A space transporter for the year 2000

Ernst Högenauer, vice president of the MBB Space group in Munich, reports on the German space program and the key role of Eugen Sänger, father of the Space Shuttle.

There is presently, a competitive atmosphere being generated between European nations and the United States. Partly this is the result of the increasingly depressed state of world trade, partly a deliberate plot by those—like the Trilateral Commission—who would see the destruction of the Atlantic Alliance as a desirable step toward placing Europe under the domination of the Soviet Union. One aspect of the trade-war scenario, is setting the United States and Europe at odds over the future of the aerospace industry.

Clearly, adoption of a joint program to develop the U.S. Strategic Defense Initiative and the European Tactical Defense Initiative, combined with a joint commitment to the colonization of Mars within the next 40 years, would pose the opposite problem. Every potential industrial resource of Europe, the United States, and Japan would need to be fully utilized and more, to meet the demands of this task.

In this issue we offer the translation of an article on the German space program, by engineer Ernst Högenauer, which appeared first in the German edition of *Fusion* magazine, December 1986. This will be followed by a more historical treatment of the German program for the development of reusable space vehicles.

While the name of Wernher von Braun is well known to Americans, another pioneer of the German space effort, Eugen Sänger, is a more obscure figure, although his concepts were at least as advanced as those of von Braun. Sänger should rightly be considered the father of the Space Shuttle. His design concepts for advanced space vehicles have yet to be fully realized to this day.

We have translated these articles, not only because of the intrinsic interest of the subject, but also to remind our readers of the crucial role which German space scientists have played in opening the space frontier. Clearly, it is of vital national interest to the United States that the work of Sänger be carried forward in Europe as well as in the United States. The frustrations expressed by Högenauer, will no doubt come as a surprise to many readers, who have been overexposed to narrowly posed appeals to so-called national interest, which are now circulating in the United States.

Cost figures are given in the West German currency, the deutschemark (DM), at present worth about U.S.$0.55.

Space transporter for the year 2000

Globally—in Europe, the United States, and also in Japan—new space transport systems are currently being planned and developed. The decisions that are to be made in this connection do not merely concern the future of space flight. They will determine our total scientific, economic, and political life.

This is particularly true for Europe and the Federal Republic of Germany. The discussion concerning a new space transport system is more than merely technical; what will be decisive is the debate on the financial and political aspects of the technology, involving two essential questions:

- Will Europe maintain its hard-won but qualified competitive ability with regard to the United States, or lose it again?
- Can the Federal Republic of Germany finally take on a contributory and formative role in the development of space flight?

Marsha Freeman

The Space Shuttle lifts off from Kennedy Space Center on April 12, 1981. Without the work of German scientist Eugen Sänger up through 1942, it wouldn't have happened.

The discussion that was carried on this year in the Federal Republic concerning the French project *Hermes* and German participation in that project, brought a bitter truth to light: For some time, no resolute initiatives in astronautics have come from the Federal Republic. All important new developments such as *Ariane* or *Hermes* were initiated by the French; then, last year, as the British brought their HOTOL project into the discussion as the possible successor for *Hermes*, it became quite clear that German space policy has arrived at a crossroads: Either continue with deficient initiative and with irresoluteness—with the consequence that German astronautical industry will fall, finally, into the role of component supplier to the major projects—or the Federal Republic will make a contribution to the further course of European space flight to a degree that corresponds to its scientific and technological potential and, not least, to its large financial contribution to European space flight.

The space transporter first proposed by Sänger, from the German side, as the future European space transport system, would represent the branch toward the second possibility, and could thus become an essential driver for the industrial future of the Federal Republic. Here lies the far-reaching significance of this project; its significance for European space flight becomes clear if we take a look at the future.

European space flight in the year 2000

The masses of payload that will be transported into space will considerably increase: Satellites, platforms, manned and unmanned space stations must be transported and maintained, and an "orbital transfer" must be established between the various orbits. The European Space Flight Agency, ESA, estimates that the European payload volume will lie between 50 and 100 tons in 1995. That is considerably more than today, though indeed quite small in comparison with the Soviet Union: Right now, the Soviets transport 300 tons of payload into space each year.

If we at first leave new, progressive transport systems out of consideration, then we will have the following means available at the end of the 1990s in order to be able to manage this steadily increasing mass of payload:

1) Multi-stage launcher rockets of the *Ariane 4* and *Ariane 5* type, and

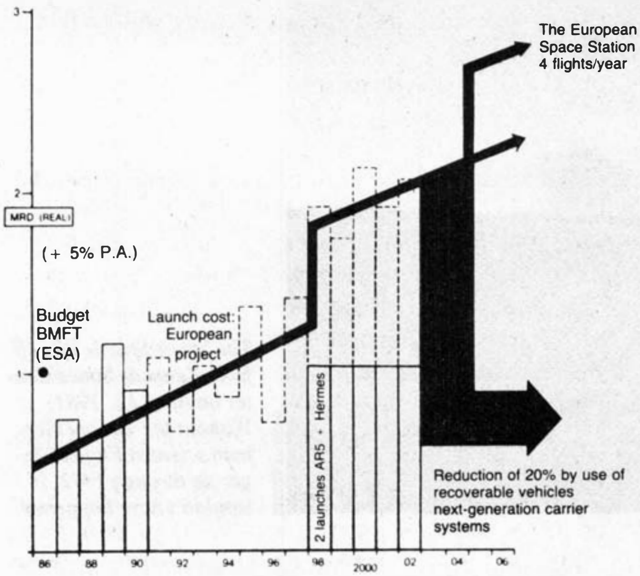
2) Multi-stage carrier rockets with returnable, reusable upper stages of the *Hermes* type.

