SELENE project

SELenological and ENgineering Explorer

Lunar Exploration Mission SELENE

June 2006

What' SELENE ?

- Japanese Moon-orbiting observatory mission,
- Largest lunar exploration after the Apollo program,
- One of the scientific missions of Japanese space agency, JAXA (Japan Aerospace Exploration Agency),
- Science and engineering research,
- Launch scheduled for 2007 by H-IIA rocket.~

SELENE Mission Objectives

Science

1. Science of the Moon

Study of origin and evolution of the Moon

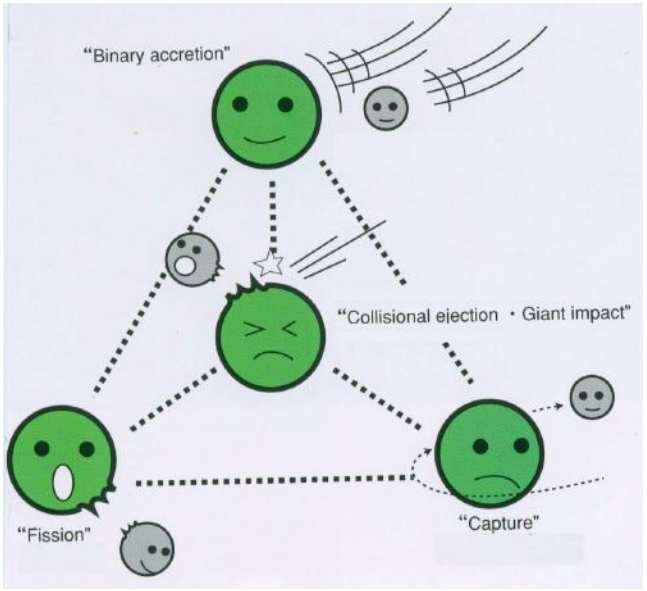
2. Science on the Moon

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

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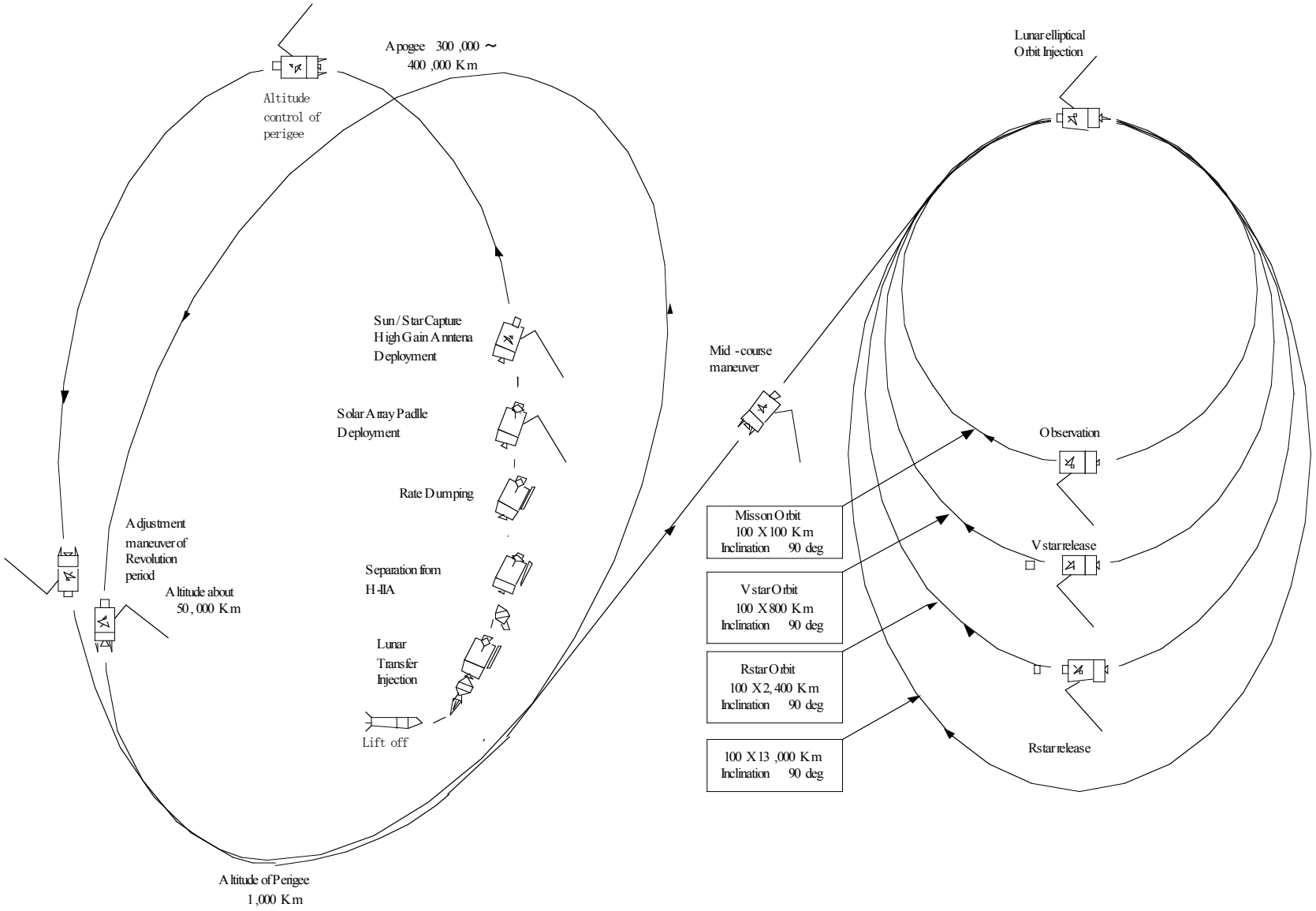
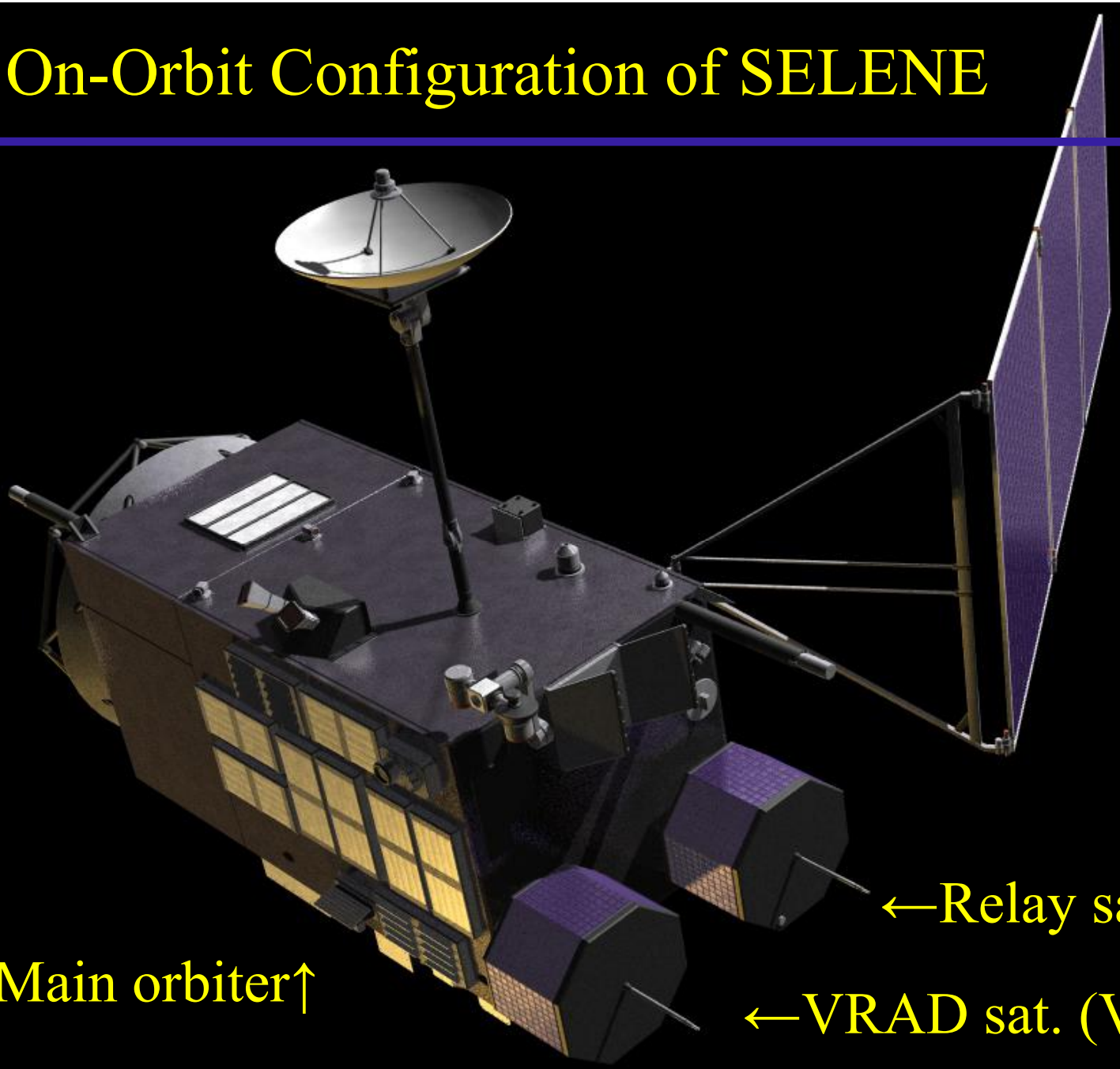
Outline of the Mission

