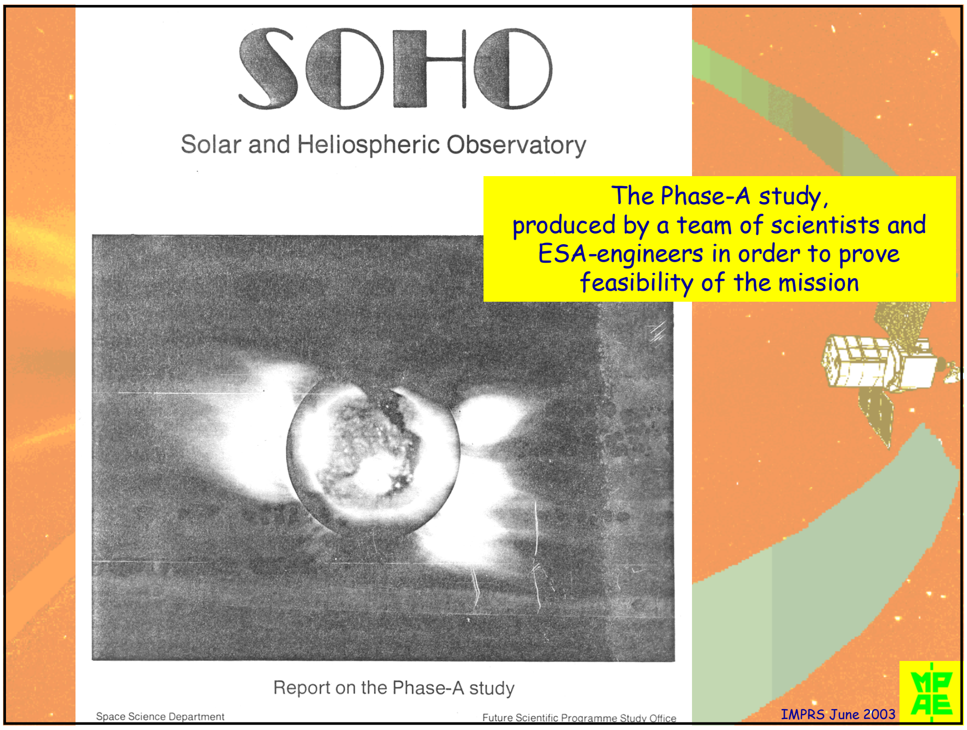
A. Stability and pointing
B. Power
C. Data rate
D. Readiness of project
E. Project cost (Class I, II, III) or of major elements such as payload, platform (questimate)
F. Suitable for :
   i) cooperation with other Agencies : why and how
   ii) national or binational framework : why

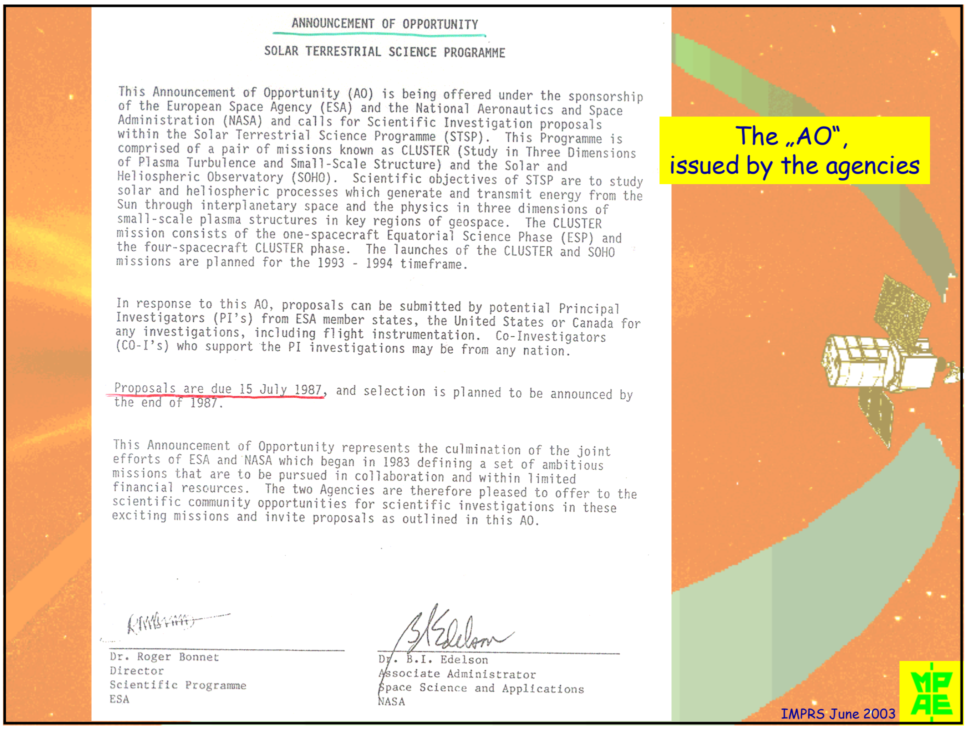
Note : the entire document should not exceed 5 pages




SCI (83) 3
September 1983
european space agency
SOHO
Solar and Heliospheric Observatory
ASSESSMENT STUDY
The Assessment Study,
produced by a team of scientists,
called in *ad hoc* by the agency
IMPRS June 2003


Solar Dynamics
Observatory
"...to understand the nature and source
of the solar variations that affect
life and society."
Report of the Science Definition Team
Science Definition Team report,
produced by a team of scientists
invited *ad hoc* by the agency
IMPRS June 2003





ANNOUNCEMENT OF OPPORTUNITY

SOLAR TERRESTRIAL SCIENCE PROGRAMME

This Announcement of Opportunity (AO) is being offered under the sponsorship of the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA) and calls for Scientific Investigation proposals within the Solar Terrestrial Science Programme (STSP). This Programme is comprised of a pair of missions known as CLUSTER (Study in Three Dimensions of Plasma Turbulence and Small-Scale Structure) and the Solar and Heliospheric Observatory (SOHO). Scientific objectives of STSP are to study solar and heliospheric processes which generate and transmit energy from the Sun through interplanetary space and the physics in three dimensions of small-scale plasma structures in key regions of geospace. The CLUSTER mission consists of the one-spacecraft Equatorial Science Phase (ESP) and the four-spacecraft CLUSTER phase. The launches of the CLUSTER and SOHO missions are planned for the 1993 - 1994 timeframe.

In response to this AO, proposals can be submitted by potential Principal Investigators (PI's) from ESA member states, the United States or Canada for any investigations, including flight instrumentation. Co-Investigators (CO-I's) who support the PI investigations may be from any nation.

Proposals are due 15 July 1987, and selection is planned to be announced by the end of 1987.

This Announcement of Opportunity represents the culmination of the joint efforts of ESA and NASA which began in 1983 defining a set of ambitious missions that are to be pursued in collaboration and within limited financial resources. The two Agencies are therefore pleased to offer to the scientific community opportunities for scientific investigations in these exciting missions and invite proposals as outlined in this AO.

