

VEXAG Update to the NASA Planetary Advisory Committee

Robert Grimm, Chair

Martha Gilmore, Deputy Chair

Feb 23, 2018



VEXAG Steering Committee

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Allan Treiman (Lunar & Planetary Institute),

Goals, Objectives, and Investigations Lead

Constantine Tsang (Southwest Research Institute)

Tommy Thompson (JPL), Scribe

Adriana Ocampo (NASA HQ) ex officio

Recent Meetings & Presentations

Planetary Science Vision 2050, Feb 27–28, 2017, NASA HQ, Washington, DC

LPSC XLVIII, March 20-24, 2017, Houston, Texas

NRC Decadal Survey Mid-Term, May 4-5, 2017, Nat'l Academies, Washington, DC

Venus Modeling Workshop, May 9–11, 2017, Ohio Aerospace Inst., Cleveland

Low-Cost Planetary Missions Conf., August 15-17, 2017, Caltech, Pasadena.

Venera-D Modeling Workshop, October 5-7, 2017, Moscow, Russia.

15th Meeting of the Venus Exploration Analysis Group, November 14–16, 2017,
Applied Physics Laboratory, Laurel, Maryland

Upcoming Meetings & Presentations

NASA Planetary Advisory Committee, Feb 27–28, 2018, Washington, DC.

Venus Bridge Report to NASA HQ, 16 March 2018

LPSC XLIX March 19–23, 2017, Houston, Texas.

International Planetary Probes Workshop, June 11-15, 2018, Boulder CO

42nd COSPAR, July 14-22, 2018, Pasadena.

Comparative Climatology of Terrestrial Planets III, Aug 27–30, 2018, Houston.

Int'l Venus Conference, Sept 11-14, 2018, Niseko, Hokkaido, Japan.

16th Meeting of the Venus Exploration Analysis Group, November 2018.

VEXAG Activities & Agenda

- Identify scientific priorities and opportunities to NASA.
- Develop & update guidance documents
 - Goals, Objectives, and Investigations (GOI) TBR 2018
 - Technology Plan TBR 2018
 - Roadmap TBR 2018
- Propagate priorities to NRC Decadal Surveys (next: 2020)
 - Flagship study 2018-19, white papers 2019.
- Foster next generation of researchers




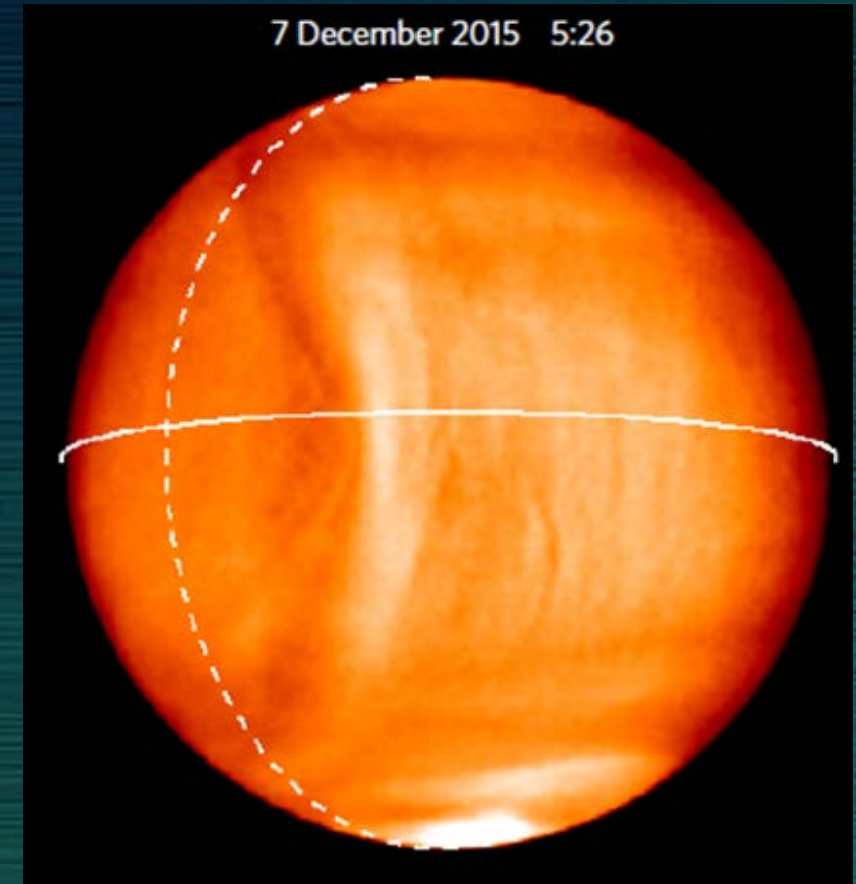
The screenshot shows the VEXAG website header with the NASA logo and the text "VEXAG Venus Exploration Analysis Group". Below the header is a navigation menu with links for "About Us", "Reports", "Meetings", "Early Career Scholars", "Venus Resources", "Venus Nuggets", and "VEXAG Internal Link". The main content area features a section titled "The Venus Exploration Analysis Group" with a sub-heading "Unveil Venus: Why is Earth's sister planet so different?". The text describes the group's mission and provides links to its Twitter and Facebook pages. A sidebar on the right contains a profile for "VEXAG Venus" with a Venus image, location "The Planet Next Door", website "ipl.usra.edu/vexag/", and a "10 Followers you know" section.

