'Sänger Project' crucial to man's future in space

The future of space exploration is being hotly debated, not least in Europe, where decisions must be made on followup programs to the Ariane 5 launcher. A report from Germany's Fusion Energy Forum.

At a time when the future of manned space exploration is gravely threatened by budgetary crises in the United States and the former Soviet Union, an exceptional responsibility falls upon Europe, as the world's rising economic and technological powerhouse. Among all of Europe's activities in the field of space technology, the program called the "Sänger Project" stands out as the most solid and most appropriate step toward securing man's future in space. "Sänger" is the German-pioneered program to develop a fully reusable, two-stage space transport system capable of accessing space from any large airfield.

The first stage of the Sänger system is a hypersonic (Mach 7) aircraft utilizing an air-breathing propulsion system. The winged, rocket-powered second stage is carried aloft "piggyback" by the first stage and accelerated up to Mach 6.6-7 for separation and launch at an altitude of approximately 30 kilometers. The first stage returns for a powered landing at a suitable airstrip while the second stage accelerates to Earth orbit. At the end of its mission the second stage makes an aerodynamic reentry and landing in a similar manner to the present U.S. Space Shuttle. Both stages could start and land at any large airfield in Europe, or in most other areas around the world.

The Sänger system is conceived as a technologically conservative "next step" using technologies which are either already mature (such as the liquid hydrogen/oxygen engine for the second stage) or are ripe for development (turboramjet first-stage engine integrating basic technologies derived from previously developed aircraft and missiles). As a result one can project a robust, dependable system which will reduce launch costs (at a sufficiently high launch rate per year) to a fraction of their present value, while greatly increasing the safety of manned space operations.

Development work on Project Sänger is presently being financed by the German Ministry of Research and Technology as the centerpiece of a National Hypersonics Technology Program. Following completion of Project Phase I in 1992, a formal proposal will be made to the European Space Agency (ESA) for realization of Sänger as a joint European program. Sänger is widely viewed as the leading candidate for the next generation launch system to follow Europe's Ariane 5, as well as the leading option for a long-term European manned space program. In this context present work on the Hermes space glider would be seen as a transition step, developing European know-how in manned space flight and in the domain of hypersonic vehicles.

Much less vulnerable to "technological bad surprises" than the more ambitious space plane projects such as the British HOTOL (horizontal takeoff and landing) or the U.S. National Space Plane (NASP), the Sänger could—according to conservative estimates—go into service by the year 2010. All that is required are moderate budgetary support and competent management for the duration of the project. Whether these will be forthcoming, or whether Sänger will fall victim to the adversive pressures which are crippling much research and development today, could have a major impact on the future of manned space exploration for many decades to come.

The ideas behind the Sänger Project

The "Sänger" space transport concept has had a continuous evolution going back to the early days of rocket development. The dream of flying into space on a winged vehicle is older still, but it was the German rocket pioneer Eugen Sänger (1905-64) who, during the early 1940s, was the first to elaborate a conceptual design for a reusable, horizontally launched rocket plane capable of reaching the outer limits of the Earth's atmosphere. Sänger's pioneering work was followed up in the 1950s in the United States by Walter Dornberger, former director of the German rocket project at Peenemünde. Dornberger conceived of a two-staged space transport system utilizing an air-breathing hypersonic first stage. In the subsequent period a great deal of development work was done in the United States on the rocket plane concept, including the famous X-15. Although the X-15 program was not followed through to the end, it did lay some of the foundations for the Space Shuttle and for present work on the National Space Plane.

Back in Germany, Eugen Sänger himself played a leading role in promoting further development of the space plane, which he saw as a means by which Europe could recover the ground it had lost to the superpowers in the field of space exploration. In the 1960s the German firms ERNO and Dornier carried out design studies. But in the late 1960s and throughout the 1970s developments were dominated worldwide by the Apollo program and the massive expansion of civilian and military space programs in the U.S. and U.S.S.R., which were entirely based on nonreusable, ballistic rocket technology. It was at the beginning of the 1980s that the time appeared ripe again for a serious effort in the field of horizontally launched, winged space vehicles. The German firm Messerschmitt-Bölkow-Blohm (MBB) took the lead in 1984, initiating on its own the line of development which eventually led to the government-sponsored Sänger Project.