Dr. Roger Bonnet
Director
Scientific Programme
ESA

Dr. B.I. Edelson
Associate Administrator
Space Science and Applications
NASA

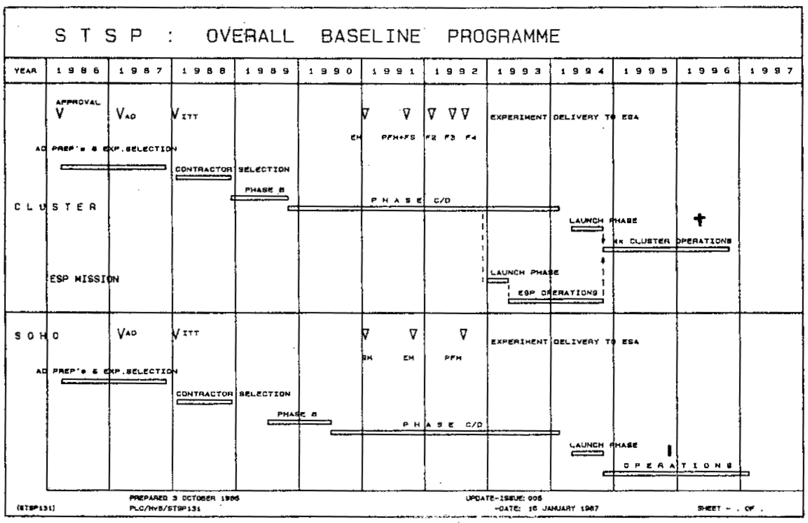
August 31, 1992
A.O. No. OSSA 2-92

The „AO“, issued by the agencies

Announcement of Opportunity

Small Explorer Missions

Notice of intent due: October 16, 1992   Proposals due: December 18, 1992



The first time schedule, as given in the AO

INSTRUMENT	ACRONYMN	MASS (KG)	POWER (W)	TELEMETRY (KPBS)
GRAZING INCIDENCE SPECTROMETER	GIS	120	57	12.0
NORMAL INCIDENCE SPECTROMETER	NIS	130	44	10.0
U.V. CORONAL SPECTROMETER	UVCS	165	36	5.0
WHITE LIGHT CORONOGRAPH	WLC	64	46	4.2
EUV IMAGING TELESCOPE	EIT	16	30	0.8
SOLAR OSCILLATIONS IMAGER	SOI	53	59	5.0 (160*)
HIGH RESOLUTION SPECTROMETER	HRS	38	22	0.1
SOLAR IRRADIANCE MONITOR	SIM	16	15	
MAGNETOMETER	MAG	2	3	
SOLAR WIND PLASMA ANALYSER	SWP	8	8	0.6
SOLAR WIND COMPOSITION ANALYS.	SWC	13	13	0.8
SUPRATHERMAL PARTICLE ANALYSER	STP	8	7	0.5
ENERGETIC PARTICLE ANALYSER	EPA	14	12	0.7
TOTAL		647	352	40 (200*)

* DURING HIGH DATA RATE OPERATIONS

Science payload for SOHO,
as listed in the AO, 1987

Part 1: Scientific/Technical Plan PROPOSAL NO. 41-T-202-88

In Response to Announcement OSSA-1-87

A Proposal to the National Aeronautics and Space Administration
and the European Space Agency

for

An Investigation of the Inner and Extended Outer Solar Corona Using
A WIDE-FIELD WHITE LIGHT AND SPECTROMETRIC CORONAGRAPH FOR SOHO (LASCO)

Principal Investigator: Donald J. Michels
Code 4173, Naval Research Laboratory, Washington, DC 20375, USA
Telephone: (202)767-2737; Telex: 5106012629(NRL4173); Telefax: (202)767-5636

Project Scientist for Europe and Co-Investigator: Rainer Schwenn, MPAE
U.S. Project Scientist and Co-Investigator: Russell A. Howard, NRL

Program Scientist: John-David F. Bartoe, NRL

Co-Investigators:

Naval Research Laboratory
Spiro K. Antiochos
Guenter E. Brueckner
Kenneth P. Dere
George A. Doschek
John T. Mariska
Neil R. Sheeley, Jr.
Dennis G. Socker

Max-Planck-Institut für Aeronomie
Patrick W. Daly
Bernd Inhester
Horst Uwe Keller
J. Rainer Kramm
Helmut Rosenbauer

Laboratoire d'Astronomie Spatiale
Philippe Lamy [Coordinator for France]
Antoine Llebaria
Andre Maucherat

Eugene N. Parker
University of Chicago

Stephen W. Kahler
Emmanuel College, Boston

Serge L. Koutchmy
Institut d'Astrophysique, Paris

Raymond N. Smartt
National Solar Observatory
Sacramento Peak, New Mexico

William J. Wagner
NOAA/Space Environment Laboratory
Boulder, Colorado

Jean-Louis Bougeret
Département de Recherche Spatiale
Observatoire de Paris, Meudon

Monique Pick
Département d'Astronomie Solaire et Planètaire
Observatoire de Paris, Meudon

Jacques-Clair Noëns
Observatoire du Pic du Midi

Richard H. Giese
Ruhr-Universität, Bochum

Martin J. Koomen
Sachs/Freeman Associates
Landover, Maryland

Frank Giovane
Nebil Y. Misconi
Space Astronomy Laboratory
University of Florida, Gainesville

U.S. funding is requested

The „proposal",
in respones to the AO,
produced by a dedicated
team of scientists

Dr. Donald J. Michels
Code 4173
Naval Research Laboratory
Washington, DC 20375

Proposal selected by the agency!

Dear Dr. Michels:

On March 1, 1987, the Announcement of Opportunity (AO) OSSA-87-1, was jointly issued by the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA) for the Solar Terrestrial Science Programme (STSP). The STSP encompasses both the Solar and Heliospheric Observatory (SOHO) and the Cluster missions. You submitted a proposal for a science investigation entitled "A Wide Field White Light and Spectrometric Coronagraph for SOHO (LASCO)" in response to this AO, specifically for flight as part of the payload for the SOHO mission. In my letter dated March 11, 1988, I informed you that the revised version of your proposal was provisionally selected for a NASA Investigation Definition Phase (IDP) pending confirmation of the recommended STSP payloads by the ESA Science Programme Committee (SPC).

The SPC has now met and has confirmed the recommended STSP payloads. I am, therefore, pleased to tell you that the revised version of your proposal, as named above, is hereby selected for the NASA STSP IDP. You are hereby appointed as Principal Investigator (PI) of this revised science investigation and, therefore, responsible for meeting all obligations associated with this investigation. The individuals listed on Enclosure 1, as derived from your proposal, are appointed as your Co-Investigators.

For your information, Enclosure 2 is a NASA press release giving the complete listing of all the investigations selected for this program, as jointly agreed by ESA and NASA. Please feel free to use this release for local publication, consistent with the public relations policies of your institution.

