AROUND THE WORLD IN A SOLAR AIRPLANE

SOLARIMPULSE

A SYMBOL UNDER CONSTRUCTION

To demonstrate the immense potential of renewable energies, Solar Impulse aims to put into the air an airplane able to fly both day and night, propelled only by solar energy, and to circle the earth without fuel or polluting emissions.

In a society that is dependent on fossil fuels, this project is a paradox, almost a provocation. It symbolizes the new technologies mankind ought to be capable of applying in order to save our planet's energy resources. It is suggesting that tomorrow's adventures need to be linked to the search for a better quality of life. "The challenge of the 21st century is to combine human creativity and pioneering spirit to develop the quality of life to which present and future generations are entitled."

Bertrand Piccard



AIRPLANE

Solar Impulse is a revolutionary concept, which is going to push back the limits of our knowledge of materials, energy management and human-machine interface. An outsized machine in relation to its weight (61 metres wingspan and 1500 kilos for the first prototype), its aerodynamic qualities are until now unrivalled. From the solar energy panels to the propellers, Solar Impulse needs to optimize the various links in the propulsion chain, respond to altitude factors which are hostile to both materials and pilot and combine the constraints of weight and resistance with the requirement to be ultra lightweight. A high-flying exercise!

How do we succeed in a mission like this knowing that, with current technologies and yields, each square metre of photovoltaic cells can provide the propeller with just 28 watts of continuous energy - the equivalent of an electric light bulb - over a 24 hour period? In other words, how can an airplane fly with the energy consumed by a supermarket window? Impossible without globally optimizing the airplane and slashing its energy consumption. Drawing extensively on new technologies, the Solar Impulse engineers have developed an aircraft that is totally new in terms of aerodynamics, structure, building methods, form of propulsion and area of flight.





VISION

Solar Impulse believes in the force of symbols. By writing a new page of aviation history with solar energy, as far as a round-the-world flight without fuel or pollution, Solar Impulse is determined to actively promote the cause of renewable energies and the energy efficiency that new technologies are offering.

The Solar Impulse initiative is at once scientific, with all the research it implies, and philosophical, by virtue of its concern to sensitize society and to bring everyone to be sparing of our planet's energy resources.



CHALLENGE

To make an airplane take off and fly under its own power, both day and night, entirely propelled by solar energy, and in so doing, take a step nearer to perpetual flight, without fuel or pollution, is an unachievable objective, unless current technological limits can be pushed back. Never before has an aircraft been constructed with such large dimensions and yet remained so light, and never before has a system of propulsion been perfected to such a level of efficiency. The greatest hurdle before the round-the-world flight will be not only to make it fly at night, but also controlling such an innovative airplane in the air.

INVENTING THE FUTURE

SOLAR IMPULSE,

The question of energy determines the entire project, from the structure's dimensions to the extreme weight constraints. At midday, each m² of land surface receives the equivalent of 1000 watts, or 1.3 horsepower of light power. Over 24 hours, this averages out at just 250W/m2. With 200m² of photovoltaic cells and a 12% total efficiency of the propulsion chain, the plane's motors achieve no more than 8 HP or 6kW – roughly the amount of power the Wright brothers had available to them in 1903 when they made their first powered flight. And it is with that energy, optimized from the solar panel to the propeller by the work of a whole team, that Solar Impulse is striving to fly day and night without fuel.



The construction of the prototype is the fruit of intense collaboration between the multidisciplinary Solar Impulse team, charged with the plane's design, and the materials suppliers, the components producers and other partners. It is only by wrestling with the specifications and fully exploring everyone's potential that totally new aeronautic solutions have appeared. In the final stages, 50 employees were joined by more than 100 experts and advisers to create an explosive synergy...



Multiple forms of energy have to be managed and their conversion phenomena understood and optimized:

- luminous the mechanics of solar radiation
- electrical in the photovoltaic cells, the batteries and the motors
- chemical inside the batteries
- potential when the plane gains altitude
- mechanical through the propulsion system
- kinetic when the plane picks up speed
- thermal the various losses (friction, heating...) to be minimized at all cost



EFFICIENCY AND STORAGE CAPACITY

The 12,000 photovoltaic cells in 180 micron mono-crystalline silicon have been selected for their capacity to combine lightness and efficiency. Their efficiency could have been greater, following the example of the panels used in space, but their weight would then have penalized the plane during night flight. This phase being the most critical, the main constraint of the project today lies with the batteries. Still heavy, they require a drastic reduction of the weight of the rest of the plane, so as to optimize the whole energy chain and to maximize the aerodynamic performance provided by a large wing span and a wing profile designed for low speeds. With an energy density of 200Wh/kg, the accumulators needed for night flight weigh 400 kg, or more than 1/4 of the total mass of the plane. Improving battery capacity would eventually allow a second pilot, a smaller wingspan or a higher flight speed.

THE ZERO FUEL AIRPLANE



The on-board computing system gathers and analyses hundreds of flight management parameters, giving the pilot information he can interpret for making decisions, transmitting key data to the ground team and, above all, providing the motors with optimal power for the particular flight configuration and battery charge/discharge status. In this way the plane can self-correct and minimize its energy consumption.



PROPULSION SYSTEM

Under the wings are four gondolas, each containing a motor, a polymer lithium battery consisting of 70 accumulators, and a management system controlling charge/discharge and temperature. The thermal insulation has been designed to conserve the heat radiated by the batteries and keep them functioning despite the -40°C encountered at 8,500 metres. Each motor has a maximum power of 10HP. A gear box limits the rotation of each 3.5 metre diameter, twin-bladed propeller to 200-400 rpm.



