Solarstratos—a Solar Airplane to the Edge of Space

P. Duvoisin, J. Escarré, J. Levrat, R. Oleiwan, C. Ballif, L.-E. Perret-Aebi

CSEM, as technological partner of the Solarstratos project, has been responsible for the design, fabrication and integration of customized solar modules on an electrical airplane conceived to reach the stratosphere with the sole means of solar power. With a total weight of 700 g/m², the developed ultra-light weight solar panels can be integrated on to the Solarstratos airplane by means of an innovative fixation system. The project will move solar aviation one step closer to its use in close to space conditions what can open new possibilities in fields such as telecommunication, observation or earth monitoring.

Solarstratos project [1] primary goal is to further demonstrate the potential of renewable energies by reaching the stratosphere with a manned electrical airplane only powered by solar means, thus, establishing a new altitude world record for this flight mode. In this project, the role of CSEM has been the design, fabrication, testing and accurate integration of customized solar modules on the airplane structure with ideally no detrimental effect for its aerodynamics.

In order to maximize the overall energy density stored in the plane a key point was to minimize its weight. In order to achieve this target, CSEM has developed ultra-light weight solar modules by laminating at room temperature the solar cells in between a composite based back-sheet and a polymeric front cover by means of a pressure sensitive adhesive. The resulting modules have a total weight of 700 g/m² including the Sunpower silicon solar cells weight of 450 g/m².

These ultra-light weight PV panels are very fragile and easily damageable if mishandled. Thus, a manufacturing process has been designed and implemented allowing the modules to be kept over a rigid plate during all different fabrication steps until its final installation on the airplane structure. Thanks to this process, production yields close to 100% have been achieved, minimizing material waste.

CSEM has also proposed and delivered an innovative solution which ensures a secure fixing of the modules on the carbon/epoxy structure of the plane. This solution adds flexibility allowing for an easy replacement of the modules after installation. Thus, installed solar panels can be updated in the future or, in case of defaults such as solar cell breakage, replaced with no damage on the plane structure. This integration scheme can also be applied on existing electrical planes turning them into solar powered ones.

Solar modules will be subjected to harsh temperature conditions of around -70°C during the flight towards the stratosphere. These extreme temperatures could reduce adhesion between materials and create thermal stresses in welds able to deteriorate electrical connections between PV panels. Such conditions have been simulated on climatic chambers where test modules have been submitted to more than 200 cycles of temperature varying from -40°C to 85°C with no significant degradation. Additionally, adhesion at critical interfaces has also been measured for temperatures ranging from -70°C to 60°C. On the other hand, low temperatures present in the stratosphere are beneficial to increase the energy yield of the PV panels, as their electrical output decreases with temperature at rates of 0.3-0.4% per degree Celsius. An experiment carried out by means of a helium-filled balloon has proven that the working temperature of a Sunpower solar cell can plunge from +40°C to -20°C when it reaches an altitude of 12 km in a sunny summer day. The data collected during this experiment is shown in Figure 1.

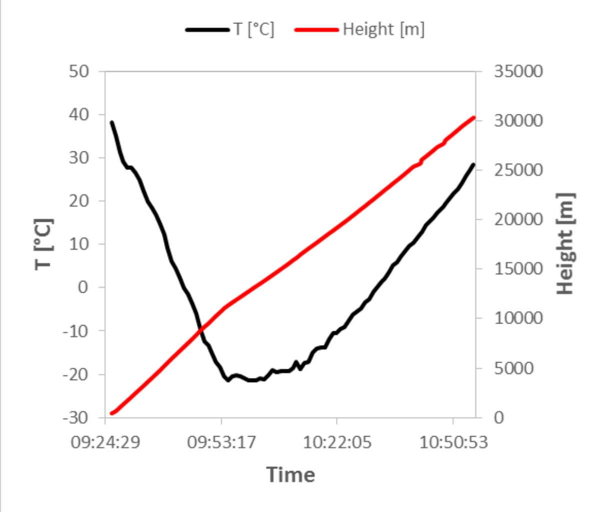

Figure 1: Solar cell operating temperature as a function of the height.

Solarstratos project represents a great opportunity for testing solar cells and materials, which are generally used in terrestrial applications, in close to space conditions gaining and accumulating an important amount of knowledge to be used in future prototypes.

The energy produced by the plane for different heights and positions relative to sun is estimated by means of a semi-empirical model developed by CSEM. This model is helping to select the most appropriate date, taking off location, flight height profile and overall plane path to optimize the solar energy generated during the flight. Moreover, data generated from this model are also used as input for the design of electronic components of the PV system such as the MPPT DC-DC converters.

Solarstratos paves the way to move solar and electric aviation one step closer to its use in space and opens new perspectives in different areas such as telecommunications, observation or earth monitoring.

[1] www.solarstratos.com