Chapter 1: On the Grand Scale

> Will man ever go to Mars? I am sure he will—but it will be a century or more before he's ready. In that time scientists and engineers will learn more about the physical and mental rigors of interplanetary flight—and about the unknown dangers of life on another planet. Some of that information may become available within the next 25 years or so, through the erection of a space station above the Earth . . . and through the subsequent exploration of the [M]oon. (Wernher von Braun, 1954)[1]

Von Braun in the Desert

At the beginning of serious Mars expedition planning in the United States stands German rocket pioneer Wernher von Braun. From 1945 to 1950, von Braun was interned at White Sands Proving Ground in New Mexico with about 60 other German rocket engineers spirited out of Nazi Germany by the U.S. Army at the end of the Second World War. Under Hitler, they had developed the first large liquid-propellant rocket, the V-2 missile, at the Nazi rocket base of Peenemünde; in the United States, they shared their missilery experience by preparing and launching captured V-2s under Army supervision.

In 1947 and 1948, to relieve boredom, von Braun wrote a novel about an expedition to Mars. Frederick Ordway and Mitchell Sharpe wrote in their history The Rocket Team that von Braun's novel "proved beyond doubt that its author was an imaginative scientist but an execrable manufacturer of plot and dialog."[2] Perhaps understandably, the novel never saw print. In 1952, however, its appendix, a collection of mathematical proofs supporting its spacecraft designs and mission plan, was published in West Germany as Das Marsprojekt. The University of Illinois Press published the English-language edition as The Mars Project a year later.[3] By then von Braun and many of his German colleagues were civilian employees of the Army Ballistic Missile Agency (ABMA) at Redstone Arsenal in Huntsville, Alabama.

Von Braun described a Mars expedition "on the grand scale," with ten 4,000-ton ships and 70 crewmembers.[4] He assumed no Earth-orbiting space station assembly base. His spacecraft were assembled from parts launched by three-stage winged ferry rockets. Nine hundred fifty ferry flights would be required to assemble the Mars "flotilla" in Earth orbit. Von Braun estimated that each ferry rocket would need 5,583 tons of nitric acid and alcohol propellants to place about 40 tons of cargo into orbit, so a total of 5,320,000 tons of propellants would be required to launch all ten Mars ships. To provide a sense of scale he pointed out that "about 10 per cent of an equivalent quantity of high octane aviation gasoline was burned during the six months' operation of the Berlin Airlift" in 1948-49.[5] Von Braun estimated total propellant cost for launching the expedition into Earth orbit at $500 million.

Seven vessels in von Braun's plan were assemblages of girders and spheres without streamlining designed for the round-trip Mars voyage. Incapable of landing, they featured inflatable fabric propellant tanks and personnel spheres. Three one-way ships would each have a winged landing glider in place of a personnel sphere. At the appointed time, the flotilla's rocket engines would ignite to put the ships on a minimum-energy Earth-to-Mars trajectory. As Earth shrank behind, the Mars ship crews would discard empty Earth-departure propellant tanks and settle in for an eight-month weightless coast.

The members of the first Mars expedition would be the first humans to see the planet up close. No robotic explorers would precede them; von Braun did not anticipate the technological advancements that enabled automated explorers.

From Mars orbit they would turn telescopes toward Mars' equator to select a site for a surface exploration base camp. The first Mars landing site, however, would be determined at the time the expedition left Earth. One landing glider would deorbit and glide to a sliding touchdown on skids on one of the polar ice caps. Von Braun chose the polar caps because he believed them to be the only places on Mars where the crew could be certain of finding a smooth landing site. In von Braun's plan, the first people on Mars would abandon their glider on the ice cap and conduct a heroic 4,000-mile overland trek to the chosen base camp site on Mars' equator. There they would build a landing strip for the pair of wheeled gliders waiting in orbit. This Mars landing approach is unique to von Braun's work.

The wheeled gliders would touch down bearing the balance of the surface exploration party, leaving a skeleton crew in orbit to tend the seven remaining ships. As soon as the glider wheels stopped, the explorers would unbolt their delta wings and hoist their V-2-shaped fuselages upright to stand on their tail fins, ready for

blast off back to the ships in Mars orbit in case of emergency. They would then set up an inflatable habitat, their base of operations for a 400-day survey of Mars' deserts. They would gather samples of native flora and fauna and explore the mysterious linear "canals" glimpsed through Earth-based telescopes since the late nineteenth century. The journey back to Earth orbit would mirror the flight to Mars. Total expedition duration would be about three years.

