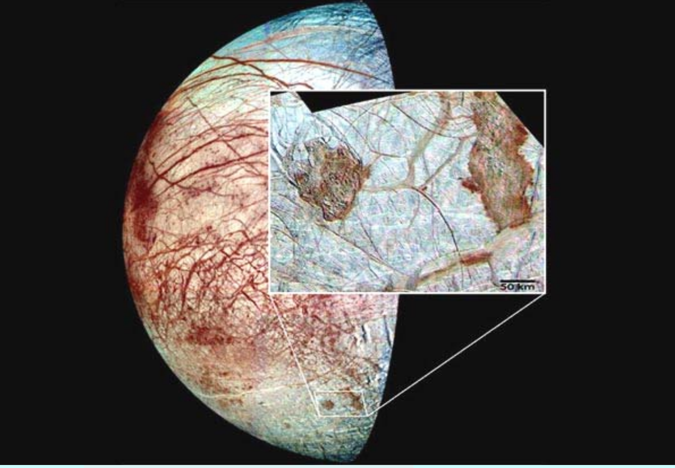


Совет по космосу РАН

29 мая 2007 года

Миссия ЕКА к Европе и системе Юпитера

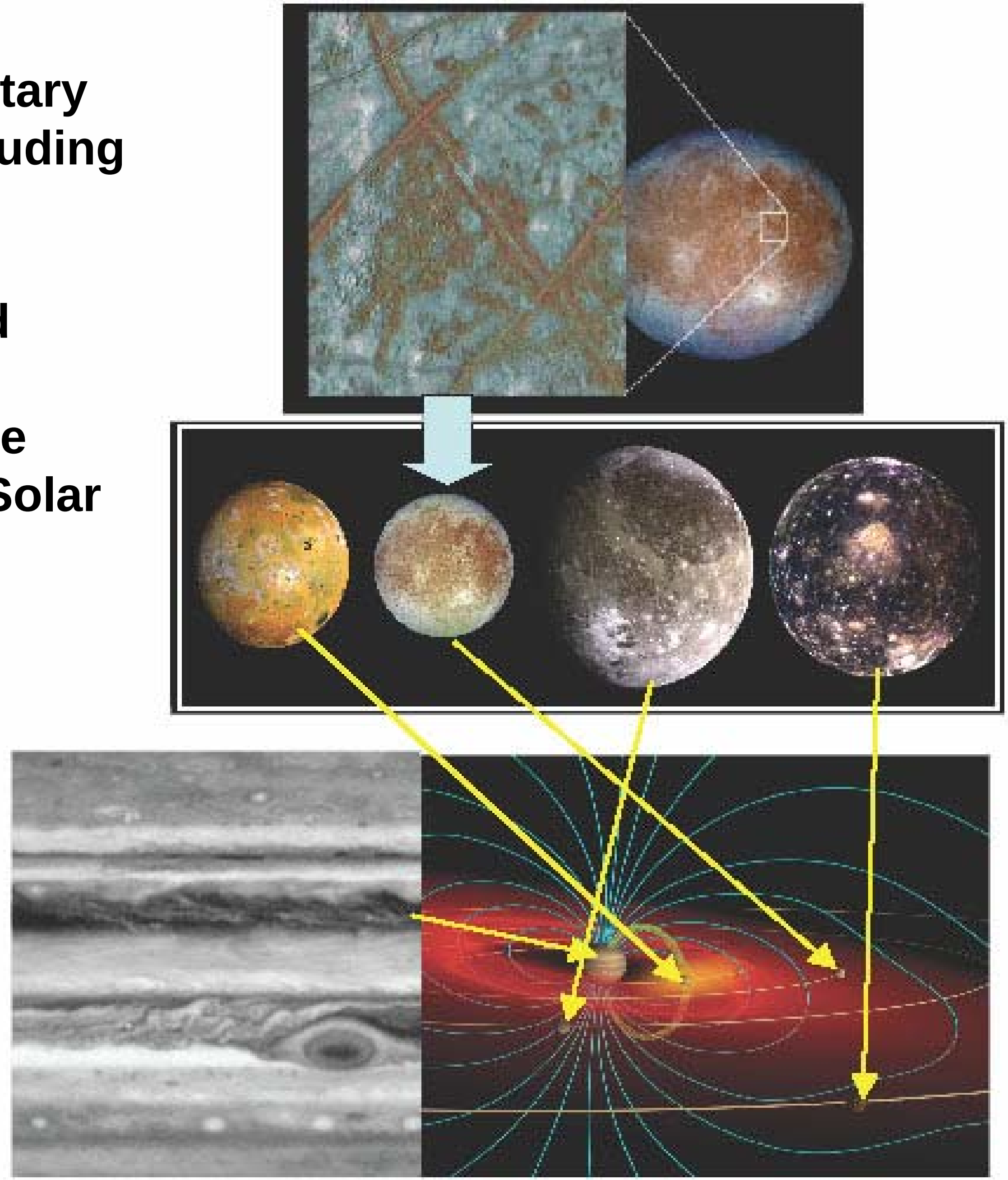
Prime targets:

1 - Characterize Europa as a planetary object and a potential habitat (including its exosphere/ionosphere)

2 – Study the origin, formation and evolution of the Jovian satellites system, and their connection to the population of small bodies in the Solar System

3 – Study the Jovian magnetodisk/magnetosphere (including its moon interactions from the large-scale perspective, i.e. the “binary system” theme)

4 – Study the Jovian atmosphere.

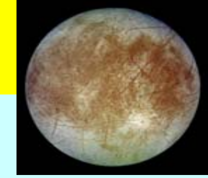


Theme 1 – Characterize Europa as a planetary object and a potential habitat

- **Existence & characterization of a sub-surface ocean**
- **Search for astrobiological signatures –**
- **Surface composition and chemistry –**
    - **Global surface morphology & dynamics –**
    - **Constraints on mantle dynamics -**
    - **Exosphere & Magnetospheric interactions –**

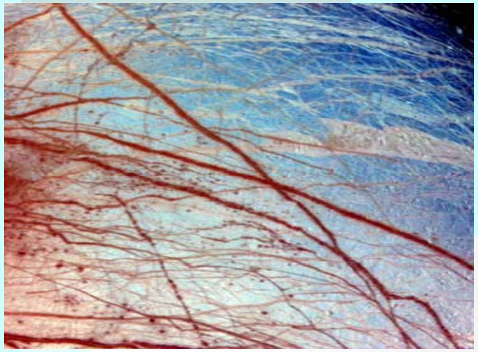
The mission will probe the **existence** of Europa's subsurface **ocean**, establish its **main characteristics** and map the **topography of its silicate sea-floor**. It will study Europa's **surface mineralogical and chemical composition**, constrain its environmental parameters and look for **possible bio-signatures**. It will study the dynamics of the mantle, the ice crust and its coupling to the subsurface ocean. Finally it will characterize Europa's exosphere and its magnetospheric interaction.

