Venus Climate Mission

VCM

Planetary Science Decadal Survey
Mission Concept Study

VCM Science Objectives

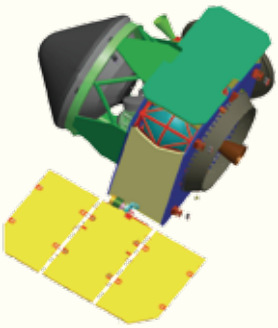
- Characterize the strong CO_2 greenhouse atmosphere of Venus, including variability.
- Characterize the dynamics and variability of Venus's superrotating atmosphere.
- Characterize surface/atmosphere chemical exchange in the lower atmosphere.
- Search for atmospheric evidence of climate change on Venus.
- Determine the origin of Venus's atmosphere and the sources and sinks driving evolution of the atmosphere.
- Understand implications of Venus's climate evolution for the long-term fate of Earth.

Mission Concept Study Report to the NRC Decadal Survey Inner Planets Panel
June, 2010

Concept Maturity Level: 4
Cost Range: Low End Flagship
Launch Date: November 2, 2021
Science Campaign:
April 7, 2022 - April 28, 2022
Launch Mass: 3,948 kg
Launch Vehicle: Atlas V 551

VCM Science Payload

- Carrier Spacecraft
  - Venus Monitoring Camera Vis-IR
- Gondola/Balloon System
  - Neutral Mass Spectrometer (NMS)
  - Tunable Laser Spectrometer (TLS)
  - Atmospheric Structure Instrumentation (ASI)
  - Nephelometer
  - Net Flux Radiometer (NFR)
- Mini-Probe
  - NMS; NFR; ASI
- Drop Sondes,
  - ASI; NFR



Carrier Spacecraft

Function: Deliver and deploy Entry Flight System; orbit Venus as communication relay for Gondola/Balloon system
Power: 5 m^2 solar panels
Attitude Control: 3-axis stabilized (Spin up for release of the EFS)
Telecom: 1.7m dia. HGA; two-way S-band comm. with gondola; two-way Ka-band comm. with Earth
Science Data Return: 14 Gb from Carrier Spacecraft Camera plus 142 Mb from Gondola/Balloon System; Mini-Probe and Drop Sondes

Mini-Probe

Function: 45 minute descent from 55.5 km to surface
Power: Distributed rechargeable Polymer Lithium-ion batteries
Telecom: 1 way S-band to gondola
Science Data Return: 5 Mb
Design: 44 cm dia., 66 cm tall titanium pressure vessel, passive thermal control

Drop Sondes (2)

Function: 45 minute descent from 55.5 km to surface
Power: Distributed rechargeable Polymer Lithium-ion batteries
Telecom: One-way S-band to gondola
Science Data Return: 1 Mb (each probe)
Design: 29 cm dia., 35 cm tall titanium pressure vessel, passive thermal control

Entry Flight System

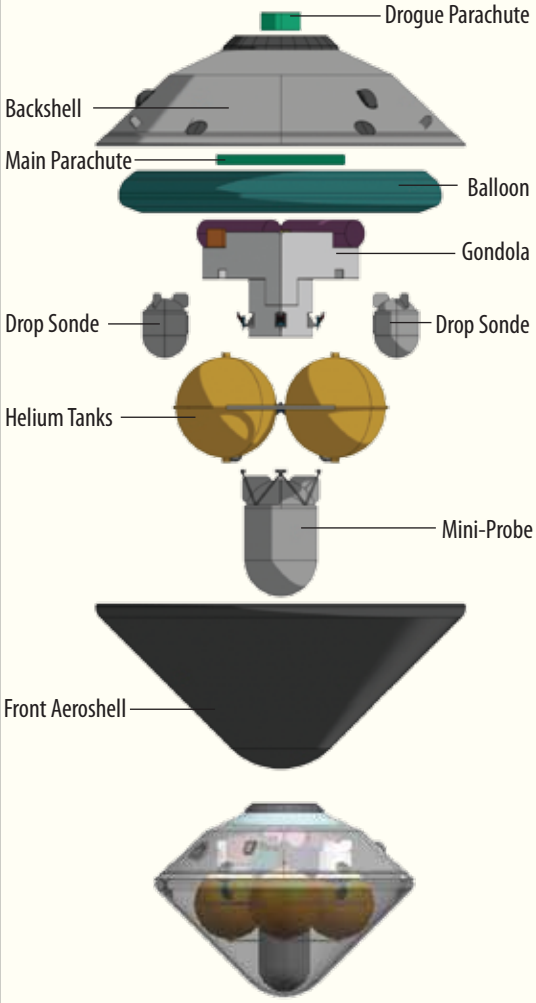
Function: Deliver in situ elements through the atmosphere; carries the Gondola/Balloon System, Inflation System, Mini-Probe and two Drop Sondes
Power: Lithium-thionyl chloride (Li-$SOCl_2$) primary battery
Design: Carbon-Phenolic front shell, Phenolic Impregnated Carbon Ablator back shell, 45 deg cone angle (Pioneer-Venus heritage), 2 m diameter