Orbit	
Inclination	90 deg (polar orbit)
Main Orbiter :	100 x 100 km (circular)
Subsatellite Vstar :	100 x 800 km (elliptical)
Rstar:	100 x 2400 km (elliptical)
Total Mass	2885 kg (mission payload 300kg)
Size	
Main Orbiter :	2.1 x 2.1 x 4.8 m
Subsatellites:	0.99 x 0.99 x 0.65m
Mission period	1 year nominal
Attitude Control	
Main Orbiter :	3 axis controlled
Subsatellites:	spin stabilized

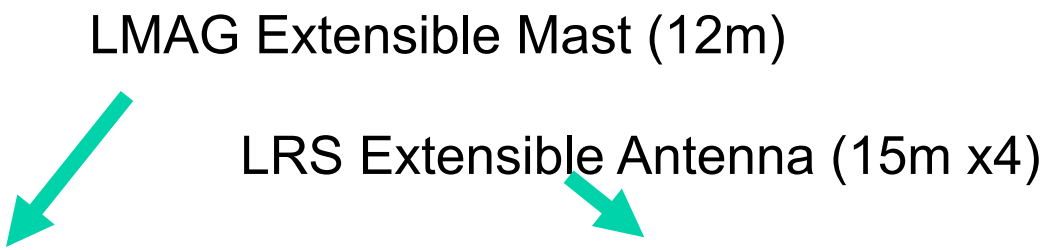
SELENE Mission Profile



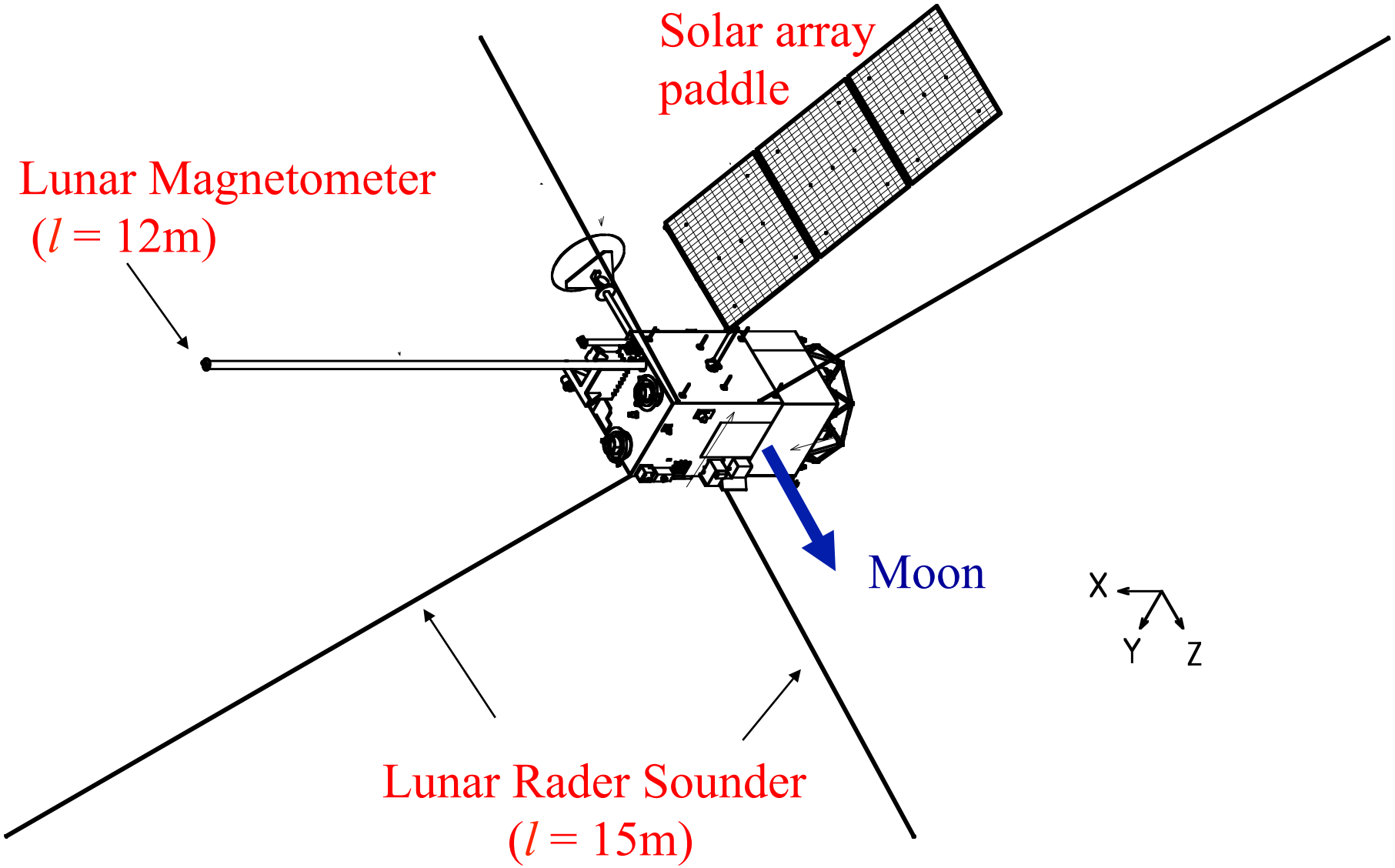
On-Orbit Configuration of SELENE



Configuration of SELENE in Lunar Orbit



On-orbit Configuration of SELENE



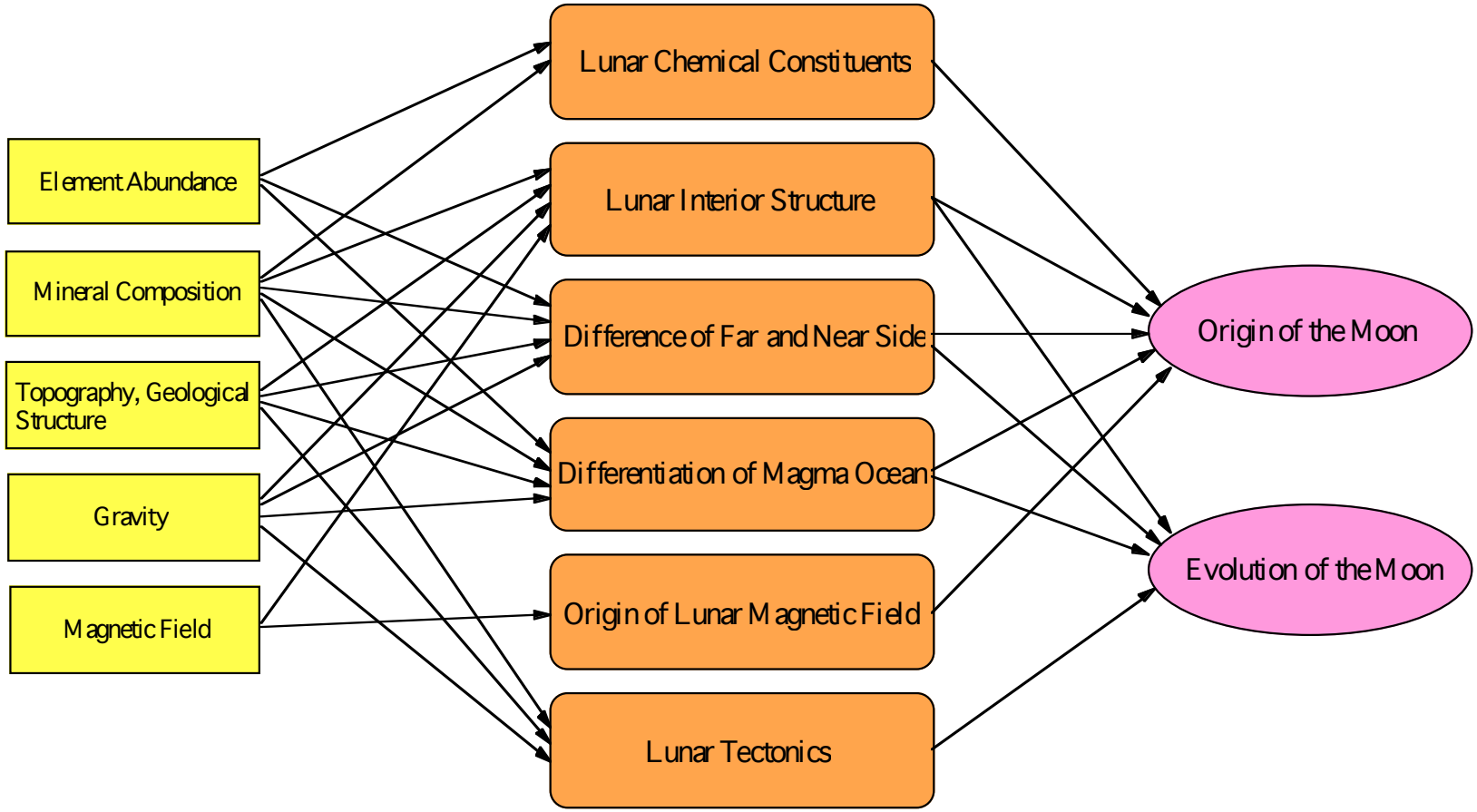
SELENE Bus Component

	SUB System	Specification and Characteristics
Main Orbiter	TelemetryTracking &Command	Anntena/Frequency:HGA/X-band(mission),S-ant/S-band(telemetry&command) BitRate:1000bps(command),2K/40Kbps(telemetry),10Mbps(mission data)
	Attitude and Orbit Control Subsystem	Attitude Control:Zero momentum system Three-axis control Attitude Control Accuracy :±0.1deg(three-axis) 4 Skew Reaction Wheel
