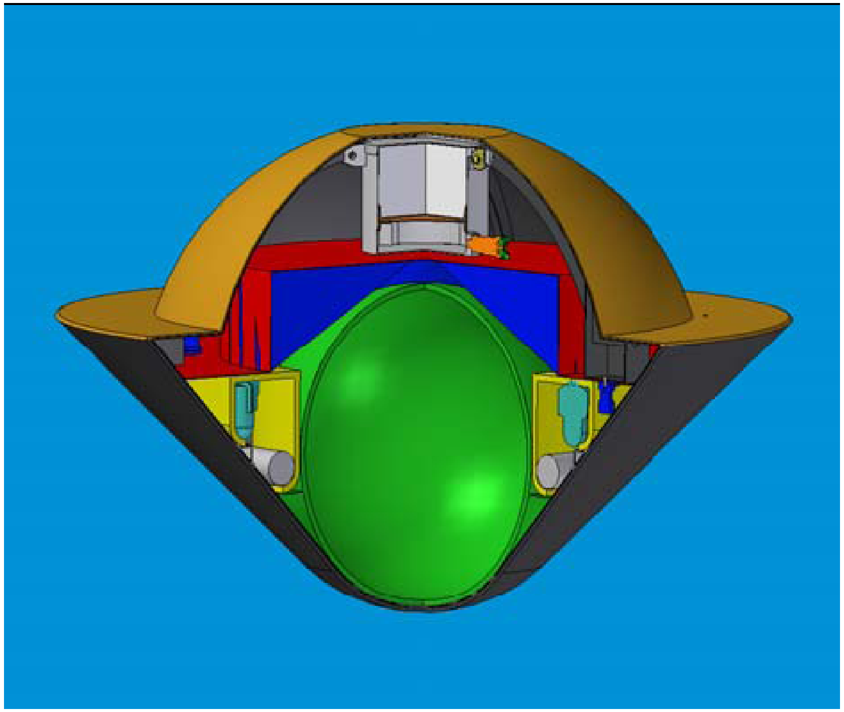
VEP cloud-top balloon

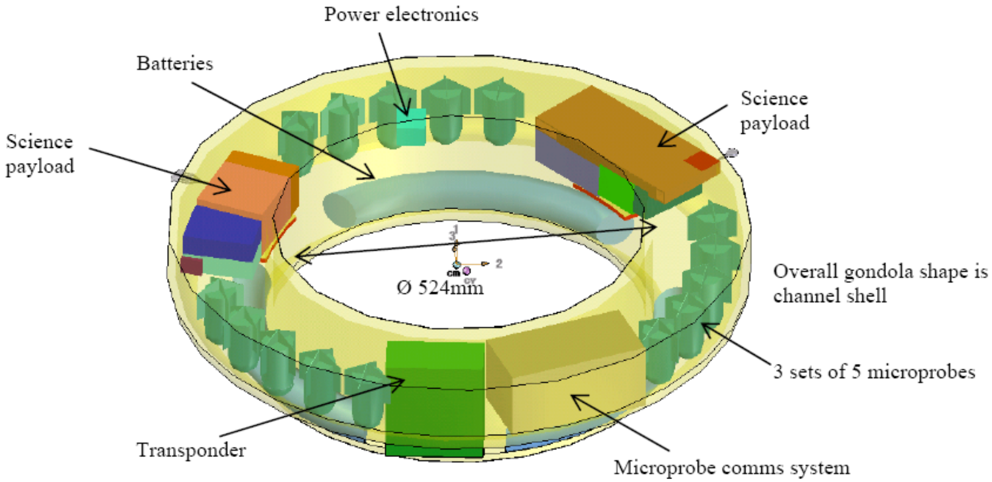
including microprobes

Jan 2007

ESA's VEP TRS balloon

constant float altitude of 60 ± 5 km





(left) Balloon as stowed in entry vehicle, and (right) layout of balloon gondola. From M van den Berg & P. Falkner, "Study overview of the Venus Entry Probe", SCI-AP/2006/173/VEP/MvdB, 2006

In comparison, the Cosmic Vision VEP balloon has a larger payload (12 kg instead of 4 kg), including more microprobes (20 instead of 15). Increased size means that probe entry mass ~ 135 kg (SCI-A/2006/173/VEP/MvdB).