The space plane designer looks at the Earth's atmosphere in a completely different way from the ballistic missile designer. For a ballistic missile, the atmosphere is mostly an obstacle, dissipating the missile's energy and placing large dynamic stresses on its structure. For the space plane designer, the atmosphere is a "staircase into space" and at the same time a reservoir of oxygen, which need not be carried along in the vehicle. By the combination of aerodynamic lift and use of atmospheric oxygen during the initial portion of its trajectory, the Sänger greatly reduces the specific fuel requirements to reach orbit.

Besides these elementary advantages, the Sänger Project is designed to answer a specific set of requirements facing manned space exploration in general and Europe's role in that effort in particular.

First, it is assumed—contrary to the myopic view which many governments are taking these days—that manned space operations will greatly expand in coming decades, including not only missions in near-Earth orbit, but also a renewed commitment to colonization of the Moon and Mars (and beyond). The long-term scientific exploration of the Solar System and beyond is unthinkable without establishing manned bases and settlements outside the Earth. Moreover, the expansion of human activities beyond the Earth is dictated by the elementary nature of man. It constitutes a kind of human right which cannot long be denied.

Second, participation in manned space exploration for peaceful goals should be open to all. There should be free access to space without political or other restrictions which might be imposed by a narrow monopoly of "space powers."

Third, access to space must, above all, be economical, which means a fully reusable space transport system must be developed for many launches per year.

And finally, a very high degree of safety must be assured for transport systems carrying human beings into space.

These requirements dictate to a large extent the choice of technology for the next generation of space transport systems. If rigorously thought through, this leads inevitably to a system essentially identical to the proposed Sänger.

Free access to space means—for Europe in particular—the possibility of launching and landing in Europe, without having to depend on remote sites situated in politically unstable areas or in the territory of the superpowers. This is not possible with foreseeable single-stage-to-orbit (SSTO) systems such as the HOTOL or the NASP. The reason is the lower velocity imparted to the vehicle by the rotation of the Earth in the case it is launched far from the equator; the loss thereby incurred would decrease the already extremely low payload ratio of SSTO systems to less than zero for launches at middle European latitudes. The minimum is therefore two-stages-to-orbit, and this is in fact realized with the Sänger system.

The demand for complete reusability and for launch from, and return to the highly populated territory of Europe can only be achieved on the basis of winged vehicles which take off and land horizontally.

The desired high degree of safety, not only for the crew but also for the densely populated areas beneath the launch and landing trajectories, can only be reached by winged vehicles with horizontal launch and takeoff. The reason for this can be grasped by anyone who reflects on the fact, that dense air traffic is routinely conducted over and near large cities; whereas rocket launches are never made near cities (except in time of war).

These requirements and considerations dictate, in effect, a two-stage system in which both stages have wings and are capable of aerodynamic flight in the atmosphere. The use of two stages permits a design in which stage separation occurs at a speed of no more than Mach 7, which avoids the need for active skin cooling of the first stage.

Takeoff from densely populated Europe requires a first-stage propulsion system with low noise, hence a relatively low-exhaust velocity. The first stage remains within the atmosphere, permitting an air-breathing first-stage engine. Only the second stage would require a rocket engine, which would be completely separated from the heavier and more complex air-breathing engine of the first stage.

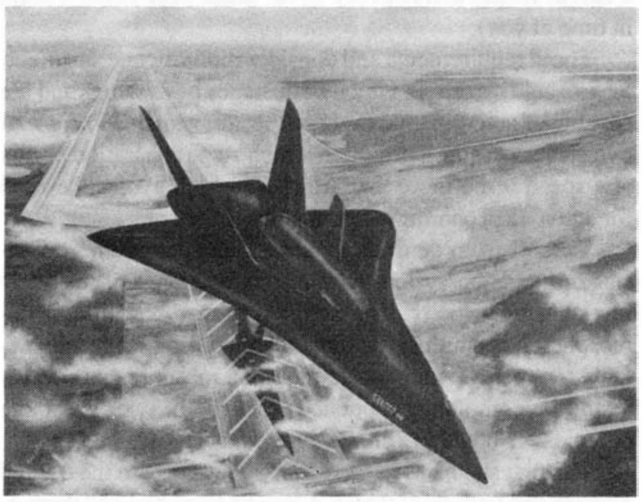
The first stage has to carry the second stage to the desired altitude and latitude at which it is to be launched and thereafter return to base. The takeoff, climb to Mach 3, and the flyback are best achieved with a turbojet-type engine. The acceleration to cruise conditions (Mach 4), final acceleration to second-stage launch velocity (approximately Mach 7), and cruise-back require a ramjet-type engine. This leads to the concept of a turbo-ramjet combined-cycle engine.

