A long time ago in a NASA far, far away....
EPISODE MMXVI

EMPIRE STRIKES BACK
It is a dark time for the Venusians. Planetary Science thrives despite budgetary environments, with missions in high competition for resources and opportunities. The second planet from the Sun remains a challenging and elusive goal.
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It is a dark time for the Venusians. Planetary Science thrives despite challenging budgetary environments, with missions in high competition for resources and opportunities. The second planet from the Sun remains a challenging and elusive goal.

A group of Intrepid Scientists seeks a new way forward, proposing two unlikely alliances; between humans and robots, and between Earth, Venus, and Mars....
Age of EMPIRE: Origins

- Beginning of over 2 decades of human spaceflight studies looking beyond the moon.
- EMPIRE - Early Manned Planetary-Interplanetary Roundtrip Expeditions
- Human space flight was assumed in an age before capable robotic craft.
Age of EMPIRE: 60’s – 70’s

- AEC-NASA nuclear rocket program, established in 1960; Nova rocket program.
- Explore advanced operational concepts necessary for flyby and orbiter missions.
- Other studies leveraged Apollo instead.

Opposition vs. Conjunction class missions: Short vs. long stay

(Drake & Watts Eds DRA Appdx2 2014, & others)
Age of EMPIRE: 60’s – 70’s

Opposition vs. Conjunction class missions: Short vs. long stay

Aerojet-General Coorp – Westinghouse
Astronuclear Laboratory
Aeronutronic Division of Ford Motor Company
General Dynamics/Astronautics
Lockheed Missiles and Space Co.
Belcomm Inc.
Univelt Inc.

(Drake & Watts Eds DRA Appdx2 2014, & others)

(Time/Life)
Age of EMPIRE: 60’s – 70’s

Planetary JAG Phase 1, 1966

• ‘Feasible’ Piloted Mars/Venus Flybys (1975-80)
  – Multiple flyby missions were possible
    • Venus/Mars mission Dec 1978,
    • Venus/Mars/Venus mission Feb 1977.
    • Dispense automated probes based on Mariner and Voyager technology.

• Piloted Mars Landing and piloted Venus Capture (orbiter) missions (post-1980) would see introduction of AEC-NASA nuclear-thermal rockets.

• EMPIRE study mandate assumed nuclear propulsion was coming, and Planetary JAG deemed nuclear propulsion “essential for a flexible Mars landing program” capable of reaching Mars in any launch opportunity regardless of the energy required.
Age of EMPIRE: 60’s – 70’s

- Piloted Venus Flybys
- Triple Planet Flybys (with abort option)
- Multiple planet flybys to Venus and Mars.
- Piloted Venus Orbiting Mission (1967)
- Nuclear rocket programs did not survive the 60’s
  - Final NERVA cancellation 1972)
Fallen EMPIRE: 80’s – 90’s

• Nuclear rocket programs long gone.
• End of Apollo was also the end of Apollo derivative human spaceflight.
• Focus of Planetary missions on increasingly capable robotic craft.
• Refocus of human spaceflight to LEO, Shuttle, ISS
• Reduction, loss of US human rated heavy lift.
Ashes of EMPIRE: 21st Century

- Human spaceflight targets: Mars, Moon, Asteroids...Venus?
  - Venus competitive with MB Asteroids (Landis, 2003)
- Human spaceflight focus on pathway to Mars
- Heavy planetary payloads as part of revived heavy lift capability (SLS)
- Venus scenarios remain in Design Reference Architecture (DRA, 2009, through latest addendum (#2) 2014)
  - But not focused upon
  - Opportunity unexplored / unexploited
Ashes of EMPIRE: 21st Century

(Drake & Watts Eds, DRA Appdx2 2014)
Ashes of EMPIRE: 21\textsuperscript{st} Century

- Opposition flight opportunities where both Total $\Delta V$ and Total Mission Duration are low.

- From near “double flyby” to Mars Mission Durations up to 100 days.

- Multiple arguments for Piloted Venus flybys
Venus to Mars: Mars via Venus

• Venus as possible essential waypoint to human Mars exploration.
• Mars via Venus
  – Reducing $\Delta V$ cost
  – Shortest total mission duration for Mars stay and reasonable $\Delta V$
    • Possibly crucial for early exploratory missions
  – Variety of Opposition Class missions to Mars
Venus to Mars: Venus flyby Precursor

- Mission opportunity cadence
  - Venus: 19 mo / <8 years
  - Mars: 26 mo / 15-18 years
- Mission Time: Missions ~ 1 year.
- Delta V Lower still

Earth-Venus-Earth (EVE) mission (Crain et al., 2000)
Venus to Mars: Human Factors

- Time: Shorter duration vs crew stress
- Power: plentiful. EVE more easily/conventionally powered for long mission
- Thermal protection
- Radiation exposure
Radiation Hazards

- Radiation Limits EVE vs EME
  - 30 day max doses less for EVE
  - Total doses comparable for both

- Solar Cycle and Solar distance:
  - More active sun reduces Cosmic Ray risk, greater reduction closer to sun

Crain et al., 2001
Radiation Hazards

- Increased CME/SPE risk
  - more mitigateable than CR
  - Mitigation (e.g. ‘storm cellars’) Necessary for all interplanetary targets regardless (French, 1967)

Energy spectra of nucleons and electrons in interplanetary space near Earth orbit. Flares also shown.
Miroshnichenko, 2003, Lin, 1980

Energy spectra of nucleons and electrons in interplanetary space near Earth orbit. Flares also shown.
The Case for, and Opportunity of Venus

- Multiple arguments for human spaceflight to include Venus as flyby destination alone and/or on way to Mars.
- Significant opportunity for Venus planetary community (science)
- Significant opportunity for diverse NASA communities (e.g. HEOMD, SMD) to advocate for common goal.
A New EMPIRE

• Large Probes Enabled by SLS carrying capacity
  – Power, Data volume, Capability
  – SLS leverage-able without piloted flyby.
• Real-Time Telemetry
  – No light speed delay
  – Tele-operated probes
  – Human decision making in the loop
    • Guided aerial and landers (flight/descent control)
    • Optimized sampling
• Sample Return (Upper atmosphere)
• Beyond (HAVOC)
...Or the rise of VAMPIRE

- Bringing a version of EMPIRE back from the dead as Venus And Mars Piloted Interplanetary Roundtrip Expeditions
- Requires revival of certain ambitions and ways of thinking, with application of current tech
- Requires new generation to be aware of the work that has been done before
- Requires advocates in Path to Mars and planetary community.

“Humans to Mars Via Venus” is logical, smart, and should be the path we take. And with that comes unprecedented opportunity for Venus science.
References 1

• Harry Ruppe, Manned Planetary Reconnaissance Mission Study: Venus/Mars Flyby (Huntsville, AL: NASA/TM X-53205, 1965).
• Spacecraft Engineering Branch, Apollo-based Venus/Mars Flybys (Houston: NASA MSC, September 1967).
• Contracting Officer to Prospective Contractors, “Planetary Surface Sample Return Probe Study for Manned Mars/Venus Reconnaissance/Retrieval Missions,” Request for Proposal No. BG721-28-7-528P, 3 August 1967.
References 2

• McNutt R.L. et al. “Propulsion for Manned Mars Missions: Roundtable 3” 10-IWCP
• Design Reference Architecture (DRA) for Mars:
  • Summary paper – same title IEEEAC paper #1205 does not mention Venus.