Venus investigations after VENUS EXPRESS: misson VENERA-D

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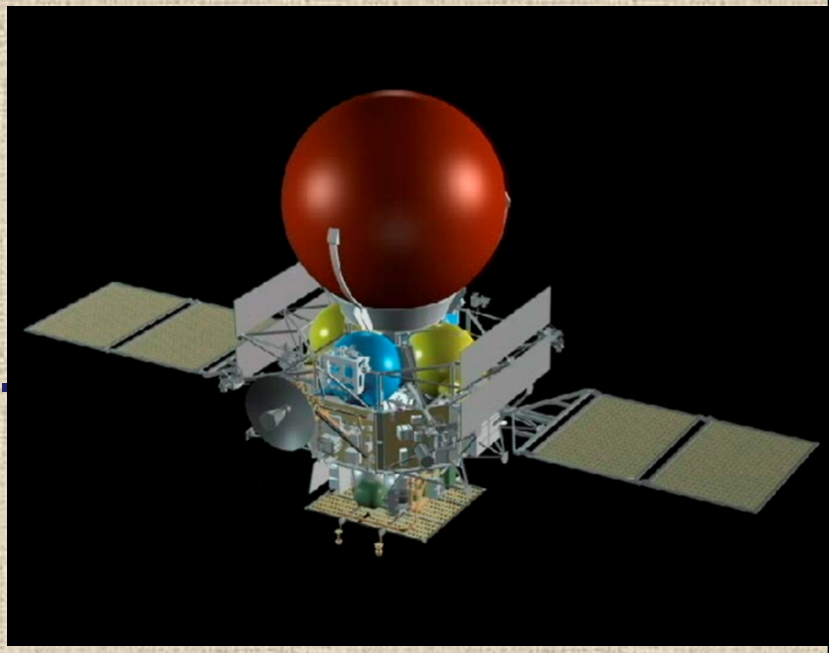
Venera-D. Baseline Mission Overview

- ROSCOSMOS-led mission.
It was included in the Russian Federal Space Program (RFSP) 2006-2015.
RFSP is revised after PH-G crash.

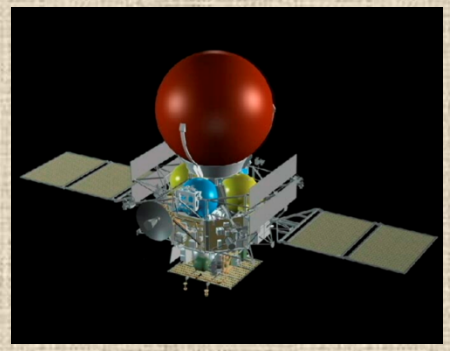
Objectives of Venera-D mission: surface, atmosphere, plasma environment



General view of Venera-D (Lavochkin Association)

In 2013- phase A will be continued with laboratory mock-ups of some elements
RFSP for 2016 – 2025 will be approved in 2013
Phase B for Venera-D may be open at 2016 earliest

Elements of mission (current)



- Lander (VEGA-type, updated)
  - 2 – 3 hours on the surface

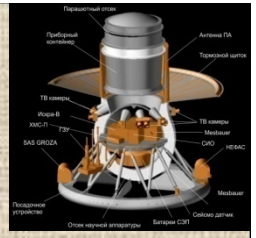
- Orbiter (Phobos-Grunt, updated to Venus)
  - on the polar 24 hours orbit , lifetime > 3 years

