Krafft Ehricke's 500 Years of Space Exploration

by Marsha Freeman

> "*In the last analysis, interstellar flight will be an extension of the process of learning through which we mature." It will be the "unfolding of human civilization."*

Aug. 10—In October 1942, Krafft Ehricke stood on the roof of a building at the Army rocket research station at Peenemünde and watched mankind's first rocket to succeed in leaving the Earth's atmosphere and crossing into space. He related many years later that he was so excited he "almost fell off the roof." It was like "Columbus or Magellan standing at the edge of a new epoch."

After World War II, Krafft Ehricke came to the United States. He was the developer of the energetic Centaur liquid hydrogen rocket that opened the Solar System for robotic exploration.

The main body of Krafft Ehricke's work is, however, devoted to looking to the future. He could see a future in which mankind left petty differences behind and as one civilization, developed the ability to leave Earth and travel among the stars. He proposed that "the ultimate meaning [of interstellar exploration] relates solely to its effect on the evolution of the human species … Interstellar operations will be experienced by the human species and in terms of a human civilization or they will not be experienced at all."

In 1957, at the opening of the Space Age, Krafft Ehricke promulgated three laws of astronautics to guide the new epoch. His second law reads: "Not only Earth, but the entire Solar System and as much of the Universe as we can reach under the laws of nature, are man's rightful field of activity."

Excerpts from some of Ehricke's writings were published in this author's book, *Krafft Ehricke's Extraterrestrial Imperative* (Apogee Books, 2008). We present here material from four chapters of his unpublished book on interstellar exploration, and from a 1976 paper, which further explicate Ehricke's concretization of this second law.

Courtesy of Krafft Ehricke

Krafft Ehricke explaining his concept of an Earth-orbiting hospital to CBS TV's Walter Cronkite.

Androcells: Flight Between the Stars

A few centuries from now, mankind will have created new, self-sufficient artificial planets. These man-made planets, which Krafft Ehricke calls Androcells, will travel through interstellar space using fusion propulsion, transporting scientists to explore beyond our Solar System. The Androcells will be made from lunar materials and will be "equipped with terrestrial life."

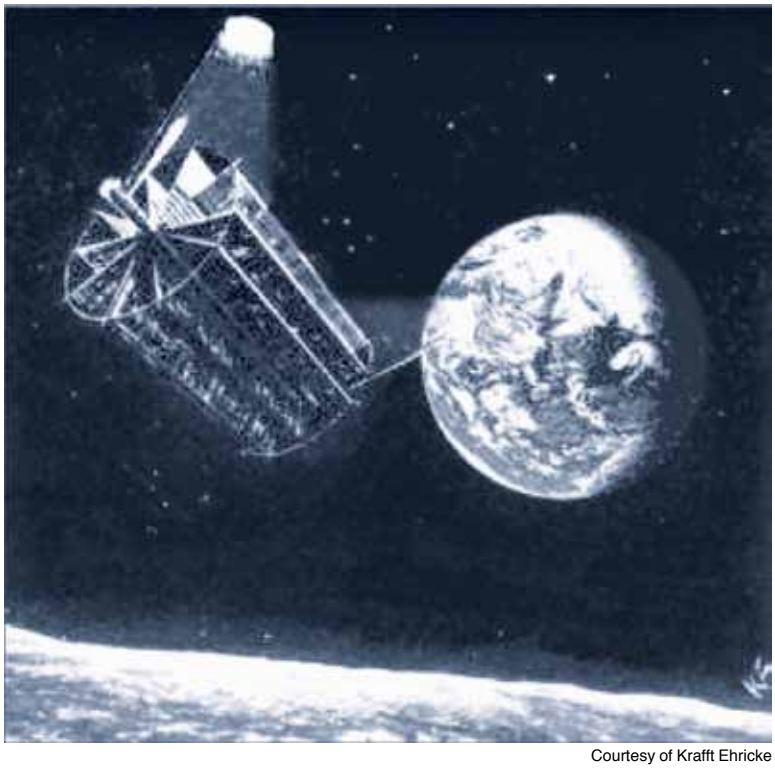
Even with the most advanced propulsion technology envisioned for centuries in the future, such as mater-antimatter drivers, only a fraction of the speed of light will be attained. Considering the distance between stars, interstellar travel times will not be over one man's lifetime but over many generations. "Androcells are characterized by complete resource autarchy," Krafft Ehricke wrote, meaning that they must be self-sufficient and independent of Earth. The travelers will have available