It is important that you should be aware that your selection for the IDP was made on the assumption of certain cost savings in your investigation, to be discussed in detail with you by the GSFC Project Office. In particular, you are strongly encouraged to pursue possible collaborations with foreign nations for collaborations that could effect a cost savings to NASA for your revised proposal. Additionally, we note (i) that your revised proposal contains deficiencies in the areas of models as specified in the AO and which, therefore, must be negotiated during the IDP; and (ii) that the United Kingdom has indicated to us the strong likelihood of providing some of the hardware for your revised investigation.

Investigation	Principal Investigator	Measurements	Technique	Mass (kg)	Power (W)	Bit rate kb/s
HELIOSEISMOLOGY						
Global oscillations at low frequencies (GOLF)	A. Gabriel, LPSP, Verrières-le-Buisson, F	Global Sun velocity and magnetic field oscillations Harmonic degree l = 0-4	Na-vapour resonant scattering cell, Doppler shift & circular polarization	31.2	30.0	0.128
Variability of solar irradiance (VIRGO)	C. Fröhlich, PMOD/WRC, Davos, CH	Low degree (l=0-7) irradiance oscillations and solar constant	Global Sun & low resolution (12 pixels) imaging, active cavity radiometers	14.6	16.6	0.1
Michelson Doppler imager (MDI/SOI)	P.H. Scherrer, Stanford Univ., Calif.	Velocity oscillations, high degree modes (up to l = 4500)	Doppler shift with Fourier tachometer, 4 & 1.5 arc sec resolution	43.4	55.0	5 (+160) *
SOLAR ATMOSPHERE REMOTE SENSING						
Solar ultraviolet emitted radiation (SUMER)	K. Wilhelm, MPAE, Lindau, D	Plasma flow characteristics (temperature, density, velocity) chromosphere through corona	Normal incidence spectrometer, 50-160 nm, spectral resolution 2 - 40000, angular res.1.2 - 1.5"	88.0	35.0	10.5
Coronal diagnostic spectrometer (CDS)	B.E. Patchett, RAL, Chilton, UK	Temperatures and density : transition region & corona	Grazing incidence spectrometer 17-50 nm, spectr. res. 5000, angular res. 2"	84.4	45.0	12
Extreme-ultraviolet imaging telescope (EIT)	J.P. Delaboudinière, LPSP, Verrières-le-Buisson, F	Evolution of chromospheric and coronal structures	Images (1024 x 1024 pixels in 42'x 42') at lines of He I, Fe IX, Fe XII & Fe XV	17.5	27.5	1
Ultraviolet coronagraph spectrometer (UVCS)	J.L. Kohl, SAO, Cambridge, Mass.	Electron & ion temperatures densities, velocities in corona (1.3 - 10 R_0)	Profiles and/or intensity of several spectral EUV lines between 1.3 & 10 R_0	107.5	35.0	5
White light & spectrometric coronagraph (LASCO)	D.J. Michels, NRL, Washington, DC	Structures evolution, mass, momemtum and energy transport in corona (1.1 - 30 R_0)	1 internal and 2 externally occulted coronagraphs. Spectrometer for 1.1 - 3 R_0	57.4	41.0	4.2
Solar wind anisotropies (SWAN)	J.L. Bertaux, SA Verrières-le-Buisson, F	Solar wind mass flux anisotropies. Temporal variations	Scanning telescopes with hydrogen absorption cell for H Lyman-alpha light	11.6	9.5	0.2
SOLAR WIND "IN SITU"						
Charge, element and isotope analysis (CELIAS)	D. Hovestadt, MPE, Garching, D	Energy distribution & composition (mass, charge & charge state) ions 0.1 - 1000 keV/e	Electrostatic deflection, time-of-flight measurements & solid state detectors	24.5	18.0	1.5
Suprathermal and energetic particle analyser (COSTEP)	H. Kunow, Univ. Kiel, D	Energy distribution & composition, ions 1.2 - 330 MeV/n electrons 0.06 - 25 MeV	Solid state, and plastic and crystal scintillator detector telescopes	18.5	22.0	0.98
Energetic particle analyser (ERNE)	J. Torsti, Univ. Turku, SF					

* MDI will transmit additional 160 kbits/s during the Soho high bit rate transmission mode.

The final (SOHO) payload, as selected by the agencies

Unterlagen für den Gutachterausschuß,
zur Beratung im Herbst 1999,
zusammengestellt von Rainer Schwenn
4.Oktober 1999

In Germany: evaluation by „Gutachterausschuß", installed by DLR/BMFT , in order to decide about funding

SECCHI für STEREO

(Sun Earth Connections Coronal and Heliospheric Investigation)

<u>*Principal Investigator*</u>: Dr. Russel Howard, Naval Research Laboratory (Washington, USA)

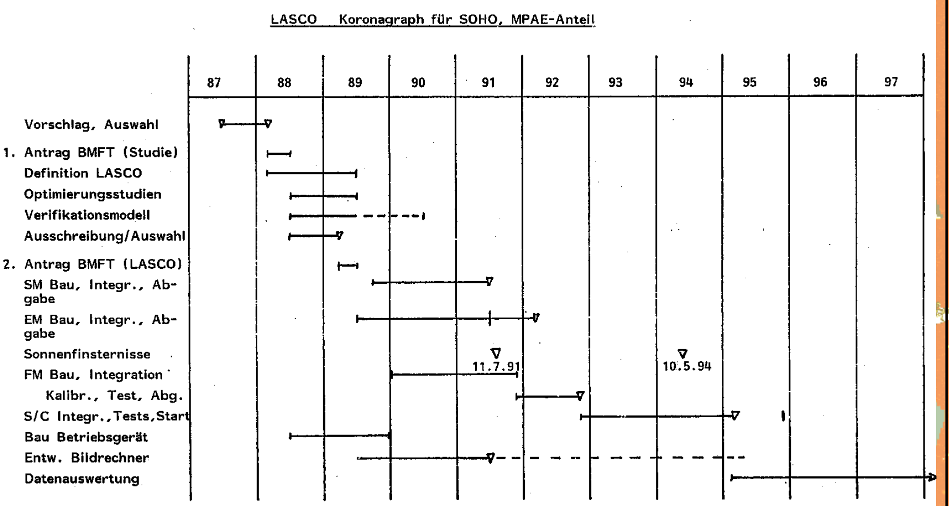
<u>*Beteiligte Institute:*</u>
Naval Research Laboratory (Washington, USA),
University of Michigan (USA),
Applied Physics Laboratory der Johns Hopkins University (Laurel, USA),
Goddard Space Flight Center (Greenbelt, USA),
Lockheed Martin Palo Alto Research Laboratory (Stanford, USA),
Stanford University (Stanford, USA),
Boston College (Boston, USA),
Jet Propulsion Laboratory (Pasadena, USA),
SAIC (San Diego, USA),
Mullard Space Science center (UK),
University of Birmingham (UK),
Laboratoire d'Astronomie Spatiale (Marseille, Frankreich),
Universität Paris (Frankreich),
Observatoire de Paris (Frankreich),
Universität Lüttich (Belgien),
Universität Kiel,
Max-Planck-Institut für Aeronomie (Lindau)