I. Definition of the science objectives

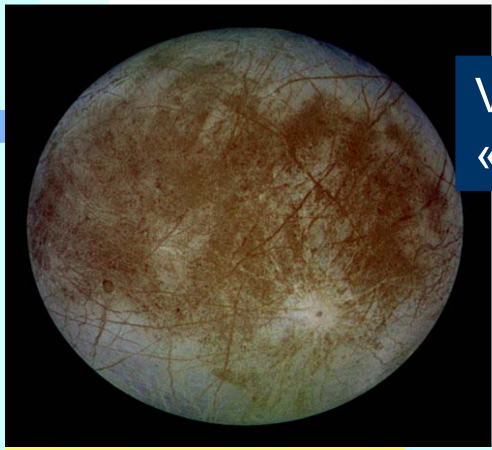


Why is Europa unique? – surface features / internal structure

Surface evidences + Geophysics

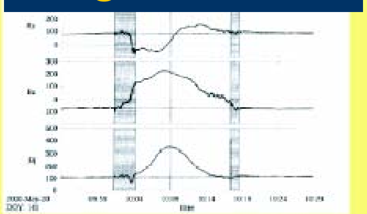


Salty material in Cryovolcanic products



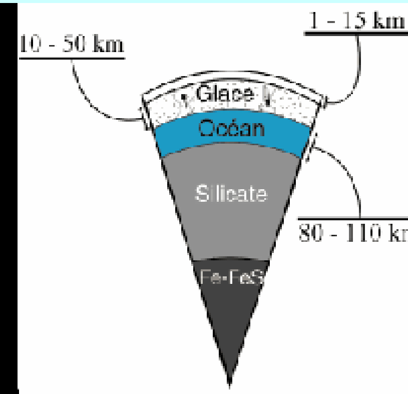
Very young surface
« Resurfacing »

Magnetic field



Kivelson et al., 2001

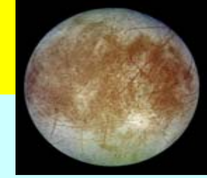
Implications



An ocean is highly probable but…

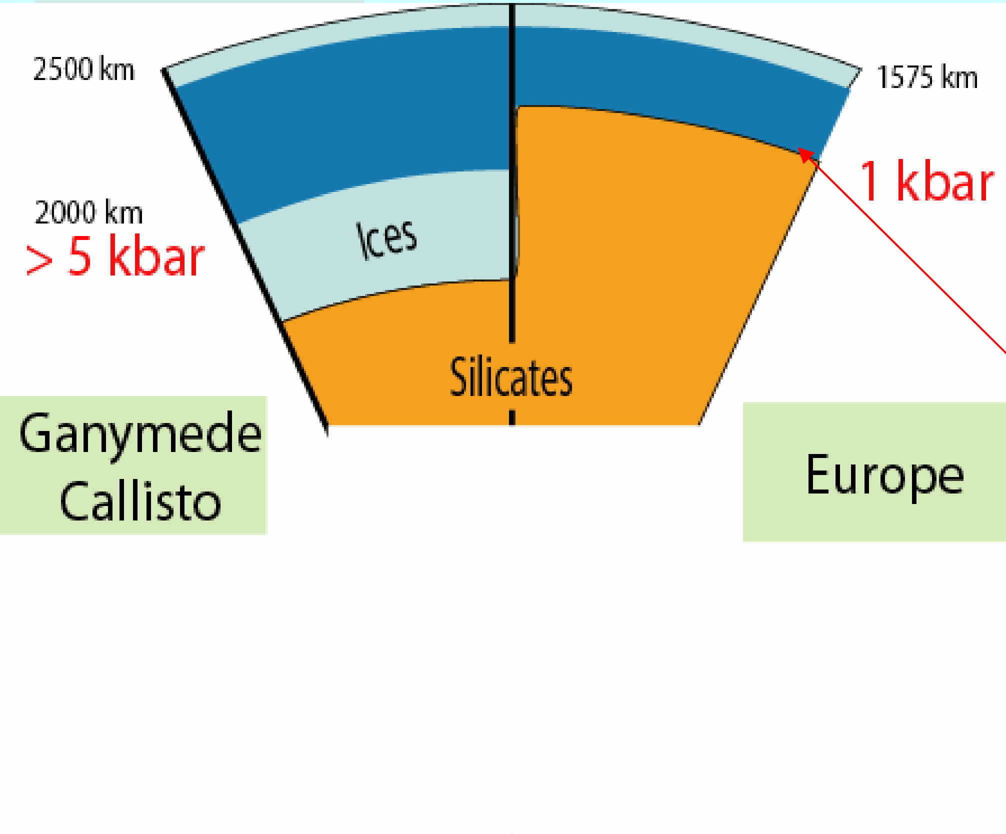
Its existence has not been proven!

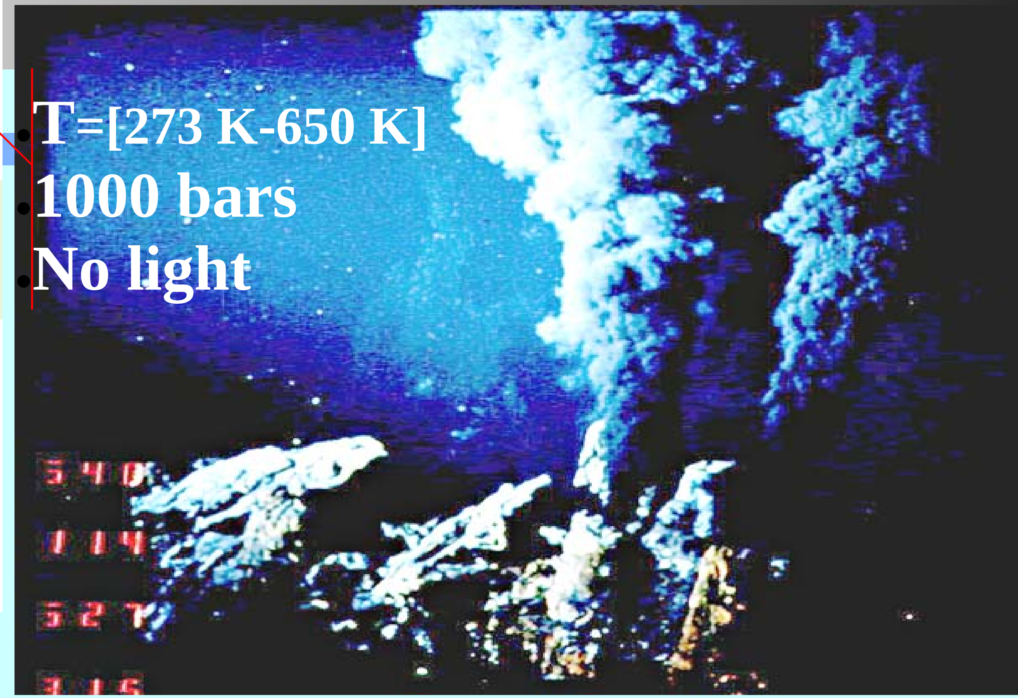
I. Definition of the science objectives



Why is Europa unique? – the ocean floor

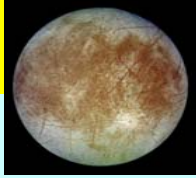
Europa: Silicates in contact with the liquid layer



