Scientific Research in the SELENE Mission

- Mission Objectives
- Mission Scenario
- System and Instruments
- Scientific Research

54th International Astronautical Congress
Sep.2003

Characteristic Features of SELENE Mission

- Moon-orbiting observatory mission,
- Largest lunar exploration after the Apollo program,
- One of the scientific mission of Japanese space agency, JAXA (Japan Aerospace Exploration Agency) which is newly organized on Oct.1,
- Science and engineering research,
- Launch rescheduled for early 2006.

New Space Agency in Japan

The Japan Aerospace Exploration Agency is to be born on October 1, 2003, merging
the Institute of Space and Astronautical Science (ISAS),
the National Aerospace Laboratory of Japan (NAL), and
the National Space Development Agency of Japan (NASDA).

JAXA
Japan Aerospace
Exploration Agency

SELENE Mission Objectives

Science

1. Science of the Moon

   Study of origin and evolution of the Moon

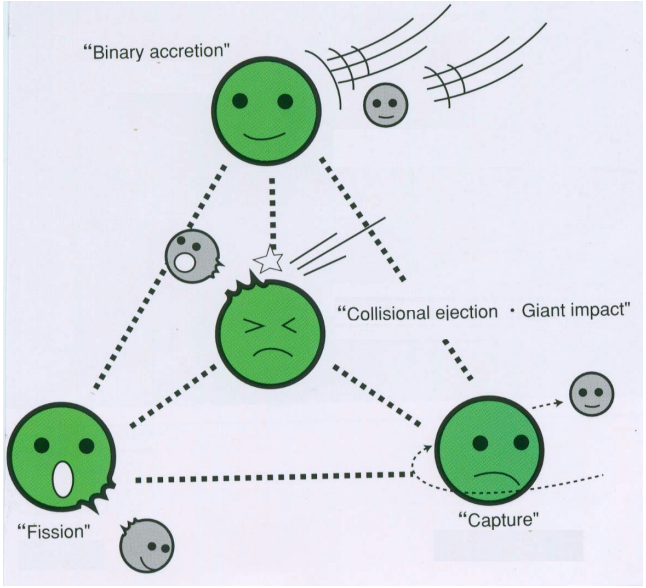
2. Science on the Moon

   In-situ measurement of lunar environment

3. Science from the Moon

   Observation of solar-terrestrial plasma environment

   Site search for future astronomical observation



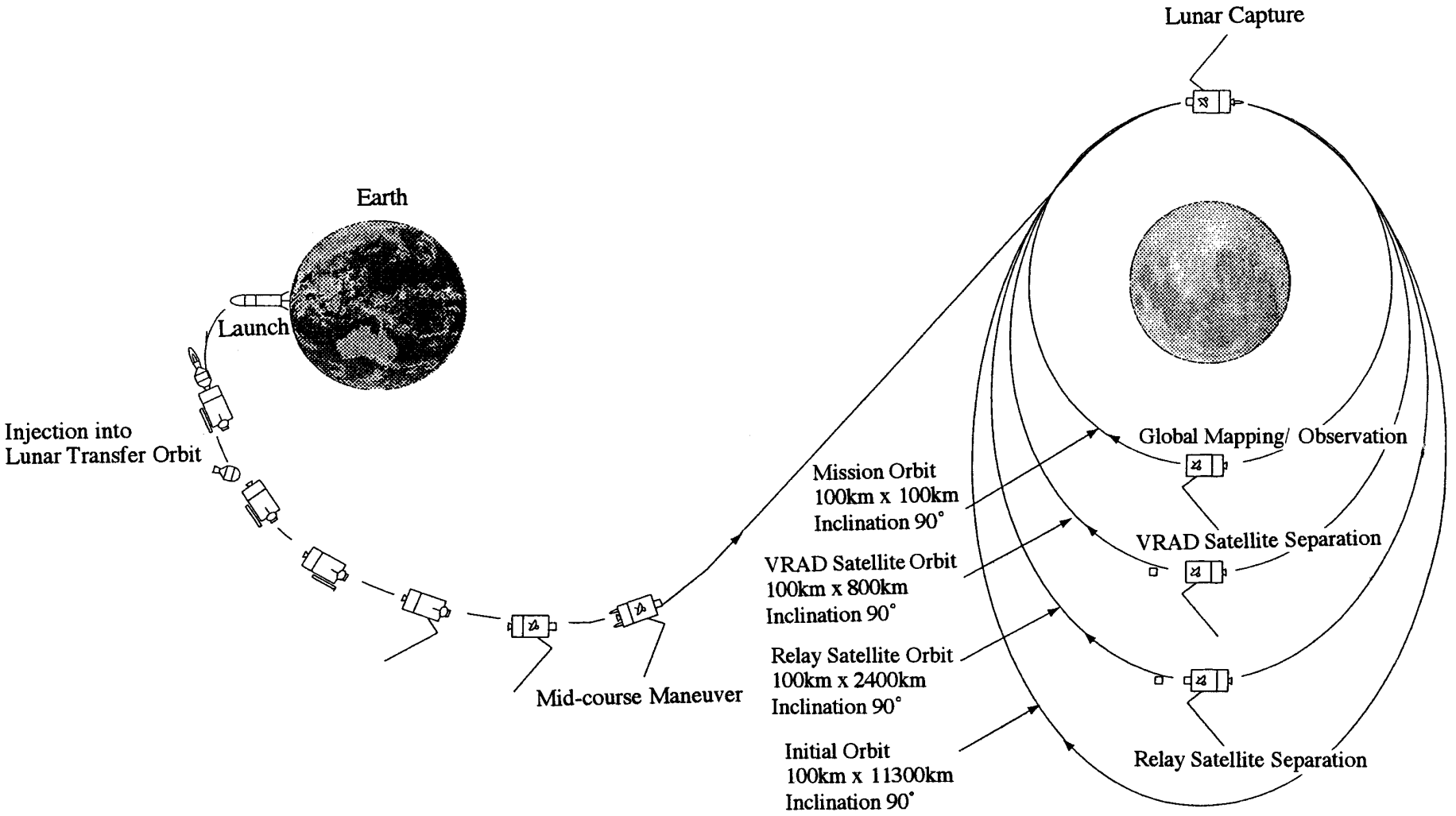
Engineering:

Technology Development for Future Lunar Exploration

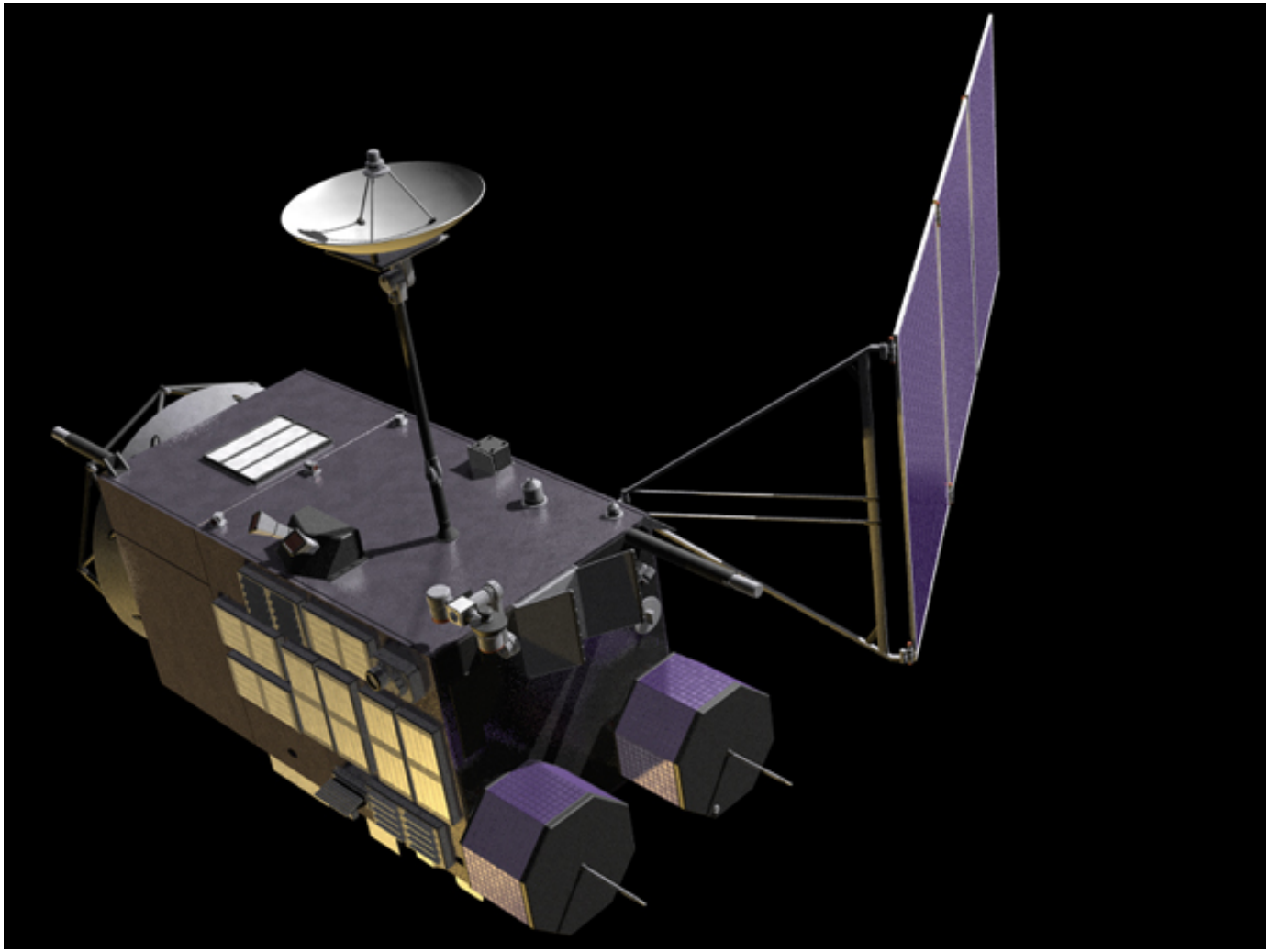
Mission Summary

Launch	H-IIA Launch in 2006 from Tanegashima
System	Main orbiter (2.1 x 2.1 x 4.2 m), Relay satellite and VRAD satellite (1 mϕ x 0.65 m)
Orbit	Direct injection to the lunar transfer orbit 100 km circular, Inclination 90˚(Main orbiter) 100 km x 2400 km elliptical, Inclination 90˚ (Relay satellite) 100 km x 800 km elliptical, Inclination 90˚ (VRAD satellite)
Mission Period	1 year nominal plus optional observation
Attitude Control System	Main orbiter: 3-axis control, 2 Star sensors, 2 IMUs, 4 Sun sensors 4 Reaction wheels(20 Nms), Pointing ±0.1˚(3σ), Determination ±0.025˚(3σ) Stability ±0.003˚/s(3σ) Relay/VRAD satellite: Spin stabilization(>10 rpm)
Thruster System	Main orbiter: 500 N x 1, 20 N x 12, 1 N x 8
Power System	Main orbiter: GaAs solar array paddle 3.5 kW, Battery NiCd, 35 AH x 4, 50 V Relay/VRAD satellite: High efficiency Si Solar Cell 70 W, NiMH 13 AH, 26 V
Communication System	Mian orbiter: S and X bands, High gain antenna(S, X), 4 Omni antennas (S), 10 Mbps(X downlink), 40 or 2 kbps(S downlink), 1 kbps(uplink) Relay/VRAD satellite:128 bps
Orbiter Data Recorder	Main orbiter: 10 GBytes
Weight	Launch 2885 kg Orbiter(Dry Weight) 1720 kg Science Payload 270 kg(approx) Relay Satellite 45 kg VRAD Satellite 45 kg

