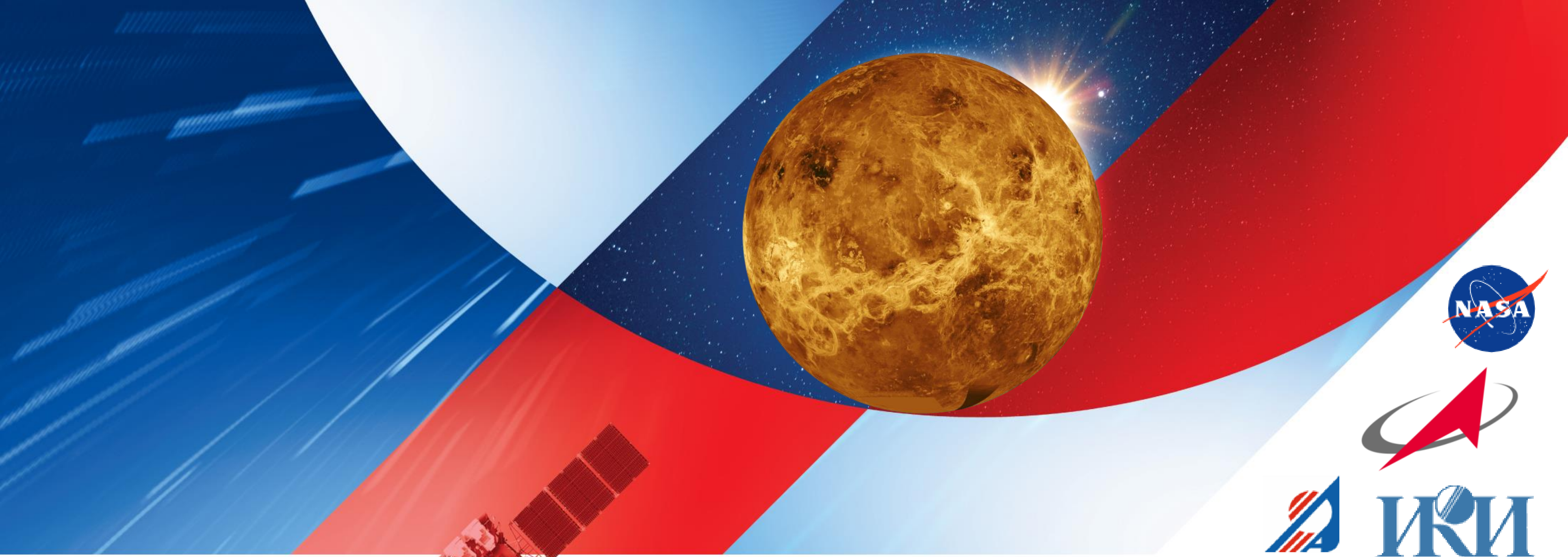
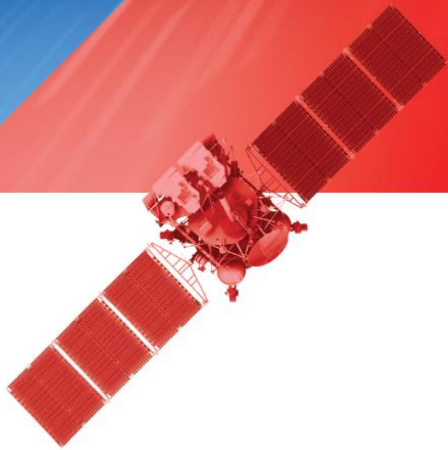
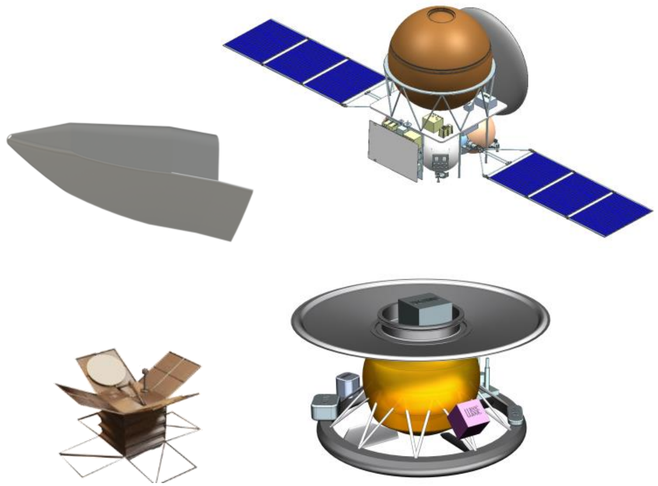




# “Venera-D” mission

## “Venera-D” lander and maneuverable entry vehicles for Venus research



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## Main tasks of “Venera-D” architecture concept development

- Development of the SC general structure for Venus investigation, including orbiter and lander.
- Accommodation of service and science equipment and other detachable payload, that may function separately by itself, within the orbiter and lander.
- Consideration of orbit options, descent and landing schemes.
- Consideration of radio link communication options between SC and Earth and also between the orbiter and lander / discharging payload equipment.
- Contemplation about options of using maneuverable entry vehicles for Venus research.

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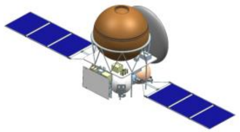
# Main scientific tasks of "Venera-D" project



**Prioritized Orbiter Goals to study:**

- dynamics and nature of superrotation, radiative balance, and nature of the greenhouse effect;
- thermal structure of the atmosphere, winds, thermal tides, and solarlocked structures;
- composition of the atmosphere (upper and low atmosphere), study the clouds, their structure, composition, microphysics, and chemistry;
- surface emissivity, and volcanic events search on the night side;
- ionosphere, electrical activity, magnetosphere, atmospheric escape rate, and solar wind interaction.

