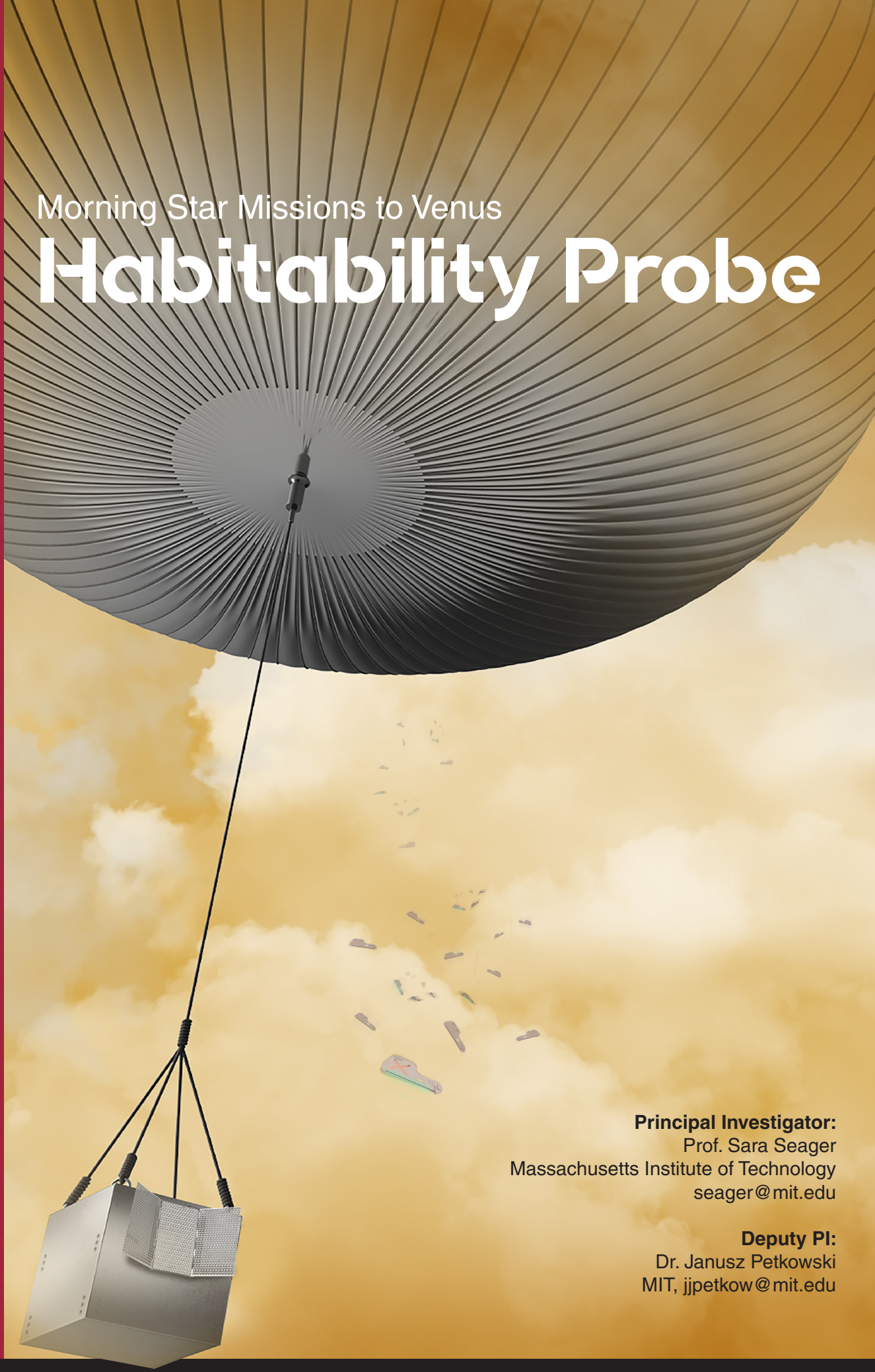
Morning Star Missions to Venus

Habitability Probe



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The exotic chemistry in the clouds of Venus has remained a mystery for four decades.

Could life be the cause? Could the technology to solve this mystery be useful on Earth?

Venus Facts

Launch opportunities every 1.5 years.

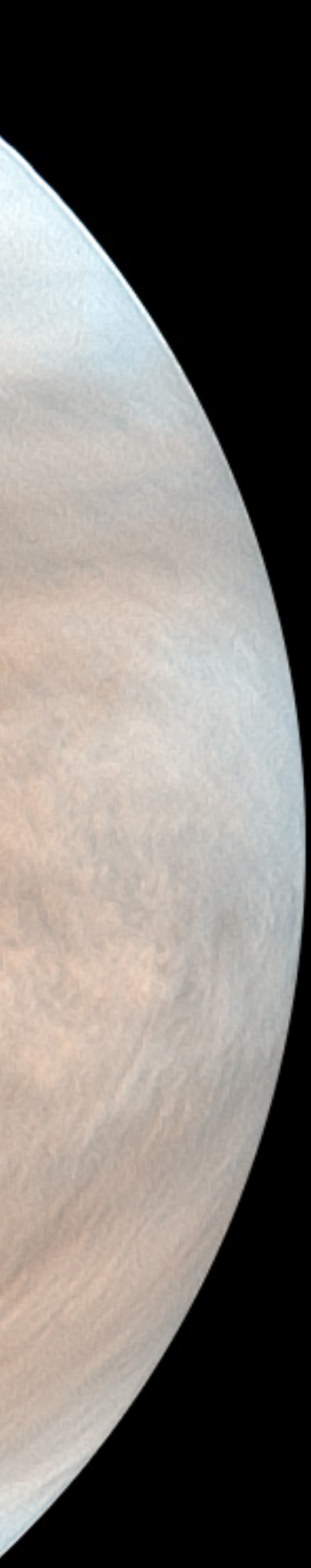
Atmosphere composed of 96.5% CO_2, 3.5% N_2, and many trace gases.

Cloud droplet composition ~75 – 98% concentrated sulfuric acid.

