History of Rocketry and Astronautics

Proceedings of the Thirty-Seventh History Symposium of the International Academy of Astronautics

Bremen, Germany, 2003

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AAS History Series, Volume 34

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 23

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2011

ISSN 0730-3564

ISBN 978-0-87703-563-3 (Hard Cover)
ISBN 978-0-87703-564-0 (Soft Cover)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

Chapter 7

From the "Silver Birds" to Interstellar Voyages[*]

Hartmut E. Sänger[†] and Alexandre D. Szames[‡]

Abstract

Eugen Sänger belongs to the second generation of space pioneers. While his works were built on earlier ideas formulated by Robert Esnault-Pelterie, Robert Goddard, Hermann Oberth, and Konstantin Tsiolkovsky, his solution to find an access to space remained personal. He followed the so-called "school of Vienna," where Max Valier, Franz von Hoefft, and Guido von Pirquet imagined aircraft capable of reaching orbital velocities. Sänger's earliest papers demonstrate a firm belief in reusable rocket planes able to provide the safest and most cost-effective way to reach the "higher ground." But Sänger also imagined them followed by space stations and electric-propelled spaceships taking advantage of the time dilation phenomenon described in Albert Einstein's special relativity theory. This threefold vision of space exploration was formulated in the early 1930s and drove, for the most part, his outstanding astronautical career. Sänger battled to turn his ideas into reality so as to make, one day, his dreams come true. His career remains largely unexplored. This chapter aims at providing a first outline.

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[*] Presented at the Thirty-Seventh History Symposium of the International Academy of Astronautics, 29 September to 3 October 2003, Bremen, Germany.

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Introduction

Eugen Sänger was born in Preßnitz (Bohemia, Austria) on 22 September 1905 and died in Berlin (Germany) at 58, on 10 February 1964. His interest in space travel dates to his early childhood, but the decisive seed was planted in 1923 while reading Hermann Oberth's book *Rakete zu den Planetenräumen.*[1] By 1929, Sänger was already working on the "rocket plane" as part of his doctoral dissertation, but the subject he originally planned to graduate with, almost browsed the entire spectrum of space exploration activities: rocket plane, space station, and long-distance travels by means of electric-propulsion spaceships taking advantage of the time-dilation phenomenon, which Einstein had described in his special relativity theory.[2] Following his professor's advice, for whom such a subject was far too broad to start with—and seemingly not ascribed to any serious agenda yet—Sänger sat back on more classical studies. But his threefold vision of space exploration formulated in the early 1930s, subsequently drove, for the most part, his outstanding astronautical career.

Figure 1: Eugen Sänger's 1933 pioneering book. Inset: drawing of a rocket plane. Credit: Hartmut E. Sänger (HES).

Seeds of an Idea: The Rocket-Plane (1924/29–1933)

In 1930, Sänger successfully graduated with "The Statics of a Multiple Girder, Parallel-Strapped Truss-Wing." A few years passed, and in the spring of 1933, he privately published, at great expense, his basic findings on rocket-propelled space flight, in what is today highlighted as the first technical engineering book devoted to "astronautics" written by a university graduate (Figure 1). *Raketenflugtechnik* was a path-breaking publication propelling Sänger as "the first major figure to advocate a Space Shuttle-type vehicle as it is now envisioned."[3] This book dealt with every technical aspect the new spaceflight method implied: horizontal liftoff; subsonic, transonic, supersonic, and hypersonic flight; gliding phase; concomitant appearance of high-speed aerodynamics heating phenomena; and horizontal landing.[4]

With a conservatively estimated exhaust velocity of 3,700 meters per second and a load ratio Me/Mo of 0.15, Sänger actually showed that a flight speed of Mach = 13, combined with flight altitudes ranging from 40 to 60 kilometers and a flight range between 4,000 and 6,000 kilometers, could be within reach.

Further Works in Vienna (1933–1934)

As Sänger combined engineering constraints (that is, maximum mass-reduction, optimized aerodynamic qualities) for this type of aircraft, with a high-efficiency rocket engine, he understood what major challenge Earth-to-orbit rocket flight vehicle designers would face: they had to develop a chemical rocket-engine with performances as close as possible to the maximum theoretical limits. Between 1932 and 1934, while serving as an assistant at the University of Vienna, he performed a series of pioneering experiments with reinforced cooled liquid rocket motors capable of burning mixtures of gas–oil and liquid oxygen (LOX), achieving thrust levels up to 30 kilopond, pressures up to 50 bars, and exhaust velocities of about 3,000 meters per second (Figure 2). He thus solved a central technical problem of rocket engine technology—the cooling.

Sänger's laboratory notes contain theoretical results derived from empirical evidence. His experiment diary relates that he coined two new expressions to define the qualities of a rocket engine, and thus compare engine performances: the "effective exhaust velocity" (later known as specific impulse—Isp) and the "characteristic length" of the combustion chamber (being responsible for the period during which burning gases remain inside the chamber).

Technological insights and lessons Sänger gained from his early tests with rocket engines are listed in his patent letters dated from the end of 1934 (Figure 3).

This "knowledge in the art" included high-pressure firing; manufacture of combustion chambers and nozzles with reinforced cooling by fuels, with tubes or milled grooves being closed by welding from the outside; burning of liquid hydrocarbons or hydrogen with liquid oxygen; fuel feed pumps driven by the evaporated coolants coming out of the reinforced cooling; ignition of the motors by injecting of alkyl metallic; fast running of liquid oxygen pumps; expansion nozzles with cooled walls and half-cone angels bigger than 25 degrees and smaller than 270 degrees; and employment of pure metals as fuel or as additives to other fuels.

Figure 2: Sänger's 1933 research notebook, in which the principle of a reinforced cooled rocket motor is explained. On the left, the corresponding test unit (where the nozzle has melted away). Credit: HES.

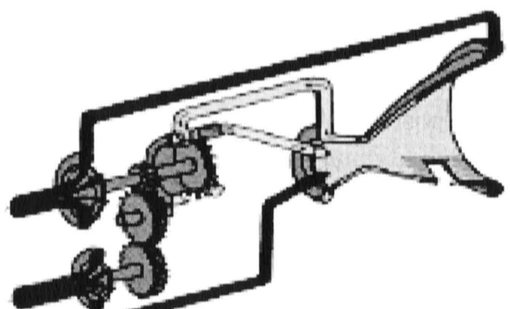

Figure 3: The original patent drawing of Sänger's rocket motor. Credit: HES.

Denoting for the situation of that time, has been the answer of the Austrian Ministry of Defence on a request for supporting this research: because of the necessary exploding character of burning the mentioned fuels, it will practically not be achievable. Many of Sänger's discoveries, innovations, and inventions subsequently came to fruition, being implemented in the stage-combustion cycle rocket engines. This family of engines, whose technology was developed in Germany by Messerschmitt-Bölkow-Blohm (MBB), is in use by the U.S. Space Shuttle, and reaches impressive performance levels (pressure of 210 bars in the combustion chamber and specific impulse Isp = 4,464 meters per second in vacuum).[5]

The Research Center for Rocket Technology in Trauen, Flugzeugprüfstelle Trauen (FPS-Trauen), and the Deutsche Forschungsanstalt für Segelflug (DFS) in Ainring/Obb. (1936–1942/45)

Boosted by the success of his research, Sänger received, in February 1936, an invitation calling him for work in Germany. He was hired by the Versuchsanstalt für Luftfahrt (DVL) in Berlin-Adlershof, where he created a rocket technology research center and outlined a research program in the field of liquid-fuel rocket engines.

