Mars 2028

Creating a Sustainable Space Ferry Route to Mars and a Permanent Mars Base by 2028

By Dr. Dan Bishop, December, 2016

In 1969, after two lunar circumnavigation missions, NASA placed Neil Armstrong and Buzz Aldrin on the surface of the moon. After five additional successful landings, a total of 12 astronauts had briefly visited the lunar surface. Then….nothing. 45 years have passed since the last human presence on the moon. Now NASA is looking to send astronauts to Mars. It plans to accomplish this next great feat by putting the Apollo program on steroids and following much the same itinerary that worked for the lunar landings.

The difficulty with this approach is that a round trip to Mars is a very different creature from a journey to the moon and back. And by following the same project outline used for the lunar mission, NASA may very well experience the same end result – a single short chapter in the history books with no follow-through. As long as the focus of "Mission Accomplished" is simply getting to Mars to prove that it can be done, the dream of a permanently manned science station and eventual colonies on Mars will evaporate as surely as they did on the Moon in 1972. 50 years from now our children will wonder why human civilization is still Earth-bound and ask in bewilderment, "What happened?"

Another problem with the NASA plan is that a significant amount of new hardware must be designed, manufactured and tested in order to scale the project up to Mars capability. The potential for huge cost over-runs, project delays, and unanticipated technical glitches should be enough to give anyone second thoughts. Given the on-again, off-again enthusiasm in Congress for space-science in general, it is not hard to imagine Congress tightening the purse strings when things don't go smoothly according to plan. The now-defunct Supercollider project in Texas exemplifies this point.

With this paper, I am proposing a radical "outside the box" approach to the Mars mission that uses current technology and slightly modified off-the-shelf hardware. My proposal could easily cost half that of NASA's project with its inevitable overruns, and send twelve astronauts to Mars within a dozen years to establish a permanently manned research station on Mars. Furthermore, my proposal treats the Mars project as an on-going endeavor with reusable ferries and landers, orbital transfer stations and fuel depots, and hardware redundancy to keep the cost of maintaining a permanent base on Mars both affordable and feasible. The Falcon 9, Dragon, and Falcon Heavy provide the solid foundation for this project.