100% global cloud coverage.

Temperate cloud deck 48 – 60 km.
Temperature: 94 °C (48 km) to -10 °C (60 km).
Pressure: 1.4 bar (48 km) to 0.2 bar (60 km).

Horizontal wind speed 60 m/s (48 km) – 70 m/s (60 km).



The unknown

Venus holds many mysteries especially in its atmosphere. A variety of anomalous gases and cloud particles have defied explanation, some for close to a century.

- A mysterious cloud component that absorbs half of all incident sunlight, dubbed the “unknown UV absorber”
- Depletion of water and sulfur dioxide in the cloud layers
- Reported tiny amounts of oxygen, ammonia, and phosphine

1969

Venera 5 & 6 Missions

Entered atmosphere in 1969, operated for 51 minutes, successfully sending data back to Earth.

First atmospheric probe of Venus

1978

NASA Pioneer Venus Mission

Multiprobe atmosphere mission

Modern-day data reanalysis supports the 2020 report of phosphine gas detection.

1984

Vega 1 & 2 Missions

Balloon atmospheric probe deployed during entry operated for two days, successfully sending data back to Earth.

Reported detection of phosphorus and iron compounds in the clouds.

2020

Ground-based telescope report of phosphine gas in the cloud decks of Venus

Atmospheric phosphine at a few ppb abundance is inferred in observation carried out at the JCMT and ALMA telescopes.

Now

The only missions in the last four decades were orbiters, including: NASA’s Magellan, ESA’s Venus Express, and JAXA’s Akatsuki

Although NASA and ESA are building missions to Venus, none focus on signs of life detection.

The Habitability Probe will search for signs of life in the clouds

Search for Building Blocks of Life

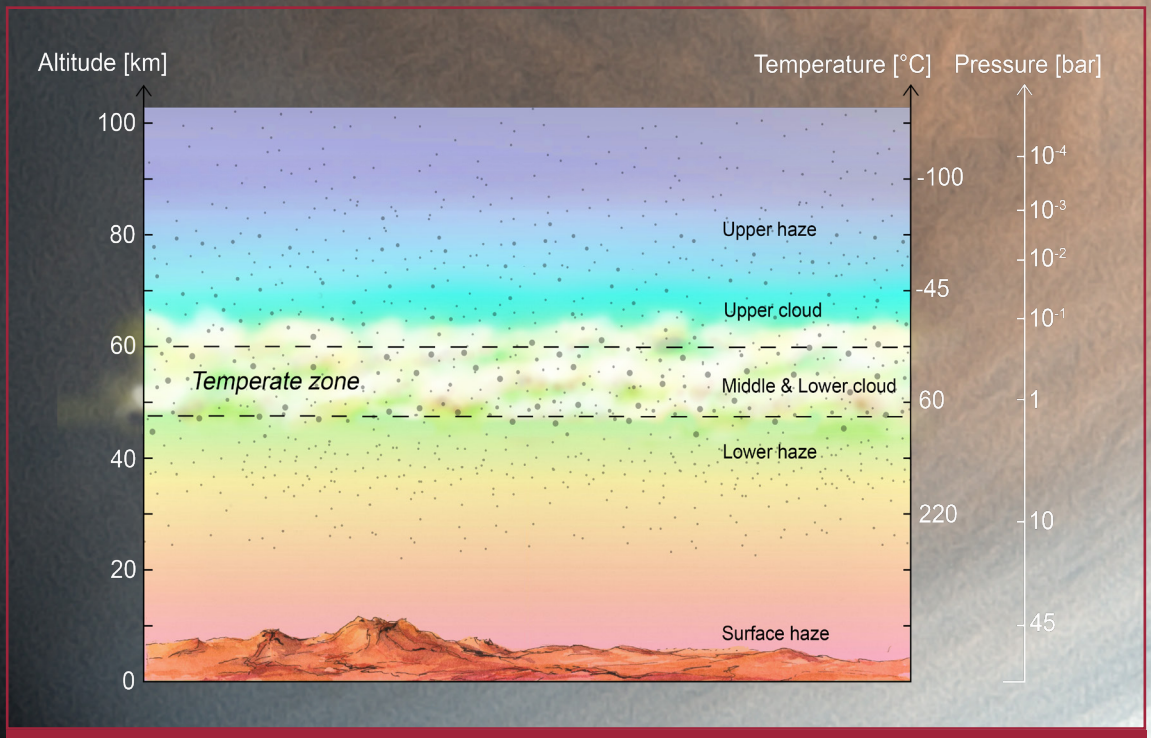
Detect and identify classes of complex organic molecules that could indicate the presence of life.

Measure Habitability Indicators

Determine the acidity of the Venus cloud particles.

Characterize Cloud Particles

Determine the unknown UV absorber in the clouds of Venus – a nearly century-old mystery.



Structure of Venus' atmosphere. The cloud cover on Venus is permanent and continuous, with the middle and lower cloud layers at temperatures that are suitable for life. The clouds extend from altitudes of ~48 km to 70 km.

Why support this mission?

Innovation

We need to push the boundaries of today's technology to invent new instrumentation and ways of exploring the Venusian atmosphere. These include:

- **Highly sensitive, autonomous molecule detection tools**
- **Tools to measure extreme environmental conditions**
- **Remote sensing technology**

The commercial applications on Earth for our technologies are far-ranging, from the medical industry to advanced environmental research and monitoring. The goal is to make these tools smaller, faster and able to work on their own, in extreme environments.