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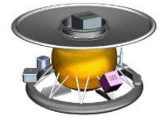
**Prioritized Lander+LLISSE Goals to study:**



- elemental and mineralogical abundances of the surface materials and near subsurface (a few cm), including radiogenic elements;
- interaction between the surface and atmosphere;
- structure and chemical composition of the atmosphere down to the surface, including abundances and isotopic ratios of the trace and noble gases;
- direct chemical analysis of cloud aerosols;
- geology of local landforms at different scales;
- seismic activity, volcanic activity, and volcanic lightning;
- variation of near-surface wind speed and direction, temperatures, and pressure (study by LLISSE: over 3 months);
- incident and reflected solar radiation (measure by LLISSE: over 3 months);
- near-surface atmospheric chemical composition (measure by LLISSE: over 3 months ).

# “Venera-D”
# mission architecture

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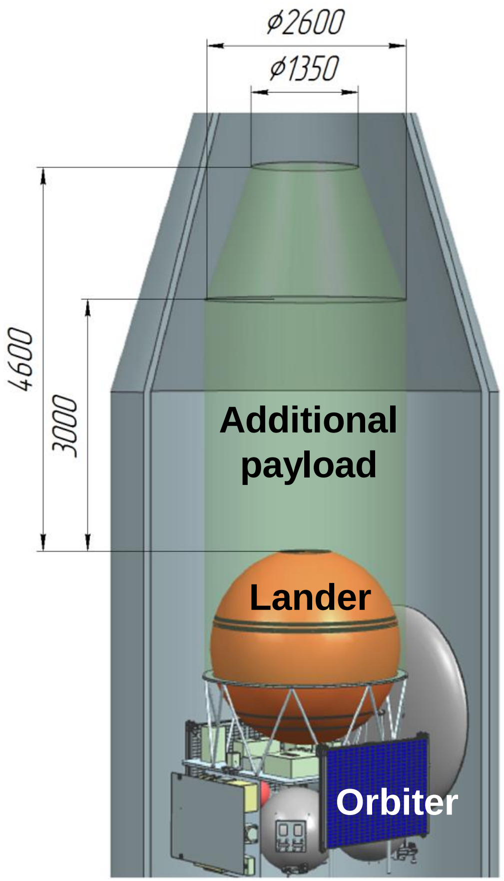
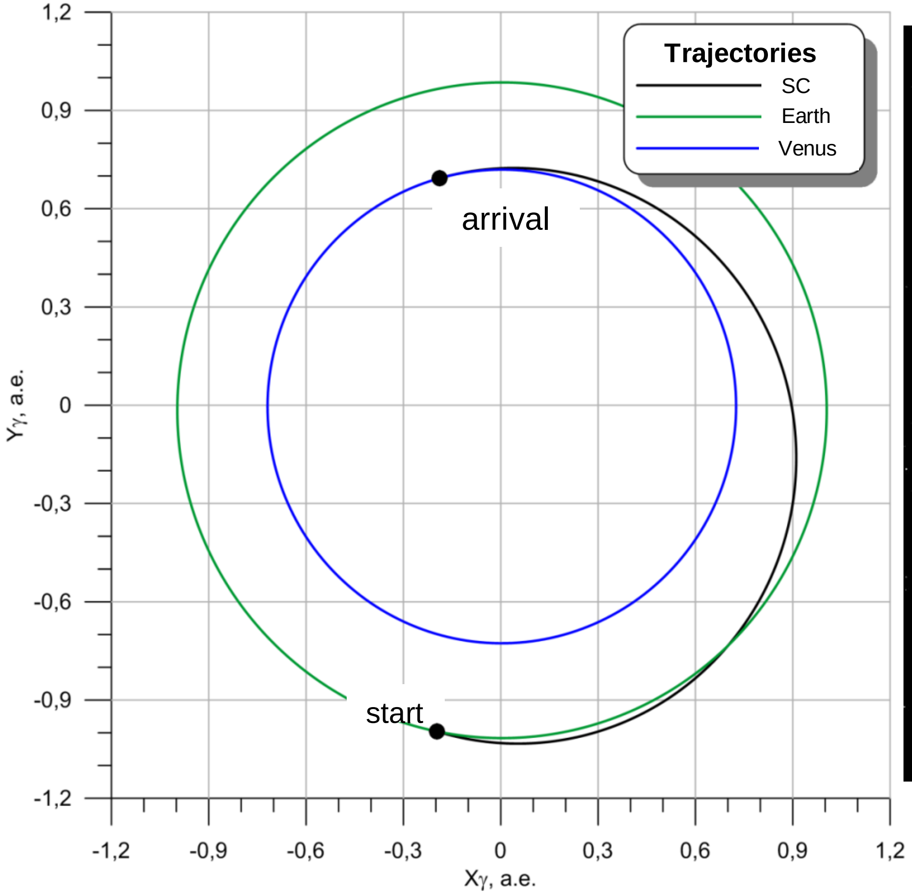
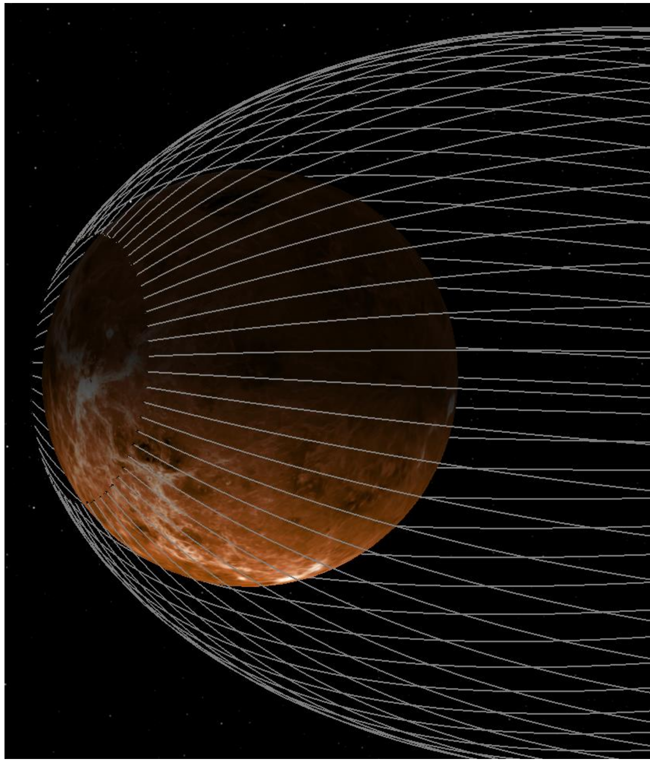
# "Venera-D" spacecraft design




