Report of Oxford Venus Entry Probe (VEP) meeting 25 January 2007
Prepared by Colin Wilson

Presentations

After an introductory presentation by Eric Chassefière, Jacques Blamont gave a presentation about different balloon concepts for exploration of Venus. These included a 40-60 km oscillating balloon – the oscillation occurs due to the phase change of a NH_3/H_2O mixture – and a low altitude metal-skinned balloon. Also introduced was the idea of passive metal balloons in the lower atmosphere, which would then be tracked by radar from an orbiter.

Following this there were presentations from T. Imamura, Masato Nakamura, and Tetsuya Yamada (ISAS/JAXA) about the status of the Japanese low-altitude balloon mission. This is now well-developed, and testing is underway of various components of the mission. They appear to be aiming for a launch as a stand-alone mission sometime in the 2013-2020 timeframe.

Russia was well-represented as well, with presentations from Nikolai Sanko (Roskosmos), Victor Vorontsov (Lavochkin association), and L. Zelenyi/O. Korablev/L.Zasova (IKI). They report that the Russian space program is back in business, having had their proposed plan for 2007-2010 approved by the Russian government. Key planetary missions in the program include Phobos sample return (launch 2009) and Luna-glob; the next mission in the roadmap is Venera-D, proposed for launch in 2016. Venera-D would consist of and orbiter, several balloons, and a probe/lander with an entry mass of 1100kg and a lifetime on the surface of >1 hour. A warm invitation was extended to the European planetary science community to participate in the Russian program in general, and in the Venera-D mission in particular.

Tibor Balint (JPL) reported from the latest VEXAG meeting in the Washington DC, which drew over 100 attendees, and on NASA's 2006 Solar System Exploration roadmap. Upcoming opportunities to propose Venus missions to NASA include: an AO for a New Frontiers mission (<$750m) is expected in 2008, for a 2015 launch – this might turn out to be a Venus In Situ Explorer. A flagship mission (<$3 bn), Venus Mobile Explorer, is recommended in the roadmap for a 2025 launch.

All international partners showed a strong interest in the formation of an International Venus Exploration Working Group, to coordinate the Venus exploration plans of different agencies. A US instrument could be contributed to the VEP mission under NASA's Mission of Opportunity scheme, as long as the cost per instrument is <$35m.

Payloads & mission configuration

Over the past six months, strawman payloads for the orbiter, balloon, and descent probes have been defined by Csaba Ferencz, Colin Wilson, and Olivier Witasse respectively. Their presentations are available on the VEP website.

Additional presentations were made by Simeon Barber (Open University) on mass spectrometers for balloons and small probes; and by Alton Horsfall (Newcastle University) on SiC-based gas sensors for operation in high temperatures.

Johannes Leitner gave a report from the meeting held in Vienna, 14-15 Nov, at which potential landing sites for VEP were discussed. Of particular interest are the tessera regions, which may be the oldest terrain on the planet.

Finally, Joel Michaud (CNES) presented mission scenario calculated at CNES for different combinations of planetary orbiter, elliptical orbiter, atmospheric sample return etc.

Discussion of mission scenario

The most important objective of the Oxford meeting was to decide on a single mission scenario which would fit within the constraints of an ESA-only mission, on which to base the Cosmic Vision VEP proposal.

It was decided that the **core platform of the mission will be a cloud-altitude balloon**. The baseline mission scenario should **include two identical such balloons**, each deployed from its own entry vehicle, which would be inserted at different latitudes (e.g. 25°N and 60°N).

As to the rest of the mission architecture: the maximum possible data rate from a balloon-direct-to-Earth transmission is to be studied (J. Michaud, CNES), and compared to the minimum possible data rate which would satisfy the science goals (C.Wilson, Oxford – current estimate is between 200 – 500 bps). Pending the results of these studies, though, **it is felt that an orbiter is necessary, both to guarantee a sufficiently high data rate from the balloon and as a platform for remote sensing measurements.**

Reasons for the decision to focus only on balloons in the VEP baseline:

- The development of two different platforms (for example, Descent probe & high balloon) is considered too ambitious for the level of funding available. Therefore we should focus on one platform. However, the inclusion of two identical balloons will allow for redundancy, as well as greater spatial coverage.
- Between Descent Probes and balloons: Balloons offer a stable, long-lived platform around from which to make measurements. Also, descent probes would require extensive high-temperature component development, of which there is currently little work in Europe, so it would prove expensive.
- This fits in with Russian and Japanese Venus exploration plans. The Russian Venera-D lander will be a very capable platform for surface science (entry mass 1100 kg, lifetime on surface > 1hour); rather than focus Europe's resources on its own small VEP probe/lander, we should participate in the Russian Venera-D lander program. Meanwhile, JAXA is proposing a low-altitude balloon mission focusing on the dynamics of the low atmosphere of Venus; this is complementary to the focus on the cloud-altitude atmosphere proposed by the VEP mission.