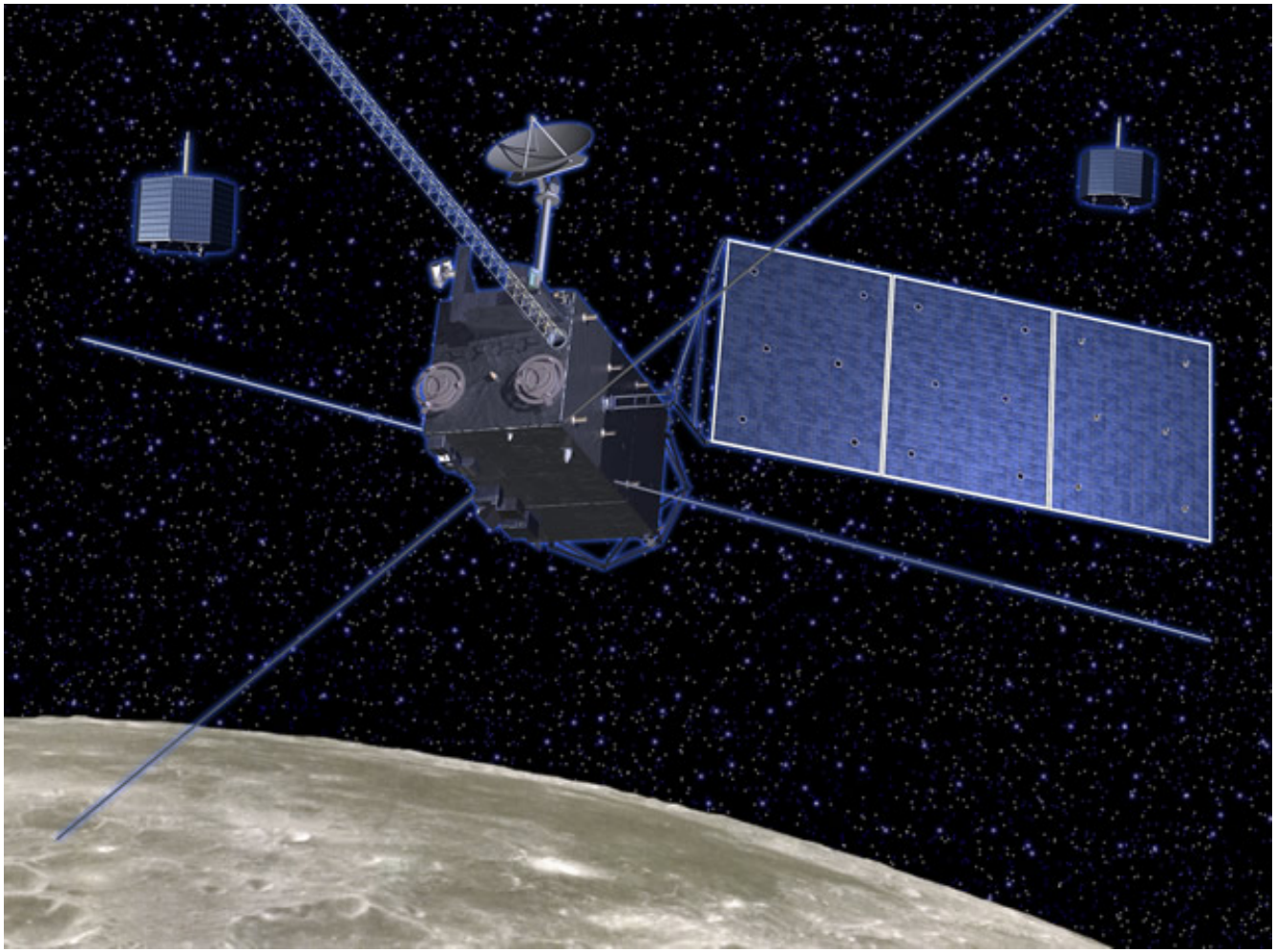
SELENE Mission Profile



Configuration of the Orbiter in Transfer Orbit



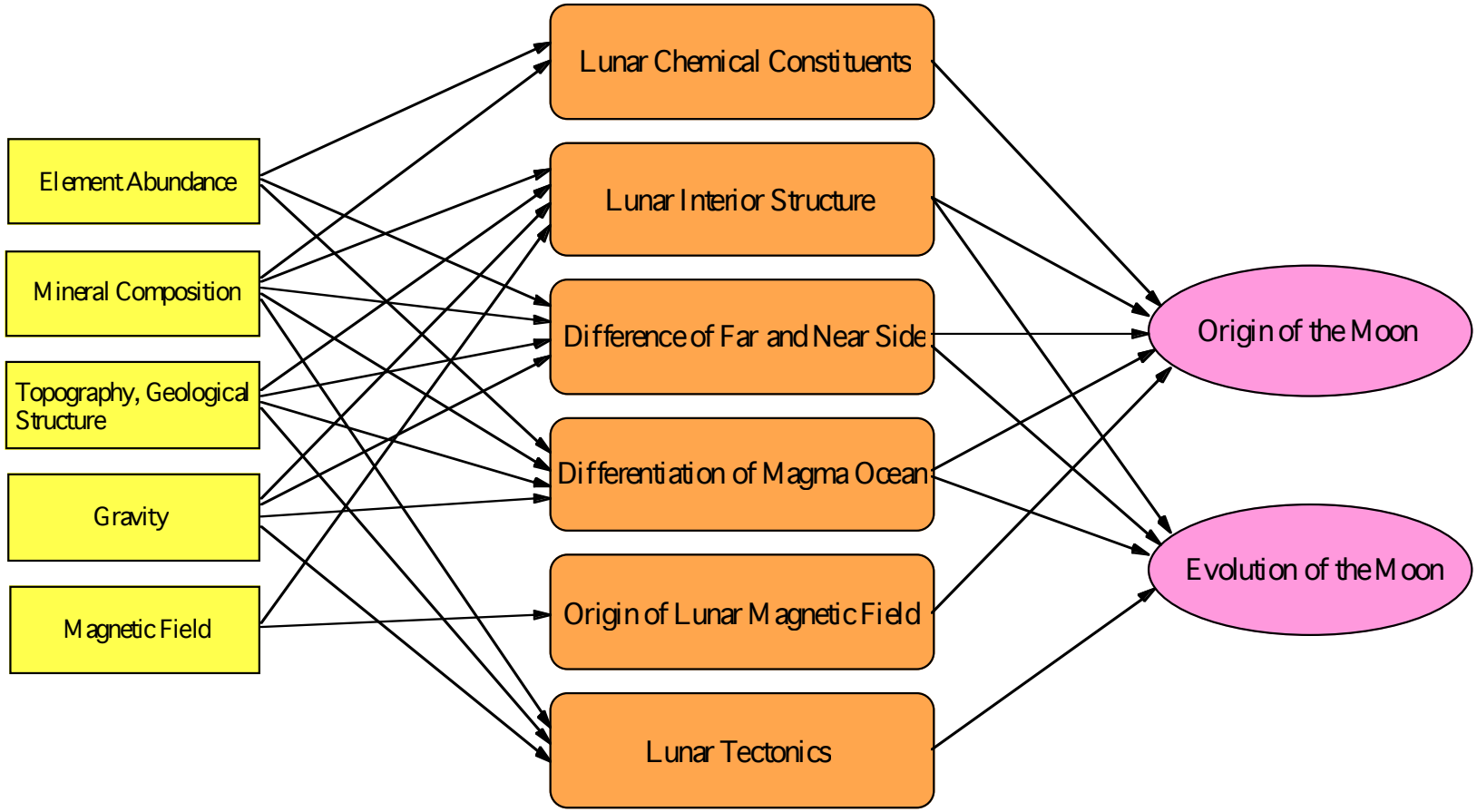
Configuration of the Orbiter in Lunar Orbit



SELENE Mission Instruments

Observation	Instrument	Characteristics
Element Abundance	X-ray Spectrometer	CCD 100cm^2, Energy range 0.7~8 keV, Resolution 90 eV, 5μm-Be film, Solar x-ray monitor, Calibrator with sample, Global mapping of Al, Si, Mg, Fe, Spatial resolution 20 km
	Gamma-ray Spectrometer	High purity Ge crystal 250 cm^3, Energy range 0.1~10 MeV, Resolution 2~3 keV, Stirling refrigerator 80°K, Global mapping of U, Th, K, O, Al, Ca, Fe, Mg, etc., Spatial resolution 130~150 km
Mineral Composition	Multi-band Imager	UV-VIS IR imager, Si-CCD and InGaAs, 9 bands in 0.4~1.6μm(Si: 415,750,900,950,1000; InGaAs: 1000,1050,1250,1550 nm), Band width 20~50 nm, Spatial resolution 20-60 m
	Spectral Profiler	Spectrometer, Si pin photo-diode and InGaAs, Band 0.5 to 2.6μm、Spectrum Sampling 6~8 nm, Spatial resolution 500 m, Calibration by halogen lamp, Observation of standard lunar site
Topography, Geological Structure	Terrain Camera	High resolution stereo camera(±15°), Si-CCD, Spatial resolution 10 m
	Lunar Radar Sounder	Mapping of subsurface structure, Frequency 5 MHz(4~6 MHz swept in 200μs every 50 ms), four-15 m antennas, 5 km depth with 100 m resolution, Observation of natural waves (10 kHz~30 MHz)