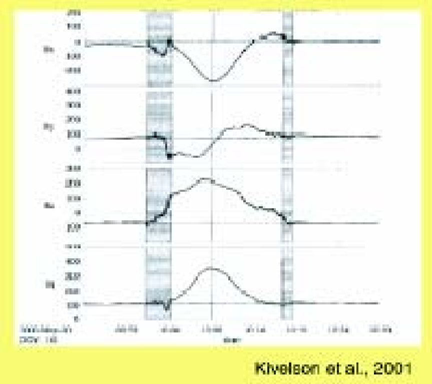


- T=[273 K-650 K]
- 1000 bars
- No light

I. Definition of the science objectives

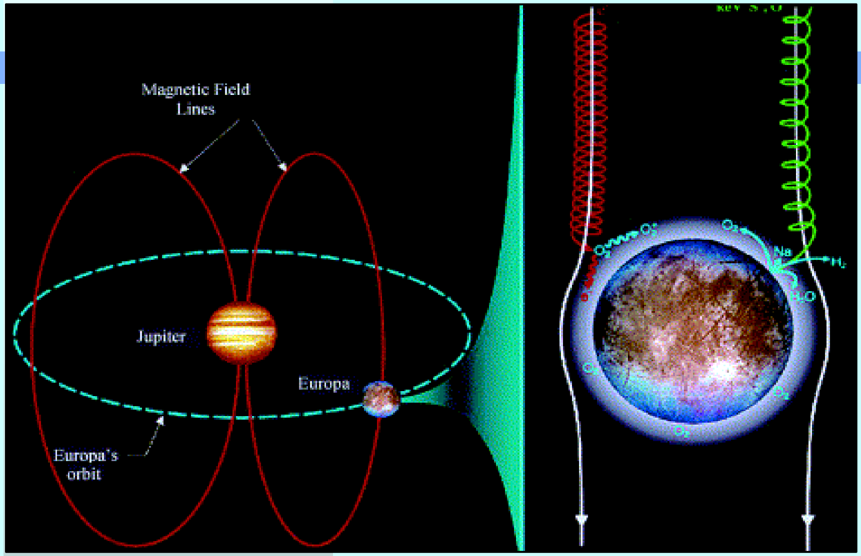


Why is Europa unique? – exosphere and magnetospheric interactions



Kivelson et al., 2001

- **Induced magnetic field:**
- **a salty water liquid layer?**



'Binary system' theme

'Alfvèn wings', relate the jovian ionosphere to the exosphere of the moons.

The coupling with Europa is apparently not very powerful, even if it seems able to generate intense waves.

Sputtering processes

Search for astrobiological signatures –

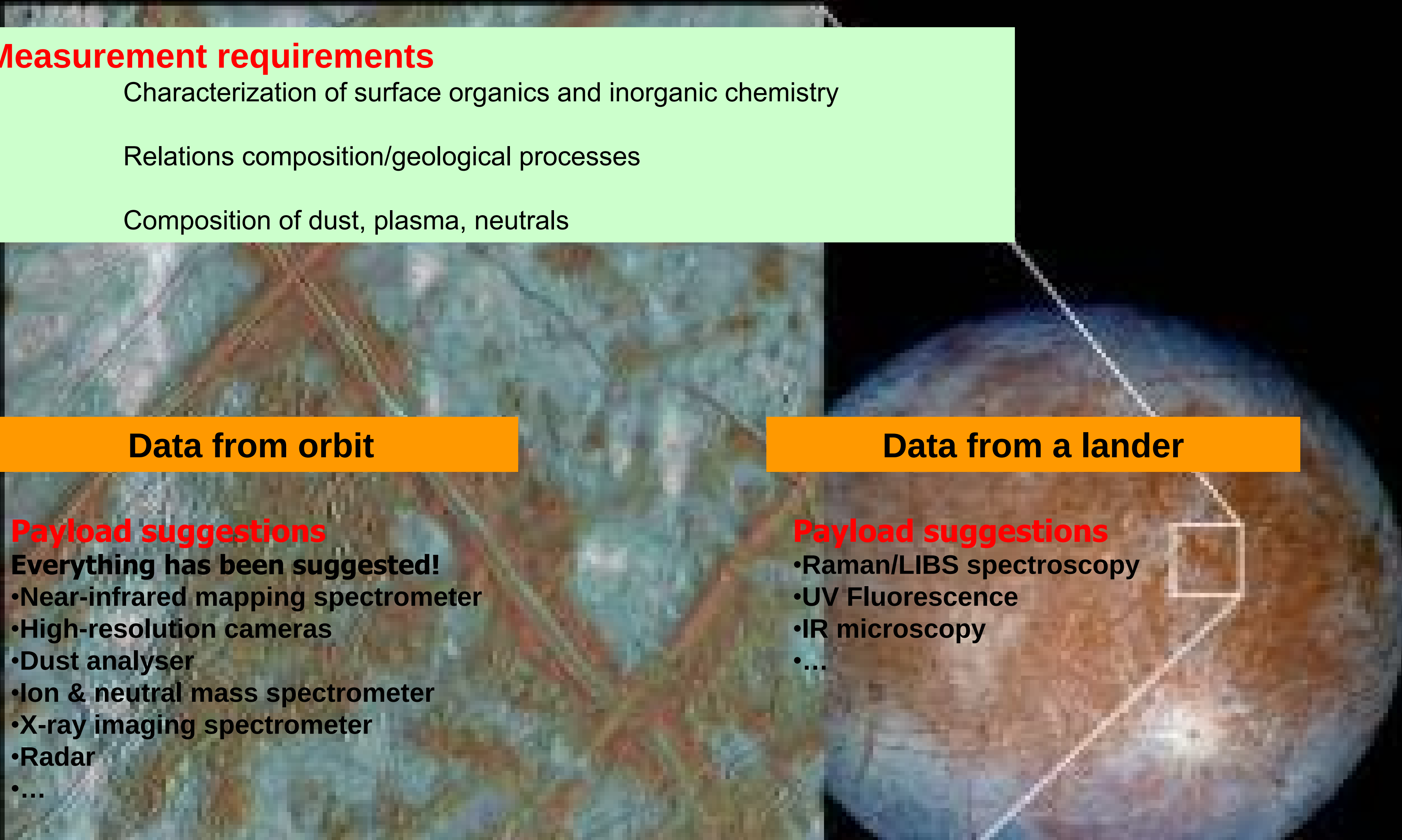
Data from orbit

Imaging spectroscopy: VIS, IR,
Gamma ray,
TOF-SIMS,
Dust impact detector
Mass spectrometer.
Nothing much to be expected

Data from a lander

Payload suggestions
- **Environmental in situ sensors: temperature, pH ...**
- **Raman, UV-VISspectroscopy, Molecular Probes, e.g.**
- **Immuno assays.**
- **Imaging 10s um**
- **Fluorescence,**
- **Test for metabolic activity.**
- **Micro-Imaging**
- **Drilling?**

Surface composition and chemistry –



Measurement requirements

Characterization of surface organics and inorganic chemistry

Relations composition/geological processes

Composition of dust, plasma, neutrals

Data from orbit

Payload suggestions

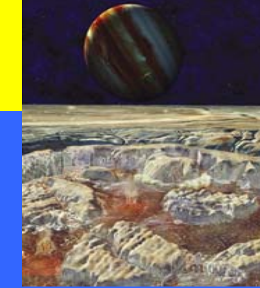
Everything has been suggested!

