Mission Trajectory

written by Clement Walsh on August 17, 2002

Whenever planning of any journey takes place, especially one the magnitude of a Mars mission, it is vital to look in detail at how best to reach the destination. Mars, at its closest to Earth, lies 56 million kilometers (38 million miles) away and at its farthest 400 million kilometers.

A Mars mission planner has three choices:

A. Hohmann Transfer Orbit

B. Opposition Mission

C. Fact Conjunction Mission

First I will discuss Mission (A) which was discovered by the German mathematician, W. Hohmann in 1925. This mission's advantage is that it is the easiest way to get to Mars. This is because you travel along an ellipse which is tangent to Earth's orbit on one end and tangent to Mars orbit on the other, reducing the course change required for a spacecraft to depart or rendezvous with each end. However, in this mission scenario, you will have to travel the full 400 million kilometers along some curving arch to reach Mars. This renders the Hohmann orbit pretty much out of the picture as far as manned missions are concerned. Thus, it boils down to just two options, Conjunction and Opposition missions, although the Hohmann Orbit remains valid for unmanned cargo shipments to the colonists.

NASA has favored Mission (B) because it minimizes the total mission duration. However, the opposition mission would have rather large propulsion requirements and increased cost). In fact, it would require 7.8km/s of "delta-V" to speed up or slow down the spacecraft. (delta-V is the velocity change required to move a spacecraft from one orbit to another.) The Apollo missions traveled between the Earth and Moon with an average speed of only about 1.5km/s.

As mentioned above, much more propellant is needed for an Opposition Mission. Indeed, the Opposition Mission would require more propellant then any other mission, which also translates into longer burn times, increasing risks of malfunction. A large sum of the propellant would be used on the return trajectory but not in a direct path to Earth. Instead, the ship would burn its way clear into the inner solar system where it would swing by Venus to pick up a gravity assist that would then slingshot the spacecraft towards Earth.

I personally favor mission (C), for the following reasons: a Conjunction Mission leads to a longer time spent on the surface of Mars and less time wasted in transit. How would you like to spend 180 days getting to Mars, have only 30 days on the surface, and then spend 430 days going back? A Conjunction Mission spacecraft can also be made heavier with more backup systems and supports. And because the crew will spend less time in transit, they will have less exposure to zero gravity and radiation. Additionally, a conjunction mission offers what is called a "free-return" trajectory, where if the ships propulsion system fails or the mission needs to be aborted, the crew can get home safely, as was done with Apollo 13, which employed a free-return trajectory to the Moon.

Below are stats for the Opposition and Conjunction Mission choices.

Quick Facts

It should be very clear after viewing the above facts that the Conjunction Mission is the superior choice.

Some folks might balk at a mission lasting 910 days, but it must be remembered that the crew will have plenty of things to do and think about. (Think of all the computer games they could play (if it's alright with mission control)! It would be great fun to play the other members of the crew in multiplayer!) Humans have already endured 910 days (about 2.5 years) in many different ways. I am confident the Human factor can be dealt with.

Just think, a whole 500 days to have fun exploring and seeing the sights!