Discovery

Scientists do not understand all of the chemical processes taking place in the Venusian clouds but do have evidence for survival of some biomolecules in concentrated sulfuric acid, the cloud composition of Venus. By going to the planet, we may establish:

- **Exotic chemistry, including new complex structure formations**
- **New biomolecules based on behaviour in extreme conditions**
- **Potential signs and/or direct evidence of extraterrestrial life**

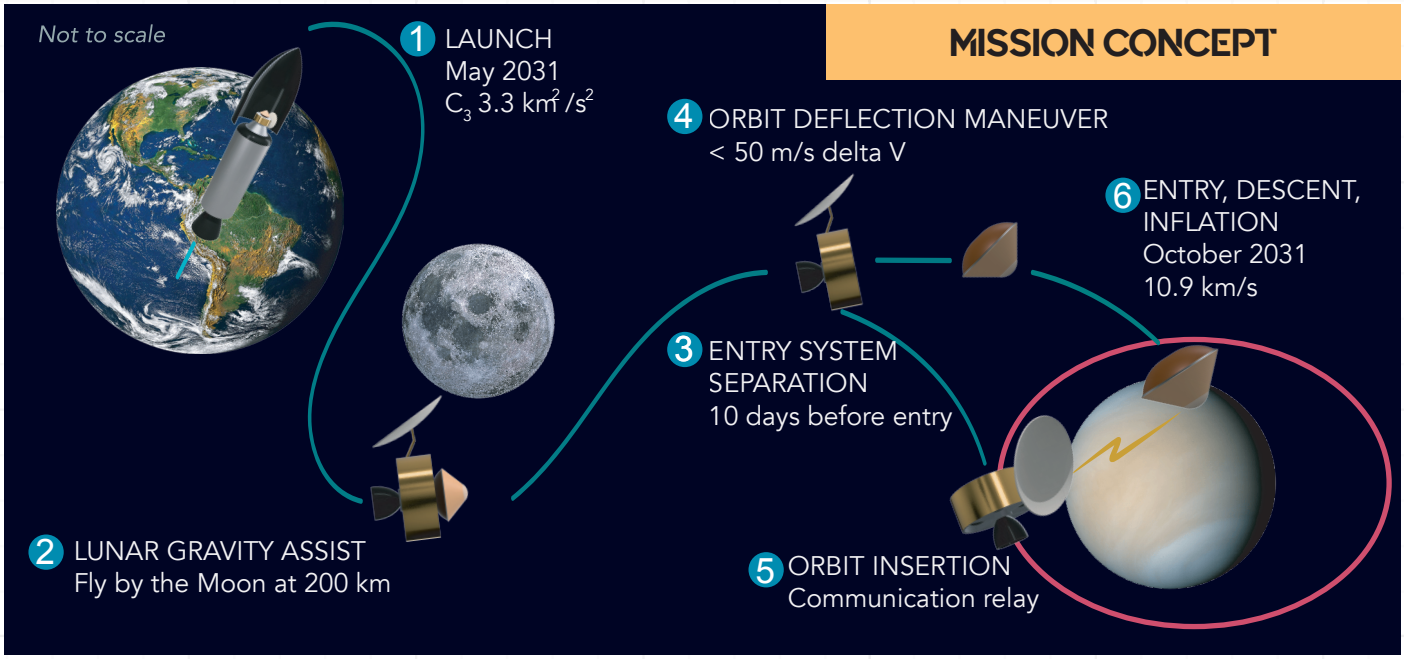
No other planned missions to Venus aim to study the chemical composition of the clouds. Only by taking this pioneering approach to the exploration of Venus will we increase our knowledge on the limits of habitability of extreme planetary environments and discover chemicals with potential applications in a multitude of Earth industries.

Legacy

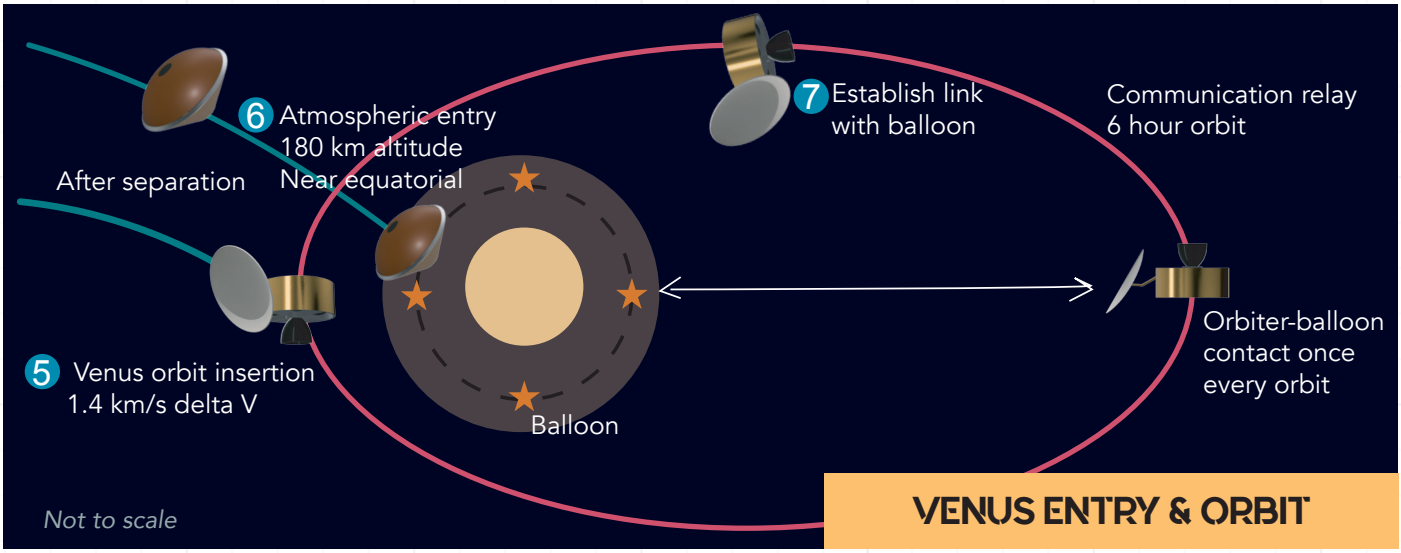
What will you be remembered for? Our truly ground-breaking mission will remain past our lifetimes to help future generations of scientists here on Earth.

Highly focused, privately funded space missions are changing the way we do space science and have the ability to give a **real return on investment**.