<u>*Ausführende Forschungsinstitute in Deutschland*</u>:
Max-Planck-Institut für Aeronomie, Lindau,
Geschäftsführender Direktor: Prof. Vytenis Vasyliunas
Universität Kiel

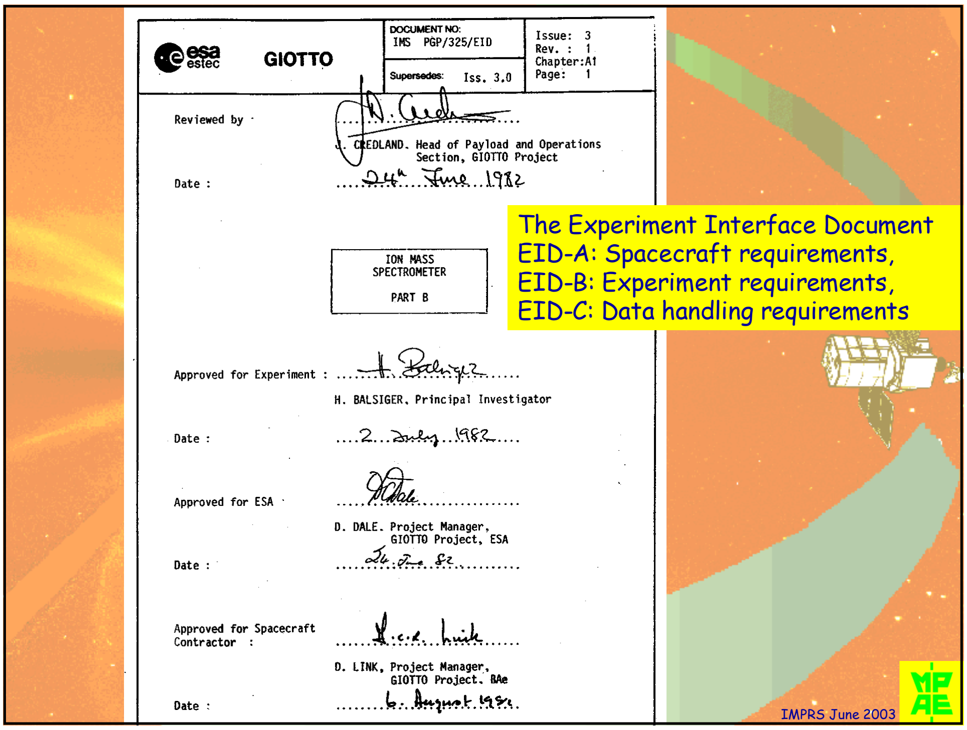
<u>*Projektwissenschaftler am MPAe*</u>: Prof. Rainer Schwenn

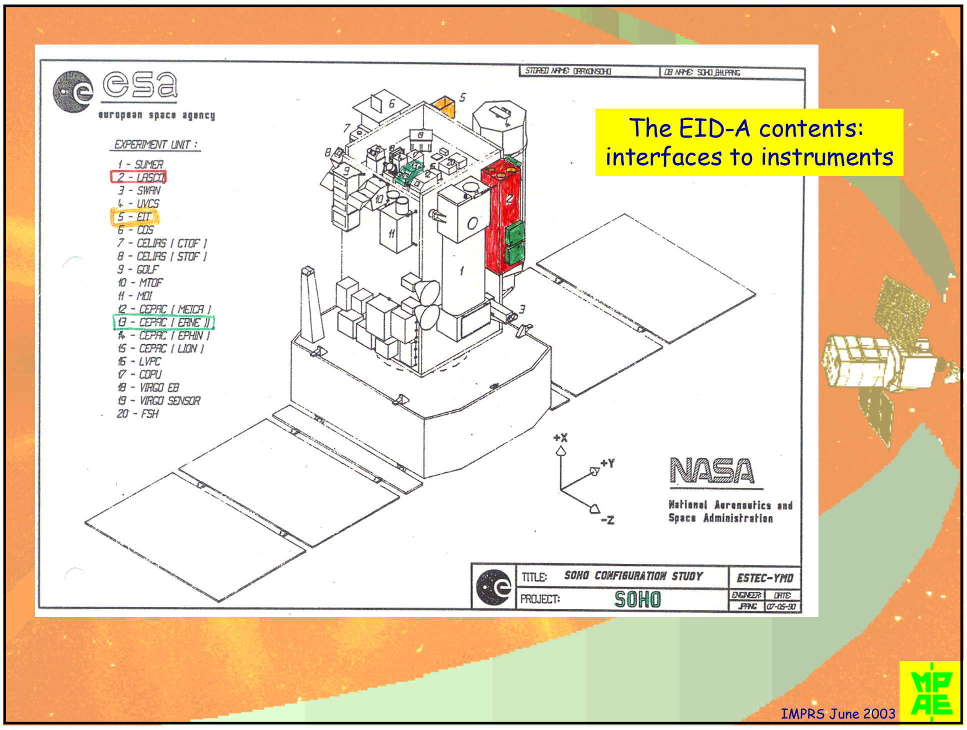
Ko-Investigatoren des MPAe Lindau: Dr. Bernd Inhester, Prof. Eckart Marsch,
Prof. Sami Solanki, Prof. Rainer Schwenn

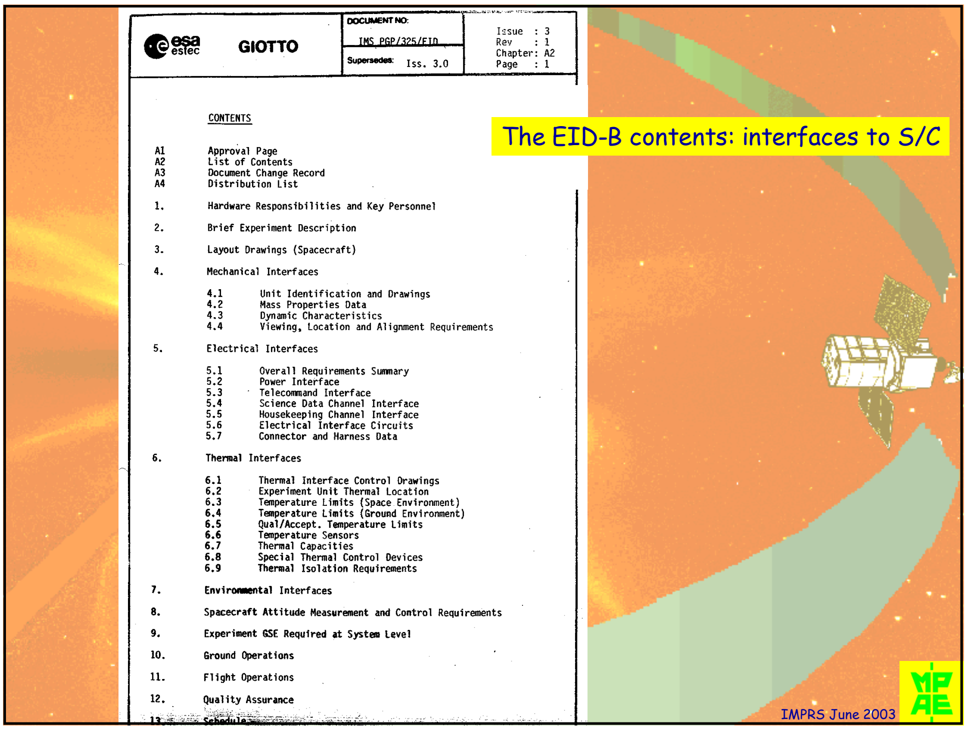
<u>*Ko-Investigatoren der Universität Kiel:*</u> *Dr. Volker Bothmer, Horst Kunow,*



