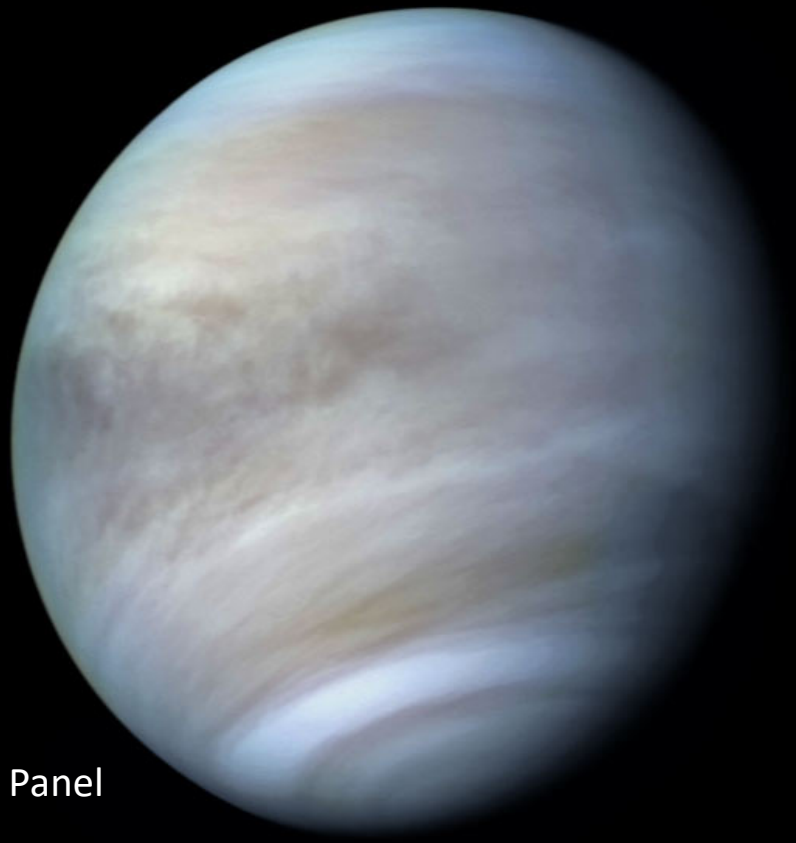
NASA Venus Missions



James L. Green
October 20, 2021
COSPAR Planetary Protection Panel

VERITAS

Venus Emissivity, Radio Science, InSAR, Topography, & Spectroscopy

What makes a rocky planet habitable?

Like Earth, Venus started with all the building blocks of a habitable world. How was habitability lost?

Science Goals

1 Rocky planet evolution

- 1a igneous rock type, surface-atmosphere interaction
- 1b ancient geologic processes
- 1c volcanic history
- 1d subduction, origins of plate tectonics

2 Active processes

Active and recent volcanism, tectonics?

3 Past and present water

- **3a** continents from a wetter past?
- **3b** current volcanic outgassing of water?