- Sub-satellite
  - orbits with 48, 24, 12 hours are considered

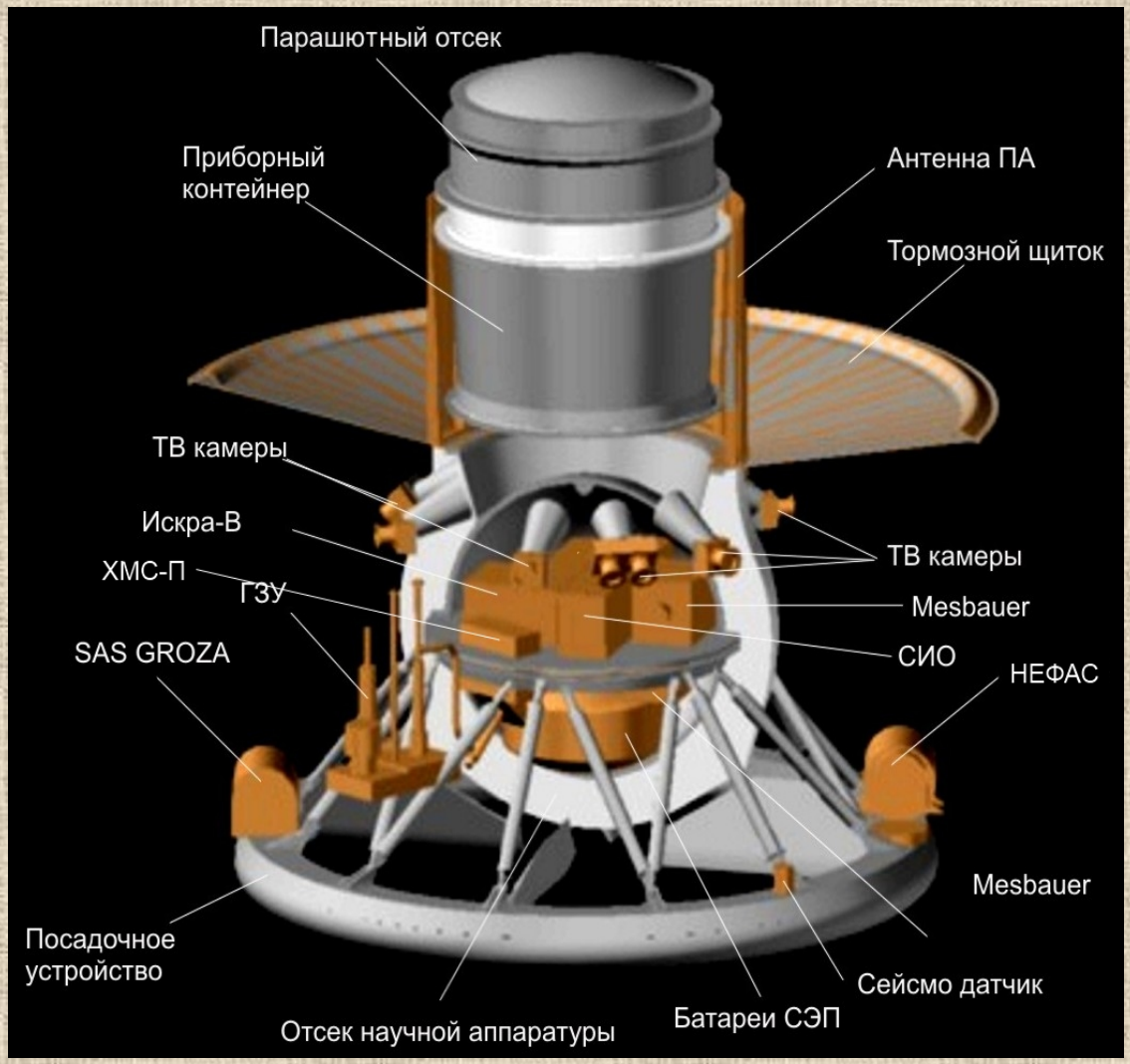
Scientific goals of the Venera-D mission

- Investigation of the structure and chemical composition of the atmosphere, including abundances and isotopic ratios of the light and noble gases;
- Thermal structure of the atmosphere, winds, thermal tides and solar locked structures;
- Clouds, structure, composition, microphysics, chemistry;
- Chemical analysis of the surface material, study of the elemental composition of the surface, including radiogenic isotopes;
- Study of interaction between the surface and atmosphere, search for volcanic and seismic activity; search for lightning;
- Study of the dynamics and nature of superrotation, radiative balance and nature of the enormous greenhouse effect;
- Investigation of the upper atmosphere, ionosphere, electrical activity, magnetosphere, escape rate