Venus Goals, Objectives, and Investigations

Atmosphere	Surface & Interior	System Interactions & Water
<ul style="list-style-type: none">• How did the atmosphere form and evolve?• What controls the atmospheric super-rotation and greenhouse?• What is the impact of clouds on climate and habitability?	<ul style="list-style-type: none">• How is heat released from the interior and has the global geodynamic style changed with time?• What are the contemporary rates of volcanism and tectonism?• How did Venus differentiate and evolve over time?	<ul style="list-style-type: none">• Was surface water ever present?• What role has the greenhouse had on climate history?• How have the interior, surface, and atmosphere interacted as a coupled system over time?

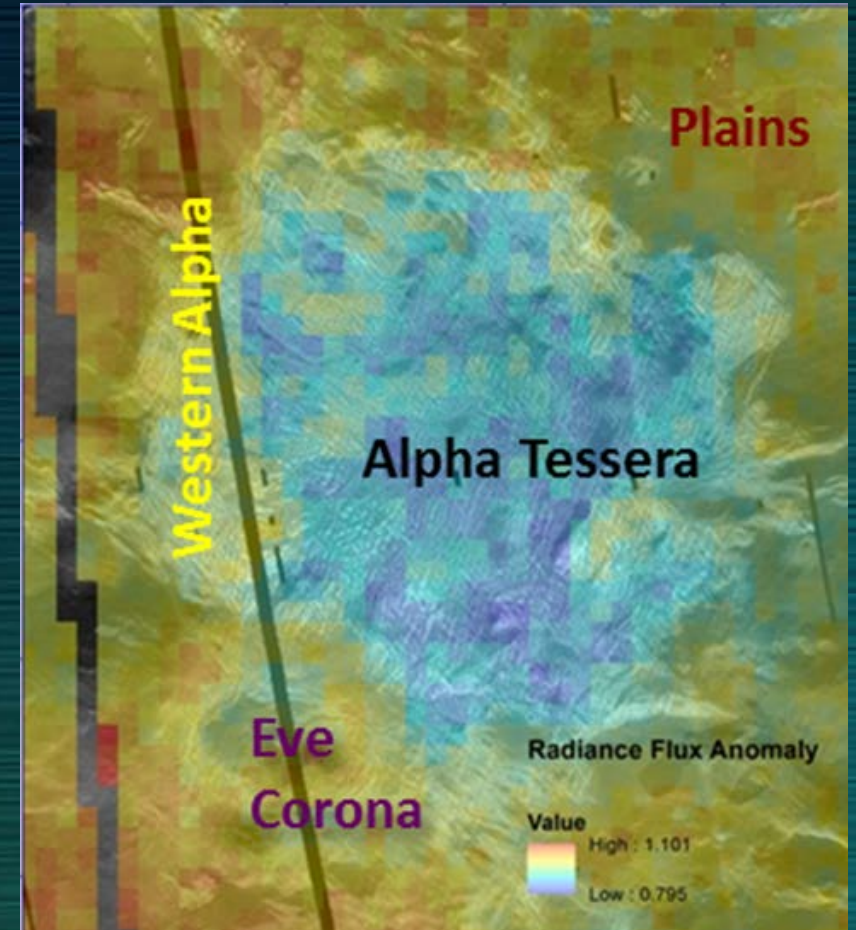
Venus Science

- Occurrence rate of exoVenuses is comparable to exoEarths (*Kane et al.*, 2014).
- Aphrodite Terra launches large gravity waves ~1500 LST (*Fukuhara et al.*, 2017). 
- OSSO suggested as ultraviolet absorber (*Frandsen et al.*, 2016).
- Ground-based observations can track several atmospheric constituents (*Arney et al.*, 2014).
- An ocean could persist until the recent past (*Way et al.*, 2016) (Unstable equilib, neglects CO₂).
- “Electric wind” can cause strong atm. stripping without solar wind (*Collinson et al.*, 2015).