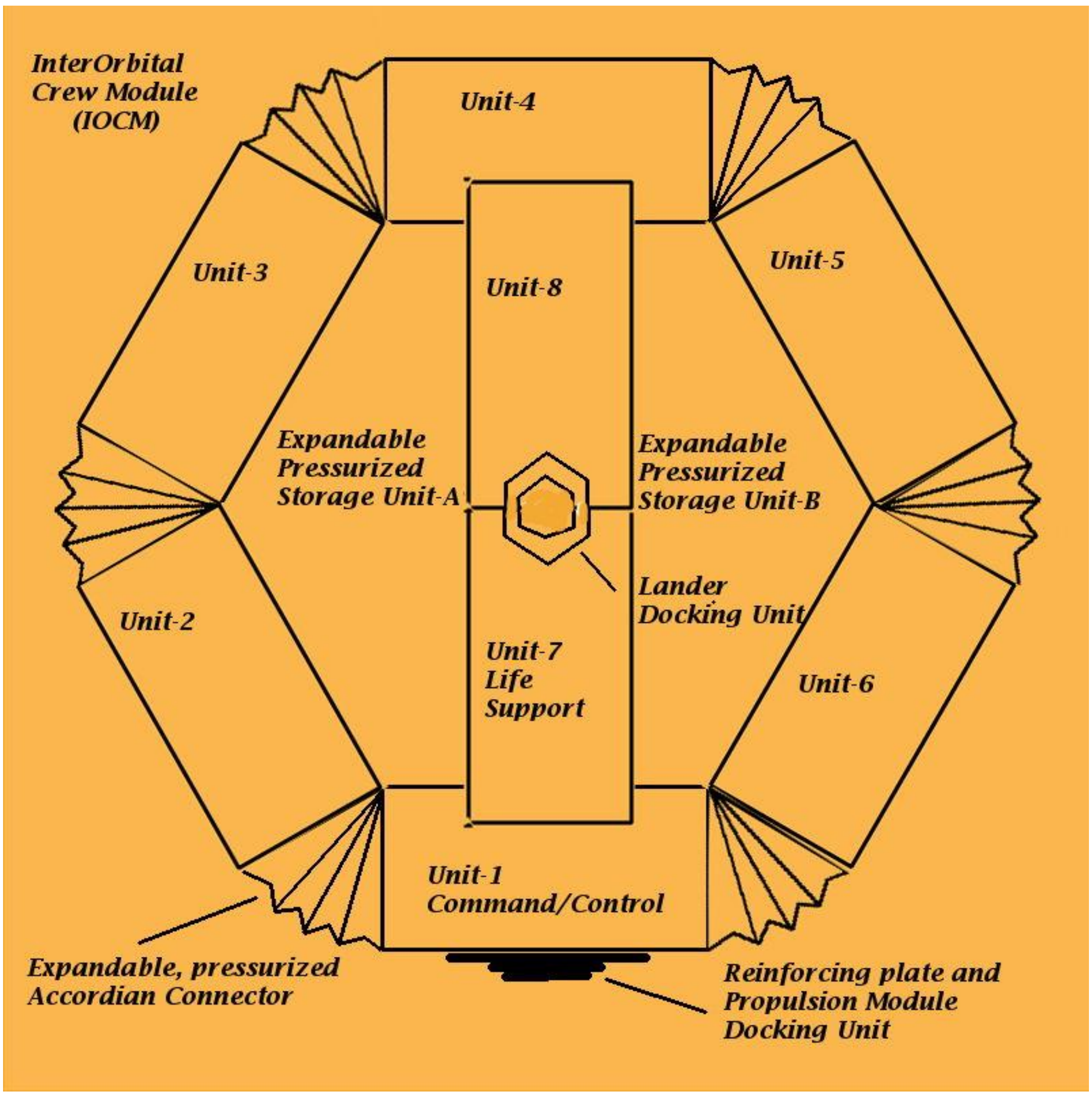
The Proposal

1. The Crew Module that will ferry astronauts to Mars and back will be an orbit-to-orbit habitat (the Crew Module) that will be detached from the Propulsion Module and fuel tanks during transit so that it can be rotated at 1 1/3 rpm, creating a 0.4 g simulated gravity along the outer rim. When propulsion is needed, the rotation is stopped and the Propulsion Module is docked to the Crew Module. For most of the trip the Propulsion Module simply tags along behind the rotating Crew Module.

   This addresses a key concern relating to astronaut's health. Up to 15% of an astronaut's bone mass is lost when exposed to zero-g for any length of time. By creating an artificial gravity similar to Mars' natural gravity for the entire trip to Mars and back, it is likely that the loss of bone mass will be reduced, perhaps significantly.

Although the Crew Module will be rotating for most of the trip, a small drone, launched from the Crew Module, will be flying directly above the Crew Module. This creates the physical possibility of generating an electromagnetic field to shield the Crew Module from cosmic radiation, which has been shown to be harmful to brain tissue after long, sustained exposure. To my knowledge, although NASA is aware of both of these issues affecting the astronauts, no practical solution consistent with NASA's program has been devised.

2. The Crew Module will be composed of six 40' by 18' cylinders (see Figure 1 below; dimensions approximate) connected to form a hexagonal ring. These cylinders are placed in orbit by Falcon 9 rockets currently in use and are sized to match the Falcon 9's payload capabilities. Flexible accordion-like wedge-shaped inserts, perhaps manufactured by Bigelow, will connect the ends of adjoining cylinders to form a continuous pressurized ring. Each wedge will have the capability of being sealed, allowing an entire cylinder to be isolated from the rest of the ring in the event of a decompression event.