LANDER PAYLOAD

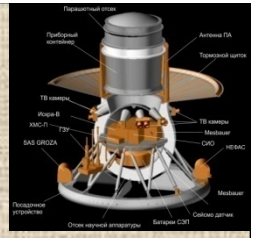


- *Active Gamma and Neutron Spectrometric for Soil Analysis*
- *GC-MS*
- *Mossbauer spectrometer (MIMOSA-2)*
- *TV- cameras (landing,stereo,panoramic, high res. up to 0.1 mm)*
- *MTDLAS – Multi channel tunable diode laser spectrometer*
- *Nephelometer-particles counter*
- *Wave-package*
- TPW- package
- Optical package
- Radio-science



Lander, preliminary assembling of scientific payload on the level of drawings(Lavochkin Association)

Prioritize measurements on Venera-D



Atmosphere: the measurements of the abundances and isotopic ratios of the noble gases and light elements (crucial for understanding of origin and evolution of the Venus atmosphere)

This measurements may be carried out only *in situ* from Lander or balloon.

-At the moment there are two instruments on Venera-D Lander :

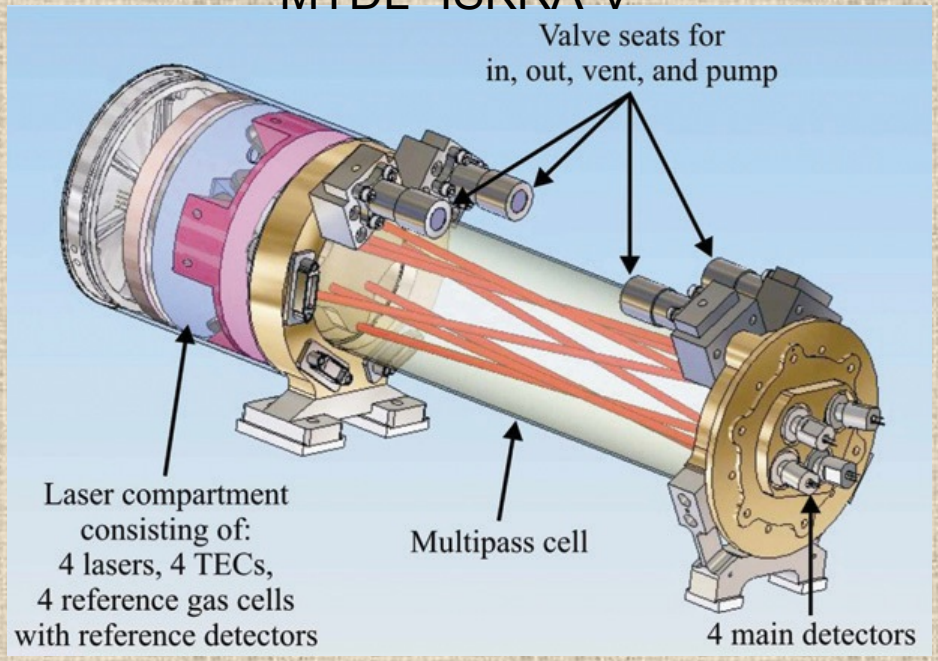
- Mass-spectrometer for noble gases

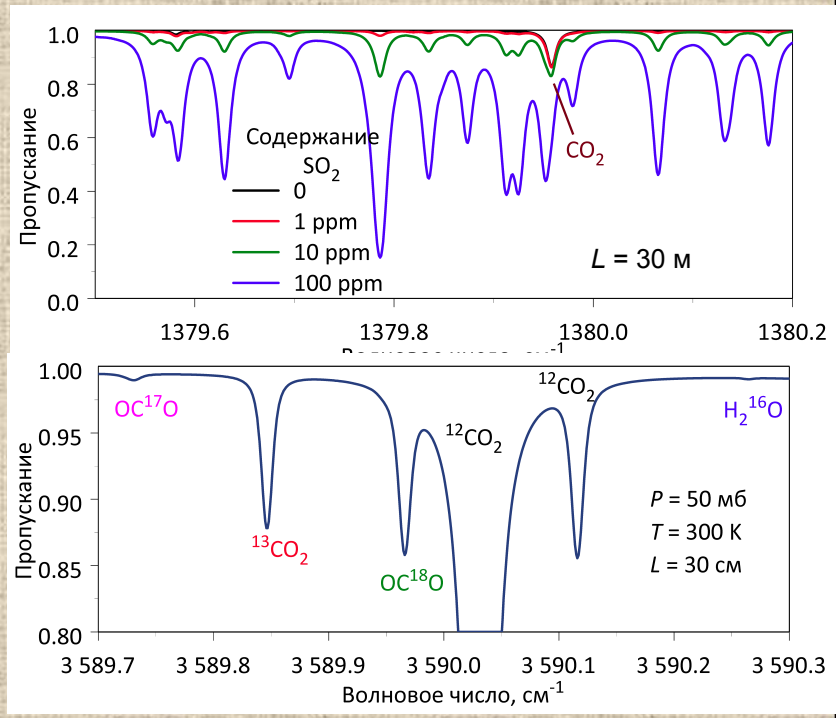
- Multichannel Tunable Diode Laser Spectrometer