Venus Science

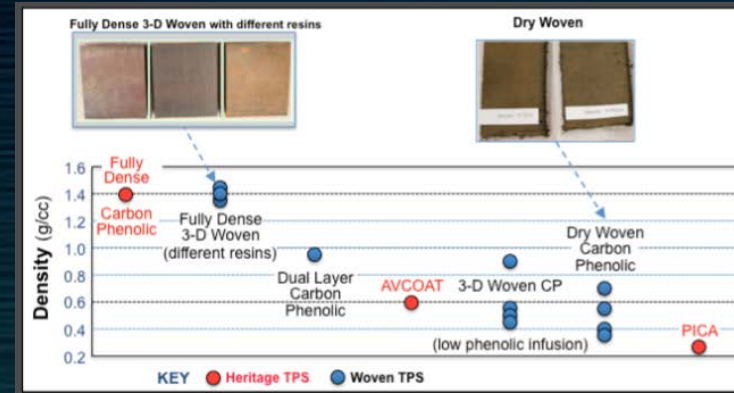
- Tessera consistent with felsic compositions (*Basilevsky et al., 2012; Gilmore et al., 2015*). →
- Radar-dark materials in tessera point to “lost” craters & resurfacing (*Whitten & Campbell, 2016*).
- Venus resurfacing and geodynamics may behave differently than thought post-Magellan (*O’Rourke et al., 2014; Ghail, 2015*).



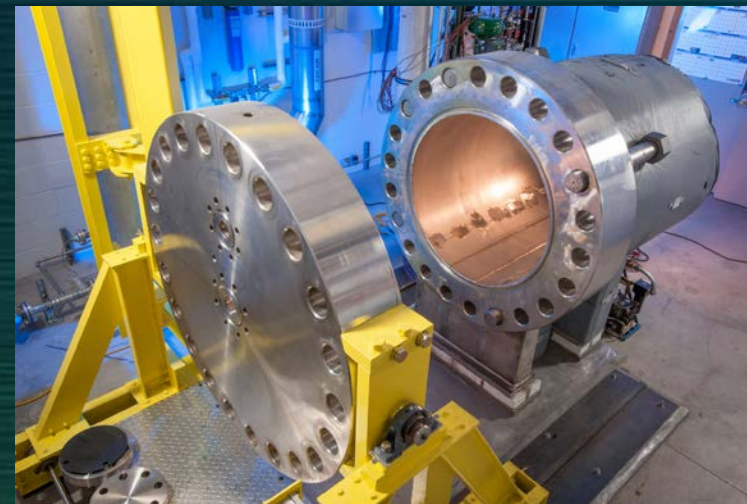
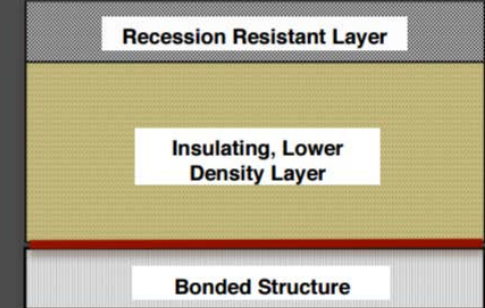
Venus Technology

- HOTTech program 2016
- Thermal protection systems
 - Ames HEEET
- Venus environmental testing facilities
 - Glenn Extreme Environments Rig (GEER)
 - 28 ft³ steel vessel can accommodate multiple gases to 1400 PSI and 500°C
- High-temperature electronics (NASA GRC)
 - 21-day IC demo at Venus conditions
 - Demo of chemical species (multiple), wind, temp, and pressure sensors for targeted 60 day operation
 - No thermal control required for Venus surface
- Deep-space optical communications
- Smallsats and cubesats
- Aerial platforms study 2017-18 (JPL).