- Near-infrared mapping spectrometer
- High-resolution cameras
- Dust analyser
- Ion & neutral mass spectrometer
- X-ray imaging spectrometer
- Radar
- …

Data from a lander

Payload suggestions

- Raman/LIBS spectroscopy
- UV Fluorescence
- IR microscopy
- …



Global surface morphology & dynamics –

Measurement requirements

Topography measurements

Identification of tectonic, volcanic, and impact features

Search for sites of recent geological activity

Orbit requirements:

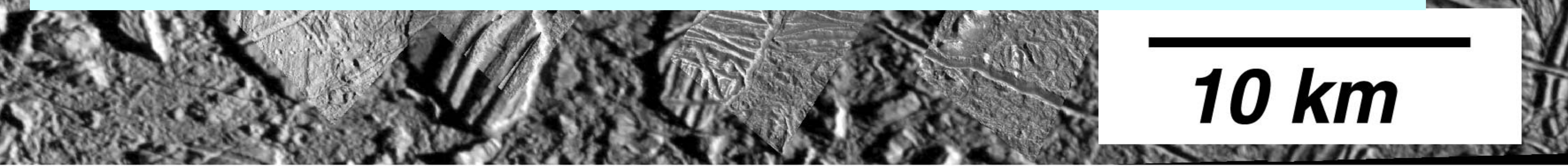
as long as possible
Need for both high and low resolution images.

Payload suggestions.

Navigation+altimetry : No specific constraints, the more precise the better. –

High resolution cameras - P1

Radar – P1



Silicate mantle dynamics –

Measurement requirements

Gravimetry and geodesy but at very high precision
Complementary data from magnetic field

What can be done from an orbiter?

Almost nothing!!!
Ask yourself what we know about mantle dynamics of Mars…

What can be done with a lander?

Almost nothing!!!
Don't believe on the seismometer!
A network is required.
One seismometer will only be useful for the icy crust.

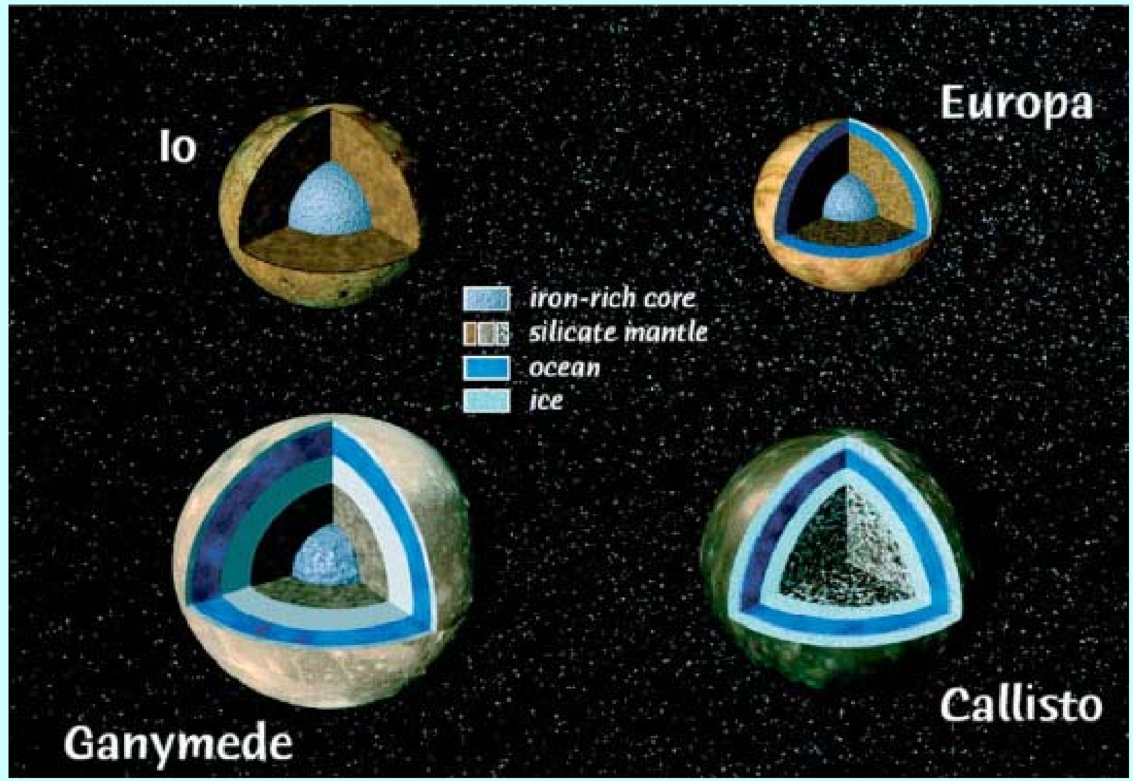
Theme 2 – Study the origin and formation of the Jovian satellites system

- Characterize Callisto and Ganymede in terms of internal structure and evolution, energy sources, internal ocean, surface state…