	Propulsion Subsystem	Number of Thrusters: 500N×1, 20N×12, 1N×8 Propellant: Nitrogen Tetroxide 335Kg Hydrazine 742Kg
	Solar Power&Electrical Power Subsystem	1 Wing Rigid panel (with 30 deg cant) Power Generation :More than 3,200W(End of Life,β＝0deg) Un-regulated Bus voltage:52.8V～32.6V Battery : Main-Orbiter ;35Ah Ni-Cd Battely×16cells×8units～
	Data Handling Subsystem	1553B data bus system MDR recording capacity:100Gbit
VRAD satellite		Mass 50Kg , Elliptical Orbit 100km×800km～ Attitude stabilization :Spin-stabilized, 13Ah Ni-MH Battery×16cells×1unit
Relay satellite		Mass 50Kg , Elliptical Orbit 100km×2,400km～ Attitude stabilization :Spin-stabilized, 13Ah Ni-MH Battery×16cells×1unit

SELENE Mission Instruments

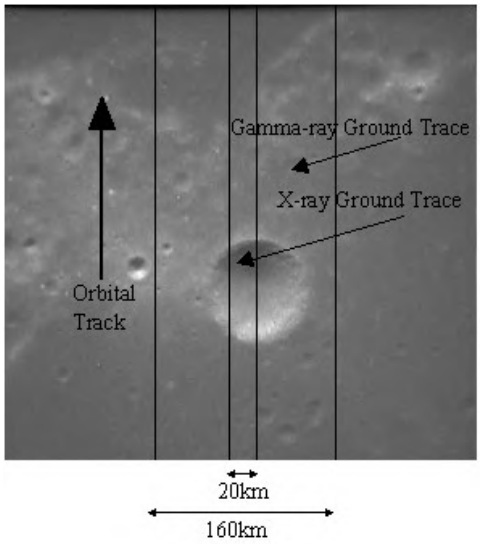
Observation	Instrument	Characteristics
Element Abundance	X-ray Spectrometer	CCD 100cm^2, Energy range 0.7~8 keV, Resolution 90 eV, 5μm-Be film, Solar x-ray monitor, Calibrator with sample, Global mapping of Al, Si, Mg, Fe, Spatial resolution 20 km
	Gamma-ray Spectrometer	High purity Ge crystal 250 cm^3, 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、