	Laser Altimeter	Nd:YAG laser altimeter (1064 nm, 100 mJ, 15 ns), Si-APD, Beam divergence 3 mrad(30 m spot) Height resolution 5 m, Spatial resolution 1600 m (pulse rate 1 Hz)
Gravity Field	Differential VLBI Radio Source	Radio sources on Relay Satellite and VRAD Satellite(3 S-bands, 1 X-band), Several tens of mW, Differential VLBI observation from ground (3 stations or more)
	Relay Satellite	Far-side gravimetry using 4 way Doppler measurement , S uplink, S spacelink, X downlink, Perilune 100 km and Apolune 2400 km at orbit injection, Doppler accuracy 1 mm/s(10 sec)
Magnetic Field	Lunar Magnetometer	3- axis flux gate magnetometer, Accuracy 0.5 nT, 32 Hz sampling, Mast 12 m, Alignment monitor
Lunar Environment	Charged Particle Spectrometer	Measurement of high energy particles, Si-detectors, Wide energy range 1.8~28(p), 4~113 MeV(Fe), High energy range 50~430 MeV(Fe), Alpha particle detector 4~6.5 MeV, 400 cm^2
	Plasma Analyzer	Plasma energy and composition measurement, 5 eV/q~28 keV/q(ion), 5 eV~17 keV(electron)
	Radio Science	Detection of tenuous lunar ionosphere using S and X band coherent carriers
Earth Ionosphere	Plasma Imager	Observation of plasmasphere and aurora, XUV(834 Å) and visible(5 bands)
Earth	High Density TV	Observation of the earth in a super-high resolution, for publicity and educational purposes

