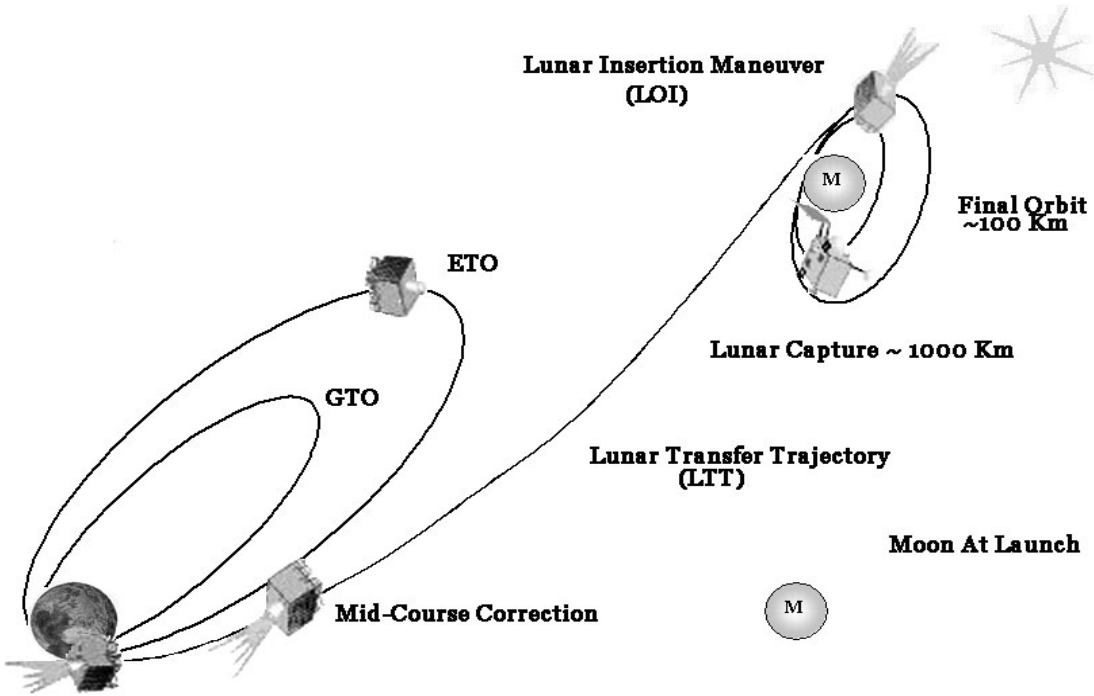
Opportunity for collaboration with India on Chandryaan-1 mission ot the Moon

Chandrayaan-1 science goals

- (a) high-resolution mineralogical and chemical imaging of the global surface of the Moon, with stereographic coverage of most of the Moon's surface with five meters resolution, to provide new insights in understanding the Moon's origin and evolution;
- (b) search for surface or sub-surface water-ice, especially at the lunar poles and study of permanently shadowed north and south polar regions;
- (c) identification of chemical end members of lunar highland rocks;
- (d) chemical stratigraphy of the lunar crust by remote-sensing of the central upland of large lunar craters, the South Pole Aitken Region (SPAR), where interior material may be expected;
- (e) mapping the height variation of the lunar surface features along
- (f) observation of X-ray spectrum greater than 10 keV to provide information on lunar volatiles.


Lunar Insertion Maneuver
(LOI)
M
Final Orbit
~100 Km
ETO
Lunar Capture ~ 1000 Km
GTO
Lunar Transfer Trajectory
(LTT)
Moon At Launch
Mid-Course Correction
M

Launch parameters using Polar Satellite Launch vehicle

Launch Azimuth	**102º from North**
Mission strategy	**GEO-ETO - TLI - LOI**
Initial Orbit	**240 * 36000 km**
Inclination	**18 º**
Argument of perigee	**178.5 º**
GTO Spacecraft mass	**1050 km**
LAM first burn propellant	**239 kg**
TLI mass	**811 kg**
LAM Subsequent burns	**287 kg**
LAM Total loading	**526 kg**
Lunar orbit	**100 * 100 km Polar**
Initial lunar orbital mass	**523 kg**
Propellant for 2-year maintenance	
and attitude control etc.	**83 kg**
Dry mass of lunar spacecraft	**440 kg**
Science payload	**60 kg**

Chronology of collaboration

- July 2000 ESTEC ILEWG4 conference, ISRO invited to ILEWG
- Jan 2002 ESA/DLR lunar workshop Berlin: first science discussions
- April 2003 letter from ISRO chair Kasturirangan asking ESA support
- May 2003 ESA visit & discussion of possible collaboration at ISRO Bangalore
- May 2003 response letter ESA D/SCI to ISRO chair Kasturirangan
- Sept 2003 Kourou, Launch INSAT 3E/SMART-1, meeting Southwood/Nair
- 11 Feb 04 Paris, ESA SPC: Presentation of possible ISRO-ESA collaboration, positive comments and recommendation to explore EC funding
- 15 March 04 Response to Chandrayaan-1 AO

