

# Reminder of what the VEP mission is

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# Core scientific and measurement objectives

(as established at 2nd VEP meeting, Paris, July 06)

- **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

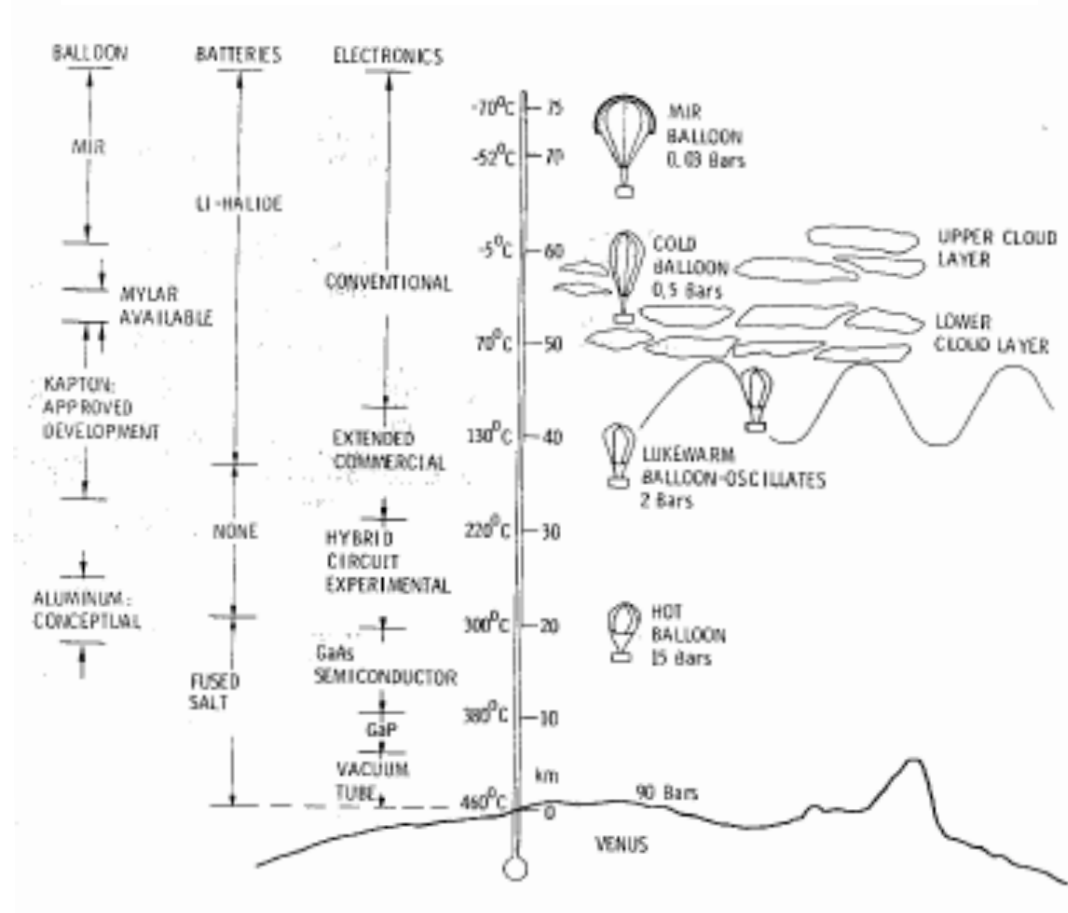
# Mission elements : baseline configuration (from previous meetings)

