Eugen Sänger: astronautical pioneer and trailblazer

Modern designs for reusable space vehicles like the Shuttle are still drawing on the early work of one of Germany's great space scientists. Günter Beyes reports.

This is the second of a two-part series. The first, "A space transporter for the year 2000" by Ernst Högenauer, vice president of the MBB Space group in Munich, was a discussion of the future of the German space effort. The proposal discussed there, that Germany build its own hypersonic space vehicle to be named the Sänger, *immediately reminds one of the debt which every nation owes to Germany's illustrious pioneers in space. In this article, translated from the German by John Chambless, Sänger's actual proposals are discussed in detail.*

Eugen Sänger (1905-64) is rightly considered the father of the reusable space transporter, the development of which has only just begun with the American Space Shuttle. This development must and will continue, despite the lull in the United States created by the Challenger catastrophe. If it does not take place in the West, it most certainly will in the Soviet Union. There are reasons to believe that this year, the Soviet "space shuttle," which, not accidentally, is indistinguishable from its American counterpart, will be launched on its first flight under power, after glider tests with a prototype are satisfactorily carried out.

Following World War II, Eugen Sänger was deeply involved in rebuilding astronautical research in the Federal Republic of Germany, which succeeded despite all political difficulties and opposition. From 1954 to 1961, he was responsible for planning, construction, and leadership of the Research Institute for the Physics of Jet Propulsion in Stuttgart, the first astronautical research institute in Europe. From 1963-64 until his death, he held the newly established chair of astronautics at the Berlin Technical University. He fought literally to his last breath for a large-scale European space program, at the center of which would necessarily be a reusable space transporter. While the United States and the Soviet Union concentrated their efforts on the employment of larger and larger ballistic rockets for space travel, Sänger saw in this the decisive moment for European astronautics, a unique opportunity for Europe to advance the development of a reusable vehicle.

Sänger's training

Eugen Albert Sänger was born on Sept. 22, 1905 in Pressitz, Bohemia. In 1919 at the age of 13, he received Kurd Lasswitz's novel *Auf Zwei Planeten* (*On Two Planets*) as a present from his physics teacher. The book awoke in him a lively interest in questions of space travel. In 1923, when Sänger began his studies of civil engineering at the Graz Technical University, he came across Hermann Oberth's recently published work, *Die Rakete zu den Planetenräumen* (*The Rocket to Planetary Spaces*). Sänger was inspired by Oberth's ideas, but, from the very beginning, he clearly saw the actually existing, matter-of-fact connection between astronautics and aeronautics: After all, every manned space flight begins and ends in the atmosphere of our own planet! According to Sänger's early conviction, space flight—and, for him, this was primarily a manned endeavor—could best be realized through a purposefully continued development of aeronautical technology. Later, he used to emphatically say, "Astronautics is a continuation of aeronautics by other means!" The first step in that direction would be a stratospheric plane with rocket drive, and so he turned his studies to aeronautics and the study of aircraft construction (**Figures 1** and **2**). A memorandum on that subject from about 1929 contained the following planned developments:

"Stratospheric plane—space boat—outer station—interplanetary ship—spaceship." He understood, by stratospheric aircraft, machines driven by reaction drive that would ascend to a flight altitude of 60-70 km, to the "technical limit" of the atmosphere, and additionally be capable of attaining a maximum flight velocity of 8,640 miles per hour—still not sufficient to reach orbit, but the ideal means for express intercontinental travel on Earth.

The next step beyond the stratospheric aircraft, would necessarily be the "space boat," which would ascend into orbit around the Earth to permit the construction of an "outer station." Behind this concept was, he explained in 1933, "a structure that, according to the plans of cosmic engineers, will orbit the Earth with such a velocity that weight and centrifugal force are in balance. The outer station would serve as a base for flights to still-greater altitudes." These altitudes are the realm of "planetary ships" and "spaceships." With this precise differentiation, Sänger makes clear what he saw as the real goal of astronautics: the vast expanses of space, beyond our home solar system.