STRUCTURE AND MATERIALS

To attain a 61 m wingspan with the necessary rigidity, lightness and flight controllability, and with just 1500 kg take-off weight is a challenge which has never been met until now. Solar Impulse is constructed around a sort of skeleton in a carbon fibrehoneycomb composite using a sandwich structure. The undersides of the wings are covered with flexible film and the upper surface with a skin of encapsulated solar cells. One hundred and twenty carbon fibre ribs placed at 50cm intervals profile these two layers and give the body its aerodynamic shape. "A challenge like this can be met only by teaming up engineers from widely diverse backgrounds. Their combined experience will give us the impetus and creativity to come up with totally original and innovative solutions." André Borschberg



TRAJECTORY

Solar Impulse is part of a long tradition of exploration, adventure and scientific development. By launching this challenge, Bertrand Piccard is continuing his family's tradition of adventure, from the exploration of the stratosphere and the ocean depths to his own round-the-world balloon flight.

Joining him in this adventure is a team headed by André Borschberg, whose competence guarantees the success of the project, and partners who are also keen to invent the future. The challenges of our world can be met only by people with a pioneering spirit who go looking for new solutions outside our current paradigms and certainties.



A TANDEM AT THE CONTROLS

Two men, both pioneers and innovators, both pilots, are driving force behind Solar Impulse. Bertrand Piccard, psychiatrist and aeronaut, who made the first non-stop round-the-world balloon flight, is the initiator and chairman. André Borschberg, an engineer and graduate in management science, trained as a fighter pilot and a professional airplane and helicopter pilot, is the CEO. The former's avant-gardist vision and the latter's entrepreneurial and managerial experience are an ideal combination. Accomplices from the very beginning, working in perfect synergy, they carry the project forward day by day, building the airplane and deploying its symbolic power.

The complementarity of their competences and the strength of their combined willpower are vital guarantees for the success of Solar Impulse.



AN EPIC IN STAGES

The project will move step by step towards its objective.

A prototype is right now under construction and will make its test flights in 2009. Its main mission will be to make the first night flight. A second plane will then be built and, starting in 2011, will retrace, this time using solar energy, some of the great firsts in the history of flight. After the crossings of the USA and the Atlantic, the culminating point will be the round-the-world flight in five stages, following the Tropic of Cancer.

The history of exploration tells us that major discoveries have never been easy, nor won in advance. In its search for the extremes, both technological and symbolic, Solar Impulse has set out on the arduous and high-risk path that all pioneers tread. A path that will allow the exploitation of the immense potential of renewable energies. A path that will lead to the changes needed for better use of energy resources and greater respect for the environment. Will the solar aircraft be able to defy the long nights and fly without any fuel? Will the adventure be possible? Will the dream of perpetual flight become reality?

PARTNERS WITH A PIONEERING SPIRIT

The Solar Impulse budget is around 70 million euros. 67% of this amount is already pledged, taking us to the completion of the first phase (construction and testing of a first prototype).

Solar Impulse's Partners have in common a pioneering spirit, a long-term vision and a desire to explore new horizons. They share the basic values and enthusiasm of the project: exploration, technological innovation, entrepreneurial excellence, passion, teamwork, dream and emotion. Like Solar Impulse's initiators, they want to use these values to promote renewable energies and the technology necessary for protecting the environment. They are contributing to the success of this adventure by financing the aircraft and providing support in their specific fields of expertise.

"It is becoming high time to reconcile the environment and finance in a single "ecomanist" vision. For this, ecology and economics have to join forces and come up with profitable solutions to reduce both energy consumption and man's impact on nature."

Bertrand Piccard

MAIN PARTNERS Solvav SOLVAY The first main partner to sign up for the Solar Impulse adventure is Solvay. This international chemicals and pharmaceuticals group is well known for its plastics and polymers and for its development of new materials and innovative technological solutions. Omega From the moon to the sun. For Omega, partnering this challenge is an opportunity to set out OMĚGA once again on the route of the pioneers and re-live an adventure which combines passion and avant-garde technological innovation, whilst bringing to the project its own expertise in micromechanics and microelectronics. **Deutsche Bank** Deutsche Bank A door to the world of finance and industry, Deutsche Bank brings to the project its experience of sustainable development, its passion for performance and its long-term vision which lend credibility to the fundamental and necessary link between economics and ecology. **ENGINEERING PARTNER** altran Altran, a leader in innovation consulting, is making available to Solar Impulse its human resources and its multidisciplinary, multisectoral expertise. *sem*per **OFFICIAL SUPPORTERS** The Official Supporters are contributing to financing the project and to promoting its values CLARINS through their communication programmes. INSTITUTIONAL AND AERONAUTICS PARTNERS Following the feasibility study carried out in 2003, the EPFL (Ecole Polytechnique Fédérale de Lausanne) became the official scientific advisor, bringing to the project the competencies of its various laboratories. For these knowledge explorers, Solar Impulse represents a field of very high level research with innumerable potential applications. Solar Impulse can also count on the know-how and experience of major aviation players, like Dassault Aviation and the International Air Transport Association (IATA), which have welcomed the solar energy adventure with open arms. Solar Impulse is relying also on the support of Official Suppliers Victorinox, BKW/FMB and SolarMax, as well as Toyota Switzerland as an Official National Supporter.

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