The Venus Entry Probe Initiative

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Motivation of this initiative

- The NEXT step in Venus Exploration after VEX and PLANET-C: detailed *in-situ* measurements.

- Framework: Cosmic Vision programme of the ESA Science Programme

Why to go back to Venus?

- Venus resembles Earth (size, volatile composition), but both evolved differently.
- Understanding why life developed on Earth requires understanding why Venus and Mars are desert worlds :
  - Why did Venus evolve toward the present strong greenhouse conditions, unlike Earth and Mars?
  - Why did Venus and Mars evolve toward a stagnant-lid regime, unlike Earth?
  - How is atmosphere evolution coupled to solid planet evolution on the three terrestrial planets?
- The deep atmosphere and surface of Venus, which contain key clues to past Venus evolution (e.g. : noble gas isotopic ratios, stable isotopes, chemical composition, oxygen fugacity, aerosols, wind field, mineralogy, outgassing activity, magnetic field…), are only poorly known.

A few important scientific questions (among others)

- Is Venus atmospheric composition representative of primitive Earth (and Mars) atmospheric composition, and what does it imply for the formation and evolution of telluric planet atmospheres?
- How are chemical species cycled through the complex mantle/ subsurface/ atmosphere/ cloud system, and to which extent do global scale chemical cycles control bulk atmosphere composition?
- How does a dry, one-plate, planet like Venus drive and lose heat from inner layers to its outer environment?
- What is the impact of cloud coverage on atmospheric greenhouse and climate?
- How does a non-magnetized planet like Venus interact with the solar wind and at which rate does it lose its atmosphere?
- Does Venus atmosphere, ionosphere and solar wind interaction region present an electromagnetic wave activity, due to various possible phenomena: seismic activity, lightnings, solar wind interaction?

How to answer these questions?

- Venus-Express will probe below clouds at several wavelengths, but with limited access to composition (only a few molecules), in a restricted altitude range and at low spatial resolution (due to cloud spreading effect).
- No access to noble gases, cloud particle composition and structure, chemical- dynamical- particle fields below clouds, surface composition- mineralogy- morphology…
- Need for in-situ measurements at cloud level, and below clouds down to the ground.
- Which kind of probes (descent/landing probes, balloons, microprobe swarm), combined with each kind of orbiter?

VEP workshop

- Held at ESA/ESTEC on 19-20 Jan. 2006
- Goal: To discuss both scientific objectives and technical constraints for a future in-situ exploration mission to Venus, consisting of a combination of orbiter(s), descent probes and/or balloons.
- 50+ participants, including colleagues from USA, Japan and Russia.
- The website at: www.aero.jussieu.fr/VEP/ contains most presentations from the workshop

Thursday 19 January :

09:30 Introduction to the Workshop: Goals and Context (E. Chassefière, M. Roos-Serote, O. Witasse)

09 :45 – 11 :00 Missions to Venus: running, plans and studies.

9:45 Overview and expected results of the Venus-Express mission (D. Titov, H. Svedhem and the Venus Express team)

10:10 PLANET-C : Venus Climate Orbiter mission from Japan (T. Imamura, PLANET-C team)

10:35 Venus Exploration Analysis Group (VEXAG) Overview (T. Thompson, S.K. Atreya, J. Luhmann, S. Mackwell, K.H. Baines, J. Cutts, A. O'Campo, S. Saunders)

10 :45 Venus Exploration Opportunities within NASA's Solar System Road Map (T. Balint, T. Thompson, J. Cutts, J. Robinson).

11:15 Introduction and status of ESA Technology Reference Studies (P. Falkner, ESA)

11:25 ESA Venus Entry Probe Study (M. v.d. Berg, ESA)

11:50 Venera D- future Russian mission (O. Korablev, L. Zasova, M. Gerasimov, A. Rodin, A. Basilevsky, V. Linkin)

12 :15 Proposal for a Venus Balloon Entry Probe (ARCHIMEDES-V) for studies of the atmosphere of Venus (H. Griebel, B. Häusler, C. Mundt, H. Rapp)

12 :30 Venus descent microprobes (N.E. Bowles, C. F. Wilson, F.W. Taylor, S.B. Calcutt)

12 :45 Autorotating Imaging Descent Probes: A simple means for examining many locations on Venus (J. D. Burke)

14 :00 - 14 :45 Venus ideas proposed in answer to the Cosmic Vision Call for Ideas

14 :00 In-orbit spacecraft coupled to a stable platform situated within the atmosphere (W. Schmidt)

14 :15 The Lavoisier mission concept (E. Chassefière)

