THE FUTURE OF VENUS SPACE EXPLORATION – THE VENUS ENTRY PROBE (VEP) INITIATIVE.

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Background: The ESA Cosmic Vision 2015-2025 framework program addresses four different scientific questions, which must be optimally achieved by proposed missions: (1) What are the conditions for life and planetary formation?, (2) How does the solar system work?, (3) What are the fundamental laws of the Universe?, and (4) How did the Universe originate and what is it made of?.

In this paper an overview is given about the Venus Entry Probe (VEP) initiative (mission) and its main mission goals. In general VEP will fit well the main scientific tasks (1) and (2) and is carried by three directive questions:

How can the detailed knowledge of the atmosphere of Venus, compared to that of the two other terrestrial planets, help in understanding future observations of Earth-like extra-solar planetary atmospheres and the search for habitability, and possibly life, signatures?

Did Venus, which is the most Earth-like planet of the Solar-System, offer suitable atmospheric and geological conditions for life to emerge at some time in the past? Why did it evolve differently from Earth, and will Earth evolve towards a Venus-like state in the future?

How does the Sun interact with Venus' atmosphere, through its radiation and particle emissions and what has been the influence of the Sun and of its evolution on the climate history of Venus?

Thus, the main mission directive of VEP focuses on the lower atmosphere and the interaction between surface and atmosphere. Within this context VEP can be seen in a step-by-step approach, whereby the first step will be done by the still operative ESA Venus Express and the upcoming Japanese Climate Orbiter and focusses more on atmospheric and cloud dynamics. As a second step VEP will concentrate on the lower atmosphere and a third step only can be done by a future highly equipped long-living surface landing mission.

Unanswered questions after the second step: After a successful completion of Venus Express and Climate Orbiter a lot of very important scientific questions or tasks about Venus will still remain unanswered: (1) The isotopic composition, especially that of noble gases, which provides information on the origin and evolution of Venus and its atmosphere. (2) The chemical composition below the clouds and all the way down to the surface with more detail than is possible using remote sensing, in order to fully characterize the chemical cycles involving clouds, surface and atmospheric gases. (3) The surface composition and mineralogy in several locations representing the main types of Venus landforms and elevations. (4) A search for seismic activity and seismology on the surface, and measurements at multiple locations to sound the interior. (5) An in situ investigation of the atmospheric dynamics, for instance by tracking the drift of floating balloons. (6) The composition and microphysics of the cloud layer at different altitudes and locations, by direct sampling. (7) Solar wind-atmosphere interaction processes and resulting escape as a function of solar activity. (8) The determination of the surface heat flow of different landforms and structure-elements. (9) The electromagnetic activity monitoring and mapping of the planet.

In order to solve some of the questions mentioned above, the main mission goals of VEP and their ranking are given in Table 1.

Mission elements: The baseline configuration consists of 4 small/medium descent probes (3 landings at the dayside and 1 at the nightside of the planet), 1 cloud-altitude balloon + 20 microprobes, 1 low-altitude baloon floating at 35 km, an orbiter for context science and as data relay and one atmospheric sample return (ASR) system. To find out the optimal configuration from a scientific point of view the scientific values of the different elements have been considered.

Thus, the value of the cloud-altitude balloon together with the microprobes is equivalent of one well-instrumented descent probe, whereby the former being rather focused on dynamics, the latter on chemistry. If adding to this balloon a low-altitude balloon, the value of the balloon component slightly exceeds the value of one descent probe, but clearly a set of descent probes (nominally 4) has the best scientific ranking. Nevertheless, using balloons providing continous geographical coverage (and operatinng during several weeks), in complement to the descent probes, proving a few instantaneous vertical profiles, is judged of high scientific interest. The scientific score of atmosphere sample return, taken alone, is below the score of probes (balloon, descent), but the added value of atmospheric sample return, in particular for the community of geo- and cosmochemists, is tremendous. Finally, the orbiter itself has a moderate scientific value, but it is necessary for the data relay function, and provides the scientific context covered by in situ probes.

Mission scenario: Different mission scenarios are at the moment under study. The first elemental scenario consists of a fly-by platform releasing descent probes and balloons from transfer orbit, sampling the atmosphere during a low altitude fly-by, relaying entry probe data to Earth during 2 hrs, and bringing back the atmospheric sample to Earth. In the second elemental scenario, the fly-by platform is replaced by an orbiter, which is inserted in orbit after the release of descent probes and balloon probes, used for telecommunications of probes, then progressively put on a lower and lower orbit by aerobraking and used in a final stage as a scientific orbiter. A composite mission scenario consits of two spacecrafts instead of one, nominally launched by a single launcher, and allows to implement within the same mission the atmosphere sample return unit and the scientific orbiter, combining elemental scenarios one and two functionalities.

Future work: At the moment several scientific and technical working groups are give the mission proposal a finishing touch, e.g. the final definition of the orbiter-, descent probes- and balloon-payloads, a first seletction of potential descent probes landing-sites and a finalization of the mission scenario.

Dynamics, structure and radiation balance	**Ranking**
Wind field below and within the clouds	High/Med.
Eddy activity	High
Static stability	High
Radiative balance	Medium
Plasma and wave processes	**Ranking**
Electromagnetic waves in the ionosphere	High
Electromagnetic activity in atmosphere/lighting	High
Surface and interior	**Ranking**
Composition and mineralogy of the surface	High
Structure and substructure and interior	Low
Surface morphology (imaging)	High
Surface-atmosphere interactions	High
Planetary heat balance	Low
Origin, evolution and escape	**Ranking**
Noble gases abundance and isotope ratio	High
Non noble gas isotope ratios (O, S, etc.)	High
Escape of superthermal neutrals	Medium
Vertical profiles of isotopes of H, O, Ar, Ne above 100 km	Medium
Composition and chemistry	**Ranking**
Abundance of trace gases not measured by VEX and VCO	High
Vertical profile of trace gases	High
Clouds	**Ranking**
Composition of cloud particles	High
Optical properties of the clouds	Medium

Table 1: Main scietific goals of the VEP mission