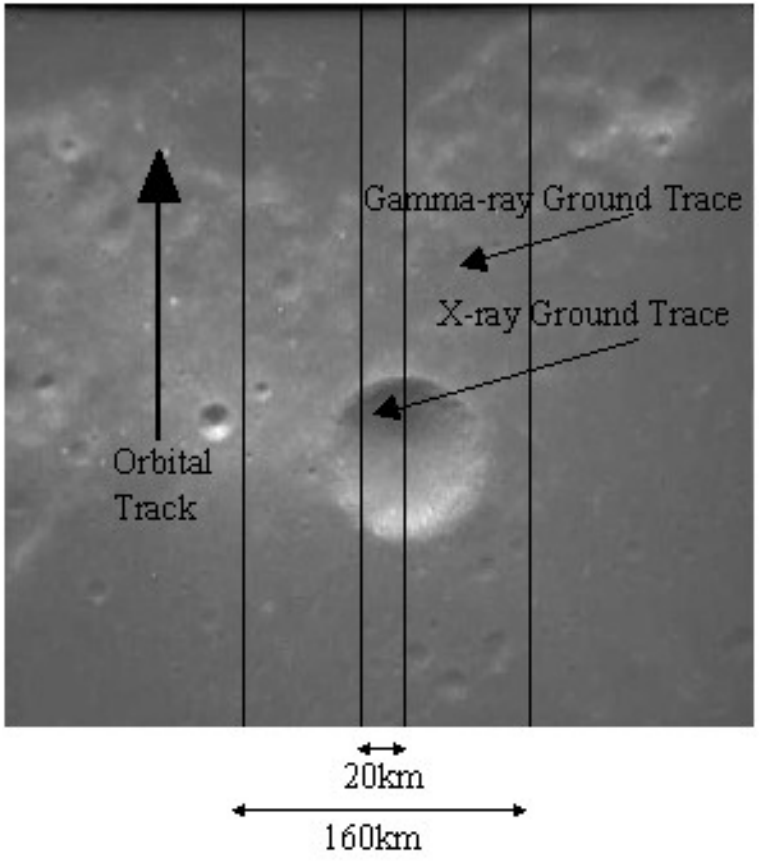
Integrated Research for Origin and Evolution of the Moon



Global Mapping of Chemical Composition

X-ray Spectrometer
Al, Si, Mg, Fe distribution
CCD sensors
Range 0.5-10keV
Spatial Resolution 20 X 20km

Gamma-ray Spectrometer
U, Th, K, Ca, Ti, Si, Al, Na distribution
High- purity Ge Crystal(250cm^3)
Range 100 keV-10MeV
Spatial resolution 160km



Ground trace of XRS and GRS

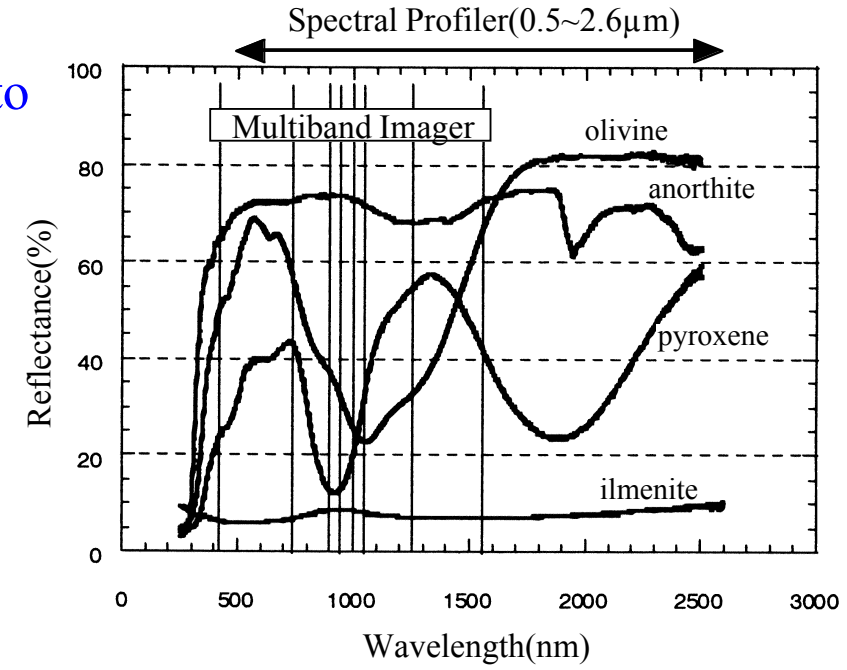
Global Mapping of Mineral Assemblage

Multi-band Imager

UV-VIS-IR imager
Spectral bandwidth ranging from 0.4 to 1.6 μm,
9 filters(bandwidth 10-30 nm)
Spatial resolution 20m

