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DLR supports planned record flight with solar glider

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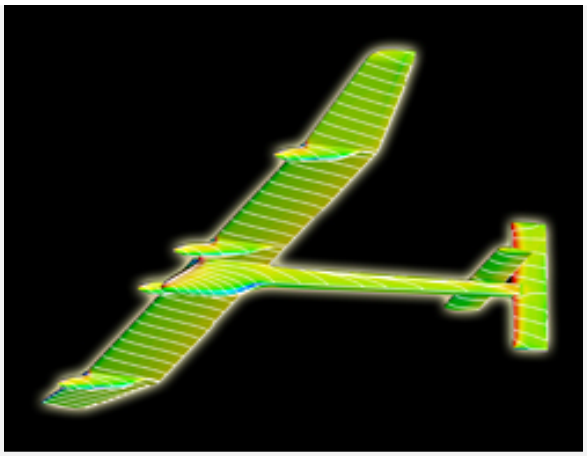
Extremely lightweight construction: the specialist aircraft Solar Impulse

The Solar Impulse project is pursuing the objective of circumnavigating the Earth powered only by sunlight. The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) has played a significant role in the development of this visionary flying technology platform, which has now been awarded the Braunschweig Research Prize.

The challenge: large wingspan and extremely lightweight construction

A specialist aircraft like Solar Impulse, with its combination of huge wingspan and extremely lightweight construction, constitutes a major challenge in terms of controllability and load-bearing capability. To test out the limits of controllability for Solar Impulse, the aircraft design was simulated on the most powerful computer in Germany, at the DLR Institute for Flow Technology in Braunschweig. The researchers in Braunschweig established various factors, including the lift and lateral forces, to which the future record aircraft might be subjected. "For our highly specialized computing processes, this was an interesting test," says Dr Martin Hepperle of the DLR Institute of Aerodynamics and Flow Technology (Institut für Aerodynamik und Strömungstechnik; IAS). The primary field of application for simulation processes is normally that of modern transport aircraft.



Aerodynamic model of Solar Impulse

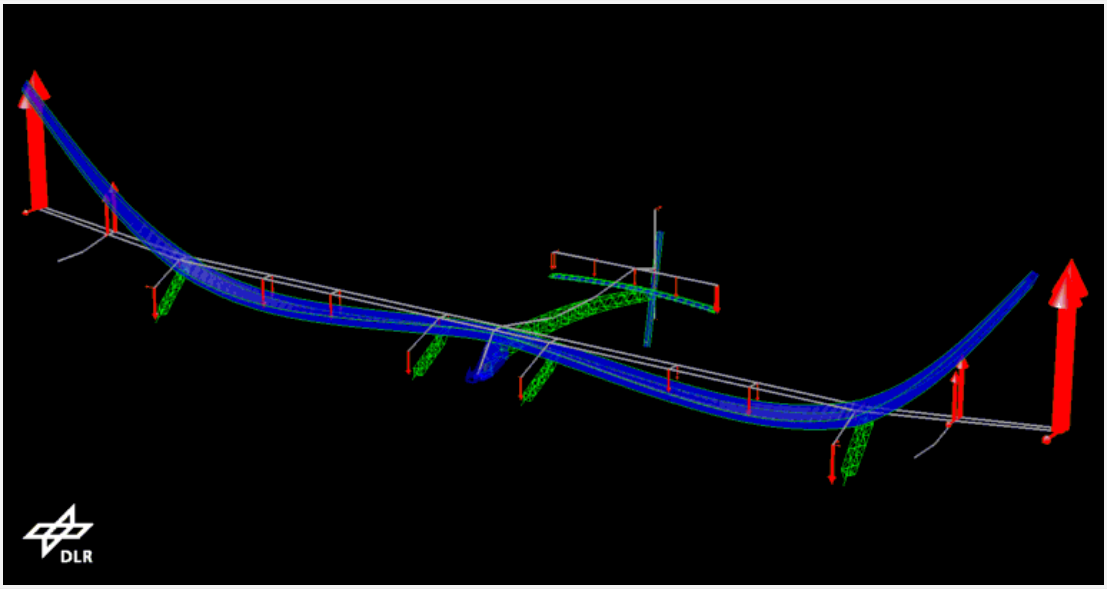
"The massive wingspan on this aircraft constituted a particular challenge," states Dr Hepperle. Airflow past the aircraft had to be calculated at 30 million points. Due to the large wingspan and the low flying speed, just 70 kilometres per hour, gusting winds have a much more severe impact on Solar Impulse than they do on much faster transport and passenger aircraft. During gusts of wind, this aircraft could be tilted much more easily, so it needs to be safely manoeuvred back into a level flight attitude. Since the aircraft has no hydraulic or electrical assistance – that is, since the pilot has to use only his or her strength to operate the flight controls – it is essential to keep the control forces as low as possible while still providing the right level of control capability. This factor determined the maximum aerodynamic and control forces applicable with the control surfaces – the flaps and rudder – at full travel.

