EXPEDITION ARES
A Saga from the Dawn of Interplanetary Travel

INTRODUCTION
Krafft Ehricke's Manned Mission to Mars

When he began writing *Expedition Ares* in 1948, German-born space scientist Krafft Ehricke (1917-1984) had been in the United States for one year, and was living on the U.S. Army base at Ft. Bliss, Texas. He was one of the German space pioneers helping to transfer to the U.S. Army the rocket technology which the Germans had developed before and during the World War II, and had brought with them to the United States. Dr. Ehricke was writing up, from memory, the technical details of the V-2, or A-4 rocket, and helping to translate the reports of other members of the group into English.

Courtesy of Krafft Ehricke

Space visionary Krafft Ehricke (left) was interviewed by CBS correspondent Walter Cronkite on Sept. 26, 1966. Ehricke, who worked for North American Rockwell at the time, is discussing the features of a reusable transport vehicle that he designed. The initial stage of the vehicle consists of 12 turbo-ramjet engines. A supersonic ramjet engine allows the vehicle to achieve orbital velocity; the hypersonic spaceplane atop the transport would return to a landing site for reuse.

Most of the men were learning English, many by sharing the one available dictionary, and watching cowboy movies. Krafft Ehricke applied his engineering knowledge and engaged his imagination to look toward the future; he created a story, written in English, describing the first manned missions to Mars.

At that time, the only large liquid-fueled rockets ever launched were the wartime V-2s, which just barely reached space. But Ehricke could see a time, even if far off in the future, when the finicky technology of chemically propelled rockets would be mastered, the political will would be marshalled, and the resources committed, so that man would embrace the possibility of leaving the Earth, to head for the stars.

Ehricke chose a writing style brilliantly employed by a 19th Century predecessor—Jules Verne—who had fired the imagination of youth all over Europe, through his series of engaging books about an imaginary trip to the Moon. Using the development of a delightful array of characters, Verne had summarized for his readers the scientific knowledge of his time about space travel, and Luna.

Expedition Ares

Ehricke's setting is more than 400 years in the future, when space travel throughout the Solar System is commonplace,

and mankind hardly remembers the first "baby steps" taken to explore the planets. He tells the story of Expedition Ares, which takes place around 2050, as "ancient" history, looking back 350 years from 2400.

Ehricke describes in exacting detail the family of different spacecraft, sent abroad as a fleet, that will take the first eight travellers to Mars. Each vehicle is optimized for its particular function, whether that is to travel from the Earth to orbit, travel from the Earth-orbiting space station through interplanetary space, or land on Mars. Ehricke's Earth-to-orbit space ship has dimensions comparable to the 1969s Saturn V rocket that took men to the Moon. His glider rockets are similar to a family of Orbital Space Plane designs which NASA is considering today, for servicing the International Space Station.

Discussing the question of what kind of propulsion system should be used for the Mars journey, Ehricke acknowledges that nuclear fission would be far superior to chemical propulsion, by shortening the risky trip. But, he reports through his fictional characters, the development of fission propulsion would delay the mission for 50 years!

In order to decrease the risk of an adventure that will have the crew travelling in space for 516 days, and staying at Mars for an additional 455 days using chemical propulsion, Ehricke provides them with eight "lifeboats," one for each crew member. These "L-rockets," he says, are "completely new devices and are vital for general safety. They offer the crew a last life-saving chance in case of an accident." This level of multiple capabilities and redundancy, which in this story saves the lives of the crew, reflect a philosophy hardly followed today, but which should be a prerequisite for the future.

After leaving the space station, the Ares crew, sets off for months of travel to Mars. Along the way, they observe fascinating new phenomena of interplanetary space never seen before by men, and they have a close encounter with a previously unknown asteroid. During their long journey, the crew must perform intricate maintenance and repair of the spacecraft, which, decades later, cosmonauts aboard the Russian Mir space station would replicate, in order to keep their station operational.

But, alas, Expedition Ares is not destined to be a success. In a series of events which eerily foreshadow the crisis decades later aboard Apollo 13, the crew suffers a near-catastrophic accident, and must head back to Earth. Like the Apollo 13 astronauts, who survived only because of the availability of the Lunar Excursion Module, or lander, the crew of the Ares Expedition makes use all of their vehicles to return to Earth orbit and Space Station I.

It is remarkable that Krafft Ehricke could imagine that the entire world would be riveted to this unfolding drama in space, and be mobilized to offer whatever help was needed, just as was the case with Apollo 13. After close calls, and even the rescue of a crew member who takes refuge on the Moon, Ehricke ends his tale stating that this first manned mission to Mars, although it failed, was "not the end, but the beginning of a great story."

A Life in Space

Krafft Ehricke became intrigued with space flight in 1929, when, at the age of 12, he saw the Fritz Lang film, *Woman in the Moon* in a Berlin theater. Two years later, he became aware of the activities of the spunky German Society for Space Travel, but he was too young to join. He continued his studies, however, and in 1934, at the age of 17, he wrote *Thoughts of Space and Man,* a collection of short stories about scientific discovery, also yet to be published.

In 1938, Ehricke helped organize the amateur Society for Space Research, and wrote articles for its journal *Space,* even through the war. He was attending the Technical University Berlin when World War II interrupted his studies, and he was drafted into the German Army.

But in 1942, two patents he had previously filed on rocket technology brought him to the attention of army technical personnel, and he was transferred to the rocket research program at Peenemünde. He later learned that his entire tank unit had been wiped out at the Russian front.

At Peenemünde, Krafft Ehricke was assigned as an assistant to Dr. Walter Thiel, Director of Propulsion Development. He was able to gain hands-on experience with the hardware of this new technology of rocketry, as well as to investigate questions, such as the use of nuclear fission energy for rocket propulsion. When he arrived in America, Krafft Ehricke had the practical experience, the theoretical background, and the dreams, that were all necessary for space travel.

Throughout his career, Ehricke tackled questions and challenges concerning every aspect of space exploration and development, from trajectories of unmanned probes to the planets, to using the microgravity of space for therapeutic treatments, to tourism. From the mid-1970s to the mid-1980s, in the last decade of his life, he devoted his energies to describing, in elegant detail, how to industrialize the Moon, and make it the "seventh continent" of man's Earth.

To Krafft Ehricke, space exploration was not an extracurricular activity, but a function of an "extraterrestrial imperative." For man to progress, he has no choice but to expand his world view and his realm of activity to the entire Universe. There are no limits to growth, Ehricke insisted, when that false notion became popular in the late 1960s, because there is no limit to man's creativity.

Were man to deny that imperative, and try to live only within the fixed limits of his original home planet, Ehricke stated, the result would be geopolitical power politics, stagnation, and eventually ecological crises, mass starvation, wars over limited raw materials, epidemics, and revolutions—a New Dark Age. Indeed, having ignored the warnings, we stand at that precipice today.

Krafft Ehricke believed that a new Renaissance was necessary. Works, such as his *Expedition Ares,* embody the optimism, the commitment to scientific and technological advancement, and the belief in the irrepressibility of the human spirit, that mankind must marshal today to make this, and other great projects, a reality.

—Marsha Freeman

EXPEDITION ARES
A Saga from the Dawn of Interplanetary Travel

by Krafft A. Ehricke

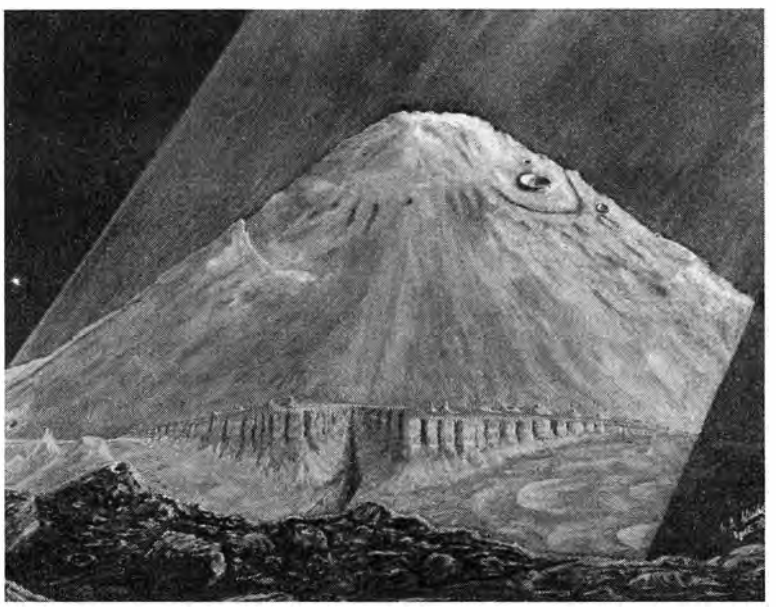
An imaginary account of space travel in the year 2050, written in 1948 by preeminent space visionary Krafft Ehricke (1917-1984). These are excerpts from his unpublished manuscript.