From the point of view of available capacity, these systems may be sufficient; however, it is already foreseeable that the current costs of these transport systems will lead to a considerable financial burden. If the total European transport costs until the year 2020 are forecast, it must be noted that these will rise explosively: 11.5 billion DM will be expended from 1987 to 1995 for *Ariane 4* launches, and between 27 and 35 billion DM for launches of *Ariane 5* from 1995 to 2005, while the launches of *Ariane-5/Hermes* from 2005 to 2020 alone will amount to 69 to 115 billion!

Figure 1, which is based on an ESA estimate, underlines this trend. By 1992, launch costs of all programs will be as high as the total contribution that the Federal Republic makes to the ESA, and, to an increasing degree, the ESA budget will have to be employed for purely operational costs. The results are foreseeable: The high launch costs will block the development of new payloads, public contributions will be cut, and private projects will simply cease.

In light of the cost situation forecast, it is obvious that astronautical activities as planned can be expanded and to an increasing degree commercialized only by means of space transport systems that permit a drastic reduction of transport

FIGURE 1
Forecast of launch costs



Graphic representation of an evaluation carried out by the ESA of launch costs that will be expended in the coming decades for the ESA's scientific programs (including operation of the space station).

costs. We expect this crucial cost reduction from recoverable technology.

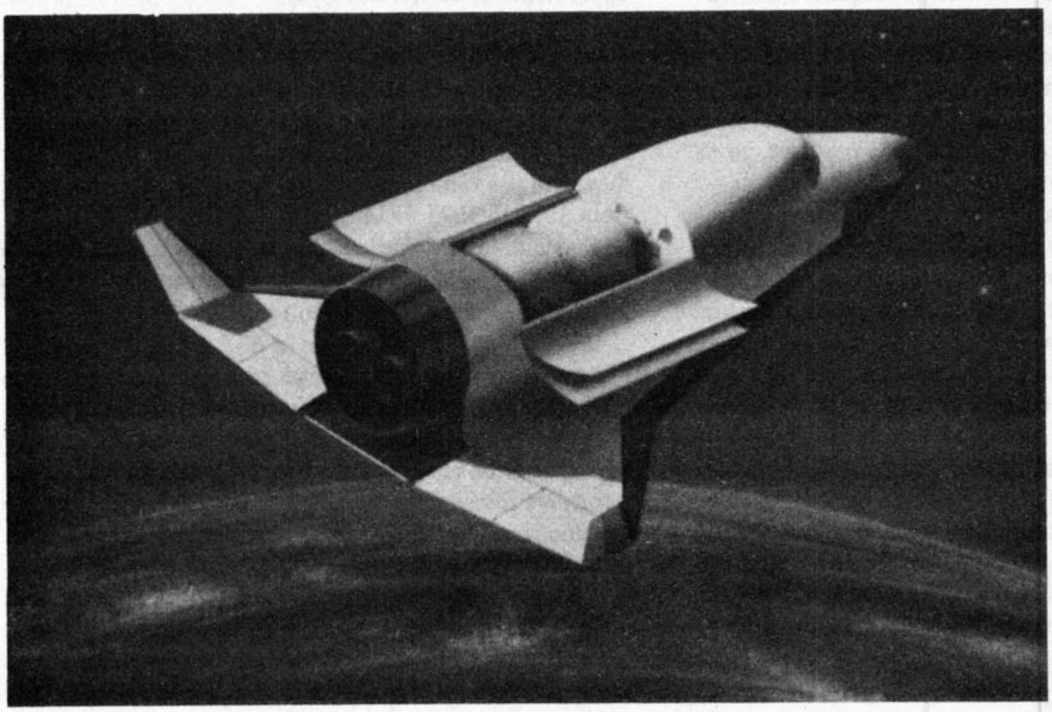
Cost reduction through recoverable spacecraft

The work on new space transport systems that is being undertaken today in the United States, Europe, and Japan, shows clearly that the developmental trend away from the "expendable rocket," which today continues to be definitive, goes, by way of the partially reusable carrier, to the fully reusable.

At least a beginning for the techniques of recoverable technology will be realized in the European space glider *Hermes* (see **Figure 2**), which derives from a French initiative. *Hermes* stands in a close connection with the planned European space station. Its task will be to transport men and materials for the station into space, and then to serve as the "umbilical cord" for the space station. According to existing designs, the transport system is to function as follows:

The glider will fly into space on the back of *Ariane 5* with a launch weight of 17-20 tons, and can carry in its cargo space, which measures 3 × 5 meters, 4.5 tons into a low-earth orbit. *Hermes* flies with two crew members and can, as a personnel shuttle, carry four additional passengers. The space glider is related to the Space Shuttle Orbiter; both are launched vertically, both return to the Earth gliding aerodynamically and land horizontally. The essential difference: *Hermes* has only 4.5 tons of fuel and a small engine on board,

FIGURE 2
The space glider *Hermes*



Hermes *means for Europe the entry into manned space flight and thus also into recoverable technology.*

and functions essentially as a passive return system. The Shuttle Orbiter, on the other hand, with its engines and the large liquid-fuel tank, is the upper stage of a two-stage system.