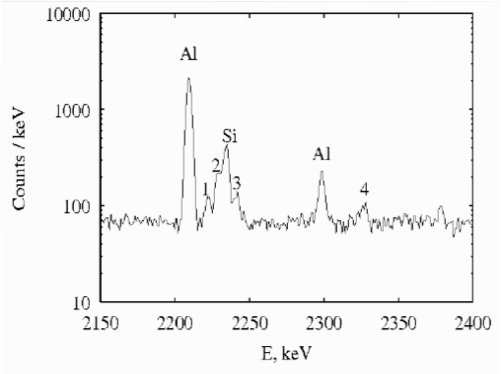
Global Mapping of Chemical Composition

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



Ground trace of XRS and GRS

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



Detection of hydrogen

Global Mapping of Mineral Assemblage、

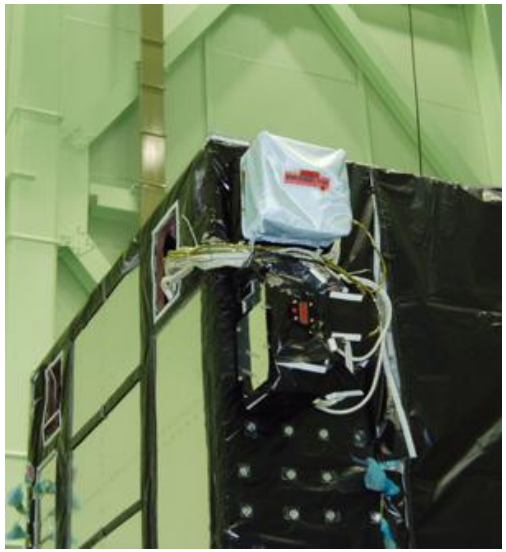
Multi-band Imager

UV-VIS-IR imager

Spectral bandwidth ranging from 0.4 to 1.6 μm,

9 filters(bandwidth 10-30 nm)

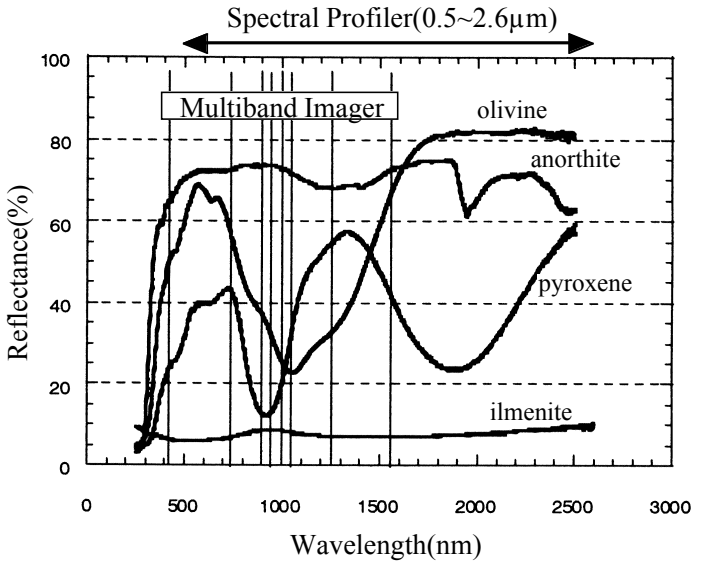
Spatial resolution 20m



Spectral-Profiler

Continuous spectral profile ranging from 0.5 to 2.6μm(spectral sampling 5nm)