3. Two additional cylinders will connect the first and fourth cylinders through the center of the ring. This will provide rigidity to the structure when the Propulsion Module, docked to the first cylinder, is firing and applying force and stress to the Crew Module. It also provides a walkway between the first and fourth cylinders and access to the storage bins (see below). These central cylinders contain the docking port for Earth-to-orbit Dragon capsules and for lunar and Mars landers, as well as an airlock to the outside. Both of these units are located at the center hub of the completed structure. An extendable crane-like arm that would be used during construction of the Crew Module, during docking maneuvers, and during supply transfers and refueling operations will be included as part of these central cylinders. Life support systems, plumbing and electrical will also be contained in these center units.

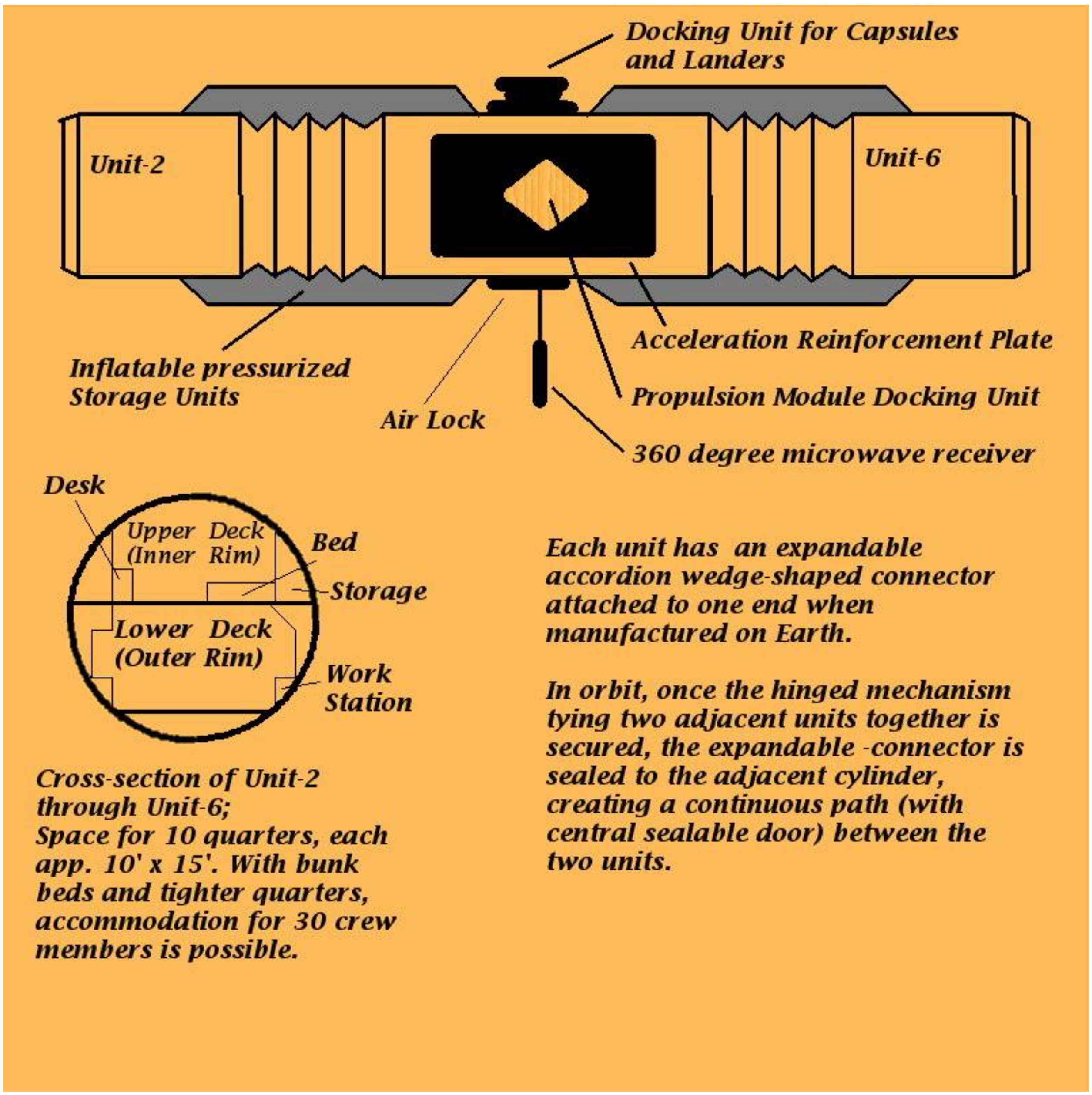


Figure 2. Side view of Crew Module and cross-section cutaway of one cylinder showing arrangement of two decks. Of course, to match the side view above, the cutaway needs to be rotated on its side.

4. The space between the ring cylinders and the two cylinders in the middle will be filled with four inflatable units, perhaps from Bigelow, that will serve as supply and equipment storage areas. These will be pressurized and accessible through sealable ports in the central cylinders. Thus the entire Crew Module when fully assembled will resemble a giant Frisbee, a six-sided disk. It will be easily large enough to transport 12 astronauts on the first mission, and double that on subsequent missions.

   As outlined here, the entire Crew Module could be completed with just eleven Falcon 9 launches into low Earth orbit. Additional launches would be necessary to rotate construction crews and to build the propulsion unit (which could consist of just two Falcon 9 engine arrays), the reusable (or refuellable) fuel tanks, and the mission power system (presumable a plutonium reactor, but possibly large solar arrays).

   Note: Once the details have been worked out, several of these basic Crew Module units can be constructed quickly and relatively cheaply. They can serve as the basis for an interplanetary fleet of orbit-to-orbit ferries. Imagine a regular 8-month flight schedule to and from Mars, regular monthly flights to and from the Moon, and perhaps even exploratory flights to Europa and Titan. The Crew Modules can serve as