Trajectory of transfer Earth-Venus with start in June 2026




Family of possible arriving hyperbolic trajectories



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| Launch date | 2026, June | 2028, Jan. | 2029, Nov. | 2031, July |
|---|---|---|---|---|
| Transit mass to Venus (Angara-A5, KVTK), kg | 7000 | 6300 | 6400 | 7000 |
| Transit mass to Venus (Angara-A5, DM-03), kg | 6900 | 6200 | 6300 | 6900 |

# Main lander design

- Lander
  - Onboard cable net
  - Onboard control complex
  - Onboard radio complex
  - Structure
  - Temperature control system
  - Power supply system
  - Telemetric system
  - Scientific equipment

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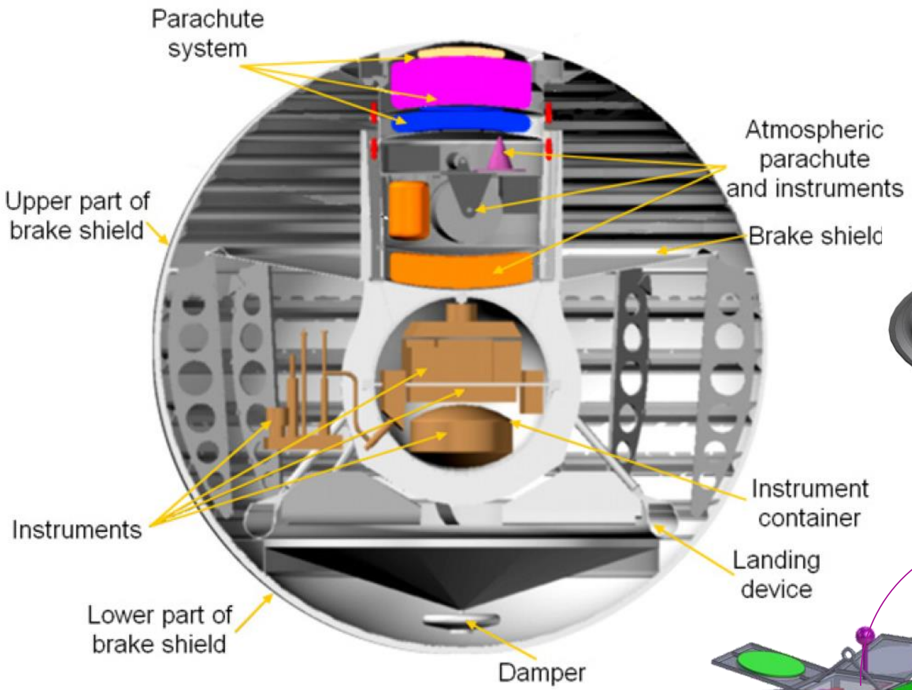
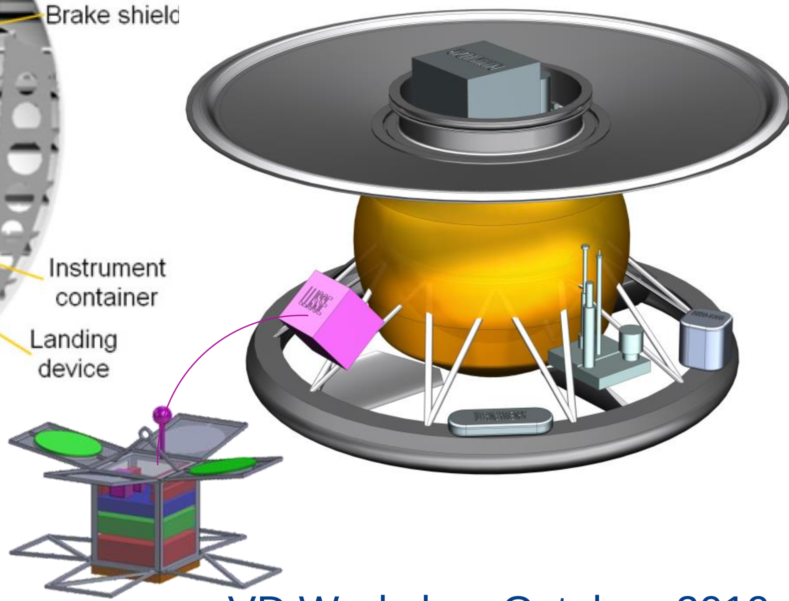
## Mass Budgets for 2028 (Worst-Case Scenario)

| Part of spacecraft | Mass, kg |
|---|---|
| **1. Lander** | **1,577** |
| 1.1 Lander dry mass | 522 |
| 1.2 Lander detachable system | 710 |
| 1.3 Lander payload | 120 |
| 1.4 Reserve for lander dry mass | 225 (18.3%) |

**Main lander design (Venera and VEGA LM type):**
- titanium structure,
- temperature-resistant cover,
- landing device with damper,
- separable structure with a parachute system