I

We live in the age of fast-flying, far-reaching space ships, and are proud of what human ingenuity has achieved in this field. Research is going on with ultra-fast ships, reaching half the velocity of light and designed as powerful instruments for visiting our neighboring stars.

But the adult soon forgets the first stumbling steps of childhood, and the first attempts to reach our nearest cosmic vicinity has almost completely vanished from our memory.

Looking back through the centuries, we perceive a chain of heroic deeds which mark man's grasp at other planets. Only 50 years ago, Glenn Wolf's party landed on Pluto. Their flash light photographs showing the men wading through helium pools amidst fantastic structures of frozen gas which tower into the eternal night, belong to the standard equipment of astronomical books today.



Krafft A. Ehricke

In 1979, Krafft Ehricke imagined Mars to be a planet with an active geologic past, unlike the Moon. He created this painting to represent that concept. Near the top of the mountain—perhaps a volcanic caldera—are gullies, very similar to those found recently on the sides of craters on Mars. They could have been produced by flowing water, or in this case, maybe seeping lava. To the lower left is the faint Sun.

A hundred years ago, Ted Aitken, the most fearless space explorer of his time, died in a bold attempt to reach Saturn. His ship, the famous "Nightmare," was smashed between the rocks of Saturn's ring after a meteor had blown away the navigation room.

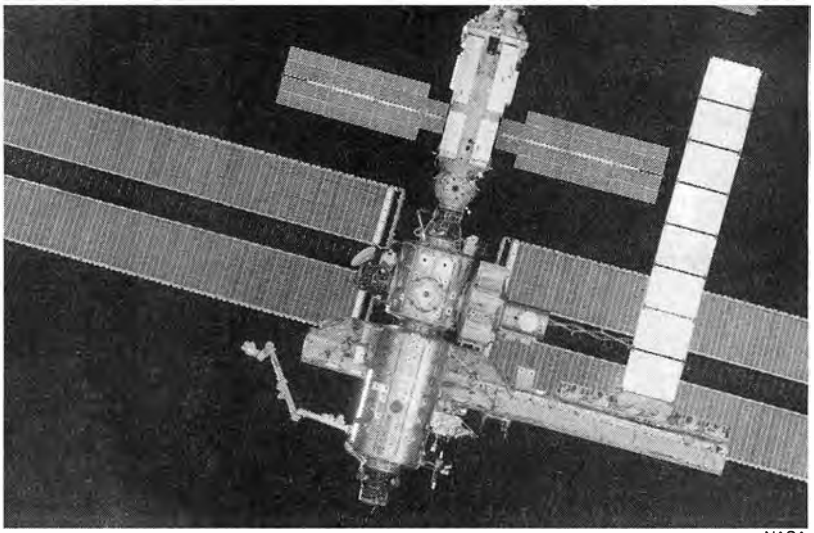
A hundred years before his time, Gordon Rockwell opened the golden age of discoveries. He was the first to jump in his ion-powered "Blizzard" over the great gulf—the vast gap behind Mars, as they called it—and intrude into the dangerous realm of Jupiter's satellites. This pioneer discovered fossils of a strange life on satellite 111. It blossomed millions of years ago when the giant planet was still the hot, animating center of its extensive system. Rockwell actually founded the cosmic branch of palaeobiologic sciences and made Jupiter's moons an El Dorado of cosmic life research.

Even farther back, old

documents reveal the tragedies connected with the exploration of Venus and tell a tale of Duke Hatchword's "sunny" trip to Mercury . . . yes, planet after planet unveiled their secrets before the eager spirit and ironclad will of keen explorers.

Yet, there is one planet which must be mentioned separately. Mars, the most familiar outer world for our generation, is connected with the very first beginnings of space travel.

Back in the 20th Century, when tiny rockets climbed a meager 200 miles (did you ever hear of a "V-2" or a "Neptune 8"?), Mars was the dream goal of those who believed in space travel, actually a fantastic conception when one considers the troubled and primitive world into which they were born. Mars was considered the most interesting planet in the system, the only one that might bear life. Some even dreamed of a Martian civilization, superior to ours, with which a cosmic exchange of ideas might be brought about. Small wonder that Mars became the first planet ever explored by man.



NASA

"One night, human eyes observed the first star in the sky which was man's creation: 'Space Station I.' " Much like the International Space Station, seen here in November 2002, Krafft Ehricke's Space Station I had living quarters and scientific laboratories. It also was the location for the assembly and launch of spacecraft headed to the rest of the Solar System.

Circling Earth in small scout rockets, scientists and engineers, dreamers and adventurers, found themselves on the brink of a vast emptiness, beyond which new worlds lured and stimulated their desire to remove the barriers erected between man and star.

The first attempt to realize these dreams is known in history as "Expedition Ares."

II

. . .It was long, long ago in the year 2000. We are in space. A giant globe arches to our right, 500 miles away. Its bulky outline covers a major part of the sky. But only a slim sickle unveils its bright shape to the observing eye. The remainder is absolute blackness. It constitutes a sinister, blind hole in the glorious panorama of stars around, suddenly interrupting the gleaming galactic arch where countless stars are blending to shining clusters, looming at the edge of infinity.

Out of this black hole came our ancestors.

At the end of the 20th Century they finally shattered the chains which kept them in bondage of time and space. Vigorously they had invaded the realm of nature, making themselves masters of energies never dreamed of before. What had been achieved in a relatively short period was really amazing. . . .

Elated with what had been done, the best among them fought for the highest goal: Detachment from their star and flight into the glaring purity of untouched space. The planets, well known to us, were unknown land for the pioneers of these old days.

A few decades later, the first step was completed. One night, human eyes observed the first star in the sky which was man's creation: "Space Station I."

No product of human skill ever earned more acclaim than this first artificial satellite. This tiny moon was hailed as the *non plus ultra,* the masterpiece of man's ingenuity. It was compared to a gigantic sign board to mark the entrance to Earth from outer worlds. Once established, Space Station I became the springboard for even more daring enterprises.

The artificial satellite was very small. It consisted of a power station, which also housed the living quarters and the radio center. Around this main body were scattered several scientific laboratories and the space observatory. Many problems had to be solved before an actual space flight could be launched.

In the medical laboratory of Space Station I, Dr. van Horn developed space medicine beyond the guesswork of his predecessors, by experimental facts which could not be gained on Earth.

The physical laboratory witnessed the development of space navigation instruments, crude prototypes of today's unerring and reliable homing devices. The 20-inch mirror in the space observatory recorded new facts about the planets. The investigation of solar and stellar spectra in the deep ultraviolet furnished new and important data for the understanding of the internal structure of the stars. Other important research objects were the primaries of cosmic radiation and the analysis of interplanetary matter, especially the mean density of meteors in space. A second tiny moon, measuring 900 feet in diameter, was discovered.

It is hardly believable with what primitive means of navigation the first ships hopped to Moon. But they did it, and gradually, as ships and navigation improved, Moon became a world "just around the corner," like the inner planets are for us now. The vast area between satellite and Moon became a training field for advanced students of the space navigation school attached to the station. Two agencies even obtained licenses for regular tourist flights around Luna, in small but rather comfortably equipped "space liners" as they were then called,

These were the general conditions at that time. They show

"Once established, Space Station I became the springboard for even more daring enterprises."

how tremendously the existence of a space station increased the possibilities for actual space flight. The familiarity in dealing with such little trips, as we possess it, absolutely did not exist in these days.

To estimate the tremendous amount of work and expenses engaged in the satellite enterprise it must be remembered that the only power source available at that time came from the reaction of chemicals, a million times weaker than the nuclear reactions with which we have worked for a long time. Nuclear science was only in its beginning, and no power unit for space ships had been developed yet. Small wonder that the space ships of the 21st Century were bulky, clumsy, and underpowered.

For instance, the ferry used for space station maintenance was unique by today's standards. It consisted of four rockets mounted one above the other. The height of this colossus was 190 feet, the diameter of its first or lowest stage was 44 feet. It may still be seen in the main hall of the Washington Museum of Space Exploration, technical department. The net payload actually delivered to the space station was only 10 tons, although the whole ship weighed not less than 3,460 tons at the moment of take-off! Ninety percent of the tremendous mass was the chemical propellants. A considerable idealism must have been essential to flying these giant firecrackers!

The start of such a ferry ship was comparable only to the eruption of a volcano. More than 59,000 pounds were bursting from its stern at 6,800 feet per second to yield 6,000 tons of thrust, which drove the tower upward with the slowness of a freight elevator. After 51 seconds of vertical ascent (the giant ship could not be inclined without breaking its back), the first booster burnt out and was jettisoned, as the second stage ignited. This second booster burned for 57 seconds with 2,000 tons of thrust. At the end, it was jettisoned like the first one.