Spatial resolution 500m、

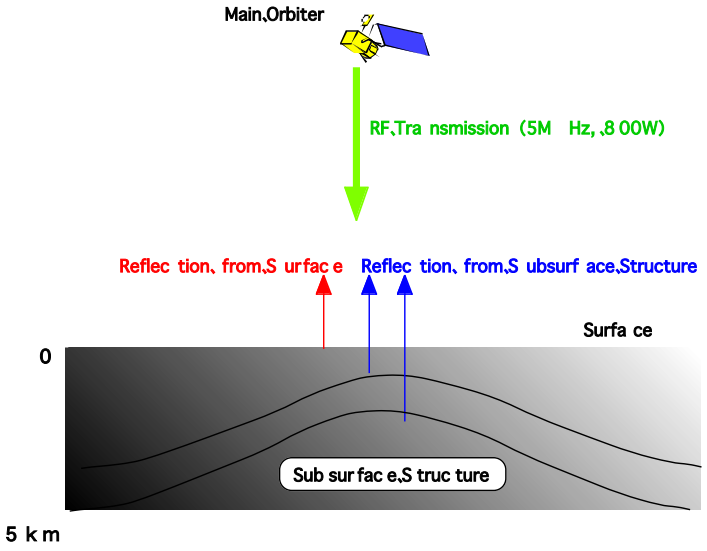


Typical reflectance spectrum of mineral

Subsurface Structure and Topography

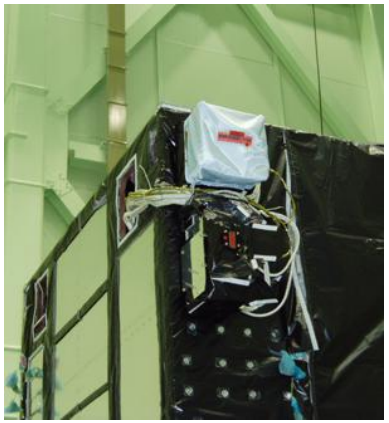
Radar- Soundar

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



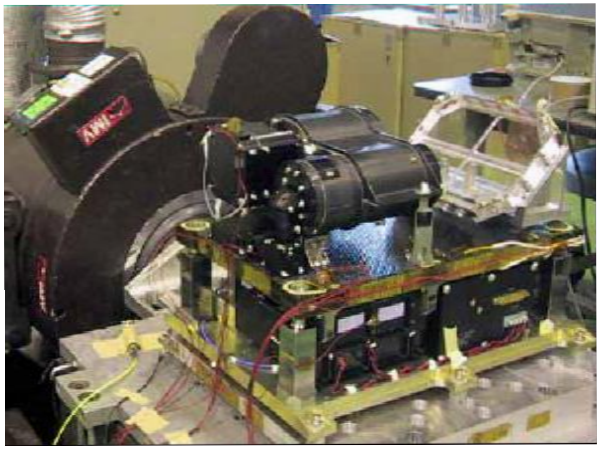
Topographic Camera

Topography, Spatial resolution 10m～



Laser Altimeter

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



Gravimetry and Selenodesy、

Relay Satellite

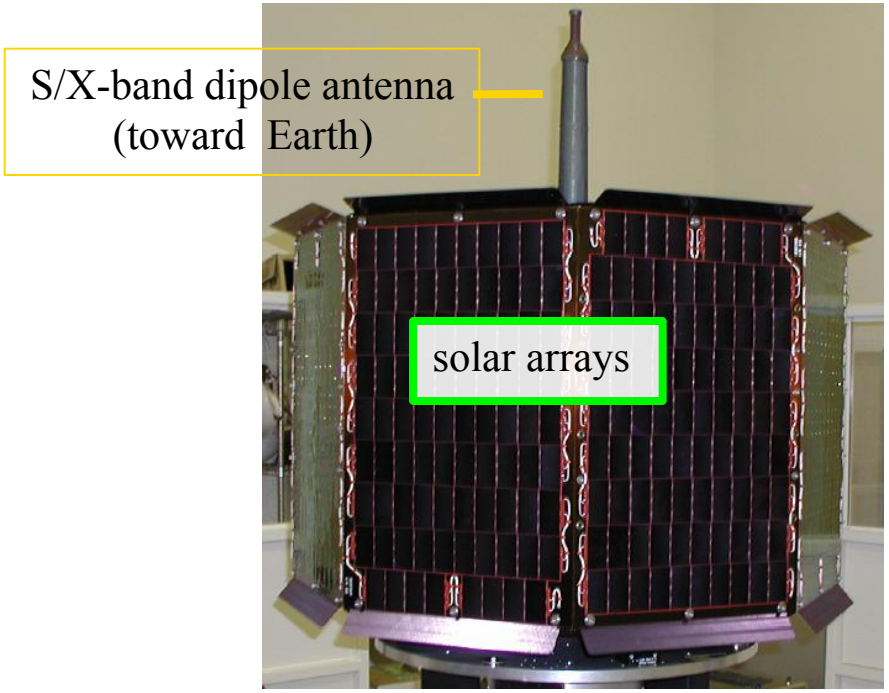
Far-side gravimetry by Doppler measurement of orbiter via relay satellite (perilune 100km, apolune 2400km in altitude)

Differential VLBI Radio-Sources

Three S-band sources and one X-band source

Relay satellite and VRAD satellite

Differential VLBI observation from ground station(3 stations).



RSAT: 4 -way Doppler measurement using Relay Satellite Transponder

The first direct determination
for the lunar far side orbit

RSAT -1
on Rstar

S-band forward-link
for 4way-Dopp

S-band up -link for
4way-Dopp / 2wayRARR

S-band return -link
for 4way-Dopp

S-band down -link
for 2wayRARR

Moon

ISAS
UDSC -64m

Orbiter
above near side

RSAT -2
on Orbiter
above far side

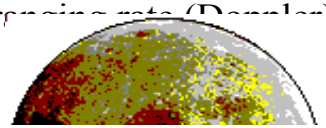
X-band down -link
for 4way-Dopp

Earth

NASDA
TACS

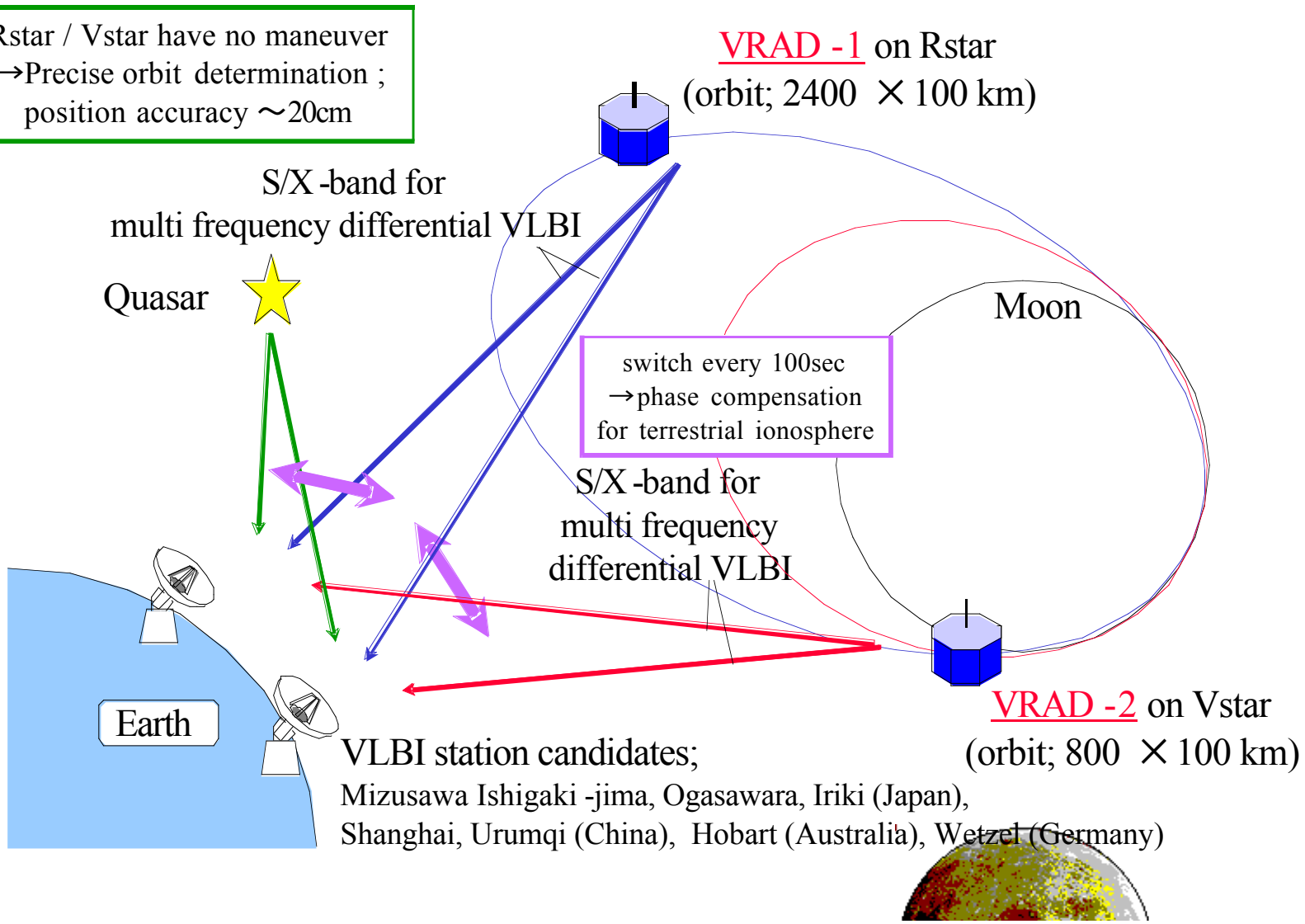
S-band for 2wayRARR

Dopp = Doppler measurement (ranging rate)
RARR = ranging and r



VRAD: Multi frequency differential VLBI using VLBI Radio Sources

Rstar / Vstar have no maneuver
→Precise orbit determination ;
position accuracy ～20cm

