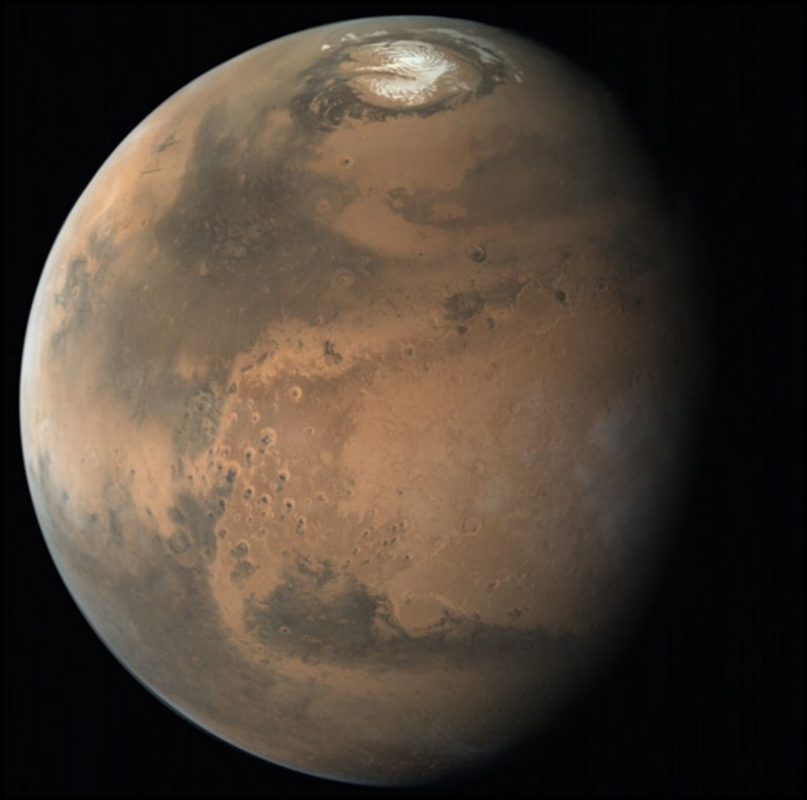
Mars Short vs. Long Stay Missions



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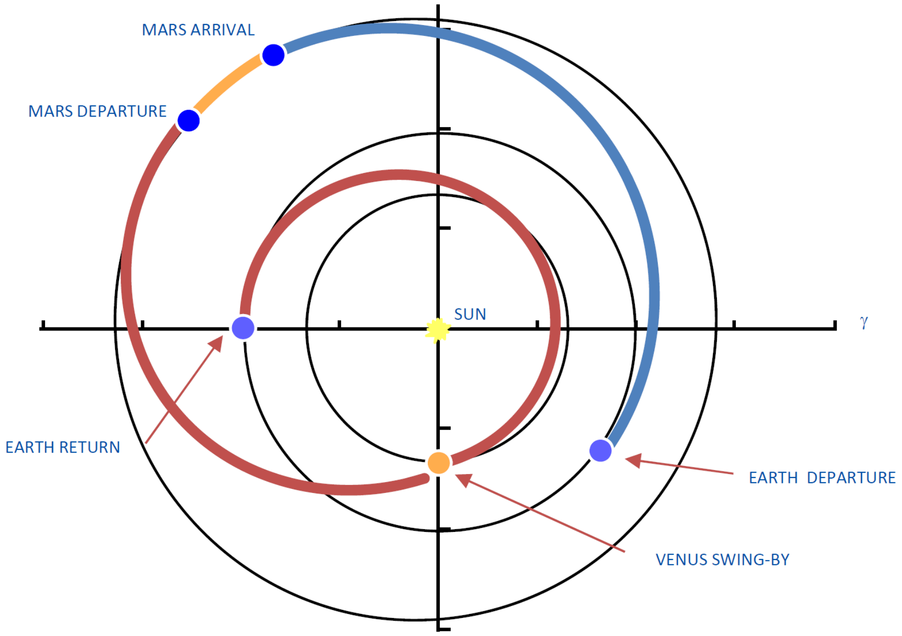
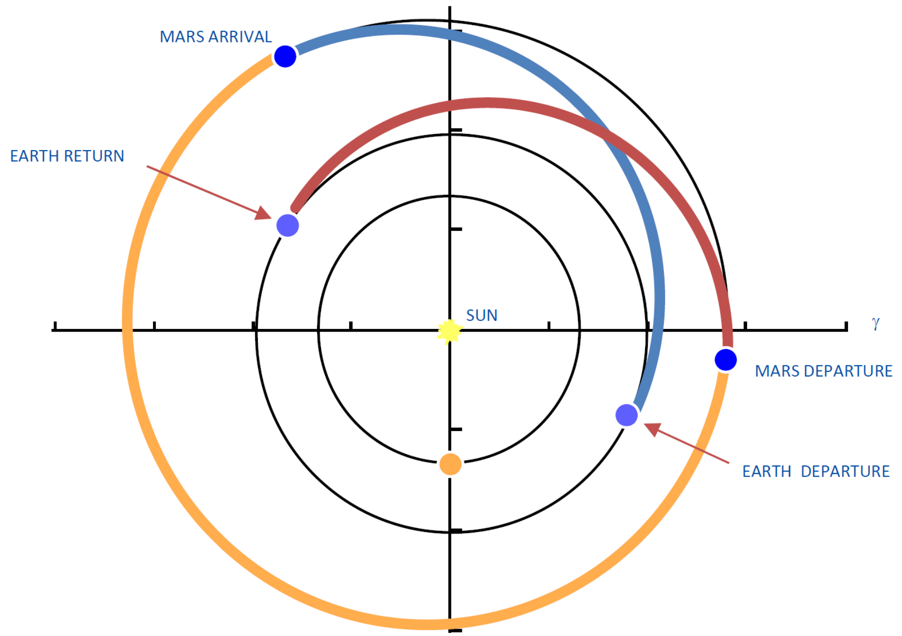
Mars Trajectory Classes