The two remaining rockets had a velocity of 9,600 feet per second, and their axis was inclined by 45 degrees against the direction normal to the surface of the Earth. The third boosted the ship to 17,000 feet per second in 158 seconds at 500 tons thrust. The final stages accelerated to a velocity of 25,000 feet per second at 70 miles altitude, where it entered an elliptic flight path which brought the ship to the circular orbit of the space station. The landing back on Earth was made by using atmospheric drag in a long gliding path, for which the upper stage was equipped with wings. The most common propellant components used were hydrazine as fuel and nitric acid as oxidizer.

Even this giant ship was not able to land on Moon in a non-stop flight from Earth! The upper stage, however, could be refueled at the space station and used for Moon trips after some adaptations, such as decrease of payload and dismounting of the wings and tail fins, which are unnecessary in space.

This fact underlines strongly how important a space station necessarily must have been for those people with the energy sources available to them. It cannot be overemphasized that in this stage of development, space travel was impossible without a space station.

Summarizing, the situation in the year 2040 was as follows: An artificial satellite had been created. It revolved at an altitude of 550 miles around Earth and served as a research station and propellant depot. Regular flights to Moon were possible because of its existence. The Moon rocket was the final stage of a giant four-step ferry, which provided the satellite with all necessities and enabled slow accumulation of sufficient propellant for more extended trips. Each 10 tons of net payload brought to the space station level a costly 3,200 tons of propellant, not to mention the expense of an elaborate organization on the ground. The artificial satellite was a first-grade economical problem!

III

In 2040, 40 years after the creation of the artificial satellite, a second and most decisive step was taken. The Research Board of the Association for Space Exploration, the

NASA

"The start of such a ferry trip was comparable only to the eruption of a volcano." The ships that serviced Space Station I were three-stage rockets, similar in design to the Saturn V rocket seen here, which 20 years after the writing of Expedition Ares, took Apollo astronauts to the Moon.

most powerful research organization of its time, stated in a memorandum dated March 20, 2050, that within five years enough surplus propellant of the hydrazine-acid type would have been accumulated in the satellite depot to permit an expedition to one of the nearer planets, either Venus or Mars. This memorandum was submitted to the government with a preliminary breakdown of the necessary preparations and the cost of an interplanetary expedition. A conference was called of leading scientists, engineers, and economists to discuss the problem from all angles, prepare a more detailed plan, and decide which planet should be visited. It was inevitable that Mars would be selected. The final report said:

"In comparing both planets, it must be stated first that merely to pass the planet at a great distance is out of the question. Such a trip would not justify its cost nor could the flight paths to and from the planet be half-ellipses. We are still bound to such orbits, since shorter paths are too expensive in propellant consumption."

"From the astronomical point of view Venus comes nearest to Earth (26 million miles). The cruising times to and from Venus would be 146 days each. The necessary "stay time" in space between capture and re-escape is 470 days, under these conditions. The corresponding values for Mars (48,600,000 miles average distance from Earth at opposition) are 516 days total travel time and 455 days stay time. The overall travel time favors Venus (762 days as against 971 days) and the escape velocity from Earth for a Venus expedition is somewhat less than that for Mars. However, the capture process on Mars requires less energy than on Venus, the absolute values depending upon the distance from the planet in question."

"If a planet is reached, it is quite naturally desired to attempt a landing on its surface by means of winged rocket gliders, carried with the main ships. In this respect, Mars is much more favorable since its atmosphere and the principal conditions on its surface are well known, while for Venus quite the opposite is true."

"Finally, there is some evidence of life on Mars; a life which possibly sustains itself by a photosynthetic process using carbon dioxide, water and light quanta. Conditions for successful biochemical research are likely to be much better on Mars than on Venus.

"After deliberating all facts, this committee recommends Mars as the goal of the first interplanetary expedition."

This historical memorandum settled the matter, and the preparations for "Expedition Ares" began.

IV

Two main groups were formed: a technical group headed by Terence Norton, chief engineer of the ASE, and a scientific group led by Dr. Vincent Brooks, a young successful man of the scientific staff of the Space Board, who ran the physical institute of the ASE. The Norton group, in cooperation with many agencies, developed the ships and all accessories, while the Brooks group organized the scientific preparations. To the Joint Development Board belonged, among others, Dr. Jean Tudor of the Space Observatory, who was responsible for the flight path calculations and the navigation program; Dr. Carter of the Department of Space Medicine, in charge of medical and biochemical work; and Professor Winter, a leading scientist in the geological and meteorological fields and well known for his research on the development of the Martian surface and atmosphere.

In the leading group, Terence Norton realized from the beginning that "Expedition Ares" represented a crucial experiment for chemical rockets. There was a group, and not a small one, which strongly opposed the whole project. Their arguments carried some weight, from both the economic and technical viewpoints. Millions of labor hours had to be expended on a project which promised no immediate return.

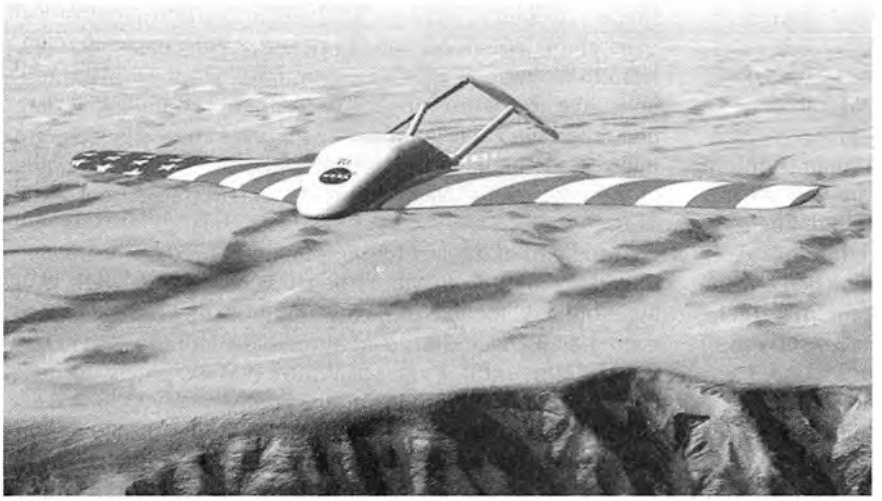
Furthermore, the use of chemical propellants was hazardous and there was considerable danger that none of the ships would ever return to Earth. These antagonists proposed that the program be concentrated on the development of a fuel or energy source far more powerful than chemical compounds. This, it was argued, would result in more dependable ships and correspondingly increased safety for the travelers. As conceived, they said, the project was premature and the future of interplanetary flight was imperiled.

Norton fully realized the gravity of those arguments. To wait for the more powerful sources would mean, he declared, a delay of at least 50 years. He determined to introduce in his ships a much higher safety factor than ever was assumed before. He permitted no calculations on the assumption that everything would run according to schedule. In one of his early reports to the Space Board, be said:

> . . .In considering the problem from any viewpoint, the question may arise: In what way may the challenge offered by a departure from the normal schedule be met with the technical resources at hand? Does such not improbable situation offer some chances to bring home the amazing results of human courage; or does a failure to cope with the situation mean certain death somewhere in the depths of space, to all on board?
>
> A study of the following pages will show that the technical group has increased the safety factor to a figure far higher than that which was considered the maximum when the project was established. The rest must be left to the character and spirit of the party. It is frankly admitted that possible dangers exist which cannot be anticipated, but the group is firmly convinced that courage, resource, and the scientific attainments of those selected to make the voyage, will meet successfully the challenge of space travel.

There follows an exhaustive description of the project from which only the most important details may be quoted:

> Eight persons will participate in the flight, to keep the overall expenditures within reasonable limits. This restriction on personnel permits ample power reserve and research equipment, thereby using only three main ships, each equipped with a system of small, independent power plants, ranging from 11,000 to 572,000



NASA Langley Research Center

"The gliders are powerful enough to fly to the surface of Mars and return to the orbit in which the main ships are circling." Ehricke envisioned a family of spacecraft for the manned Mars journey, to provide redundant capabilities to increase safety. NASA has been developing designs for a Mars airplane, which would fly in Mars's thin atmosphere, but not be powered to return to orbit.

pound thrust. Any power plant can be jettisoned without affecting the others. All ships are built according to the "building-set" principles, which allow application of the stage principle to the fullest extent and assure that no unnecessary parts are carried through any propulsion period at the expense of propellant consumption.

The main ships consist of a frame in which the spherical [fuel] tanks, supply containers, auxiliary machines, auxiliary ships, and the gondola for the crew are mounted. Because they are built for space flight only, they need no protective skin or streamlined, outer shape. This reduces the weight, gives very good accessibility to all parts, and simplifies considerably the technical work required between the propulsion periods.