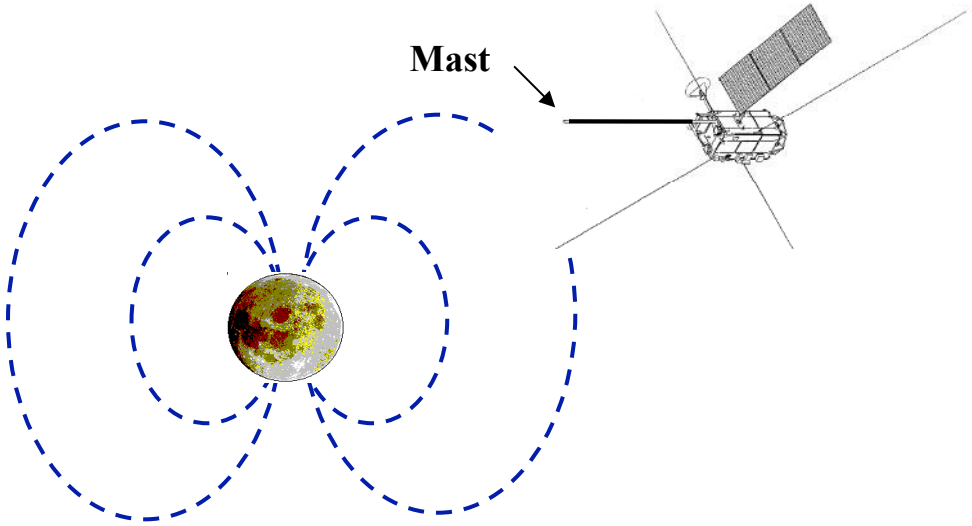


Magnetic Field Measurement

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
Mast 12m

Electron Detector of Plasma Analyzer
Range 10 eV/q-30 keV/q



Science on the Moon

Charged Particle Spectrometer

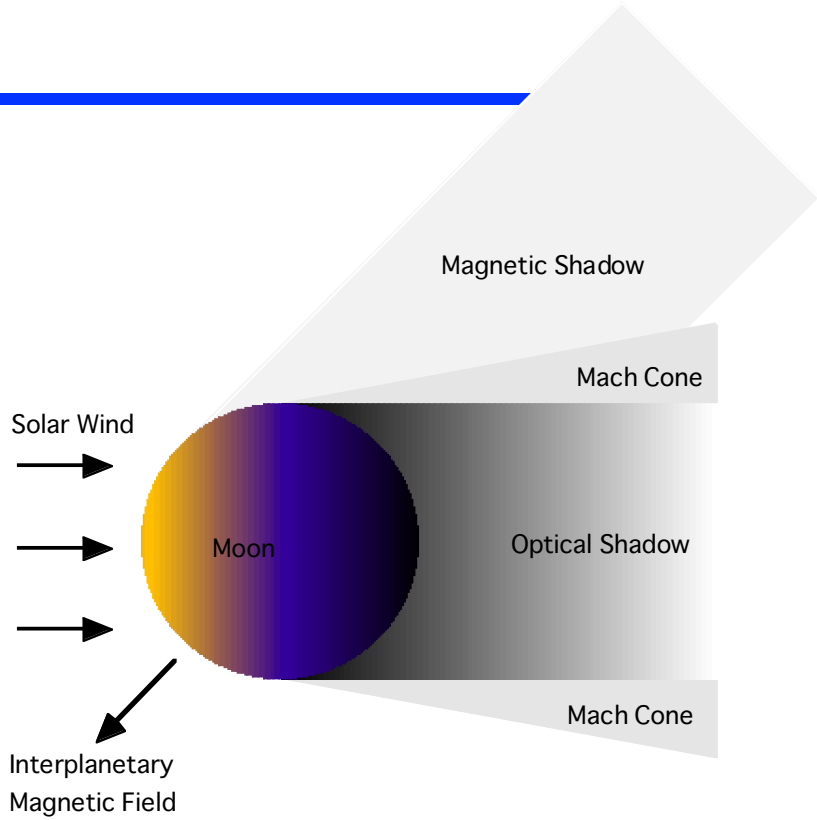
Measurement of high-energy particle
Isotope detector (1-30MeV(LID) and 8-300MeV(HID))
Alpha ray detector 4-6.5MeV

Plasma Analyzer

Electron energy analyzer 5 eV-17 keV
Ion energy analyzer 5 eV/q-28 keV/q
Ion mass/energy analyzer 1-60 AMU

Radio Science

To detect the tenuous lunar ionosphere using S, X-band coherent carriers on VRAD satellite.、

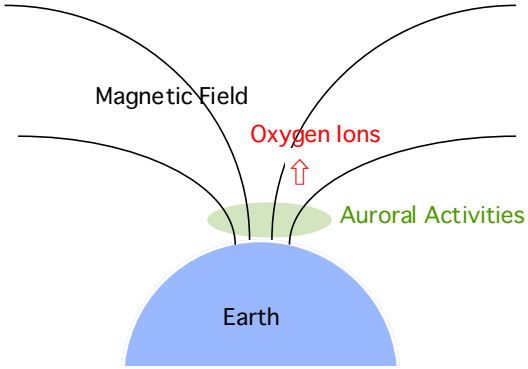


Study of plasma environment around the Moon

Science from the Moon

Plasma Imager

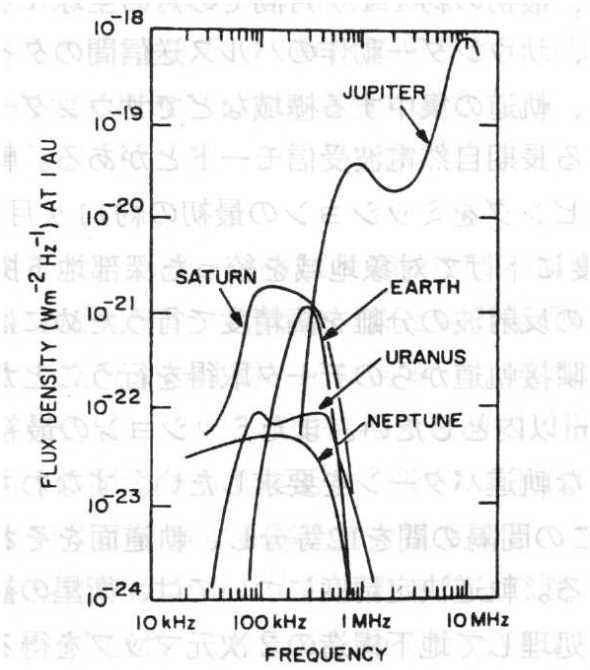
Observation of plasma dynamics around the earth from lunar orbit, EUV-VIS.