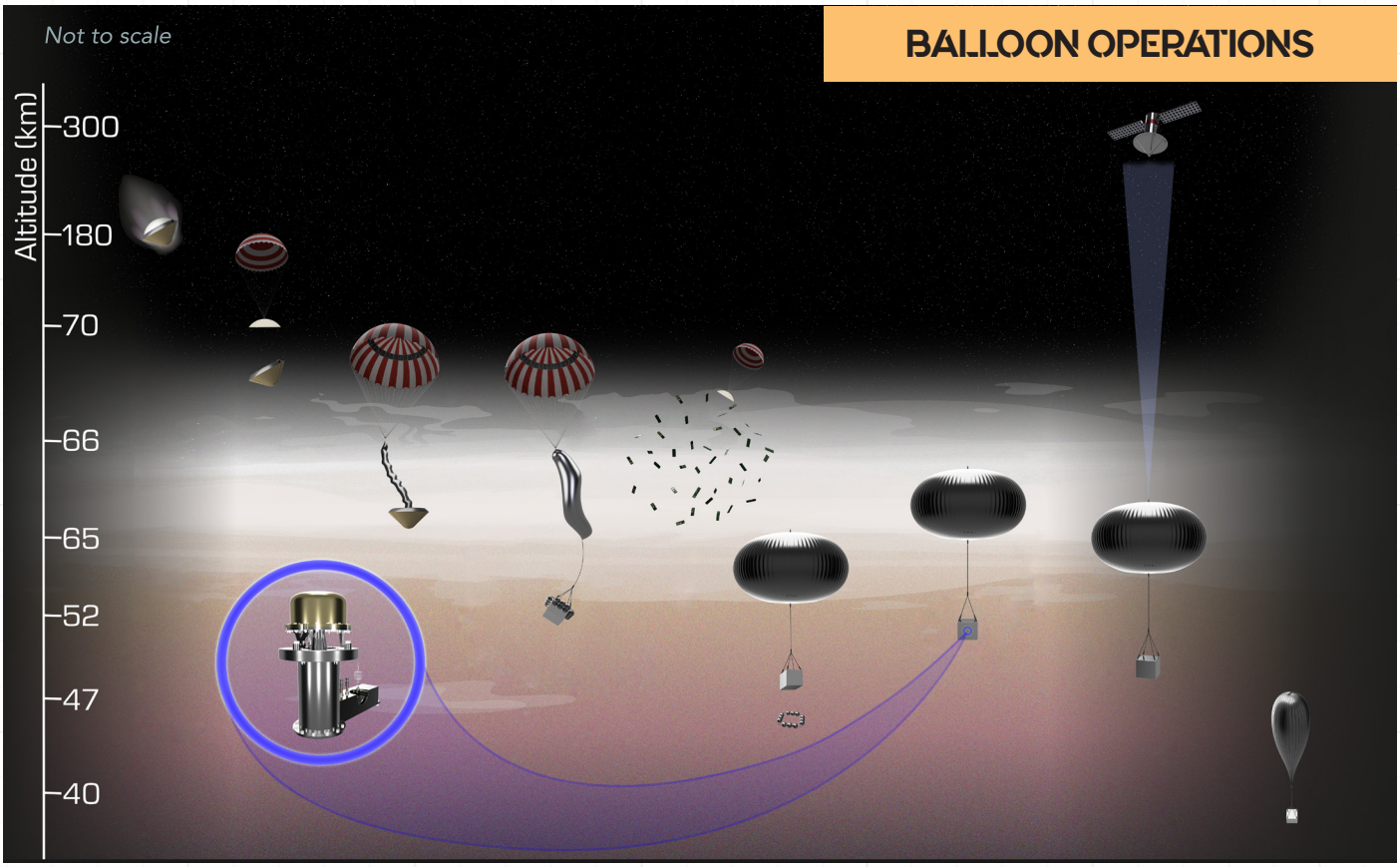
MISSION CONCEPT



VENUS ENTRY & ORBIT

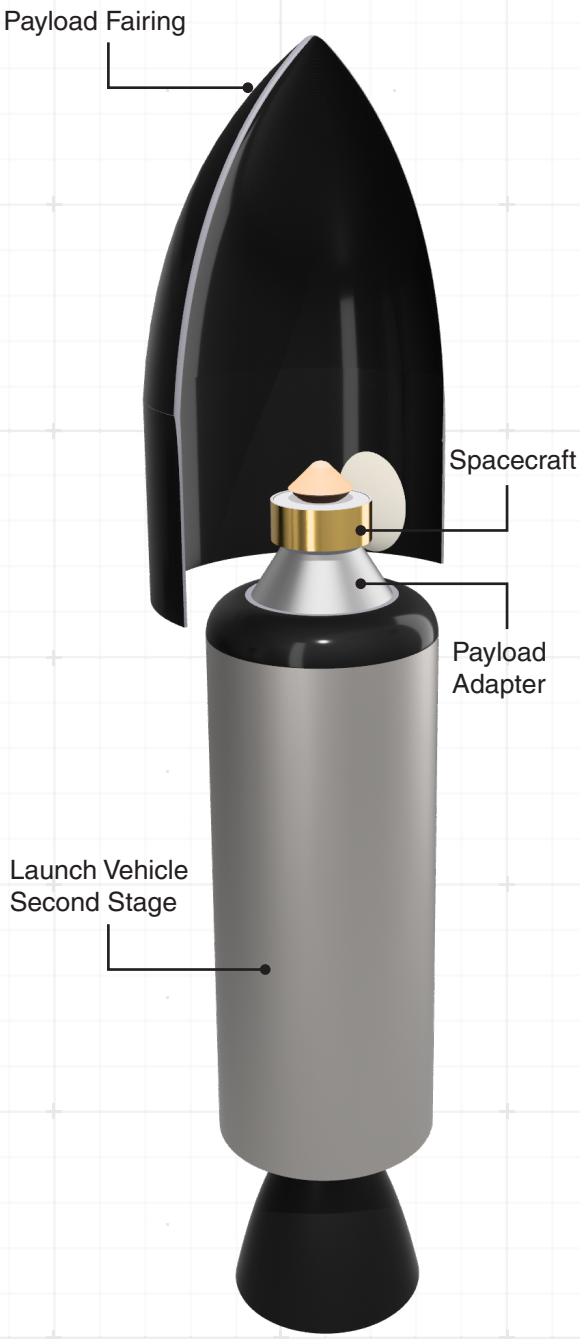


BALLOON OPERATIONS

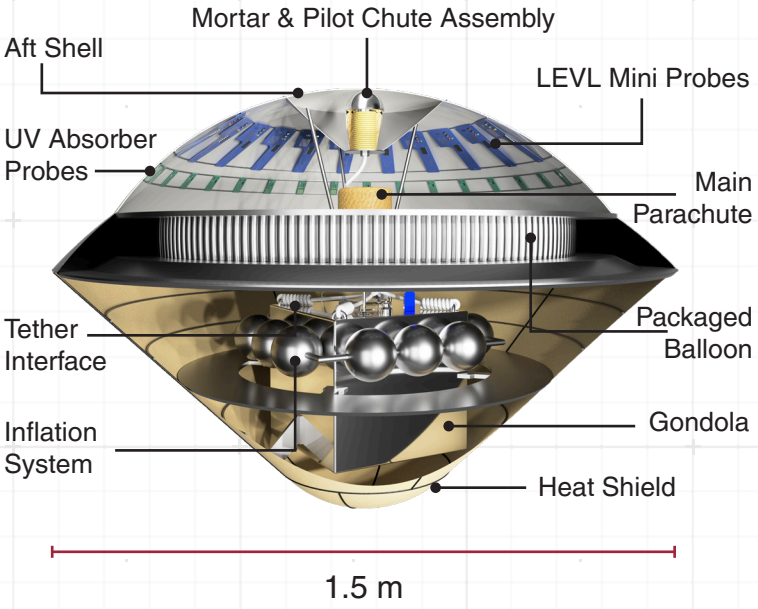