He describes the principal load distribution of the three main ships as follows:

(I) The flagship carries the crew, the most important scientific equipment, food for 260 days, and practically all the oxygen supply. It is the only ship which will return to Earth.

(2) The second ship, a [cargo] carrier, transports the bulk of the food supply, two landing gliders, and the astronomical equipment. The gliders will be detached and the food supply transferred to the third ship before arrival in the final circular orbit around Mars. The carrier will swing into the equatorial plane of Mars and land on Phobos, the inner moon. There, an astronomical observatory will be established for a detailed investigation of the surface of the planet during the stay time of the ships. The large difficulties connected with a free-floating space observatory are thus avoided.

(3) The third ship and the two gliders (under their own power after the detachment) follow the flagship into a circular orbit in the ecliptic plane which requires less propellant consumption since this is the plane in which the ships fly all the way from Earth.

The third ship is a tanker and carries all propellant required for the different propulsion periods during the trip. The other ships are refueled from it after each propulsion period. For this purpose, the corresponding tank spheres will be detached from the carrier and brought close to the ship to be refueled. The propellant will be transferred by a movable feeding system. The weightlessness of all matter in space facilitates the work considerably and makes it possible for a few men to do the job. The empty tanks and other excess parts will be pushed into space by means of small powder [solid fuel] units. The tanker will be abandoned after departure from Mars when it has delivered its last propellant to the flagship.

The auxiliary ships are two winged rocket-propelled gliders for surface research, and eight lifeboat rockets (L-rockets), one for each participant.

The gliders are powerful enough to fly to the surface of Mars and return to the orbit in which the main ships are circling. Propellant is provided for two flights for each glider to different spots on the Martian surface. The gliders use the same propellant as the main ships.

The L-rockets are completely new devices and are vital for general safety. They offer the crew a last life-saving chance in case of an accident. The term 'accident' means in this connection the possibility that something may prevent the main ships from gaining the velocity necessary for capture within the gravitational field of a planet. Under these conditions, without L-rockets, the ships would pass the planet in a hyperbolic path, and consequently would be lost with all on board.

There are actually only a very few crucial moments which decide the success or failure of an interplanetary trip. These moments are the propulsion periods when near the planet, and it is here that the L-rockets may prove their value. If the main ships are disabled, the crew can take to the L-rockets and gain the necessary velocity accelerations or decelerations.

The L-rockets represent the highest development of the stage principle, and are in themselves the most important safety device that is carried. They will operate in the vicinity of the planet, but outside its atmosphere, and then either remain in an orbit around the

planet or glide to the surface. Their wings will support them in unpowered gliding flight. Their design and power depends consequently on the largest planet contacted, so for "Expedition Ares" they are laid out for Earth.

Their mass is a tiny fraction of that of a main ship, but their mass ratio and exhaust velocity are very great, since their fuel is a special halogen compound. Their ideal performance is 3.3 miles per second, but this speed can be increased by reserve tanks attached to the wing and body which will yield a maximum performance of 5.5 miles per second with three reserve tanks. Because a velocity of 2.23 miles per second is needed for re-capture by Earth at satellite distance, if the ships approach along the scheduled ellipse, the L-rockets have ample power to cope with the majority of emergencies.

The program outlined in Norton's report was followed. Shipload after shipload of parts were transported to Space Station I where they were checked and assembled. New control and navigation devices were tested in flights to Moon.

Two years before the day of departure, the crew was selected.

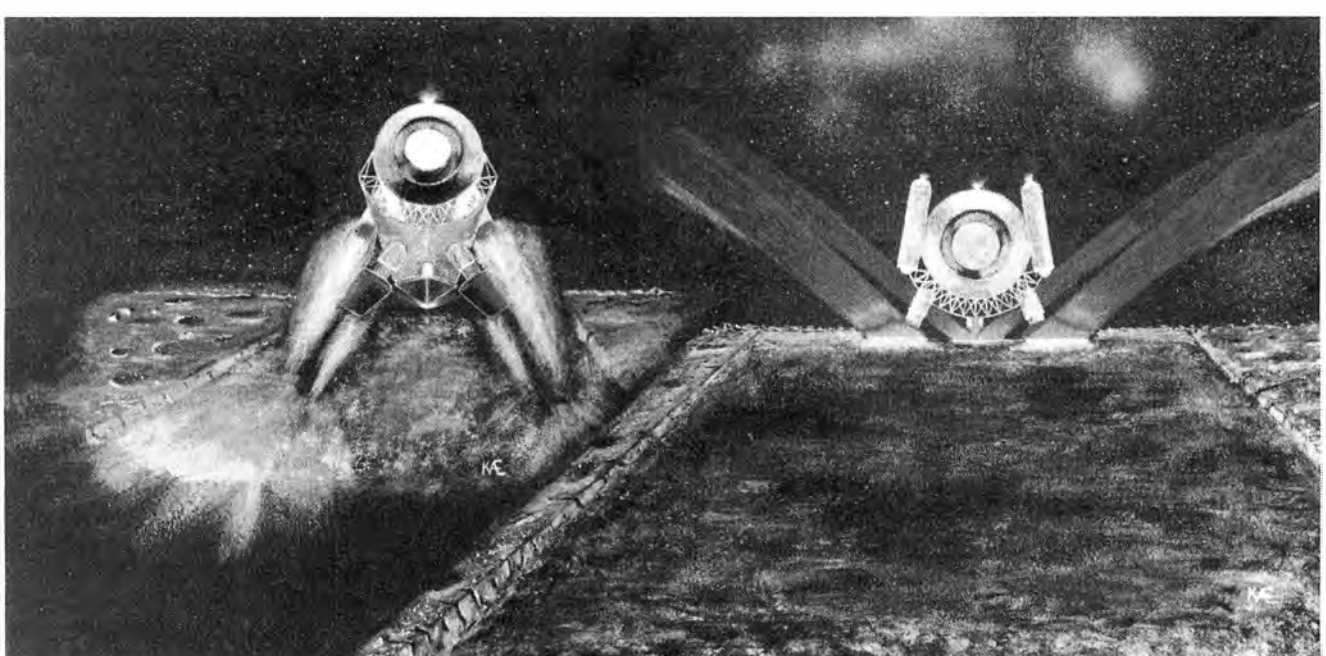
. . .For two years the team trained together. There was space ship piloting, space navigation, knowledge of the ships in all details, including maintenance and repair, interplanetary communication, glider and L-rocket piloting, and space medicine. The climax of the training was a Mars trip simulation, elaborated by Norton and Dr. Tudor. They prepared spacecraft which were in most detail a true model of the Mars ships, equipped with L-rockets. With these ships the team made several trips to Moon, training for all manipulations like the jettisoning of excess parts, refueling during flight, and the capture process with one carrier swinging out into a plane inclined by 23 degrees against the orbital plane of the other ships. Many improvements resulted from these trips.

At the end of the last training flight, the models were sacrificed. Coming from Moon the ships ran against Earth with hyperbolic velocity. The crew entered the L-rockets and each man navigated his ship alone back into the [space station] satellite orbit. Professor Winter was extremely excited. He missed the satellite orbit and finally revolved in a slender ellipse, the perigee being in 20,000 miles distance from Earth. Upon his hectic emergency calls with a tiny radio set that was standard equipment of each L-rocket, an upper ferry boat stage rescued him. His adventure inspired many newspaper cartoons which showed the professor as a new satellite of Earth. But his misfortune had brought about an idea.

"It is very possible," said Norton. "that after exhaustion of the propellant our L-rockets might run in some mad orbits around Earth. We need a radar detection on the satellite and a special Coast Guard service with rescue ships until the expedition is home again."

This new idea was immediately included in the preparations.

Finally, the gigantic work was completed. On a silent, transparent September night, the party started for the ceremony of christening the Mars cruisers which floated quietly beside the



Krafft A. Ehricke

"The climax of the training was a Mars simulation . . . the team made several trips to Moon." The evolution of manned space capabilities envisioned by Krafft Ehricke included the development of Moon, before the journey to Mars. In this painting, he shows "slide landing on the snowy lunar dust," using the surface material to slow the spacecraft, which "minimizes propellant consumption and release of gas into the industrially valuable high vacuum on the surface."

". . . X-day, January 1, 2046! The world held its breath when the flaming gases erupted out of 61 nozzles to push the huge ships forward. . . ."

space station. Jean, accompanied by her fellows and many guests of honor, all in space suits, was sponsor. Radio and television transmitted the ceremony to Earth. The girl threw a slim bottle of liquid helium against the giant frame of the flagship:

"I christen thee 'Santa Maria.' May you bear us safely to the shores of a new world, like Columbus's flagship whose name you are given. We pray that your keen flight through the immeasurable gulf of space may create a new and bright age for those millions of brave men and women to whom we owe the proudest mission of all times: Foundation of interplanetary flight."

The two carriers were named "Eagle" and "Condor." The gliders received the names "Enterprise" and "Investigator."