For a functional *Hermes* system, a functional infrastructure must be built up, in addition to the development of the space glider. This system consists essentially of the following components:

- Integration center for the space glider;
- Training center for the crew;
- Control center for the total mission with the sub-tasks of launch and landing control and orbital control;
- Landing orbits;
- Communication system with a data-relay satellite at the apex and a global network of surface stations.

With *Hermes*, many trend-setting techniques will be developed, tested, and thus made available to Europe:

1) Reentry technique;

2) Hybrid flight control and positional control for navigation inside and outside the atmosphere;

3) New materials;

4) Manned space flight.

Hermes thus signifies a step in the right technical direction; of course, the operation of the entire carrier system will be extremely cost intensive. The cost-lowering tendency that is hoped for from recoverable technology will be more than offset in the case of *Hermes* by three factors. These factors are the decisive causes for the explosion of launch costs referred to above.

1) The glider will be shot into space by *Ariane 5*, and thus continue to be supported by expendable rocket technique. Complicated and expensive technology will be produced, integrated, and subjected to expensive tests, only to be lost after a single use. According to present estimates, a launch of the *Ariane 5* will cost 230 million DM.

2) The combination of *Ariane 5* and *Hermes* reduces transport capacity from 10 to 4.5 tons. *Hermes* functions like a "dead payload," and thus increase the specific launch costs.

3) Only through additional infrastructural measures, which were referred to above, can the mission of the manned space glider be successful. This also costs additional money.

Thus, *Hermes* will not be able to solve the definitive problem for the future of European astronautics—inexpensive access to space—but will, on the contrary, intensify that problem. Yet, it must not be dispensed with—it is necessary as a technologically intermediate step, as the transition to European transport systems of the third generation, which will replace *Hermes* at the beginning of the next century.

A third-generation space transporter

The future transporter must allow sufficient latitude for the development of scientific and commercial payloads and, additionally, be able to stand up against its competition in a world market, which will further expand. The following set of priorities specifies the requirements that are to be placed on the European third-generation space transport system:

1) The specific payload costs for the transport of men and materials into space shall be at most 20% of the costs of *Ariane* and *Hermes*. This corresponds approximately to the value for which the United States is striving with its future carriers.

2) Development costs must be as low as possible; available and tested technology, at least at the beginning, should be relied on;

3) Reliability and safety of the carrier system must be comparable to that of passenger planes;

4) No policy decision to pursue exclusively manned or exclusively unmanned space flight is to be made. The principle should be, "As much unmanned space flight as possible, as much manned flight as necessary";

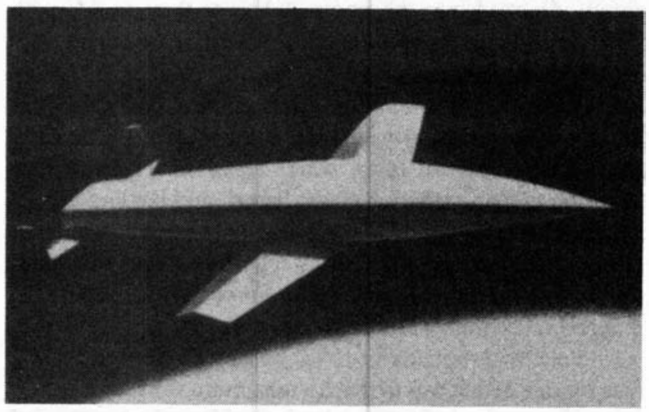
5) First choice for launch and landing sites are major European airports. The geographical connection to the equator for the beginning and end of missions should be eliminated.

Many technological and conceptual studies have been undertaken since the beginnings of space flight in order to realize the mentioned requirements, with the emphasis on the key component, the engine. Various initial solutions with one- or multi-stage carriers are conceivable; common to all the proposals is, however, the designation of the drive: In a substantial part of the atmosphere, an air-breathing engine will be employed for acceleration into the hypersonic range; beyond the atmosphere, the carrier will be carried into circumterrestrial orbit by means of a rocket engine.

Eugen Sänger: father of spacecraft

Reusable, winged spacecraft first came into consideration in Germany more than 40 years ago at Peenemünde, begin-