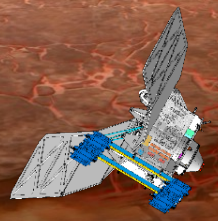
Mission Overview

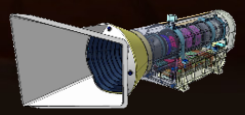
Launch Date: 2028

Venus Orbit Insertion: TBD

3 years of science operations from orbit

>40 Tb of science data returned





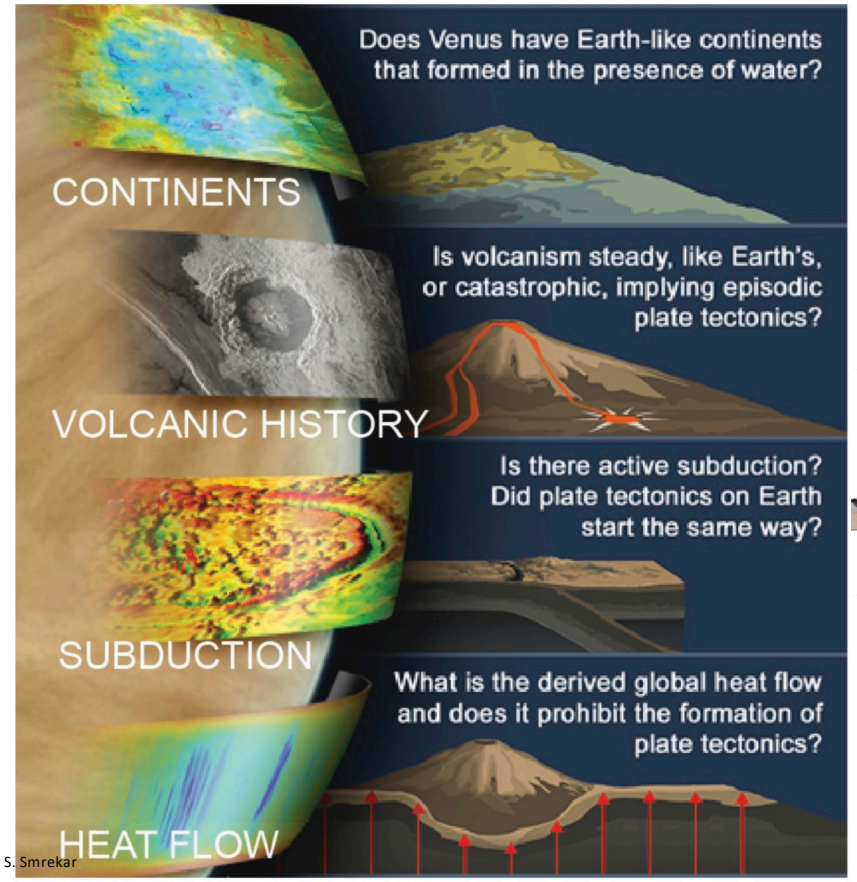
High-Resolution Global Reconnaissance

1. ***VISAR*** (Venus Interferometric Synthetic Aperture Radar)
   - Highest resolution global topography for terrestrial planets
   - 1st planetary active deformation map
   - Global data sets:
     - Topography: 250 m horiz, 5 m vertical
     - SAR imaging: 30 m
   - Targeted data sets:
     - SAR imaging: 15 m
     - Surface deformation: 1.5 cm vertical
2. ***VEM*** (Venus Emissivity Mapper)
   1st near-global map of igneous rock type, weathering
   - 6 NIR surface bands with robust SNR
   - 8 atmospheric bands for calibration / water vapor
3. ***Gravity Science Investigation***
   1st global maps of derived elastic thickness & core size

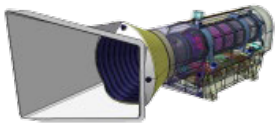
PI: Sue Smrekar, JPL; Managed by JPL

VERITAS

Venus Emissivity Radio science, InSAR, Topography And Spectroscopy



Payload



- **Venus Emissivity Mapper (VEM): DLR**
  - NIR multispectral imager for surface rock type, active and recent volcanism, and volcanically outgassed water

- **Venus Interferometric Synthetic Aperture Radar (VISAR): JPL/ASI**
  - Radar for geologic evolution, volcanism, tectonism, and active deformation

- **Gravity Science Investigation**
  - Uses two-way Ka-band telecom (ASI) to obtain elastic thickness and density variations, core size and state

