Flags and Footprints on Phobos and Deimos

By

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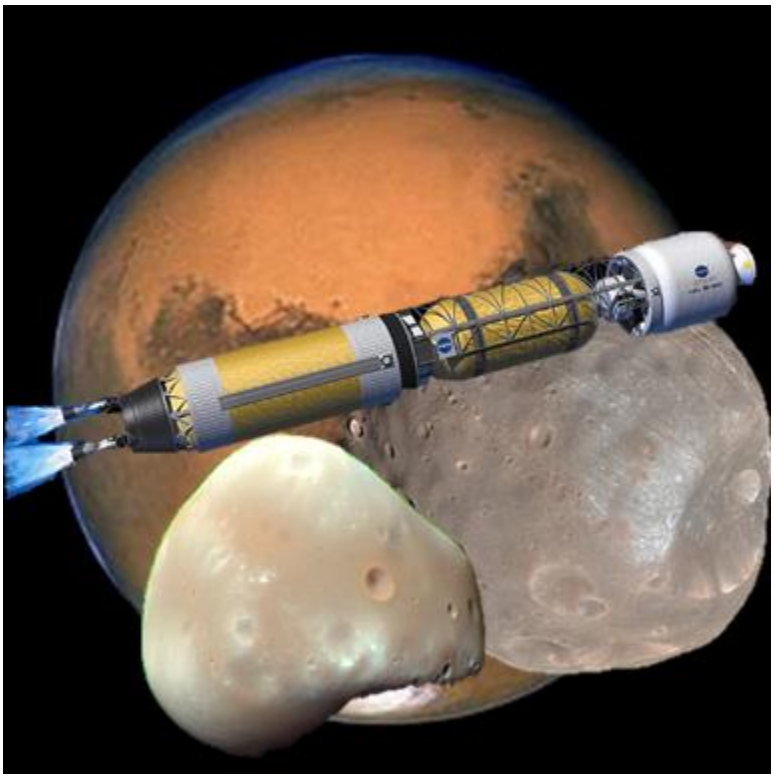

Abstract

Scanners on balloons and rovers digitize the Mars surface. Remote controlled rockets launch sample containers. A Robonaut 5 captures the containers. A flight engineer uploads the surface models to a virtual reality metaverse for the public. Robonaut 5 assists with excursions to Phobos and Deimos.

Prologue

Sept. 13, 2030 A Block-2 Space Launch System (SLS), with a capacity of 130 MT, launches a Solar Electric Propulsion (SEP) Mars Transfer Vehicle (MTV); the USS Minerva starts her 900 day voyage to Mars.

Oct. 18, 2030 A Block-2 SLS launches a SEP MTV named Minerva's Owl. Hauling a stage containing Liquid Oxygen (LOX) and methane tanks, Minerva's Owl flies to Mars.

July 28, 2032 A Block-2 SLS launches an Exploration Upper Stage (EUS) with LOX and methane tanks, a propulsion system, and a truss with robotic arms.

Aug. 4, 2032 A Block-2 SLS launches an upper stage with liquid oxygen and methane tanks. An Orbital Maneuvering Vehicle (OMV) moves the stage into a position where the robotic arms on the EUS truss can pull the tank stage and lock the stage to the truss.

Aug. 11, 2032 A Block-2 SLS launches another tank stage and an OMV moves the stage to a position where the EUS robotic arms attach the stage to the truss.

Aug. 19, 2032 A Block-2 SLS launches a Bigelow Aerospace Olympus habitat. (BA 2100)

Aug. 24, 2032 A Block-2 SLS launches an upper-stage with an Orion spacecraft, solar power system, and an OMV. After reaching the EUS, the Orion ejects the upper-stage and the EUS truss robot arms latch the Orion to the end of the truss. Docking with the BA 2100 completes the vessel named the Anna Perenna.

Aug. 27, 2032 A three person crew and a Robonaut 5, aboard the Anna Perenna, depart for a 200 day voyage to Mars.

Arrival of the USS Minerva

Friday, March 1, 2033 - The ship is named after the virgin goddess of wisdom who was a sponsor of arts and desired by Mars. Configured like a swordfish, a long truss extends from Minerva's bow. A dozen bell-shaped, surface exploration system pods, arranged in four groups of three cling to the truss via docking mechanisms in the tips of the pods' shrouds. Heatshields at the bases of the pods face outwards and the docking mechanisms are spaced 120 degrees apart. Six of the pods carry 700 kg payloads and the other six carry 7,500 kg payloads.