V

. . . X-day, January 1, 2046!

The world held its breath when the flaming gases erupted out of 61 nozzles to push the huge ships forward, slowly at first, with a power of more than 3 million pounds of thrust.

Even we, to whom a Mars flight means little, can imagine the significance of that moment, which will not be repeated until the first of our new giant scout ships leaves for Alpha Centauri!

The fleet quickly gained speed. Within 500 seconds they stormed over a "runway" of 5,115 miles, and then jumped off into space with a velocity of 20.5 miles per second with respect to Sun.

. . . Escape from Earth was successful. The giant spacecraft strung out along their comet orbit exactly as precalculated. But the men could not yet relax. First the tanks of the flagship and the "Eagle" had to be restored to maintain maneuverability. The corresponding containers were disconnected from the huge frame of the "Condor," and carefully moved close to the other ships by small auxiliary rocket-motors. Pressure lines were connected and within an hour 180 tons [of fuel] had been pumped into the flagship from two spherical tanks, each 17 feet in diameter. More than 600 tons were transferred into the "Eagle" from seven 22-foot globes. The entire process was completed in four hours and all excess parts hurled away with attached powder units. Everything worked out all right, and when the men retreated into the flagship, the tanker had lost considerable mass. All ships were ready for further action.

Jean had prepared a tasteful lunch which was highly welcomed. There was of course no cook on board of these first space ships. Every man's weight meant many tons propellant more to be carried, not to mention food and oxygen, which in turn required propellant too for transportation. A job so far off the purpose of the trip was out of place in the age of chemical rockets, which knew no stricter law than that of the mass ratio.

. . . The ships were drifting apart slowly, because of small moments they had received at the cutoff. Furthermore, a thorough check and, if necessary, a correction as to their position, velocity, and flight direction had to be made. At the end of the first "day" Norton called all men to duty through the intercom. Carlson had received additional observation data and position measurements from Earth.

. . . Jean turned to her work. She evaluated in electric calculators the reports received by Carlson and also her own measurements. She gave Norton all data necessary for the maneuvering of the ships. His orders were fulfilled, with highest precision, as she had trained hundreds of times. The ships turned their sterns in flight direction by means of tiltable control motors. One second full thrust out of all nozzles removed a small velocity excess and corrected a slight deviation from the plane that connected the orbits of Earth and Mars. A further maneuver eliminated the small divergences in the movements of the individual ships. Further corrections would not be made until the errors of second order had been summoned up sufficiently by the time.

. . . The fifth day of their journey found them 560,000 miles from Earth. The gravitational forces of the planet had diminished practically to zero. As it is known from Tisserand's considerations in his ancient book *Mecanique celeste,* this is the distance where Earth ceases to perturb the flight paths of other bodies in space. From now on they would be subject only to solar forces until 400,000 miles before Mars, when the first perturbations of this planet would become effective. This distance of 560,000 miles marked the proper end of the ascension path and the beginning of the "comet orbits" to Mars. New position checks and corrections were made.

. . . [In] the pale bluish light of the receding Earth and the still undiminished sunny brightness behind, the ships shot forward into the huge dark vastness ahead. Seen from a distance they looked like strange, fantastic deep-sea fishes. The bright light that streamed from the many circular windows on the night side of the gondola made them look like gloomy, staring eyes. Nothing indicated that they were moving at all. Time and motion stood still in complete silence. It seemed as if they had anchored in the center of the universe.

But some hours later the ships entered a tremendously thin cloud of cosmic gas, a delicate, greenish veil that wound up from unfathomable regions somewhere into infinity. Then their tremendous velocity became evident. The black night sides of the huge propellant globes turned into a shade as if covered with scintillating patina, a startling aspect of inexpressible beauty. Space began to unfold its breath-taking wonders before their eyes.

It lasted several minutes only. Then the fabulous space monsters precipitated again into complete emptiness.

"There it is now!" wrote Jean in her diary on this day.

> We really are in space. Earth fades away. This is so easily written down; but you should see it. You should

experience this farewell! It is very different whether you look at the stars, lying in the fragrant green grass and dreaming; or whether you see your world as a star among stars while you are floating in the immenseness of space, detached from all the little nameless things that make you feel at home on Earth.

Space skippers are dreamers, all right. They have to be; but only once in a while. Blue skies and silvery clouds . . . seagirt islands . . . a quiet evening in the country . . . dark, green forests and snow-capped mountains . . . be careful, skipper, space gets you!

NASA

"Norton and his engineers investigated all parts of the ships with a desperate thoroughness." Throughout the many-month journey to Mars, constant maintenance and repair were required, Ehricke reports. Here, in January 2003, International Space Station Expedition 6 science officer Don Pettit performs in-flight maintenance on the treadmill used by the crew to counteract the debilitating effects of weightlessness.

Norton and his engineers investigated all parts of the ships with a desperate thoroughness.

Pumps, turbines, valves, governors, and other installations were inspected, disassembled, cleaned and reassembled again. Batteries were charged, bolts, connection pieces and welding spots checked. They crept through the nozzles right into the combustion chambers, through the huge cable nets and relay arrangements, exchanging defective parts, testing others. The lack of gravity made it easy to handle masses for which on Earth cranes and many more men would have been necessary. In spite of this, it was tremendous work, but it kept them alert.

Carter examined them all at regular intervals. He experimented on himself and on an assortment of small animals he had taken with him. The men got used to the fact that he disappeared for many hours without telling anybody. He hung around somewhere in space, many miles away from the ships, alone with his animals. But he promised Norton to go only so far away that he could easily recognize the bright green and red cruising lights on the bow and stern of the ships. The lights showed a characteristic flickering modulus so that they could easily be recognized among the myriads of stars.

Brooks and Foster devoted themselves to their physical and chemical experiments. Moreover they checked the air conditioner and the water regenerative plant which regenerated the moisture from the stale air for use as cleaning water. They cooperated with the engineers in periodical temperature control of the cabins and propellant containers. Together with Dr. Carter they supervised the hygienic conditions in the gondola. Jean plunged deeply into her astronomical observations and regular position measurements.

. . . Norton awakened with the vague feeling that something was wrong. He would have been unable to explain the unrest which brought about the interruption of his sleep, although he was still tired. First he listened, but there was no irregularity in the familiar pattern of damped sounds which came from the various auxiliary machines.

He looked through the window of his cabin and saw a figure floating several hundred feet away. The figure had a telescope mounted before its helmet. He called the person through the intercom, but got no answer. This man had obviously forgotten to switch his receiver on, although this was a strict order for everybody who worked outside the ship.

Norton was just turning away from the window, when a sudden movement of the figure stopped him. The man drew his reaction pistol—the instrument by which the spacemen drove themselves around outside the ships—and shot, obviously without placing the instrument in a correct manner. Something seemed to have frightened him terribly, since he whirled around as if mad, thereby approaching the ship much slower than possible.

Norton jumped out of the cabin and hurried along the gangway toward the air lock which the figure tried to reach. He wondered why the guard did not call the person through the intercom. Where was the guard?

A body bounced against the outer lock door. Norton pressed the button of an electrical emergency valve which emptied the lock room in a second. No time now for pumping the air back into the container. The gas shot into the emptiness as a straight, blue-white jet. Norton heard a thin remote voice calling on the gangway loudspeaker, but did not register. He saw through the peephole the figure enter and close the outer door. He opened the "Air-In" valve and unlocked the inner door. The man staggered into the gangway.

It was Winter. He snatched his helmet off. Norton looked into a pale, horrified face, the eyes wide opened.

"Ye Gods! What's the matter Winter!"

"Ghosts!" exclaimed Winter, trying to catch his breath.

"There are ghosts around our ships!"

". . . A big celestial body is approaching the ship . . . Nature of body unknown. Certainly no comet, at least I can see only one single body, no cluster . . . size is hard to estimate, since distance unknown. Seen with the naked eye it looks like a silver dollar from three feet distance. Body has grey-greenish shade. Irregular form . . . seems to rotate slowly . . . partly illuminated as it is now it looks like an ugly mask through my telescope . . . velocity of approach is moderate . . . direction of motion seems to be rather parallel to that of the ship, but I may be wrong. Immediate measurements necessary!"

"That's strange," murmured Jean, moderate velocity of approach . . . parallel direction of motion.."

She disappeared into the control room.

"Carlson, Davis," ordered Norton, "don your space suits and take the carriers over. Hang on! We might have a traffic jam."

Jean called Norton through the intercom. She did not turn from the observation instrument when be entered the control room.

"I think my tacit assumption was correct. We have detected a new asteroid. I'll give it the number 3350 until we decide on a name."

Why do you think it's an asteroid?"

"The body has a diameter of about 4 miles. That's too large for a meteorite; and, as Carter observed correctly, it's a single body, no comet. Present distance approximately a hundred miles."