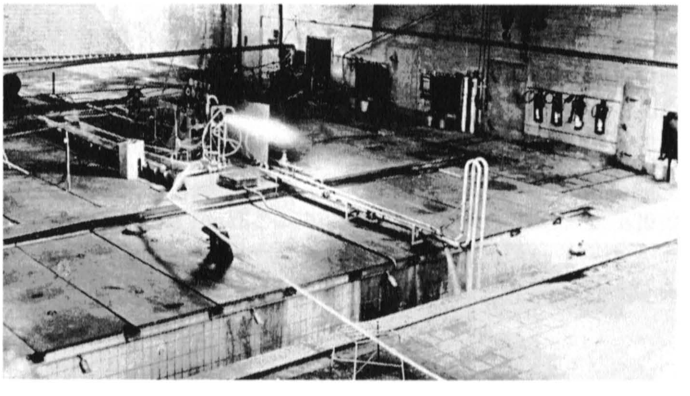

Figure 4: The large test bed in Trauen with a 1-ton motor test. Credit HES.

The research center was by no means a small one: a horizontal test bed for engines with thrust levels up to 100 megapond had been built, together with a large facility designed to produce and store 56 tons of liquid oxygen. The first series of high-pressure rocket engine (1 megapond thrust) tests began in the summer of 1939 (Figure 4). Pressures as high as 100 bars were reached in combustion chambers and exhaust velocities of 3,000 meters per second measured. In addition to these tests, other advanced research areas were explored: successful tests, with light-alloy dispersions, when gas–oil and hydrogen–oxygen were burnt; design of optimal shapes for hypersonic rocket planes fuselage having semi-ogival cusped and gore-shaped wing profiles, and measurements of their subsonic polars; rising and operating a test rig designed to investigate, for the first time, friction at velocities up to 800 meters per second in order to prepare a launch sledge up capable of 500 meters per second; and from 1939 onward, ground-based and airborne test trials of new types of high-temperature ramjet engines patterned after René Lorin's ideas (1908/13).[6]

Other fundamental theoretical researches were also performed in parallel: among them, the development of an aeroballistic flight theory within the atmosphere aimed at maximizing the vehicle range while spending the smallest possible amount of energy. The solution would later be known as the "skip-off flight." Together with his collaborator, Irene Bredt (who later became his wife), he explored the "substantiation of fluidics called gas kinetics," making it possible to calculate high-altitude aerodynamic forces and free molecular flows for the first time. In the post-war period, these groundbreaking works set a trend within U.S. aeronautical research circles, for all those active in the newborn discipline of highly rarefied gas (aero)dynamics.[7] In collaboration with Bredt, he also explored the precise calculation of flow fields in rocket and ramjet engines, considering the finitely installing velocity of the balance.

With the scarcity of fuels resulting from war-time conditions, large-scale tests in Trauen came to a halt in April 1942.[8] Flight tests of large-scale experimental ramjet engines nevertheless continued until April 1944[9] (Figure 5). These results were published in 1953. Sänger and Bredt combined all their results in a report "About a Rocket Space-Plane," meant to be a sequel, a second volume of *Raketenflugtechnik*[10] (Figure 6).

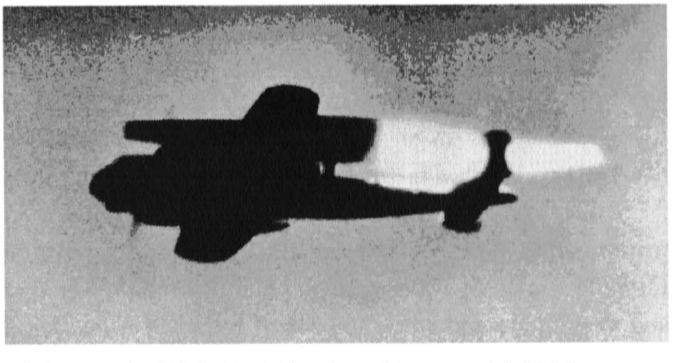

Figure 5: The flying test bed DO 217 E-2 with a 15 meter, 20,000 horsepower ramjet tube achieving 200 meters per second. Credit: HES.

This report, whose contents were supplemented by additional military-related chapters (it even included "calculations of an attack against a surface target at the center of New York") and titled "About a Rocket Propulsion for a Long Distance Bomber," was published in August 1944 and classified at "top secret command affair" level.[11] After World War II, this rocket–bomber project served as a prospective reference base for various experimental and advanced development projects, paving the way for many pioneering achievements in various countries. Some of them (U.S. Bell X-1, North American Aviation X-15, Spiral, etc.) achieved worldwide fame.

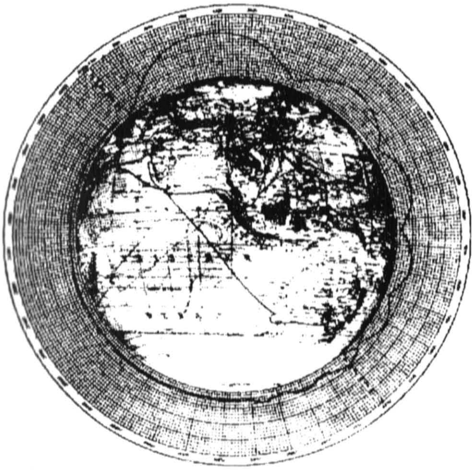

Figure 6: A rocket plane concept described as able to circle Earth using a "skipping effect" on the upper, denser layers of the atmosphere. This conceptual vehicle was studied in an "antipodal strike" bombing variant during World War II. Credit: HES.

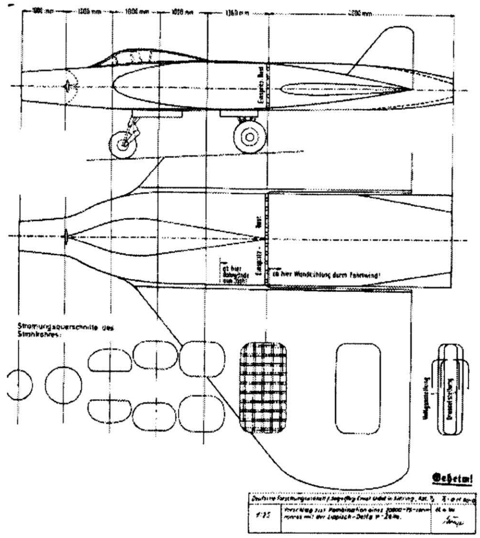

Figure 7: Design of a ramjet plane with integrated propulsion, together with Alexander Lippisch. Credit: HES.

Sänger and Wernher von Braun met only twice in World War II and befriended each other on these occasions. Von Braun, who was technical director of the Peenemünde Rocket Center since 1937, and formally known as the Heeresversuchsanstalt Peenemünde (HVA), discovered the existence of the highly secret Luftwaffe Trauen facilities while looking for a new rocket engine ignition system. In 1940, he was granted the authorization to visit Trauen, together with two of his colleagues (Walter Thiel and Rudolf Hermann). In October 1940, Sänger was returned this favor when von Braun invited him to attend a major hypersonic research conference in Peenemünde.[12]

Working for France (1946–1954)

Sänger stopped his large-scale ground and airborne experiments in 1945, at the war's end. Knowing the Allies would try to recruit him, he made it clear he wanted only to work for France and no other country.[13] Between 15 May and 23 November 1945, a team of Allied military and engineers visited him no less than 25 times. During 7–11 June 1945, Sänger was incarcerated at Garmisch-Partenkirchen and interrogated by U.S. scientific intelligence experts. During 3–11 September 1945, he and Walter Georgii, who were both erroneously suspected of belonging to the Reichsforschungrat (the highest research-and-development authority in the Third Reich), were imprisoned by the Counter Intelligence Corps (CIC) in Bad Reichenhall, and then released.