It was clear to Sänger that the systematic pursuit of these developmental steps represented the most obvious and economical route to space travel. In 1929, after transferring to the Technical University of Vienna, in the draft of a dissertation on the subject, *Rocket Flight Technology*, he wrote: "This investigation consists of a purely theoretical, critical comparison of the various possibilities for advance into space, reached by the most economical and safe methods (air boat—outer station—spaceship), and provides a complete theory of these methods. . . . The advance into space with a minimum expenditure of energy takes place according to the following principle: Advance by means of an air boat to the altitude of the outer station, and, from there, further advance with special spaceships; air boat ascent according to the principle of least energy, air boat descent without energy as a glider. . . ."

This dissertation draft, unfortunately, remained in his drawer. Sänger's doctoral adviser dissuaded him, since Sänger would be "an old man with a long beard" before he could be given a degree on this topic. And so Sänger switched, as it were, "according to the principle of least energy," to a conventional topic in the area of aeronautical stress analysis, and passed over the academic hurdles with brilliance—but without ever losing sight of his real goal.

The actual development of astronautics went, to Sänger's deep regret, in a different direction, using large ballistic, nonreusable rockets. He did not live to see the beginning of the American Space Shuttle program in 1972, nor the historic first launch of the Columbia orbiter on April 12, 1981. But, on the basis of these experiences, hypersonic planes are now planned in many countries; for example, the British HOTOL and the corresponding American plans for a transatmospheric vehicle, in whose realization Sänger originally saw the very first step toward space travel.

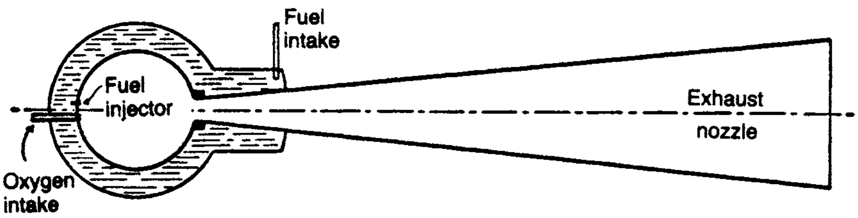
In the notes to a book he planned in 1929 entitled *Cosmotechnology*, there is already found, along with chemical liquid-fuel rockets, the entries "Radium- and Röntgen-rockets." Radium-rockets would today be designated nuclear-heated rocket drive systems, and the Röntgen rockets we encounter in Sänger's later work, "photon-rockets," which will make possible human flight to stars light-years away. But reaching these distant goals of cosmo-technology first requires a space station in circumterrestrial orbit, whose manifold functions Sänger enumerates in this draft.

This process, in his view, would effect the totality of science, economy, and culture, in ways ranging from "interventions into natural geological and meteorological processes" and "lifting of natural resources from other planets" to the now self-evident insight, that the possession of superior space technology would soon decide the political importance of a culture.

In 1930, after completion of his studies, Sänger received a position as an assistant at the Institut für Baustoffkunde (Institute for the Study of Construction Materials) at the Technical University of Vienna. This did not, however, prevent him from carrying out a systematic series of investigations on model rocket combustion chambers which he built himself—acting on his own, without any "research contract" or formal "authority," but with, however, the understanding support of the director of the university. From December 1932 to October 1934, in a modest barn on the grounds of the institute's building yard, he carried out 235 separate experiments in which combustion-chamber geometry, building materials, fuel, fuel proportions, coolants, and coolant delivery were systematically varied in order to reach the optimal results. At the same time and in parallel, the core of what would later become the German rocket team, was carrying out similar propulsion tests near Berlin.

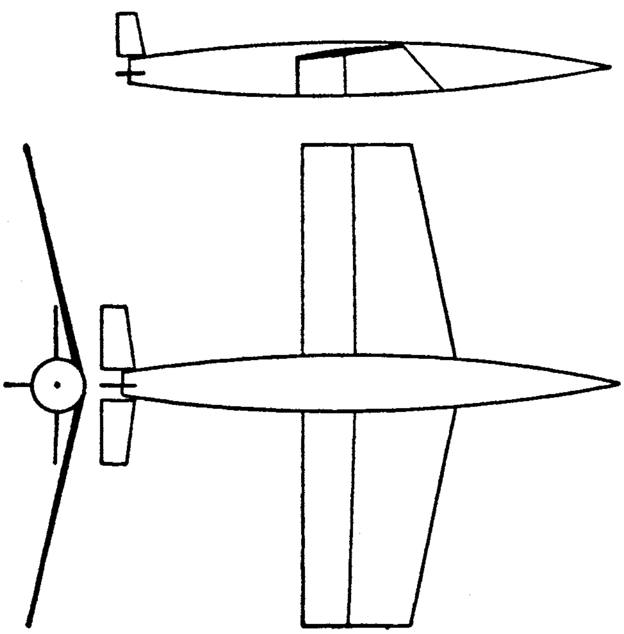
His goal was to reach the highest possible rocket exhaust velocity and the longest possible operational time. From the physical relation, the "fundamental rocket equation," known to Oberth, Konstantin E. Tsiolkowski, the great Russian space pioneer, and Robert H. Goddard, the American space researcher, it was clear that these two quantities, exhaust velocity and operational time, delimited the attainable maximum velocity of the rocket body. The geometry of our immediate cosmic environment also determines definite minimum velocities that man must exceed in order to travel from the surface of the Earth into a circumterrestrial orbit, then to the Moon and other planets, and, ultimately, out beyond the Solar System. Finding engines to finally reach the necessary velocities and then surpass them—that is the key problem of astronautical technology, to which Eugen Sänger devoted the greatest part of his theoretical and practical life's work.

