

Report on the First Community Meeting of VEXAG

Held on Friday, 4 November 2005 at the Sheraton Hotel, Pasadena

Prepared by

Sushil Atreya and Janet Luhmann, Co-Chairs

VEXAG background and history

In July 2005, Dr. Andrew Dantzler, Director of NASA's Solar System Exploration Division, in consultation with Dr. Steve R. Saunders, appointed Sushil Atreya of the University of Michigan, Ann Arbor and Dr. Janet Luhmann of the University of California, Berkeley as Co-Chairs of the newly formed Venus Exploration Analysis Group (VEXAG). The principal charge of VEXAG is to reassess the current state of Venus science, and identify (a) outstanding science questions, (b) spacecraft missions for achieving them, and (c) enabling technology. The VEXAG Charter is contained in *Appendix A*, and additional information may be found on the VEXAG website: <http://www.lpi.usra.edu/vexag/vexag.html>

To achieve above objectives, the VEXAG Steering Group, comprising the above Co-Chairs, Drs. Steve Saunders and Adriana Ocampo (NASA Hq), Dr. Steve Mackwell (LPI), and Drs. Thomas Thompson and Kevin Baines (JPL) began preparations for a community-wide kick-off meeting of VEXAG. Three preparatory coordination telecons were held on July 28, September 15, and October 11, 2005. Other telecons between a subset of the Steering Group were held in the interim. It was decided that all VEXAG meetings will be open-forum, i.e. they will be open to all interested scientists, media, and the public. Two Focus Groups on (a) Atmospheric Evolution and (b) Surface and Interior Evolution, were formed, with Dr. Baines and Mackwell, respectively, as FG leaders. The FG's were formed to provide some structure to the activities at VEXAG meetings. Neither the number nor the membership of the FG's was preordained, although some key members of the Venus science community were contacted to encourage their participation. Each FG currently has more than one dozen active members who signed up previously or at the November 4 meeting.

VEXAG Community Meeting on 4 November 2005

The first community meeting of VEXAG was held at the Sheraton Hotel in Pasadena on 4 November 2005. Local arrangements and support were expertly provided by Tommy Thompson, Andrew Morrison and Debbie Calderon of JPL. The Meeting Agenda is contained in *Appendix B*. Since July 2005, over one hundred and fifty people world-wide had registered at the VEXAG website indicating their interest in the VEXAG. Prior to the meeting on 4 November 2005, sixty five people had registered at the VEXAG website to participate in the meeting. The actual attendance in the meeting topped 90! Although most of the participants were from the United States, a sizeable number represented the international Venus community, notably from Japan and Europe.

Presence of the members of the press, including Emily Lakdawalla from the Planetary Society was also noted. The gathering signified a historic event, marking a rejuvenation of interest in and thrust for the exploration Venus by the United States after a long hiatus. The highlights of the meeting were: View from NASA Headquarters, presentations on Venus exploration by spacecraft already approved or launched (Venus Express, Venus Climate Orbiter, and Messenger), the Solar System Exploration Roadmap, Focus Group presentations, and Open-Mike presentations. Relevant material presented at the meeting has been posted on the VEXAG website: <http://www.lpi.usra.edu/vexag/vexag.html>

Dr. Steve Saunders presented the view from the NASA Headquarters, reiterated the charge to VEXAG as outlined in the VEXAG Charter, and stressed the importance of identifying "enabling technology" needs on a relatively short time scale of approximately one month. This urgency was triggered by the fact that NASA had set aside \$10 Million for "Technology", and some of the technology needs identified by VEXAG goals could be furthered with a portion of this fund. This was taken as an action item.

