# Körber European Science Prize 1999

## High Altitude Platforms for Telecommunications

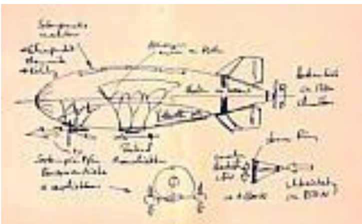
Bernd Kröplin, Per Lindstrand, John Adrian Pyle, Michael André Rehmet

*An idea takes on shape. At the beginning there is only a quickly drawn sketch illustrating some of the basic elements and a few of the technical details, such as solar panels, a tail propeller, a ballonet for equalizing the pressure, and a system platform.*

It all started with “Lotte”, the name that Prof. Bernd Kröplin and his Stuttgart crew affectionately gave to their first solar powered airship. The floating lady was first rolled out of its hanger and made its maiden flight in 1993, during the International Garden Show in Stuttgart. “With Lotte we tried out solar flying for the first time,” as Kröplin recalls. The principle according to which it functioned was that a thin layer of silicon on the upper side of the body transformed sunlight into electricity, which powered the propeller at the back, moving the airship that was filled with helium.

"Lotte“, the first solar powered airship, has been flying since 1993 and is the starting point for the development of the high-altitude platform. (Photo: Colin Barschel)

In the following years, this group built Icaré, the world's first airplane that can be run exclusively with solar energy. For the take off, solar powered batteries are used, while horizontal flight is strictly solar powered. This plane was designed largely by Dr Michael Rehmet as part of his Ph. D. thesis. Dr Rehmet was also the main engineer of Lotte and today works for Dornier Luftfahrt in Oberpfaffenhofen. There can be no doubt that the Stuttgart engineers are pioneers in building solar-powered flying machines.



An idea takes on shape. At the beginning there is only a quickly drawn sketch illustrating some of the basic elements and a few of the technical details of the high-altitude airship.

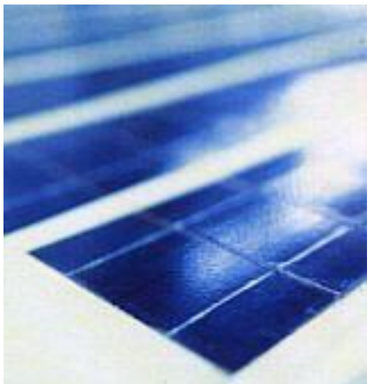
“And then one day we asked ourselves: Is it not possible to use solar power in high altitude platforms?" Kröplin's use of the word “platform" here is obviously figurative, since he was thinking of round airships or balloons. Such flying objects, floating at great height, maintained at one and the same location by using solar energy, could for example be used as a relay station for mobile phones and supplement or replace expensive satellites or radio towers. The thought itself was not new and had been considered by other engineers. For example, solar airplanes had already been tested in the United States.

“We found out that it hardly works with airplanes,” says Bernd Kröplin, referring to results gathered in Rehmet's dissertation. “The power required to propel an airplane is too large, and all existing batteries are too heavy to store enough solar energy for nights.” Balloons or airships filled with helium do not have this disadvantage. On the one hand, they float on their own and only require energy to hold their position despite wind streams. On the other hand, they are very voluminous flying objects within which enough solar energy can be stored for the night in the form of hydrogen.

In 20 kilometres altitude airship-platforms can take over tasks of satellites.

These facts led to the idea, which has now been awarded the Körber European Science Prize, to attempt to build such platforms using airships. Rehmet and the Stuttgart team, together with Per Lindstrand, a Swedish balloon designer, and Dr John Adrian Pyle, a British chemist who studies the atmosphere, want to develop a high-altitude platform. They can draw on their experience with Lotte, which is still around even though its surface has been patched several times and numerous modules of its internal workings have been replaced. In the immense test hangar of the Institute for Static and Dynamics of Aviation and Space Construction, Lotte is floating just above the floor and looks, despite its 16 meter length, rather small. There are numerous machines for working with metal, canisters with helium, a crane, a huge pressure chamber for simulating the thin cold atmosphere of higher altitudes, a pile of oil drums, the wings of a wind mill, computers, cables, and consoles – this is obviously a place where people develop things in a practical, pragmatic, and creative sense. It is the creative playground for Kröplin and his 60 co-workers, several of whom were working on Lotte.