# Landing sites and requirements

# Descent scheme and landing requirements

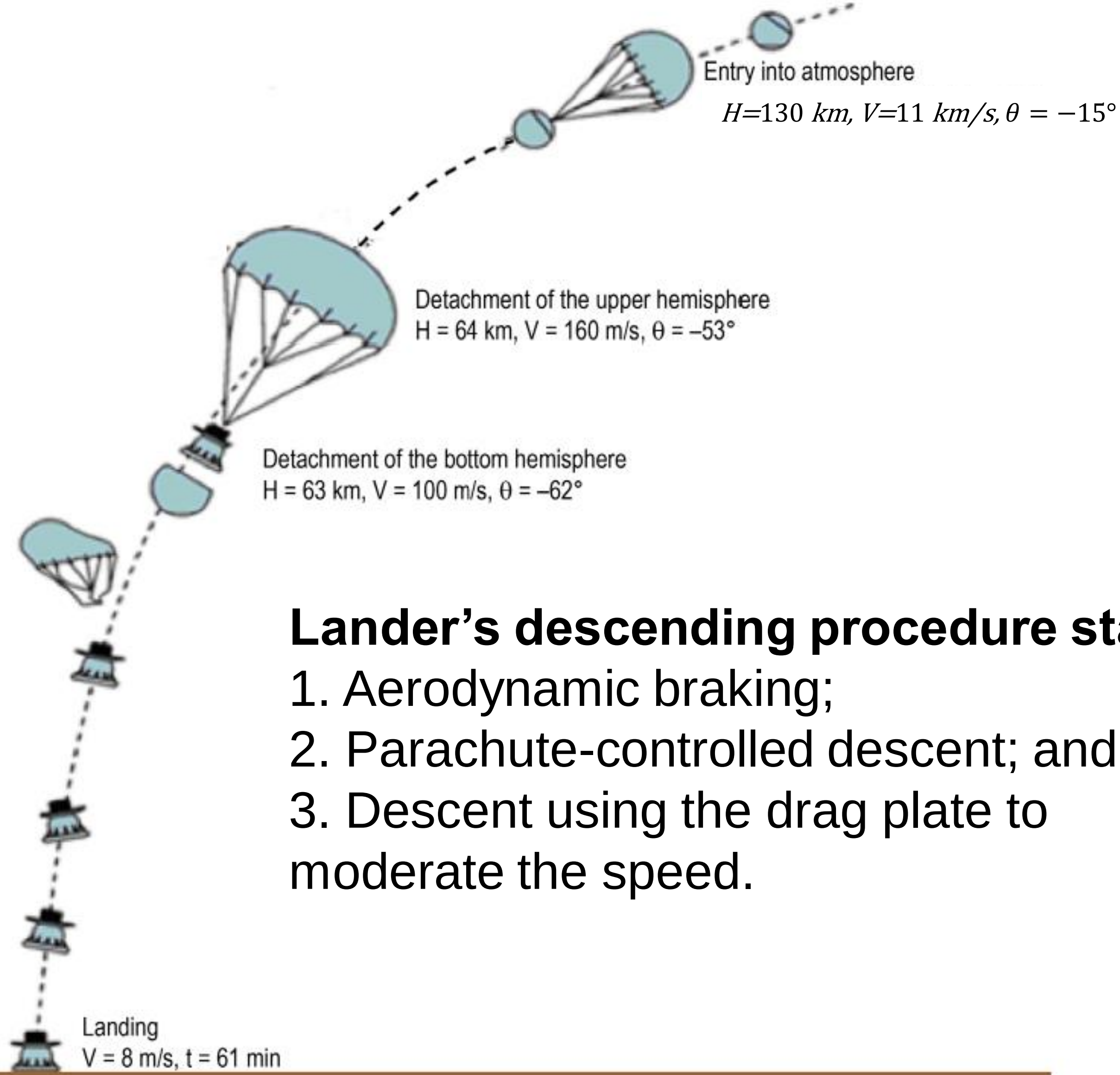
**Requirements:**

- landing on a slope: < 30°;
- duration of the descent process: ~ 60 min

**Limitation:**

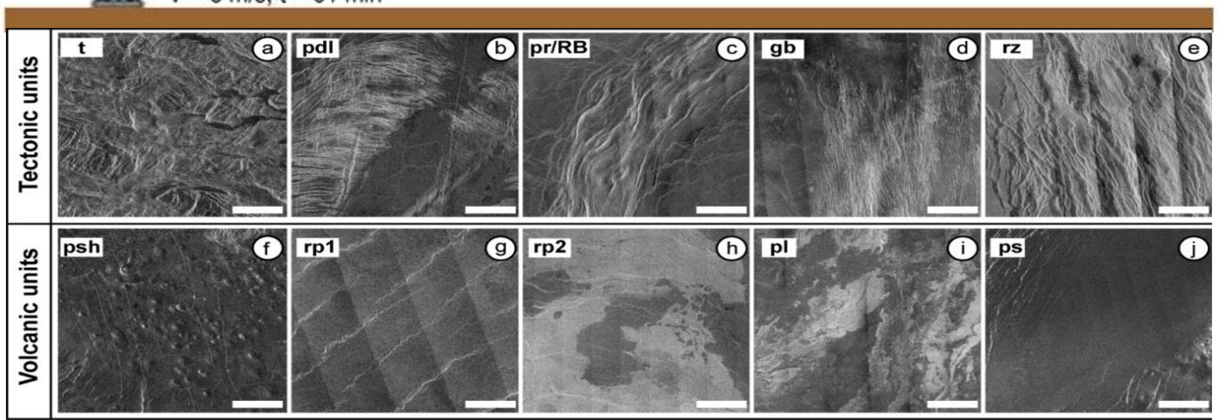
radiolink visibility time

longitudinal range: +200 km




**Lander’s descending procedure stages:**

1. Aerodynamic braking;
2. Parachute-controlled descent; and
3. Descent using the drag plate to moderate the speed.

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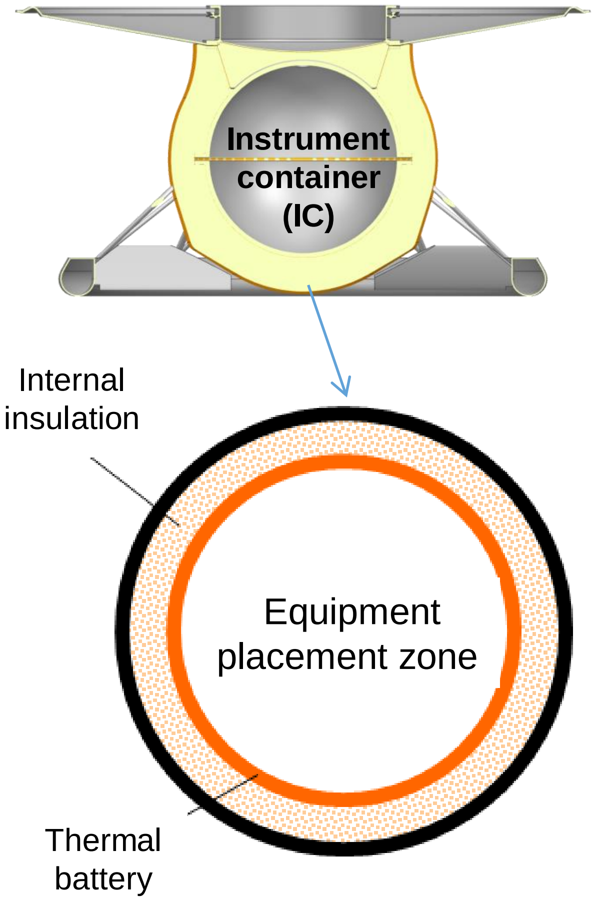
# Thermodynamic model




Earth-Venus flight trajectory: temperature from **–50°C up to+50°C** inside instrument container (IC)

↓