Dr. Gerhard Schwehm gave an overview of ESA's Venus Express (VEX) mission. The investigations focus on atmospheric composition and dynamics, using infrared spectroscopy at a relatively high spectral resolution (PFS), high spatial resolution (VIRTIS), UV stellar occultations (SPICAV), and a Camera in the visible, on magnetic field and particle measurements (ASPERA-4), and radio observations including bistatic radar (VeRa). He noted the Venus Express mission includes a significant contribution of scientific talent from the United States, due the participation of ten NASA-ESA selected US Participating Scientists who are also CoI's on various VEX investigations (list in *Appendix C*). Gerhard Schwehm noted that ESA intends to make the VEX data available to the planetary community through the planetary data archiving facility in Europe and its mirror site, PDS, in the US. [During the week following the VEXAG meeting, on November 9, 2005, the Venus Express spacecraft was launched successfully from Baikonur, using the Soyuz-Fregat rocket. The systems and instruments on-board have been checked out in-flight. The mission is operating nominally. Insertion into a polar orbit is planned for the morning of 11 April, 2006 (CET), with the prime mission lasting for approximately two Venusian days (~500 Earth days).]

Dr. Takeshi Nakamura described JAXA's plans for a PLANET-C mission called Venus Climate Orbiter (VCO). The spacecraft is scheduled for June 2010 launch, with arrival at Venus in December 2010. The various cameras on-board VCO cover a wide range from the ultraviolet to long wavelength infrared. The primary goal is to understand the meteorology, atmospheric dynamics and the climate of Mars. The mission goals will thus be complementary to the Venus Express mission goals.

Dr. Noam Izenberg described how the instruments on board the Messenger spacecraft will be turned on to observe Venus during two gravity assist swingbys of the planet in 2006 and 2007. The 2006 flyby will be used primarily for calibration purposes, whereas the 2007 flyby at 300 km distance holds promise for some good atmospheric remote sensing data. The payload on Messenger is optimized for measurements at

Mercury. Dr. Izenberg, who made the presentation on behalf of the Messenger team, will be the Messenger point of contact for VEXAG.

Dr. James Cutts reviewed the work done by NASA's Strategic Roadmap team for solar system exploration, and asked for VEXAG's guidance on future NASA Flagship mission concepts for Venus that were identified by this team. In addition to setting science priorities, technology readiness would be a major goal of this activity. It was noted that the New Frontiers mission line lists a Venus surface mission as one of its short list of desired targets as well. The consideration of future Venus missions was taken on as an action item by the two Focus Groups. Jim Cutts and Steve Saunders also asked that a special Technology Development focus group of VEXAG be created. In a closing discussion it came to our attention that the availability of suitable environmental simulation chambers for technology development should be considered as a part of technology development needs.

The Open-Mike presentations were a very important part of the VEXAG meeting, as it gave everyone an opportunity to present their ideas, thus engaging a wider community. Nine presentations were made, ranging from new technologies to astrobiology at Venus to EPO activities underway relevant to Venus exploration, etc. Since the next VEXAG meeting is planned for two days, it is our intent to expand the time for Open-Mike presentations in the future.

The Focus Group Leads, Dr. Kevin Baines and Dr. Steve Mackwell, held break-out sessions for general discussion of the scientific priorities and enabling technologies in the areas of atmospheric evolution studies and surface and interior evolution studies, respectively. No attempt was made to define a mission concept, as it was considered premature and perhaps better left to mission definition teams or NASA roadmapping panels. The assembled community participated actively in the break-out sessions. It was commonly agreed that the NRC Decadal Report was an excellent resource that could be adopted by VEXAG as their baseline statement of Venus science goals, with possible modifications considered by VEXAG in future meetings. The Focus Groups spent considerable effort on identifying priorities for technology development, in order to produce a White Paper that was requested by Dr. Saunders. A copy of the resulting technology needs document is appended to the report in *Appendix D*.

Dr. Larry Esposito reported on the rapid progress made toward a Chapman Conference on all aspects of Venus science, in particular focusing on outstanding questions for future research and exploration. The Chapman Conference is considered by NASA as one of the main activities that will benefit VEXAG. Larry was asked to keep the VEXAG Steering Committee posted on the status of the talks and arrangements. The VEXAG website gives a link to the Conference.

Rosalyn A. Pertzborn provided a report on Education and Public Outreach, noting that she has plans to form partnership with ESA's Education and Public Outreach program for Venus Express.