MTDLAS- ISKRA-V

- **Abundance of isotopomers CO_2, H_2O, CO, SO_2, COS, HF, HCl**
- **Working interval : from 65 км to the suface with vertical resolution ~ 1 км**
- **The cell should be cleaned between measuremets**
- **It is obtained a spectrum of atmospheric sample in the cell at *p*=50 мб и *T*=300 K for 4-6 spectral channels**
- **The width of the spectral intervals ~0,5 $см^{-1}$, tuning of the wavelength in the range 5 $см^{-1}$**
- **Spectral resolution $\lambda/\Delta\lambda \sim 10^7$, sensitiviy of 10^{-5}**
- **Optical path length in the multipass cell from 30 см to 30 м**

MTDL- ISKRA-V





Examle of construction (C. R. Webster et al., NASA)

Modeled spectra at 7,2 and 2,78 мкм

MTDLAS on the Lander
-measurements from 65 km to the surface
-vertical resolution of 1 – 2 km.

Measurements on Lander may give vertical profiles of measured components

The device for atmospheric sampling will take a probe and rarefy it (to 50 -100 mb)

Number of channels are limited only by existing laser diodes.

MTDL- ISKRA-V

The choice of molecules and spectral ranges within the parameters of existing diode lasers

Wavelength	Molecule	DFB laser
2,17 мкм (4608 $см^{-1}$)	$^{12}CO_2$, $^{16}O^{12}C^{18}O$	GaInAsSb / GaAlAsSb
2,36 мкм (4220 $см^{-1}$)	CO	
2,43 мкм (4100 $см^{-1}$)	HF	
2,78 мкм (3590 $см^{-1}$)	CO_2, H_2O, $^{13}C/^{12}C$, $^{16}O/^{17}O/^{18}C$ (CO_2) D/H , $^{16}O/^{17}O/^{18}O$ (H_2O)	
2,84 мкм (3514 $см^{-1}$)	$^{13}CO_2$, $^{12}CO_2$	
3,35 мкм (2984 $см^{-1}$)	$H^{35}Cl$, $H^{37}Cl$	Difference-frequency generation with 2 lasers range 1.5 мкм
4,82 мкм (2073 $см^{-1}$)	CO, CO_2, OCS $^{13}C/^{12}C$ (CO_2) $^{34}S/^{33}S/^{32}S$ (in OCS)	QCL
7,2 мкм (1380 $см^{-1}$)	SO_2	