Four times per orbit, the USS Minerva releases a pod. With each orbit, the drop-points advance by three degrees. When a 700 kg pod deploys, it descends to an altitude where parachutes can deploy. The heat-shield falls away and the parachutes pull the shroud from the payload. As the parachutes pull the shroud from the payload, a dark grey Montgolfier balloon unfurls and inflates as it plummets through the Mars atmosphere. The inflating balloon serves as a parachute for a rover attached to the bottom of a gondola. As the rover approaches the surface, a compressed nitrogen tank fills a bladder that cushions the rover during impact. The bladder bursts, the balloon detaches, and the rover starts a self-diagnoses.

Sunlight heats the atmosphere within the Montgolifier balloon causing it to rise. The Montgolfier brothers first flew their hot-air balloon in the 1780s, they would be proud to see their invention enabling the exploration of another world. In the gondola, a 3D Laser Radar (LIDAR) system

generates a geometric mesh model of the surface. During the nights, a heater in the gondola keeps the balloon aloft.

When a 7,500 kg pod descends, the heat-shield falls away the parachutes deploy. A descent propulsion system gently lands the payload and crushes the engine bell. Solar panel petals open and serve as ramps for two rovers to deploy to the surface. The rovers begin a search for suitably sized rocks. Four drills augur 20 core samples from the surface perimeter of the lander. Robotic arms place the core-samples rocks returned by the rovers into a sample return container. This sample container is located on top of a solid rocket supported by a small gantry on the lander.

Arrival of the Anna Perenna

Tuesday, March 15, 2033 - On the Ides of March, the Anna Perenna arrives in Mars orbit. The ship is named after the aged goddess of long-life who disguised herself, as Minerva, so Mars would take her to his bed chamber. The Bigelow Aerospace BA 2100 Olympus habitat measures 17.8 m (58.4 ft.) in length and 12.6 m (41.3 ft.) in diameter for a roomy 2,250 cubic meters (79,000 cu. ft.). A gymnasium in the aft compartment includes a Gravitron, a tread-mill with a harness, and other exercise equipment. Three floors include compartments for farming, cultured meat production, food storage, a galley, a dining area, equipment storage, maintenance, crew quarters, incinerator toilets, a recreational area, a couple of laboratories, and the bridge.

Wednesday, March 16, 2033

Commander Gretchen Windheuser, pilot Bernie Mullier, and Robonaut 5 are on the bridge. A rested and relaxed flight engineer, Rhiver Locklear, floats onto the bridge to relieve the commander. The human crew members have staggered shifts so that two of them are on the bridge and the third is exercising, relaxing, or resting.

One could describe the bridge of the Anna Perenna as a paper cockpit. A few electrophoretic (electronic-ink) displays present data visualization dashboards with subsystem statuses including avionics, propulsion, environmental control, life support, air-locks, and robotics. Augmented reality glasses superimpose 2D data visualizations and 3D virtual reality models on flat white surfaces around the bridge.

Rhiver settles into his workstation and processes the incoming scanned 3D geometric surface models from the Montgolfier balloon gondolas and the rovers that were deployed by the balloons. The 3D LIDAR systems in the gondolas provide large-region surface models, albeit at a lower resolution. On the surface the rovers capture high resolution models of smaller areas. Concluding a quality check, Rhiver uploads the models to a metaverse comprised of commercial and academic virtual worlds, including Second Life, All These Worlds, and Open Sim servers.

Bernie reviews the status of the sample return launchers. Through his augmented reality glasses, Bernie views 3D visualization of the orbital trajectory of the Anna Perenna and planned trajectories of sample return containers. Bernie selects the order of containers to capture. Signals sent to the sample return launchers initiate a countdown.

A few kilometers below, an OMV flies with Robonaut 5 perched on top. As the launched containers approach the peak of their trajectories, Bernie remotely launches a tethered Automated Rendezvous & Docking (AR&D) mechanism from the OMV. As the tether reels-in the container, Robonaut 5 attaches the container to the side of the OMV.

Four out of the six retrievals were flawless; the AR&D mechanism made minor course corrections and connected with the corresponding docking mechanism on the containers. Unfortunately, one of the solid-rockets exploded during ascent. During the sixth retrieval, the tether wildly misses the target. Bernie curses under his breath, initiates another targeting sequence and remotely launches a second tether from the OMV. As the container passes the trajectory peak and begins its descent, the AR&D system on the second tether connects with the target.

After capturing the containers, Bernie remotely flies the OMV back to the mother ship. Robonaut 5 latches the containers into an external storage area. Each container includes a small box that Robonaut 5 removes and brings back into the ship. These small samples will enable Gretchen to conduct some analysis and provide nearly immediate results to the world geological community.