Finally, it was announced that the next VEXAG community meeting was tentatively scheduled to be held over two days on March 23 and 24, 2006 in the Washington DC area. These dates were chosen to avoid conflicts with other major national and international meetings, Venus Express critical events, and availability of VEXAG Steering Committee.

The meeting was adjourned at 4 pm, after wrap-up and closing remarks by the VEXAG Co-Chairs, Sushil Atreya and Janet Luhmann.

Status of Action Items, following the November 4th meeting of VEXAG

1. Technology White Paper: Several telecons of the VEXAG Steering Committee and some technologists were held following the meeting. Sushil Atreya advised the group to also think about multiple uses of the technology, as much as possible. Jim Robinson (NASA HQ) stressed to the OPAG (Outer Planets Assessment Group) that technology developments for the outer planet exploration would be far more appealing and attractive to fund if they had uses at other planets. An example is operation in and communication from extreme environments, that has applications to both outer planet probes and probes at Venus. Two separate White Papers were prepared by the two VEXAG FG's. They were combined into a single White Paper, considering the large overlap between the two. In November, 2005, a White Paper on the High-Priority Technology Development Requirements was delivered to Dr. Steve Saunders, and is reproduced in *Appendix C*.

2. Subgroup on Technology: The Focus Groups identified members of the Venus community to serve on the Technology Subgroup that Jim Cutts had asked for in his presentation. Jim also asked Sushil Atreya to be part of this group. Sushil has agreed to serve in ex-officio capacity.

3. Chapman Conference: Larry Esposito reports that the planetary community has shown an overwhelming interest in the Chapman Conference on Venus. The announcement of the conference (flyer in *Appendix E*) appeared in EOS, DPS News, and other outlets worldwide. Judging from the number of abstracts received and the list of invited talks, the conference is expected to be a major event for the future of Venus exploration. Larry Esposito will prepare a report on the conference in time for delivery at the next VEXAG meeting.

APPENDIX A

VEXAG Charter

The Venus Exploration Analysis Group is NASA's community-based forum designed to provide scientific input and technology development plans for planning and prioritizing the exploration of Venus over the next several decades, including a Venus surface sample return. VEXAG is chartered by NASA's Solar System Exploration Division and reports its findings to NASA. Open to all interested scientists, VEXAG regularly evaluates Venus exploration goals, scientific objectives, investigations and critical measurement requirements, including especially recommendations in the NRC Decadal Survey and the Solar System Exploration Strategic Roadmap.

APPENDIX B

Agenda for the First Community Meeting of VEXAG
Friday, 4 November 2005, Sheraton Hotel, Pasadena

- 8:00 a.m. - Sign-In / Pick-up Handouts / Coffee and Pastries
- 8:30 a.m. - VEXAG Introduction – Overview and Expectations - Steve Saunders
- 8:45 a.m. - VEXAG Meeting Goals - Sushil Atreya and Janet Luhmann
- 9:00 a.m. - Current Missions: ESA's Venus Express Overview - Gerhard Schwehm
- 9:20 a.m. - Current Missions: JAXA's Venus Climate Orbiter Overview
- Masato Nakamura and Takeshi Imamura
- 9:40 a.m. - Messenger at Venus - Noam Izenberg
- 9:50 a.m. - Future NASA Venus Exploration Opportunities - Jim Cutts
- 10:10 a.m. - Coffee Break
- 10:30 a.m. - Atmospheric Evolution Focus Group - Kevin Baines
- 10:50 a.m. - Planetary Formation and Evolution Focus Group - Steve Mackwell
- 11:10 a.m. - Open Mike Presentations (1-slide, up to a max of 8 mins)
- Please give Power-point slides in advance to the projectionist
on a memory stick during the 10:00 AM Coffee Break.
- 12:30 p.m. – Lunch - Focus Group Splinter Sessions
- 2:40 p.m. - Splinter Session Report – Atmospheric Evolution Focus Group - Kevin Baines
- 2:50 p.m. - Splinter Session Report – Planetary Formation and Evolution Focus Group
- Steve Mackwell
- 3:00 p.m. - Chapman Conference - Larry Esposito
- 3:15 p.m. - Education and Public Outreach - Rosalyn Pertzborn
- 3:30 p.m. - Wrap-up – Next Meeting – Recommendations – Action Items
- Sushil Atreya and Janet Luhmann
- 4:00 p.m. - Adjourn