Spectral-Profiler

Continuous spectral profile ranging from 0.5 to 2.6μm(spectral sampling 5nm)
Spatial resolution 500m



Typical reflectance spectrum of mineral

Subsurface Structure and Topography

Radar- Soundar

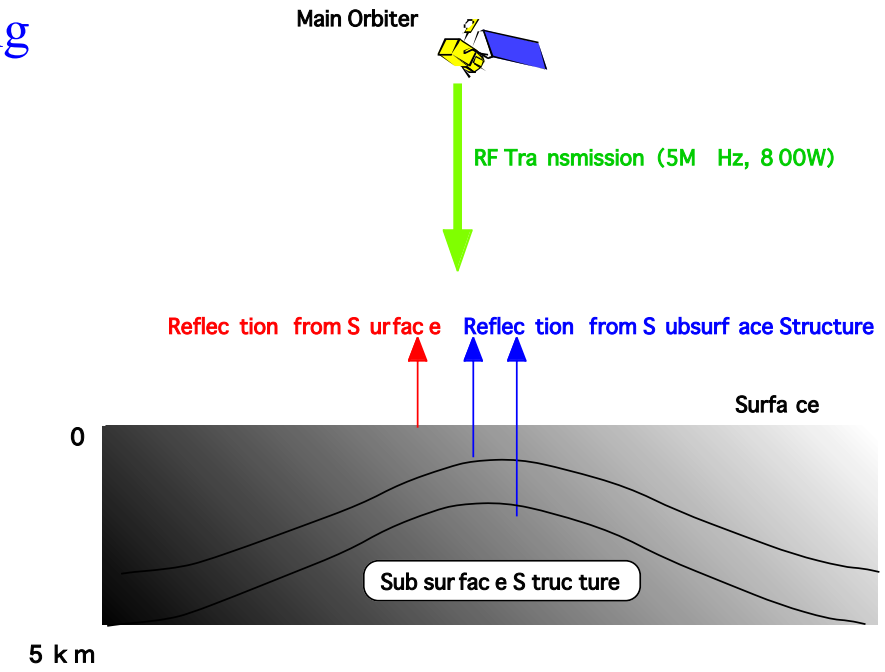
Mapping of subsurface structure using active sounding (frequency 5 MHz)
Depth 5 km(Resolution 100m)

Topographic Camera

Topography, Spatial resolution 10m

Laser Altimeter

Nd:YAG+ADP laser altimeter,
Footprint 30m
Height resolution 5m,
Spatial resolution 1600m
(pulse rate 1Hz)



Concept of Radar Sounder Experiment

Gravimetry and Selenodesy

Differential VLBI Radio-Source

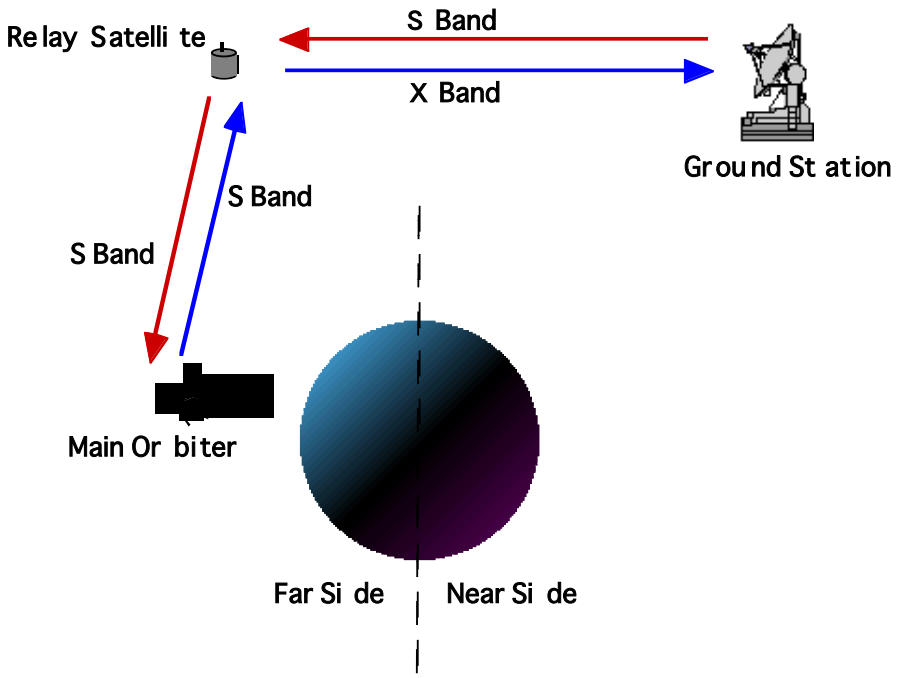
Three S-band sources and one X-band source

Relay satellite and VRAD satellite

Differential VLBI observation from ground station(3 stations).