FIGURE 1
Dr. Sänger's experimental rocket motor



For the first step into circumterrestrial orbit, a propulsion system must necessarily attain a velocity of 8,000 meters per second (m/s); from the Earth to the Moon or to another planet, by contrast, at least 11,200 m/s velocity is required. Sänger's miniature combustion chambers, which were small enough to fit in the palm of his hand, reached exhaust velocities of up to 3,000 m/s, with thrusts of up to 30 kp, combustion-chamber pressures of about 50 atmospheres, and operational times of up to 26 minutes. The long operational times were attained using a cooling process that he developed himself, so-called cycle or regenerative cooling. Here, the fuel flowed through tubes placed in the wall of the combustion chamber, then into the chamber such that "the fuel arrives pre-warmed in the chamber and the chamber walls are cooled by the fuel."

FIGURE 2
Dr. Sänger's sketch of a stratosphere rocket plane



This principle, used today in all large liquid-fuel rocket motors, was patented by Sänger in 1935 in Austria, and later in other countries.

In the context of these experiments, Sänger naturally concerned himself with the work of other rocket pioneers, active primarily in Russia, German-speaking countries, and France. He soon recognized the necessity of bringing together the scattered knowledge of engines, aerodynamics, and trajectories of liquid-fuel rockets, including his own results, in a systematic form. The result was the first textbook in the world on *Astronautical Technology,* which appeared under this title in 1933 and was subsequently translated into English, Russian, and Japanese. In the introduction, Sänger concretized his goal:

"In the narrower sense, we discuss every rocket flight that takes place in the upper levels of the stratosphere with such velocity that the inertial forces of the orbital curvature essentially contribute to the lift.

"This type of rocket flight is the next fundamental developmental step of the tropospheric flights undertaken in the last 30 years, and is the first step toward space flight, the most enormous technological problem of the present.

"This first step, and the way to an outer station orbiting the Earth, is the principal, but presently still not immediately realizable, mission of astronautics."

Yet, Sänger, like Hermann Oberth before him, had difficulties in finding a publisher for his manuscript. Eleven publishing houses refused to publish it. Finally, the Oldenbourg Verlag publishing company of Munich—which had already published the books of Oberth and other space pioneers such as Dr. Walter Hohmann and Max Valiers—declared that it was prepared to publish the book, but only if the author contributed 2,000 marks toward the cost and committed himself to ordering 50 copies. Sänger was able to meet these financial conditions only at great personal sacrifice.

Forced under these circumstances to find additional sources of financing for the continuation of his experiments, he presented his report on the first series of experiments and his further plans to the Austrian ministry of defense, "for expert evaluation and enabling of the experiments." When he finally received an answer, Sänger had every reason to be shocked and angered by the mediocrity of his contemporaries: "In reference to your letter of Dec. 26, 1933, it is hereby communicated that the Federal Ministry for National Defense, after examination of your rocket project, does not see itself in a position to consider this matter further, since the fundamental principle of your construction (use of liquid hydrocarbons and liquid oxygen) does not appear to be practically realizable because of the unavoidable explosive character of the process of combustion of the operational materials named. . . ." American space pioneer Robert Goddard got a similar response to his rocket proposals from the U.S. military a few years later.