APPENDIX C

**US Participating Scientists (also selected as US Co-I's) on
ESA's Venus Express Mission**

Acton	Charles	Jet Propulsion Laboratory	SPICE for Venus Express
Atreya	Sushil	University of Michigan Ann Arbor	Coupled dynamics and chemistry
Baines	Kevin	Jet Propulsion Laboratory	To The Depths of Venus with Venus Express
Brandt	Pontus	The Johns Hopkins University APL	ASPERA-4 investigation
Crisp	David	Jet Propulsion Laboratory	To The Depths of Venus with Venus Express
Limaye	Sanjay	University of Wisconsin Madison	Exploration of dynamics and chemistry
Luhmann	Janet	University of California Berkeley	Building on PVO
Russell	Chris	University of California Los Angeles	Venus Express Participating Scientist
Stern	Alan	Southwest Research Institute	Venus Express Participating Scientist Program
Tyler	Len	Stanford University	Radio Science

APPENDIX D

VEXAG Report on High-Priority Technology Development Requirements

Stephen Mackwell, *Chair, Planetary Formation and Evolution Focus Group*

Kevin Baines, *Chair, Atmospheric Evolution Focus Group*

The Venus Exploration Analysis Group held its first public meeting in Pasadena, CA, on November 4, 2005. Together with a broad representation from the Venus science and technology community, the Planetary Formation and Evolution Focus Group and the Atmospheric Evolution Focus Group discussed the status of understanding of the current and past history of the atmosphere, surface and interior of Venus, identifying critical areas in need of further investigation through future robotic missions. In the process of discussing these data needs, we identified key technologies that need to be developed in order to make these measurements. While several potential missions would involve remote sensing from orbit, many important measurements require surface or near surface components that must survive temperatures in the range of 350 to 470°C, transient exposure to corrosive environments in the atmosphere during entry, and static pressures up to around 90 bars for periods of ~1 day to as much as a year. In contrast, prior missions to the surface have only survived several hours. In addition, several key measurement technologies (instruments) must be developed in the near-term that are specific to the Venus environment.

The consensus of the discussion groups was that priority be given for the development of the following technologies for exploration of Venus. This list is not meant to provide any prioritization for mission planning, as there are a number of potential priority missions to study Venus that do not require significant technological development but build on existing capability.

An important aspect of the enabling technologies identified for Venus exploration here is that they have applications to the exploration of other solar system bodies. For example, technology challenges of the operation in and communication from the extreme high-temperature and high-pressure environments at or near the surface of Venus are similar to those for deep entry probes at the outer gas-giant planets. Communications microsattellites are equally useful for multiple planetary missions, and in-situ instrumentation (such as chemical analysis tools, and seismometers) may also be useful for other terrestrial planets or icy satellites.

Specific high-priority technologies for "short-duration (hours to days)" <http://www.lpi.usra.edu/vexag/vexag.html> missions to Venus:

- Development of passive cooling systems to enable survival of communications systems and instruments for measuring chemical, thermal, mechanical and physical (including seismic) properties at external temperatures of 470°C and pressures of 90 bars for periods of at least 1 Earth day.

- Development of high-temperature electronics for instruments and communication systems that will survive temperatures of up to 470°C for both short- and long-duration missions, so that cooling systems are not required for sustained surface lifetimes. Electronic systems with lower temperature tolerances are still desirable for passively cooled, short-duration missions, or for high-altitude missions (potentially 350 – 400°C).
- Development of balloons with mobility in both the vertical and horizontal directions. In the vertical, this should include a means to ascend and descend from near the surface to ~ 50 km altitude repeatedly during a week-long mission. Survival of the mission hardware (balloon, gondola, instruments, etc) in corrosive environments (H₂SO₄, HF, HCl, etc.) at warm and hot temperatures (e.g., from 100 to 470°C), and with rapid excursions in temperature (several hundred degrees over periods of several hours).
 - Development of precision landing capability, as many scientifically interesting sites for landers have relatively modest landing ellipses.
 - Development of autonomous hazard avoidance systems to reduce risk for safely landing spacecraft.
 - Development of communications systems to handle large data volumes (requiring potentially expanded capability in Earth-based receivers), multiple in-situ surface or floating platforms, and/or non-ideal landing sites (requiring low-power, light-weight orbiting communication microsattellites).
 - For measurements of the chemical composition of rocks at a landing site, technology requirements include high-temperature extraction (potentially including drilling) and handling capability.