stand-alone orbital space stations as well. And they are expandable. Instead of a 6-unit ring, 8, 10, or even 12 units could be used. If the initial design is made to allow for future expansion, a 6-cylinder station might later be expanded while in orbit to include 12 cylinders. In fact, if properly designed from the outset, they might even be stackable! Those Lagrange Point space colonies might actually become a reality!

5. At least two Mars landers, each accommodating 5 astronauts, will be placed in Mars orbit before the astronauts leave for Mars. These landers will be designed to use rocket propulsion to slow safely into Mars' atmosphere without the need for bulky re-entry shielding and to land in an upright position. They will be squat and wide, so that a landing tip-over would be virtually impossible. A fuel depot will also be placed and maintained in Mars orbit along with the landers to provide enough fuel for several round trips to the surface for the landers, and to refuel the Propulsion Module on the main ship for the return flight to Earth. Also in Mars orbit prior to launching the Mars Mission ship will be a resupply ship containing the necessary provisions for the return trip from Mars. By caching fuel and supplies in Mars orbit for the return trip, the overall weight and volume requirements for the Mars ferry are reduced, making it possible to use existing Falcon engine arrays for the ferry's Propulsion Module.

   Keeping to the concept of reusability, the propulsion unit and fuel tanks that ferry the landers to Mars orbit may be designed to release the ferries and sweep around Mars without decelerating. The landers would then use their own engines and fuel to decelerate and achieve orbit near the fuel depot. The large ferry will swing around Mars and return to Earth orbit for another mission.

6. In addition to the units placed in Mars' orbit, supplies, equipment and habitats will have been placed on the surface of Mars at the Mars Base site, all prior to launching the Mars Mission ship. These supplies might well be launched from Earth's surface using Falcon Heavy rockets. Reusability would not be a factor in this case.

Many months later, by the time the first Crew Module is ready to return to Earth, a second will already be on its way, with two dozen astronauts on board. Perhaps by then several of the original crew will have opted to remain on Mars as well. In other words, the colonization of Mars with a permanent human footprint will have begun.