Sänger was able to continue the experiments in 1934 with the aid of the Technical University; from February to October, he achieved numerous constructive improvements that were to lead to the accomplishments already mentioned. But he had to leave his position at the university at the beginning of 1935. Burdened with the 2,000-mark debt for the publication of his book, he faced financial ruin, but his optimism was unbroken: "Despite all, my silver bird will fly," he wrote on March 23, 1935 in his diary.

At the beginning of 1936, his onerous situation improved: The Deutsche Versuchanstalt für Luftfahrt (German Experimental Institute for Aeronautics) accepted his application, and shortly afterward, he was commissioned by the German Ministry of Aeronautics with the planning of an astronautical research institute and the development of a plan for a research program for liquid-fuel rockets. Under Sänger's direction, a modern test-stand site came into existence at Trauen, in the Lüneburg Moor, suitable for motors with up to 100 tons of thrust and equipped with the first large-tank liquid-fuel facilities in the world, which Sänger developed especially for this purpose, working with the Heylandt firm of Berlin.

After the completion of the facility at the beginning of 1939, the task was to stabilize larger versions of the Vienna "model combustion chambers," to produce reliable operation, and simultaneously, to test innovations that would make higher power possible. Thus, experiments with 1,000 kp of thrust served primarily for the development of high-pressure fuel-delivery cycle pumps that were driven by waste heat from the motor. This principle, too, is still valid today.

At the same time, preliminary work on the development and construction of a 100-ton rocket motor, for which the test stand had actually been designed, continued, as did numerous fundamental theoretical investigations. Sänger found, among other things, a technique for low-Earth space flight with the least possible energy expenditure, today called "ricochet" or "jump" flight, in which the orbit of the space vehicle re-entering the atmosphere resembles a small, flat stone that, skillfully thrown, skips and bounces numerous times in a flat trajectory along the surface of water. Sänger showed that an increased range could be attained in this way, as opposed to a purely aerodynamic ascent—indeed, that using this undulating flight, the Earth itself could be circled numerous times (**Figures 3** and **4**).

This principle was to be used by the rocket vehicle that Sänger and his co-worker—later his wife, Irene Bredt—described in their report, "Concerning a Rocket Space Vehicle." In 1944, the report was classified "Top Secret" under the title, "Concerning a Rocket Drive for a Long-Distance Bomber," and only 100 copies were circulated to a select group of eminent scientists and engineers, including Oberth and Wernher von Braun. It concerned a single-stage rocket vehicle of 100 tons launch weight that could circle the Earth with a minimum payload of one ton, though not in a stable orbit. Alternatively, it could carry a payload of up to eight tons in less than an hour to a point on the opposite side of the Earth. This plane, using a horizontal launch with a rocket catapult on rails attached to the ground, would be accelerated to 1.5 times the velocity of sound before its own drive system was activated.

These project studies created great excitement at the end of the Second World War, when the report fell into the hands of the victorious powers. Stalin personally sent his son, Air Force Maj. Gen. Vassilii Stalin, to quickly get hold of the author of the work at any cost, but in vain: Sänger, Irene Bredt, and a small group of their co-workers were safely in France. In the United States, however, Sänger's plans contributed to the building of various rocket vehicles such as the X-15, with which altitudes of 100 km were reached—the first "jumper in space." A disastrous policy of budget cuts by the American government prevented this work being continued in parallel with the Apollo Project; however, the experience gained with these rockets through 1968 played an important role in the development of the Space Shuttle.

During his activity as an adviser in France from 1946 through 1954, Sänger resumed a project that had previously much occupied him at Trauen: the ramjet engine, which had been originally proposed by the Frenchman René Lorin, but