Presentation of schedule for the Gutachterausschuß

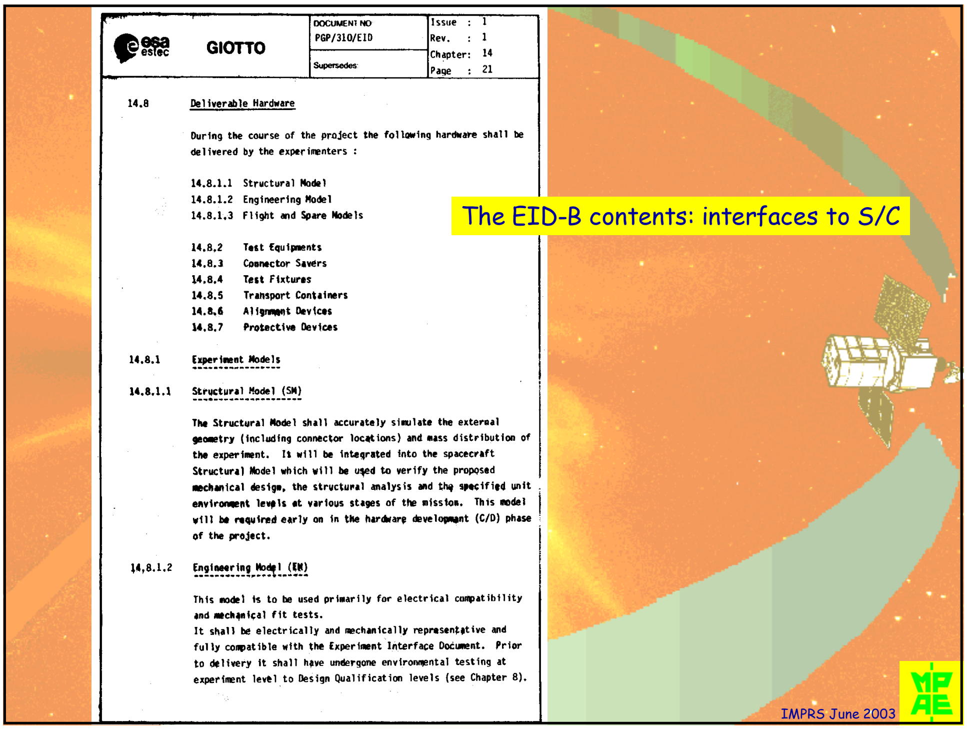

esa estec
GIOTTO
DOCUMENT NO: IMS PGP/325/EID
Supersedes: Iss. 3.0
Issue: 3
Rev. : 1
Chapter:A1
Page: 1
Reviewed by
CREDLAND. Head of Payload and Operations Section, GIOTTO Project
Date : 24th June 1982
ION MASS SPECTROMETER
PART B
Approved for Experiment :
H. BALSIGER, Principal Investigator
Date : 2 July 1982
Approved for ESA
D. DALE. Project Manager, GIOTTO Project, ESA
Date : 26 June 82
Approved for Spacecraft Contractor :
D. LINK, Project Manager, GIOTTO Project. BAe
Date : 6 August 1982
The Experiment Interface Document
EID-A: Spacecraft requirements,
EID-B: Experiment requirements,
EID-C: Data handling requirements
IMPRS June 2003


esa
european space agency
EXPERIMENT UNIT :
1 - SUMER
2 - LASCO
3 - SWAN
4 - UVCS
5 - EIT
6 - CDS
7 - CELIAS / CTOF /
8 - CELIAS / STOF /
9 - GOLF
10 - MTOF
11 - MDI
12 - CEPAC / MEICA /
13 - CEPAC / ERNE /
14 - CEPAC / EPHIN /
15 - CEPAC / LION /
16 - LVPC
17 - COPU
18 - VIRGO EB
19 - VIRGO SENSOR
20 - FSH
The EID-A contents:
interfaces to instruments
NASA
National Aeronautics and Space Administration
TITLE: SOHO CONFIGURATION STUDY
PROJECT: SOHO
ESTEC-YMO
IMPRS June 2003



esa estec | GIOTTO | DOCUMENT NO: IMS PGP/325/EID | Issue : 3 Rev : 1 Chapter: A2 Page : 1
Supersedes: Iss. 3.0

CONTENTS



esa estec | GIOTTO | DOCUMENT NO PGP/310/EID | Issue : 1 Rev. : 1 Chapter: 14 Page : 21
Supersedes

14.8 Deliverable Hardware

During the course of the project the following hardware shall be delivered by the experimenters :

14.8.1.1 Structural Model
14.8.1.2 Engineering Model
14.8.1.3 Flight and Spare Models

14.8.2 Test Equipments
14.8.3 Connector Savers
14.8.4 Test Fixtures
14.8.5 Transport Containers
14.8.6 Alignment Devices
14.8.7 Protective Devices

14.8.1 Experiment Models

14.8.1.1 Structural Model (SM)

The Structural Model shall accurately simulate the external geometry (including connector locations) and mass distribution of the experiment. It will be integrated into the spacecraft Structural Model which will be used to verify the proposed mechanical design, the structural analysis and the specified unit environment levels at various stages of the mission. This model will be required early on in the hardware development (C/D) phase of the project.

14.8.1.2 Engineering Model (EM)

This model is to be used primarily for electrical compatibility and mechanical fit tests.
It shall be electrically and mechanically representative and fully compatible with the Experiment Interface Document. Prior to delivery it shall have undergone environmental testing at experiment level to Design Qualification levels (see Chapter 8).

The EID-B contents: interfaces to S/C

esa estec GIOTTO	DOCUMENT NO: PGP/310/EID Supersedes	Issue : 1 Rev. : 1 Chapter: 14 Page : 22

It is expected that the electronic components will be of an identical type but of a lower reliability standard than those in subsequent models; commercial standard components would be acceptable. As there will be no spare unit for this model the Experimenter shall ensure that adequate spare components are available to effect a rapid repair; prefabricated key modules would facilitate this.

14.8.1.3 Flight Model (FM) and Flight Spare Model (FS)

Flight standard models shall comply with all GIOTTO interface specifications, use space approved components, and have a reliability in excess of (TBD) for the one year orbital life.