Specific high-priority technologies for *long-duration* (months to years) missions to Venus:

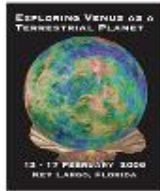
- Development of active cooling systems able to enable survival of scientific instruments and communication systems at external temperatures of 470°C and pressures of 90 bars for periods of at least 1 Earth year. Somewhat lower temperature requirements of around 350 - 400°C would be required for high-altitude missions.
 - Development of high-temperature power systems capable of providing power for instruments and communications with reduced requirements for active cooling systems.
 - Development of long-lived balloons capable of operating within the cloud layer and below the cloud deck for a combination of atmospheric measurements and observations/measurements of the surface (notably at frequencies not available to orbiting spacecraft). Tolerance to high temperatures at lower elevations and potentially corrosive environments (within the clouds and near the cloud deck).
 - Development of seismometers capable of operation under Venus surface conditions, with suitable communications systems. Sensitivity requirements are probably similar to Earth systems. Seismometers must be able to be suitably coupled physically to the solid planetary surface and must have a low aerodynamic profile in order to minimize wind-induced noise. Communications systems must be able to deal with relatively high data transfer rates; some rapid triggering of the data recording system at pre-defined levels of ground motion would be necessary.

- Development of heat flow measurement capability for the Venus near surface, perhaps requiring emplacement of thermal sensors after drilling into the near surface below a lander. Requirements would include suitable drilling technologies (may also be used for sample extraction for in situ measurements of chemistry) and potentially high-temperature electronic systems.

The order of these items loosely reflects priority for development of flight hardware, although the development of individual instruments may require significant time (but is also dependent on the items nearer the top of the list), so will need synchronous and coordinated development.

APPENDIX E

Second Announcement



CHAPMAN CONFERENCE
EXPLORING VENUS AS A TERRESTRIAL PLANET
13–17 FEBRUARY 2006
KEY LARGO, FLORIDA

This Chapman Conference will review the current knowledge of Venus including surface and interior processes, atmospheric circulation, chemistry, and aeronomy; and compare the evolution of Venus with that of Earth and Mars. It will preview observation plans and results expected from Venus Express and identify objectives for future research and missions. (See the conference home page below for more detailed information.) Young scientists and graduate students are strongly encouraged to participate.

Papers of exceptionally high quality are solicited for submission as an AGU Monograph or a special issue in an AGU journal pending approval of the AGU Publications program.

The conference will run Monday-Thursday and include morning and afternoon sessions of invited talks and tutorials, from 15–45 minutes each—tentative program below. The late afternoons will consist of poster sessions on first three days, and a general discussion the last day. There will be a banquet on Tuesday night. Other evenings, and long lunch breaks, will be free for informal meetings and recreation. The program committee will stay an extra half-day on Friday to write a summary report.

This Chapman conference is sponsored by NASA's Jet Propulsion Laboratory, the European Space Agency and the University of Colorado

CONFERENCE HOME PAGE: <http://www.agu.org/meetings/cc06bcall.html>

LOCATION: Sheraton Beach Resort Key Largo in Key Largo, FL
<http://www.keylargoeresort.com>
+1 888-627-8545
\$179.00 per night, for single or double occupancy. (This rate will only be available until 12 January 2006)

REGISTRATION: Information will be posted on the conference home page after 15, November when abstracts are counted.
(*Conference fee estimate, for planning purposes only, should be between \$300-\$400.*)