ESA's Venus Entry Probe Workshop and Cosmic Vision Proposal

Word document prepared for the 4th Science Team Meeting
Oxford (UK) on January 24-25, 2007

by
Eric Chassefiere

Presented at the
3rd Meeting of the Venus Exploration Analysis Group (VEXAG)
Crystal Gateway Marriott Hotel, Crystal City, Virginia

January 11-12, 2007

Presented by
Tibor Balint

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 grater 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

1^{st} Elemental Scenario – ES-1

- **FbP/ASR** (flyby platform + atmospheric 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

2^{nd} 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).

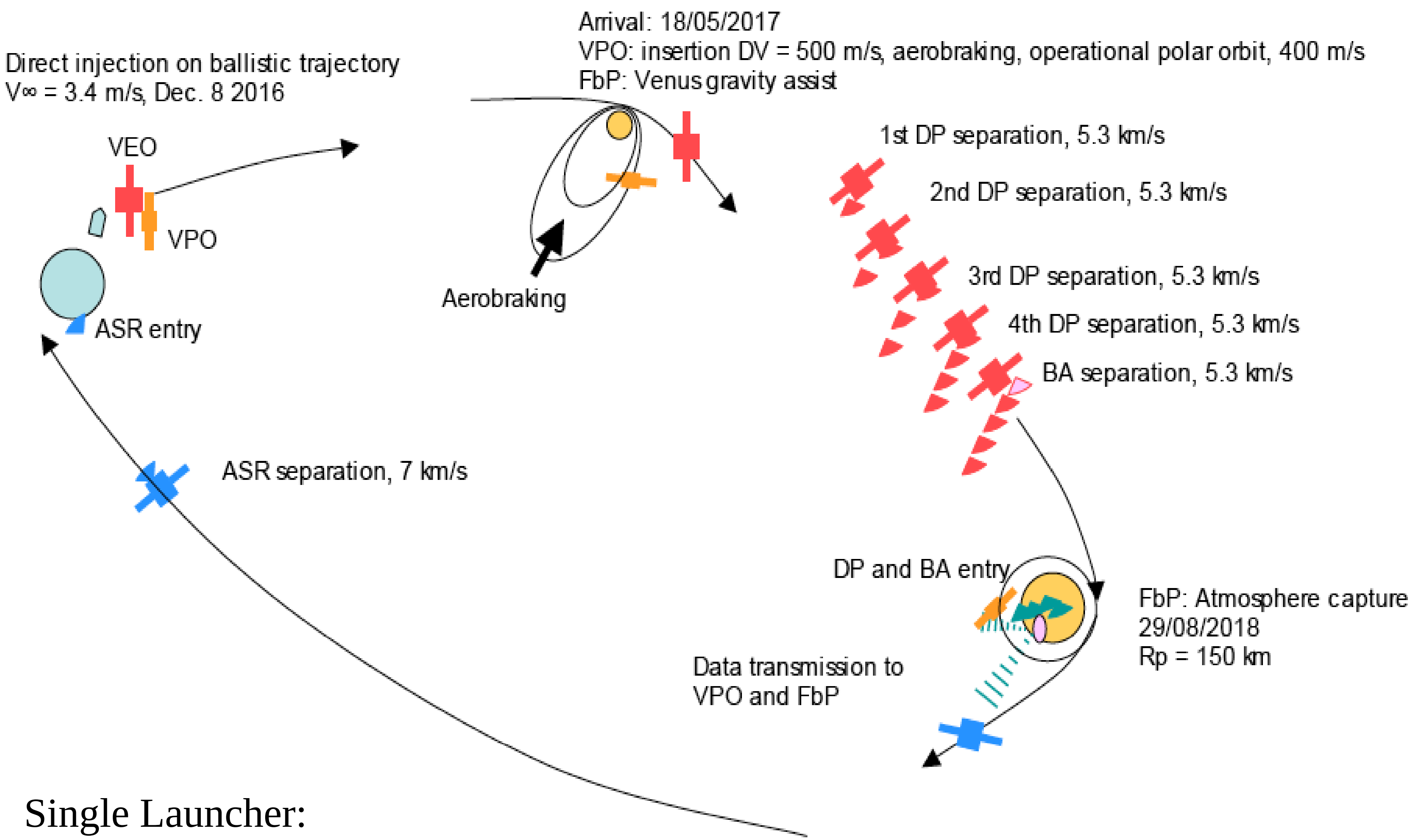
3rd Composite or Core Scenario – CS

- **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.**

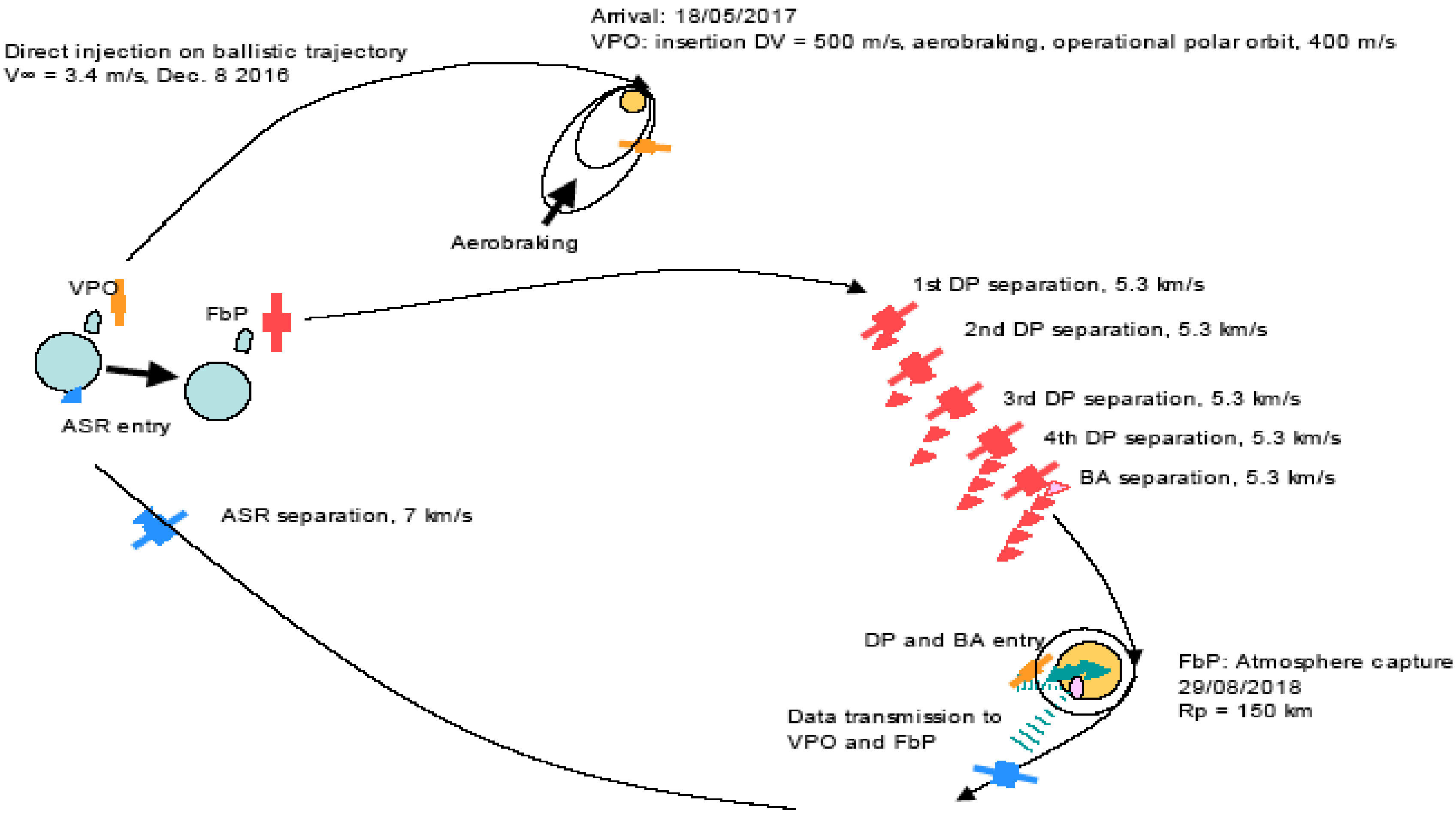
- **The Core Scenario clearly requires a high level of international cooperation**

3rd Composite / Core Scenario – CS – w/ Single Launcher



Single Launcher:
- Wet mass at launch: 2520 kg

3rd Composite / Core Scenario – CS – w/ Two Launchers



Two launchers:

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