All flight standard models shall be environmentally tested to Flight Acceptance (see Chapter 8) levels prior to delivery to ESTEC.

14.8.2 Ground Support Equipments

The G.S. equipment is defined in Chapter 9.

One set of G.S. equipment is to be delivered with the Engineering Model. The second set shall be delivered with the Flight Model at which time the first set will be returned to the Experimenter for modification and updating for use with flight spare models and for calibration purposes.

14.8.3 Connector Savers

These are covered by Chapter 5.

14.8.4 Test Fixtures

In the event that test fixtures are required in order to vibration test the experiment, it shall be the responsibility of the Experimenter to provide them.

For other details see chapter 8.

How to make an instrument space proof?

- Chose a sound design
- Build up a collaborative, competent team
- Chose good contractors,
- Spend much effort into testing.

Environmental testing for space instruments

„Qualification testing", usually performed with prototype instrument:

- Prove conformity of instrument with EID-B with respect to phsyical properties (shape, mass, mounting provisions) and electrical function using a S/C simulator.
- Prove that instrument is capable of withstanding even worse environments than expected during the whole mission (including ground tests, launch, and mission operations in space).

„Acceptance testing" required for Flight units and flight spare unit

- Prove conformity with EID-B,
- Prove that instrument will withstand expected mission environments

Qualification testing includes usually:

Vibration (at 150% levels!):
- Sinusoidal excitation
- Random noise,
- Shock acceleration,
- acoustic noise

Thermovacuum (at 10^0 beyond requirements!)
- Functionality under both hot and cold exposure in vacuum,
- Switch-on capability after hot and cold storage in vacuum,
- Functionality after a series of thermal cycles.

Electromagnetic compatibility (EMC)
Magnetic cleanliness.

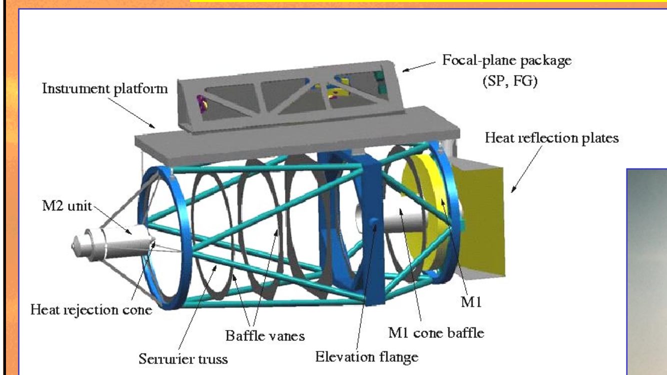
All these test have to be passed successfully before FM production!

Qualification testing includes usually:

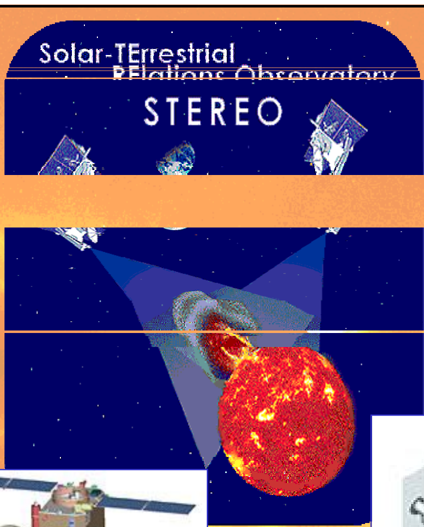
The same tests as qualification, but at „normal" levels.
Acceptance test have to be repeated each time the instrument has been modified!

Planned missions and instruments

The Sunrise balloon-borne telescope

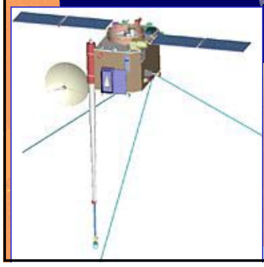


- Vector-magnetograph/polarimeter (1 m mirror!),
- extreme high spatial resolution,
- International project, PI at the MPAe,
- long-duration balloon flight over Antarctica,
- Launch date 2006,
- future space application not excluded...

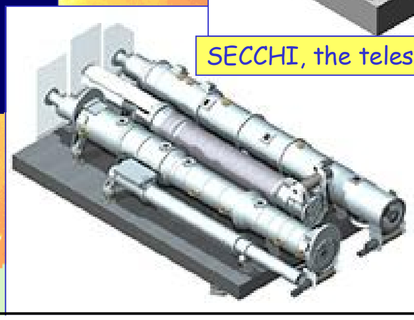


STEREO

- A NASA mission within STP
- dedicated space weather mission,
- to be launched in 2006,
- made international: Europe funds 50% of payload!

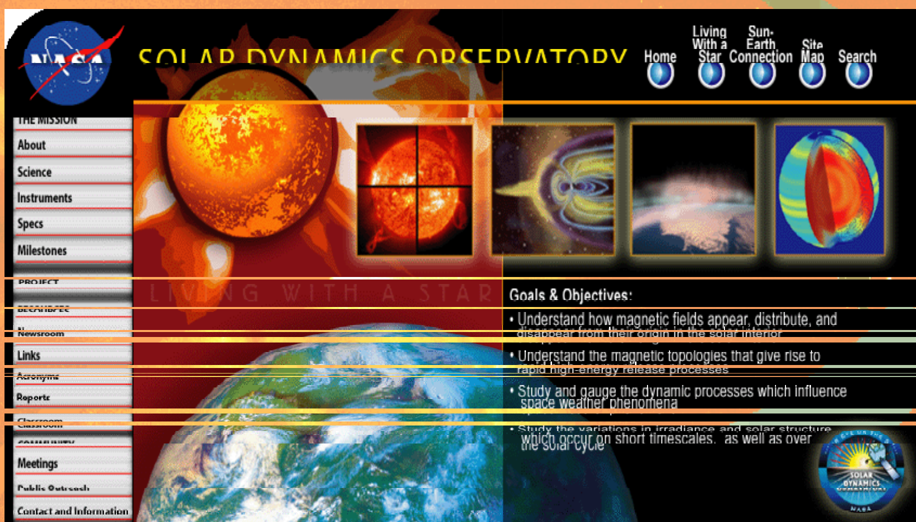


SECCHI, the telescope array

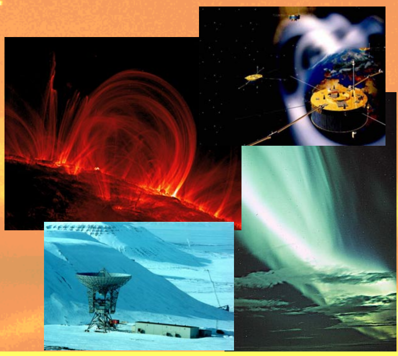


Future important missions

http://sec.gsfc.nasa.gov/ilws/ilws.htm



Planned missions and instruments



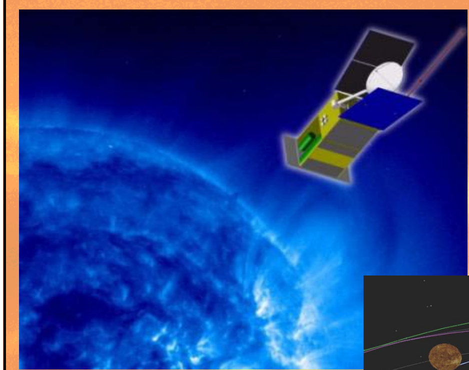
Solar Dynamics Observatory (SDO)