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

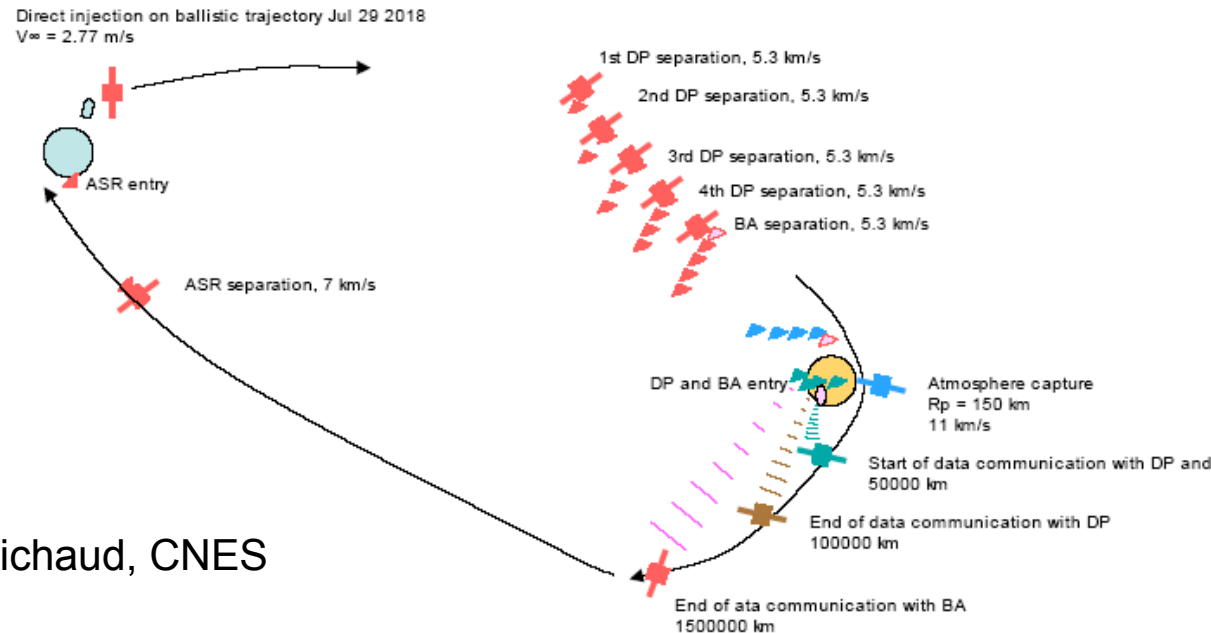
## Additional elements : low/ variable altitude balloons

- Concepts developed in the 70's and 80's (Taillet & Blamont, Romero et al,...).
- Science :
  - Dynamics : radar tracking of a flotilla from orbiter.
  - Chemistry : chemical analyzer + cryocooler onboard.
- Cf next talk by J. Blamont.



# 1<sup>st</sup> type of scenario – ES-1

(4 descent probes + small balloon(s) + ASR option)



From J. Michaud, CNES

- 4 medium-size (200 kg) descent probes + small balloon(s) (e.g. JAXA's balloons). *Variant : 10 small-size (80 kg) descent probes*
- *Option : use the fly-by platform for atmosphere sample return.*
- Compatible with Soyuz launch only for 1-2 medium (or 3-5 small) descent probes, and a few small balloons.
- **No Delta-V required : nearly purely ballistic orbit**
- Probably fits L-size cost cap.

# Comments on ES-1 scenario

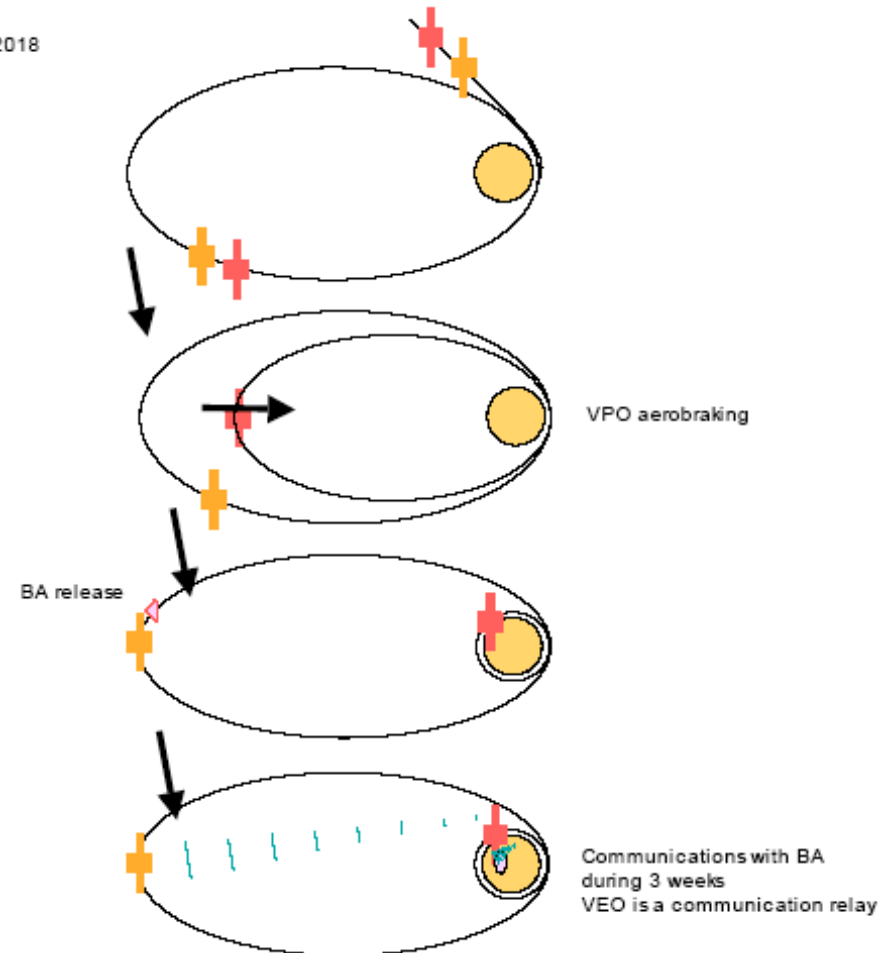
- A large ESA VEP-type balloon may be deployed from transfer orbit, but it requires the use of the Square Km Array (for direct transfer of data to Earth).
  - If SKA is NOT available, a variant called VEO/ASR is used (cf talk by J. Michaud tomorrow),
    - the platform being inserted in a high elliptical 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<sup>nd</sup> type of scenario – ES-2 (ESA VEP concept)