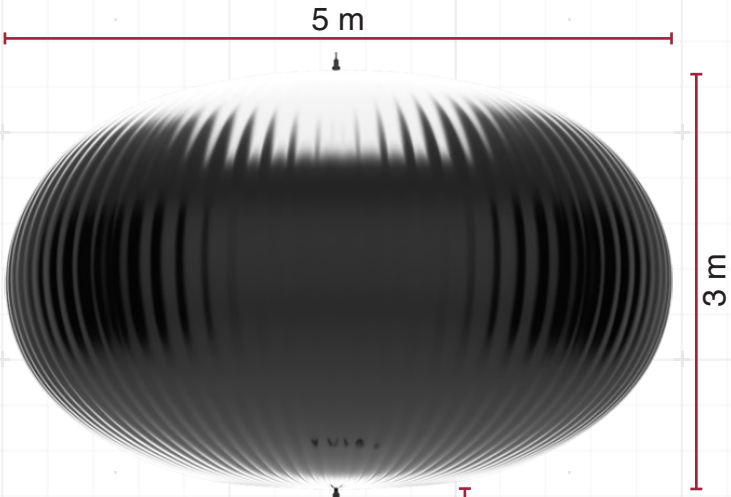
Flight System Elements

LAUNCH VEHICLE FAIRING



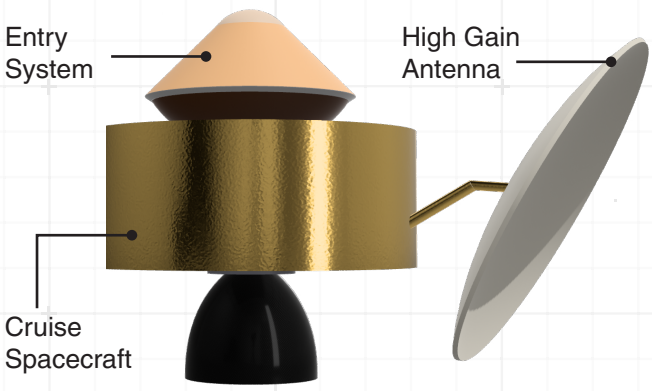
ENTRY SYSTEM





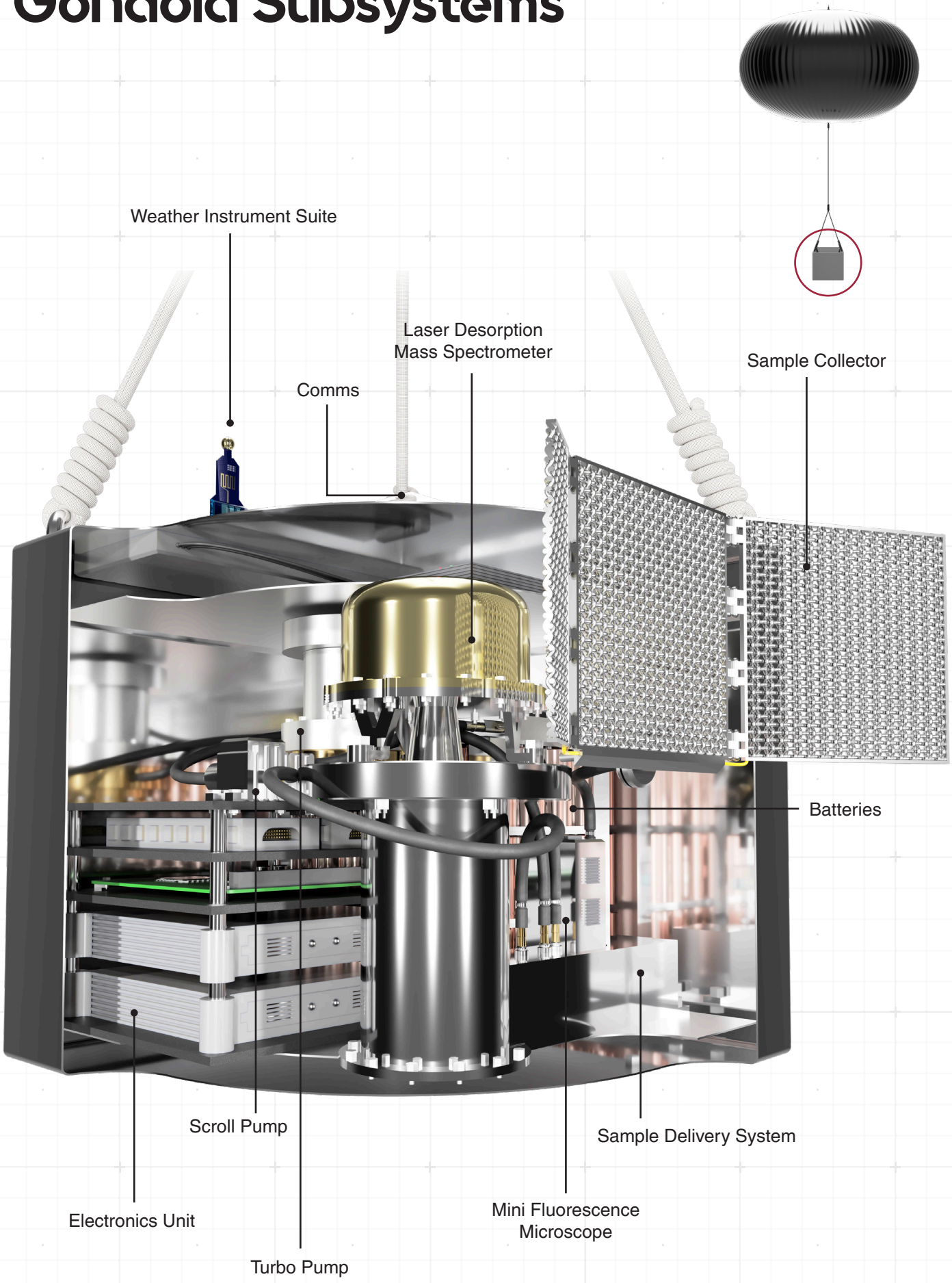