Relay Satellite

Far-side gravimetry by Doppler measurement of orbiter via relay satellite (perilune 100km, apolune 2400km in altitude)



Concept of 4-way Doppler measurement

Magnetic Field Measurement

Mapping the distribution of crustal magnetic field and their direction

Determination the correlation of magnetic anomalies with surface geology

Magnetometer

- 3-axis fluxgate
- Precision 0.5 nT
- Truss 12m

Plasma Analyzer

- Range 10 eV/q-30 keV/q

Observation for "Science on/from the Moon"

Charged Particle Spectrometer

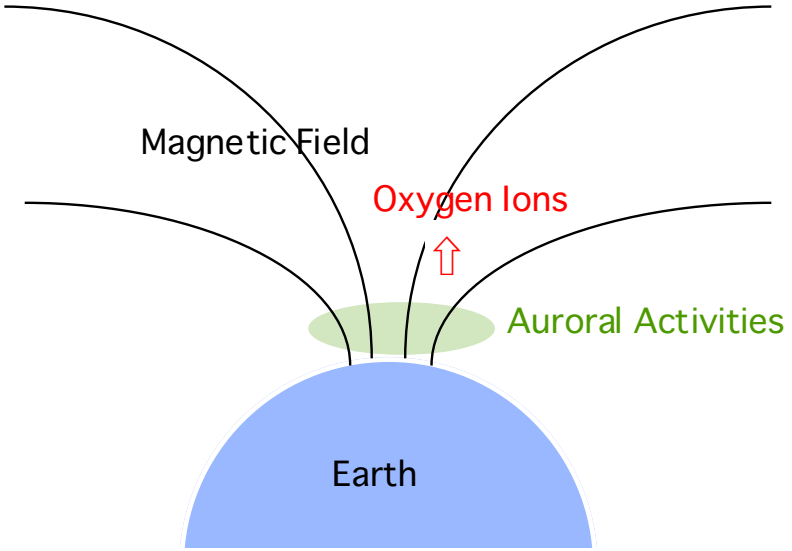
Measurement of high-energy particle
Isotope detector (1-30MeV(LID) and 8-300MeV(HID))
Alpha ray detector 4-6.5MeV

Plasma Imager

Observation of plasma dynamics around the earth from lunar orbit, EUV-VIS.