Before entrance: temperature inside IC **–50 °C**

↓

Temperature on the Venus surface: **+30°C ±10°C** during lifetime (~3 hours)

↓

on the Venus surface:

Exhaustion of the heat sink’s capacity → Temperature inside the IC increases → The end of LM functioning - thermal “death” of radio transmitting equipment (90 – 120°C inside).

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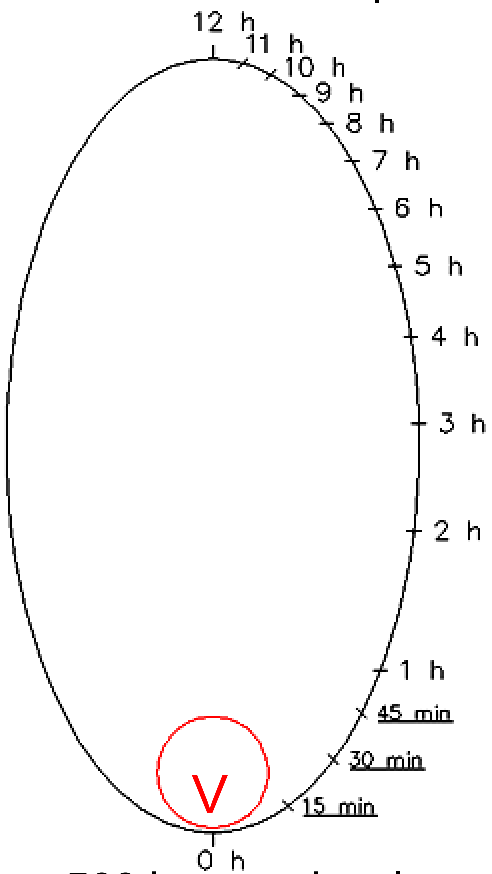
# Worst-Case Scenario



## Radio link visibile zones

Orbit 500x72000 km
72 000 km, north pole




500 km, south pole

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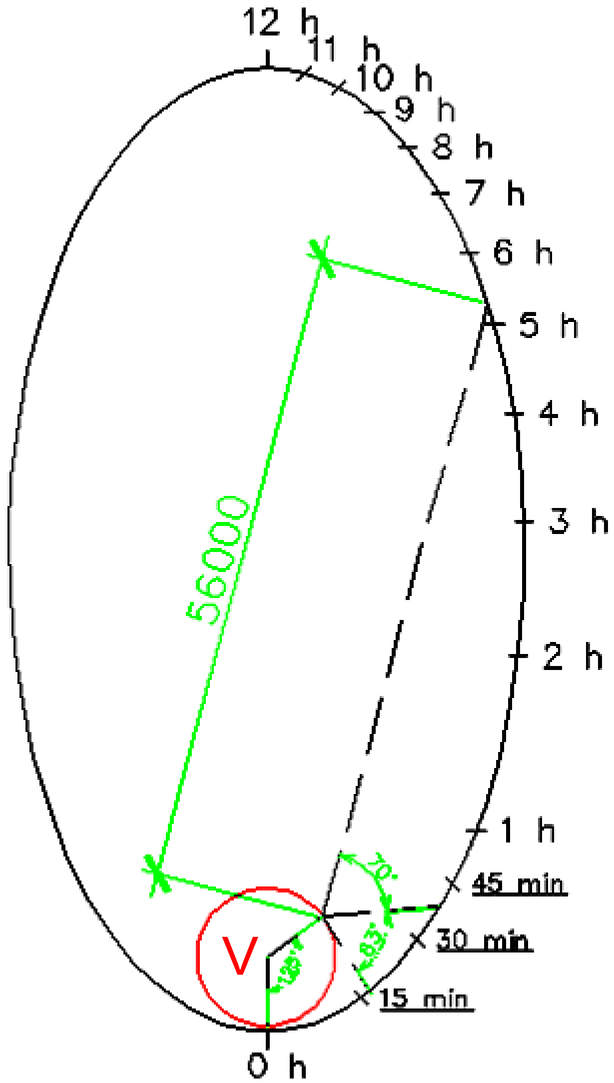
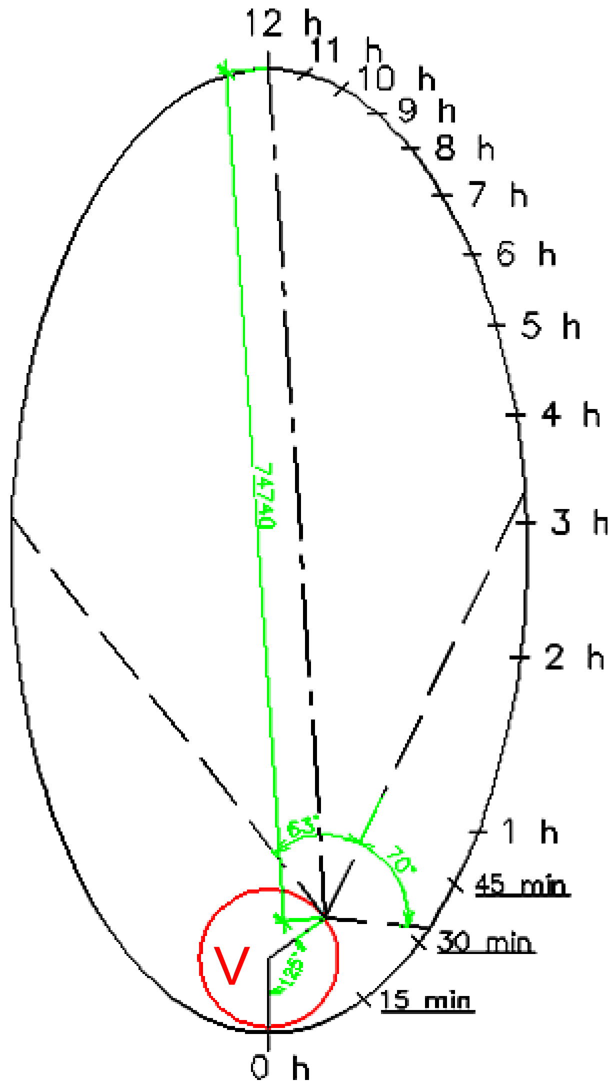
Slope 30 °
towards the pericenter
Communication duration 5 h