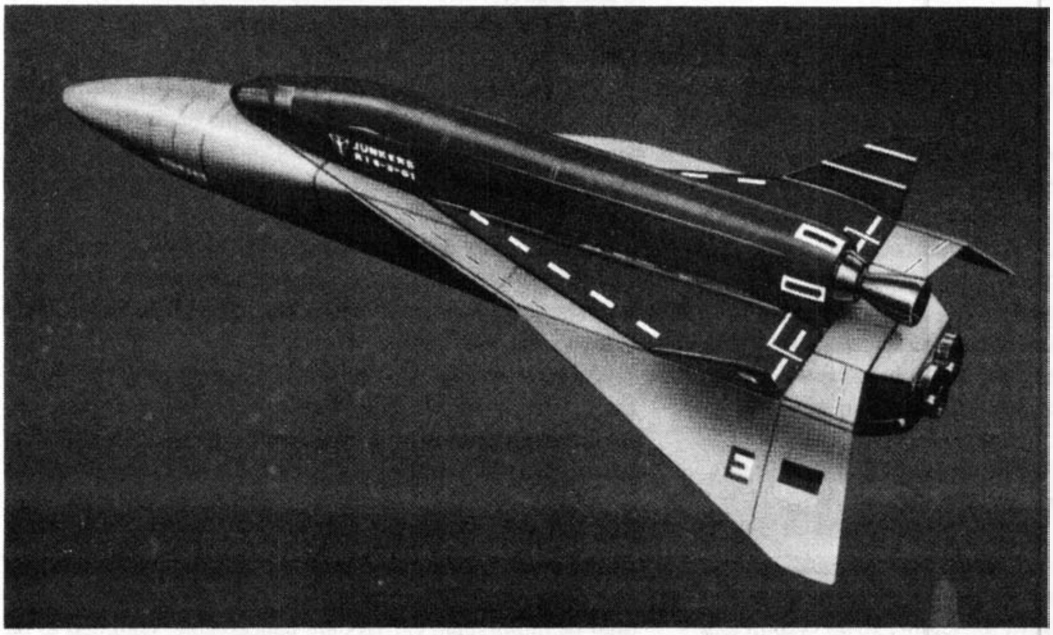
FIGURE 3
Sänger's rocket aircraft



In 1942, Eugen Sänger conceived the world's first rocket aircraft, a one-stage vehicle that can be considered the "primordial ancestor" of all winged spacecraft.

FIGURE 4

Sänger I: space transporter out of the 1960s



In the 1960s, a working group of the ERNO, Junkers, and Dornier firms conceived a completely reusable spacecraft. Eugen Sänger inspired this project, which, however, remained a study on paper. The results of the work were placed at the disposal of NASA and influenced its research on the Space Shuttle.

ning with Project A9, a liquid-fuel rocket with airfoil wings. However, the astronautical pioneer Eugen Sänger has to be considered the authentic father of space aircraft; he constantly advocated the conception that the way into outer space should lead through the further development of the aircraft.

This idea is completely obvious, since the aircraft "uses" the atmosphere that we must cross on the way to space, while conventional ballistic rockets work *against* the atmosphere: They carry with them—at the cost of payload—large amounts of oxygen that could be taken from the surrounding atmosphere; they are braked by the atmosphere rather than using its lift; and, finally, the expensive, spent rocket stages are simply dropped into the ocean, whereas they could, with wings, return to the Earth.

Sänger designated the era of ballistic rockets as the "primitive condition" of astronautics, and constantly emphasized the advantages of the winged route into space: full reusability and a better payload ratio, which leads to a considerable lowering of transportation costs; launch and landing at normal airports, which makes the construction and operation of expensive rocket launching sites superfluous and which additionally—a special advantage for Europe—makes possible manned space flight from European soil.

Sänger had, already in 1942, conceived a space aircraft (see **Figure 3**) that was to reach a maximum velocity of 5,000 m/s with a payload of 1 ton. A horizontal launch was intended using a rocket sled that would accelerate the aircraft to 500 m/s. Subsequently, the glider would ascend to an altitude of 100 km, and then, exploiting the atmosphere in a "jump flight" (similar to that of a flat stone that skips along the surface of water), would circle once around the Earth. This aircraft, of course, remained a study on paper, yet it was the first one-stage, reusable space transporter of astronautics and thus, conceptually, the primordial ancestor of all winged spacecraft either now existing (such as the American Shuttle Orbiter) or planned.

As a continuation of this fundamental work, Walter Dornberger, who had previously directed the work at Peenemünde, conceived a two-stage rocket aircraft in the United States in the 1950s. The first stage had an air-breathing engine; the supersonic glider was designed for velocities from Mach 10 to Mach 15 and a range of 15,000 km. Numerous further plans for two-way technology were worked up in the following period by American rocket firms and, in part, also tested.

In the 1960s, German firms also began to occupy themselves with this kind of project—as a result of Eugen Sänger's initiative. He viewed the winged space transporter as a great opportunity for Germany and Europe to gain ground on the already established space powers. In 1964, the firms ERNO and Nord Aviation projected a two-stage winged space transporter whose first stage was to be driven by combined ramjet drives with 72 tons of thrust, while the second stage was provided with four rocket engines, each with 35 tons thrust. With a launch weight of 300 tons, the 3-ton payload was to be carried into a circumterrestrial orbit at an altitude of 300 km. The stage separation was planned to take place at Mach 7 at an altitude of 35 km. Further plans at this time stemmed from the firms Junker, Dornier, and ERNO, which were concerned with two- and multi-stage reusable transport systems. **Figure 4** shows one result of these efforts, a supersonic aircraft with rocket engine as the first stage, from which a rocket craft was to carry the payload into orbit.

Contemporary projects

None of these projects advanced beyond the stage of hopeful formulations on paper. In the 1940s, realization was not possible given the technical possibilities. Twenty years later, a breakthrough did seem near with the development of reusable space transporters, since studies were worked out conceptually on a broad basis in the United States as well as Europe, but then the Saturn/Apollo Program channeled all efforts into the development of more powerful multi-stage expendable rockets. Today, on the other hand, 20 more years later, the time seems ripe for the realization of reusable technology with spacecraft, since the technological, financial, and political preconditions are fulfilled.

For quite some time now, new concepts for future generations of the space transporter have been developed and presented in the United States and Great Britain. Both nations are moving away from the multi-stage principle, and propose single-stage systems in which personnel and payloads can be taken into low-earth orbit. These systems cover, therefore, the entire range of velocities between Mach 0 and Mach 25, with a still-to-be-conceptualized combination engine.

The American project NASP (National Aerospace Plane) and the British project HOTOL (Horizontal Take-Off and Landing) are currently being investigated for technical feasibility, using funds from national astronautical budgets. Project NASP is receiving an essential stimulus from the military, in particular from DARPA (Defense Advanced Research Projects Agency), which is especially pushing the engine technology.