Cables are hanging out of Lotte's belly, connected to a electronic box. They are the end of a “bus,” that is, an electrical line made of numerous cables for transporting data. The data come from sensors in Lotte's body, are stored in its board computer, and also sent to the ground by radio. They are supposed to provide information about the forces affecting the airship during flight, such as distortions on the body, pressure, winds, the position of the airship, and how it reacts to steering.



A larger challenge is the storage of solar energy for the night. The plan is to split water by day with solar energy in hydrogen and oxygen and to store both gases in the large body of the airship. (Photo: Friedrun Reinhold)

“Much less is known about the aerodynamics of airships that about that of airplanes,” Kröplin explained. In contrast to slim airplanes, the surface layer effect, i.e., air vortices (or eddies) that originate on the surface of a flying object, plays an important role on thick, cigar-shaped flying objects. This effect, as far as we know, can be affected by, for example, the form and material of the body. “Lotte is our guinea-pig. The knowledge we gain with her can be transferred to larger airships. To do this we want to develop a program for calculating the aerodynamics of airships."

Lotte's nose is now moving upward while the back end stays on the ground. The engineers are measuring the angle, comparing it with the angle given by the board computer by using an gyroscope and correcting the latter. This calibration is necessary to enable the board computer to correctly calculate its position in space at any time. Aerodynamics and spatial positioning play an important role if a future airship platform is supposed to maintain its position above a location on the ground in 20 kilometers altitude for years despite all the forces of nature.

At that altitude there are winds blowing at speeds up to 150 km per hour. These jets are limited in diameter, which offers the airships at least theoretically the chance to avoid the winds and search for calmer regions while trying not to blown away. To make it possible for the airship to do this, a steering system and all the necessary electronics are supposed to be developed. In doing so, it would have to stay within an corridor about one-half kilometer in diameter in order for cell phones to be able to reach it, but it could move vertically up to 5 km.

An independent system of maintaining position in space is one of the three key issues that will have to be solved with the Körber Prize. The second is gaining and storing energy, because the airship can only maintain its position against the winds if enough energy is available to drive its propellers. “Solar cells are sufficiently developed for our purposes, although thin layer cells would be even better," as Bernd Kröplin explains. Despite all of his numerous activities as a Jack of all trades, he speaks very calmly, almost cautiously. Solar cells made of ultra-thin layers of silicon would be even lighter than those used previously, an advantage because the cells will have to be installed over a large surface area of the platform in order to produce as much electricity from sunlight as possible.

Bernd Kröplin
(Photo: Friedrun Reinhold)

A larger challenge is the storage of energy for the night. Since the sun is not available, solar energy captured during the day will have to be transformed into chemical energy and deposited somewhere. Since ordinary rechargeable batteries would be much too heavy, the engineers came up with the idea of using solar energy to split water into hydrogen, which is lighter than air, and oxygen. The two gases will be stored somewhere in the large body of the airship. In the night they could be fed into a fuel cell, creating water and electric energy to power the propeller. “Such fission is in principle nothing new," explains Kröplin. “It is just that it has not been attempted at temperatures as low as minus 60° C, such as may be encountered at that elevation. Moreover, there is no fuel cell that can be used in flight, and we have to develop a tank for the hydrogen." All of these problems are supposed to be overcome in the project.

The third key issue concerns the materials that the ship is to be made of. The platform will probably be built according to the same principle as Lotte, namely as a blimp, i.e., a cigar-shaped tube made of a thin material, whose shape is maintained by keeping the helium at a pressure higher than that of air. In contrast to Zeppelins, a blimp does not have a rigid frame, which means it is lighter. “Lotte's surface is made up of patched sheets of laminated film," says Bernd Kröplin. “The inner layer is made of Mylar, gastight and tension proof, while the outer layer of Tedlar is gastight and also resistant to ultraviolet light." “The surface has to be pliable in order to resist being deformed by the winds,” he adds. Most artificial materials become brittle in the cold, Mylar for example at -4° C. Research has to be done on the features of brittleness, gas tightness, and resistance to ultraviolet rays.