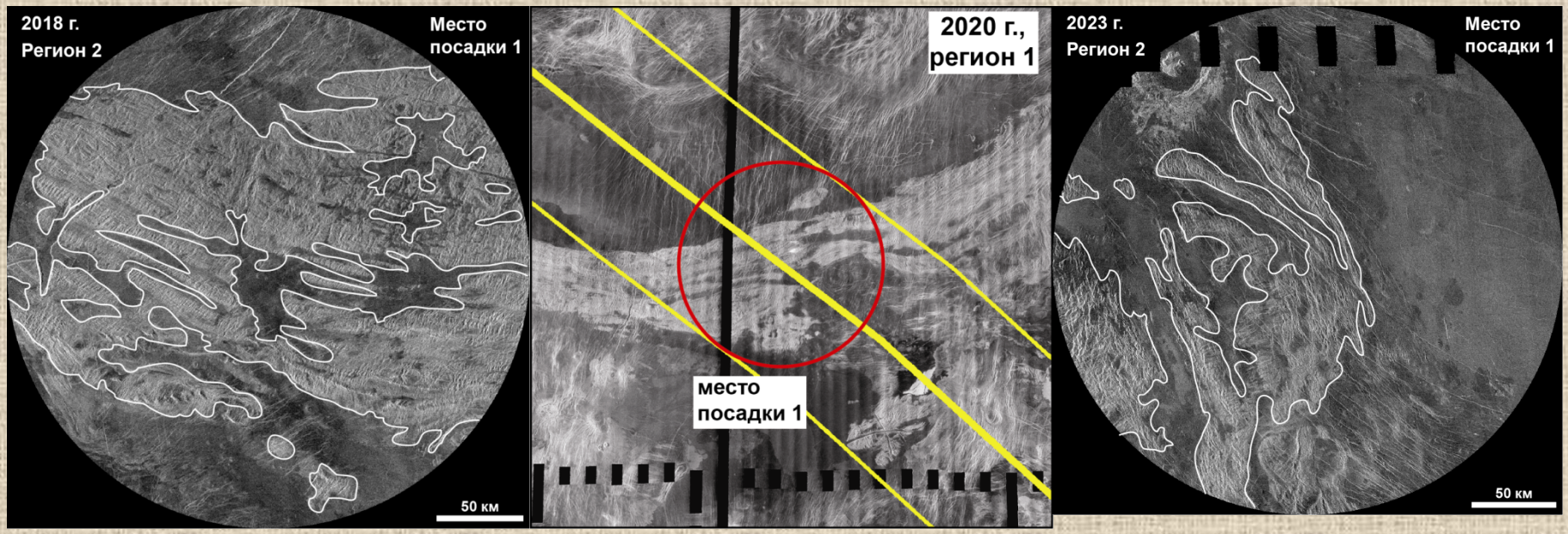
Important Lander scientific goals on the surface:

Chemical composition of the surface material, elemental composition of the surface, including radiogenic isotopes, oxidation state of the surface, geology, geochemistry

- Active Gamma and Neutron Spectrometric Soil Analysis
- GC-MS with soil sampling
- Mossbauer spectrometer
- TV - cameras

Landing sites – tesserae (A. Bazilevsky)

Landing ellipces for windows of launch 2018 (a), 2020 (b), 2023 (c), with tesserae inside



a b c

In ballistic reachable areas for windows of launch 2021 and 2024 the tesserae terrains are not found.

Experiments on the orbiter

Spectrometer-Interferometer PFS-VD λ= (1) 5-40 μm, ν=(10000)2000-250 см-1 , Δν= 1 cm -1

Solar and star occultation UV (0.1-0.3 μm) and IR (2-4μm)

MM-sounder λ =3-10 мм

UV-mapping spectrometer λ = 0.2-0.5μm, Δ λ =0.0004 μm

IR-mapping spectrometer λ = 0.3-5.2 μm, Δ λ= 2.4 nm

Multispectral monitoring camera

Radio science (L, S and X ranges)