- The balloon is the ideal platform for high-precision isotopic ratio measurements, for which a long-life platform with reasonable temperature stability is needed.

Having decided that the mission should be based around the core platform of a cloud-altitude balloon, the primary science goals clearly become (in equal priority):

1 – Planetary Evolution
Key Measurement: Isotopic ratio of atmospheric gases including noble gases
Key Measurement: Escape processes (measured from orbiter)

2 – Chemistry of atmosphere at 40-60 km, especially cloud processes.
Key Measurement: GCMS for composition measurements, with dedicated aerosol sampling inlet (like Huygens Aerosol Collector / Pyrolyser instrument)

3 – Dynamics, structure & radiative balance
Key Measurement: tracking of balloon (VLBI, inertial sensors)
Key Measurement: pressure, temperature, solar & IR fluxes
Key measurement: Determination of cloud optical & microphysical properties (size distribution & scattering properties)

Other science goals being addressed include:

4 – Surface Characterisation
Key measurement: subsurface radar mapping from orbiter
Key measurement: multispectral imaging of surface from small (~1 kg) probe deployed from balloon (feasibility to be confirmed)

5 – Electrical properties & EM wave characterisation
Key measurement: EM wave monitoring, electrical properties, lightning search

The balloon type was previously based on that used in the ESA VEP TRS study, i.e. a helium-filled balloon at a constant float altitude of ~60 km. Following a presentation by Jacques Blamont on alternative balloon concepts, it was decided that the desired balloon configuration is a balloon filled with H_2O/NH_3 mix, which results in an oscillation between 40 – 60 km, with a period of roughly 6 hours. (This corresponds to a pressure range of 0.2 – 3.5 bar and a temperature range of –10 °C – 150 °C). This balloon technology has been demonstrated on Earth, and has been studied in numerous studies at JPL, CNES/ONERA and elsewhere, so it is felt that this is probably going to be viewed as sufficiently reliable by the Cosmic Vision selection panel.

If the 40-60km oscillating balloon is viewed as too high a risk, a Helium-filled balloon floating at 55-60 km, as in the ESA VEP TRS, would be the fallback option.

Advantages of the 40-60 km oscillating balloon:

- **multiple vertical profiles** will be obtained through almost the whole thickness of the cloud layer. This is essential for understanding chemistry, dynamics, and radiative balance.
- Although the temperature will oscillate widely (roughly -10 – 150 °C), this is achievable using commercially available electronics. If these temperature excursions are judged to be negatively affecting the performance and/or calibration of any components, only a small amount of thermal insulation would be needed to significantly reduce the temperature excursions experienced.by the equipment.
- The 40-60 km oscillating balloon achieves most of the goals that were to be achieved by 100g microprobes; it was therefore decided that **100g microprobes are no longer part of the baseline mission**

The 40-60 km balloon will obtain multiple vertical profiles to be obtained using the balloon's full suite of instruments, so providing profiles of dynamical and composition measurements. This removes the need for 100g microprobes, which were designed to fill this need for multiple vertical profiles.

It was pointed out that a small probe deployed from the balloon, weighing 500 – 2000 g, would reach the surface intact and might be able to obtain surface imaging at multiple wavelengths. This would enable mineralogy and surface morphology at each small probe site; The small mass of each probe might allow 1-4 of such probes to be deployed from each balloon.

A small group of VEP scientists will assess the feasibility of work on the feasibility of such surface imaging from such ~1kg probes. This group will include the surface science working group, led by J. Leitner (U of Vienna), and will also include C. Wilson (Oxford) and P Grindrod (UCL). The possibility of imaging from 1kg probes may be studied in an industrial study (TBD soon!).