14 :30 Constraining Venus internal and external geophysics with radar sounding (G. Occhipinti, R. Garcia, P. Lognonne

14 :45 - 16 :00 Science presentations

14 :45 Models for the Surface Heat Loss on Venus (J. Leitner, M.G. Firneis)

15 :00 Ion-aerosol interactions in the lower atmosphere of Venus (K.L. Aplin)

15 :15 Modeling the visible and infrared emissions in the lower and upper atmosphere of Venus: airglow, non-LTE radiative transfer and greenhouse effect calculations (J. Martin-Torres)

15 :30 Diverse conditions of the motion of natural cosmic bodies in the atmosphere of Venus including crater formation (V. Stulov)- Not Present. See contribution to the Ideas section.

15 :45 Benefits of electromagnetic monitoring of the planet Venus (C. Ferencz, J. Lichtenberger)

16 :30 - 18 :00 Instrument presentations (I)

16 :30 Applications on Venus of a miniature mass analyser (J. Whitby, P. Wurz).

16 :45 Integrated sampling and mass spectrometer systems for Venus probe and balloon missions (S. Barber, S. Sheridan).

17 :00 State of art of micromachined mass spectrometers (J.-J. Bertheller E. Chassefière, J.P. Pineau, P.G. Tizien).

17 :15 A mass spectrometer to analyze noble gases (A. Jambon, E. Chassefière, J.-J. Bertelier)

17 :30 Direct measurement of an oxygen concentration profile in the lower layers of the venusian atmosphere (E. Chassefière, M. Gantès, J.-C. Sabroux).

17 :45 A Venus polarization nephelometer (M. Roos-Serote, D. Banfield, R. Dissly, P. Gierasch, O. Muñoz, D. Stam, H. Volten).

18 :00 End of the first day.

Friday 20 January :

08 :30 - 11 :00 Instrument presentations (II)

08 :30 Using lidars onboard atmospheric probes for investigating deep Venus atmosphere (E. Chassefière).

08 :45 Optical detection of alpha emitters by gaseous scintillation of Venus' atmosphere (J.-F. Pineau, J.C. Sabroux, E. Chassefière).

09 :00 X-ray and Gamma-ray Spectrosopy for the Elemental Composition and Density of the Venusian Surface (D. Talboys, N.Nelms, R. Ambrosi, G.W. Fraser, A. Ball, M. Bentley)

09 :15 Studying the surface composition of Venus in the near infrared… …with VIRTIS on Venus Express … *and some ideas for doing the same with SurVenTIS – Surface of Venus Thermal Imaging System* (J. Helbert, L. Marinangeli, N. Muller, G. Hashimoto, R. Garcia, J. Benkhoff, K. Baines, Y. Langevin)

09 :30 A meteor detector in Venus orbit (J. Oberst, J. Flohrer, H. Michaelis, R. Schoedter).

09 :45 Planetary Science and Instrumentation at Imperial College London - Applications to Venus (I.C.F. Mueller-Wodarg, M. K. Dougherty, M. Galand, N. Achilleos, C. Bertucci)

10:00 Break

10:15 Venus Ionospheric Science Probe (VISP) (J.-E. Wahlund. L.G. Blomberg, S. Barabash).

10:30 Venus Ionospheric Science Probe (VISP) (L.G. Blomberg, S. Barabash, J.-E. Wahlund, J.A. Cumnock).

10 :45 Thermal Plasma Investigations at Venus (TPIV) : An Experiment Proposed for the Orbiter of a Venus Mission (J. Trotignon, M. Parrot, J.L. Rauch, R.J. Strangeway, M. Hamelin, J.P. Lebreton, O. Witasse, C. Bertucci, H. Perez-de-Tejada, K. Sauer, C. Mazelle, E. Dubinin)

11 :00 Atmospheric density profile from Venus entry accelerometry (A.J. Ball, J.C Zarnecki, B. Hathi, M.R. Leese, M.C. Towner, F. Ferri, G. Colombatti, M. Fulchignoni).

11 :15 Discussion and elaboration of science objectives (all)

11 :15 Science at Venus (O. Witasse).