Norton observed the asteroid through a second telescope. The general outline was very irregular, some parts of the periphery seemed to be even jagged.

"It's only partly visible."

"Yes, approximately last quarter. It moves between us and Sun and probably will be invisible when passing."

"That's bad. How about the motion?"

"It's orbital plane must be inclined toward ours; I cannot say right now how many degrees. It moves somewhat faster than we do. Velocity excess less than a quarter of a mile from angular measurements. It will pass us in about six minutes. The small velocity difference indicates that it's remotest point from the Sun, the aphelion, cannot be much farther than Mars distance, although in a different plane."

". . . Attention all ships!" said Norton from the control room. "The body will pass at a small distance in about five minutes from now. Everybody has to don his space suit!" The distance between the ships was approximately 1 mile, the flagship flying between the two carriers. Norton gave the order to disperse so that the distance of both ships from the flagship was about 10 miles. This gave enough room for eventual maneuvers of a single ship which might run into the danger zone. The relative velocity of the asteroid with respect to the fleet was low enough to allow maneuvers.

They waited in their space suits. Jean made some more position measurements and, drawing a line on a large chart which showed their own flight path over the various star constellations, she said:

"Extrapolating the measured position coordinates, this is roughly the line of motion of No. 3350. It's a pity that we weren't alerted earlier. As things are, I cannot get it more correctly now. The asteroid will pass me within a sphere of 50 miles radius around the flagship. It seems as if the inclination of its orbital plane against the ecliptic plane in which we move is very small, not more than 10 degrees."

Everybody heard Jean's announcement through the intercom. She called again:

"Attention all ships! Distance of asteroid about 30 miles now . . . 20 miles. . . . It'll pass us in a minute!"

The quickly approaching asteroid flung its huge shadow on them dreadfully. It suddenly became completely dark around.

"Asteroid eclipses Sun!" called Jean. "Attention Davis! It passes on your side!"

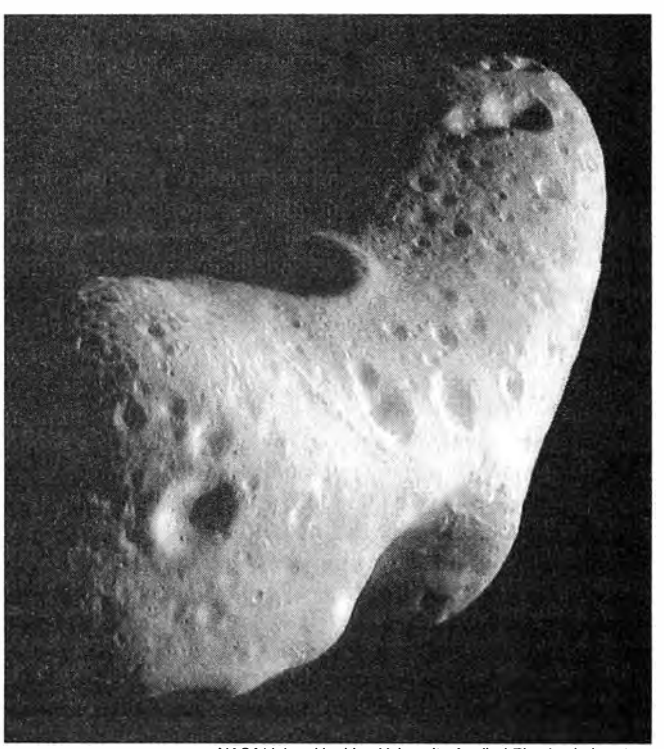
"Hope it doesn't smash our propellant supply." growled Davis.

This was the last observation. The body was a giant shadow slipping over the starry background. They held their breath. . . . It passed by . . . no sound in the intercom . . . nothing had happened.

Sunshine flooded again through the windows on the dayside.

"It passed quite close to me! Guess it was less than a half mile!" cried Davis. "Hey! This thing is pretty radioactive! My outboard microammeters indicate strong alpha and beta activity. No slow neutron radiation announced by string electrometer of boron chamber."

"That's interesting," replied Norton." Our counters show



NASA/Johns Hopkins University Applied Physics Laboratory

"Norton observed the asteroid through a second telescope. The general outline was very irregular, some of the periphery seemed to be even jagged." Asteroid Eros—quite irregular—was photographed up close, not by a human crew, but the Near Earth Asteroid Rendezvous spacecraft on June 5, 2000.

some activity too. Did you recognize something on the surface?"

"Not when it passed. Now it's already a bright sickle again which increases quickly. Surface color is essentially a very dark gray. Some greenish spots are perceivable. Surface is very rifted."

The body became steadily brighter now in spite of its increasing distance. A growing portion of the illuminated surface became visible.

"Why not pay a visit to No. 3350!" called Norton suddenly. "I think we shouldn't miss such a rare chance. Who comes with me?"

"I'll go with you," said Foster quickly.

"Okay. We'll take our L-rockets. Dr. Tudor, you take over meanwhile. Come on Foster!"

The L-rockets were quickly separated from the frame. In less than a minute the tiny ships flung out and followed the body with full steam. The L-rockets were equipped with a variety of radiation detectors, because they were supposed to serve as scout ships besides their main purpose to be emergency craft.

Several minutes later they flew parallel to the asteroid, keeping carefully on the sunny side. It was an impressive aspect for these newcomers in space to see that huge body floating close to them in empty space.

"Do we land?" asked Foster.

"First let's check on radiation."

They moved as close as 500 feet to the body. The audible detectors responded strongly.

"No indication of slow neutrons," observed Foster. Expose nuclear film for fast neutrons!"

They approached the body as close as 100 feet. The intensity of the showers became startling. The neon bulbs, visible indicators, flashed as if mad. The crackling of the audible devices turned into a continuous rustling. Deadly rays of immense intensity blazed around their ships.

"We have at least 10,000 milliroentgen gamma ray intensity outside!" called Norton. "Look on your dial. Corpuscular radiation intensity is several rep. It's impossible to leave the ships."

"What a pity that we aren't equipped with lead-lined space suits."

"Our order from Earth is to explore only, Foster. We'll come back and attack this dangerous fellow with more adequate means. Anyway, it's important to know about the existence of such power sources in space."

"Okay, let's move out of the danger zone. The air in our ships is already very ozonized by secondary radiation. The ships are getting radioactive." They retreated as far as far as one mile away from the body. The radiation became tolerable. They made observations and took photographs of the surface. At the same time Jean made pictures of the asteroid and the ships through a 20-inch Schmidt telescope which gives sharp definition over a very large field to be photographed. These were really memorable photographs of a decisive opportunity that had brought them a most important discovery.

An hour later the little rockets hooked smoothly on the flagship. With regret they observed the interesting visitor disappear into the depths of space. Again they were alone. Carter examined Norton and Foster closely when they came back, but found no signs of contamination. He ordered them, however, to change their space suits and abandon the old ones, because these showed a slight radioactivity, especially the metal parts, such as helmet connections, shoe soles, breath package containers, and others.

"Well," asked Norton, "which name do you propose for No. 3350. You are the actual discoverer after all."

"All right," laughed Carter." I think its predominant character makes it easy. Let's call it Radiant."

. . .When Norton came back to the control room his busy navigation officer had already a rough idea of the orbit of (3350) Radiant.

"She revolves in a rather circular orbit of small eccentricity. Perihelion is in about 0.9 astronomical units. Length of perihelion is approximately 190 degrees. Remotest point from Sun is about 1.7 astronomical units, that is about a 160 million miles. Inclination of her orbit against the ecliptic is close to 9.5 degrees."

"How do you explain the high radioactivity?"

"That's not easy, Norton. Concluding from the elements found in meteorites on Earth, the nature of (3350) Radiant is a surprise. Only negligible traces of some radioactive elements, such as radium and thorium have been detected in meteorites."

"Okay, but Radiant is an asteroid."