In almost every Mars expedition plan from von Braun to the present, propellant has been potentially the single heaviest expedition element. Von Braun attempted to minimize total Mars expedition weight—and thus the number of expensive rockets required to launch the expedition from Earth's surface—by reducing as much as possible the amount of propellant needed to boost the expedition from Earth to Mars and back again. His mission profile—a minimum-energy Mars transfer, followed by a long stay during which the planets moved into position for a minimum-energy transfer back to Earth—was the chief means he used to reduce required propellant. This approach, called a conjunction-class mission, will be described in more detail in chapter 3. Extensive use of inflatable fabric structures also helped reduce spacecraft weight, though von Braun invoked them primarily because they could be folded to fit within the cargo bay of his hypothetical ferry rocket.

Use of multiple Mars ships and landers minimized risk to crew. If one ship failed, its crew could transfer to the other ships at the price of increased crowding. Von Braun's expedition plan boosted science return through large crews (including professional scientists), a small fleet of tractors for wide-ranging surface traverses, and ample scientific gear. His thinking was shaped by large Antarctic expeditions of his day, such as Operation High Jump (1946-47), which included 4000 men, 13 ships, and 23 aircraft.[6] In the days before satellites, Antarctic explorers were largely cut off from the world, so experts and technicians had to be on hand to contend with any situation that might arise. Von Braun anticipated that Mars explorers would face a similar situation.

In keeping with his assumption that little automation would be available for precursor probes, von Braun's piloted ships were largely manually controlled, making large, naval-style crews mandatory. Lack of automated systems also dictated that some crewmembers remain in Mars orbit to tend the Earth-return ships.

It is interesting to compare von Braun's vision with the Apollo lunar expeditions, when just two astronauts landed on Earth's Moon. An army of personnel, including scientists, formed part of each Apollo expedition, but remained behind on Earth. This separation was made possible by communication advances von Braun did not anticipate. In 1952 von Braun stated that television transmission between Earth and a lunar expedition would be impractical.[7] Sixteen years later, Neil Armstrong's first footsteps on the dusty, cratered Sea of Tranquillity were televised live to 500 million people.

Collier's

Von Braun's slender book of proofs was not widely distributed. His vision, however, won over the editors of the colorful Collier's weekly magazine, who commissioned him to write a series of space exploration articles. The Collier's editor for the project, Cornelius Ryan, also solicited inputs from astronomer Fred Whipple, physicist Joseph Kaplan, physiologist Heinz Haber, United Nations lawyer Oscar Schachter, science writer Willy Ley, and others. Technical and astronomical art by Chesley Bonestell, Rolf Klep, and Fred Freeman brought von Braun's technical descriptions to life. Collier's, now defunct, had a circulation of three million, making it one of America's most popular magazines. Through the Collier's articles, charismatic von Braun became identified with space flight in the minds of Americans—the quintessential white-coated rocket scientist.

Collier's published eight articles laying out a logical space program blueprint. The first, published on 22 March 1952, described von Braun's winged ferry rockets and a spinning, wheel-shaped artificial-gravity space station in Earth orbit.[8] Collier's readers reached the Moon in October 1952[9] and explored Mars in the 30 April 1954 issue.[10] Each step in von Braun's program built infrastructure and experience for the next.

Von Braun's Collier's Mars plan was identical to that described in The Mars Project, except that the ten-ship Mars flotilla would be assembled near an Earth-orbiting space station. Again, von Braun assumed no robotic precursors. This time, however, telescopes located on the space station, high above Earth's obscuring atmosphere,

would be used to refine knowledge of Mars and select candidate landing sites before the expedition left Earth.

Mars plans tend to focus on spacecraft, not astronauts. In the Collier's Mars article, however, von Braun explored the psychological problems of the Mars voyage. "At the end of a few months," he wrote, "someone is likely to go berserk. Little mannerisms—the way a man cracks his knuckles, blows his nose, the way he grins, talks or gestures—create tension and hatred which could lead to murder . . . [i]f somebody does crack, you can't call off the expedition and return to Earth. You'll have to take him with you." He also proposed censoring radio communication to prevent the crew from hearing dispiriting news about their hometowns.[11]

The Collier's articles were expanded into a series of four classic books. The first four chapters of the 1956 book The Exploration of Mars[12] covered the history of Mars observation and the then-current state of knowledge. Wrote von Braun and his collaborator Willy Ley: "This is the picture of Mars at mid-century: A small planet of which three-quarters is cold desert, with the rest covered with a sort of plant life that our biological knowledge cannot encompass . . ."[13] For von Braun, life on Mars was a given. In fact, von Braun's Mars was not too different from the New Mexico desert where he penned Das Marsprojekt.