FIGURE 3
Dr. Sänger's antipodal bomber

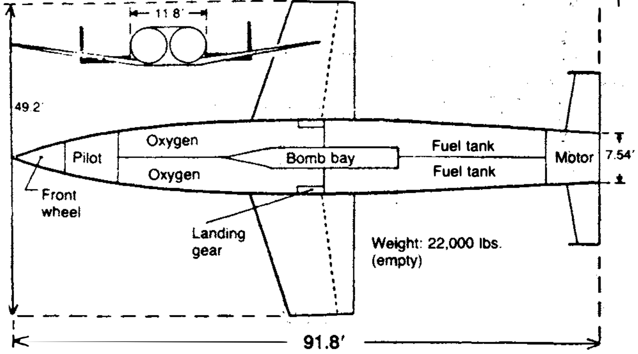
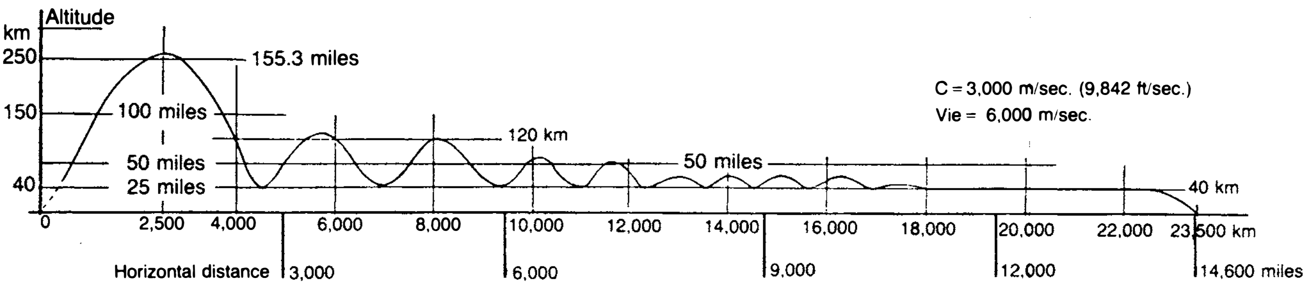


FIGURE 4
Dr. Sänger's design for a 'ricochet' or 'jump' flight space vehicle



could only be properly realized after extensive fundamental research in the area of the physics of flow. Technically, however, it is generally one of the simplest drives, since there are no moving parts. It consists merely of a tube moving rapidly through the air whose interior cross section is so formed in the direction of flow that the air flowing in accumulates and is compressed. If the air is then heated, for example, through injection of a fuel, the combustion gases exit through the nozzle at the outlet end of the tube more rapidly than the air at the inlet end. That means propulsion! Because of its shape, the ramjet quickly gained the appropriate nickname "flying stovepipe" during the airplane towing tests at Trauen used by Sänger to prepare for the construction of a ramjet plane.

In France, Sänger played a considerable role in the development of the supersonic experimental plane *Griffon*, which, on his advice, was equipped with a high-temperature ramjet drive as the casing for the turbojet.

Ramjet drives unite properties of the turbojet drive with those of a pure rocket motor. Sänger showed that, in principle, they work better the higher the velocity of flight, and thus could represent an economic alternative to a pure rocket drive in the narrow transition range between aero- and astronautics—and particularly if nuclear fission is employed as an energy source. Therefore, the combination drive, which unites turbojet, ramjet, and rocket motor and which is therefore efficient in all anticipated ranges of velocity and altitude, is being considered for the transatmospheric planes planned today.

In 1953, Sänger began work again on his idea of the photon rocket, originally conceived in 1929. He developed systematic representation of rocket engines, ranked according to drive possibilities and deployment range, beginning with his favorite, the hot-water rocket, as a launch auxiliary. Then followed rockets with chemical fuel, which are sensible only in space flight in low-Earth orbit. Interplanetary traffic requires a nuclear rocket engine, with which the drive jet can achieve a thousand times what is possible with chemical drives. The highest possible exhaust velocity, however, is possessed by the photon rocket, namely, the speed of light, so that attainable flight velocities can, with an appropriate expenditure of energy, approach arbitrarily close to the speed of light.

He listed three possible constructions: 1) partial photon engines, such as the photonic fission rocket; 2) pure photon engines, with which the total mass of fuel is converted into directed electromagnetic radiation; and 3) photon-ramjet engines, which take their fuel from interstellar plasma, so that the cost of fuel is near zero.

Along with economic considerations, Sänger's standard for which drive is right for which purpose is always keeping flight time at a minimum for the sake of the crew. What is crucial for this is the attainable flight velocity. The key problem of astronautical technology is therefore the production of ever more powerful engines that can use ever higher energy densities. Thus, he arrived at the provocative thesis: Absolute distances, however breathtakingly great they may seem, are for space travel a secondary consideration, because there are no "absolute distances"! That is shown precisely in interstellar distances, which even a light ray—from the terrestrial point of view—must travel for years, even millions of years to cross. But at very high flight velocities—from the spaceship's point of view—the distance to be covered shrinks the nearer the velocity approaches the speed of light.