- The first NASA mission within the ILWS enterprise,
- to be launched in 2007,
- a mission for 20 years,
- with TV telemetry rates,
- international partners

Primary scientific goals:

- Characterize the dynamic state of the Sun on temporal and spatial scales that enhance understanding of solar processes and space weather phenomena
- Explain the evolution, emergence, and decay of magnetic regions and their relationship to the onset of solar flares and coronal mass ejections
- Understand how solar activity affects irradiance and how changes in irradiance affect the Earth
- Improve the predictive capability of large-scale solar events

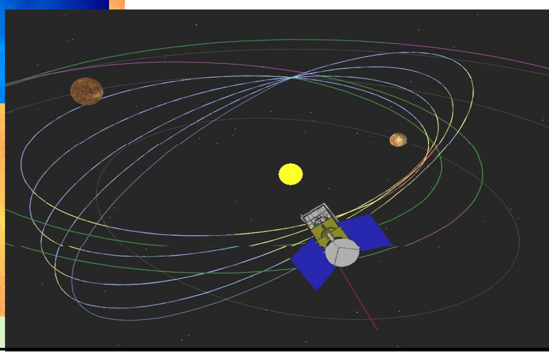
The Solar Orbiter



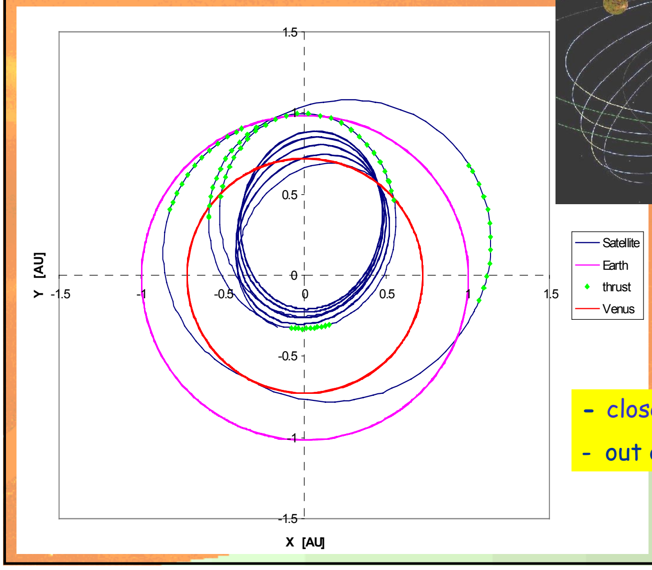
Solar Orbiter firsts

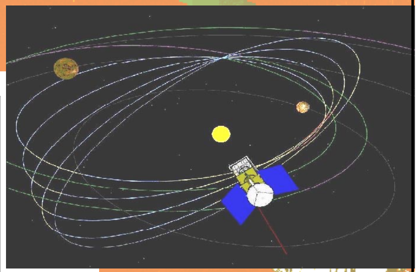
- explore the uncharted innermost regions of our solar system
- study the Sun from close-up (45 solar radii or 0.21 AU)
- fly by the Sun tuned to its rotation and examine the solar surface and the space above from a co-rotating vantage point
- provide images of the Sun's polar regions from heliographic latitudes as high as 38°

- An ESA initiative,
- explore new territory,
- to be launched in 2011 (?),
- new technology required



Solar Orbiter: Novel Orbital Design





- closer to the Sun
- out of the ecliptic

Solar Orbiter: Heliospheric *in-situ* package

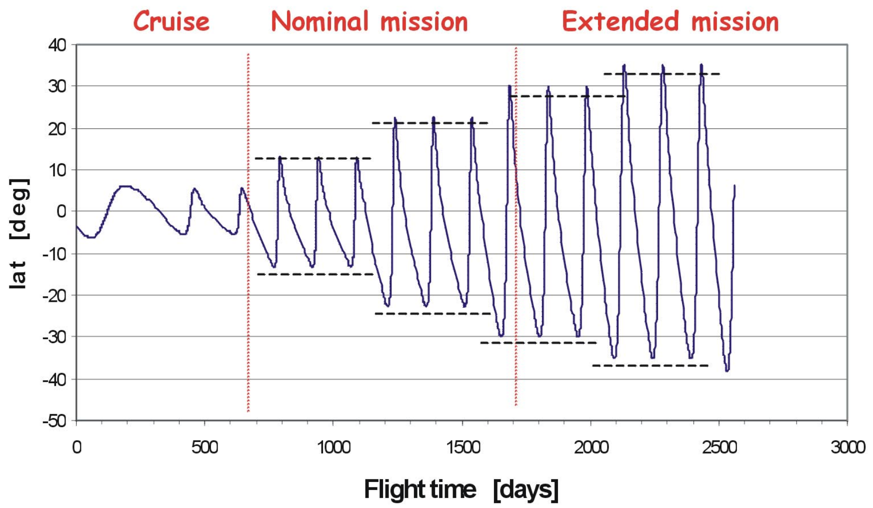
Instrument	Mass kg	Power W	kb/s
Solar Wind Plasma Analyser (SWA)	6	5	5
Radio & Plasma Waves Analyser (RPW)	10	7.5	5
Coronal Radio Sounding (CRS)	0.2	3	0
Magnetometer (MAG)	1	1	0.2
Energetic Particle Detector (EPD)	4	3	1.8
Dust Detector (DUD)	1	1	0.05
Neutral Particle Detector (NPD)	1	2	0.3
Neutron Detector (NED)	2	1	0.15

Gamma-ray Detector (GRD) (ext. of EPD)			

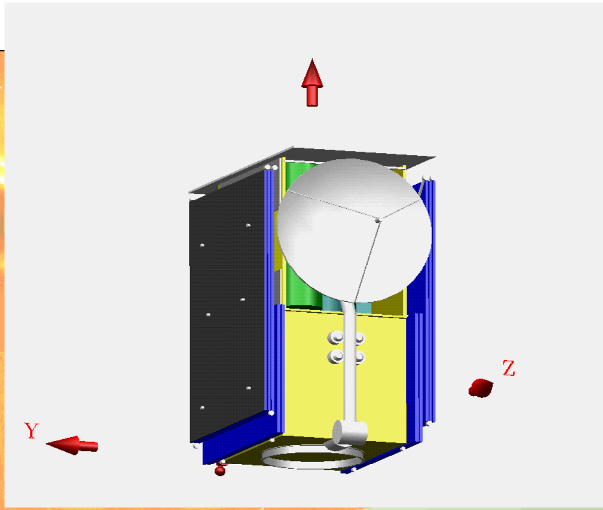
Solar Orbiter: Remote-sensing Instruments