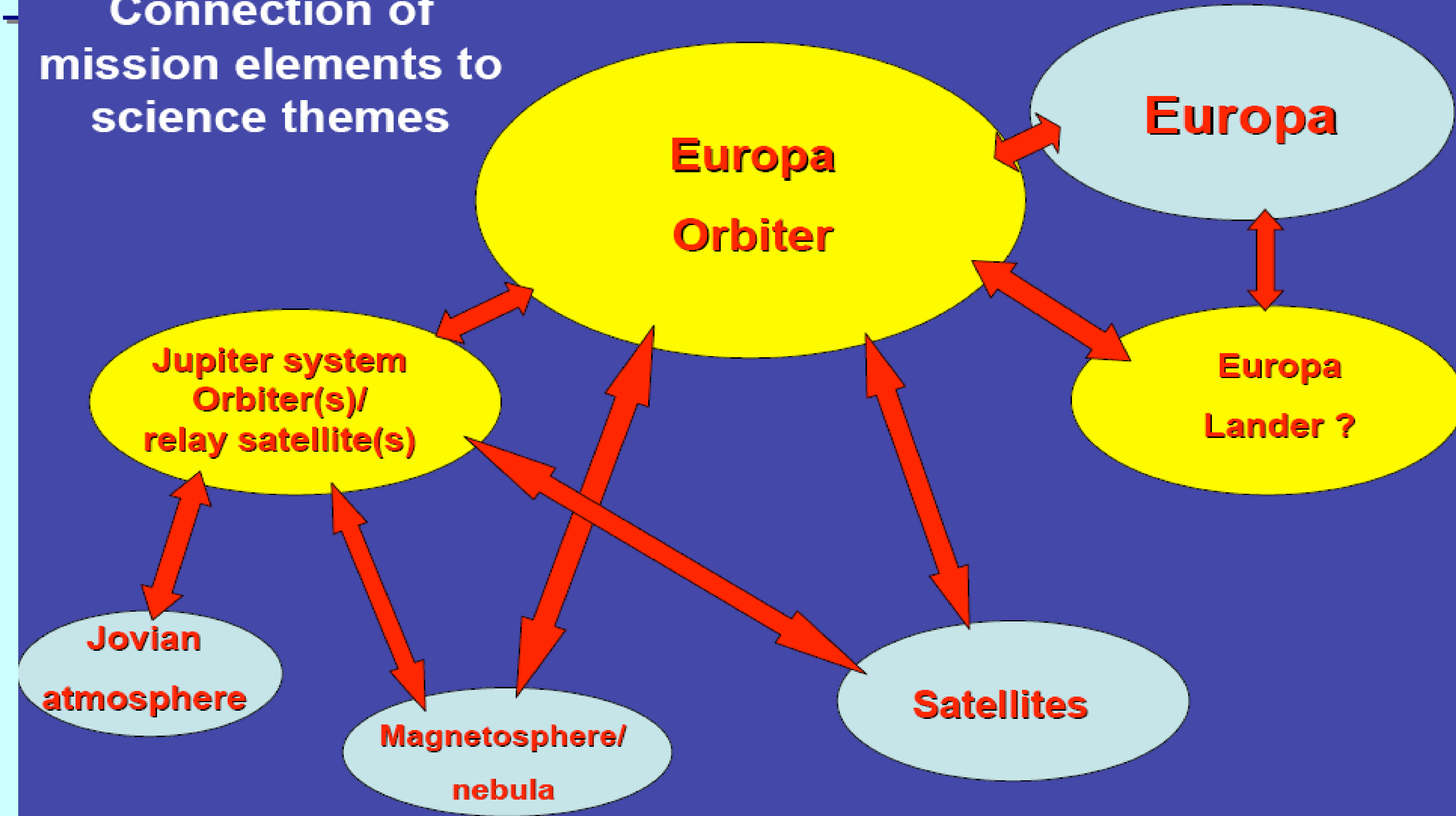
- Origin, formation and evolution of Callisto and Ganymede
LOST ATMOSPHERES??

- Origin of the irregular satellites

- How do these origins connect to the origin and formation scenario of Jupiter itself, and ultimately to the formation scenarios of the outer planets?



Connection of mission elements to science themes



Mission scenarios and s/c elements

- baseline composed of:

- two Jovian orbiters:

  one 3-axis-stabilized platform for remote sensing instruments: JRS

  one spinning platform for in-situ fields-and particles measurements: JIS

- one Europa orbiter **(nadir-pointing platform there), which necessarily performs the beginning of its mission in Jovian orbit (three-axis stabilized there):** JEO

Optional add-on:

- One surface element for Europa: SE
- JRS ends as Ganymede Orbiter: GO
- Dedicated p/l for interplanetary phase: IP

Mission scenarios vs launcher capacity vs international collaboration

- Launch opportunities between 2016-2024 (transfer duration ~ 6 years)

- Scenario 1 **- Two medium capacity launchers with:**
  - JRS + JIS **on one launch**
  - JEO + (optional) SE **on the second launch.**
  Candidate launchers; S/F, HIIA and upgrades, Atlas 5-5,…

- Scenario 2 - **One heavy launcher with two s/c:**
  can accommodate 1 JEO +1 JRS/JIS
  capacity for carrying SE (with JEO) or JIS independent of JRS to be investigated during assessment phase.
  Candidate launchers: Ariane 5, Atlas 5-5…

- Scenario 3 - **ESA-only mission.**
  One S/F launch.
  Two s/c: JRS (including the in-situ instruments of JIS), JEO.
  Challenge is to focus on key science objectives for Europa.
  Candidate launchers: Soyuz-Fregat…

Payload capacity

	Scenario 2	Scenario 1	Scenario 3
JEO	TBD (50-75kg)	~50-75kg,50W	~40kg,35W
JRS	~50kg,50W w/o Ganymede	~50kg,50W w Ganymede	~20kg,12W
JIS	-	~20kg, 30W TBC with JAXA	-
SE	-	-	-
IP	-	-	-

Astrobiology arguments for direct measurements

- **A landing system is required**
- **for astrobiology studies**
- **for our   knowledge of Europa internal structure**

•• **Inter-space-agency cooperation may provide the budget required**

- **A landing system (impactor, penetrator, lander)** should not be definitely excluded

- Landing options and associated science should be studied

RUSSIAN INVOLVEMENT:

1.ORBITER SCIENCE:

- Participation in UV-EUV spectrometer
  NEXT generation of PHEBUS/Bepi Colombo,
  with Europe and Japan

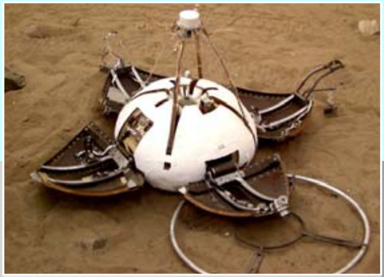
- **A high-resolution IR spectroscopy in solar occultation**
  Next generation of SOIR / VEX, with Europe
  - **Radar**
  - **Gamma- neutron instruments**

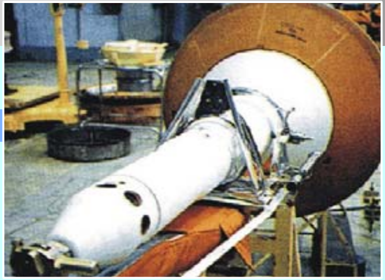
- **Participation in Plasma-Wave package**

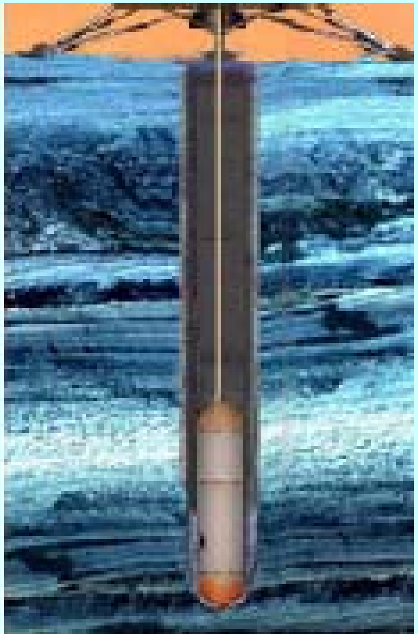
- **A high-spectral resolution UV imager to map ortho-para hydrogen distribution.**
  Next generation of MSASI / MMO Bepi Colombo, with Japan

RUSSIAN INVOLVEMENT

LANDER- *"in situ"* studies







Stations ?