"local" resources, such as helium-3 fuel for their fusion-driven propulsion system from the giant gas planets of the Solar System, and minerals and raw materials from small bodies they will come across, such as asteroids and comets. Helium-3 fusion will not only be key for supplying electric power and propulsion, but also for carrying artificial suns, illumination, powering laser tools, materials processing, and changing temperatures.

Scientists on these traveling Androcells would be able to make (relatively) close observations of stars in every phase of their evolution. It would be possible to examine some of the thousands of planets and solar systems that have already been discovered orbiting other stars, which are barely visible from Earth.

This project would be aided, Krafft Ehricke reports, by earlier research:

> Advanced orbiting and especially advanced lunar observatories will permit us to search systemically for planetary systems among the stars, and we may be able to recognize systematic differences between stellar spectral classes so far as abundance of planetary systems is concerned …



Courtesy of Krafft Ehricke

Androcells are self-sufficient, fusion-powered new "planets," which will carry the multi-generational explorers of interstellar space.

Knowing certain distinctions between star types could narrow the search for solar systems, which closer examination may reveal, could be possible abodes for life.

This future exploration of the far reaches of interstellar space, 500 years from now, will set man free from any limitations. Mankind will be able to establish new civilizations with new cultures, that conform to Ehricke's Third Law: "By expanding through the Universe, man fulfills his destiny as an element of life endowed with the power of reason and the wisdom of the moral law within himself."

The precedent Krafft Ehricke cites, in accordance with his Third Law, is the setting of principles by the Declaration of Independence and the Constitution, in the creation of the United States.

'Remaking the Solar System'

In October 1976, at the dedication conference of the International Space Hall of Fame, in Alamogordo, New Mexico, Ehricke presented a paper titled, "Astropolis and Androcell—The Psychology and Technology of Space Utilization and Extraterrestrialization."

Extraterrestrialization, the creation of whole new worlds, Krafft Ehricke explains, takes place through three phases. First, machines are put into space. Then, human and biological elements are introduced. "Extraterrestrialization integrates the two into components of whole new worlds."

In the third stage, mankind will be ready to "leave the harbor and emerge into the open sea of space." The civilization that develops through the Androcell "is truly three-dimensional, and becomes four-dimensional as it spreads out through interstellar space. …The two-dimensional existence on Earth's land surface ultimately becomes only a brief (by evolutionary standards) interim phase …The growth potential of all life forms (not only human) capable of emerging into this infinity exceed all comprehension. It relegates all its previous history to the proverbial first step in a journey that lasts a thousand miles."