13 :00 Lunch

14 :00 Possible mission configuration/scenario to be pursued (all)

Plans for the future : preparation of the cosmic vision proposal (all)

16:00 End of the workshop

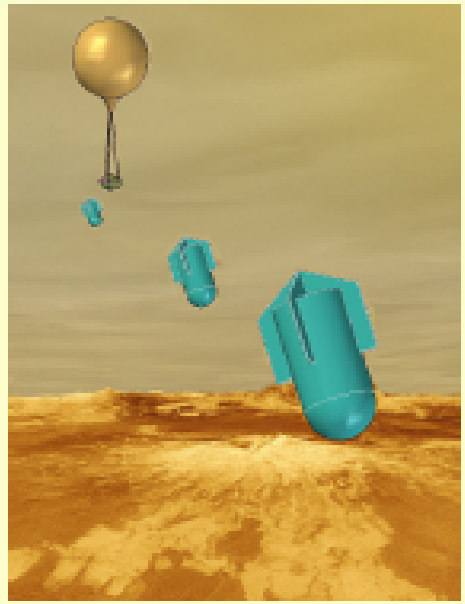
Missions scenarios considered

1. Focus on history of the climate
   - One descent probe + bus for data relay
2. Focus on clouds and low atmosphere dynamics
   - One relay orbiter, one science orbiter, one or several balloons with microprobes deployed at 50-60 km altitude
3. Focus on low atmosphere chemistry and surface/atmosphere interactions
   - Several descent probes + bus for data relay
4. Focus on surface remote sensing and atmosphere investigations at regional scales
   - Low altitude balloons, one descent probe + bus for data relay

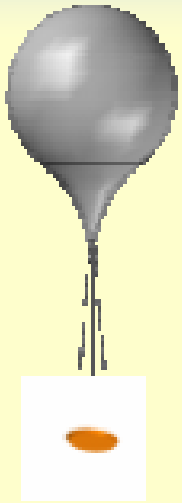
Still preliminary….

Mission study concept

- Aerobot
  - Middle cloud layer (40-57 km)
  - Global in-situ atmospheric coverage
- Atmospheric microprobes
  - Profiles of p, T, solar flux, wind velocity
- Two small-sats:
  - o Venus Polar Orbiter
    - ✓ Continuous remote sensing atmospheric investigations (also concurrent with aerobot)
  - o Venus Elliptical Orbiter
    - ✓ Deploys entry probe from HEO (250 km x 215,000 km)
    - ✓ Data relay satellite (Venus-Earth)



Venus aerobot concept

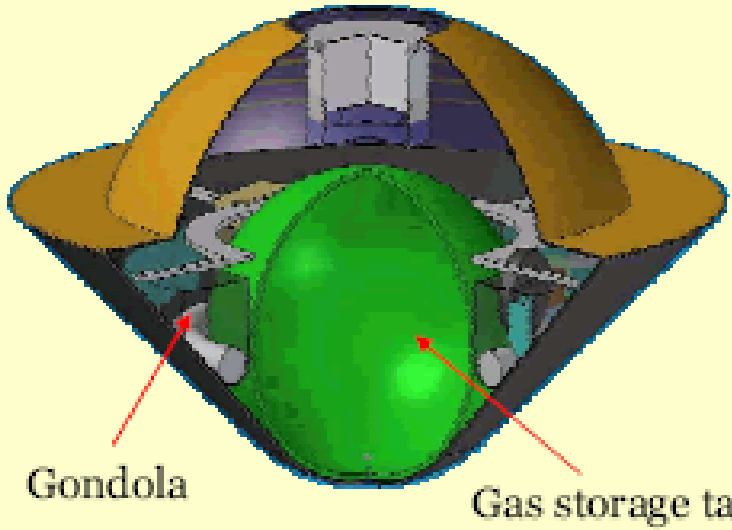


- Baseline: Hydrogen super-pressure balloon
- Altitude: ~ 55 km (30 °C, 0.5 bars)
- Duration: > 14 days (twice around Venus)
  - Ballast drop campaigns
  - Gas release mechanism
  - Ammonia gas replenishment
- Power: Solar cells (daytime) and batteries (nighttime)

Mass budget:

Item	Mass (kg)
Gondola	26
Balloon	6
Gas storage tank	17
Parachute system	4
Entry system	38
TOTAL	91

Accommodation:



International collaboration

- Needed to achieve such an ambitious mission.
- Very successful in the case of Cassini-Huygens.
- Strong interest from: USA, Japan and Russia.
- Preliminary contacts with India.

Next steps

- Finish a white paper
- To be ready to reply to the Cosmic Vision Call for Ideas in a couple of weeks.

- Call for Ideas release in May 2005 (TBC).
- Ideas due by mid September 2005 (TBC).
- ESA will select a total of six ideas for further study, distributed over three science areas: fundamental physics, astrophysics and planetary exploration.
- Next meetings (TBC)
    - July
    - September, at the Europlanet conference in Berlin