Direct injection on ballistic trajectory Jul 29 2018  
 $V_{\infty} = 2.77$  m/s



- ESA-VEP type mission (VEP balloon + microprobes, small balloon(s), 1 or 2 orbiters).
- Orbiter(s) used for both science and data relay.
- Aerobraking may be used for lowering VPO orbit. Saved mass can be devoted to 1-2 descent probes.
- Compatible with Soyuz launch.
- Probably fits L-size cost cap.



From J. Michaud, CNES

# Comments on ES-2 scenario

- Delivery of entry probes
  - Before OR After orbit insertion (at the expense of mass), or both.
  - **If entry probes are delivered before insertion, science context provided by the orbiter (operated later) may not be relevant.** Another scenario allows to solve this difficulty (insertion of VPO first, swing-by of VEO, arrival of VEO at Venus  $\approx 1$  year later). *See further slide.*
- **If no addition of descent probes, no access to low atmosphere chemistry and surface-atmosphere interaction.**
- ES-2 does not allow 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).

# Ranking of mission scenarios by science value

(as established at 2nd VEP meeting, Paris, July 06)

## **BEST VALUE:**

[4 descent probes (nominal) + LB balloon] = BEST science rank

– But limited horizontal coverage, and no orbiter for context

## **EQUAL VALUE:**

[HB balloon + microprobes] = [well-instrumented single descent probe]

– The former focuses on dynamics; the later on chemistry.

## **SLIGHTLY GREATER VALUE:**

[HB balloon + microprobes + LB balloons] slightly greater than [descent probe]

## **LOWER VALUE:**

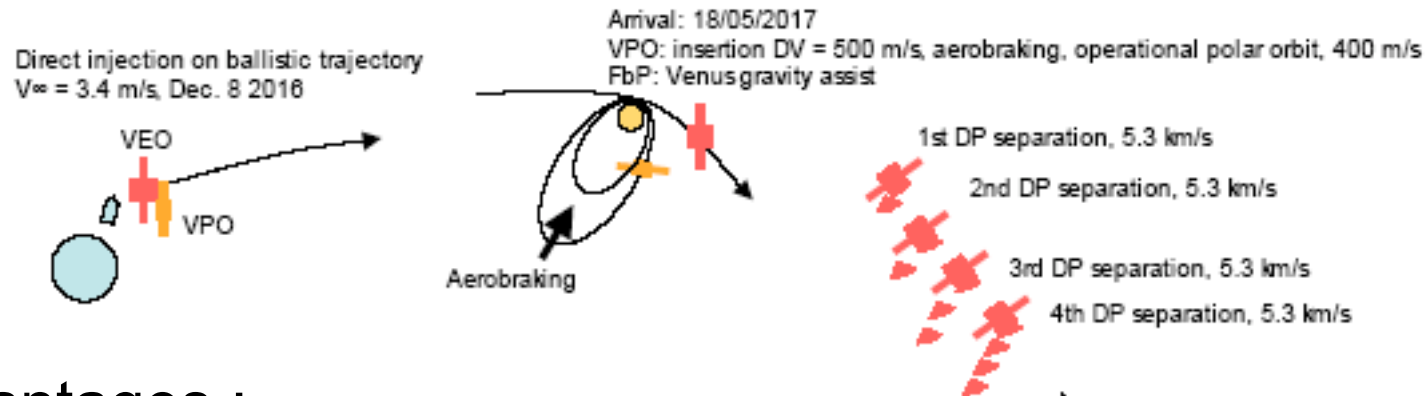
[Atmosphere sample return alone] lower than [probes (balloon, descent)]

