VEIL: A New Frontiers Class Mission Concept for Exploring Venus

Kokorowski, M.,[1] (mkoko@u.washington.edu) Benson, J., [2] Desiano, S.,[3] Gifford, C., [4] Hannel, T.,[5] Huang, W.,[6] Johns, B.,[7] Lichtenberg, K.,[8] Macke, R.,[9] Minelli, G.,[10] Neish, C.,[11] Poppe, A.,[12] Schmidt, B.,[13] Taniguchi, S.,[14] Thompson, D.,[3] Balint, T.,[15]

1.*Department of Earth and Space Science, University of Washington, Seattle, WA, USA* ***2.****Department of Physics and Astronomy, University of Toledo, Toledo, OH, USA* ***3.****Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, USA* ***4.****Department of Electrical Engineering and Computer Science, University of Kansas, Lawrence, KS, USA* ***5.****Department of Chemistry, University of Kentucky, Lexington, KY, USA* ***6.****Department of Aerospace Engineering, University of Michigan, Ann Arbor, MI, USA* ***7.****School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA, USA* ***8.****Department of Earth and Planetary Sciences, Washington University in St. Louis, St. Louis, MO, USA* ***9.****Department of Physics, University of Central Florida, Tampa, FL, USA* ***10.****Robotics Systems Lab, Santa Clara University, Campbell, CA, USA* ***11.****Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA* ***12.****Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA* ***13.****Department of Earth and Space Sciences, UCLA, Los Angeles, CA, USA* ***14.****Atmospheric, Oceanic and Space Sciences Engineering, University of Michigan, Ann Arbor, MI, USA* ***15.****Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA*

NASA Planetary Science Summer School at JPL

"The student teams carry out the equivalent of a mission concept study responsive to a typical NASA Science Mission Directorate Announcement of Opportunity, prepare a presentation for a proposal authorization review, present it to a review board and receive feedback."

- Assigned Venus in-situ mission
- Team determined primary science goals and preliminary mission architecture before arrival at JPL
- One week at JPL spent shadowing Team X members and finalizing mission architecture

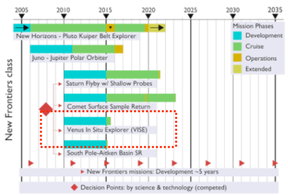
Science Motivation and Objectives

A New Frontiers AO is expected in 2008. Our VEIL concepts target this opportunity.

Main Science Objective: Investigate Venus to understand its current state and the conditions that gave rise to its extreme environment.

Connection to NASA SSE Roadmap:

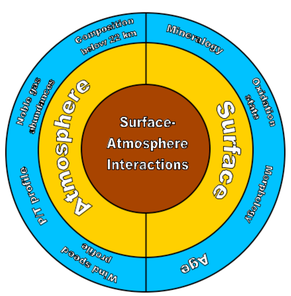
- Understanding solar system diversity
- Understanding habitable regions around other stars
- Understanding the future of Earth



Timeline for New Frontiers Announcement of Opportunity (NASA 2006 SSE Roadmap).

Specific Science Objectives:

1. Characterize the nature of weathering and surface-atmosphere exchange on Venus
2. Characterize the lower Venusian Atmosphere
3. Determine the present surface conditions on Venus
4. Look for evidence of Volcanism on Venus
5. Investigate the dynamics of the upper atmosphere
6. Search for lightning signatures
7. Investigate the space environment around Venus



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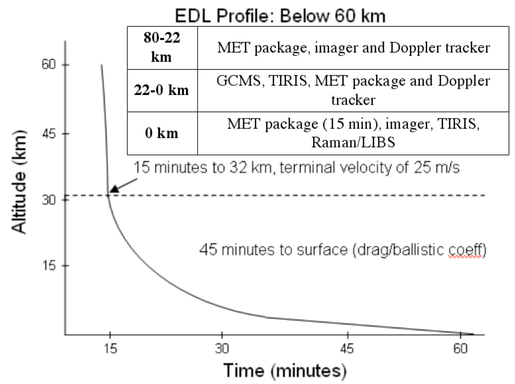
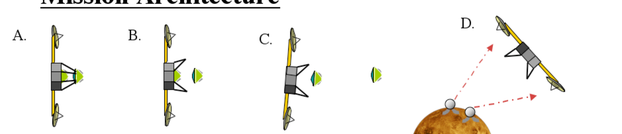
Instrumentation

Instrument	Science Requirement	Heritage	Sample Rate	Total Samples	Total Data Volume
Visible Imager	Image surface features	Based on MER cameras (Navcam)	Variable; 2 sec., 5 sec., 2 min.	536	113.2 Mbits
Meteorological Package	Determine wind speeds, T/P profile of atmosphere	Based on MSL MET package (temp. and press. only)	Every 5 sec.	420	0.013 Mbits
Gas Chromatograph-Mass Spectrometer (GCMS)	Determine composition of lower atmosphere	Based on Pioneer Venus design (optimized for lower alt. study)	Every 20 sec.	120	1.92 Mbits
Thermal Infrared Imaging Spectrometer (TIRIS)	Determine mineral composition and thermal properties of surface	Based on mini-TES design		33	163.8 Mbits
Raman/Laser-Induced Breakdown Spectrometer (LIBS)	Determine mineral and elemental composition of surface	Will fly on MSL; further lab work needed for Venus application		50	1.6 Mbits