AERIAL PLATFORM

CRUISE VEHICLE/ORBITER



Not to scale

Gondola Subsystems



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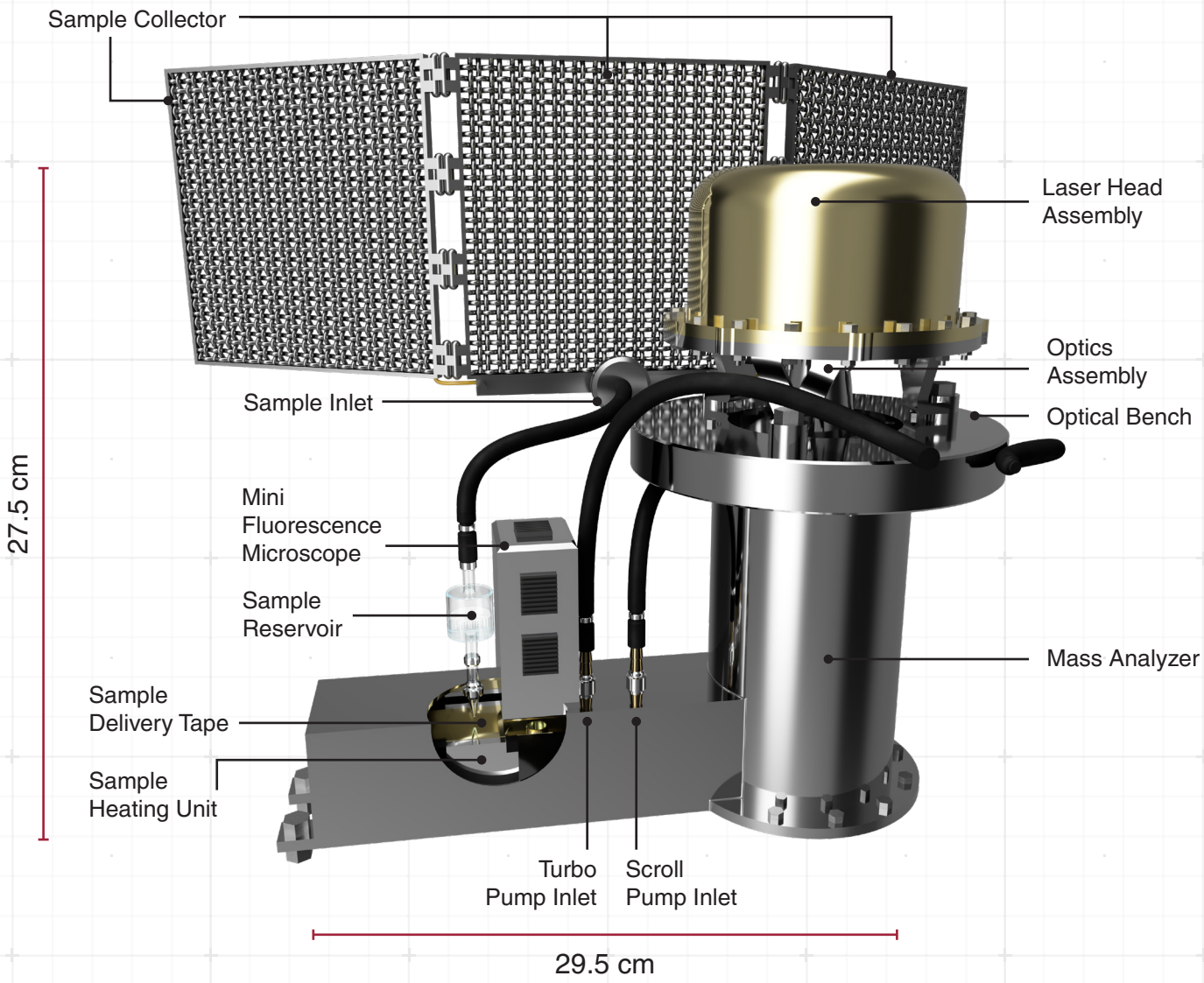
Primary Instrument