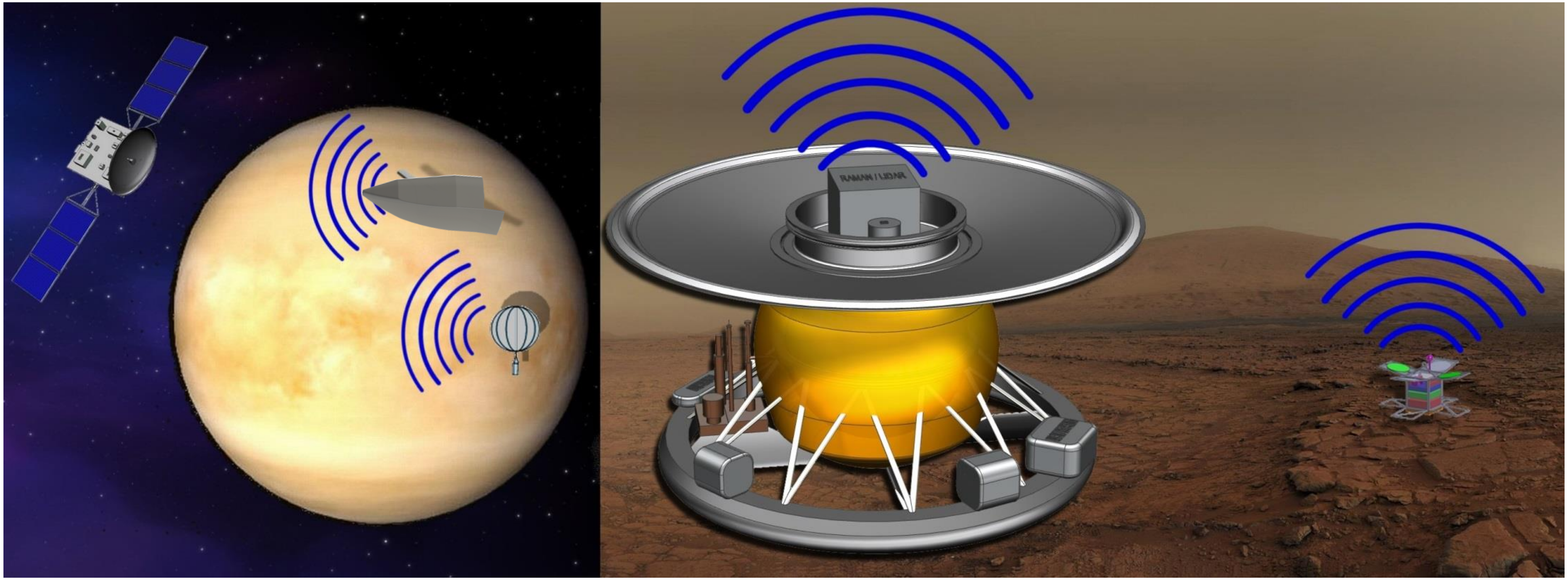



Slope 30 °
towards the apocenter
Communication duration 4 h 40 min




**Lander lifetime ~3 hours**

# Radio Communication Procedures



**Orbiter: 300-500×72,000 km orbit with lifetime ~3 years.**

**Transmission rate of SC-Earth radio line:**
**X-band - 256-512 Kbit/s, Ka-band - 16 Mbit/s.**

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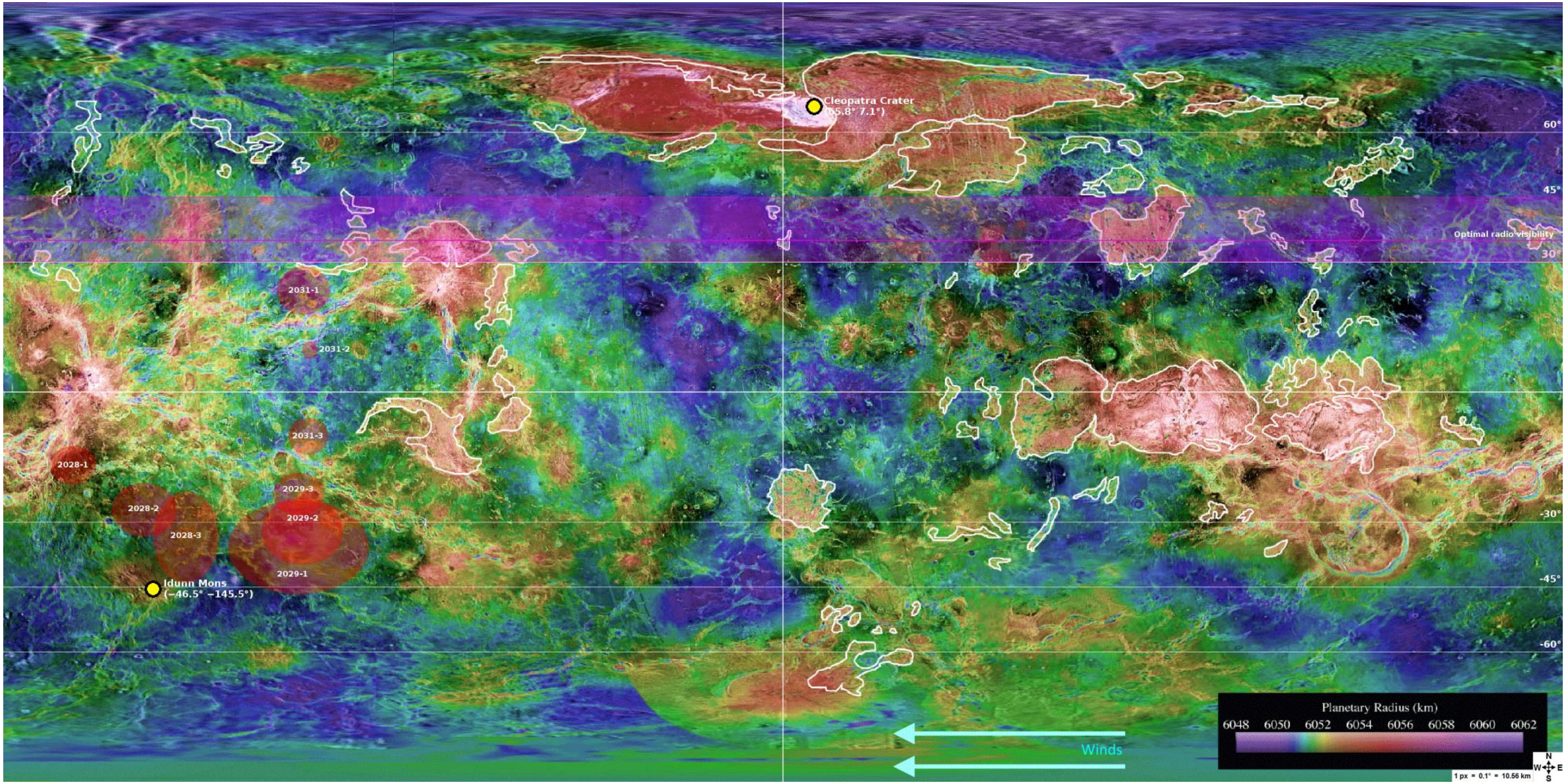