NASA ARC



HEEET Architecture



NASA GRC



Thin Red Line Aerospace

Venus Roadmap

Pushed to the Right in Planetary Science Vision 2050

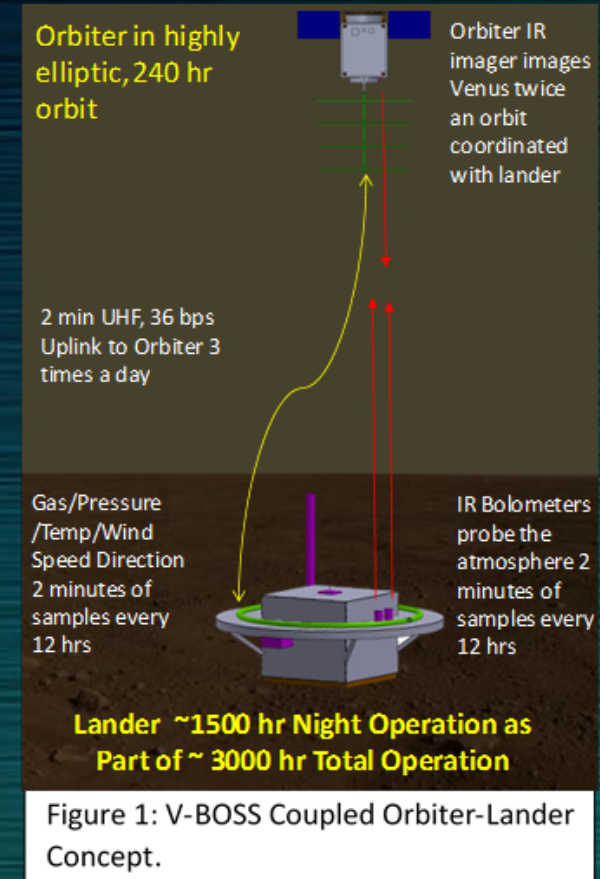
- VEXAG's abstract (Cutts et al.) emphasized that a detailed roadmap already exists and made the case for its implementation, now by 2050.
- Near-Term (now to 2030)
 - Orbital remote sensing (radar imaging, infrared emissivity, gravity, topography), sustained aerial platform, deep probe, short-duration lander, multiple probes/dropsondes, flyby opportunities.
- Mid-Term (now to 2040)
 - Multiple deep probes, short-duration tessera lander, long-lived geophysical lander.
- Far-Term (now to 2050)
 - Surface (or near-surface) platform with regional mobility, long-lived seismic network, sample return

Venus Missions

- 2 of 5 **Discovery** Phase A finalists in 2016 were Venus, but neither selected.
 - NASA assures no bias against Venus
- Three Venus proposals to **New Frontiers** 2017—none selected for Phase A.
 - VOX was Cat 1
- **Venus Bridge** study – \$200M cap, report to AA in March.
- **Flagship** study – authorized by HQ for 2018 (GSFC)
- **VeGASO** (ESA BepiColombo, NASA Parker Solar Probe, ESA Solar Orbiter)
 - Only BC is committed
- **Venera-D** (Russia) – Joint SDT; include US flight element (aerial platform?); launch 2026 to 2031
 - Pending funding, completion of lunar program, and selection ahead of Phobos.
- **EnVision** (ESA) – M5 on hold (no M-mission has yet launched).
- **Akatsuki** (JAXA) – continues to operate after 2015 rescue, likely ext. into 2021.

Venus Bridge

- Outcome of AA inquiry “what can you do for \$200M?” post-Disco-decision.
- Focus Group assessed useful science or technology demonstrations likely within nominal cost cap.
 - Gap-filling with broadest impacts; launches in early-mid 2020s
 - Decided on linked orbiter + in situ element
 - Whole greater than sum of parts; distinct from PSDS3.
- Separate design studies by GRC and JPL
 - “V-BOSS” (GRC) orbiter and long-lived lander.
 - JPL IR or aeronomy orbiter + atmospheric skimmer, probe, or balloon
 - \$200M target likely requires some development and operations costs outside cap.
- Venus BRIDGE named for a reason
 - Pathfinder to get scientists working again on Venus soon.
 - Not a substitute for larger, more scientifically capable missions.



Path Forward For Venus

- Understand value & viability of smallsat missions.
- Prepare for 2020 Decadal survey
 - Update guidance documents, execute flagship study, write white papers.
- Continue science, meeting participation, and messaging.
- AA says continue to compete:
 - “NASA’s mission selection process is highly competitive,” says Thomas Zurbuchen, associate administrator for NASA’s science mission programs in Washington, D.C. “Earth’s so-called ‘twin’ planet Venus is a fascinating body, and of tremendous interest to our science community ... the Venus community should continue to compete for future missions.” (Science News 2/3/18)
- Four Cat 1 missions spanning last Disco and last 2 NF: what else is needed?

The Fading Evening Star

- Venus is the key to understanding where Earth-sized means Earth-like elsewhere in the Universe. Venus is the cornerstone of comparative planetology.
- With no NASA mission since Magellan in 1989 the Venus science workforce and technical heritage in the US has steadily declined.
 - There have been nearly 30 US proposals.
 - Earliest medium-mission launch >35 years after Magellan.
- The Venus science community is poised now with mature mission concepts, intellectual capital, and experience. Venus exploration needs NASA advocacy and recognition by planetary scientists at large.