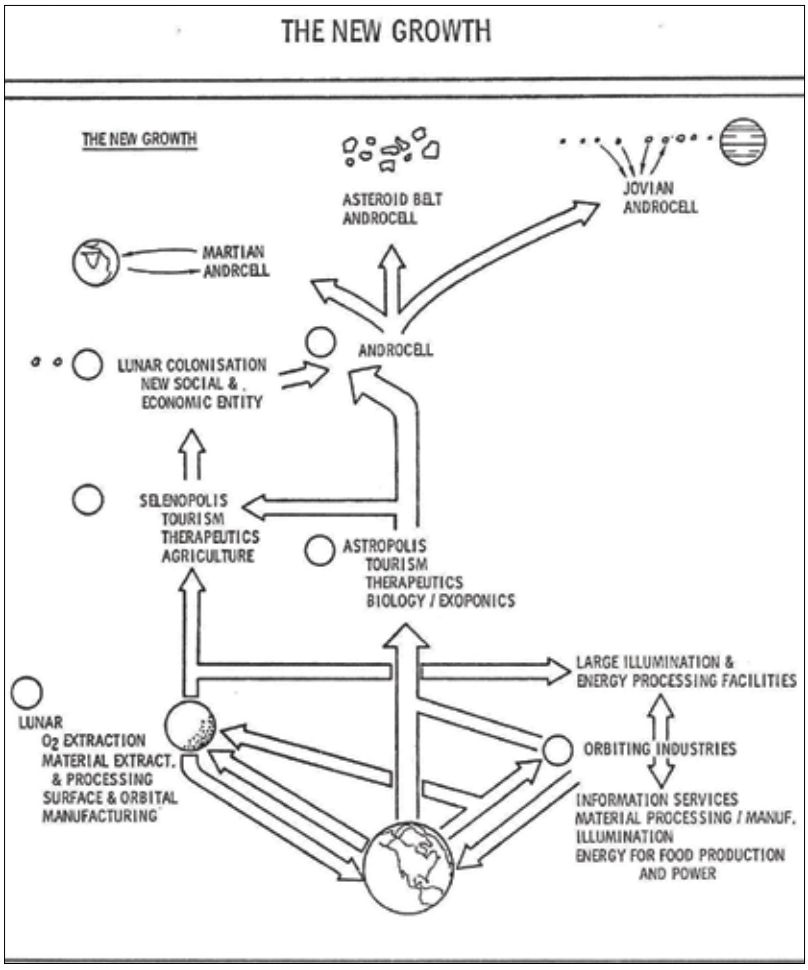
Before crews set off for expeditions in interstellar space, to develop the technology as well as the intellectual stamina for multi-decade, multi-generational missions, technology will be developed on self-sustaining new worlds—planetellas—which will operate within

the Solar System. These new "Earths" will be the foundation of the Androcells, which will be cut lose from Earth, to explore interstellar space.

Krafft Ehricke proposed that planetellas be placed in heliocentric orbit, 1 astronomical unit (A.U.) from the Sun (the distance between the Earth and the Sun, approximately 93 million miles). This is described as the "goldilocks" zone, where a planet is neither too hot nor too cold, but is within the range of pressure and temperature for water to persist in a liquid state, and, therefore, for life to persist. Of course the Earth only occupies a tiny portion of the huge circumference of its orbit. Were new planets to fill in the empty space, 70,000 Earths could be accommodated, if they were lined up side by side like a string of pearls.

Konstantin Tsiolkovskii suggested in 1895 that mankind may eventually *reconstruct* the Solar System so as to more efficiently use that biologically valuable region at around 1 A.U. One option would be to move some of the mass in the outer Solar System inward toward the Sun, to 1 A.U. This would, in essence, allow the Sun's total output to be used to support a population that Tsiolkovskii estimated at 300 billion billion.

Flow of Development from Earth to the Moon to the Planets



Courtesy of Krafft Ehricke

Freeman Dyson, Krafft Ehricke reports, calculated in 1959 that Jupiter's mass alone would suffice to construct a spherical shell of 2 A.U. radius and two to three meters thickness around the Sun.

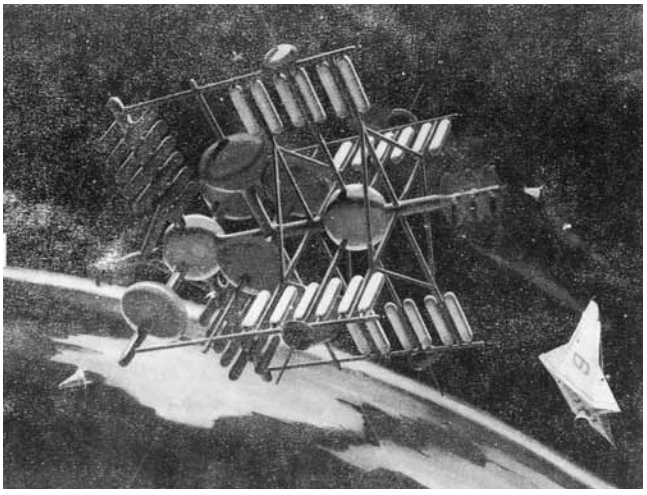
"Compared to such endeavors as Tsiolkovskii's and Dyson's, the establishment of planetellas for a few thousand and eventually for a few million people is a modest undertaking indeed, which should be realizable in the next one or two centuries," Krafft Ehricke asserts.