- 2 proposals D-CIXS2 and SIR2 submitted with cover letter from ESA D/SCI
- 1 proposal SARA submitted to ISRO, with copy to ESA for possible support
- contribution to HEX, and data compression chip submitted via CNES, F

- May 04 Brussels, Positive ESA Meeting with European Commission (Mr Tytgat) on support to Chandrayaan-1
- 8 June Noordwijk, status report on C-1 given to ESA SPC
- July 04 Paris, COSPAR lunar session; ILEWG, discussions with C-1 scientists
- Aug 04 reorganisation of EC commission (in particular space affairs)
- 8 Nov 04 ESA - ISRO cooperation highlighted in EU - India Summit declaration
- 22-26 Nov Udaipur, ISRO-PRL-ESA-ILEWG ICEUM6 lunar conference
  - very successful , declaration and address by President A. Kalam)
  - science and technical meetings on mission and instruments C-1 collaborations
- 17 dec 04 Letter of Mr Nair to ESA DG requesting support for cooperation on C-
- 20 dec 04 teleconf D-SCI /Mr Nair(chairman of ISRO)
- Jan 05 Definition of draft ISRO/ESA agreement on C-1

Payload	Configuration	Range	Resolution	Objective
Hyper Spectral Imager (HySI)	Wedge filter pixelated image	0.4 - 0.9 μm	Spatial - 80m Spectral-15nm 32 channels	Mineralogical mapping
Terrain Mapping Camera (TMC)	Three stereo cameras with pixelated imagers	Panchromatic (40 Km swath)	Spatial - 8m Vertical - 5m	To prepare a high resolution Atlas of the whole moon
Laser ranging (LLRI)	Pulsed Nd-Yag laser	1064 nm	Vertical - 10 m or better	Gravity model and topography
Low energy X spectro-meter (LEX)	X-ray CCD or SCXD type detector 50 sq. cm area	0.5-10 keV	10-20 km	Elemental mapping Si, Al, Mg, Ca, Fe, Ti
High energy X-spectro-meter (HEX)	CdZnTe detector 100 sq. cm. Area	10-200 keV	80 km	^{210}Pb, Radon degassing, U, Th
Solar X-ray Monitor (SXM)	Si-Pin Diode 2 or 3 detectors viewing orthogonally	2-10 keV	-	Solar X-ray flux monitoring

Possible contribution of ESA

- 1. Coordinate European institutes in providing to ISRO the scientific instrumentation listed below together with the associated equipment, software, project documentation and manpower support:
- - Chandrayaan-1 Imaging X-Ray Spectrometer (CIXS) (1 instrument);
- - Sub-keV Atom Reflecting Analyzer (SARA) (1 instrument);
- - Near-Infrared Spectometer (SIR-2) (1 instrument);
- 2. Perform in Europe these additional tasks:
- (a) support the integration of the European-furnished payload elements;
- (b) provide technical advice and consultation in areas such as thermal design, flight dynamics, lunar correction manoeuvres;
- (c) provide expertise and tools inherited from SMART-1 and ESA in areas of data handling, payload planning, planetary data system archiving;
- (d) provide test of ISRO ground segment using SMART-1 spacecraft
- (e) provide access to SMART-1 scientific data for collaborative studies between European and Indian scientists, and for the preparation of the Chandrayaan-1 Mission
- (f) enhance participation and data exploitation by European scientific community

CIXS X-ray Spectrometer *for Chandrayaan-1*

- PI: M. Grande , RAL UK
- Co-Is: RAL UK, Helsinki, PRL India, RSSD
- Associated scientists from enlarged D-CIXS team
- globally map the Moon elemental composition at 20 km resolution in a two-year long orbit (Mg, Si, Al, Fe, Ca, Ti).
- based on SMART-1 D-CIXS
- upgraded range from 0.85 to 2.50 μm.
- Higher resolution and sensitivity in 2008-2009 solar cycle
- Cost: 500 kE (RAL), 500 kE (ISRO tests), 2000 kE (requested to ESA/member states)

SIR-2 Near-Infrared Spectrometer *for Chandrayaan-1*

- PI: U. Mall , MPS Lindau
- Co-Is: MPS Lindau, U. Bergen, RSSD
- globally map the Moon highly integrated mineralogy, in a two-year long orbit.
- based on SMART-1 SIR, new detector/ Peltier cooler
- upgraded range from 0.85 to 2.50 μm.
- angular resolution in the range between 1.11 and 3.3 mrad.
- Collaborations: Open data policy and MPS school support
- Cost: 1120 kE (by MPS), 957 kE by ESA/member states

SARA Sub-keV Atom Reflecting Analyzer *for Chandrayaan-1*

- PIs: S. Barabash Kiruna Space Physics, A. Bhardwaj Trivandrum
- Co-Is: IRF Kiruna, VSSC Travandrum (DPU), Bern (ioninsation surface), JAXA (front end and I/F elecronics)
- Moon environment LENA : (1) sputtering by precipitating solar wind ions, (2) solar photon stimulated desorption (PSD), and (3) micrometeorite vaporization.
- Replica of ENA for Bepi-Colombo
- Cost: manpower (IRF), hardware expenses ESA/member states 450 kEu