VENUS FLAGSHIP MISSION CONCEPT STUDY

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AND THE VENUS FLAGSHIP MISSION STUDY TEAM

VEXAG
November 6-8 ,2019

Wesleyan University

Jet Propulsion Laboratory
California Institute of Technology

VENUS FLAGSHIP MISSION CONCEPT SCIENCE TEAM

Name	Institution	Expertise
Sushil Atreya	Univ. of Michigan	Interior-surface-atmosphere interaction
Patricia Beauchamp	JPL-Caltech	Technology, Instrumentation, Chemistry
Penelope Boston	Ames Research Center	Astrobiology
Mark Bullock	Science & Technology Corp	Chemistry of Atmospheres and Surfaces
Shannon Curry	U.C. Berkeley	Solar wind interactions with Venus
Martha Gilmore	Wesleyan. University	Surface processes, spectroscopy
Robbie Herrick	Univ. of Alaska	Geology and Geophysics
Jennifer Jackson	Caltech	Mineral Physics
Stephen Kane	U.C. Riverside	Exoplanet Science
Alison Santos	GRC	Petrology
David Stevenson	Caltech	Geophysics
Colin Wilson	Oxford University	Atmospheric Physics
Janet Luhmann	UC Berkeley	Venus escape processes
Robert Lillis	UC Berkeley	Modeling of plasma and magnetic processes
Joshua Knicely (student)	Univ. of Alaska	Venusian Volcanoes

Mission Design at GSFC, M. Amato Lead

SCHEDULE AND REPORT

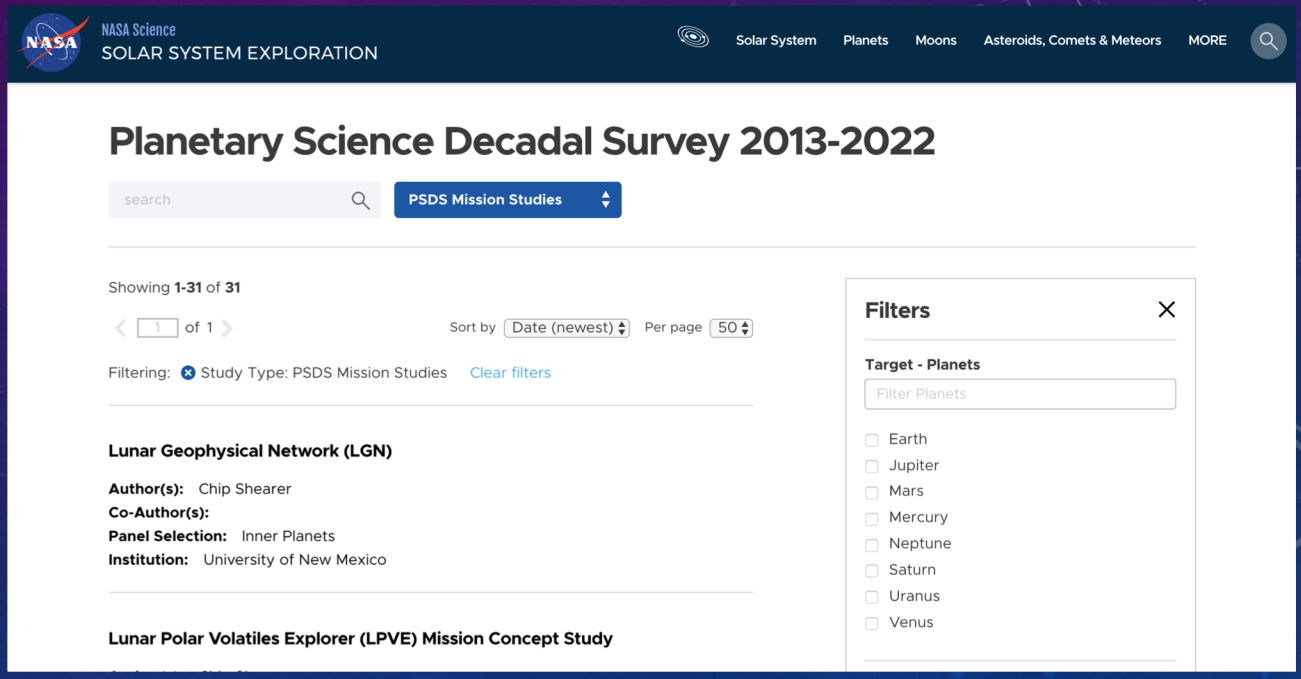
Nov/Dec 2019 - Input from community, refinement of STM

