ESA’s Venus Entry Probe Workshop and Cosmic Vision Proposal

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by

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Presented by
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Core measurement objectives

- Top measurement objectives of VEP, as defined at the VEP meeting, Paris, 6-7 July 2006

- **Isotopic composition**
  - Provides information on the origin and evolution of Venus and its atmosphere.
  - *Measurement objectives:* noble gas and non-noble gases isotope ratios, some of them with an accuracy up to 0.01%; vertical profiles of isotopes of H, O, Ar, Ne above 100 km to improve models of isotopic fractionation by escape, together with, optionally, selected key measurements of atmospheric escape.

- **Surface composition and mineralogy at several locations**
  - Representing the main types of Venus landforms.
  - *Measurement objectives:* composition and mineralogy of the surface (e.g. by spectroscopy, and other techniques), surface morphology (e.g. by imaging, and other techniques), surface-atmosphere interactions (by combination of atmosphere and surface chemical measurements).

- **Chemical composition below the clouds**
  - With more detail than is possible using remote sensing.
  - *Measurement objectives:* abundance of trace gases not measured by Venus-Express (ESA) and Venus Climate Orbiter (JAXA), vertical profiles of trace gases, trace gases below 20 km.

- **In situ investigation of the atmospheric dynamics**
  - *Measurement objectives:* wind field below and within the clouds, wind field in the mesosphere, eddy activity, static stability, radiative balance.

- **Composition and microphysics of the cloud layer** at different altitudes and locations by direct sampling.
  - *Measurement objectives:* composition of the cloud particles, optical properties of the clouds

- **Electromagnetic activity monitoring and mapping** of the planet.
  - *Measurement objectives:* electromagnetic waves in ionosphere, electromagnetic activity in atmosphere/lightning. Optionally, selected key measurements of the plasma environment, providing the context for electromagnetic
Mission Elements & Scientific Values

The baseline configuration is:

- **4 small/medium descent probes**
  - 3 day-side and 1 night-side

- **1 cloud-altitude balloon (HB) + 20 microprobes - ESA TRS concept**
  - Balloons: continuous geographical coverage (and operating during several weeks)
  - Descent probes: few instantaneous vertical profiles (high scientific interest)

- **1 low altitude balloon (LB) floating at 35 km - JAXA concept**

- **Orbiter**
  - Maybe necessary for data relay function
  - Provides scientific context to in-situ probes

- **Atmospheric sample return (ASR) system**
  - E.g., free return trajectory
  - Added value of ASR is tremendous for the community of geo and cosmo-chemists
Ranking of Mission Concepts by Science Value

BEST VALUE:
[4 descent probes (nominal)] = BEST science rank

EQUAL VALUE:
[HB balloon + microprobes] = [well-instrumented single descent probe]
– The former focuses on dynamics; the later on chemistry.

SLIGHTLY GREATER VALUE:
[HB + LB balloons] slightly greater than [descent probe]

LOWER VALUE:
[Atmosphere sample return alone] lower than [probes (balloon, descent)]

MODERATE VALUE:
[Orbiter alone] = moderate scientific value
Core Mission Scenarios

• **3 main mission scenarios**, with a certain number of variants, consisting of:
  
  – Two “elemental” scenarios, and
  
  – **One** more powerful “composite” scenario

  • allowing to address all scientific objectives.

• These scenarios are presently under study at CNES

• Detailed presentation on them will be given at the Oxford meeting in 2 weeks
1st Elemental Scenario – ES-1

- **FbP/ASR** (flyby platform + atmospheric sample sample return)
  - Fly-by platform releases **descent probes and balloons** from transfer orbit
  - Relaying entry probe data to Earth during 2 hrs
  - **Atmosphere sampling during a low altitude fly-by**
  - Atmospheric sample return to Earth
  - **No scientific orbiter for context measurement**

- Assumptions:
  - DTE data transfer from high altitude balloon during three weeks,
  - Requires the use of the Square Km Array.
  - If SKA is NOT available, a variant called VEO/ASR is used,
    - the platform being inserted in a high elliptical orbit for HB data transmission,
    - then de-orbited to get back samples to Earth.
  - **No scientific orbiter** - decreased science return in specific fields of atmospheric dynamics, electromagnetic activity monitoring, and
  - somewhat weakening the scientific return from entry probes
2nd Elemental Scenario – ES-2

- **VPO**
  - **Orbiter** replaces the fly-by platform
  - Orbit insertion after the release of descent probes and balloon
  - **Probes** use orbiter for relay communications
  - Orbit then progressively lowered by aerobraking, then
  - Then Orbiter used as **scientific orbiter**.

- **Assumptions:**
  - Delivery of entry probes
    - Before OR After orbit insertion (at the expense of mass), or both.
  - ES-2 does not allow for an atmosphere sample return
    - De-orbiting a low altitude orbiter is too expensive in terms of ergol resources,
    - weakening the science return relative to isotopic composition (climate history).
3rd Composite or Core Scenario – CS

• **VPO + FbP**
  – (Relay & Science, or Remote Sensing) + (Deep Probes / Balloon / Atmospheric Sample Return)
  – 2 spacecrafts (instead of 1)
  – Nominally launched by a **single launcher**
  – ASR + Science Orbiter + combined functionalities of ES-1 and ES-2

• **ES-1 and ES-2:**
  – Only one type of entry probe is implemented (ESA balloon or descent probes, with the Japanese balloon in both scenarios),
  – Probably could be implemented as an ESA-alone mission (L-class, with small foreign contributions)

• **Full ES-1 or ES-2 scenarios:**
  – With both descent probes and balloons, could be more problematic to implement within the 650 M€ L-class budget,
  – This would probably require a significant level of international cooperation.

• The Core Scenario clearly requires a high level of international cooperation
**3rd Composite / Core Scenario – CS – w/ Single Launcher**

Direct injection on ballistic trajectory

\[
V_\infty = 3.4 \text{ m/s, Dec. 8 2016}
\]

**Arrival:** 18/05/2017

**VPO:** insertion DV = 500 m/s, aerobraking, operational polar orbit, 400 m/s

**FbP:** Venus gravity assist

**1st DP separation, 5.3 km/s**

**2nd DP separation, 5.3 km/s**

**3rd DP separation, 5.3 km/s**

**4th DP separation, 5.3 km/s**

**BA separation, 5.3 km/s**

**DP and BA entry**

**FbP:** Atmosphere capture

29/08/2018

**Rp = 150 km**

**Single Launcher:**

- Wet mass at launch: 2520 kg
Two launchers:
- Wet mass at launch: 570 kg for VPO (RS)
- Wet mass at launch: 1950 kg for FbP (DP/BA/ASR)