The most expensive development work on NASP is thus to be done in the area of the engine. A combination engine system is necessitated to cover the broad Mach range. In the lower velocity range to Mach 5, turbo engines or subsonic jet propulsion engines are necessary, following which a different engine principle can and must be employed: *Scramjet* (Supersonic Combustion Ramjet) or a combination of Scramjet and Scramrocket.

Air is not, as in a ramjet, decelerated to the subsonic range and compressed for combustion of liquid hydrogen; rather, the hydrogen is combusted in a less hot supersonic flow, which drastically increases the effectiveness of the engine. However simple this may sound, considerable problems are entailed.

The greatest publicity effect was achieved by the British with their conception of HOTOL, an extremely ambitious technological project that is no longer seen by the British as an alternative to *Hermes*, but rather as a possible successor.

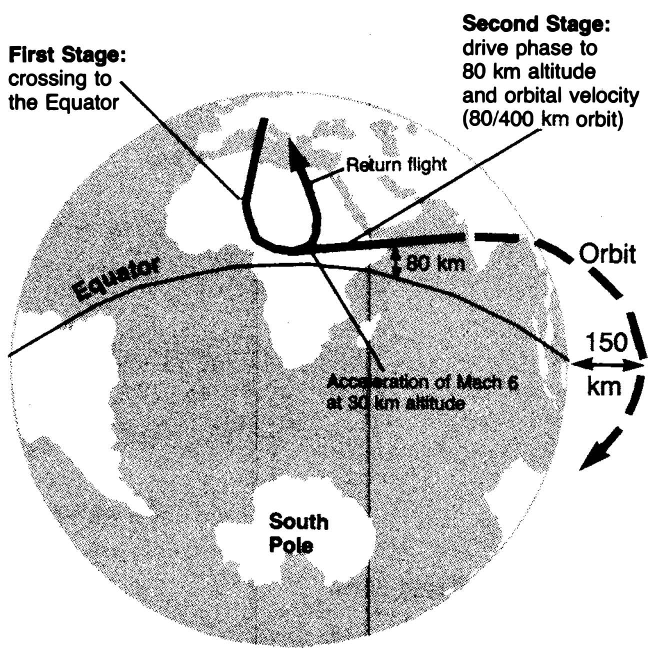
HOTOL, like NASP, is a one-stage, completely reusable transport system that is launched from and lands at a normal taxi strip. The vessel sits at launch on a wheeled subsection that accelerates it to an initial velocity of 500 km/h before release. There is to be a manned and unmanned version of the transporter, with payload capacity of 7 tons.

The magic word with HOTOL is LACE—Liquid Air Cycle Engine. With this type of engine, the breathed-in air is so cooled in a heat exchanger by means of hydrogen that a drastic volume reduction is achieved. The cooled air is then pumped into the rocket's combustion chamber and combusted with the hydrogen. For the launch phase and transatmospheric flight, the transporter has liquid oxygen on board, for which air is substituted in the range of Mach 5 to Mach 7 at altitudes of 26 to 32 km. Because of the advantages of this weight-saving substitution, an extremely light construction, and aerodynamic optimization of hypersonic flight, the engineers responsible expect a payload gain of 3.5%, that is, 7 tons of payload given a 200-ton launch weight.

Project Sänger

In 1984, Messerschmitt-Bölkow-Blohm, Inc. again began work—on its own initiative and with its own funds—on winged and reusable spacecraft. These investigations led to a German space transport concept that was presented to the ESA board at the beginning of 1986. The concept was of a two-stage, completely reusable air- and spacecraft that, in connection with the great German astronautical tradition,

FIGURE 5
Sänger mission profile



Launch from a European airport; flight to the equator; separation there of the second stage, which flies into space; return of the first stage to the airport—these are the essential steps of the Sänger*'s flight.*

was given the name *Sänger*.

Figure 5 illustrates how space flight in the year 2000 will appear, corresponding to the *Sänger* concept: The two-stage transporter launches from a major European airport—perhaps the new Munich Airport. The first stage, which corresponds in size to a large contemporary aircraft, cuts across Africa to the equator, accelerating to a velocity of Mach 7 and attaining an altitude of 35 km. Now, the second stage, a rocketcraft, is released and its rocket motor ignited. In 280 seconds, the upper stage accelerates to a velocity of 8 km/sec, and arrives at the transfer orbit to the desired terrestrial orbit. While the second stage carries its payload to the circumterrestrial orbit, the first stage returns to Earth, landing horizontally.

The first stage, the basis for the new space transporter, is a hypersonic aircraft equipped with six air-breathing engines. Each engine produces a thrust of 400 kN; the total thrust is sufficient to accelerate a launch mass of 400 tons into the hypersonic range within a few minutes.

The required turbo-jet engines, of course, do not as yet exist, but can be developed as an extension of existing technologies. **Figure 6** shows an appropriate design with the TRA-400 engine. It runs on liquid hydrogen as fuel and uses atmospheric air as the oxidizer. The weight of one motor is three tons; with help of the turbine and an effective air-entry area of 2.5 m^2, 200 kg air per second can be sucked in. In supersonic flight, the adiabatically compressed air will, of course, reach a high entry temperature. It must therefore flow through an entry cooler, thus increasing the efficiency of combustion.

The volumes of ambient air from which the engine obtains the necessary flow-through of 200 kg per second varies, of course, with altitude. Close to the ground, it is 150 m^3; at an altitude of 15 km, however, it is 1,000 m^3. Under these conditions, attaining uniform combustion, and thus uniform thrust, presents a tremendous technological challenge.