Von Braun and Ley then described the Mars expedition. They conceded that it was "entirely possible . . . that within a decade or so successful tests with some sort of nuclear rocket propulsion system might be accomplished"; however, for the present, it was "exciting as well as instructive" to show that humans could reach Mars using available (1950s) technology.[14]

Their Mars expedition was a cut-price version of the 1952 Das Marsprojekt/1954 Collier's expedition, with just 12 crewmembers in two ships. Four hundred launches would put the parts, propellants, and supplies needed for the expedition into Earth orbit at the rate of two launches per day over seven months.

A single-passenger ship would complete the round-trip voyage. The craft would have an inflatable personnel sphere 26 feet across, with a control room on deck one and living quarters on decks two and three. The one-way cargo ship would carry the expedition's single 177-ton landing glider in place of a personnel sphere. The ships together would weigh 3,740 tons before departing Earth orbit; the passenger ship would weigh only 38.4 tons when it returned to Earth orbit alone at the end of the expedition.

Upon reaching Mars, the crew would turn powerful telescopes toward proposed equatorial landing sites selected using telescopes on the space station. Equatorial sites were preferred, von Braun and Ley wrote, because they would be warmest. Citing the many kinds of surface features nearby—including two of the mysterious canals—they proposed as prime landing site candidate Margaritifer Sinus, a dark region visible in Earth-based telescopes.[15] The glider would descend to Mars with nine crewmembers on board (leaving three in orbit to mind the passenger ship's systems) and land on skids at about 120 miles per hour.

After the glider stopped, the intrepid explorers would walk out onto the wing, leap 18 feet to the ground (the equivalent of a six-foot drop in Earth gravity), and immediately prepare the ship for emergency liftoff—this despite having just spent eight months in weightlessness. They would remove the wings and use the expedition's two caterpillar tractors to hoist the bullet-shaped fuselage upright. They would then inflate a 20-foot hemispherical pressurized "tent" to serve as expedition headquarters.

After a year of Mars surface exploration, they would lift off, rejoin their compatriots in orbit, and blast for Earth. The last drops of propellants would place the ship in a 56,000-mile-high Earth orbit. A relief ship would ascend from the space station to collect the crew; they would abandon the Mars ship as a monument to the early days of planetary exploration.

Mars Beckons

Every 26 months, the orbits of Earth and Mars bring the two planets relatively close together. At such times Mars becomes a bright red-orange "star" in Earth's skies. Because Mars appears opposite the Sun in the sky when it is closest to Earth, astronomers call such events oppositions.

Mars has an elliptical orbit, so its distance from Earth at opposition varies. The best oppositions, when Earth is closest to Mars while the planet is closest to the Sun, occur roughly every 15 years. During the best oppositions, Mars' disk appears about twice as large in telescopes as during the poorest oppositions, when Mars is farthest from the Sun.

In the 1950s, all knowledge of Mars' conditions came from telescopic observations made during the best oppositions. Since the invention of the telescope in the early seventeenth century, astronomers eagerly awaited the best oppositions to attempt to pry new secrets from Mars. For example, the canals were first seen during the excellent 1877 opposition. When the first printing of The Exploration of Mars arrived on bookstore shelves, astronomers were eagerly awaiting the close opposition of September 1956.

The year 1956 marked the last "best" Mars opposition upon which astronomers would entirely depend for data, because humanity's relationship with Mars was about to change. A year after that Mars opposition, on 4 October 1957, the Soviet Union launched Sputnik 1 into Earth orbit. Von Braun's U.S. Army rocket team launched the American response, Explorer 1, on 31 January 1958. By 1971, when again Mars shone as brightly in Earth's skies as in 1956, spacecraft reconnaissance had revolutionized how we learn about the solar system. As we will see in the coming chapters, the 1956 and 1971 "best" oppositions neatly bracketed the early heyday of NASA Mars exploration planning.