Professor and doctor of philosophy Dr.-Ing. Walter Georgii, head of DFS and head of the research command of the Luftwaffe, remains a difficult-to-understand figure of World War II. He was a world-known meteorologist, a world-class expert in gliding and glider aerodynamics, and kept good connections with France where he had always supported, among other things, gliding activities. He managed to contact French Army and/or intelligence representatives and "negotiated," beyond his own transfer, Sänger's and others departures. On 30 November 1945, Major Pariot, from the Ministère de I'Air in Paris, invited Sänger to pursue his research activities in France. It seemed that GANES, a French Navy organization, was somehow implied, at another level, in this "brain drain" operation.

Sänger moved to France in July 1946 with his close collaborators.[14] He was hired by the Arsenal de l'Aéronautique (renamed Nord Aviation after a merger in 1958) based in Châtillon, near Paris, and worked there on various projects[15] as a consultant engineer. He studied a broad range of propulsion issues, such as a ramjet-surrounded jet-engine, rocket-engine cooling,[16] the theory of mixture preparation of stationary firings,[17] and also participated in the development of various liquid- and solid-rocket engines; an anti-tank missile (the SS-10); the manned experimental ramjet aircraft Griffon, the first plane to use a combined turbo-ramjet power plant, which first flew in 1957 (Figure 8); and the ramjet missile R-010.

Sänger's activities in France were interrupted in 1948 by one of those curious episodes typical of the Cold War. On 4 April 1947 a closed-door meeting was held at the Kremlin where Sänger's Raketenbomber report, a copy of which Stalin had been provided, was discussed. Facing Stalin was a state commission composed of Gen.-Col. Ivan Aleksandrovich Serov (head of the KGB—Komitet Gosudarstvennoi Bezopasnosti or Comittee for Security of the State), Gen.-Maj. Vassili Stalin (son of his father), Lt.-Col. Grigorii Aleksandrovich Tokaev (Zhukovsky Akademy), Mstislav Vsevolodovich Keldysh (Research Institute NII-1) and S. T.

Kishkin (VIAM).[18] Stalin who had been deeply impressed by the report, ordered his son to tour Western Europe, locate Sänger and "convince" him to work for the Soviet Union. The operation failed when Tokaev defected to the United Kingdom and revealed the whole plan. In mid-December 1948, the French daily *L'Aurore* reported on Tokaev's escape and his order to kidnap Sänger and Bredt. French security services took immediate measures to prevent this from happening.[19] A few months later, all of Sänger's arsenal reports were classified.

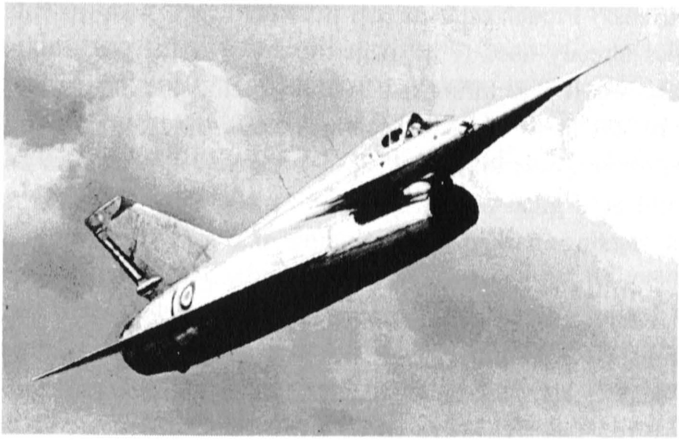

Figure 8: Griffon was the first plane with a combined turbo–ramjet powerplant. It first flew in 1957, and broke world records in 1960. Credit: HES.

As to the 1947 state commission meeting, it marked the beginning of Soviet attempts to build a 12,000-kilometer range intercontinental, hypersonic, nuclear-carrier, bomber capacity and fired Soviet industrial involvement in hundreds of space shuttle research-and-development"studies."[20]

From Ananoff to IAF (1946–1950)

At the turn of the 1950s, space travel was not yet perceived as a subject of governmental or industrial interest. Sänger ranks among the earliest technical writers whose preliminary estimates had shown that this activity could neither be afforded by a single company, however powerful, nor by a small country.[21] This awareness drove his subsequent strategies to promote spaceflight activities and draft out a general framework in which they could ever take place.

It was about the time when like-minded space enthusiasts, most of whom had already teamed up in national astronautical societies and clubs, undertook to federate within a dedicated international organization.

Alexandre Ananoff, a Russian-born, later French aerospace science writer, stands out as a catalytic figure who handled this challenge. This idealist character with an absolute faith in humankind's "spacefare" destiny, was known for trying to foster the interests of the widest possible audience while corresponding with most of the historical figures in the field. (He also had a special talent for making no concession to his passion, while generating personal animosities with individuals occupying influential positions.) From 1945 onward, Ananoff force-migrated his tiny French astronautical group from a pre-war astronomical sphere to post-war aeronautical circles.[22] French astronomers were unpleased with astronautics requiring technologies already used to advance the art of artillery and expand upward territories of warfare. It was during this troubled period that he met with Sänger. In a July 1946 letter, the latter wrote: "I read in Austria, and later in Germany some of your very interesting works on rockets, and, because I also worked a little on this subject, it would be a great honour for me to meet with you."[23] In the words of Ananoff, "this meeting marked the beginning of a long collaboration and a true friendship."[24]

In 1947, Ananoff undertook writing a unique encyclopedia, *L'Astronautique*, which was published in March 1950[25] after Sänger and others from whom he had sought some advice, had read the galley proofs.[26] While completing this book, Ananoff discovered that the board of directors of the Stuttgart Gesellschaft für Weltraumforschung (GfW) had passed, in June 1949, "a resolution calling for an international meeting of all societies concerned specifically with rockets, interplanetary flight, and space research, to foster collaboration and consider the possibility of forming an international astronautical association."[27] This announcement triggered a sequence of events ultimately leading to the foundation of IAF.

On 4 November 1949, Ananoff organized a meeting in Paris attended by H. Gartman, acting as the GfW representative, Sänger, and R. Engel, who decided not to "choose" London to host the first international meeting, as had been proposed. The GfW publicly acknowledged this decision in February 1950.[28] Empowered as a liaison, Ananoff secured Paris as the first meeting place.[29] On 16 February 1950, the British Interplanetary Society (BIS) accepted the proposal.[30] The "Premier Congrès International d'Astronautique" was inaugurated on 30 September 1950 and attended by representatives from eight nations. The decision to create an International Astronautical Federation (IAF) was taken on 2 October, the closing day.

This decision generated an inflow of ideas as to what should be done. Some believed in a place where to mature and crown, through actual practice, the ancient dream of spaceflight—orbiting artificial Earth satellites, achieving human spaceflight, or reaching other distant interplanetary bodies. Sänger was one of them.

Sänger, who had been looked to chair the provisional IAF committee, envisioned an organization tasked with performing research and development activities, which he not only called the international "Astronautical Research Institute" but planned to settle (blueprints of the buildings were eventually sketched) in Strasbourg, France. In February 1951, in a letter addressed to the chair of BIS, he suggested this research center could be funded through UNESCO and other participating bodies, such as national space societies, private individuals (acting as generous donators), or industrial companies. The center, he believed, could be administered by IAF.

This visionary proposal, which Sänger kept advocating for years, was rooted in his earlier economic analysis. It received strong support from the Stuttgart-based GfW. It came at a time when Germany was still under the provisions of Allied Control Council Laws (Kontrollratsgesetz) No. 25 and No. 26 (April 1946) and forbidden, as such, to conduct certain types of university and applied research (aeronautics)[31] while its scientific and engineering community dwindled as a result of the many "brain-drain" operations conducted from abroad since war's end.

In mid-1951, Sänger was designated as the official representative of Arsenal de l'Aéronautique to attend the second International Astronautical Congress in London.[32] Four more country representatives showed up, including delegates from the American Rocket Society (ARS). Ananoff, at his side, received little if no support from French official organizations. In conjunction with other IAF members, he tried to secure Soviet participation—an "obsession" causing him much trouble.

