SOLARIMPULSE

SOLVAY OMEGA Deutsche Bank

INVENTING THE **FUTURE**

1999 VISION
Birth of an idea

«The question facing us today is not so much whether man will be able to go even further and people other planets, but how to organize ourselves so as to make life on earth more and more worthy of living», August Piccard declared in 1931 following his first balloon ascent into the stratosphere. What could be more logical than that his grandson should, seventy years later, launch a project that combines scientific exploration with the promotion of renewable energies?

The idea of Solar Impulse came to Bertrand Piccard following his the first round-the-world balloon flight with Brian Jones in 1999. It was the realization that a lack of fuel could have caused his adventure to fail that led him to promise to circumnavigate the world a second time, but this time without fuel or polluting emissions.

«The grand exploits of the 20th century were conquests: the two Poles, Everest, the depths of the ocean, the Moon. Those of the 21st century, in my view, will need to consist much more of preserving, if not improving, the quality of life on our planet. How do we reconcile economic and ecological interests and promote the use of new technologies to save energy and create alternative resources? Solar Impulse is a symbol of this mindset», Bertrand Piccard explains.

2001-2003 EPFL FEASIBILITY STUDY
Scientific support

In 2001 Bertrand Piccard and his team-mate Brian Jones criss-crossed the USA to investigate the status of research into solar energy and to team up with several solar aviation specialists. Everyone encouraged them to take up the challenge to fly a manned aircraft around the world. Bertrand then turned to the Ecole Polytechnique Fédérale de Lausanne, which agreed to conduct a feasibility study. He also entrusted management of the project to engineer and fighter pilot André Borschberg. The conclusive results of this study enabled the project to be officially launched on 28 November 2003.

By teaming up with Bertrand Piccard, André Borschberg brought to this project a new and essential competence, that of the entrepreneur who would convert vision into reality. The company Solar Impulse SA was officially founded on 29 June 2004 by Bertrand Piccard, André Borschberg, Brian Jones and sports marketing specialist Luiggino Torrigiani. A core technology team was then put together and the first scientific partnership agreements signed with the Ecole Polytechnique Fédérale de Lausanne, the European Space Agency and Dassault Aviation.

From then on Solar Impulse could rely on the expertise and experience of partners whose advice has been as valuable as the credibility and prestige they have brought to the project. These collaborations would go on to stimulate very high level research with huge potential applications for both the environment and the quality of life:

The **Ecole Polytechnique Fédérale de Lausanne (EPFL)** brings to the project its scientific and intellectual skills in more than ten areas of research. It is particularly keen to meet challenges in the fields of ultra-light structures, energy chain management, and man-machine interfaces.

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The expertise of the **European Space Agency (ESA)** has proved invaluable in several areas of technology: batteries and solar cells, energy management systems and ultra-light construction materials.

Dassault Aviation committed as aviation adviser to review the design of the solar airplane. It has also provided its expertise to the development program, particularly in the fields of aeroelasticity and flight commands, safety and systems reliability.

2004-2007

FINANCING TO START UP THE PROJECT
Launching the project

The idea and structure were now in place. It remained to find people with sufficient belief in them to make them come true. It was Bertrand Piccard's privileged contacts with a number of business companies that helped bring in the funding. Sensitive to energy and environmental problems, convinced of the many advantages of this long-term project and the strength of its symbol, the main partners were to provide Solar Impulse with both the necessary launch funding and their technological skills.

In summer 2004, **Semper**, a Geneva private asset management company, became the first Official Supporter.

The arrival of Solvay, the major Belgian industrial group, in October 2004 as the first main partner, made it possible to hire the first engineers. The project could now start in earnest. Solvay's contribution to the Solar Impulse project would focus on the search for innovative materials and technical solutions, modelling and simulating their behaviour in extreme environments, technical assessment of these materials and conducting various series of tests.

The partnership concluded subsequently with **Altran** as engineering partner, offered Solar Impulse multidisciplinary (project management, risk management) and multisectoral expertise (aerospace, energy management, simulation and modelling).

André Borschberg set about putting together and motivating a team of engineers from different backgrounds, with very varied skills, and building up a network of technical partners, experts and specialists who would be critical for the project. A technical office was opened in Winterthur and the design of the aircraft began.

Joining the Solar Impulse project in May 2006, **Omega** made the strengths of a globally recognized brand available to this project at the frontiers of technology. Beyond international visibility and substantial financial support, Omega also brings in its know-how in automation and hybrid propulsion. Its test bed has served to optimize the entire energy chain of the prototype, from the solar panels to the engine, and under temperature conditions from -40°C to +55°C. Based on an idea by the test flight team under Claude Nicollier, Omega has developed a flying instrument which is as revolutionary as the aircraft itself. By indicating to the pilot the aircraft's angle of tilt to the nearest degree, this provides essential assistance both in flight and on landing.