Per Lindstrand, from Sweden, will contribute his practical experience to the construction of the high-altitude platform. In some 23 years he and his company, which is now located in Great Britain and employs 58 people, have constructed about 120 airships and more than 5000 balloons. He holds many records in flying hot air balloons and became famous by being the first person to cross the Atlantic in a balloon and by trying several times to circumnavigate the earth in a balloon. “Kröplin and I have known one another for a long time, because we move in the same circles," says Lindstrand recalling their first contacts. “We kept meeting at conferences and symposia. Thus it was only natural for us to talk, and Kröplin finally asked me to join his team for the high-altitude platform.”

Per Lindstrand
(Photo: Friedrun Reinhold)

John Adrian Pyle
(Foto: Friedrun Reinhold)

Responsible for studying the meteorological conditions under which the airships are supposed to work is Dr John Pyle. “We were busy conducting a large scale ozone measurement in North Sweden last winter when Kröplin called me and told me about his project of a high-altitude platform," he says. “At first, I thought it was a crazy idea but now I am glad to be part of the team.” Pyle's actual field of study is modeling of the ozone layer, for which he is interested in getting data from the stratosphere. Although the ozone layer does not affect airships, both the meteorological conditions at high altitudes and the ultraviolet radiation will be of decisive importance. Pyle's task in the team is thus to devise computer models to simulate the conditions to which the airship will be exposed at altitudes of 20 km.

The fourth recipient of the Körber Prize is Michael Rehmet, a builder of flying machines. He was responsible for the design studies for the platform. The four researchers want to use the 1.5 million DM Prize money to finance the first technical steps towards a prototype. They hope to fly a demonstrator in 2001, to show that the technology works. A real prototype, Rehmet estimates, would cost about DM 15 million and take two years to develop. The platform would be ready for industrial production two to three years later at a price of about DM 100 million. That sounds like a lot of money, but the investment could pay for itself quickly. “Such a platform could transmit 50,000 to 100,000 telephone calls simultaneously," according to Bernd Kröplin. “That would amount to income of about DM 500 million a year.”

Michael Rehmet
(Photo: Friedrun Reinhold)

A single airship could transmit all the cellular telephone calls of an urban region such as London, making it unnecessary to maintain numerous expensive radio towers. A system of such airships would cost just a fraction of the costs of a system of satellites, such as Motorola's Iridium project. Although the telecommunications industry is still reluctant to provide financial support, various organizations such as the European Space Agency (ESA) and DASA, the German airplane manufacturer, have expressed interest. “We are receiving more and more support and are gradually closing in on our goal,” Lindstrand says. The fact that airships have a real commercial chance and are experiencing a renaissance is documented by two other recent projects in which Kröplin and his Stuttgart crew are involved: the Zeppelin NT, which is supposed to carry tourists over Lake Constance, and the Cargolifter, a 240 meter long heavy duty transporter designed to carry up to 160 tons of cargo.

Kröplin and his collaborators see a large number of worthy potential uses for a high-altitude platform. A single station could, for example, provide the entire infrastructure for a nation-wide cellular telephone network in developing countries. Or it could take over all the media communications during events of world-wide interest, such as a Winter Olympics in an isolated city, or take the place of an infrastructure destroyed in a catastrophe, such as an earthquake. Floating over European cities, they could provide faster internet connections or the basis for traffic control systems, or even automatically read equipment such as parking meters or gas meters. They could also collect meteorological or geographic data. Bernd Kröplin is absolutely sure: “As soon as we demonstrate that such high-altitude platforms are technologically feasible, then they will come, it is inevitable.”

Heavy-duty transporters of the future: the 240 meter long CargoLifter is soon supposed to be able to carry up to 160 tons of cargo over long distances.

Contact
Körber Foundation
Körber Prize
Kehrwieder 12
D-20457 Hamburg
Phone +49 40 · 80 81 92 -181
E-Mail koerberprize@koerber-stiftung.de