Early 2020 – Engineering Run I

March 2020 - Interim Report at LPSC

April 2020 – Engineering Run II

June 2020 – Final Report Due



Marty's 2018 VEXAG Rant: Overview/ Punchlines – we need a plan

- Status of Venus in last decadal –
  - assumed Disco was perfect for Venus
    - *Need to show everyone (NASA/public) that Venus is important*
  - NF carryover from previous decadal (along with SPA)
    - *Should we push (somehow) the idea to redefine the NF call?*
  - Last of the 5 flagships
    - *Can we promote the flagship to the top of the decadal?*

What do we want to do, should be do, can we do?

- Community white papers – flood the panel!
- Publish paper in a journal ala the ocean worlds roadmap
- Publish paper in EOS or other journal with greater reach

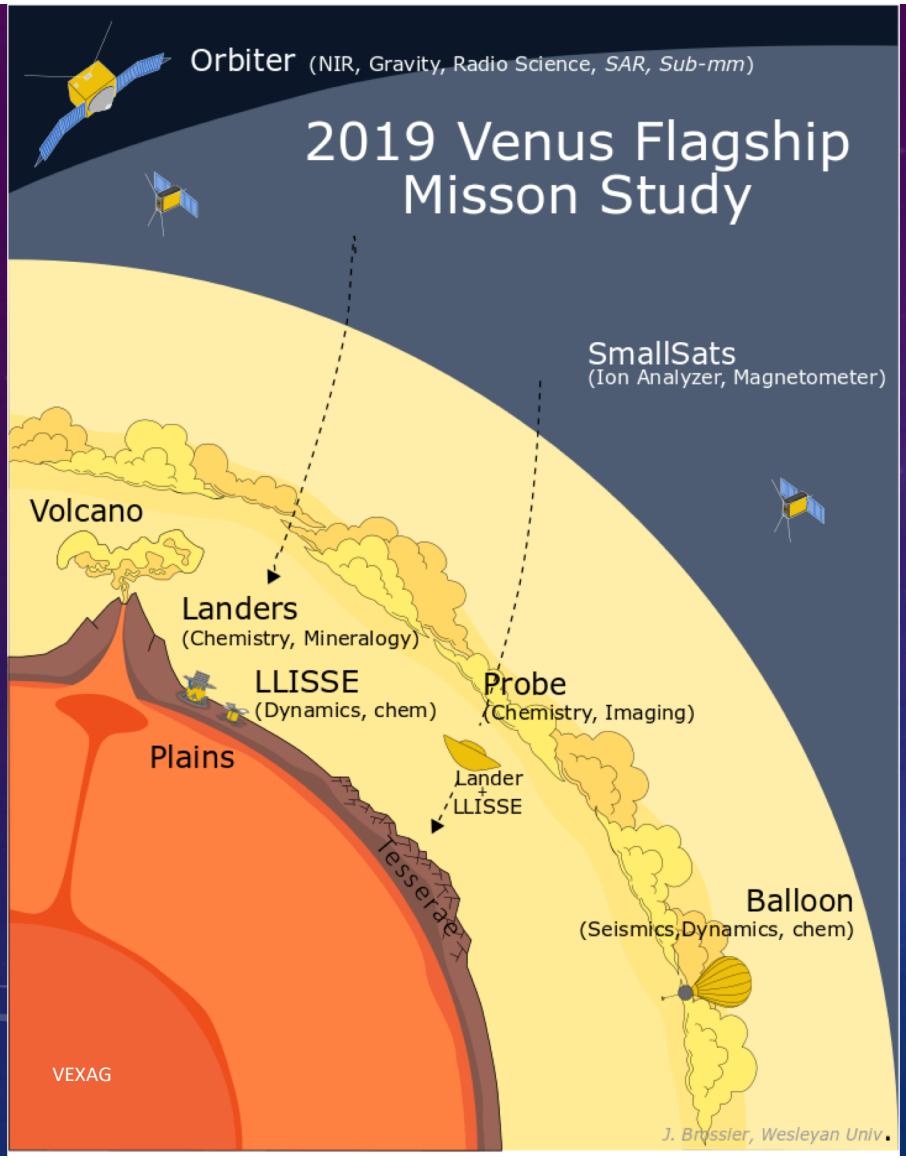
2013 Decadal White Papers n = 199

1. **Ariel D. Anbar**, Astrobiology Research Priorities for Mercury, Venus and the Moon
2. **Robert F. Arentz**, NEO Survey: An Efficient Search for Near-Earth Objects by an IR Observatory in a Venus like Orbit
3. **Kevin H. Baines**, Venus Atmospheric Explorer New Frontiers Concept
4. **Tibor Balint**, Technologies for Future Venus Exploration
5. **Mark A. Bullock**, The Venus Science and Technology Definition Team Flagship Mission Study
6. **Larry W. Esposito**, Mission Concept: Venus in Situ Explorer (VISE)
7. **James B. Garvin**, Venus: Constraining Crustal Evolution from Orbit via High-Resolution Geophysical and Geological Reconnaissance
8. **Sue Smrekar**, Venus Exploration Goals, Objectives, Investigations, and Priorities