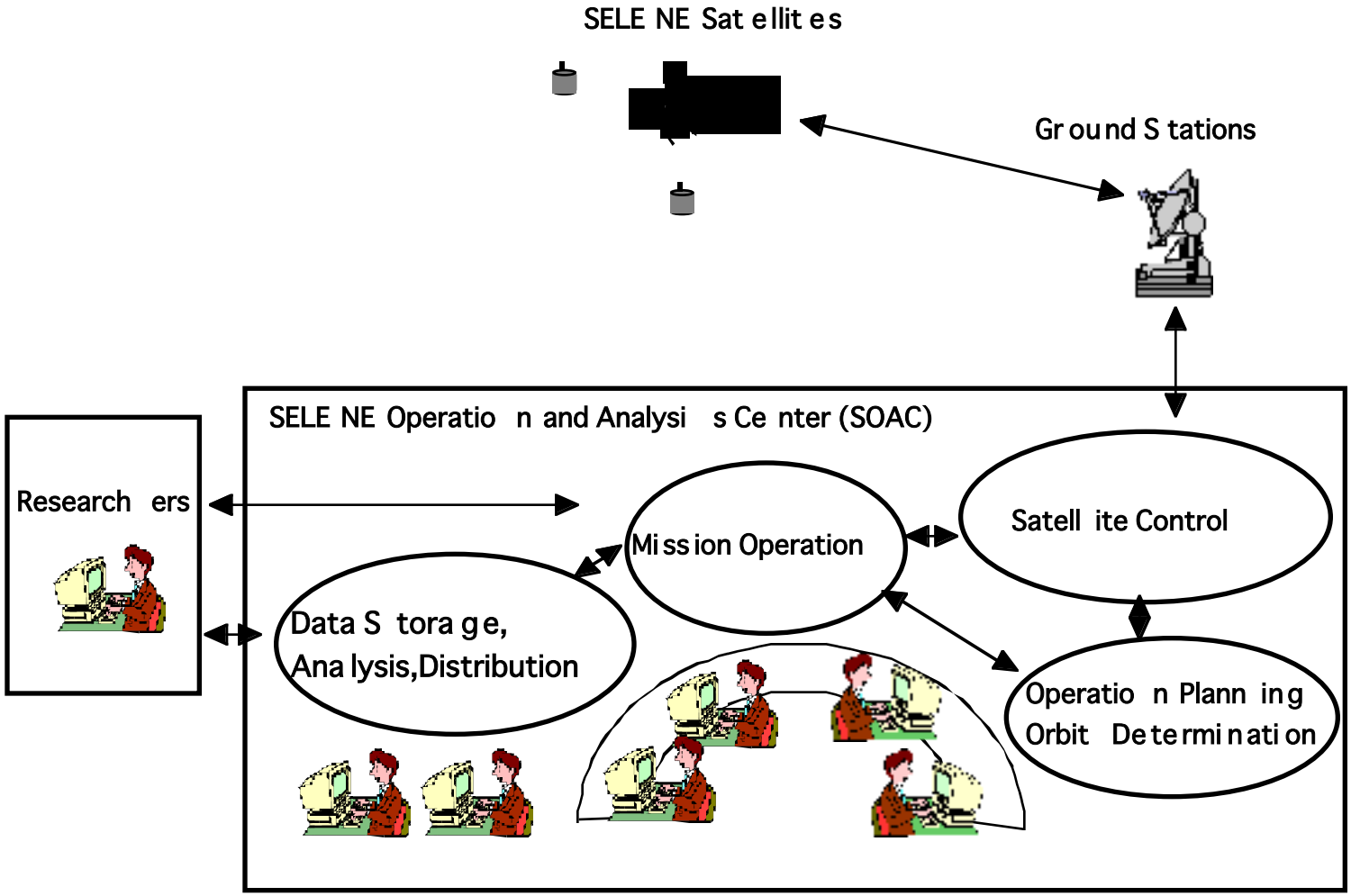
Radio Science

To detect the tenuous lunar ionosphere using S, X-band coherent carriers.

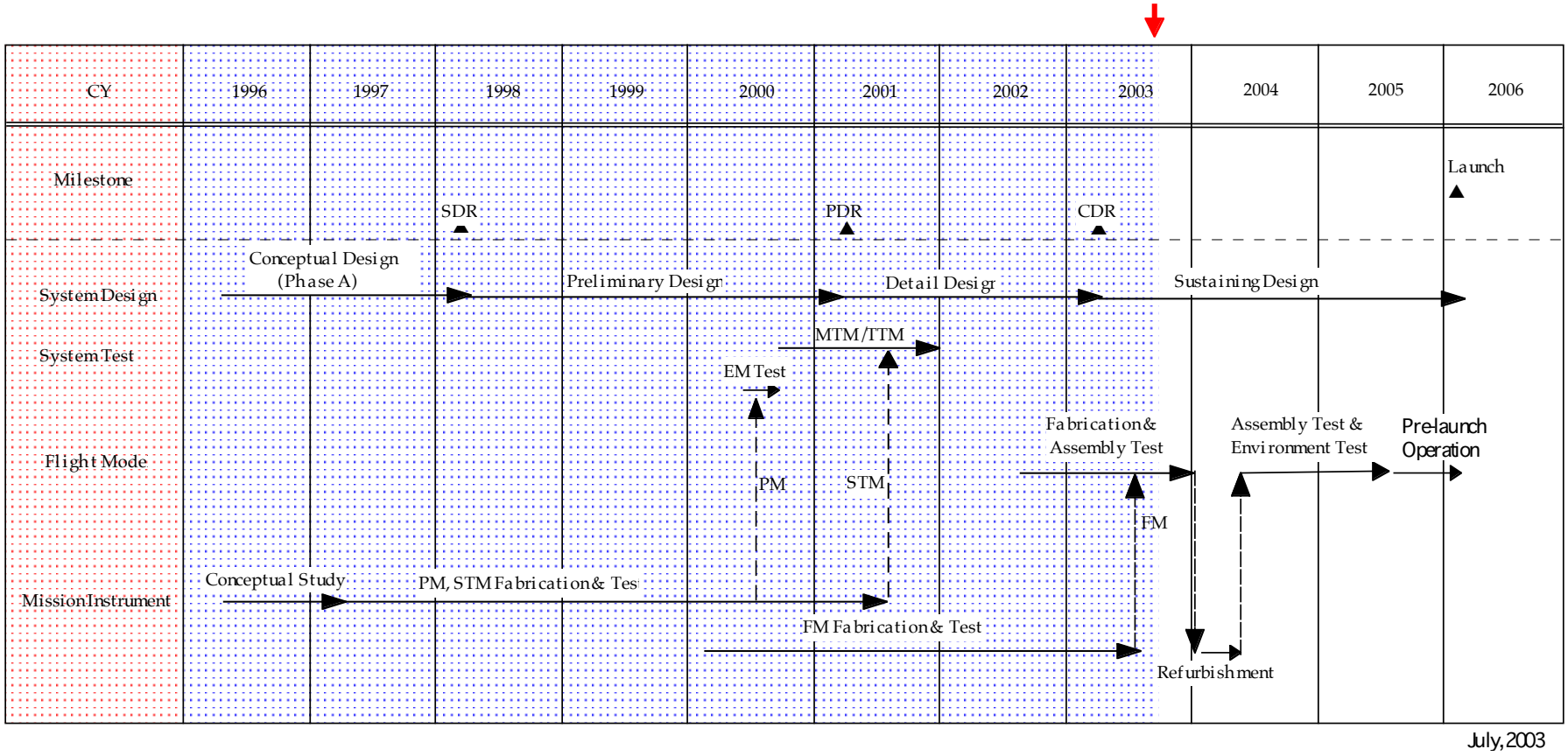


Observation of the earth magnetosphere from the lunar orbit

SELENE Operation and Analysis Center



SELENE Development Schedule



SELENE Mechanical Test Model

Concluding Summary

- Moon-orbiting observatory mission, "SELENE", will carry 15 mission instruments.
- It will provide scientific data to clarify the origin and evolution of the Moon, which will be used as a common data base for planetary scientists in the world.
- Almost all flight hardware have already been fabricated.
- Integration test is now underway, targeting launch early in 2006.
- Operation and data analysis center is now under development.