Observation of the earth magnetosphere from the lunar orbit、

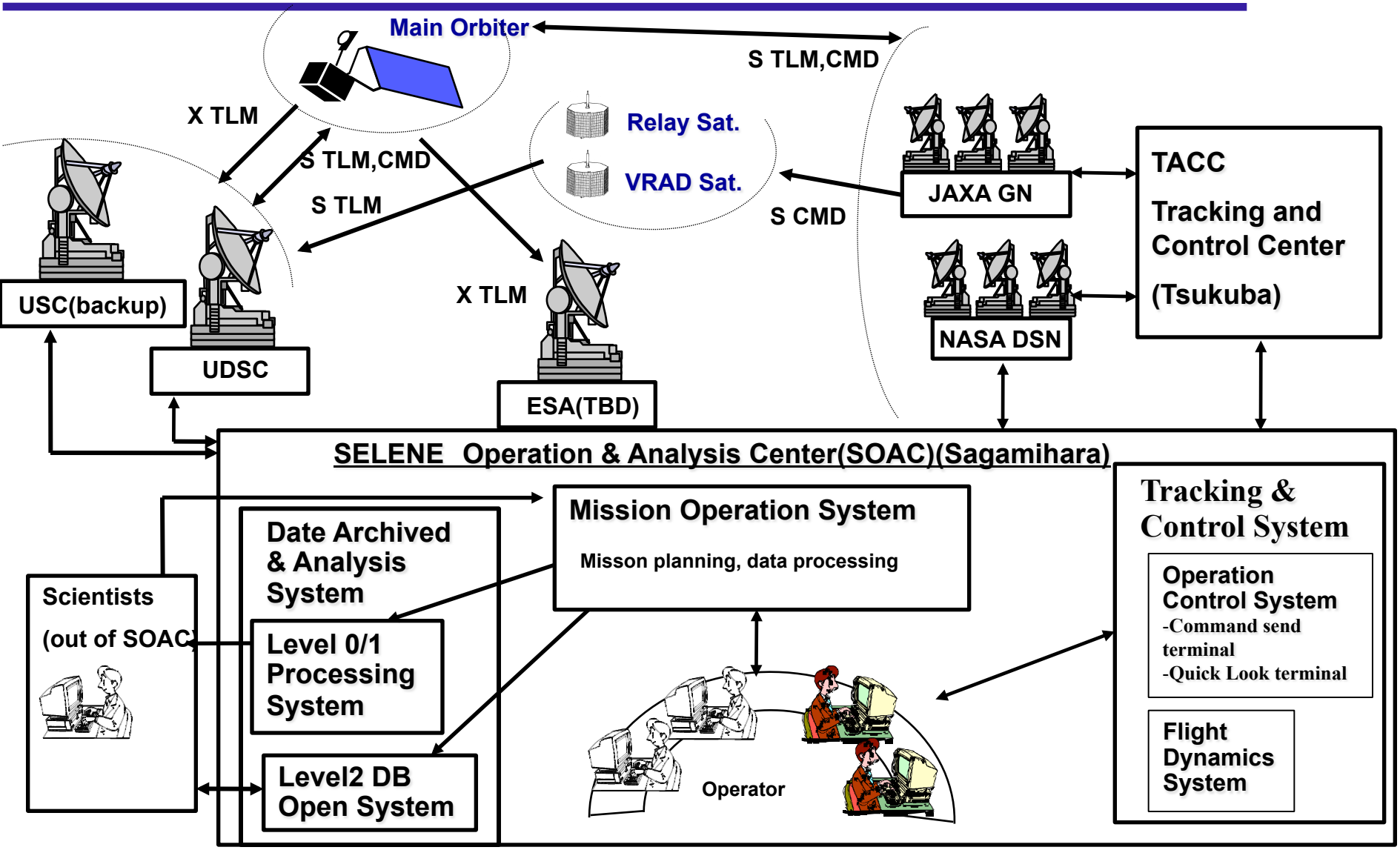
Wave Receiver of Radar Sounder Experiment

Measurement of plasma waves, radio waves, and planetary radiation, Frequency range 10 Hz to 3 0 MHz.