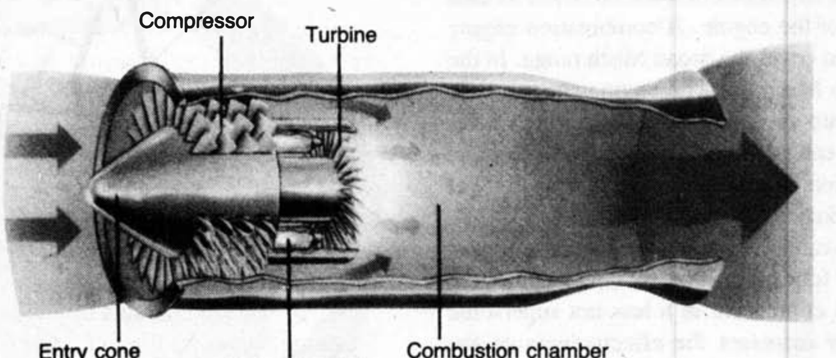
Two further examples may illustrate the technologically demanding tasks posed: Without the employment of highly integrated, fast computers, the development of the engine and the aerodynamic structural design for hypersonic flight will not be possible, and there are innovations required even for the materials, since high demands are placed on the weight and on thermal and mechanical strength. The materials used must be simultaneously light, heat resistant, and of high rigidity.

Sänger's first stage will also form the technological basis for a future European hypersonic passenger aircraft. There are therefore technological similarities with the "Orient Express," a hypersonic passenger plane planned by the United States to which President Reagan ascribed so much importance in his speech before Congress.

The development of *Sänger* therefore embraces two projects: an essential plus of having two stages. The technology for a future hypersonic passenger plane falls out as a "by-product," so that *Sänger* not only offers the possibility of securing technological competitiveness of the Federal Republic (and Western Europe) in astronautics, but in aeronautics as well.

FIGURE 6

The TRA-400 engine

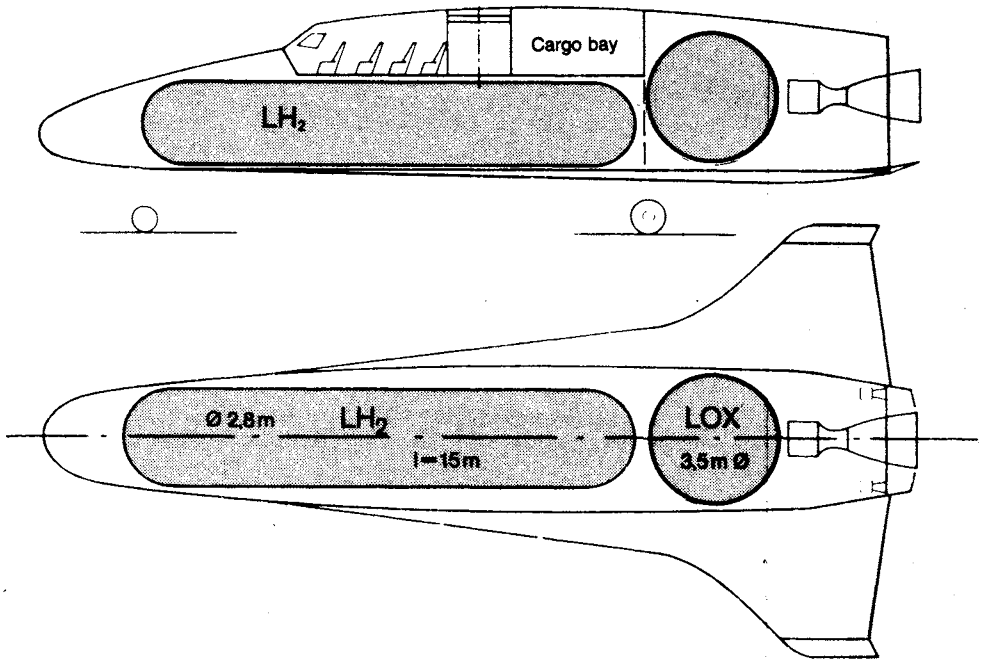


Basic data:

Thrust	400k N	Pressure ratio (launch)	ca.6
Maximum specific impulse	39,200 N s/kg at Mach 3.5	Entry temperature at turbine	1,200° K
Specific impulse at crossing	32,800 N s/kg at Mach 5	After burner exit temperature	ca.2,000° K
Entry area/diameter	2.5 m^2/2 m	Mass	ca. 3,000 kg

Six such engines will drive Sänger's first stage.

FIGURE 7
The second stage, HORUS



HORUS serves for manned flight into space and can transport between 2 and 10 astronauts.

Sänger's second stage flies with a rocket engine, hence it must carry hydrogen as fuel and liquid oxygen as oxidizer on board. Two versions are possible: HORUS (Hypersonic Orbital Research and Utilization System) for manned flight and CARGUS (derived from "cargo") for pure payload flights.

HORUS represents a further development of the U.S. Space Shuttle Orbiter and of the space glider *Hermes*, and is provided with an active drive and return system. **Figure 7** shows its construction. Within the fuselage of the vehicle, located beneath the cargo area, is a long tank with fluid hydrogen. According to the size of the cargo that is carried, there will be space for between 2 and 10 astronauts. Behind the hydrogen tank and the loading bay, which accommodates up to two tons, is the spherical tank for liquid oxygen.