The IAF was established in London on 4 September 1951 and Sänger unanimously elected its first president, a post he held for two terms, until 1953[33] (Figure 9). Many factors motivated this choice: Sänger, whose works were highly respected within the professional community, was "neutral," that is, not affiliated with any national space organization (thus softening or postponing possible inter-society battles for power) and benefited from a public notoriety (visibility), which he partly gained from Ananoff's unconditional, supportive writings.[34] Key issues were settled under his presidency, such as accepting a definitive constitution or debates (IAF participation in UNESCO).[35]

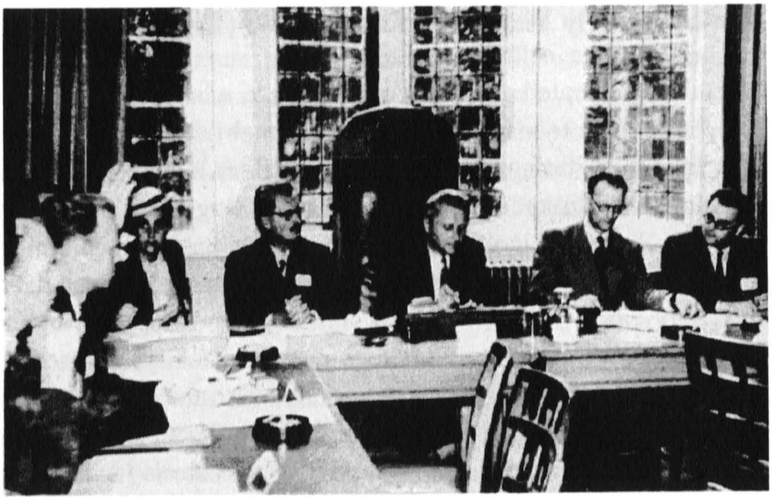

Figure 9: Start-up conference of the International Astronautical Federation with Sänger-Bredt, Oberth, Sänger, Arthur C. Clarke, and Andrew G. Haley. Credit: HES.

As IAF entered "service," Sänger quickly understood, to his greatest chagrin, that none of its activities would ever become practically oriented within the IAF structure. The Congress would serve as a platform where the rising aerospace community would regularly meet, communicate, and debate on ideas, projects, and results having potential "dual-use" applications—with all of what it implied in a Cold War context. The IAF was to become a unique international organization to feel the beat of international cooperation and competition. This description needs, however, further refinements. In his published memoirs, Ananoff insisted that in 1952, a diplomatic "gaffe" originating from a seemingly ill-worded invitation issued to Soviet representatives[36] delayed their observers from attending the Congress much earlier. True to say, the invitation was sent at a time when Eastern scientific and technical information was scarce in the West.[37] For example, a U.S. expert recalled finding "surprising amount of scientific research progress if virtually nothing on its technical applications" at this time. This apparent lack of information concerned, among others, guided missile industry and programs.[38] Technological progress in this and any other related disciplines were known to possibly impact astronautics, but information available was much too sensitive to be dealt with outside closed circles.[39] Official history records show that U.S. intelligence experts only acknowledged in September 1954, the existence of a major guided missile effort in the Soviet Union.[40] One month later, in October 1954, a committee of the International Council of Scientific Unions proposed that small scientific satellites would be launched sometime during the second semester of 1958, as part of the International Geophysical Year (IGY).

The Soviet Union sent its first delegates to the sixth IAF Congress, held in Copenhagen (Denmark) in 1955. This meeting marked a turning point in the history of astronautics. It was on this occasion that both the United States and the Soviet Union announced the existence of national programs to launch artificial satellites for IGY. From this date on, astronautics broke with its traditional science-fiction past. The exploration of space rimmed with strategic, military, economic, legal, industrial, technological, and scientific interests. But the general public would have to wait until 1957, that is, the *Sputnik* premiere, to take the full measure that something new had happened. As to the Congress, it gained in international prestige and served as an interface between Western and Eastern experts. The IAF was part of the diplomatic scene.

In order to remain accurate, I. Sänger-Bredt acknowledged that official delegates from both Eastern and Western satellite projects personally met for the first time during the "international conference of ramjets and rockets" organized by the FPS in Bad Freudenstadt, 6–8 February 1956.[41] The actual empowerment of the IAF annual Congress as a main technical information exchange platform came only after that. In 1960, the establishment of an "International Academy of Astronautics (IAA) of the IAF" strengthened this situation. Sänger was one of the earliest proponents of the IAA, which would consist of individuals who would have "distinguished themselves in one of the fields of astronautics or one of the branches of all sciences of fundamental importance for the exploration of space." IAA tried to "foster the development of astronautics for peaceful purposes," and "provide a program through which the membership can contribute to international endeavours and cooperation in the advancement of aerospace science, in cooperation with national science or engineering academies." This history has already been accounted elsewhere.[42]

Astrophysical Frontiers

It was during the 1956 IAF Congress in Rome (Italy) that Sänger delivered a lecture on the accessibility of stars. He described a spaceship fitted with a unique photon-propulsion system, making it possible to accelerate and reach a velocity close to the speed of light. This propulsion system would allow crew members to travel to distant solar systems, perform their mission, and return to the starting point—within their own lifetimes.[43]

Einstein's special relativity theory served as a basis for some computations. Among others, the theory says that when an object or vehicle travels at relativistic velocities (speeds not negligible when compared to the speed of light), this object or vehicle can be associated to a given, velocity-dependent space-time coordinate system. Based on this assumption, a simple model could be derived: a spaceship starting its journey from Earth, accelerating to near speed-of-light velocities, and finally slowing again, could reach a 100-light-year distant star after a 10-year journey only calculated in the vehicle's frame—or 100 year long for an Earth-based observer. To achieve such a remarkable performance, the propulsion system had to be able to transform the fuel carried along with it and expel it as radiation. The "ray-drive" could be as fast as light itself (Figure 10). A first design was thus completed. This subject was revived in 2002 by Nobel Prize in physics winner Carlo Rubbia.[44]

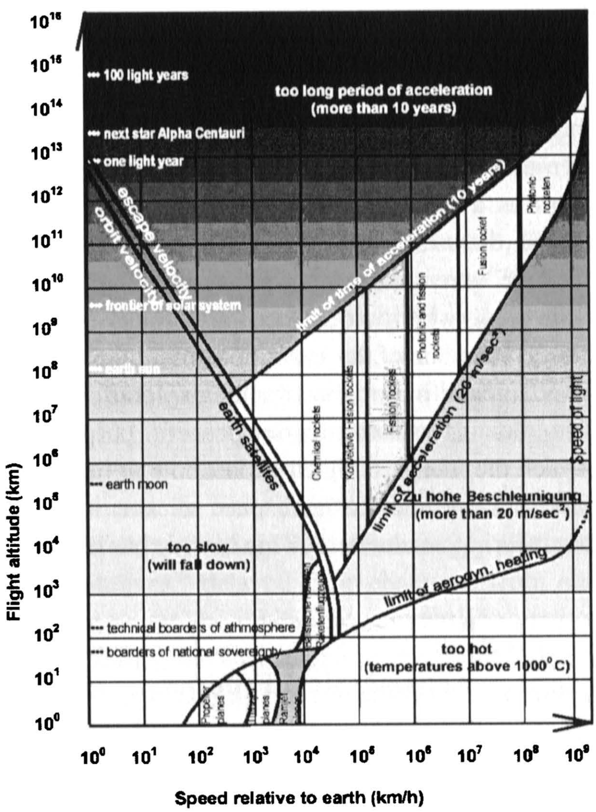

Figure 10: Astrophysical frontiers. Credit: HES.