Science focus for balloon (+ 100g microprobes)

- Composition of gas and cloud particles
- (Isotopic composition, noble and non-noble gases
  - This may be measured from large descent probe rather than a balloon)
- Atmospheric dynamics, structure, radiative balance
  - multiple vertical profiles, from 20 – 65 km
- Chemistry of the middle atmosphere
  - Cloud processes, relation with dynamics, radiative balance
- electromagnetic activity & electrical properties
  - lightning, volcanic, seismic and/or ionospheric sources

Balloon payload - 1

- Cloud chemistry, microphysical properties
  - GC/MS w aerosol sampling inlet (& stepped heating / pyrolysis, like Huygens ACP?)
  - Nephelometer (refractive index & size distribution)
  - Micro-balance (mass loading, aerosol composition)

- Dynamics / atm structure / radiative balance
  - Tracking of balloon & of microprobes
  - Direct measurement of p, T
  - Radiometry of upwelling & downwelling light
    - at visible, 1.0 μm, 1.7 μm, 2.3 μm, 5 μm
  - Accelerometer for upper-atmosphere structure

Balloon payload - 2

- Mass spectrometer for isotopic ratios
    - this could also be on a different platform, e.g. descent probe?
  - Medium mass resolution ($m/\Delta m \sim 1000$)
  - Use of cryotraps and/or getters to isolate compounds
  - Long integration times to improve sensitivity

- Electromagnetic / Electrical properties
  - EM wave analyser
  - Electrical permittivity, conductivity, relaxation probe
  - Lightning optical detector

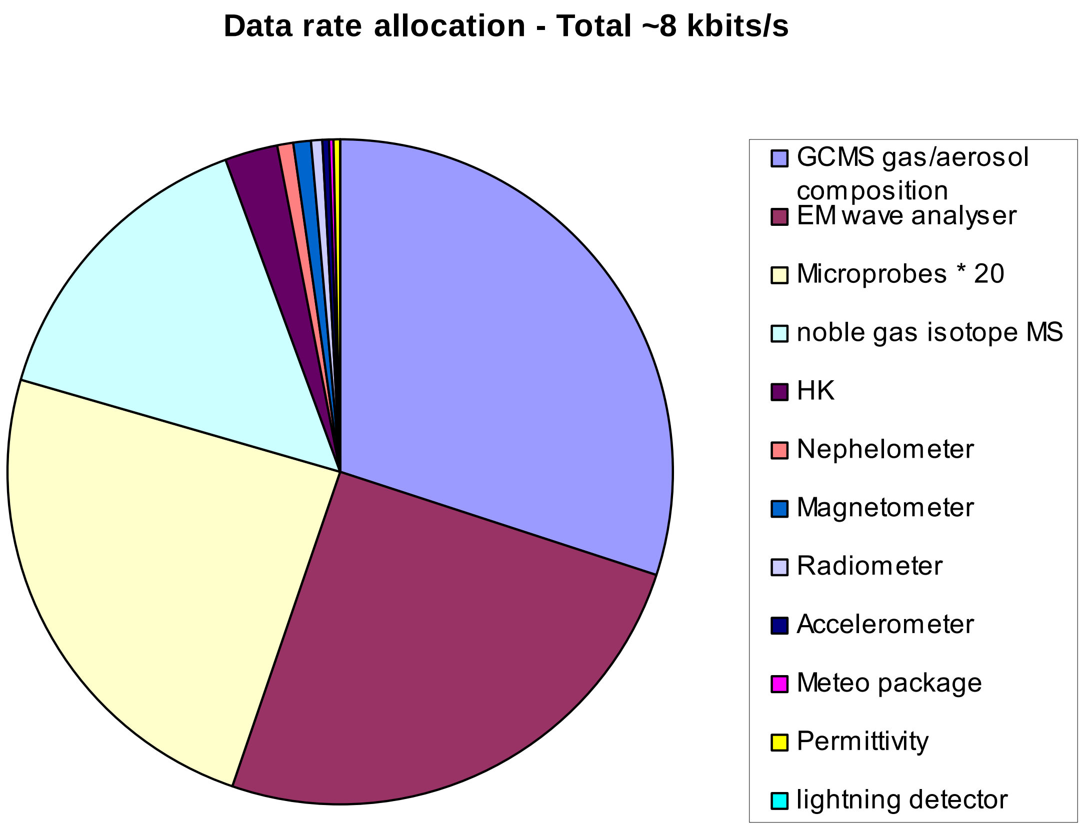
- (Magnetometer)
  - (if better on balloon than satellite)