Sänger was convinced of the necessity of interstellar space travel, and he simultaneously demonstrated that it is, in fact, possible. Sänger showed with his
rocket that no insurmountable problems will be encountered on the way to the stars, since, according to Einstein's General Theory of Relativity, it is completely possible to reach "within a few years of life of the crew the fixed star systems that are, from our terrestrial perspective, millions of light-years distant.

"Within our Solar System, only small, atmosphereless worlds await humanity traveling in space, worlds that appear, in some cases, appropriate for the establishment of certain laboratories and industries, but certainly not a fertile paradise or a new home. . . ."

Sänger's physically well-founded thesis on the possibility of space travel at virtually the speed of light aroused, to his astonishment, a tremendous sensation and outcry among scientists, even to the point of sheer hysterical and personal animosity. That abated only after Nobel Prize winner Max Born, speaking as a high academic authority in the area of relativity theory, reluctantly admitted in February 1958 that there was no logical fallacy in Sänger's theory of space travel using photon rockets. Born could not resist, of course, sneering at Sänger's work as a "victory of the understanding over reason." This statement is explicable only as a deliberate low blow against Sänger's self-conception and philosophical conviction.

For Sänger, space travel was nothing less than "man's departure, out of trivial terrestrial narrowness into the greatness and immensity of space," one of the most elevated and ennobling activities of mankind in general. "The thirst for knowledge and the power of creation, and the fullness of power to subdue the Earth that follow therefrom, are not merely some human properties among others, as perhaps beauty, cleverness, tenacity of character, loyalty, and so forth; rather they are, along with the striving toward heaven, among those elemental, fundamental characteristics of man *per se* that, in general, ultimately and truly elevate him above the beasts," Sänger wrote in his 1963 book *Raumfahrt—Heute, Morgen, Übermorgen* (*Space Travel: Today, Tomorrow, and the Day after Tomorrow*).

One of the most profound experiences of Sänger's life were the words of Pope Pius XII, spoken in 1956 in Rome to the participants in the International Astronautical Congress, including Sänger himself:

"Some of you have advanced so far as to consider the theoretical possibility of flight to the fixed stars, which the name 'astronautics' itself shows as the ultimate goal of your work. We do not intend to discuss details, but it has not escaped you, gentlemen, that an intention of such magnitude includes intellectual and moral aspects that cannot possibly be overlooked. Such an intention demands a definite idea of the world, of its meaning, of its purpose. The Lord God, who put an insatiable desire for knowledge in the heart of man, did not intend to set a limit to man's drive to conquest when He said, 'Subdue the Earth.' Rather, He entrusted all of creation to him, and offered it to the spirit of man, that he might penetrate into it and through that learn to understand more and more profoundly the infinite greatness of his Creator."

The theatre of the absurd around relativistic space flight was still fresh in memory when Sänger directed a passionate appeal to those in political power in the Federal Republic of Germany and Western Europe in his 1958 book *Raumfahrt—Technische Überwindung des Krieges* (*Space Travel: Technical Conquest of War*), that they might immediately grant the proper cultural, scientific, and political place to astronautical research. What he wrote there could have been formulated today:

"The difficulties in understanding the conditions of interstellar space travel today are not at all bad, for this area is still in the original research stage. . . . It would be fundamentally worse if the public in Europe had no understanding of the tasks of supersonic air travel, which immediately confront us, and of international space travel, concerning which each and every one of us must directly decide. . . . Germany also will be able to preserve its prosperity, regained through its inflexible determination, only through a thriving industry that must have at its cutting edge a thriving aeronautical and astronautical industry, or else fall back into the condition of an underdeveloped country."

Because of years' long, in part bitter experiences with national and international research bureaucracies, Sänger advocated more private economic initiatives in the area of astronautics. During 1963-64, he directed the European consortium's study project Space Transporter *Eurospace*, in which the Junkers-Werke firm was prominently represented. The study proposed a stepwise plan spread over 15 to 20 years for realization of a horizontally launched, reusable space transporter. At a Eurospace conference in Brussels on Jan. 23, 1964—a mere 18 days before his death—he appealed to the delegates from European aero- and astronautical industries to bring the plan to realization:

"An economical space traffic system with great transport capacity will become actual at the moment when the problems of rendezvous techniques of manned space vehicles in circumterrestrial orbit are solved and the first landings of men on the Moon have been achieved, and therefore, the construction of large, manned, permanent Earth space stations and secured bases on the Moon must be begun. It is even an absolute presupposition of these undertakings, which foreseeably will be attacked in the next decades.