Instrument	Mass kg	Power W	kb/s
Visible Light Imager & Magnetograph (VIM)	26	25	20
Extreme UV Spectrometer (EUS)	22	25	17
Extreme UV Imager (EUI)	36	20	20
UV & Visible Light Coronagraph (UVC)	17	25	5
Radiometer (RAD)	4	6.5	0.5
Hard X-ray Imaging Spectrometer (STIX)	5	4	0.5
Heliospheric Imager	3	10	5

Solar Orbiter: S/C heliographic latitude



Solar Orbiter: Launch



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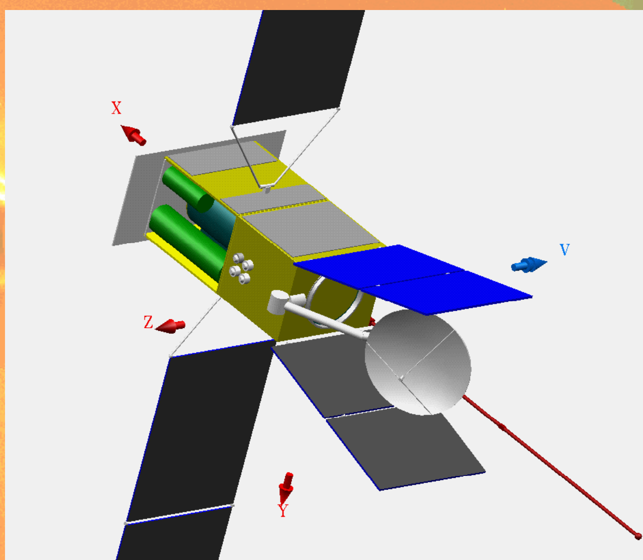
Solar Orbiter in Cruise Phase



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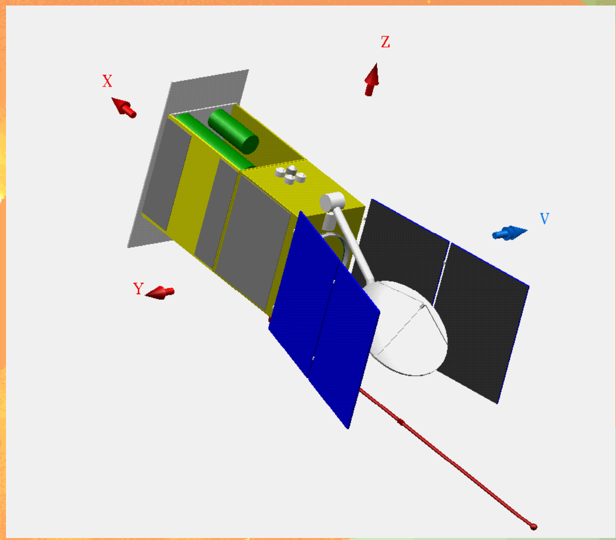
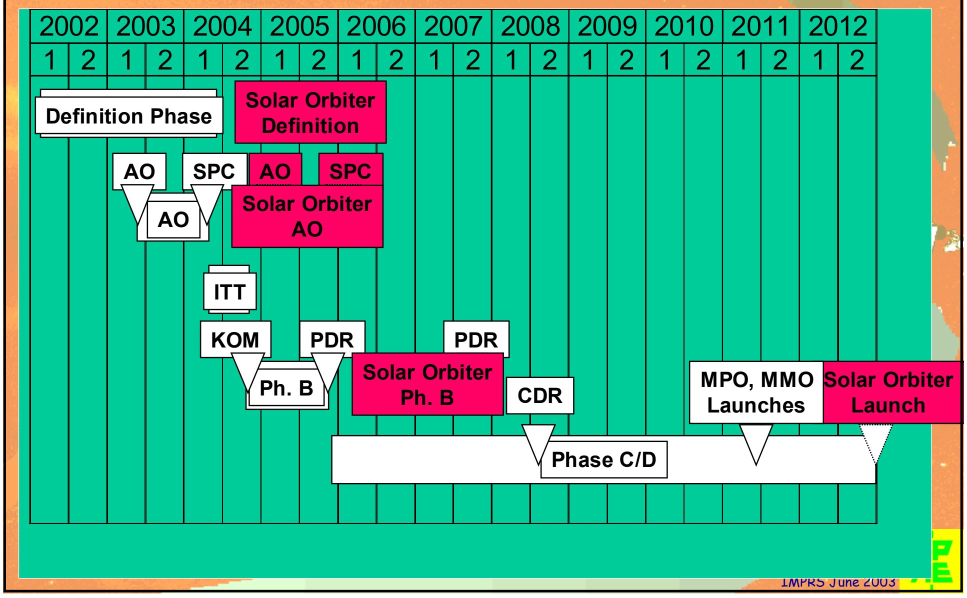
Solar Orbiter in Observation Mode



BepiColombo/Solar Orbiter Schedule



Space Research!

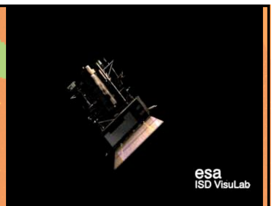
Basic rules for developing instruments and missions:

No mass,
No power,
No cost.

Further advice for potential space researchers:

be young, and live long,
be experienced,
select your CoIs cafefully,
build up a good team of scientific and technical coworkers at home,
have creative ideas,
stop having creative ideas in time,
have an demo-instrument ready in time,
develop good contact to your bosses, space agencies and funding agencies,
be communicative,
be patient and stress-resistent...
do not forget to keep up-to-date in science!

Space Instrumentation



Lectures for the IMPRS 23. 6. to 27.6. 2003 at MPAe Lindau
presented/ compiled/ organized by Rainer Schwenn, MPAe,
supported by Drs. Curdt, Gandorfer, Hilchenbach, Hoekzema, Pardowitz, Richter, Schühle

Mon, 23.6.	14:00 Introduction into the techniques of space research (RS) 15:00 An illustration: the „Ozonometer". From the idea to the publication of results (RS) 16:00 Plasma detectors. Electrostatic analyzers: Helios, Giotto IMS, TAUS (RS)
Tue, 24.6.	14:00 Seminar extern, Dr. Jon Rotvig: Dynamos and convection: mean flow generation 15:00 Modern particle analyzers in planetary research: TOF, ENA (RS) 16:00 Energetic particles. Detection of interstellar gas (RS)
Wed, 25.6.	14:00 Measuring magnetic fields in space (Richter, TU Bs) 15:00 Radioastronomy from space (RS) 16:00 Optical instruments, an overview (RS)
Thu, 26.6.	14:00 Solar EUV spectroscopes (Curdt) 15:00 Imaging detectors in various spectral regimes (Pardowitz, Gandorfer, Schühle) 16:00 Planetary and cometary exploration: cameras, landers (Hoekzema)
Fri, 27.6.	14:00 In-situ instrumentation for planetary surface exploration (Hilchenbach) 15:00 How to do experimental research in space (RS).