But why be limited to the distance from the Sun of the only planet in the Solar System—as far we know—that supports life? What if we could make our own artificial sun, using the same fusion energy that powers the stars? This is what Krafft Ehricke proposes to do.

The basis for the development of helioids or artificial sunlets, is advances in nuclear fusion and giant heliocentric transports. "The helioids provide the necessary prerequisites for opening the outer solar system to human colonization." Although Tsiolkovskii in his time "could not envision it," there is an alternative to "reconstructing the solar system by transporting more planetary matter into the Sun's ecosphere," approximately Earth's distance from the Sun, which can support life. Instead, Krafft Ehricke suggests, carry the "nuclear fire" into the outer Solar System.

"These helioids would circle their new planetellas at a relatively close distance, not radiating omnidirectionally, which would be quite inefficient, but illuminating and irradiating them, primarily by means of a directed beam—Ptolemaic systems in which the sun revolves about the habitat instead of vice versa in the Copernican system."

Having their own sun and fusion for energy and propulsion, the planetellas set the stage for multi-generational expeditions, possible within the next 500 years.



Courtesy of Krafft Ehricke

Astropolis will be a city in space, built in Earth orbit with materials from the Moon.

Astropolis: A City in Earth Orbit

As Krafft Ehricke conceived the pathway to the stars, it will require a step during which a smaller-scale version of the interstellar Androcell would be designed. This large structure in near-Earth orbit, he says, is no longer a space station or a construction base. Astropolis is a model city in space.

The design of such a city will be modular, with the possibility of adding new sections as needed, as the population grows; as science and technology advance; and to replace sections that are out-of-date. A broad array of human activities will take place in the city—many of which were actually originally conceived as possible activities for the International Space Station, but were never implemented.

These activities include research facilities, manufacturing facilities, and hospital care. Residential sections of the city will have to take into consideration factors required for a healthy mental and social environment, and will include private apartments, and open spaces for public use.

The Research Section is designed to carry out "extensive and applied research," Ehricke explains. For example: "On Earth, laboratories may simulate many environments, but they cannot simulate the correct combination of gravity, vacuum, temperature, and radiation environment on the surface of bodies like our Moon, Mars, Mercury, the surface of the Martian moons or the asteroids [bodies smaller than the Earth, with a fraction of a 1-g gravity level]. This becomes possible on Astropolis."

The breadth of activities in Astropolis is possible because it will be slowly rotating. This provides the environment for microgravity experiments and also a 1-g environment to prevent people from becoming deconditioned during their stay.

Selenopolis: A City on the Moon

Our nearest neighbor, the Moon, has a vital role to play in laying the foundation for all future phases of space exploration—in the construction of new planets crucial for exploring the Solar System, and in creating Androcells, which will go beyond our Solar System. All of this will require raw materials and manufactured goods produced on the Moon.

Krafft Ehricke's vision for the future of the Moon was not just as a way-station for crews headed to other places, but as the Earth's "Seventh Continent," through which the Moon's economy would become integrated with Earth's. The most advanced technologies would be developed and tested on the Moon. The Moon will also enable us to test the human factors involved in adjusting to long-duration space missions.