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In March 2007 an agreement was formalized with **Deutsche Bank**. For Solar Impulse this marked an important step in its plan to forge strong links between the economic and ecological worlds. With this third main partner, renowned for its long-term vision, a decisive step forward was taken in the financing of the project. Deutsche Bank brings its long experience in sustainable management, as well as Corporate Social Responsibility (CSR), and provides ecofriendly communication tools for disseminating the messages of Solar Impulse.

Several partnership agreements have been concluded with official suppliers, like **SolarMax, Victorinox, Toyota Switzerland, BKW-FMB** and **SQS**. Selected for their specificity, their skills and know-how, a large number of SMEs have stepped into the project as specialist partners, playing a fundamental role, from the design to the completion of the aircraft. Their contribution has taken the form of targeted technical developments, bespoke production, assistance and advice.

2004-2007

AN EVOLVING DESIGN
The definitive HB-SIA aircraft

The first configuration, that of the feasibility study, reflected what the researchers had discovered and had dreamed up, that is a plane with a very large wingspan and aerodynamically extremely efficient. However, at this stage, not all details had yet been taken into account, and the first images were only artist's views.
In early 2004, more detailed studies led to the first prototype version, already significantly different. The engines had shifted to the leading edges, in order to balance the force of propulsion of the aircraft and the aerodynamic forces. The cockpit in this version was clearly detached under the wing. Finally, a third version was born from the work of the engineers who decided to start with a first prototype with a non-pressurized cabin. It took boldness and confidence in the projections to freeze the design and start construction.

In November 2007, after 4 years of research, calculations and simulations, Bertrand Piccard and André Borschberg presented the final design of the first prototype with a wingspan of 63 meters and weighing 1,600 kg, registration code HB-SIA.

The construction of the prototype was the result of intense collaboration between the multidisciplinary Solar Impulse team, responsible for the design of the aircraft, and the various partners such as materials suppliers and component manufacturers. As the requirements of the new aircraft were compared with the potential solutions offered by everyone involved, so new aeronautical solutions came to light. As André Borschberg points out, «a challenge like Solar Impulse can be met only by bringing together engineers from every background. This diversity, sought at every level, stimulates their creativity and represents their strength. It is from comparing and confronting their experiences that new and original solutions have emerged.» It is the summation of the strengths over 50 staff supported by more than a hundred experts and advisers which has made to possible to push back the boundaries of knowledge and achieve real technological progress.

Although designed with the most sophisticated means, the HB-SIA prototype remains a 'rough' aircraft. Its maximum altitude is limited to 8500 meters in

order to avoid the additional weight and congestion of a pressurized cabin, to limit energy consumption and reduce the control panel to the essentials. As a first approach, it is the most convincing answer to the need to optimize energy consumption, weight, performance and controllability, without which night flight is impossible.

2007-2008 VIRTUAL FLIGHTS Initial training

In May 2007, a virtual flight mission, made possible by software developed by Altran, provided confirmation to André Borschberg and Bertrand Piccard that their dream of pioneers could indeed become reality. The many strategies that they simulated in real-life weather conditions brought a wealth of lessons. The simulation demonstrated that, with the current design, it is possible successfully fly through the night with a solar airplane, by storing sufficient solar energy in the batteries during the day for the engines to run all night. Experimenting with the aircraft's reactions also provided much data leading to the adaptation of certain procedures and which will be of directly value during the actual flights.

In May 2008, the flight simulator developed in collaboration with Dassault and EPFL enabled both pilots to pilot the HB-SIA for the first time during 25 hours, equipped and harnessed as they will be during the actual flight: helmet, safety harness, parachute, oxygen mask and with food and accessories for their natural needs. Five projection screens arranged 210° around the cockpit gave the pilots the impression of live flight.

Preparing the pilots is also a first line concern. During the various missions, the human beings at the heart of the adventure will have to demonstrate adaptability and mental resistance in the face of extreme flight conditions. To meet this unprecedented challenge, the **Hirslanden** group of clinics is acting as medical advisor and developing a concept of permanent made-to-measure monitoring.

2008-2009 CONSTRUCTION ASSEMBLY TESTS

By September 2008, after assembly of the cockpit and the tail boom of the HB-SIA prototype, construction of the wing could begin. Three rectangular carbon fibre and honeycomb sandwich beams, the longest over 20 meters in length, made by **Decision SA**, were placed end-to-end to form the central wingspar, the backbone of the wing, with its total span of 63 meters.