9. **Allan H. Treiman**, Venus Geochemistry: Progress, Prospects, and Future Missions
10. **Ethiraj Venkatapathy**, Thermal Protection System Technologies for Enabling Future Venus Exploration

Who will write the white papers? Also solicit contributions from Astrobio and Exobio – set a schedule.

VENUS FLAGSHIP
A MISSION TO ASSESS THE HABITABILITY OF VENUS
GOALS

1. History of volatiles and liquid water on Venus and determine if Venus was habitable.
2. Composition and climatological history of the surface of Venus and the present-day couplings between the surface and atmosphere.
3. The geologic history of Venus and whether Venus is active today.



Launch ~2029-2032

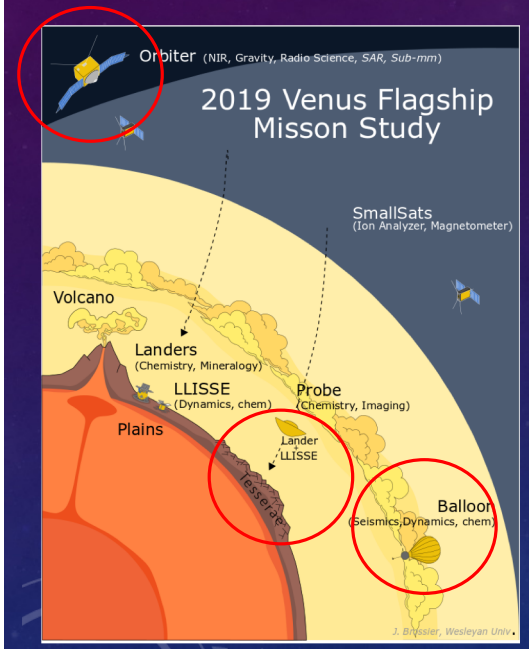
1 Orbiter
2 Orbiting SmallSats
2 Short-lived landers/Probes
1 Balloon
1 Long-lived lander (LLISSE)

Carry ESPA ring

Cost $2B

GOAL 1. UNDERSTAND THE HISTORY OF VOLATILES ON VENUS AND DETERMINE IF VENUS WAS HABITABLE.

<u>Objective 1.1:</u> Did Venus once have liquid water at the surface?



- ***<u>Investigation 1.1.A</u>*** *<u>- Measure the mineralogy and chemistry of the tesserae</u>*

  NIR on Orbiter/Descent | Mineralogy/Chem on Tessera Lander

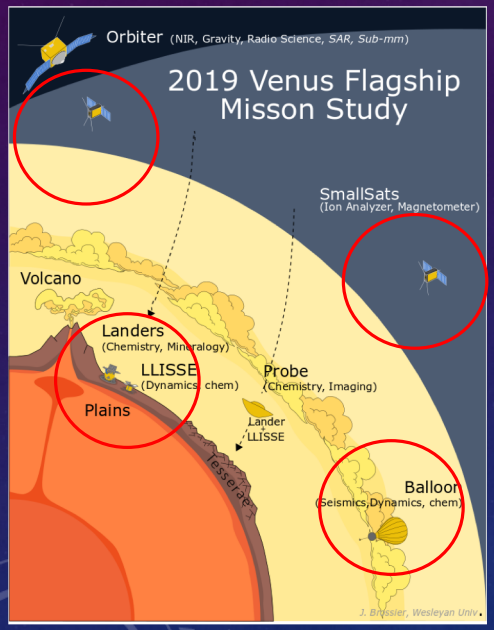
- ***<u>Investigation 1.1.B</u>*** *<u>- Look for evidence of fluvial morphologic surface features.</u>*

  SAR on Orbiter | Imaging on Descent and Lander

- ***<u>Investigation 1.1.C -</u>*** *<u>Measure the atmospheric D/H in a number of gas species below the cloud deck to the surface.</u>*

  Mass Spec on Descent and Balloon

GOAL 1. UNDERSTAND THE HISTORY OF VOLATILES ON VENUS AND DETERMINE IF VENUS WAS HABITABLE.