"If these developments in the United States and the Soviet Union are still not in motion, that is because the total intellectual and material potential of these countries is presently bound up in what is actually pioneering work, above all the race to the Moon. As soon as this exertion is past, they will devote their efforts to the next stage of practical space travel—the preparatory works of the American astronautical industry show that clearly.

"Thus, there exists for Europe a unique but temporary opportunity to become fully active, both intellectually and materially, in an area of astronautics in which the great powers have not yet gained an unchallengeable leadership . . . so that these countries could even become customers of European astronautical industries. . . ."

Sänger's demands are even more valid today, after many squandered opportunities: We need an ambitious new scientific beginning, so that we can participate in the technological achievements of the future.

Sänger on 'Astronautics in the Federal Republic'

In March 1963, out of concern for the progress of German efforts in the area of rocket technology and astronautics in general, Eugen Sänger wrote a memorandum to the President of the Federal Republic of Germany. The reflections formulated in that memorandum have again attained a burning relevance, following the largely self-inflicted decline of the culture, science, and economy of the Western world and the standstill of the overall Western space program. Sänger's remarks are equally valid, perhaps even more so, for strategic defense.

Sänger's memorandum gives a fundamental outline of the intellectual and material resources for space travel, the industrial goals of European astronautics, the derived tasks for applied astronautical research, the broader tasks of fundamental research, and the organizational measures to be undertaken in West Germany. What follows are some of Sänger's thoughts on the political, social, and economic effects of astronautical technology.

The present buildup of civilian and manned space travel by both sides of Europe promises to the nations involved . . . an important economic, cultural, and strategic dominance. . . .

Technically, of course, the possibility exists of building up presently existing low-Earth space flight programs into a military space-weapons system, using the installations also serving civilian space travel such as space vehicles, Earth satellites, space stations, pure space vehicles, and lunar stations.

Such a weapon system in the hands of an individual nation could allow an absolute military dominance of the total surface of the Earth and paralyze all types of classical weapons.

The temptation to that kind of misuse of astronautical installations becomes the greater, the greater is the advance of one of the rival groups in the construction of astronautical installations.

In fact, such an advance has taken place in the past years in the crucial areas of manned space flight and the preparations for landing men on the Moon by Europe's eastern neighbor, and is continually being extended. . . .

One of the most interesting by-products of space travel seems to be the advent of terrestrial aeronautical systems that have the greatest possible velocity, and that travel with the greatest economy halfway around the Earth in 90 minutes. These are even today tending to outstrip efforts for supersonic air transport.

Also in the competition for world prestige in these civilian areas, Europe cannot be allowed to abstain from participation if it wishes to preserve its position as the greatest industrial complex in the world, as a densely populated continent that is still an intellectual and civilizing center.

The radical dominance of the countries pursuing astronautics, however, does not at all derive from the areas of military superiority or of material, economic preeminence. Rather, it follows . . . from superiority in science and technology that is so deeply impressive to any human being and that accrues to the country that actually fulfills the nature-given tasks of humanity, because these represent to the highest degree the extension of mankind's sphere of action into space, to the Moon, Mars, and Venus, into the Solar System and beyond.

Whoever opens up the starry heavens to mankind will win the minds of men and will, like a magnet, draw the best of the world's youth to himself. . . .

This cultural mission can, ultimately, be lost by ancient, culturally creative Europe.

A European effort in the area of astronautics comparable to that of the Russians and the Americans is therefore necessary:

1) that Europe come to the aid of its American partner in order to equalize the ever-greater temporal advantage of Soviet Russia in the conquest of secure positions in space, and the military dominance thereby threatened;

2) to maintain in the long run the economic competitive edge of European industry in all its areas;

3) to preserve the cultural and civilized reputation and heritage of Europe.

Sänger's memorandum concludes as follows:

German fundamental astronautical research and, quite especially, German astronautical industry, and the applied astronautical research dependent on both, must receive rapidly increasing material resources—just as the last two must receive public contributions—so that Germany can cooperate on an equal level, and not merely within the European context, but can also regain its former scientific and technical position in astronautics.