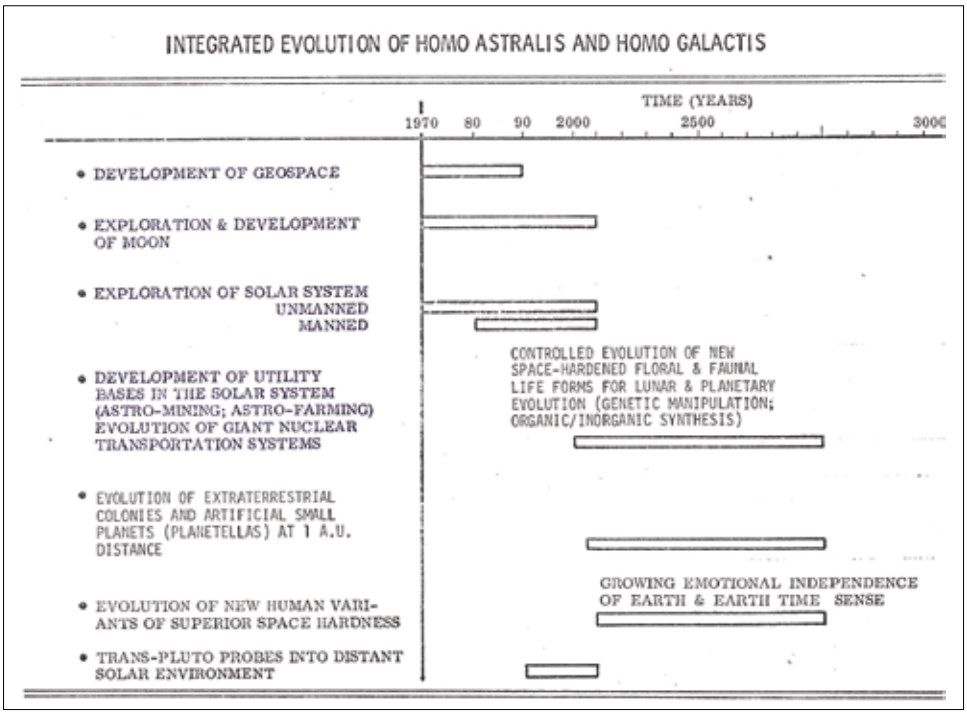
Fusion/Chris Sloan

Selenopolis, Krafft Ehricke's lunar city, will enable the industrial development of the Moon.

The residents of Krafft Ehricke's Moon project would not be living on a base such as that on Antarctica, but in a city Ehricke named Selenopolis. The tens of thousands of people living in Selenopolis will be em-

ployed in mining, manufacturing, and transportation industries as well as in managing the infrastructure of the city. Some will also be specialists in charge of research, such as agricultural experiments and food production. Astronomers and other physical scientists will be studying the Moon itself and the cosmos.

The economic development of the Moon is the first stage in what Krafft Ehricke describes as exo-industrialization. He proposes that the men and women who "make up industrial teams [will] operate in space for more or less limited periods. They are and remain terrestrials," as do tourists and other visitors.



Courtesy of Krafft Ehricke

"Through the demands of exo-industrialization, new infrastructure will be required, including advanced space transportation, human habitats," and the ability to construct large facilities in orbit and on the Moon. Ehricke wrote in his 1976 paper, "The new material resource base acquired in this phase will be the Moon."

Although Krafft Ehricke described in detail the products that would accrue from mining the Moon and promoted the use of helium-3 as a fusion fuel, he does not mention mining helium-3 on the Moon. It was only after he passed away that scientists, taking another look at the lunar rock samples that the Apollo astronauts had brought back from the Moon, discovered that there was enough helium-3 on the Moon—deposited over eons by the solar wind—to make the Moon a viable supplier of this precious fuel for fusion.

Ehricke envisioned Selenopolis as "the transition from the early industrial settlements to a more comprehensive colonization of the Moon." Further, he wrote that the Moon "offers an ideal testing and proving ground for rationally and effectively exploring and developing all aspects involving the building of whole new worlds."


Courtesy of Krafft Ehricke
Krafft Ehricke

The United States is now embarked on the Artemis program to land astronauts on the Moon. Establishing human civilization on the Moon is being discussed by many nations in the world today, with an eye to exploiting lunar resources for humanity's future, such as helium-3. And indeed, helium-3 is pivotal, both as a fusion fuel to make manned, deep space exploration possible, and to create a new standard against which all other sources of power are measured. The lunar programs, some still in formation, should be seen in the way that Krafft Ehricke saw the next 500 years: as the opportunity for all nations to work together as one civilization, embarking upon the proverbial "journey of a thousand miles that begins with a single step."