The fuels supply a type ATC-500 rocket motor (ATC is the abbreviation for Advanced Topping Cycle). This motor delivers a thrust of 533 kN. The specific impulse attained in a vacuum is 4,630 m/sec, thanks to a pressure of 250 bar behind the combustion chamber. This engine's expansion ratio of 300 is especially impressive, and is, for example, many times higher than that of the HM-60 engine of the *Ariane 5*.

HORUS begins its ascent at an altitude of 30 km, after the first stage has brought it to a velocity of 2 km/sec. The space vehicle attains a velocity of 8 km/sec through combustion of 6 tons of hydrogen with 30 tons of oxygen; the relevant trajectory ends in a low-earth orbit of low eccentricity with an apogee value of 400 km.

The total mass of HORUS is approximately 60 tons, with the capability of transporting selective freight or crew or, with additional fuel, of reaching higher orbits. Additionally, *Sänger*'s versatility is revealed by the fact that, by means of an unmanned version—called CARGUS—which is based on a single-stage expendable technology, up to 10 tons of payload can be transported.

An overview and summary of the *Sänger* conception (also see **Figure 8**) is as follows:

1) The two-stage transport system allows maximum operational flexibility. Only with this system are all terrestrial orbits within reach from Europe.

2) The first stage includes two projects in one development. From it, the "know-how" for the development of the European hypersonic passenger plan can be derived. Experience with *Hermes* will merge into the development of the second stage.

3) System studies must be initiated (especially for the air-breathing engine of the first stage), resulting in an identification of the technological focal points.

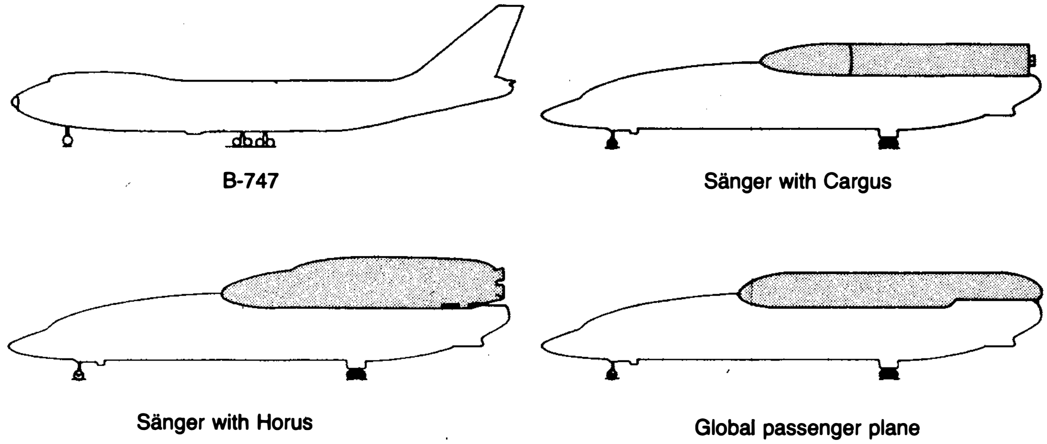
4) The operational employment of the space transport system can be expected in 2004-08, if the prepratory work begins in 1987.

Taking off from this conception, investigations of launch costs have yielded that, in fact, a considerable reduction may be expected in comparison with the standard carriers *Ariane* and *Hermes*.

With the space transporter depicted here, Europe will,

FIGURE 8
Sänger: a versatile system

The versatility of the Sänger *concept is illustrated here: The first stage, which is roughly as large as today's large aircraft of the Boeing-747 type, serves with CARGUS and HORUS for transport into space, and can, with the addition of a passenger cabin, be used as a global passenger plane.*



after a development period of 15 years, have available a system that will appear on the market at the right time with the right technology at the right price. This "timing" will secure Europe's competitive ability against the United States and Japan.

Sänger compared to other projects

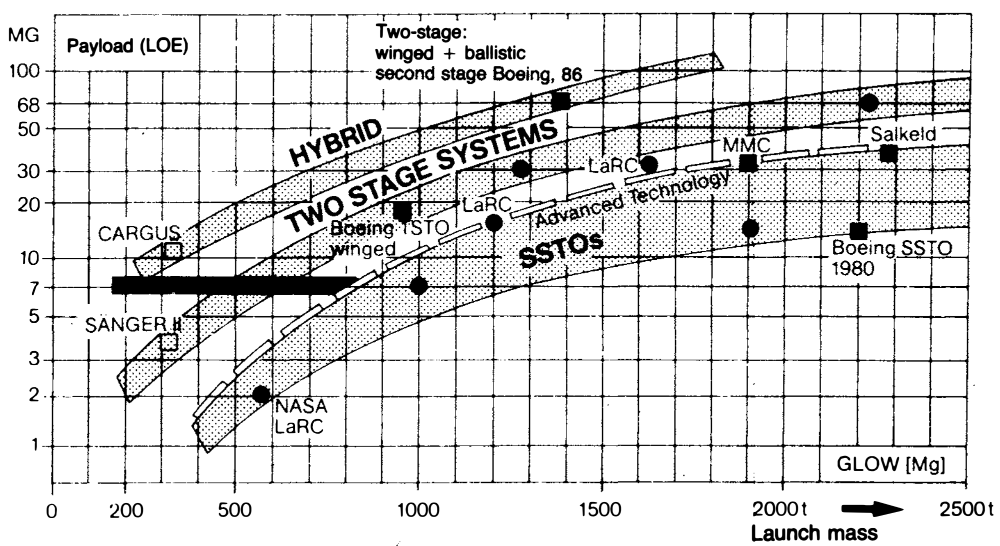
In Europe, there are two projects in the offing for the period after *Hermes*: *Sänger* and *HOTOL*. The United States is pursuing similar activities with the *National Aerospace Plane* or NASP. How are these projects to be evaluated in relation to *Sänger*? Are they alternatives or competitors?