- ***Investigation 1.1.D*** *- Determine isotopic ratios and abundances of D/H, noble gases, oxygen, nitrogen, and other elements in the atmosphere of Venus.*

  Mass Spec/TLS on Descent and Balloon

- ***Investigation 1.1.E -*** *Determine atmospheric escape rates over a full solar cycle.*

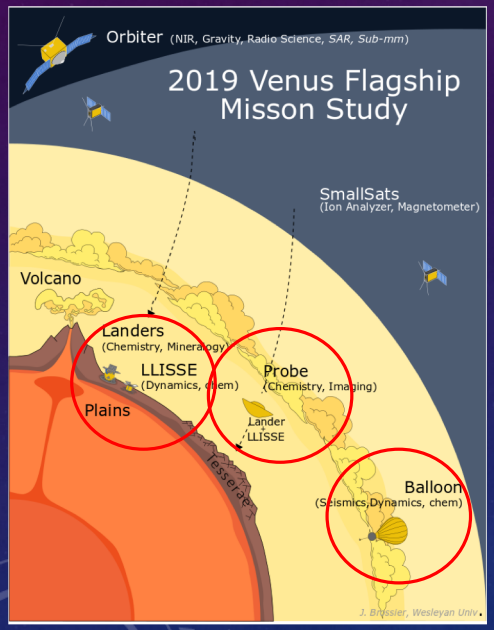
  Ion analyzer, magnetometer on multiple SmallSats

- ***Investigation 1.1.F -*** *Search for evidence of a past magnetic field.*

  Magnetometer on Balloon and Lander

GOAL 1. UNDERSTAND THE HISTORY OF VOLATILES ON VENUS AND DETERMINE IF VENUS WAS HABITABLE.

Objective 1.2: Where Is Venus' Water Today?



- ***Investigation 1.2.A*** *- Measure the volatile content, chemistry, mineralogy, and oxidation state of less weathered basalt.*

  Mineralogy/Chem on plains Lander

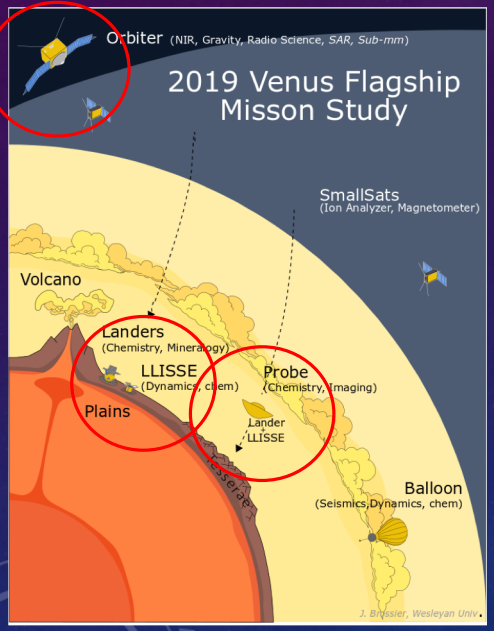
- ***Investigation 1.2.B*** *- Measure the composition and distribution of volatiles in the atmosphere.*

  Mass Spec/TLS on descent and balloon

- ***Investigation 1.2.C*** *- Characterize transport mechanisms from the solid surface to the upper atmosphere.*

  Balloon tracking | Wind sensor on LLISSE

GOAL 2. UNDERSTAND THE COMPOSITION AND CLIMATOLOGICAL HISTORY OF THE SURFACE OF VENUS AND THE PRESENT-DAY COUPLINGS BETWEEN THE SURFACE AND ATMOSPHERE.



VEXAG

<u>Objective 2.1:</u> What is the composition of the surface and what are the implications for past and present climate?