Incidentally, Eugen Sänger also computed what the dilated universe would look like, as seen by an observer moving at velocities close to the speed of light. The "sevencoloured star-bow" describes a toroidal star bow in the colors of the rainbow.[45] Pope Pius XII read the article and heralded it as a reason to announce astronautics as mission from God.[46]

Stuttgart's Research Institute for Physics of Jet Propulsion (FPS) and Berlin Technical University (1954–1964)

In autumn 1954, when the Federal Republic of Germany (FRG) was reauthorized to resume aeronautical research, Eugen Sänger responded to a call from Stuttgart, where he established the first research center dedicated to explore the frontiers between aeronautics and astronautics. In 1957, he was awarded a honorary professorship at the University of Stuttgart. In addition to performing large-scale tests with a hot water rocket having a 30 megapond thrust and 210 megapond impulse, he kept investigating various problems of theoretical interest, such as the kinetics of chemical reactions to obtain maximal drag forces; the reflexion of gases on solid walls, so as to enhance the part of the mirroring reflexion with the aim of reducing flow resistance and heat conversion (for instance, for aerodynamical heating); and testing small plasma arc rockets.

There was no further test working for Eugen Sänger. In the summer of 1961, the experimental laboratories were completed, in the main building of the Stuttgart Pfaffenwald, built in Lampoldshausen, with departments of thermodynamics and flows, plasma physics, photonics, molecular jet physics, high temperature spectroscopy, and chemistry of fuel and large test beds, (Figures 11 and 12). German federal authorities expressed their wish to disband this complete research complex (against Sänger's will), and reactivate it within the framework of various independent institutes connected to the DVL. This "request" was closely tied to the so-called "Egyptian affair."

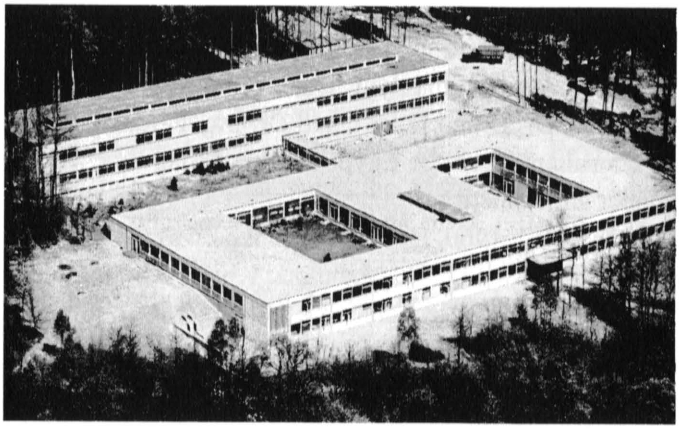

Figure 11: Research center for physics of jet propulsion (FPS) in Stuttgart Pfaffenwald. Credit: HES.

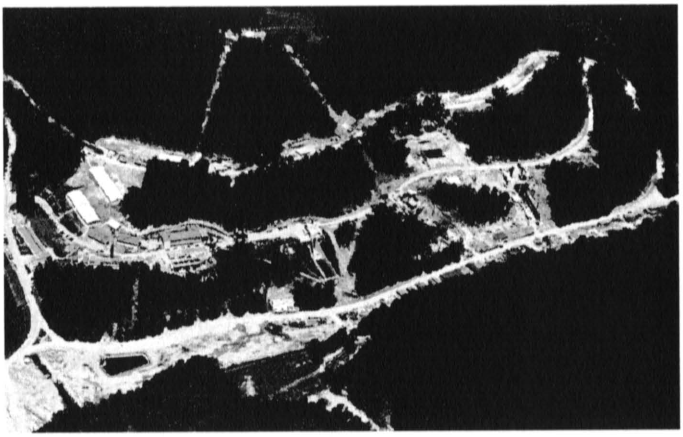

Figure 12: Rocket test center Lampoldshausen. Credit: HES.

The "Egyptian Affair": Personal Insights in the Geopolitics of Intrigues (1960–1965)

The "Egyptian affair" bears an interesting reading for scholars of covert technology transfers, but seems to have received, in Sänger's case at least (whose personal archives were opened to these authors), careless publicity driven by diverging interests and hidden agendas.[47] Some key issues thus needed to be clarified. It is the authors' understanding that a mature history of this highly sensitive episode in international life will only be accurately written when primary source materials, that is, government archival documents, are made available to historians and/or released from all of the interested parties (which is far from being the case at this time).

Sänger's involvement with Egypt began on 8 March 1960 when both the head of the FPS board, Dr. Bruno Eckert, and Dr.-Ing. Ferdinand Brandner[48] asked him to perform consultant work for Egypt on a multistage rocket research project to explore the upper atmosphere.

During 19–27 March 1960, Heinz Krug,[49] who was the FPS managing director, went to Cairo and met with E. A. Mahmoud Khalil, who introduced himself as the head of Centre National de Recherche du Caire (CNRC), to negotiate the contract. Khalil had other duties. He happened to be a high-ranking intelligence officer on a secret mission for Egypt's President G. A. Nasser: accelerate the pace of "foreign assistance" to sustain the country's indigenous high-tech military build-up. After World War II, Egypt had attracted many Germans. In the late 1950s, the country welcomed an ever-growing population of scientists and engineers. To the best of the authors' knowledge, the FPS agreement on which Krug and Khalil settled in Cairo, dealt with consultant activities to be performed by a small working group of the FPS placed under Sänger's direction. The group had traveled to Egypt on this occasion and toured existing rocket research facilities, whose construction had already begun. On 26 March 1960, Sänger received a formal invitation from Cairo University's Faculty of Mechanical Engineering to lecture on spaceflight. He made several trips to Egypt, and spent "about 50 days" there, to deliver courses at CNRC, attended by selected Egyptian specialists in engineering and natural sciences. These introductory lectures to space technology covered a broad range of subjects. The consultant work on a "two-stage meteorological sounding rocket" was part of this teaching program. Other FPS personnel were involved in this initiative. "To what extent former coworkers made consultant work for the Egyptian government in other areas, particularly after my lecture course had ended, is beyond my knowledge."[50] That Sänger met with and visited, during his trips on a personal basis, some of the German experts who he knew well and who were deeply involved in Egypt's missile program, is logical but a seemingly other story.

While the FPS had no competence for building a guided missile, a basic technical expertise could likely be gained from such an experience and feed less visible military projects, provided an effective guidance system was developed or made available. (Egypt seemingly hired several German experts in this field.) This situation is classical whenever "dual use" technologies are implied.

A second point deserves attention. While Nasser sparked a crash program to develop missiles in the wake of the Suez crisis, space activities also shone bright high above Middle East horizons. The October 1957 *Sputnik* premiere not only shook the entire world, but fired many imaginations and triggered still poorly known initiatives. In 1960 for instance, the Israel Academy of Sciences and Humanities formally created a "National Committee for Space Research." The Shavit-II, a two-stage sounding rocket was developed and test flown for the first time in 1961. At about the same time, Egyptian authorities seemingly decided their rocket-related activities could encompass much higher objectives. Egypt not only planned to develop two ballistic missiles, known as the Al-Zafir and Al-Qahir, and the two-stage rocket, Al-Ra'id, whose respective ranges were 370, 600, and 1,500 kilometers, but also envisioned launching an artificial satellite and a manned space vehicle. Some publications described the Al-Ra'id as being able to carry a "1,000 kg scientific payload." Later in the 1960s, the Egyptian press even circulated low-quality pictures of a "trainee cosmonaut."

In 1960, a few weeks after the FPS contract was signed, Krug was empowered as the director of a new company based in Munich called INTRA (International Raketen), which was to play a central role in Egypt's acquisition effort of rocket-related technologies. INTRA likely belonged to a sophisticated network of companies set up to provide Egypt with such technologies.