The United States, as the greatest space nation, will develop its own systems in any case. That is, NASP will be a competitor for Europe and not an alternative, since Europe must not lose its astronautical independence, but must rather—on the contrary—develop it further.

HOTOL, which is in the meantime viewed by the British as a successor of *Hermes,* is quite otherwise. Of course, there are many experts who hold the opinion that the very optimistic claims about HOTOL cannot yet be realized. Thus, the value of 7:200 for the payload/launch mass that is specified stands in clear contradiction to American investigations of one- and two-stage space transporters. According to these investigations, as **Figure 9** shows, a one-stage transporter must, for a payload of 7 tons, have 800 tons (and not 200

FIGURE 9
Mass ratio for one-stage and two-stage vehicles

American investigations, which are reproduced in this graphic, make it appear doubtful whether HOTOL will function as planned. The ratio of payload to launch mass for one-stage vehicles is, according to this study, at 7:800, while the British are assigning 7 tons payload to a launch mass of only 200 tons.



tons, as assumed for HOTOL) at launch. Also, the developmental risk with futuristic combination engines, which many conceivable drive types involve, can hardly be estimated at present.

Therefore, HOTOL may rather be the basis for a space transporter of the fourth generation. It is thus not to be considered an alternative to *Sänger* but rather a successor, if we consider an extrapolation of the technological development.

What is our position with regard to *Hermes*? Is the participation of the Federal Republic in this project sensible?

The line of development of the space transporter can only run from expendable rockets through partially reusable to total use of reusable technology, or, expressed in terms of European project names, from *Ariane* through *Hermes* to *Sänger*. Because the second stage cannot be done without the first, since the systems of the third generation cannot be developed without the experience with those of the second generation being available, the question, on further thought, can also be put as follows: Does the Federal Republic intend to remain true to its own initiative and participate further in the conceiving of future transport systems, and thus become a space nation making productive contributions and decisions?

If the question is answered positively, then there is no way to bypass *Hermes*. A substantial participation, that is, participation with co-determination and joint formation on the system level, must be ensured. Only in that way will the relevant technologies and knowledge of systems be available for the Federal Republic.

For, whatever disadvantages *Hermes* may have, the development, construction, and operation of *Hermes* is indispensable as an entry into the area of reusable technology, as a precondition for European autonomy in space and as the essential technological developmental step in the direction of advanced space transport systems of the third generation.

If the Federal Republic abandons substantial participation in these projects, it will irreversibly decouple itself from a crucial technological area of European astronautical development. On the other hand, the role of component supplier, initiated with the *Ariane* project, would be established through a half-hearted participation.

In any case, this danger, because of the delayed decision, can no longer be excluded, and can be reduced only through special efforts from industry. Even today, doubts must be raised whether a systematic leading German role in the development and the construction of the space transporter of the next generation is possible in general.

A German Space Agency

As already said at the beginning, the Federal Republic of Germany has arrived with *Hermes* and *Sänger* at a crossroads. These projects offer us perhaps the last chance to turn the "steering wheel of astronautical policy" and to secure ourselves a place in European astronautics that corresponds to our great tradition in this field, as well as to our industrial and scientific capabilities.

There are many reasons for the passive, reactive role that the Federal Republic plays in astronautics and which has again been revealed in the controversy over participation in *Hermes*. One reason is the self-caused absence of conceptions in astronautical policy. This has its causes in the confusion of authority and in the diverging and competing interests of many political and industrial powers that are not, in fact, sorted out in advance.

How can that be remedied?

The Federal Republic of Germany needs, in my opinion, a strengthened coordination of all responsibilities, so that it can be effectively and decisively represented with a coordinated strategy both internally and externally, in order to attain an active position.

For that, an agency possessing clear overarching authority is needed, a *national space agency* (NARAB), which, with centralized authority, defines astronautical strategies for the Federal Republic and represents that strategy internally and externally. This agency must be furnished with an astronautical budget that it translates independently and self-sufficiently into programs, projects, and free research. It must be the general discussion partner with the ESA and the national space agencies of other nations, whenever it is a matter of representation of the German space industry.

Only by means of this structural reform will the preconditions be created for being an equal partner in European and international astronautics. The United States, France, and, finally, also Great Britain have already shown us what competent initiatives can result from a national space agency.

Summary

What must now be done so that the Federal Republic can meet the great challenges in science and technology that are produced by the future of European astronautics?

1) We require the *Hermes* project as the entry into returnable technology.

2) We must, in addition to that, begin parallel national as well as international studies, in order to be able to identify the technological focal points in the development of the space transporter of the next generation. The goal of the development should be the two-stage space transporter *Sänger* proposed by Germany (or some better concept). Only its realization establishes the simultaneously challenging and realizable goal, and its development will secure for Europe the ability to compete in space and in future international air traffic.

3) We need a German space agency for coordination of all activities discussed under point 2).

If our nation embarks in this direction, it will hold all the possibilities in its hand to deploy its great technological potential for rewarding and advanced goals—and, not least, in recognition for the space pioneer Eugen Sänger. It is not a matter here of "gigantism," but rather of the preservation and expansion of our position among modern industrial societies.