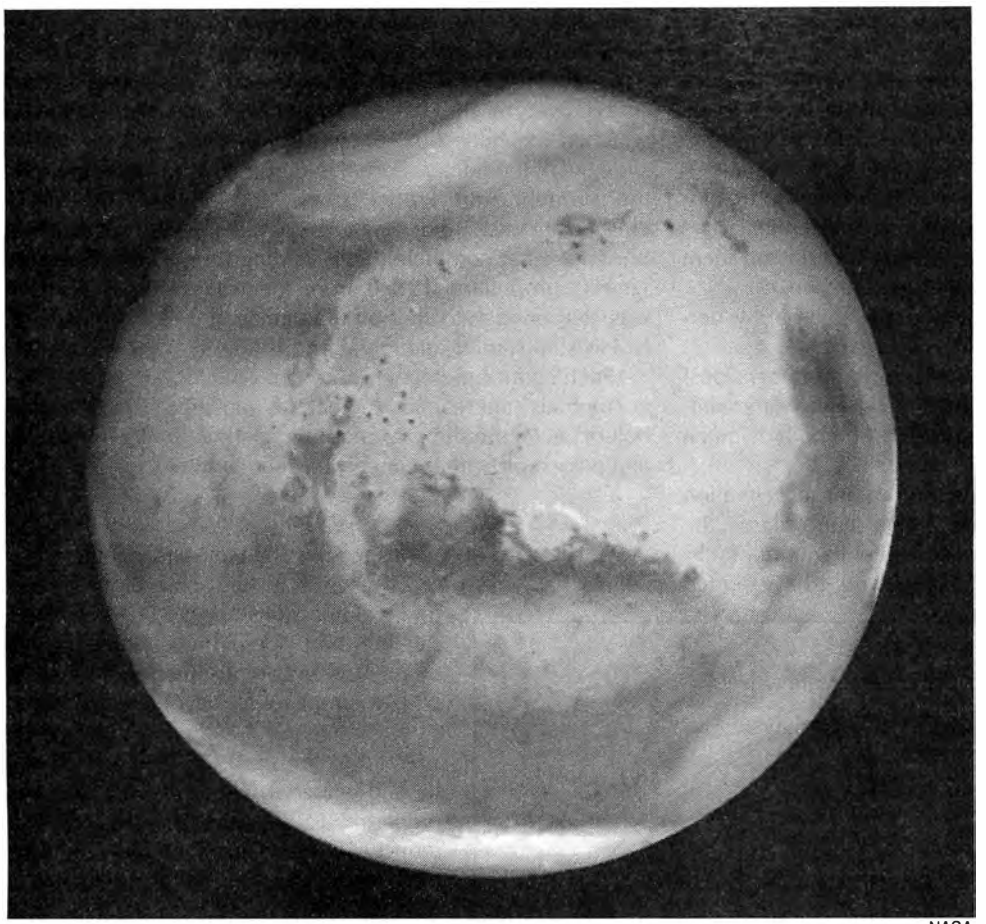
"Which means that she is probably the fragment of a planet that has been torn to pieces by Jupiter a long time ago. If this is true, we are tempted to assume that this planet should have had essentially the same composition as Earth. But our knowledge about the abundance of radioactive matter in planets is still very superficial. We only know that concentrations as we detected then on (3350) Radiant do not occur on the surface of Earth."

"How about the composition of the interior of our planet; I mean the abundance at radioactive elements."

"At least we know that the interior contains the heaviest parts, especially the heavy metal core. But it's improbable that we would find these parts enriched with uranium or thorium, although they are very heavy. Decisive for the depth in which to find an element, however, is not its atomic weight, but rather the specific weight of the phase into which that element turns as a result of its inherent chemical properties. Uranium and thorium have high ion volumes. This fact and their affinity to oxygen, which is stronger than that of iron, explains why these heavy elements tend to accumulate in the outer shells."

"Well, then this would mean that the broken planet must have had a much higher surface abundance of radioactive elements than Earth?"

"Not necessarily. The local concentration only might have been different. Besides, what do we know yet about the actual radioactive content of (3350) Radiant? Our investigation had to be very superficial, unfortunately. The dark parts might consist of a kind of pitchblende, containing very much U_3O_8, but they might as well be harmless slate in its majority. The greenish spots might exist because of strong UO_3 content or have some other reason. Anyway, I guess this asteroid will



NASA

"MARS! Its reddish disc flung out of the depths, shining in the damped light of a remote Sun." This full disc of Mars was taken on June 10, 2001, by the Mars Global Surveyor spacecraft. It is a view not yet seen firsthand by human eyes.

become a first class research object for further space expeditions. She might help us to bring some light into the question of the distribution of radioactive matter in the Solar System at the time of its formation, probably by the interaction of three large bodies."

"Not to forget the technical importance such an asteroid might gain. I hope we can convince the people on Earth how stimulating space travel will become for all sciences."

"You certainly are right," agreed the astronomer. "There are no sensational alien civilizations to be expected by exploring our Solar System through space flight, but an amazing variety of basic questions and answers that affect the very foundation of our own existence."

VI

. . . MARS!

Its reddish disc flung out of the depths, shining in the damped light of a remote sun.

. . .It was high time to transfer the food supply from the "Eagle" to the tanker. Norton ordered Brooks and Foster to this job. He and Jean were fully occupied with preparations for the imminent capture maneuver. Davis and Carlson, detached and prepared the gliders "Enterprise" and "Investigator." Three hours later everything was ready. Norton directed the fleet from the control room as usual.

"Attention all ships! In 30 minutes we start picking up speed. Our present distance from Mars is 50,000 miles. Mars will now pass ahead of us. Angular measurements of surface objects indicate that our perturbations from the planet's mass correspond to those accounted for in the calculations. Our position, as corrected, is as exact as it can be. All orders must be obeyed precisely now. If so, we'll hook on the planet successfully!"

The ships flew in close formation. To the left of "Santa Maria" were "Enterprise" and "Investigator," piloted by Brooks and Foster. To the right hung Carlson with the "Condor." Slightly above their common plane floated the "Eagle" with Davis. He was the best pilot in the crew and drew the most difficult tasks. He flew the tanker away from Earth when the ship was heaviest, and now had to land the carrier on Phobos.

"Distance 45,000 miles!" called Jean without turning her face from the instruments." Mars is passing ahead of us now. Look . . . at that!"

Mars was already eight times as large to the naked eye as Moon when seen from Earth. Two bright spots were visible at the sides of the disc, the moons Phobos and Deimos. The men stared silently at the planet, which slowly moved ahead, unveiling more details with every minute.

. . . The last minutes were tension-packed silence. Mars now lay to their left. It was no longer a disc, but a huge globe that arched before their eyes.

"Attention all ships! Start pressure-fed motors! One second . . . two. . . ." Tiny, glowing jets emerged from auxiliary motors to yield a small acceleration which pressed the large propellant masses in the main tanks toward the suction pipes of the pumps.

"Turbines on! Full throttle!!"

Fiery jets burst out of all power plants. With relief, the men felt their own heaviness again. Davis disappeared in upward direction. The ships jumped forward like panthers to catch the planet ahead.

Jean observed the sky ahead through her space-fixed Schmidt. For the first time since they had left Earth, part of the stars were eclipsed by a giant sphere again. The full phase of Mars that was visible when the planet passed them outside

their own orbit had shrunk to a slim sickle, because they approached its night side.

. . . She turned her telescope around 180 degrees to check the star field around the ships. It was still necessary to be watchful in all directions. Yet her movement was routine rather than that of genuine concern.

There she saw it. A sudden alarm paralyzed Jean so that for a second she couldn't utter a cry. Among the familiar stars flashed a light, bright and dreadful. A body shot toward them like a projectile aimed to destroy their fleet,

"Attention all ships!" she cried mechanically, hardly perceiving her own voice. . . .

"A body from behind! Coordinates zero in all dimensions! Negligible lateral component! Probably unknown Mars satellite! Disperse . . . disperse I say! Quickly!! The body is much faster than we."

They flew with a predetermined constant acceleration which left ample reserve in power. Upon Jean's alarm, the ships tilted all available motors and spread out with full throttle. The tremendous lateral acceleration would have hurled them off their seats if they had not been strapped in. The body grew with startling abruptness.

A sudden cry: "The food containers! Our food!" They stared over to the tanker, speechless, horror-stricken and watched the huge boxes, each piece many tons in weight, slide out of the frames. Part of the mounting had broken under the sudden, unforeseen lateral acceleration. The cases crashed against pipelines and connection bars, destroying one motor set completely, the feeding lines of another. Self-igniting propellant flamed from the leaking pipes. Carlson was alert enough to shut off the damaged motors immediately. His ship started rotating about its lateral axis.

"Pitch control motors on, Carlson! Quick!"

The body had reached the fleet. It appeared like a thunderbolt between the ships, a smashing, glaring fire line in the sky, and passed off with inconceivable suddenness.