Mission Architecture



A. Carrier craft and two surface lander probes on 172 day cruise to Venus

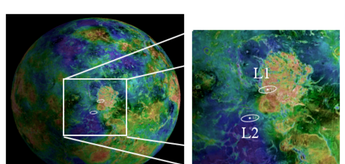
B/C/D. Probes separate at T-5 and T-4.5 days until encounter on 11/08/2015 where they land on the dayside within 1000km of each other

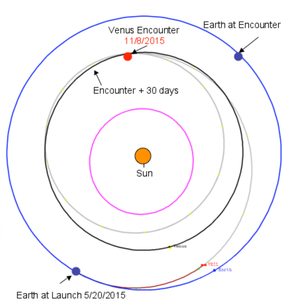
E. Data telemetered to Earth over a 30-day span from the carrier

Landing Sites:

L1 - Alpha Rigio: Tessera.
May represent older crustal material

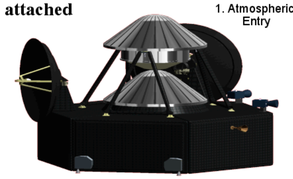
L2 - Lavinia Planitia: Lowland
Opportunity to explore extreme lower atmosphere (altitude < 0.7 km)

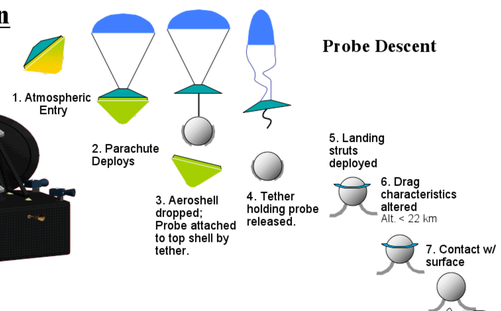




Spacecraft Design

Carrier spacecraft with two probes attached





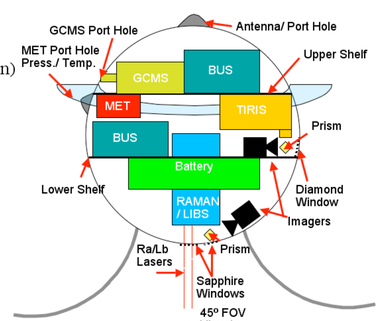
Carrier Subsystems:

- Attitude Control (3-axis stabilized)
- Power (2m² solar array)
- Propulsion (dv, pitch, yaw, roll)
- Thermal (temp. sensors, heaters, insulation)
- Command and Data (1 GB storage)
- Telecom (to and from earth, from probe)

Probe Subsystems:

- Power (344 W-hr battery)
- Thermal (phase change material; multi-layer insulation; Xe cover gas at 1atm)
- Command and Data (single string, redundancy through two probes)

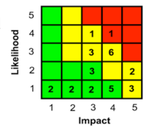
- Abrasion drill and probe rocker for spectroscopy and imaging below surface.



Programmatics

Risk Assessment:

- Only one major risk Although Russian spacecraft have survived more than 1 hour on Venusian surface, VEIL would be first US mission to accomplish this feat.



Projected Cost:

Item	Cost (M$, FY07)
Carrier	158.1
Probe (2)	197.8
Misc. (launch vehicle, reserves, etc.)	420.0
Total	775.9

Mass and Power Allocation:

- The Atlas V vehicle can propel 2900kg to Venus for a C3 of 7.9 km²/s².
- Probes have a 344 W-hr primary battery
- Carrier has 2 m² solar array (~700W)

Subsystem	Carrier Mass	Probe Mass (ea)	Carrier Power	Probe Power
Instruments	0.0 kg	20.6 kg	0 W	35 W
ACS	9.1 kg	0.2 kg	22 W	2 W
CDS	7.4 kg	7.2 kg	35 W	35 W
Power	41.1 kg	6.4 kg	12 W	12 W
Propulsion	18.4 kg	0.0 kg	39 W	0 W
Structures	199.0 kg	117.3 kg	0 W	0 W
Telecom	28.7 kg	3.3 kg	70 W	65 W
Thermal	13.7 kg	32.7 kg	49 W	0 W
Total	324.8 kg	187.7 kg	227 W	149 W
Total + Contingency (~ %30)	413.0 kg	240.7 kg	387 W	209 W

Education and Public Outreach

- Contests to name the probes and carrier vehicle
- Real-time downlink of descent imagery
- Classroom activities:
  - Interpretation of "Venus-like" images of Earth
  - Pressure cooker experiments to simulate the Venus environment

Conclusions

- Venus is ripe for scientific exploration with many important, unanswered questions with a wide range of implications.
- Surface science is very difficult in the extreme Venusian environment, but is possible on a New Frontiers budget.
- A VEIL-type mission may prove an invaluable step for a future Flagship mission to Venus.