**Volume of transmitting science information:**
**300 MB for the Lander lifetime (~3 hours).**

# Potentially interesting and achievable landing sites

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# Prospective Technology - maneuverable entry vehicles (MEV)

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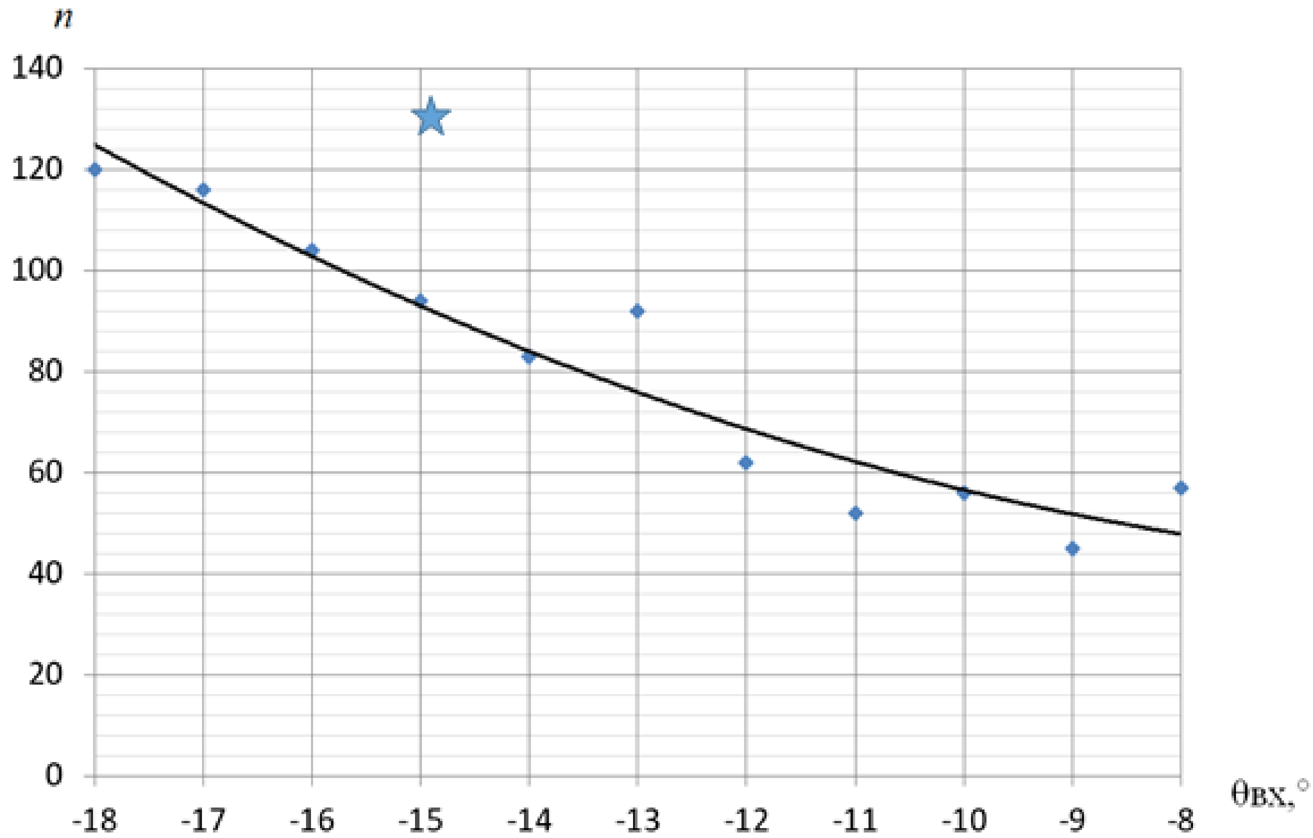
# Characteristics of the descent trajectory for the MEV