7. To construct the Crew Module, the first cylinders to be put into orbit will be the two central units, which will then be attached end-to-end. The first of these will include a docking unit for the Dragon crew capsules and supplies and an airlock for entrance and egress. These will be followed by a Dragon capsule with 6 astronauts aboard who are trained in space construction techniques. These six will live inside the first cylinder at the start, which contains the fully functioning life support systems that will become part of the finished Crew Module and a robotic arm-crane unit to be used for the construction phase that follows.

   Following these three launches, six more Falcon 9 launches will bring up the remaining six cylinders, each configured during manufacture on Earth for the Mars mission and packed with supplies and equipment. The extendable crane-arm will be an invaluable tool for bringing the individual units together and assembling the Crew Module.

   Another two Falcon 9 launches will bring up the four Bigelow inflatable units that attach to the inside of the ring cylinders and connect to the central cylinders. Once these have been put in place and inflated, the supplies and equipment initially stored in the ring cylinders for transport to orbit will be relocated to the Bigelow storage bins.

   Ring cylinder 1, or Unit-1, which includes the docking unit and acceleration reinforcement plate on its outer rim for the separate Propulsion Module, will be the command and control center and will be equipped with 12 acceleration chairs for use by the crew when accelerating and decelerating. This placement makes sense, because Unit-1 is the only cylinder for which the outer rim will be "down" both during acceleration and deceleration, and during transit when the artificial gravity from spinning the Crew Module takes effect.

   Also note that Unit-1 and the center cylinders, the two critical units, are also the most protected. During acceleration/deceleration, Unit-1 is positioned at the back of the Crew Module and protected from behind by the Propulsion Module. The central units, with the airlock, docking mechanism, and life support system, are surrounded on all sides except top and bottom by the other cylinders in the Crew Module.

8. The Propulsion Module consists of the rocket engines and removable, reusable fuel tanks, perhaps identical to those used for the Mars (and lunar) landers as well. Several Falcon 9 trips will be needed to bring these into Earth orbit. Since a fuel depot will be established in Mars orbit, only enough fuel for the trip out to Mars would need to be attached to the Propulsion Module. Furthermore, since launch is from Earth orbit, smaller Falcon 9 rocket assemblies can be used. The mammoth rocket assembly in NASA's proposal to achieve liftoff from Earth's surface for the entire round trip to Mars (and including Mars landing and takeoff) is totally unnecessary. Smaller engines firing for a longer period of time will serve to gently lift the Mars ferry out of Earth orbit and achieve escape velocity. The potential for a catastrophic failure is greatly reduced, not to mention project delays and cost over-runs as a totally new and untested generation of gigantic engines is developed.

The Crew Module power source will also be attached to the Propulsion Module, whether it be a plutonium generator or solar panels (or both). The power generated by these units will be converted to microwaves and beamed to a 360-degree receiver (to accommodate the Crew Module rotation) on a mast located at the very center of the Crew Module. In this way, a continuous beam of power can be transmitted to the rotating Crew Module from a stationary power source on the Propulsion Module. Communications will also be a stationary unit attached to the Propulsion Module. This will include a full set of 360-degree global video cameras that will send real-time video to the command/control center's video monitors. To the crew inside, it will seem that they are looking through portholes directly into space rather than at LED monitors, with the added capability for digital control of the images.

9. Once the Crew Module and Propulsion Module have been constructed, six astronauts will perform a test run to lunar orbit. A lunar lander and small fuel depot, identical to those now in Mars orbit, will have been put in place in lunar orbit. After docking with the lunar lander, several of the astronaut crew will board the lander, descend to the surface of the moon for a short visit before returning to the orbiting Crew Module, which then refuels and returns to Earth orbit. In this way, all of the systems involved in the Mars mission will be thoroughly tested and any unexpected glitches ironed out before launch to Mars. Among the critical tests are docking and undocking with the Propulsion Module and with the landers, spinning and stopping of the Crew Module after separation from the Propulsion Module, adequacy of the designed life support systems, reliability of the microwave power feed from the Propulsion Module's solar cells or plutonium generator, and refueling the Propulsion Module and lunar lander while in orbit.