To say the Egyptian covert high-tech military build-up worried Israel remains a weak word. It comes as no surprise, then, that diplomacy entered the scene. In 1960, Israel managed to ask West Germany, possibly via French diplomatic channels, to put an end to the country's "unadministrated" scientific assistance to the Egyptian military efforts. Sänger was the best known German astronautics expert (after von Braun) and one of the most prolific: in the 1960–1961 timeframe, he participated in the creation of the International Academy of Astronautics (IAA), was engaged in the creation of an intergovernmental Groupe d'Études Européen pour la Recherche Spatiale (GEERS) leading to the establishment of a Commission Préparatoire Européenne de Recherches Spatiales (COPERS), was invited to represent FRG at an expert meeting in the United Kingdom on the Blue Streak program (meant to prepare what would later be known as the Europa effort), and was engaged in government-level discussion groups to help define FRG participation in a European space program (launcher and satellites). During this period, the longest leave of absence from the FPS these authors are aware of, was a six-week tour of U.S. space centers at the U.S. Department of State's invitation. Sänger also participated in the creation of Eurospace (formally established on 21 September 1961). Last, but not least, it was during this period that he wrote his most important book, *Raumfahrt, heute-morgen-übermorgen,* which can be considered as his scientific testament.

To the best of these authors' knowledge, the media campaign against Sänger began in October 1961. On 5 October 1961, as a consequence of this unwelcome publicity, Dr. Eckert suspended Sänger from work and forbade him to enter FPS buildings any more. On 11 October 1961 Sänger, who had asked for an appointment with the German minister of transportation, was received by state secretary Dr. Seiermann, and was requested to terminate immediately the Egyptian contracts and to avoid speaking to the press. Sänger followed this advice and terminated, the same day, his consultant work for Cairo. But his case was not closed. On 20 October 1961, the German minister of transportation asked Dr. Eckert to fire Sänger from the FPS. Eckert asked him, again, to terminate his contract with Egypt (this had already been done).

Soon after this episode, on 16 November 1961, FRG parliamentary press services accused Sänger of spying for the Soviet Union (Pripolzew case). Sänger was interviewed by a federal court judge and not found guilty of breaking any law. On 11 November 1961, Cairo went back to Sänger, asking him to complete his contract. Sänger put a definitive end to his involvement, in a letter he addressed to Khalil.

Sänger's institute was absorbed on 23 November 1961 within the DVLR structure. On 7 June 1962, Irene Sänger-Bredt, vice-director of FPS, resigned from this organization on the grounds that it would be dissolved and integrated to DVLR where her employment could not be considered positively (Figure 13).

Figure 13: Irene Sänger-Bredt and Eugen Sänger. Credit: HES.

On 27 July 1962, dummies of Nasser's missiles were paraded in Cairo, unleashing a new rash of press reports on German scientific and technical assistance. Sänger's name resurfaced in the media. On 8 August 1962, he counteracted on the same grounds, so as to correct the statements on his consulting activities for Egypt, he gave a press declaration and settled the debate. This article did much to rehabilitate Sänger in West Germany. On 2 October 1962, on the occasion of a ceremony celebrating the 15th annual anniversary of the foundation of the community of German airports (ADV) in Burg Stettenfels, Sänger was unofficially rehabilitated by the German minister of transportation Hans-Christoph Seebohm. A few months after, on 15 January 1963, Sänger was received by the German President, Dr. Heinrich Lübke, who asked him to outline the new German space program.

In early 1963, Sänger positively responded to a call from the Berlin Technical University, where a "professorship for elements of astronautic technologies" had been created. He became a Professor and worked there until he died, one year later.

Industrial Collaboration with Junkers Flug-Zeug Und Motorenwerke (JFM) Company in Munich (1961–1964)

Working as a consultant for various German air and space industries, Eugen Sänger carved out, between 1961 and 1964, a voluminous report on the "provisional proposals for the development of a European space plane" for the JFM company.[50]

The focus of these proposals, which comprised a series of preliminary studies, was a manned space plane having a 200-ton launch weight and a 3-ton payload. There had been considered a horizontal catapult launch with a hot water rocket in the first developing phase, with liquid oxygen (LOX) / liquid hydrogen (LH2) rocket propulsion and well-known technology (w = 4,200 meters per second), in the next phase a one-stage-to-orbit concept with an impulse augmentation of the jet with a ramjet-like sheathing of the liquid propulsion, where the obligatory fuel excess should be after burned (Figure 14).

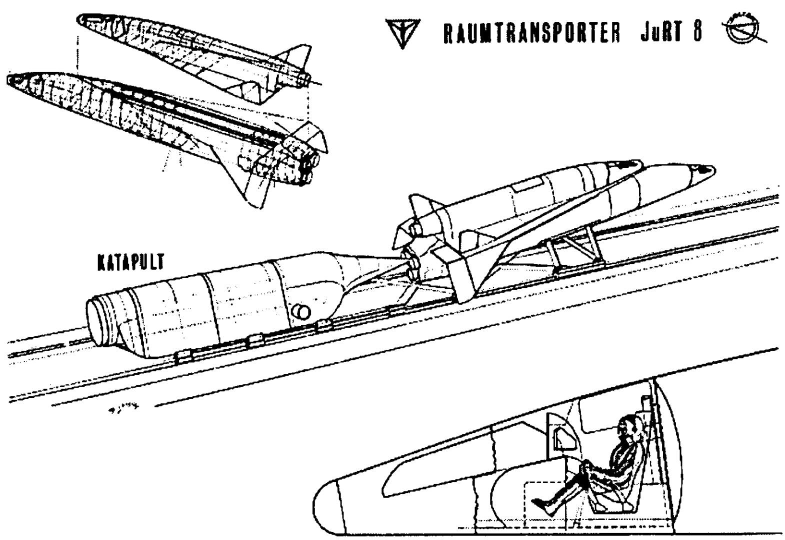

Figure 14: Junkers RT-8, a two-stage-to-orbit proposal with an acceleration sledge. Credit: HES

At the last forenoon of his life, Sänger completed the 32nd chapter of his space-transporter report for the JFM company. He thus had dedicated his last hours to the same subject he had been enamored with since his youth, keeping an obstinate faith in what he once wrote, prophetically, in his diary: "And my Silver Birds will fly."[51]

Conclusion

Most early pioneers of astronautics remained dreamers of unfulfilled prophecies. Eugen Sänger, however, was one of the rare, gifted, engineer–physicists whose deep understanding of a technical knowledge, which he partly created, combined with a real talent for large-scale project management, could turn some of those dreams into reality and, as such, help astronautics break the "science-fiction" barrier. Dreams require efforts, energy, personal battles, and sweat to crystallize in the open. But in troubled times, dreams also share the burden of a dark side too. History teaches that during World War II, and in the course of the Cold War, advanced technologies and those scientists who had contributed to originate them, were perceived as major assets of potentially limitless power. Sänger's complex career illustrates this turning point in contemporary history. Beyond the many conceptual and technical breakthroughs which he achieved, and are briefly reviewed in this chapter, these authors tried to highlight how difficult it was for scientists, to form a clear vision of complex geopolitical battles and hidden agendas. Most of those understood that real technical progress could create war machines before spinoffs were available on a social scale. To circumvent these international realities, scientists, wherever they came from, developed their own strategies—through national or international organizations, meetings, or joint programs—to keep their dreams alive. Sänger struggled all his life to make spaceflight come true, and he had an inflexible faith in humankind's future in space so that one day heirs of the "Silver Bird" could reach the most distant heavens.

Notes

[1] H. Oberth, *Die Rakete zu den Planetenräumen* (München und Berlin: Oldenbourg, 1923).