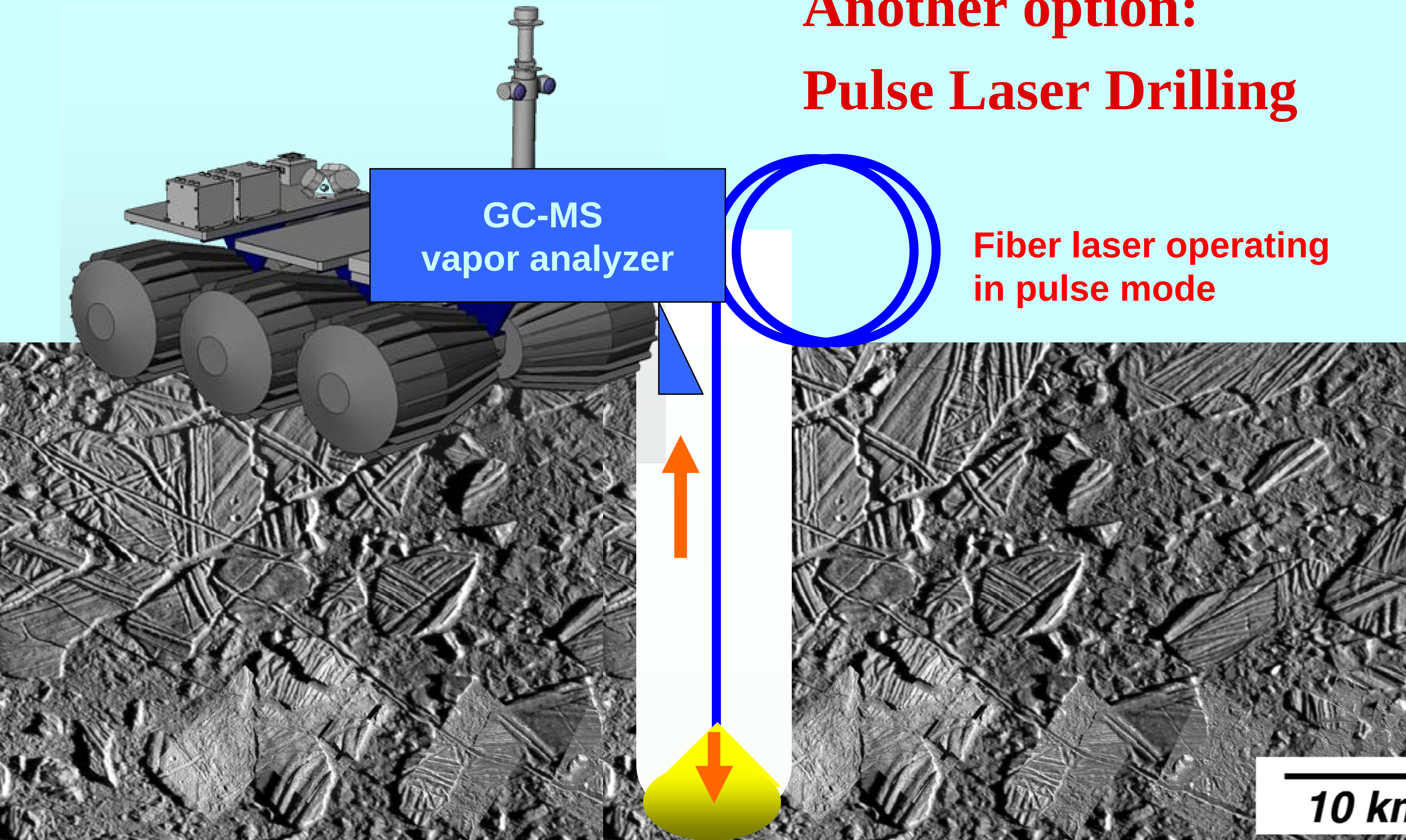
ROVERS ?

Penetrators?

Immersing module with an RTG heater?

RUSSIAN INVOLVEMENT

Another option: Pulse Laser Drilling



RUSSIAN INVOLVEMENT

MISSION SCENARIO:

ORBITER

1. + active ice excavations

Shooting of explosive pellet(s) to the preselected targets at the icy surface .

Ejection of the under-ice material to the vicinity of the target area.

Using cumulative shooting method (implosive drill)

(similar to armour-piercing shell)

RUSSIAN INVOLVEMENT

LANDER

Landing of spacecraft in the vicinity of Target – in the excavation area

Deployment of the ROVER

In situ investigations of the original icy surface and the under-ice material ejected after the explosion

RUSSIAN INVOLVEMENT

SCIENCE AT LANDER/ROVERS

- **PHOBOS HERITAGE**

Instruments for the in situ analysis

- MASS ANALYSIS --GCMS+TDLAS

- **Laser-induced methods**
- **Secondary ion methods**
- **……………………………….**

Passive seismic experiments →

to determine the thickness of ice shell

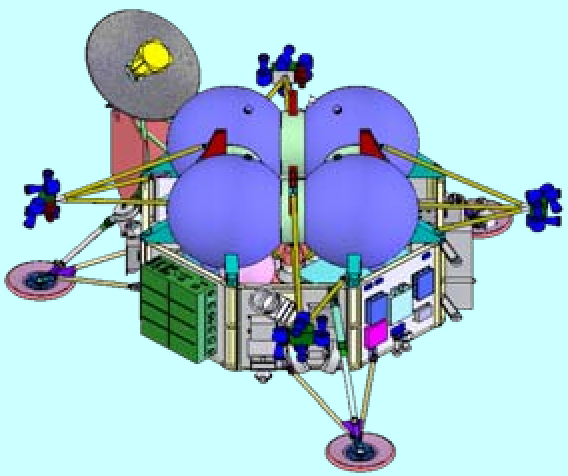
- **(Sunwoong et al., 2002)**

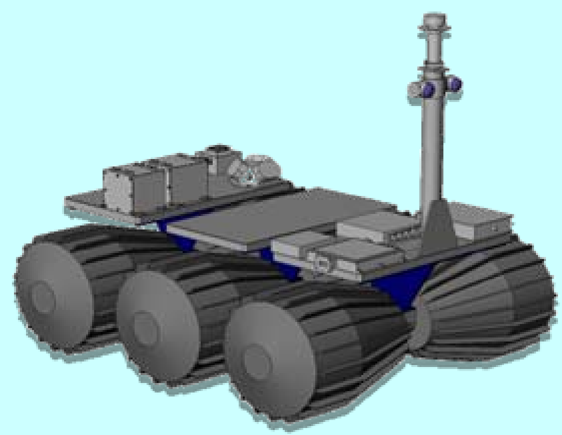
Lander conception

Lander
«Europa»