– Large added value

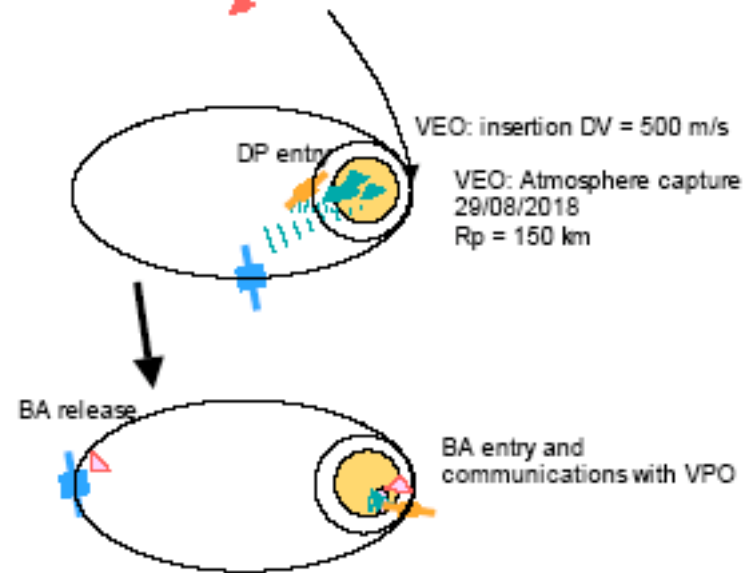
## **MODERATE VALUE:**

[Orbiter alone] = moderate scientific value

# Two-step insertion alternative scenario



- Advantages :
  - VPO put on optimal (science/relay trade-off) polar orbit before entry probe release (1 or 2 Venus turns about the Sun)
  - Different kinds of entry probes may be released from VTO, before VEO insertion.
  - VEO can be just a Fly-By platform (if VPO is sufficient as a relay).



From J. Michaud, CNES

# Possible mission scenario architectures

“Elemental”

ES-1 type : Unique Venus Fly-By  
with :

- Deployment of entry probes before FB
- Optionally : atmosphere sample return

ES-2 type : Unique Venus Orbit  
Insertion with :

- VPO & VEO insertion (optionally : one single orbiter)
- Deployment of entry probes (before or after VOI)

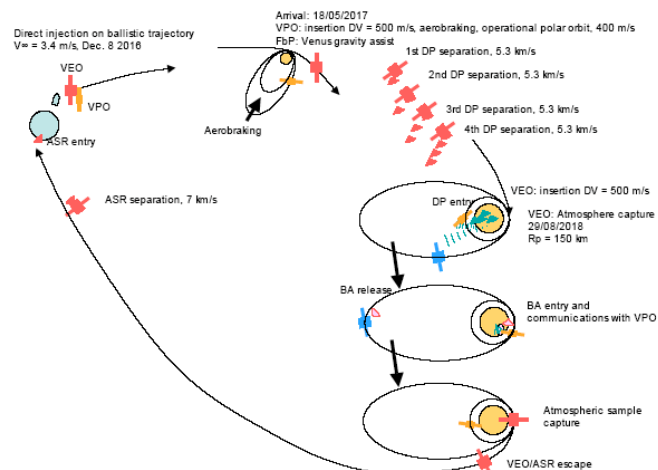
“Composite”

Two-step VOI-FB (several months between) sequence with :

- Insertion of VPO, then aerobraking.
- Deployment of entry probes before FB
- Optionally : atmosphere sample return

Two-step VOI-VOI (several months between) sequence with :

- Insertion of VPO, then aerobraking.
- Deployment of entry probes before or after VEO insertion.
- VEO insertion.



Three-step VOI-VOI-VDO (several months between) sequence with :

- Insertion of VPO, then aerobraking.
- Deployment of entry probes before or after VEO insertion.
- VEO insertion.
- VEO De-orbitation and ASR.