[2] Early technical readings that influenced E. Sänger to propose such a wide dissertation subject—too often presented as limited only to the rocket plane "chapter"—remains largely ignored. These authors believe that Sänger might have accessed *Die Rakete*, journal of the Verein für Raumschiffahrt (vfR) where he might have read R. Esnault-Pelterie, "Astronautik und Relativitätstheorie," *Die Rakete* Nos. 8/9 (1928) quoted by N. A. Rynin, *Interplanetary Flight and Communication* Vol. III, no. 9 (1932), translated from Russian, published for NASA and the NSF by the Israel Program for Scientific Translation, Jerusalem, 1971, p. 183. Sänger's access to and influence by early astronautic literature requires, however, additional research.

[3] R. P. Hallion, "[Preface] In the Beginning was the dream..." in R. P. Hallion, editor, *The Hypersonic Revolution, Volume I (1924–1967)* (Wright-Patterson Air Force Base: Special Staff Office, Aeronautical Systems Division, AFB, 1987), p. xiii.

[4] E. Sänger, *Raketenflugtechnik* (München und Berlin: R. Oldenbourg, 1933).

[5] K. Stöckel, "Die Entwicklung des Hochdruck-Hauptstrom-Raketentriebwerks in Deutschland," *Zeitschrift für Flugwissenschaften und Weltraumforschung,* volume 1 (1985).

[6] E. Sänger und I. Bredt, *Über einen Lorinantrieb für Strahljäger* (Deutsche Luftfahrtforschung, Zentrale für wissenschaftliches Berichtswesen, UM Nr. 3509, Ainring, 1943).

[7] E. Sänger, *Gaskinetik sehr hoher Fluggeschwindigkeiten, ZWB,* VB 972, Berlin-Adlershof, 1938. After World War II, this discipline was known as "superaerodynamics" and was extensively studied by T. von Kármán's protégé, Tsien Hsue-shen, who subsequently fathered the People's Republic of China's ballistic missile and space programs. As early as 1934, Tsien had corresponded with Sänger.

[8] E. Sänger, Gaskinetik sehr hoher Fluggeschwindigkeiten; ZWB, VB 972, Berlin-Adlershof, 1938.

[9] E. Sänger und I. Bredt, *Exakte Berechnung der Triebwerksströmung in Raketen und Staustrahlsystemen unter Berücksichtigung der endlich großen Einstellgeschwindigkeiten des Gleichgewichts*, (VDI-Forschungsheft 437, 1953).

[10] I. Sänger-Bredt, *Flugschleppversuche mit Überschall-Staustrahlrohren bei mäßigen Unterschallgeschwindigkeiten* (VDI-Forschungsheft 437, 1953).

[11] Über einen Raketenantrieb für Fernbomber. Zentrale f. wissenschaftl. Berichtswesen, Berlin-Adlershof, UM 3538 (1944) (together with I. Bredt). French translation: Arsénal de l'Aéronautique E5/16 (1946). English translation: Bureau of Aeronautics, Technical Information Branch, BUAER Navy Department Translation CGD-32 (1946) and Dr. Robert Cornog, Santa Barbara, California, 1952. New print: Mitteilung aus dem Forschungsinstitut für Physik der Strahlantriebe Nr. 13, Verlag Flugtechnik, Ernst von Olnhausen, Stuttgart 1957.

[12] W. von Braun, unpublished contribution to Sänger's biography (1965). HES archives.

[13] Some of the recently published material dealing with the U.S. capture and exploitation of the Luftwaffe's secret technology erroneously claimed that "the Jet propulsion laboratory at Cal Tech, America's premier Jet and rocket engine research center became the home for German propulsion experts such as Eugen Saenger." Such statements are untrue. Quote extracted from: C. R. Christensen, *A History of the Development of Technical Intelligence in the Air Force, 1917–1947—Operation LUSTY* (Lampeter, United Kingdom: The Edwin Mellen Press, 2002), p. 192.

[14] In 1944, a scientific section was created within the Service de Renseignement Opérationnel (SRO) and placed under the leadership of Capitaine de Corvette Saint-Guily (French Navy). The section was tasked with recruiting German scientists and locating and recuperating documents and targets of high scientific value. See H. Navarre et al., *Le Service de Renseignements 1871–1944* (Paris: Plon, 1978), pp. 310–311. For scholarly studies of the French "brain drain" see, among others, M. F. Ludmann-Olivier, "Un autre aspect de la chasse aux cerveaux: Les techniciens allemands en France, 1945–1949," *Relations Internationales* Vol. 46 (1986): pp. 195–208; D. Pestre, "Guerre, renseignement scientifique et reconstruction, France Allemagne et Grande—Bretagne dans les années 1940," *Cahiers d'Histoire et de Philosophie des Sciences* Vol. 47 (1999): pp. 183–201; A. Teyssier and R. Hautefeuille, "Recherche scientifique et politique militaire en France (1945–1958)," *Revue Historique des Armées,* no. 2 (1989): pp. 111–122.

[15] E. Sänger, Projet d'un engin Lorin de D.C.A. à vitesse subsonique, Rapport No.ES/18, Arsenal de l'Aéronautique, Service de Documentation, 1946.

[16] E. Sänger, Projet d'une Fusée de 3 tonnes refroidie par circulation forcée, pour utilisation rapide, Rapport No.ES/15, Arsenal de l'Aéronautique, Service de Documentation, 1946; G. Chayvialle; Note sur le refroidissement des fusées par Sänger, Arsenal de l'Aéronautique Service de Documentation, 1946.

17 E. Sänger, *Die Grundlagen der Staustrahl-Flugzeuge,* Rapport E5/65, Arsenal de l'Aéronautique, 1946; E. Sänger, *Schuberhöhung von Triebwerken durch Luftzumischung zum Abgasstrahl,* Arsenal de l'Aéronautique, Rapport E5/98, 1947; E. Sänger, *Theorie der Gemischaufbereitung in stationären Feuerungen,* Rapport E5/150, Arsenal de l'Aéronautique, 1948.

18 P. Coué, private communication, 4 September 2003.

19 G. Tokaev, *Stalin Means War* (London: Weindenfeld and Nicolson, 1951), p. 158.

20 P. Coué, private communication, 4 September 2003.

21 E. Sänger, "Was kostet Weltraumfahrt?" *Weltraumfahrt* 2 (1951): pp. 49–55. Several reprints or translations subsequently appeared, among others: *Rocket Science, J. Detroit Rocket Soc.* 5, no. 2 (1951): pp. 26–33; *Techn. Rundschau* 45, no.31 (1953): pp. 12–14.

22 In 1937, while organizing an exhibition on Astronautics in Paris, the idea of a "universal" congress took shape in Ananoff's mind. The discipline, he believed, would have to be undertaken on an international cooperation basis through formal national organizations. From 1938 on, he fathered several ill-fated astronautics organizations (within the Société Astronomique de France, the Aéro- Club Universitaire et Scolaire de France, or the Aéronautique-Club de France).

23 E. Sänger may refer here to A. Ananoff, "La fusée de guerre," *Revue de l'Armée de l'Air*, no. 104 (March 1938); A. Ananoff, "Comment fonctionne une fusée à combustible et comburant liquides," *L'Aérophile* (August–September 1938); A. Ananoff, "Où en est la fusée de guerre?," *Science and Vie* no. 274 (April 1940); A. Ananoff, "L'évolution des recherches sur les fusées à travers le monde," *L'Aérophile* (October–November 1940).