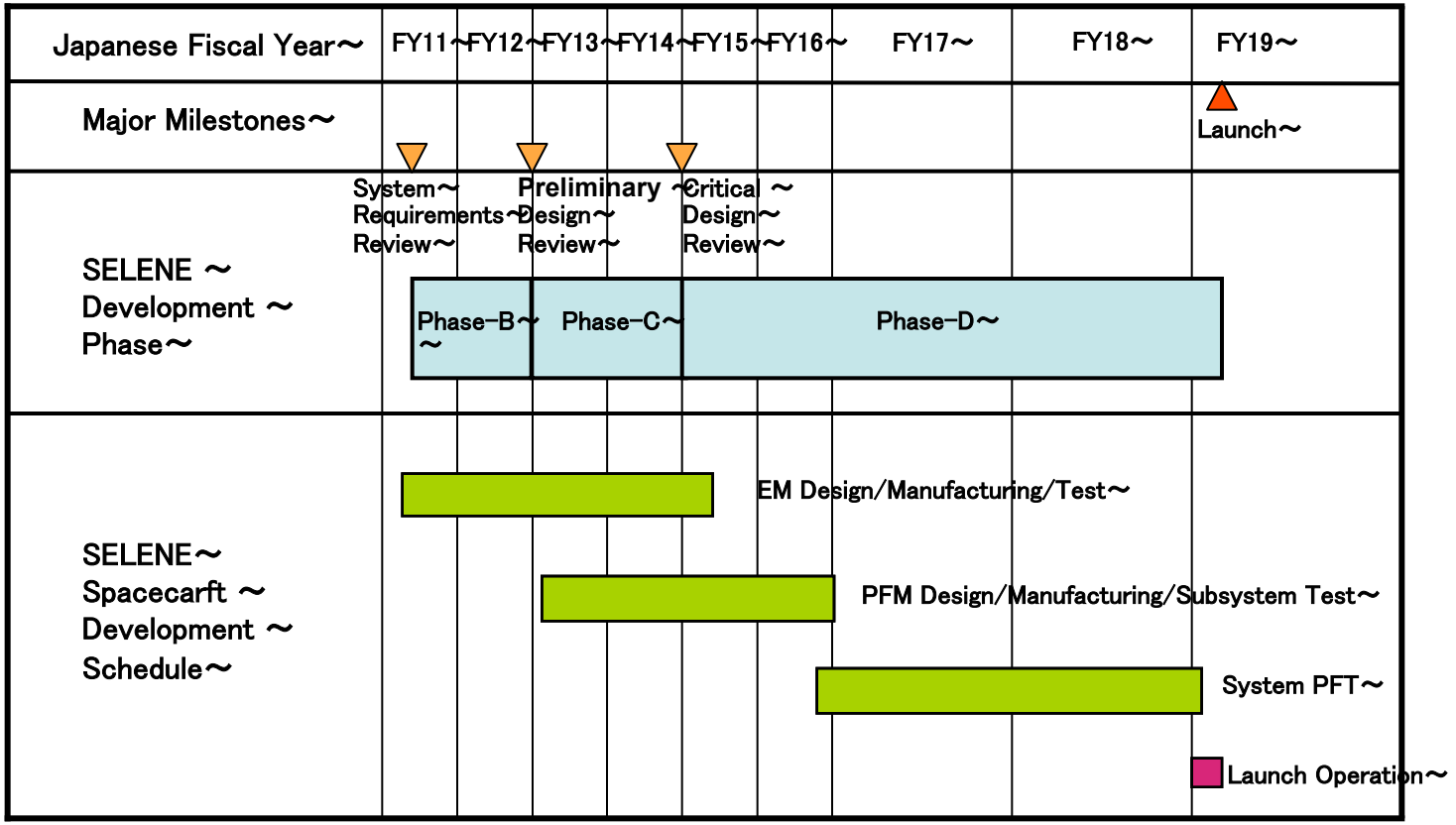


Planetary radiation

SELENE Ground System Configuration



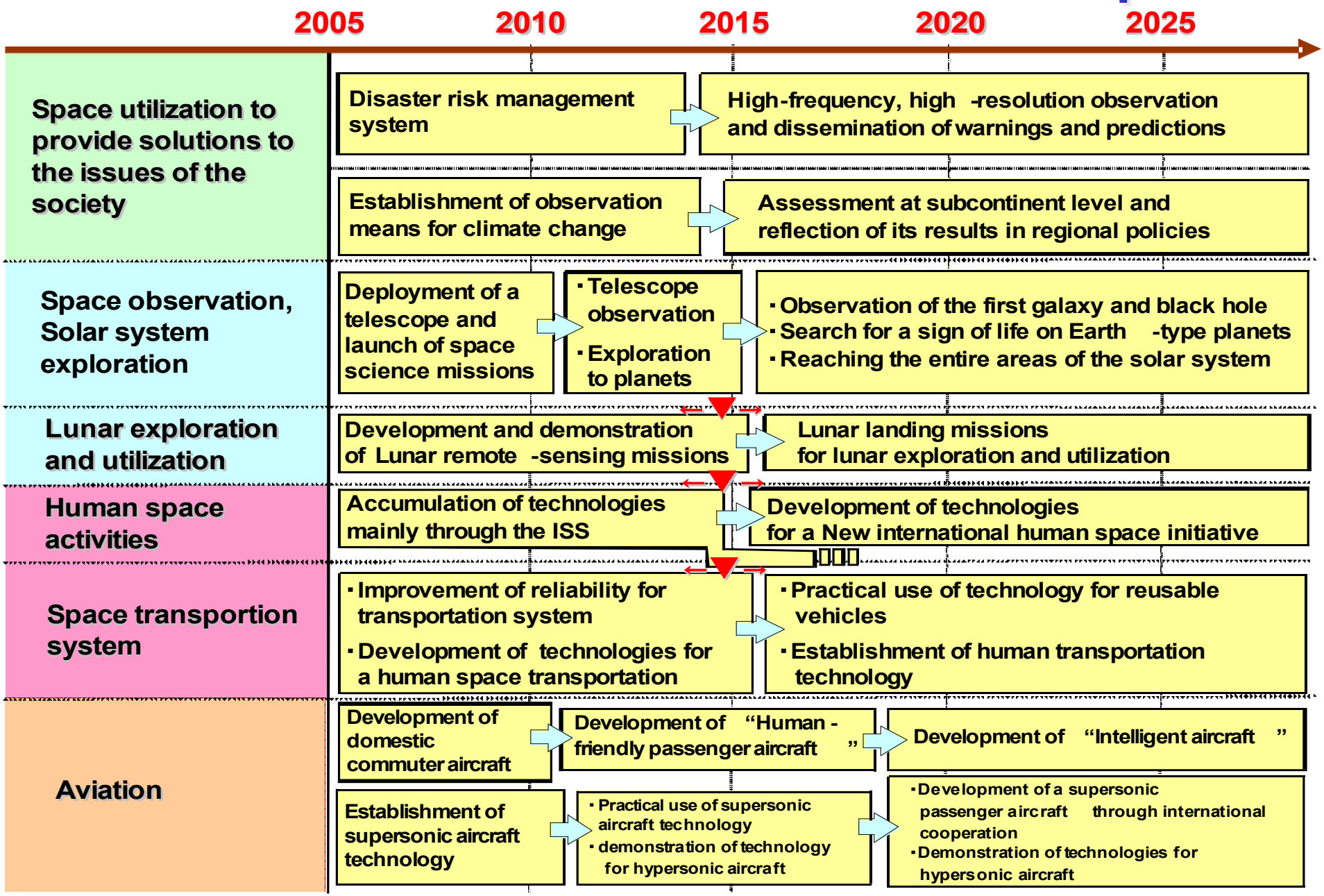
Schedule



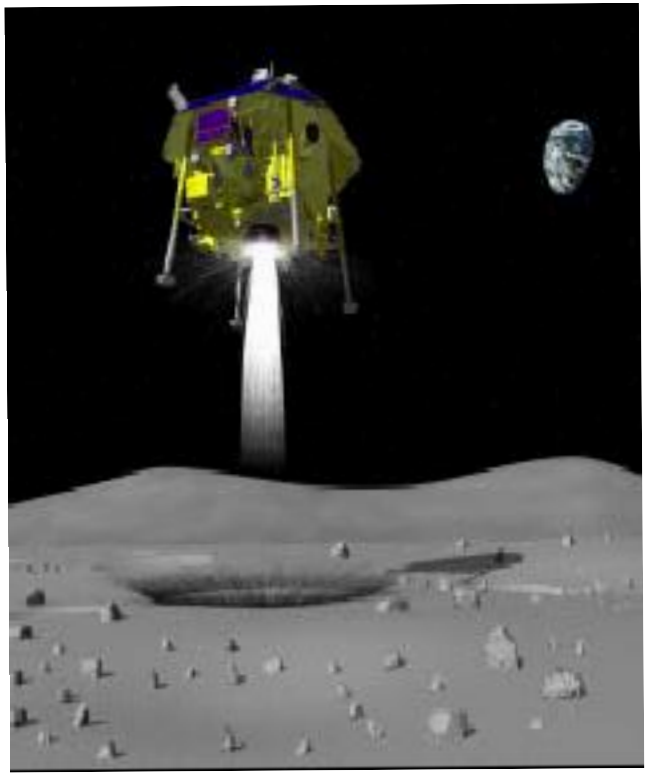
Abbreviation～
EM: Engineering Model～
PFM: Proto Flight Model～
PFT: Proto Flight Test ～

@As of October 2005～

JAXA Vision Overall Roadmap



Future Scenario –Lunar Lander



Technology development
– Guidance, Navigation & Control System for pinpoint landing
– Autonomous obstacle detection & avoidance system for safe landing
– Landing Gear to absorb the impact energy of landing
– Rover system to probe the Moon surface～

Future Scenario –Lunar Rover

Lunar Surface Exploration
– Geological survey to investigate Lunar evolution
– Characterization of the Lunar surface environmental condition
Data Collection for future Lunar Utilization
– Lunar Observatory
– Temporal Lunar base
– Permanent Lunar Base, etc.～

Summary and Concluding Remarks

Configuration of SELENE (without Solar Array Paddle and Rstar/Vstar)

- Moon-orbiting observatory mission, "SELENE", will carry 15 mission instruments.
- SELENE 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.
- SELENE will be a kick-off mission in the series of Japanese lunar exploration and utilization program.