# What is the best architecture?

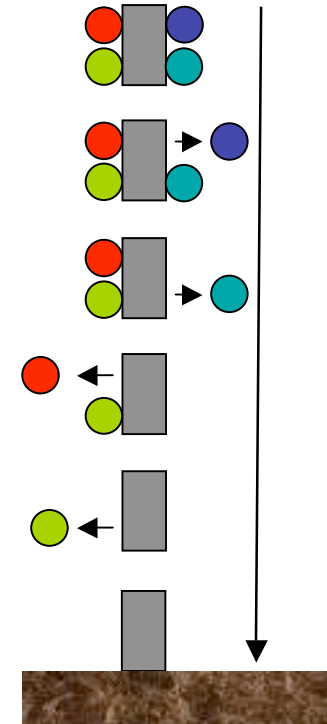
- A good mission scenario architecture must be :
  - As simple as possible (technical feasibility, cost)
  - Offer as much data relay capabilities as possible for entry probes
  - Offer as much mission element combinations (types of probes, number of orbiters -1 or 2-...) as possible.
  - Offer as much deployment configurations (before or after VOI) as possible.
  - **OFFER THE MAXIMUM OF FLEXIBILITY** in view to adapt to future evolutions.
- Seems to favour a two-step mission scenario architecture (VPO inserted first and put on optimal orbit, entry probes deployed later, *whatever the nature, number and deployment sequence of entry probes are*). **But does it fit the L-class cost cap?**
- To be decided first (to my opinion)!

# Possible mission elements

- Already identified elements... :
  - VEP balloon (ESA study),
  - Low altitude (35 km) meteorological balloon (JAXA study)
  - Descent probes : medium-size (200 kg/ 20 kg PL) or mini-probes (80 kg/ 3 kg PL)
  - Atmospheric Sample Return
  - Low/ variable altitude balloon flotilla (CNES)
- Possibilities of combination (descent probe/ balloon) to be studied, e.g. :
  - A large entry vehicle ( $\approx 300$  kg) formed of one 200 kg DP and one VEP balloon.
  - A small entry vehicle ( $\approx 100$  kg) formed of one 80 kg DP and a few small balloons
  - ...

# Why not, for example?

- A small entry vehicle ( $\approx 100$  kg) composed of :
  - 1 DP with 3-4 kg payload (meteo/rad sensors + imager + chemical package + VLBI tracking)
  - 4 small passive balloons (4 different floating altitudes between 20 and 60 km)
- providing :
  - Vertical wind/ meteo/ chemical profiles and surface images.
  - Horizontal wind pattern at meso-global scales and at different altitudes.



- Mission with  $\approx 10$  such small descent/balloon probes + 1 large DP and/or VEP (20 kg science payload with powerful chemical/isotopic analyzer)? (*requires an Ariane V...*)
- **WE MUST BE IMAGINATIVE!**

Any other ideas of entry probes...

- **TO BE DISCUSSED TOMORROW  
MORNING**

# Instrumentation

- About 40 instrument forms received :
  - ≈25 for in-situ experiments (chemical, close remote sensing, radioactivity, EM activity...)
  - ≈10 for remote sensing observations (UV, visible, sub-mm, radar...)
  - ≈5 for technological developments (Stirling cooler, balloon guidance system...)
- Preliminary identification of payloads for orbiter, descent probes and balloon probe/ microprobes, in progress (cf talks by C. Ferencz, O. Witasse, C. Wilson).
- To be refined as a function of mission scenario, elements and detailed scientific objectives.

## Strategy for the proposal : proposed approach (to be discussed)

- *Goal of the proposal : obtain funding for additional feasibility studies (mission timeframe > 2020)*
- Propose a nominal ESA-alone mission M1 (or rank in priority order 2 or 3 possible missions : M1a, M1b, M1c) compatible with a cost cap of 650 M€.
- Present ASR only as an option (if compatible with mission scenario), to be further studied.
- Propose a larger mission M2 (extending the capabilities of the M1 ESA-alone mission), led in an international context, with a preliminary description of participations (JAXA, Russia, USA...).

# Main expected outputs of the Oxford meeting

- Identification of an **ESA-alone favorite mission (first : mission architecture, second : mission elements)**, or of several options in priority order.
- **Provide information (detailed sequences, data rates...)** for mission scenario refinement and cost estimate, to be done by CNES and Astrium/Toulouse.
- Advanced definition of **science payload for each type of platform.**
- Identification of **critical technologies.**
- Preliminary definition of a **large international Venus in-situ mission** in terms of mission scenario and international cooperations. Create an **international science working group?**
- **Organization for proposal writing...**