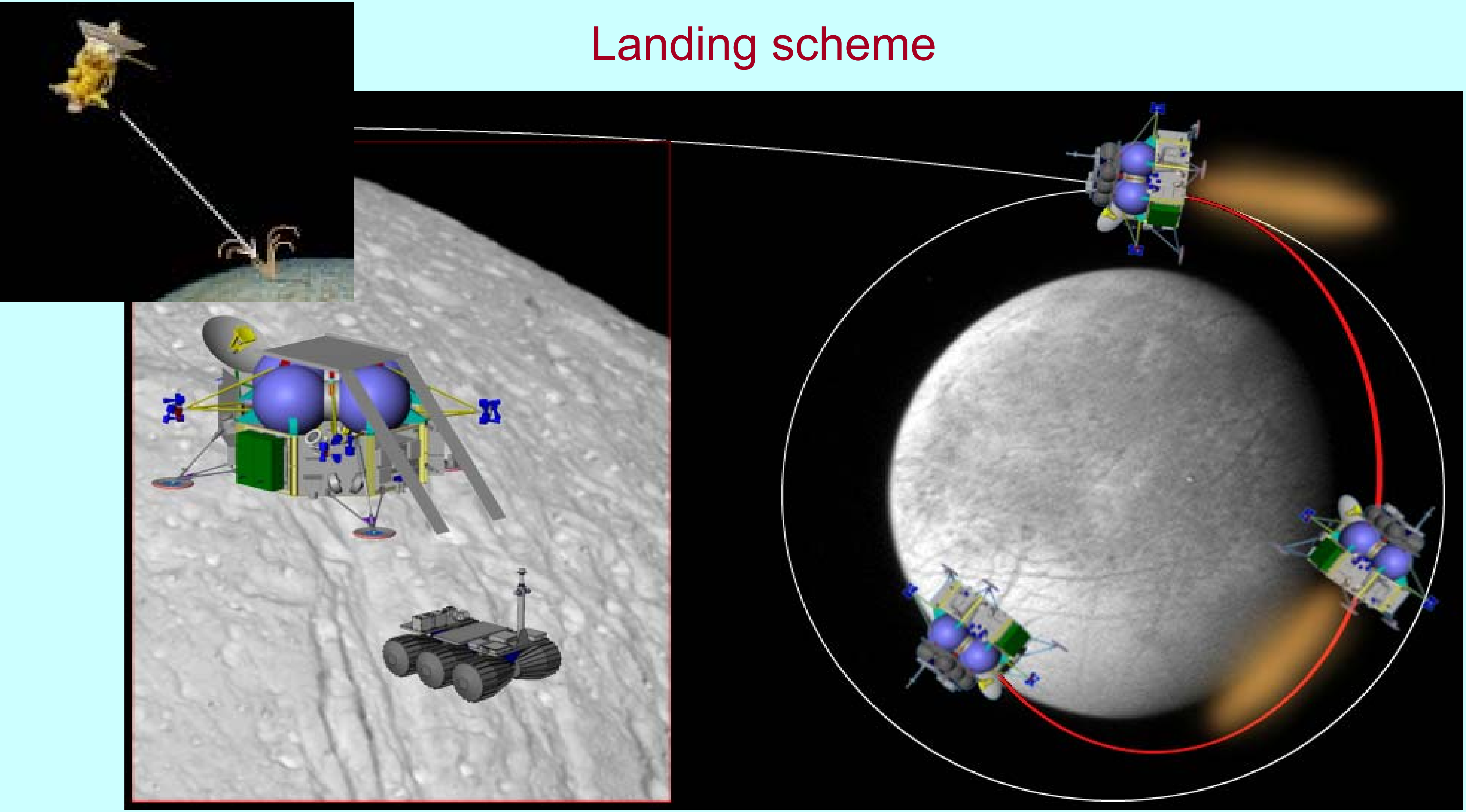
Base landing platform

Rover

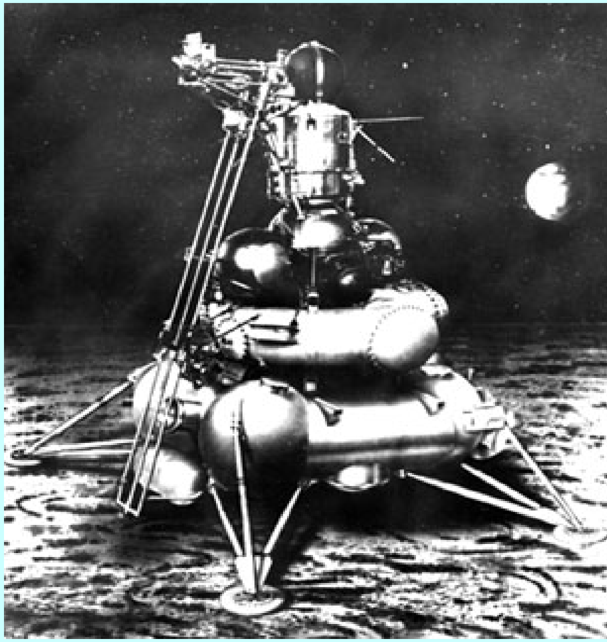


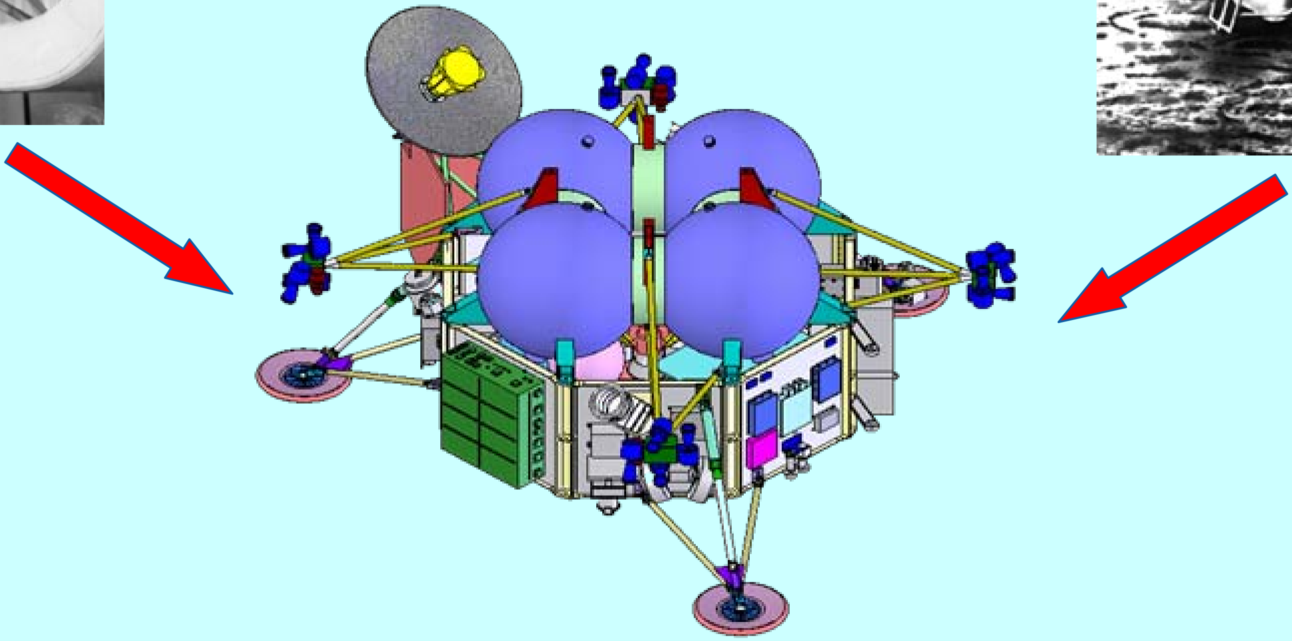


Landing scheme



Lander with rover





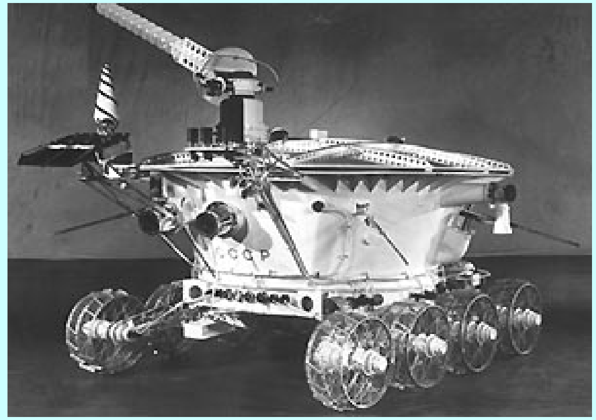
Lander – mass budget

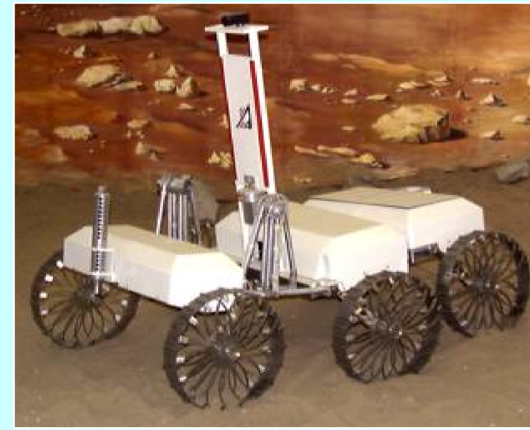
Propulsion subsystem	180
▪ **tank unit**	**113**
▪ **gas tanks**	**24**
▪ **main engines**	**3*4 = 12**
▪ **trusters**	**1,2*8 = 9,6**
▪ **valves, pipes**	**21,4**
Structure	81
▪ **box**	**60**
▪ **landing system**	**16**
▪ **rover platform**	**15**
Control system	38,5
▪ **computers**	**1,8**
▪ **controllers**	**1,6*3 = 4,8**