UNIVERSITÄT BERN

ORIGINS Laser Desorption Mass Spectrometer

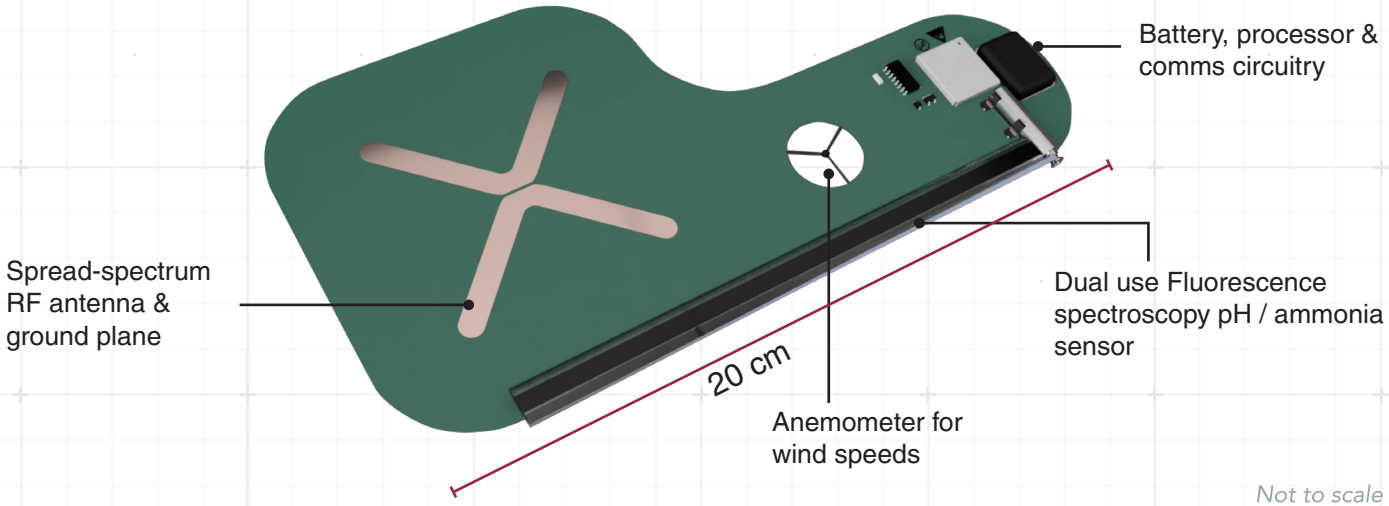


*Dimensions do not include sample collector.

Mini LEVL Probes

SPACE-AM GO LIGHTER · GO FURTHER

Thirty individual auto-rotating probes, each of 30 g mass, to measure cloud acidity, ammonia, large and small-scale fluctuations in wind, temperature & pressure.



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Aerial Platform Requirements

Science Instruments	
Mass	15 kg
Energy	4500 Wh
Gondola Volume	34 liters
Nominal Measurement Altitude	52 km
Science Mission Duration	7 days

Gondola Ambient Conditions	
Average Temperature (Range)	60 °C (-10 to 94 °C)
Average Pressure (Range)	0.8 bar (0.2 to 1.4 bar)
Operating Temperature	10 to 40 °C (operating temp. of instruments)

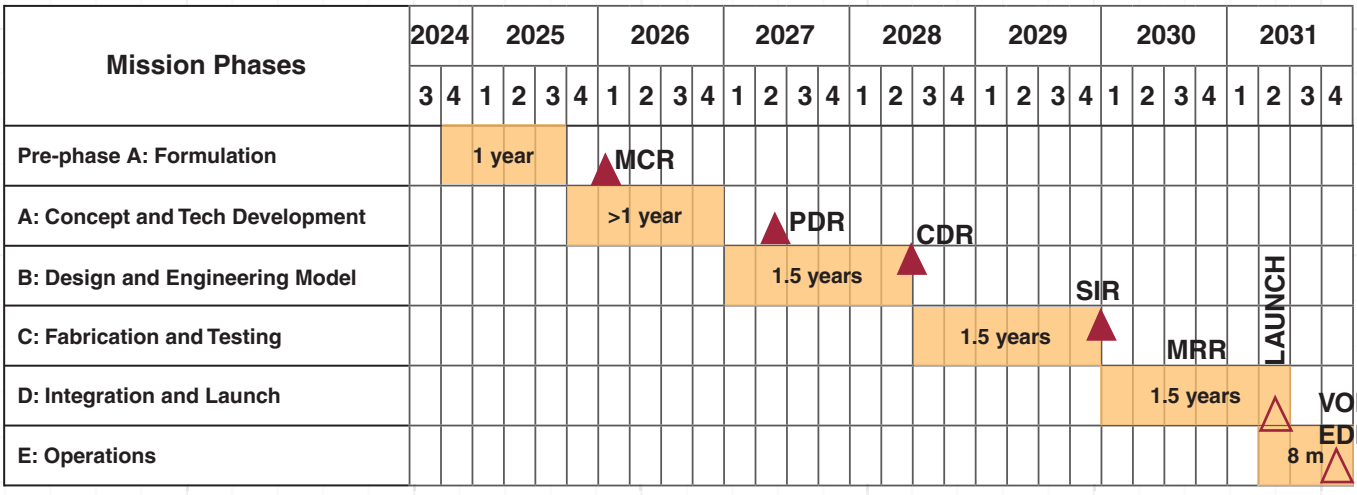
Communication System	
S-band Radio relay	6-hour period, 300 km periapsis altitude orbit
Total Data Volume	150 to 250 Mbytes
Data Rate	Variable from 10 kbps to 1600 kbps
Antenna	Patch (Gondola), Parabolic 0.6 m aperture (Orbiter)
Mini-probes to Gondola	S-band X-band, ~1 kbps

Estimated Entry System Parameters	
Total Entry Mass	200 kg
Balloon Envelope Mass	12 kg
Gondola Mass	33 kg