The supersonic combustion scramjet projected for systems such as the NASP is not required for this mission, thereby avoiding a major technological jump. The basic technologies for a turbo-ramjet combined-cycle engine are available from existing aircraft and missile systems, including the management of cryogenic hydrogen as a fuel. Avoidance of the scramjet also obviates the need for active skin cooling, since the scramjets operate economically only above Mach 8 where such cooling is necessary. Basic concepts for structural designs giving the necessary passive thermal protection for the Sänger first stage have been developed and tested.

Development work on a turbo-ramjet engine for Sänger is well under way. A hydrogen ramjet-combustor has been operated at MBB in Ottobrun since early 1989. A cryogenically cooled combustion chamber has been successfully tested. A series of alternative concepts have been elaborated for the integration of turbojet and ramjet modes, and technical solutions developed for the variable-configuration air intake required for operation in different velocity modes.

The Sänger would take off at significantly less than maximum thrust, a feature enhancing the safety of the system.

As for the second-stage engine, the essential solution is already available in the form of high-performance staged-combustion cycle engines such as the Space Shuttle Main Engine. It is worth noting that the basic technology for this engine was developed at MBB in the 1960s (Project P 111). MBB developed the essential liquid oxygen/liquid hydrogen (LOX/LH) engine technology which was the basis for the Space Shuttle Main Engine and the Ariane third-stage engine. The Ariane 5 engine with 100 metric tons of thrust is now in development, based on the MBB core engine using LOX/LH and integrated with turbopumps by the French engine manufacturer SEP.



Artist's conception of the Sänger space plane, showing the two-stage manned launched system taking off from a commercial airport.

A low-pollution requirement for takeoff in Europe points to use of liquid (cryogenic) hydrogen as the propellant. The low density of this fuel presents no major problem, since in any case air-breathing systems need to carry only one-fourth of the combustant in the first stage as compared with rockets. The heavier component (oxygen) is taken from the air.

The propellant solution is, therefore:

- First stage: liquid hydrogen/air
- Second stage: liquid hydrogen/liquid oxygen.

Cryogenic hydrogen, it should be noted, is already in routine use as a space flight fuel.

Operational costs of the projected Sänger system have been estimated on the basis of experience with the X-15 and U.S. Space Shuttle on the one side, and the supersonic transport Concorde (relevant to first-stage refurbishment) on the other. In one study, a figure of 3.5 times the refurbishment and maintenance cost of the Concorde was taken as reference for the first stage, while an improvement on Shuttle costs was assumed through the use of improved technology on the second stage. Horizontal launch eliminates much of the large preparation areas, vehicle assembly buildings and launch pad structures required for the present Space Shuttle. The personnel required for launch preparations would be reduced to between 500 and 1,000 persons, as compared to the Space Shuttle launch preparation staff of about 7,000. Together with the condition of complete reusability, this adds up to an enormous saving in launch cost. Launch cost for a manned mission to low-Earth orbit (second-stage crew of three plus one pilot) was estimated at approximately 146 man-years (or about $25 million) for a launch frequency of 12 missions per annum.

Sharing the project's benefits

Present efforts to realize the Sänger Project are inspired by the perspective of a broad participation of interested countries—not necessarily only in Europe—in advanced development and production of this system, and sharing of the benefits of improved access to space among the nations of the world.

Utilization of the Sänger system will have many common features with that of large commercial aircraft today. Sänger vehicles could be sold or leased like an Airbus or Boeing 747 to governments, institutions, or even private firms. A common infrastructure would be set up for repair and maintenance. Sänger could be used by any nation, the only restrictions being observance of United Nations rules and international air traffic safety regulations.

With commercial operation of Sänger, the era of "free enterprise" manned spaceflight will have begun for real—a *sine qua non* for large-scale space expeditions, space industrialization and colonization.