▪ **gyro**	**0,9*2 = 1,8**
▪ **sun sensor**	**0,65*2 = 1,3**
▪**lidar**	**8**
▪**TV camera with wide FOV**	**1,7*2 = 3,4**
▪ **TV camera with narrow FOV**	**2,7*2 = 5,4**
▪ **doppler**	**12**

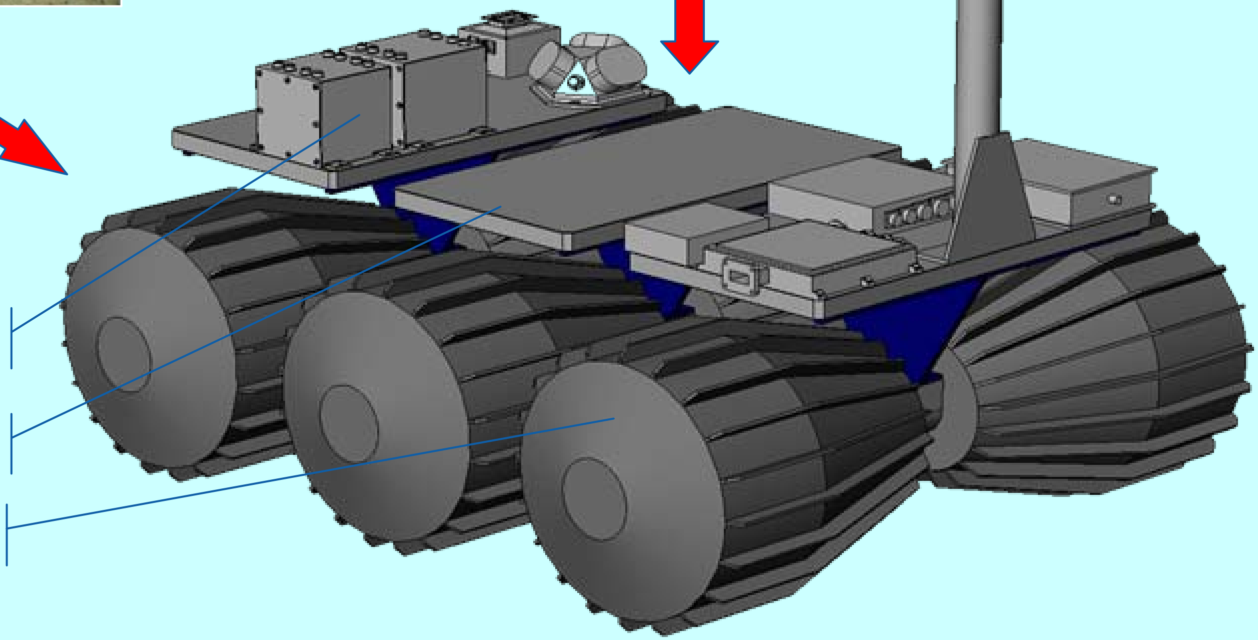
radio	5
▪ **radio**	**0,9**
▪ **antenna**	**0,8**
Power system	33,1
▪ **accumulator**	**7,5**
▪ **Chemical current source**	**10**
▪ **controller**	**4,5**
▪ **radionuclide generator**	**3,7*3 = 11,1**
Thermal system	15
Scientific instruments	20.7

Total: 370 kg

Rover







Rover
Main parameters

✓ high mobility;

no clearance, therefore high flotation ability

Two types of movement:

pacing

rolling motion