The Solar Impulse project then went through two further important test phases. In December, the Deutsches Zentrum für Luft-und Raumfahrt (DLR) in Göttingen, an institute that specializes in aeroelasticity calculations, carried out a week of vibration tests. These were aimed at assessing the risks of resonance, defining the aircraft's specific frequencies, and verifying by physical experimentation the correspondence between the model the engineers had calculated and the technical characteristics of the actual aircraft. The fuselage, the wingspar and the horizontal and vertical stabilizers of the HB-SIA were assembled for the first time. Compared with the computer model developed by the engineers, the results showed only minimal differences. The modulus of elasticity of the whole turned out a little lower than expected, indicating a greater rigidity of the aircraft structure – which was good news.

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Mid-February 2009, a series of more robust tests put the wingspar through its paces. These were designed to directly test its resistance to high loads. Fully conclusive, these impressive load tests were conducted in an almost religious silence. On the one hand in order to be able to hear the slightest crack, and also to permit the intense concentration and the essential coordination of all involved.

The electrical generating set and propulsion system also underwent detailed testing. The four engines, with their 3.50 meters diameter propellers, the lithium-polymer batteries, the optimization and control circuits, the cabling, the power controls... all components of the aircraft were tested one by one, without exception.

The combined efforts of each member of the team, the courage to undertake a totally innovative project and the confidence of all the partners made it possible to complete the construction of the aircraft in June 2009. Following its presentation to the public, ground tests and the first flight tests are programmed for late summer 2009.

2008-2009

SYMBOLIC AND POLITICAL SCOPE
A federating project

In April 2008, the European Commission assured Bertrand Piccard and André Borschberg of its endorsement, thereby recognizing the impact and the action of Solar Impulse in support of renewable energies. For the European Commission, Solar Impulse is a demonstration of what needs to be done in industry and energy policy in terms of energy and clean mobility.

Contacts were also established with the Swiss political world. Bertrand Piccard presented the project to the Swiss federal parliament, and federal councillors Doris Leuthard and Moritz Leuenberger came in turn to visit the construction hall and test the flight simulator. Not only is the project progressing technically, but its reputation and its symbolic value are being affirmed well beyond the natural borders of Europe. Bertrand Piccard and André Borschberg have presented Solar Impulse in China during the Beijing Olympics, and in India and the Emirates.

Endorsement of the project has come from prominent personalities committed to seeking concrete solutions to ensure the future of our planet. Among them are Prince Albert II of Monaco, Buzz Aldrin, Yann Arthus-Bertrand, Paulo Coelho, Nicolas Hulot, Hubert Reeves, Jean-Louis Etienne and Nobel Peace prizewinners Elie Wiesel and Al Gore.

2008-2009

NEW PARTNERS

Other organizations and companies have joined the project, providing concrete collaboration or wishing to demonstrate their values and actions in favour of the environment. **The International Air Transport Association (IATA)** has become an institutional partner of Solar Impulse, providing logistic support – a critical component of the round-the-world flights. It was followed by the **Clarins** group, unconditionally supporting its vision of technological innovation and respect for the environment.

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The next partner was **SIG (Services Industriels de Genève)**, very attentive to developments in the field of sustainable energy and itself active in the photovoltaic sector. Most recently, telephone operator **Swisscom**, fascinated by the attraction of the technological and human adventure and its prospects for communication, signed up in turn to support Solar Impulse. **La Semeuse** coffee and the **Abächerli Druck** printing company have also joined the project. Each partner recognizes the project as mirroring its own desire to innovate and to find solutions to energy and climate problems, in order to better respect the environment and resources.

2008-2009 SUPPORTERS PROGRAM

To provide a platform to all those wishing to participate in the adventure and support to the project, Solar Impulse is launching a Supporters Program simultaneously with the presentation of HB-SIA prototype. This original and playful program, accessible via the **www.solarimpulse.com** website, offers supporters an opportunity to acquire one of the 10,748 solar cells of the wing, to visit the solar airplane base or even place their names on the fuselage. Communication is intensifying, in order to publicize as widely as possible the technological evolution of the project, but also its philosophical goals in favour of the environment and renewable energy.

2010-2012 TOMORROW... PERPETUAL FLIGHT?

After 6 years of design, calculations, simulations and construction, the solar airplane HB-SIA will have to prove itself before embarking on its 36 hour flight, which is the major objective of the project. Numerous tests will need to be carried out, first on the ground, then in flight, always higher and further, before the first night flight can be undertaken. Will Solar Impulse be able to defy the long nights on solar energy alone?

Using the lessons learned from the first prototype, a second plane, the HB-SIB, will then be built in order to rewrite, using solar energy, some of the great firsts of early aviation history, such as the crossings of the United States and of the Atlantic. The culminating point of the project will be the subsequent world tour, starting in 2012, in five stages of about five days each.