Plasma package

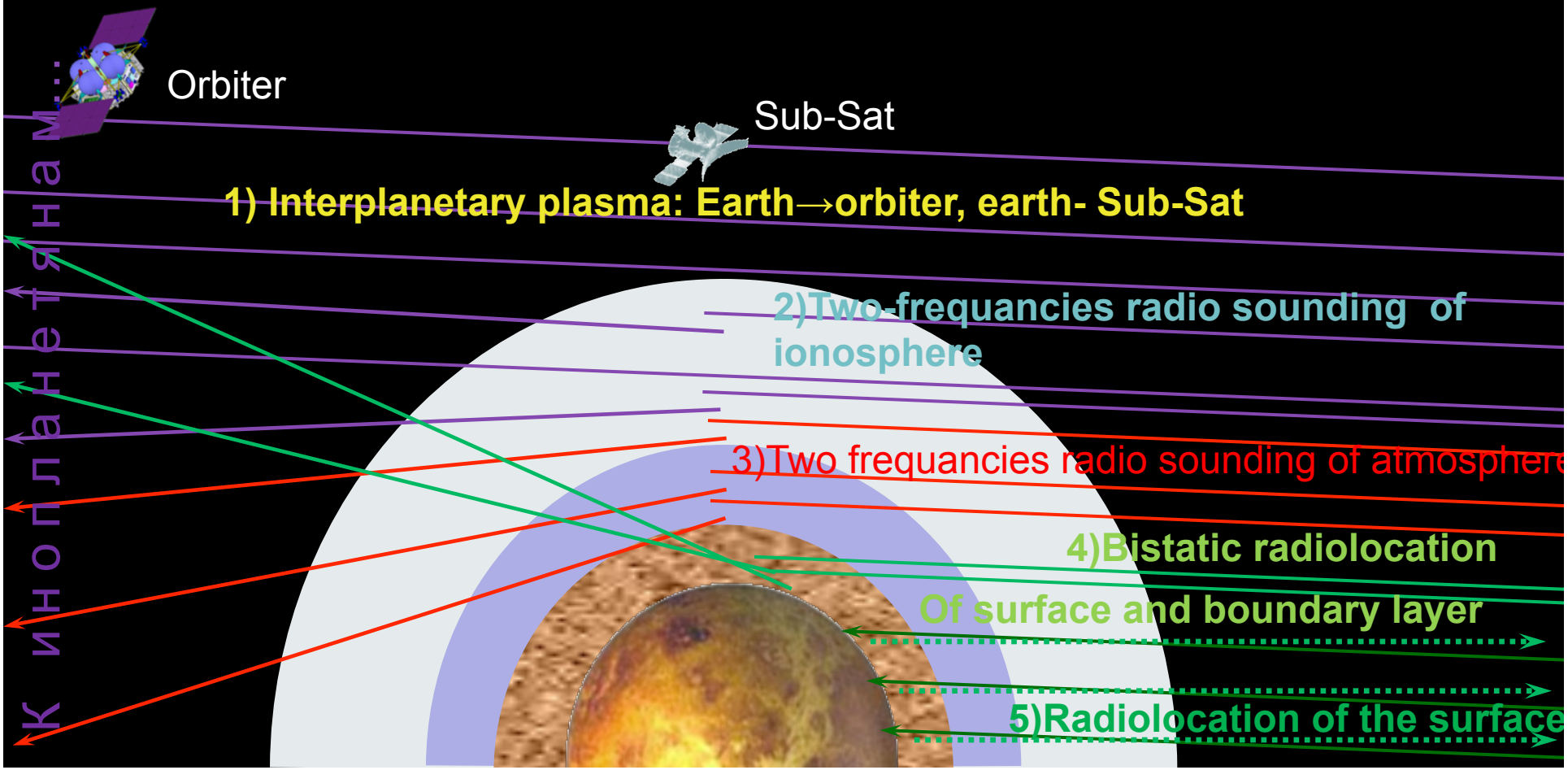
On the sub-sattelite - scientific payload includes plasma package and radio science

Important instruments on Venera-D, absent or not functioning on VEX (for thermal structure, superrotation, dynamics, thermal balance):

- Thermal IR Fourier spectrometer
- UV imaging spectrometer
-MM radiometer

Other instruments, proposed for the orbiter are modernized experiments being installed on VEX or Veneras

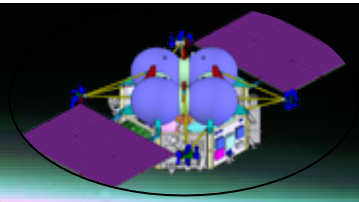
New conseption of the RS experiment (FIRE RAN):
To emit signal by ground based transmitter and receive on board of orbiter and sub-sat. by three-frequency detector of L, S , X diapasons. Using 70-m antenna , the gain in power of signal transmitted from the Erath may be an order of magnitude comparing with traditional scheme. With high power of the signal five experiments may carried out simultaneously:



Measurements on orbiter : H, He, O, N, N2, CO
H+, He+, O+, N+,C+, CO2+, N2+, O2+, NO+