Through the results they obtained, the Braunschweig researchers helped to determine much more accurately the limits of the safe flight envelope within which Solar Impulse can operate.

At the limit of what can be measured

The DLR Institute of Aeroelasticity (Institut für Aeroelastik) in Göttingen conducts what are known as stationary vibration tests. These tests are conducted on conventional aircraft to ensure that no dangerous vibration conditions – for example, judder – arise while in flight. "On Solar Impulse, the stationary vibration test was not carried out primarily in response to the need for judder investigations," says Dr Marc Böswald, who led the tests. "Judder is a secondary problem, due to the relatively low flying speed of about 70 kilometres per hour." Instead, the results of the stationary vibration test are more intended to examine the simulation models of Solar Impulse. This should enable reliable conclusions to be drawn about the structural integrity characteristics of the aircraft while in flight. The DLR researchers have already investigated the basic load-bearing structure of the aircraft, about a year ago. Based on the data obtained at that time, it was possible to improve the precision of the simulation models of the Solar Impulse prototypes.

The extremely lightweight construction constitutes a special challenge for the Göttingen-based scientists – in particular as a result of the 63-metre wingspan. "Solar Impulse has an exceptionally large wingspan, certainly comparable to that of a transport aircraft," states Dr Böswald. "Due to the extremely lightweight construction of this aircraft, vibration frequencies are much lower than they are on conventional aircraft – they are at the limit of what it is physically possible to measure." Not many research institutions are able to do this: "We are the only one in Europe," says Dr Böswald. "The lowest vibration frequencies are significantly below one hertz – they are almost twice as high on transport aircraft like the A340."



Animation of wing deflection measured in the stationary vibration test

DLR will be continuing to support the Solar Impulse project in future. Next year, another stationary vibration test will be carried out. Then, among other things, an attempt will be made to find out how the multitude of solar cells and the control system influence the vibration characteristics of the aircraft. These components had not been fitted at the time of the first stationary vibration test. Following a successful first flight, the Braunschweig-based DLR Institute of Flight Systems (Institut für Flugsystemtechnik) was able to support the project with its system identification and dynamic analysis capabilities. This made it possible to gain insights into the flight characteristics and handling of this unusual aircraft.

Research prize for a visionary project

On 6 November 2009, this year's Braunschweig Research Prize was awarded to Swiss researchers Dr Bertrand Piccard and André Borschberg. This was how the city of Braunschweig and the Braunschweig Regional Research Association chose to recognise the research efforts of these two international pioneers in the field of solar-powered flight. Their visionary project, Solar Impulse, an aircraft powered solely by solar energy, without fuel or polluting emissions, sets new standards for a sustainable mobile future with alternative forms of propulsion. In June 2009, the prototype was unveiled. Following the first flight trials, now being conducted, the duo of researchers is hoping to fly round the Earth in 2012.

The Braunschweig Research Prize comes with funding to the value of 30,000 Euro, and is awarded every two years by the city of Braunschweig in collaboration with the Braunschweig Regional Research Association.

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