Measurement Objectives

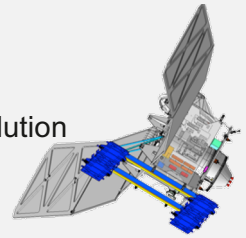
VISAR

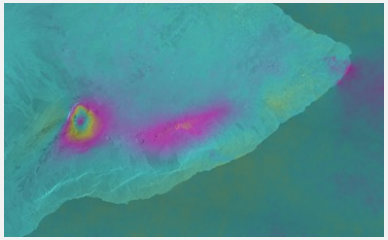
***Science Measurements*:**

Global DEM
- 250 m horz, 5 m vert resolution

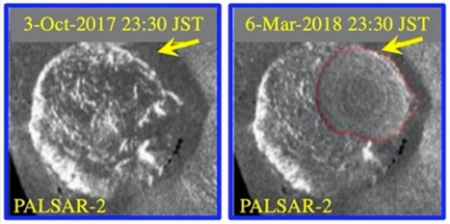
Global SAR Imaging
- 30 m resolution

Targeted imaging (27% of planet)
-15 m resolution



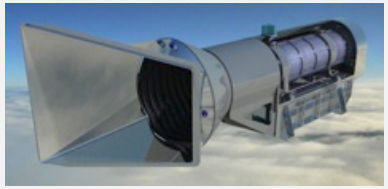


1st Interferometric Deformation Maps



Searching for Surface Change

VEM



***Science Measurements*:**
- 6 surface bands, SNR > 150
- 8 atmos. bands & calibration

Global Rock Type

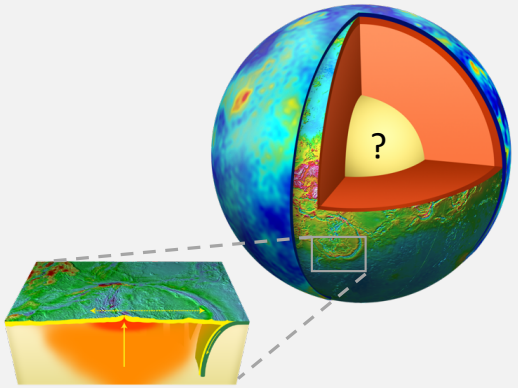
Search For Volcanic Activity

Gravity

***Science Measurements*:**

Gravity field (155 km) , 3 mgal

MOIF to ±0.005, k2 to ±0.01



Interior Structure
Core Size and State

DAVINCI will explore past and present Venus

Deep Atmosphere Venus Investigation of Noble Gases, Chemistry, and Imaging

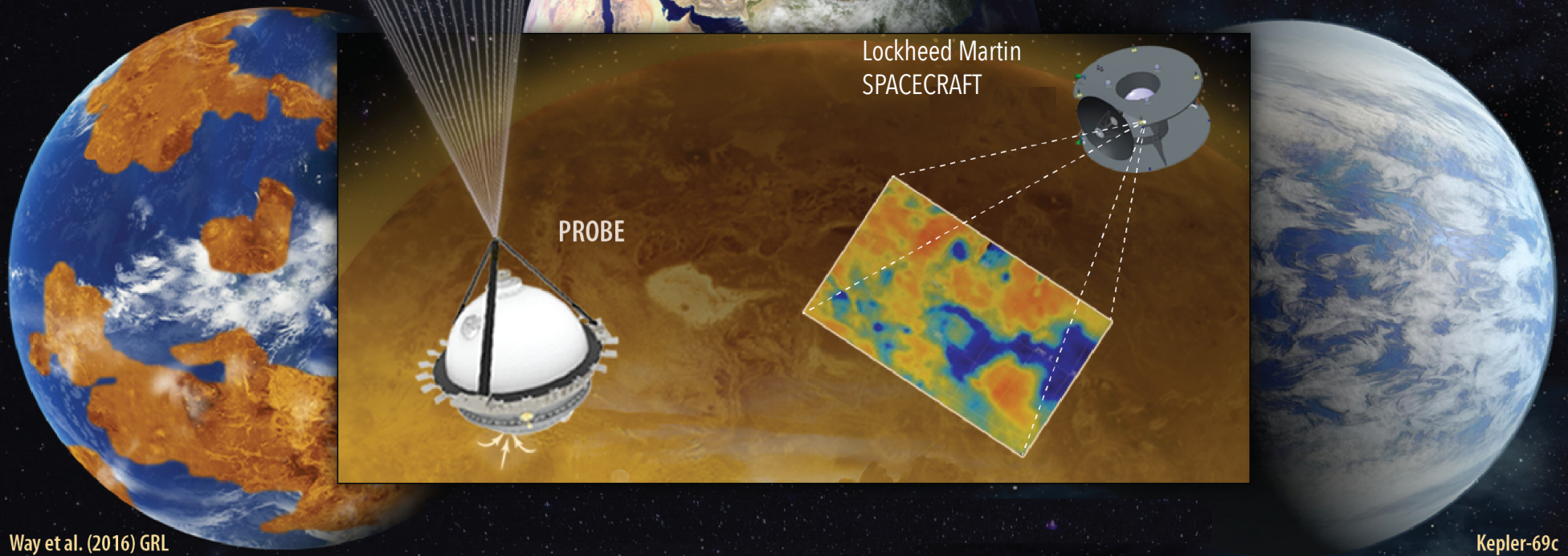
Establishing Venus' place in our Solar System

Enabling exploration of Venus-like exoplanets and Earths

Ancient Oceans on Venus?