Измерения на ОА: Эмиссии O2, OH, O,CO,CO2…

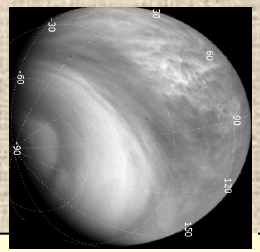
СС



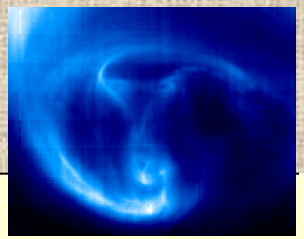
ОА

H=100 км

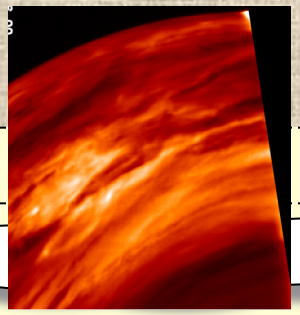
Upper clouds,VMC,UV



S-polar «dipole»
VIRTIS, 5мкм



Lower clouds,
VIRTIS, 1.7мкм



Measurements on orbiter :
H2O, SO2, SO, CO, HF, HCl,
HDO, ClO, H2S, H2O2, OCS

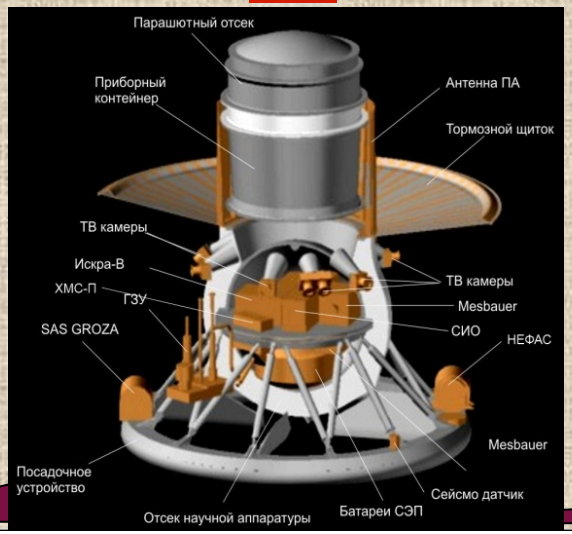
H2SO4+УФ-поглотитель?

H2SO4+кристаллы?

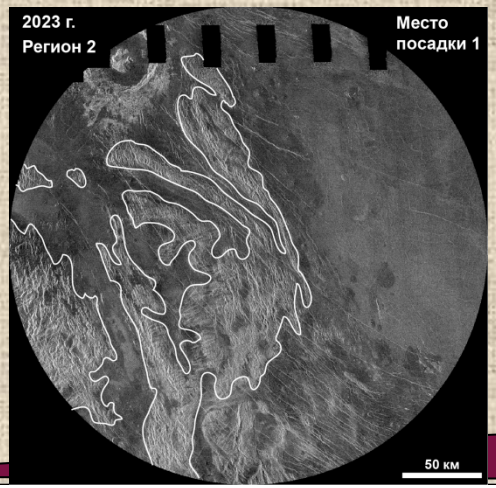
H=50 км

Time of descent in atmosphere – 30 min, lifetime on the surface > 120 min

ПА



Landing site-
tesserae terrain



Measurements on the descent :
CO, H2O, SO2, OCS, HCl, HF,
Ne,Ar, Kr,Xe,O,C,N

Measurements on the surface:
Si, O, Ca, Na, Al, Mg, Fe (Fe^{2+},
Fe^{3+}, Fe^{6+}), Ti, K, Th , U

Other works, connected to Venera-D:

- Technical description of the long-living station was developed. It was shown that for available at the moment technology, which uses traditional materials on the basis of silicon electronics, the lifetime of the station of mass of 100 kg on the surface of Venus is limited by 24 hours.

- Technical description of the high pressure camera (P up to 150 bar) is created. We hope to have this camera in IKI with working volume 10-15 liters inside to test the separate instruments, which needs to be installed outside

Summary

-Mission Venera-D is delayed to 20th

-Current conception is two orbiters and Lander

-Long living station (for 24 hours) with just simple measurements of PTW may be included

- Inclusion balloon may be considered

- International status of mission would accelerate the start of phase B of the project

- Dialog NASA with Roscosmos about cooperation would be very useful