Gondola/Balloon System

Function: 21 day science campaign at 55.5 km float altitude
Power: Lithium-thionyl chloride (Li-$SOCl_2$) primary battery
Telecom: Two way S-band (plus Doppler) to Carrier Spacecraft; one way S-band from Mini-Probe and Drop Sondes
Science Data Return: 135 Mb from Gondola science + 7 Mb from Probe & Sondes science
Balloon Design: 8.1 m diameter helium filled balloon; teflon coated for sulfuric acid resistance; Vectran fabric plus Mylar film construction; metalized for low solar heating
Inflation System Design: 4 x 0.5 m dia. titanium tanks; pipes; valves

Entry Flight System

with Gondola/Balloon System, Mini-Probe and Drop Sondes



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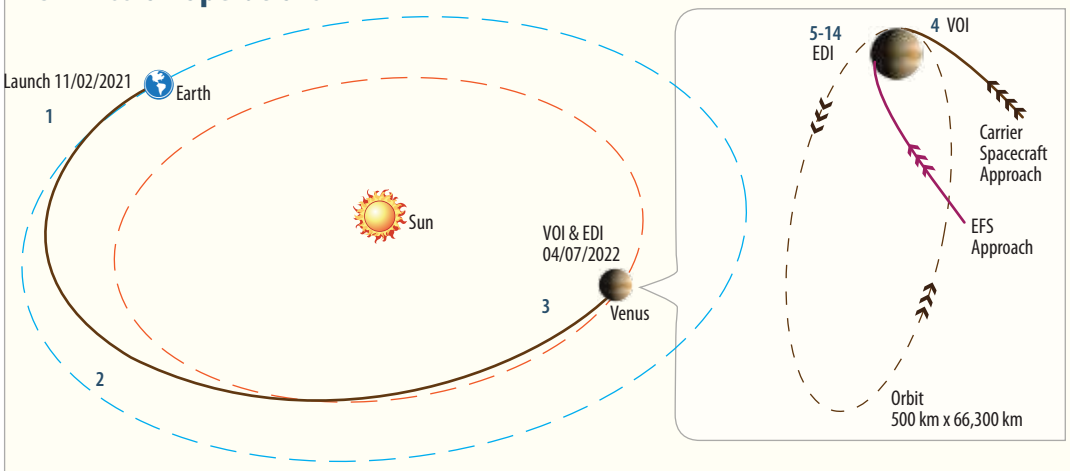
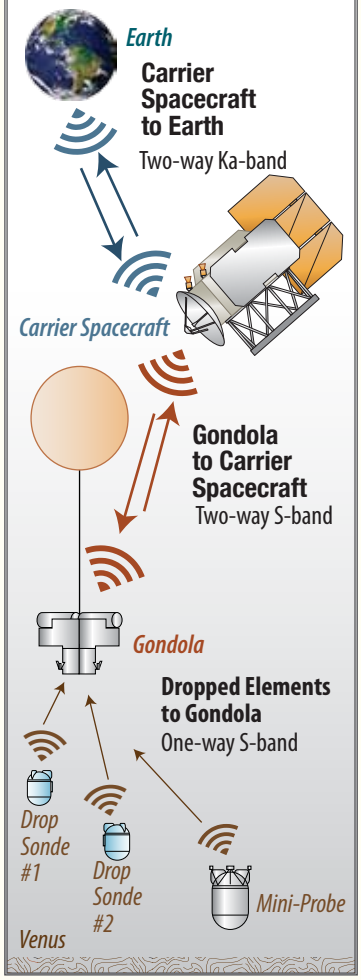
VCM Mission Operations



1. VCM launches in November 2021 on an Atlas V 551 L/V, with a C3 of 8.8 km²/sec², capable of delivering up to 5,141 kg of mass
2. Five month cruise to Venus
3. Ten days prior to Venus entry, the Entry Flight System (EFS) is released with 5 rpm from the Carrier Spacecraft, a day later the Carrier Spacecraft diverts for a Venus Orbit Insertion (VOI) approach
4. Carrier Spacecraft performs VOI and enters an elliptic orbit to provide telecom support to the in situ elements (Gondola, Mini-Probe, two Drop Sondes)
5. EFS reaches atmospheric entry interface at 175 km altitude, decelerates over a minute
6. Drogue parachute opens at subsonic speeds, further decelerates the EFS
7. Aeroshell separates
8. Back and front Aeroshell jettison and Balloon inflation begins
9. Main parachute jettisons
10. Balloon inflation is completed in 5 minutes; Helium inflation tanks are jettisoned and the Mini-Probe is released at 53 km (lowest altitude)
11. Balloon chord extends as the Balloon rises to a float altitude of 55.5 km
12. Balloon begins its 21-day science operation, spiraling toward pole multiple times
13. First Drop Sonde is deployed on command or at a predetermined time
14. Second Drop Sonde is deployed on command or at a predetermined time

Telecon



Telecom strategies: The Probe and Sondes communicate data on S-band to the Gondola during their 45 min descent; the Gondola sends all science data to the Carrier Spacecraft; the Carrier Spacecraft relays all data (incl. Carrier Spacecraft camera) to Earth on Ka-band.