## Descent trajectory parameters

| Entry angle, degr | Lateral maneuver, km | Longitudinal range, km | Maximum overload | Descent time, s |
|---|---|---|---|---|
| -9…-18 | 4970..4250 | 7774…5696 | 45…120 | 1715..1905 |

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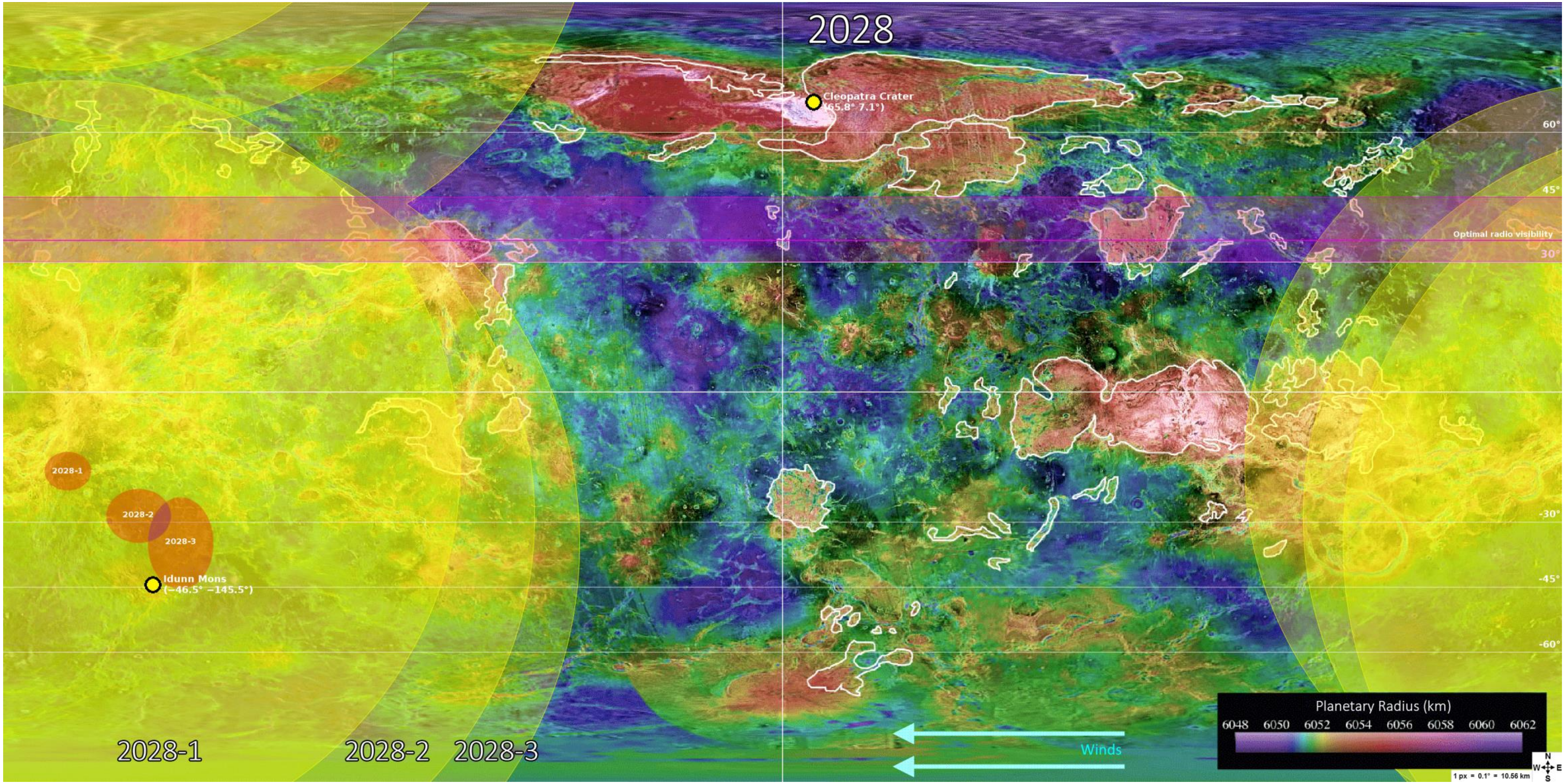
# Potentially interesting and achievable landing sites

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# Conclusion

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# Conclusion

1. “Venera-D” main lander has a Venera and VEGA LM type the design of which is capable of carrying all needed science equipment to the Venus surface and some additional payload (LLISSE, aerial balloon etc.).

2. There were determined requirements to the landing sites according to the lander design and radio link visible zones, presented potentially interesting and achievable landing sites according to the launch dates.

3. Main lander can transmit scientific information during no less than 4 h 40 min according to the radio link communication duration (in case of landing in optimal radio visibility zone) whereas the lifetime of the lander is ~3h which is proposed to be enough to transmit all information that we get.

4. There were proposed maneuverable entry vehicles as an additional payload which are capable of making measurements during the descent and also can provide landing in potentially interesting for scientific research landing sites.

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Thank you for attention
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