In summary, the baseline mission is:

- 2x identical balloons platforms (~150kg entry mass & ~15kg science payload) inserted at different latitudes: ~25° and ~70 °, float altitude = 40-60 km

- Orbiter with an orbit optimised for data relay from the balloons, likely to be a polar orbit with an altitude of >1000km (pending further study)

- We aim to have a launch mass consistent with a Soyuz launch vehicle (<1500 kg)
De-scoping options:
- 1x balloon instead of 2x balloons (to save mass, save cost).
- No orbiter: Balloons communicate direct-to-earth (datarate to be studied)

<u>'Up-scoping' options:</u>
- balloon-deployed probes, of mass ~1kg, to image surface and get composition profiles. There would be ~3 probes per balloon. These 3 probes, plus tracking/comms system, would require ~5kg of the balloon payload.

- Deploying passive balloons, from balloon entry vehicle behind heat shield, to be tracked by radar.
- Carrying a JAXA-provided low-altitude balloon (35kg entry mass).

VEP paper / VEP website / Next VEP meetings

Karen Aplin has been compiling the VEP white paper, which is essentially a compilation of submissions following the first VEP meeting at ESTEC in January 2006. Karen found volunteers to complete a few missing sections. The paper, now ~150 pages long, is to be used mainly as a reference document for the VEP proposal.

Johannes Leitner reports that the new VEP website design is nearing completion and will be online in mid-Feb 2007.

There will be a technical meeting with CNES, Astrium, and other industrial partners, to be held in Toulouse – this meeting is to identify technical points which need addressing before proposal submission, and to allocate these tasks to different industrial partners. **This technical meeting is likely to be in early February (6 Feb?).**

The next VEP team meeting will depend on the timing of the AO from ESA. It is expected that all teams will be invited to ESA to be told detailed conditions of the AO. We expect to hold a small meeting of the core proposal-writing members, at ESA, possibly the day after this ESA_scheduled meeting. **This meeting, for the steering committee, is likely to be early March, at ESTEC.**

No meeting for the full VEP community has currently been set, but it will probably occur in April, in Vienna, hosted by Johannes Leitner.

Colin Wilson
Oxford
28 January 2007

List of attendees at VEP oxford meeting

NAME	INSTITUTION	Country
Alton HORSFALL	Newcastle University	UK
Andrew BALL	Open University/PSSRI	UK
Chris COCHRANE	Imperial College	UK
Colin Wilson	Oxford University	UK
Constantine TSANG	Oxford University	UK
Csaba Ferencz	Eötvös University	Hungary
Dmitry Titov	MPS	Germany
Ellen Stofan	Proxemy / UCL / VEXAG	USA
Eric Chassefière	Service d'Aeronomie/IPSL	France
Essam HEGGY	IPGP - LPI	USA / France
Francesca Ferri	CISAS / Univ. Padova	Italy
Franco FOSSATI	Alcatel Alenia Space	Italy
Hugh MORTIMER	Oxford University	UK
Ian Whittaker	Aberystwyth University	UK
Jacques BLAMONT	CNES	France
James Schofield	Open University/PSSRI	UK
Jean Gabriel Trotignon	LPCE/CNRS, Orléans	France
Jean Louis Rauch	LPCE/CNRS, Orléans	France
Joachim Flohrer	Inst. Plan. Research / DLR	Germany
Joël Michaud	CNES	France
Johannes Leitner	Univ. Vienna	Austria
Jon Merrison	Aarhus University	Denmark
Jose J. Lopez-Moreno	IAA-CSIC	Spain
Karen APLIN	Rutherford Appleton Lab	UK
Lars BLOMBERG	KTH, Stockholm	Sweden
Marko Aittola	University of Oulu	Finland
Masato Nakamura	ISAS / JAXA	Japan
Mikhail Balikhin	Sheffield University	UK
Ming-Hung WENG	Newcastle University	UK
Neil Bowles	Oxford University	UK
Nikolai Sanko	Roskosmos	Russia
Oleg KORABLEV	IKI	Russia
Olivier Witasse	ESA / ESTEC	ESA
Peter Grindrod	UCL	UK
Rob SCOTT	Qinetiq	UK
Sandor Szalai	KFKI RMKI	Hungary
Sharon TSANG	MSSL/UCL	UK
Simeon Barber	Open University/PSSRI	UK
Simon Calcutt	Oxford University	UK
Stephen Lewis	Open University	UK
Steven ECKERSLEY	Astrium UK	UK
Takeshi Imamura	ISAS / JAXA	Japan
Tetsuya Yamada	ISAS / JAXA	Japan
Tibor Balint	JPL / VEXAG	USA
Victor VORONTSOV	Lavochkin Association	Russia