Balloon payload

Instrument	**Scientific Goals**	**Mass** (kg)	**Power** (W)	**Data rate** Ave – (kbits/s)
Isotope Ratio Mass Spec.	1	< 4	15	1.1
Gas & cloud GC/MS/pyrolisis	3 & 5	< 4	<15	2.2
nephelometer	5	0.6	2	0.07
Environmental sensors (p,T, humidity)	4, 5	0.5	2	0.02
accelerometer	4	0.3	1.7	0.02
Aerosol μ-balance	5	0.5	1	0.02
Lightning camera	6	0.2	0.2	0.005
EM wave & elec. Properties*	6	0.7	4	1.9
Radiometer**	4, 5	0.5	1.2	0.04
Magnetometer	2	0.5	0.5	0.05
Microprobes	3,4,5,6	0.1 (x 20)	-	1.8
Option:Imaging Microprobes	*2,3,4,5,6*	*0.5 (x 6)*	-	*2.2*
MP tracking & comms sys.	-	1.5	20	-
Scientific payload total:		**~ 15 kg**	**~ 20 W**	**~ 8 kbits/s** *daily average*

Data bandwidth

Name/Acronym	bits/s
GCMS gas/aerosol composition	2222.2
EM wave analyser	1876.3
Microprobes * 20	1800.0
noble gas isotope MS	1111.1
HK	200.0
Nephelometer	67.2
Magnetometer	50.0
Radiometer	44.8
Accelerometer	22.4
Meteo package	22.4
Permittivity	11.2
lightning detector	4.7
TOTAL	~ 8 kbits/s



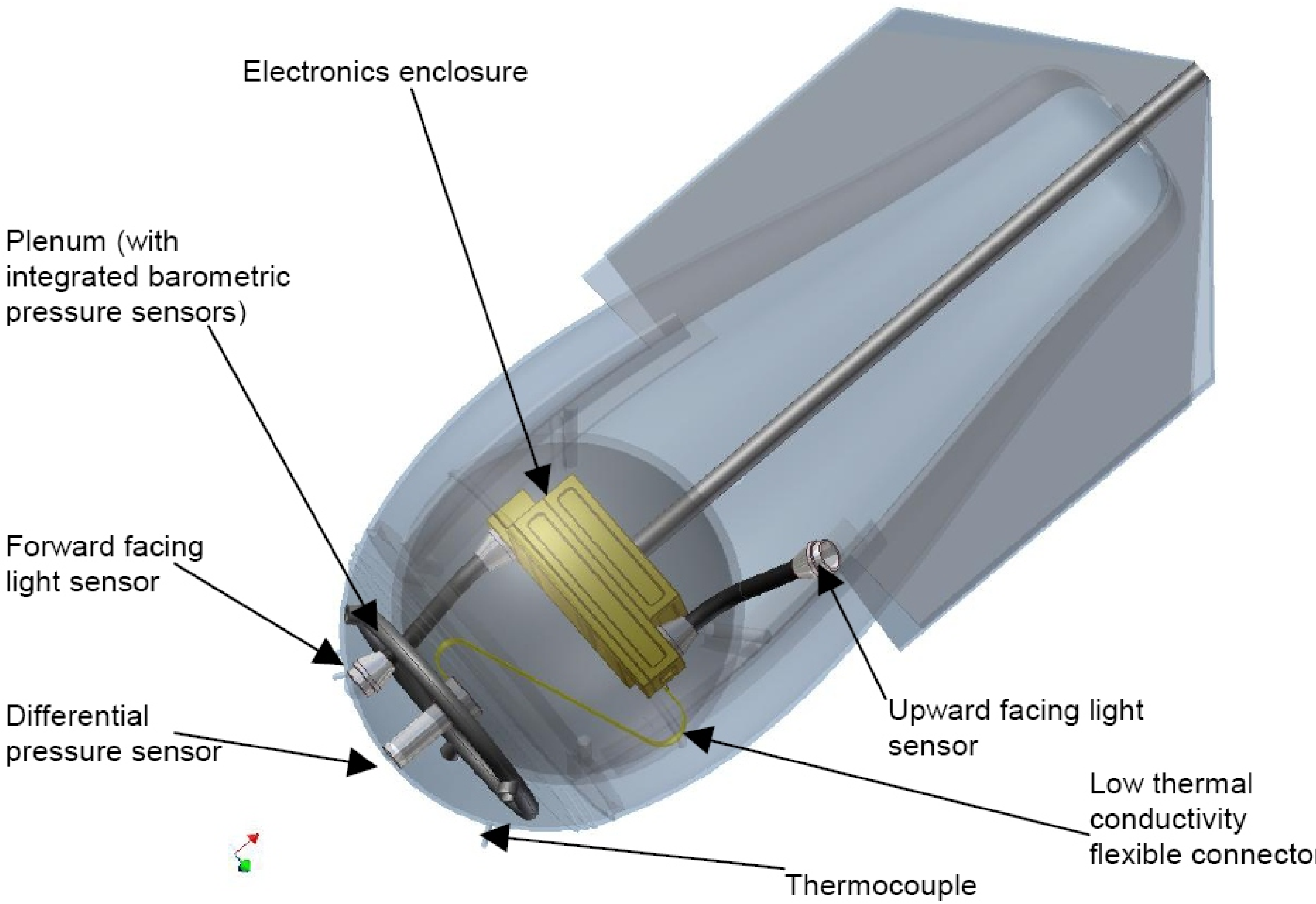
Compared to:

0.17 kbits/sec – Lavoisier proposal

10 kbits/sec – VEVA proposal

Microprobes

100 g each, 46mm ø x 110mm L



Microprobes

- Original scheme (ESA / Qinetiq / Oxford) uses 100g microprobes
  - Microprobes operate from release (60 km) until 10-20 km (when they finish operation due to high temperatures)
  - Payload measures p,T, light flux (up&down).
  - Also wind profile, from tracking of probe from balloon
  - Focus is on atmospheric dynamics, although probes fall too fast to measure small vertical velocities associated with convection and waves.
- We envisage 20 microprobes, deployed at different longitudes during balloon flight
- Microprobes communicate to balloon

Option: 500g Microprobes

- There is some desire to add functionality to Microprobes
  - Chemistry profiles
  - Camera to image surface at multiple locations

- A 500g microprobe would be able to reach the surface, with careful thermal design.
  - Distance from balloon will be greater => more power needed for comms
  - Duration of descent will be longer => more battery life needed
  - The highest data rate (imaging data) is needed when the probe is furthest from the balloon
  - Probe needs inertial navigation sensors to enable image orientation => more data rate, more mass
  - A <100g GC/MS currently has a low Technology readiness level.

- *However, the 5x increase in microprobe mass means a 5x decrease in number of probes available.*

Chemistry from Microprobes

- Chemistry profiles
  - Option A: use micro- mass spectrometer
    - Although MS itself can be very small (<20g), one needs to account for ionisation source, vacuum, valves, power supply, electronics. Total mass TBD.
    - To be studied by Open U (Simeon Barber); other studies welcome.
  - Option B: Or using simpler contact sensors (pH, oxidation, thermal conductivity, etc.)
    - Low mass; low data rate
    - But have to avoid ambiguous detections
    - Contact sensors are usually sensitive to a particular *absolute* concentration of reagent; so an array of different sensitivities may be necessary during a whole descent profile (from p = 0.5 bar to p = 90 bar)

Science focus for balloon + 500g microprobes

- Composition of gas and cloud particles
- (Isotopic composition, noble and non-noble gases
  - This may be measured from large descent probe rather than a balloon)
- Atmospheric dynamics, structure, radiative balance
  - multiple vertical profiles, from ~~20 – 65 km~~ 0 – 65 km
- Chemistry of the middle & lower atmosphere
  - Cloud processes, relation with dynamics, radiative balance
  - multiple vertical profiles, from 0 – 65 km
- electromagnetic activity & electrical properties
  - lightning, volcanic, seismic and/or ionospheric sources
- Imaging of surface at multiple sites

Other Balloons?

- The main focus of the cloud-altitude balloon is clouds – chemistry, dynamics, radiative balance.
- A 40 – 60 km oscillating balloon would be ideal for studying cloud processes: chemistry, dynamics, radiative balance.

Two different mass spectrometers

- GC/MS to focus on gas + aerosol chemistry
  - Aerosol sampling inlet, perhaps with pyrolysis (like Huygens ACP)
  - Low mass resolution ($m/\Delta m$ ~100)
  - Measurement cycles should be ~few minutes, to enable spatial resolution of ~few 10s of kms

- Mass spectrometer for isotopic ratios
  - Medium mass resolution ($m/\Delta m$ ~ 1000)
  - Use of cryotraps and/or getters to isolate compounds
  - Long integration times to improve sensitivity

Mission focus

- Cloud-altitude balloon(s) to focus on cloud chemistry & dynamics
- Descent probe(s) to focus on surface ESA probe? Or Venera-D?
- Low-altitude balloon from Japan
- Orbiter for relay + context imaging

Expanded Microprobes?

- For cloud chemistry: a 100g probe on a microprobe is not as good as a 2kg instrument on a 40-60 km oscillating balloon
- For imaging: I do not think that the poor quality of imaging will be sufficient to justify this approach, compared to large descent probes.
- Also, the 5x increase in microprobe mass means a 5x decrease in number of probes available.