- ***<u>Investigation 2.1.A</u>*** *- <u>Measure global mineralogy to distinguish major rock types and place in geologic context.</u>*

  NIR on Orbiter/Descent | Mineralogy/Chem on Tessera Lander

- **<u>Investigation 2.1.B</u>** *- <u>Determine the oxidation state, chemistry and mineralogy of primary and secondary minerals in basaltic rock and tessera terrain.</u>*

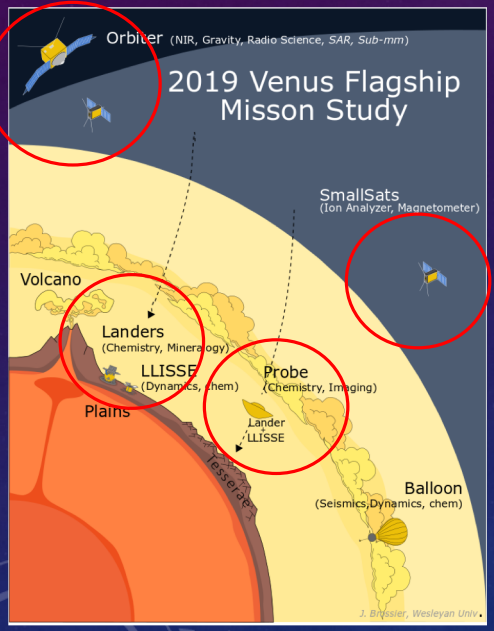
  NIR on Orbiter/Descent | Mineralogy/Chem on landers | Chemical sensors on LLISSE

- ***<u>Investigation 2.1.C</u>*** *- <u>Constrain the near surface atmosphere conditions to constrain surface-atmosphere exchange and buffering.</u>*

  T,P,x on descent and lander

GOAL 3. UNDERSTAND THE MECHANISMS OF GEOLOGIC ACTIVITY AND IF VENUS IS ACTIVE TODAY

<u>Objective 3.1</u>: Does Venus show evidence of a current or past plate tectonic regime?



- ***<u>Investigation 3.1.A</u>*** *- <u>Constrain the interior structure of the crust, mantle, and core.</u>*

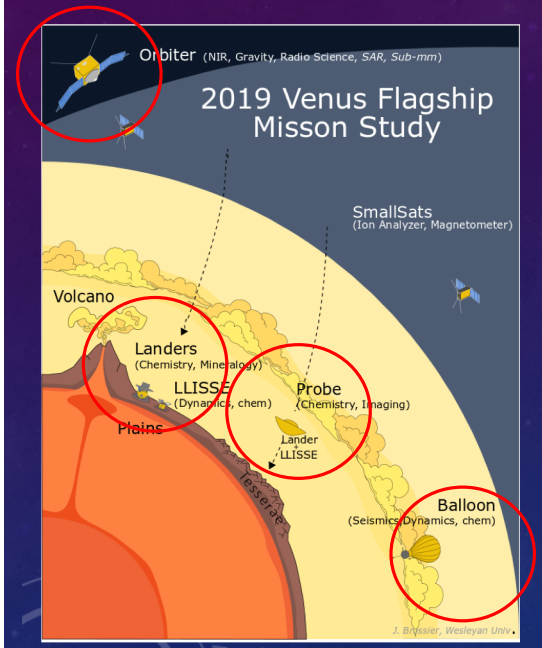
  Gravity tracking of Orbiter | Infrasound on Balloon | Magnetometer on Lander and multiple SmallSats

- ***<u>Investigation 3.1.B</u>*** *- <u>Characterize tectonic features & establish stratigraphic relationships</u>*

  SAR on Orbiter | Descent Imaging

GOAL 3. UNDERSTAND THE MECHANISMS OF GEOLOGIC ACTIVITY AND IF VENUS IS ACTIVE TODAY

Objective 3.2: How tectonically and volcanically active is Venus today?



- ***Investigation 3.2.A*** *- Look for present day seismicity.*

  Gravity tracking of orbiter | Infrasound on balloon

- ***Investigation 3.2.B*** *- Look for present day volcanism.*

  Infrasound on balloon | Mass spec on descent and balloon

- ***Investigation 3.2.C*** *- Determine the composition of non-H2SO4 particulates.*

  Mass spec on descent and balloon

SOME MAJOR EARLY TRADES

Trade	Consider…
Many general instrument trades e.g., How to measure ground motion	Seismometer on lander vs. airglow or infrasound (orbiter/balloon). VFM will consider with help from experts.
Lander sampling mechanism/instrumentation Instrument(s) determine if ingestion is necessary	Raman/LIBS/PIXL/XRD/SAM/NGRS/Mössbauer - TRL and risk
Direct Entry vs Deploy from Orbit	Landing site knowledge/risk
How to accommodate the selection of Venus missions prior to Flagship?	Discussions with proposed mission teams and community. Can we outline several scenarios in report.