VII

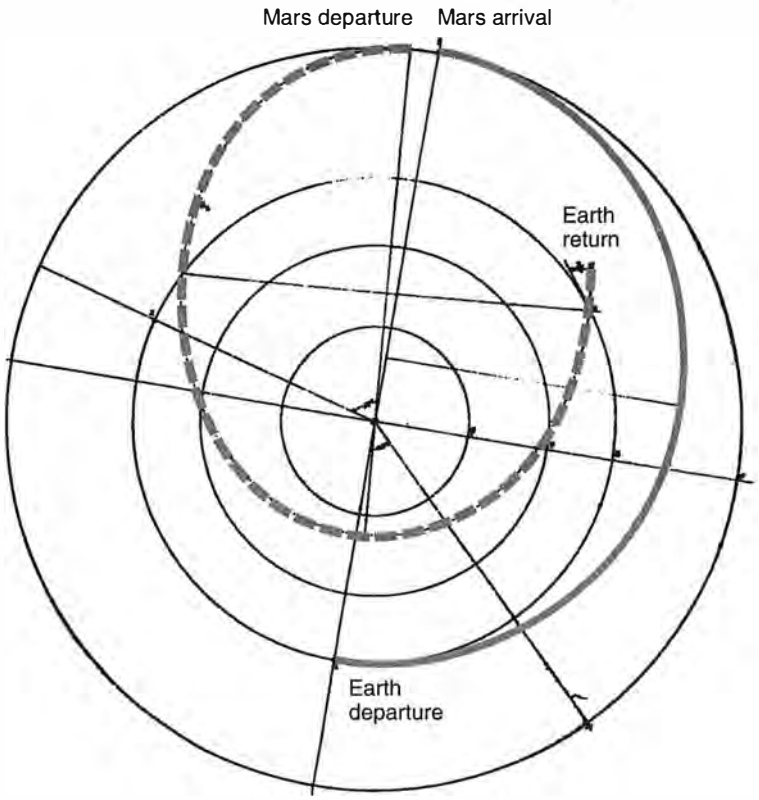
. . . They had accomplished the flight to Mars, but there was neither happiness nor satisfaction in this achievement. . . . A few welding spots and an unknown little satellite had spoiled everything at the moment of accomplishment. That malice of fate simply was beyond comprehension.

A radiogram from Davis, reporting that he had landed safely on Phobos and was preparing to establish the big research reflector of the "Eagle," emphasized only the bitterness of the general situation.

Norton, together with Carter, Jean, and Carlson made an immediate investigation of the remaining food. They found that not everything had gone astray. At the mountings of the lost boxes they investigated the broken welding spots. The weakness of these spots could not have been perceived earlier, since the food was hooked on the "Eagle" before. Nobody was to blame. If not for the little satellite and the sudden lateral acceleration, their bad qualities even might not have become fateful at all. And later . . . when they had started back, the remainder of the food would have been in the flagship anyway, and then the devil might have cared for the welding spots.

That capture maneuver on Mars actually was the only opportunity for these spots to break and, the deuce, they broke.

. . . Jean calculated feverishly to determine the orbit for the return. Norton instructed Davis of the general situation and advised him to make as many photographs of the Martian surface with the powerful magnifying telescope as possible until he would be called back. Norton could not allow anyone else to join Davis in his interesting job, because



THE MISSION PROFILE OF 'EXPEDITION ARES'

Krafft Ehricke designed his mission using chemical rockets, which limits the flight path to a low-energy transfer orbit, possible only every 26 months, when Mars and the Earth are in the proper relationship. The crew departs from Earth, and meets Mars months later. But the Expedition Ares crew cannot stay, and must make an immediate return to Earth. To do this, they swing toward the inner Solar System, between the orbits of Venus and Mercury.

"There are no sensational alien civilizations to be expected by exploring our Solar System through space flight, but an amazing variety of basic questions and answers. . . ."

they could not afford to spend a single drop of propellant for such purposes.

Their prospects were critical but not hopeless. The remaining food and water would last for 230 days, if strictly economized. This dictated a flight path back to Earth which would require more energy than was available. Observation of the dark areas of Mars by Davis confirmed what they knew before! There was no possibility to sustain their life on Martian ground. They had to return quickly or to perish.

The L-rockets were their only chance of survival. Jean calculated a cruising path which represented the optimum under the circumstances. They had to jump off the Martian orbit, decelerating approximately by 4 miles per second, retrograde to the planet's direction. They would fall then, toward Sun, and cross the orbits of Earth and Venus until they approached within 44 million miles of Sun. Then they would swing back again and finally approach Earth at tremendous velocity and in a direction declined by 33 degrees toward the tangent of Earth's orbit.

"It's a mad trip," said Jean as she announced the results of her calculations, "but we have no choice."

Norton informed Davis to leave everything behind and to join the main fleet with the L-rocket the "Eagle." He ordered all propellant containers transferred from the "Condor" to the flagship. New mountings had to be provided and the men worked madly, since they had only 10 days before the start if they were to meet Earth at the second cross point. When all spheres were attached, one day remained to throw all dispensable parts out of the flagship and reduce its mass as much as possible.

When all was ready they assembled in the observation room. Norton gave the final directions:

"Friends, we are going to try a desperate jump across the inner Solar System to save for Earth what is left of this sad expedition. In just 224.6 days, if everything goes okay, we will enter the gravitational field of the Earth. Keep your nerve . . . especially during the perhihelion transit. That will be the tough spot. . . ."

. . . The jets roared. Mars fell away into the night. The ship drilled through space toward the blazing center of the Solar System.

. . .The Sun grew in size as they drove steadily toward their perihelion. Finally the disc was 50 percent larger than seen from Earth. An overwhelming flood of light dazzled their eyes, though protected by dark glasses. Norton had stopped any work outside the ships since they had passed Venus. The heat became unbearable. As a last resort they closed all hatches, but the reflector steam plant in the outside frame burst, paralyzing the generators, and some had to be opened again.

Norton gave the ship a rotation to provide at least a temporary shadow for all parts, especially the propellant tanks, the oxygen and water containers. Although the ship was heavily insulated and all vital parts had been covered with a highly reflected surfaces, the temperature rose.

. . . The ship hurled between Earth and Moon. The "Santa Maria" was nearly completely dismounted. Even the gondola in which they lived was doomed to be thrown away. This was not possible however, without mounting some indispensable devices into the frames. Among these, the most important were the remote-control arrangement of the power plant and the radio set.

. . . They stormed toward the right side of the giant Earth globe. Carlson's emergency calls were caught by the large receiver on Space Station I, and plunged the world into one of its greatest sensations. The ships on all seven seas, cities and villages on all continents, were notified. The radar seekers on the station turned their beams, and the telescopes their reflectors, toward the approaching ship. The station announced that 12 rescue ships had been alerted and were ready to take off.

Starving, dying of thirst, hardly humans any more, the crew of the "Santa Maria" squatted in their L-rockets. The flagship was virtually a wreck. Among the many parts, even two of the four motors had been jettisoned with the gondola. Only Norton remained outside among the frame bars to burn the last propellant in a first, but completely inadequate acceleration.

They were 2,000 miles from Earth when Norton turned the motors on. The propellant burnt out in 174 seconds. The once proud "Santa Maria" was an empty wreck now and had to be abandoned. Norton jumped into his L-rocket and gave the last orders;

"Abandon ship! Good luck to all of you! We'll meet on the space station!"

Carter with his heavier ship remained behind and was soon lost from sight. Everyone had to fight himself alone through the last part of the journey. Many days later they learned that he had circulated around Earth too often, each time contacting the atmosphere. He dropped finally below his local circular velocity and had to go down to the ground. The lookout on a luxury liner between San Francisco and Honolulu saw the parachute descend. A rescue boat fished Dr. Carter out of the Pacific. He later said that be never had enjoyed a bath so much in his life! The captain had to confine him to his own cabin when the enthusiastic passengers learned that he came direct from Mars.

Carlson made a perfect flight and was first to arrive at the station.

Davis had bad luck when, one of his fuel lines broke. He had to cut off his motors immediately and plunged into the atmosphere with too high velocity. This broke one wing from the L-rocket and as Davis whirled into space again he realized that he could not risk a second transit through the atmosphere. He was thrown into an elliptical course, as he found out from position calls, whose apogee was 500,000 miles away from Earth. This made things critical as his oxygen supply would have been exhausted long before he had completed one revolution through that ellipse.

He studied his position tables and found that he would pass

THE KRAFFT A. EHRICKE
INSTITUTE FOR SPACE DEVELOPMENT

The Krafft A. Ehricke Institute for Space Development, founded in 1992, is dedicated to preserving and disseminating the work of Dr. Krafft Ehricke, in order to provide the technical and philosophical foundation for the future progress of space exploration. The Institute has donated Dr. Ehricke's collection of writings and research materials to the National Air & Space Museum in Washington, to make this treasure available to the public.

The Institute plans to prepare for publication a selection of Dr. Ehricke's writings, additional unpublished manuscripts, and his book, *The Seventh Continent: Industrialization and Settlement of the Moon.*

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close to Moon. Quickly determined, he repaired his damaged fuel line, threw everything dispensable overboard and radioed to the space station that he was going to hang himself on Moon.

When approaching Moon, Davis spent his last propellant in a desperate capture maneuver. He broke down when the last fuel drop was burnt. With glowing nozzles the lonely ship circulated around Moon in a slightly elliptic orbit, fifty miles above the craters.

The rescue party of "Space Station I" found Davis unconscious but still alive. His breath pack was empty.

. . . When they entered the rescue ship, Jean knew that this was not the end, but the beginning of a great story. . . .

For Further Reading

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