Sunday, April 3, 2033

Observing an X10-class solar flare and a spike in protons, Rhiver reports “Commander, there is an 80% chance of a CME within the hour.” Flares and Coronal Mass Ejections (CME) can produce proton storms lasting for hours or days. Gretchen orders Robonaut 5 to back-up memories to the ship’s archives and the crew to their quarters. The habitat walls around the crew-quarters and recreational areas include a layer with water bladders. The water helps to reduce the incoming radiation during a proton storm. Gretchen, Bernie, and Rhiver ride out the storm in their crew-quarters and in the gym.

Located in the gym, an enclosed ring measuring 11.8 meters in diameter and spinning at 11 revolutions per minute, the Gravitron provides a centripetal force equal to 80% of Earth's gravity. An adjoining fly-wheel spinning in the opposite direction counteracts the gyroscopic effect of the Gravitron. Rhiver rides his all-terrain recumbent bike along Brandywine in the Shire. With his head-mounted display, he is completely immersed in a virtual reality model of Middle Earth. A C-shaped base of the recumbent bike wraps around the top of a T-shaped electromagnetic track within the circular wall of the Gravitron. Pedaling the recumbent bike generates power that electromagnetically levitates and propels the bike, which can increase the centripetal force to one Earth gravity.

Monday, April 4, 2033

The proton storm fried one of the circuit boards in the communications system. After the storm, Robonaut 5 removed the burnt board and brought it into the ship. Rhiver applies additive manufacturing to reproduce the circuit board. Though the system can print relatively complex circuit boards, the complex processor chips cannot be printed. Rhiver opens a couple of canisters and checks part-numbers until he finds the needed chips. He hands the chips to Robonaut 5 who

quickly plugs-in the chips and solders the leads to the printed circuit. Robonaut 5 conducts another Extra-Vehicular Activity (EVA) to replace the communications board.

Tuesday, April 5, 2033

With Robonaut 5 perched on top, Gretchen flies the OMV to Phobos. As the OMV hovers a couple of feet above the surface near Stickney crater, Gretchen steps out in her EVA suit. She gazes upon the Phobos monolith as Robonaut 5 comments as a tourist guide, "First photographed in 1998 by the Mars Observer Camera on the Mars Global Surveyor, this monolithic surface feature is approximately 85 meters (279 feet) in diameter and at least 170 meters (557 feet) tall."

"Rhiver, are you getting this?" asks Gretchen as she captures video of the Phobos Monolith. Rhiver replies "Affirmative!" Gretchen observes the interesting light and dark patterns on the surface of the monolith and comments "The pareidolia geeks are going to love the apparent lines and shapes." After planting an American flag and collecting some regolith and a few rocks, Gretchen reenters the OMV and returns to the Anna Perenna.

April 5, 2033

Minerva's Owl, the second SEP MTV, arrives in Mars orbit. Gretchen issues the command to drop an empty stage and Bernie initiates the routine for the EUS truss robotic arms to detach the empty tank stage. Maneuvering within a safe distance of the Anna Perenna, Minerva's Owl detaches from the tank stage. Robonaut 5 flies the OMV to the tank stage and moves it within reach of the EUS truss robotic arms. The robotic arms pull the full tank stage to the truss and lock it in place.

April 10, 2033

Bernie flies to Deimos in the OMV with Robonaut 5 mounted on the outside. Wearing his EVA suit, Bernie steps out of the OMV upon arrival. As Bernie plants a flag near Swift crater, Robonaut 5 comments "This crater is named after Jonathan Swift because his book 'Gulliver's Travels' predicted the discovery of the moons of Mars". The OMV follows Bernie as he visits several sites around Deimos. Robonaut 5 scans the local area and generates 3D models with dense tracking and mapping code. On the Anna Perenna, Rhiver receives the incoming data and integrates the models into the metaverse. After a few hours, Bernie flies the OMV back to the mother ship.

The Voyage to Earth

April 15, 2033 - The Anna Perrena departs Mars orbit.

August 18, 2033 – A micrometeoroid punctures the Orion spacecraft. Rhiver uses a Kit for External Repair of Module Impacts (KERMIt) to patch the small hole.

November 1, 2033 – The Anna Perrena enters the Moon's orbit around Earth. A lunar descent-ascent spacecraft docks with the ship and the human crew members climb aboard. The spacecraft descends to the Moon. Doctors check out the crew for radiation sickness. After a few days of rest and relaxation, the crew returns to Earth aboard a commercial space tourism spacecraft.

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