Evolution of Habitability

Venus-like Exoplanets

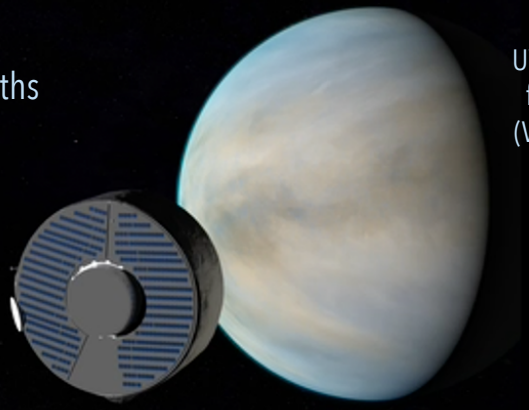


Way et al. (2016) GRL

Kepler-69c

Flyby 1

First flyby occurs six months after launch



UV observations during both flybys track cloud motions (VISOR) and characterize the unknown UV absorber (CUVIS)

Flyby 2

IR observations during both flybys (VISOR) constrains surface composition in key regions

Probe Descent

VASI, VMS, VTLS, and VfOx make detailed measurements of the atmosphere, including noble gases.

VenDI measures surface topography & composition

Probe Entry and Descent with Science

In 2031, the probe will carry a suite of instruments into the Venus atmosphere

These instruments will work together to characterize the atmosphere and surface, seeking evidence of ancient water.

DAVINCI

Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging

Mission Phases

Science Every Step

DAVINCI Flybys and Probe Descent reveal Atmosphere and Oceans

Was Venus habitable in the past?

Venus Express
Akatsuki
DAVINCI

DAVINCI Probe

DAVINCI Probe begins taking measurements & continues to the surface

≈ 70 50 0 0 0 0

Vega Balloons

Pioneer Venus Probe

Largely Unknown

75% of Venus Atmospheric Mass

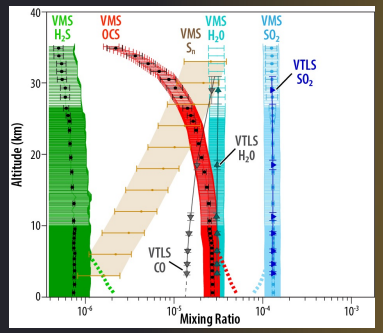
DAVINCI

Vega & Venera Landers

Magellan Radar

Launch 2029

Spacecraft with Probe



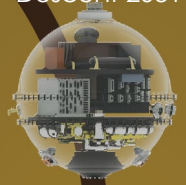
Altitude-resolved atmospheric measurements will reveal origin, composition, and cycles

Probe Flight System

Descent

Carrier

Descent 2031

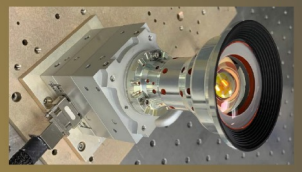


Descent Sphere

Probe Instruments

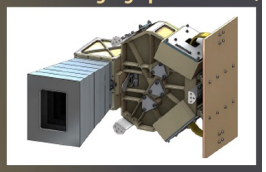
Carrier instruments *(on Venus flybys)*

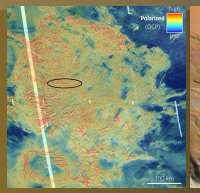
VISOR (Venus Imaging System from Orbit for Reconnaissance)



Based on OSIRIS-REx/ECAM

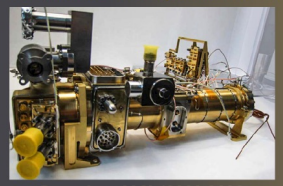
CUVIS (Compact Ultraviolet to Visible Imaging Spectrometer)





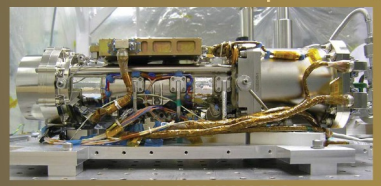
Local composition and topography inform how highland landforms have evolved in the distant and recent past

VMS (Venus Mass Spectrometer)



Based on MSL/SAM QMS

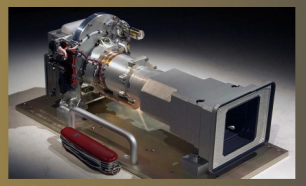
VTLS (Venus Tunable Laser Spectrometer)



Based on MSL/SAM TLS

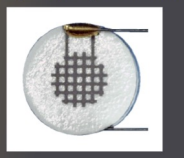
VASI (Venus Atmospheric Structure Investigation)

VenDI (Venus Descent Imager)



Based on MSL/MastCam, MARDI, MAHLI

VfOx (Venus Oxygen Fugacity Experiment)



Questions?