10. An uneventful trip to Mars should follow, which includes a gentle acceleration from Earth orbit to the necessary velocity to escape Earth and reach Mars. Once launched from Earth orbit, the Propulsion Module undocks from the Crew Module, the EM drone is released above the Crew Module, and the Crew Module is set to a 1 1/3 rpm rotation to simulate 0.4g along the outer rim.

    Crew quarters are distributed among Units-2 through 6, with each unit divided lengthwise to form two floors (refer to cutaway in Figure 2). The larger outer floor is for common living quarters, (food prep and dining, exercise, conference, etc.) experiment stations and labs. The "upper" inner floor is used for sleeping quarters and individual study/entertainment "rooms", 2 to 4 per unit. The beds are configured with a protective shield over the pillow area to provide additional protection from cosmic radiation for at least the 8 hours per day that the astronaut is sleeping.

    It should be noted that this two-floor ring design, along with the small personal dorm units, provides more "space" and allows for more privacy than the "single canister" approach for the crew. This will relieve much of the psychological pressure the crew would otherwise experience during such a lengthy space voyage.

    On approach to Mars, the Crew Module rotation is halted, the EM-drone is retrieved, the Propulsion Module docks with the Crew Module, the ship is rotated 180 degrees and the rockets are fired to decelerate the ship and place it into Mars orbit and rendezvous with the

Mars landers, resupply ship, and fuel depot. On entering orbit, the ship will have used most all of the fuel on board.

11. Landing on Mars entails docking with a lander, 5 astronauts boarding the lander, and the lander undocking and descending to the surface, landing near the previously positioned supply ships using reverse thrust techniques perfected by Space X with their first-stage recovery program. Once safely down, the second lander brings 5 more astronauts to the surface, leaving the orbiting Crew Module with a crew of two. Over the course of the next several months, the landers will make repeated trips to the orbiting Crew Module to rotate crews, to transfer supplies and soil samples, etc. Not all lab work need be done on the surface, saving the cost of sending some of the more delicate laboratory equipment and supplies to the surface.

12. While in orbit, the Crew Module, detached from the Propulsion Module, will be rotated as before. It may be possible that the landers can be synchronized with the rotating Crew Module before docking, thus alleviating the need to stop and restart rotation with every docking maneuver.

13. The return trip to Earth is merely the reverse of the trip out, accomplished after refueling the Propulsion Module and re-supplying the Crew Module with provisions while in Mars orbit. Hopefully, of the twelve astronauts initially sent to Mars, only 5 or six will wish to return, knowing that a second ship is already on its way with 24 astronauts on board. By the time the second ship reaches Mars, one might hope that two additional Crew Modules will have been built and put in permanent orbit around both the earth and the moon and that a permanent Lunar Base will have been established.

14. The time framework for this project will be considerably shorter than that proposed by NASA, perhaps seeing fulfilment by 2028. If the project is initiated in 2017, Crew Module cylinders could be designed and fabricated over a two or three-year period, the same time currently allocated for the Dragon Earth-to-orbit crew capsule. Thus by 2020, six astronauts could be living in orbit aboard Cylinder 7 and awaiting delivery of the other cylinders. 2021 and 2022 then become the years that all of the remaining Crew Module components are delivered to Earth orbit and assembled. 2023 and 2024 sees the Propulsion Module, with the Crew Module power unit(s) and communication units assembled and equipped fuel tanks. In 2025 the Mars ship is taken for its trial run to the moon. By mid-2026, the twelve-person crew is delivered to Earth orbit in two Dragon capsules and the Mars launch is initiated, with arrival set for early 2028.

    Coincident with this schedule are the design and production of the Mars landers and the habitat modules that will be delivered to Mars' surface. The landers and fuel carriers will need to be launched by 2024 to achieve satisfactory orbit around Mars before the Mars Mission ship is launched. The same deadline is required for the supply ships and habitat carriers that will land on Mars' surface, with the realization that if any of these trips meets with failure, a backup must be ready for immediate launch to replace the missing link.