24 A. Ananoff, *Mémoires d'un astronaute* (Paris: Blanchard, 1978).

25 A. Ananoff, *L'Astronautique* (Paris: Fayard, 1950).

26 E. Sänger, *Correspondence* 9 November 1949, quoted in A. Ananoff, *Mémoires...*, pp. 100–101(note).

27 IAA, *Conception, Birth and Childhood of the International Academy of Astronautics,* International Academy of Astronautics, www.iaanet.org/history/conception.html#conception_3 (accessed July 2002); H. Moulin, "September 2001... The International Astronautical Federation is 50 Years Old," H. Moulin, editor, *IAF: The First 50 years—The Spirit of Astronautics* (Paris: International Astronautical Federation, 2001), pp. 9–11 (p. 9).

28 *Weltraumfhart* 1 (February 1950) quoted by Ananoff, *Mémoires...*, p. 115.

29 These arduous "diplomatic" negotiations might have postponed the Paris congrès. See Ananoff, *L'Astronautique,* 1950, p. 440, and Ananoff, *Mémoires*, p. 116.

30 A. Ananoff, *Mémoires...*, pp. 115–116.

31 Winfried Schulze, La politique de la science en allemagne du vingtième siècle (conference de l'Institut Historique Allmemand) (Sigmaringen: Jan Thorbecke Verlag, 1998), pp. 35–51.

32 E. Sänger, *Correspondence,* 15 July 1951, quoted by Ananoff, *Mémoires*, 149.

33 For a personal recollection, see, for instance: L. R. Sheperd, "Eugen Sänger. Germany. 1951–1953" in Moulin, *IAF: The First 50 Years,* 2001, pp. 16–17.

34 Anytime Ananoff could boost his German friend into publicity, he would do so. Along with Sir G. de Havilland, R. Esnault-Pelterie, H. Farman, G. Voisin, and other leading aeronautical figures, E. Sänger was interviewed in early 1951 on the "flying saucers" controversy and the Silbervögel project reminded the readers, as to what could be considered "state of the art" in aeronautical thinking. See A. Ananoff "Les soucoupes volantes—Vérités, possibilités, illusions," *Science and Vie*, no. 403 (April 1951): pp. 216–226.

[35] A. Ananoff, *Mémoires...*, p. 152.

[36] Ananoff was made aware of this "gaffe" on reading a letter from F. Durant III (ARS President) dated 26 June 1952. See Ananoff, *Mémoires...*, p. 156.

[37] R. Peiss, "Problems in the Acquisition of Foreign Scientific Publications," *Department of State Bulletin* 22 (30 January 1950): pp. 150–155, quoted and analyzed by Pamela Spence Richards, *Scientific Information in Wartime—the Allied-German Rivalry 1939–1945* (Westport, Connecticut: Greenwood Press, 1994).

[38] J. J. Bagnall, "The Exploitation of Russian Scientific Literature for Intelligence Purposes," *Studies in Intelligence,* Langley, Virginia (Summer 1958): pp. 45–49 (p. 45). Confidential (Declassified NNP947003). Declassification date unknown.

[39] As illustrated by a joint 1949 United Kingdom–U.S. study on Soviet guided missile efforts, mostly based on German sources. See U. Albrecht, A. Heinemann-Gruder, and A. Wellmann, *Die Spezialisten: Deutsche Naturwissenschaftler und Techniker in der Sowjetunion nach 1945* (Berlin: Dietz Verlag, 1992) not consulted; P. Madrell, "British–American Scientific Intelligence Collaboration during the Occupation of Germany," *Intelligence and National Security* Vol. 15, no. 2 (Summer 2000): pp. 74–94 (see in particular p. 81); P. Madrell, "La Pénétration de la zone soviétique de l'Allemagne et de l'Union Soviétique par les services de renseignement britanniques, 1945–1955," J. Delmas and J. Kessler, editors, *Renseignement et propagande pendant la Guerre froide (1947–1953)* (Bruxelles, Editions Complexe, 1999), pp. 153–171 (pp. 160, 165–167).

[40] P. Madrell, "La Pénétration," 1999, p. 164.

[41] H. Gartmann, *Sonst stunde die Welt still* (Dusseldorf: Econ Verlag, 1958).

[42] IAA, http://www.iaanet.org/intro/index.html, (see note 27).

[43] E. Sänger, "Die Erreichbarkeit der Fixsterne," *Rendiconti del VII Congresso Internazionale Astronautico,* Assoziazione Italiana Razzi, Roma (1956), pp. 97–113. See also Mitteilungen der Landesgruppe Nordbayern der DGRR vom (13 May 1958).

[44] A. D. Szames, "La fusée photonique à l'épreuve de la critique," *Air and Cosmos* 1850 (5 July 2002): pp. 34–35.

[45] E. Sänger, "Zur Flugmechanik der Photonenraketen," *Astronautica Acta* 3 (1957): pp. 89–99. English translation, *AeroDigest* 73 (1956): pp. 68–73. Traduction française, *Fusées* 1 (1956), pp. 253–259.

[46] E. Sänger, "Warum Raumfahrt," *Festvortrag bei der 12. Jahrestagung der DGRR,* Heidelberg, 23 May 1960.

[47] M. Bar-Zohar, *La Chasse aux Savants Allemands (1944–1960)* (Paris: Fayard, 1965), (see in particular pp. 227–269); J. Scheffran, "Die Heimliche Raketenmacht—Deutsche Beiträge zur Entwicklung und Ausbreitung der Raketentechnik," *Information stelle Wissenschaft and Frieden* Vol. 9 (April 1991) also available online at www.uni-muenster.de/PeaCon/wuf/wf-91/9111201m.htm (accessed 27 August 2003); T. Pirard, "German Rockets in Africa: the Explosive Heritage of Peenemünde," IAA paper 96-IAA.2.3.05, in *History of Rocketry and Astronautics*, Hervé Moulin and Donald C. Elder, Editors, (San Diego: Published for the American Astronautical Society by Univelt, Inc., 2003), AAS History Series, Vol. 25, 2003, pp. 201–234 (paper presented at the 47th International Astronautical Congress, Beijing, China, October, 1996). This paper contains some erroneous statements. E. Sänger died in 1964, not in 1970. During World War II, E. Sänger did not work for Peenemünde, whose existence he came to know about (see paper contents for the details), nor did he ever deal with guided ballistic rockets. (H. E. Sänger, *Correspondence with T. Pirard* (Stuttgart, 30 April 2000).

[48] Dr.-Ing. Ferdinand Brandner was a school friend of E. Sänger, and not an employee of the FPS, when he asked him to perform consultant work for Egypt. In April 1937 Brandner joined JFM company, where he became head engineer in charge of the JUMO 222 turbojet development. At war's end, he went to the Soviet Union, where he pursued various aircraft engine developments. On return to Austria in the mid-1950s, he became one of BMW's technical directors. In the early 1960s Brandner headed the development of Egypt's small, lightweight supersonic fighter Helwan HA-300 power plant and was instrumental in the cooperation of Egypt with India on fighter aircraft technology.

[49] Dr. Heinz Krug became the director of the Munich-based INTRA (Internationale Raketen) company, founded in 1960. He was likely murdered on 10 September 1962. See M. Bar-Zohar, *La Chasse,* 1965, p. 260.

[50] E. Sänger, *Meine Tätigkeit in Ägypten* (Presseerklärung, 12 September 1962).

[51] E. Sänger, Vorläufige Vorschläge eines Europäischen Raumflugzeuges; Hausbericht der Firma Junkers Flugzeug und Motorenwerke in München, 1961–1964.

[52] I. Sänger-Bredt, Die Geschichte vom Silbervogel; Lecture during the 21st Congress of the IAF (Constance, Federal Republic of Germany, October, 1970). "The Silver Bird Story," *Journal of the British Interplanetary Society*, London (1971). Also published as "The Silver Bird Story: A Memoir," in *History of Rocketry and Astronautics*, R. Cargill Hall, Editor, (San Diego: Published for the American Astronautical Society by Univelt, Inc., 1986), *AAS History Series*, Vol. 7, Part I, 1986, pp. 195–228.