- A trip to Mars with a return back to Earth is a double rendezvous problem
  - Relative planetary alignment is a key driver in the mission duration and propulsion required

Example "Short-Stay" Opposition Class Mission



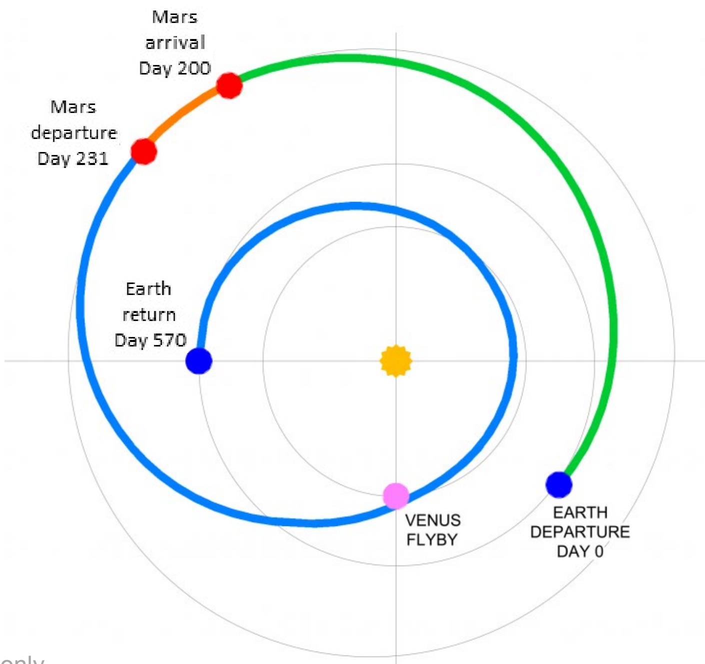
Example "Long-Stay" Conjunction Class Mission



This material is taken from Bret Drake's Feb. 2013 "Human Missions to Mars Key Challenges" webinar

Short vs. Long Duration Missions

- Opposition missions are typically 650 days vs. 950 days for conjunction missions, but they require much greater ΔV (~2-5 km/s)
  - Opposition missions vary greatly, and many opportunities are terrible
  - Conjunction missions are pretty consistent and available every two years
- Long duration missions spend ~550 days at Mars, whereas short duration spend ~30 days
- Even though opposition missions have shorter duration, the actual transit times in deep space between Mars and Earth are longer
- Most short stay trajectories perform a Venus flyby gravity assist on either the outbound or the return leg
- The 2033 opportunity offers a unique 570 day short stay opportunity
  - The ΔV penalty is lower than for other years, but still requires 3.3 km/s for the Earth return burn vs. 1.1 km/s for the long stay mission



Thermal Control for Venus Flyby Gravity Assist

- For the Venus flyby, inside 1 AU, a sunshade would probably need to be deployed to provide thermal control for the Mars transit vehicle
  - The sunshade would need to be pointed toward the sun to shade the vehicle, and solar arrays would need to be off-pointed
  - Brief periods off sun-point would need to be allowable for performing Trajectory Correction Maneuvers (TCMs) or surviving off-nominal pointing events. Non-cryo propellants would make this less problematic.
- There is a risk trade-off of performing a Venus flyby for a 1.8 year mission vs. a longer 2.6 year mission that does not go inside 1 AU
- Solar flares could present a greater threat for the crew inside 1 AU, so an adequate radiation shelter area would need to be provided inside the crewed vehicle

Alternate Option for Fast-Transit Conjunction Mission

- Conjunction mission transit times can be reduced by a month or more each way with additional ΔV
  - This option could require less additional propulsion performance than needed for opposition missions
- The trajectories never go inside the orbit of the Earth (i.e., 1 AU), reducing the thermal challenges, especially for cryogenic propellants, and reducing risk to the crew from solar radiation
- The total time spent in microgravity and in deep-space radiation environments is lowest for this option.
- The surface times on Mars can be equivalent or longer than regular conjunction missions

Conclusions

- Short stay opposition missions offer advantages to minimize deep space exposure time for the crew, but with the cost of significant engineering challenges
  - Some years have huge propulsion requirements and some years are not that much shorter than the conjunction missions
- If advanced propulsion capabilities are available (e.g. NTP), or if more propellant mass is allocated for current propulsion technologies, fast-transit conjunction missions could be an attractive option for reducing crew exposure to the deep space environment