Expected Entry Conditions	
Entry Velocity	10.92 km/s
Entry Flight Path Angle	-15°
Peak g-load	125 Earth g's
Peak Heat Rate	~1500 W/cm^2
Total Heat Load	~10.5 kJ/cm^2

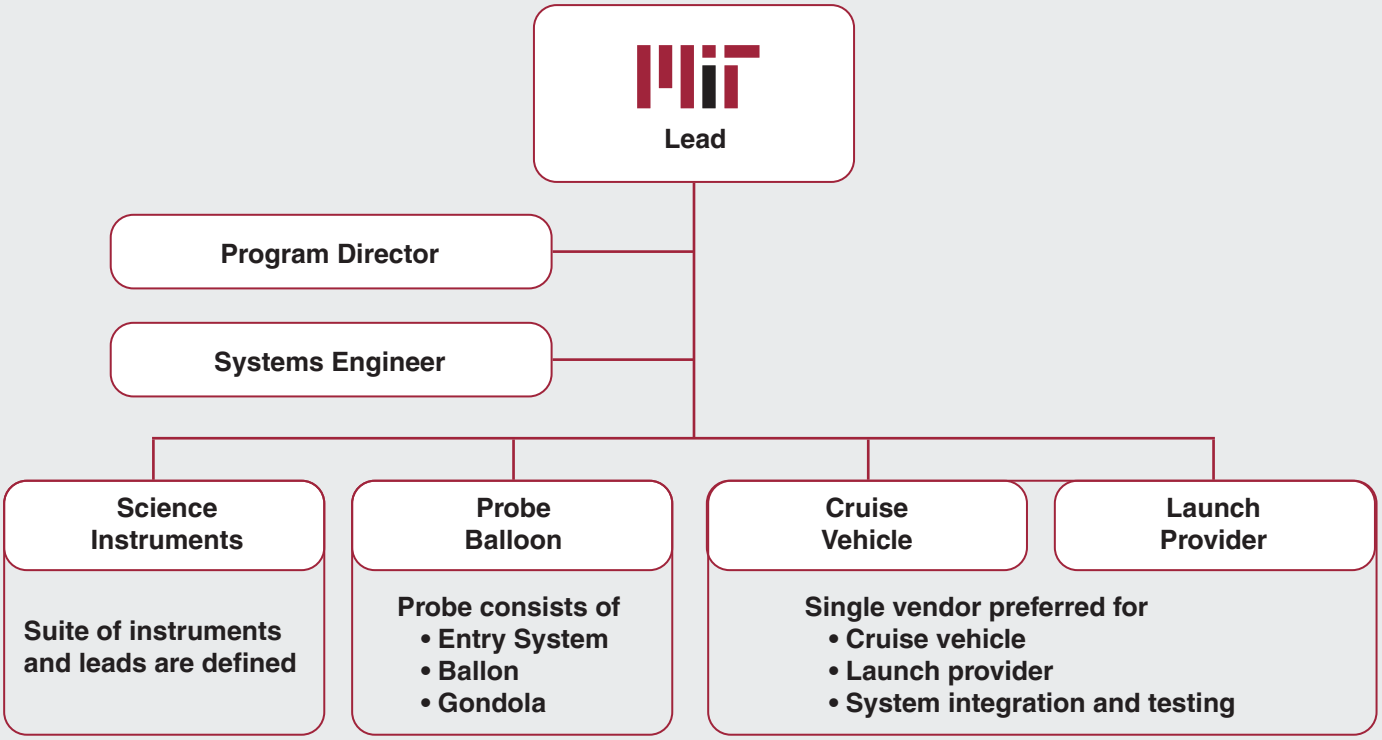
Mission Schedule

May 2031 Launch



MCR Mission Concept Review
SIR System Integration Review
EDI Entry, Descent, Inflation
PDR Preliminary Design Review
MRR Mission Readiness Review
CDR Critical Design Review
VOI Venus Orbit Insertion

Mission Organization



Habitability Probe - Lead

Professor Sara Seager, PhD

MIT Professor of Planetary Science, Physics, Aeronautical and Astronautical Engineering

Space Missions:

TESS Mission
Deputy Science Director for the MIT-led NASA Mission.
Set up and ran the TESS Science Office and the workflow (software, staff, etc.) to deliver planet candidates to the astronomy community.

ASTERIA space telescope
Brought the idea from concept to launch.
Successful technology demonstration in precision pointing a small satellite 100 times better than anything in its mass category. MIT-Draper Lab initial collaboration, later implemented by JPL-MIT.

Starshade lead
Led the 2013 team that brought Starshade to a mainstream viable concept, a legacy which continues on today.

Awards:

Kavli Prize in Astrophysics.
Mac Arthur "Genius" Fellowship.
Member in the US National Academy of Sciences.
Royal Canadian Geographical Society Gold Medal.
Officer of the Order of Canada.
Asteroid 9729 named in her honor.
Emmy award-winning documentary for "The Hunt for Planet B" .

Discoveries:

Founded the field of exoplanet atmospheres by inventing the primary methods exoplanet atmospheres are studied today.
A host of new exoplanet discoveries.

Habitability Probe - Program Director

Jared Atkinson, PhD

Leadership:

Senior Manager at a global technology consulting firm, leading Canada's space activities and developing integration strategies for space robotics, Earth observation, satellite communications, drone technology and remote sensing, in-space manufacturing and life sciences R&D across the Americas.

Program Execution:

Led and delivered dozens of high-impact international projects by managing technical execution, multi-million dollar budgets, timelines and deadlines, personnel, risks, vendors, deliverables' quality control. Capital projects range from offshore wind platform foundation development, exploration seismology and multinational mining.

Space Experience:

Research and development for NASA Lunar and Martian applications. For the SAMPLR (upcoming CLPS mission), developed an approach using an arm-mounted penetrometer to analyze Lunar regolith characteristics, including cohesion, angularity, and ice content. Managed regolith simulant preparation and instrument testing for the Stinger and Lunar Resource Prospector Drill, in the category of rover-mounted geotechnical prospecting tools.

Morning Star Missions to Venus

Habitability Probe

www.morningstarmissions.space

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