To the Edge of Space — with Solar Energy

The Solarstratos adventure and exploration

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SolarStratos is developing a solar powered airplane to fly in the 2020/2021 timeframe to the stratosphere. The goal is to demonstrate that renewable energy, namely solar energy allows flight at altitudes where no internal combustion engine or jet engine can operate, providing for sustainable flight.

Keywords: Solar Powered Aircraft; Stratosphere; Space Suit; Edge of Space; Human Adventure; Climate Change.

THE ADVENTURE

Flying limitless and without any noise emission nor CO₂ emissions, wouldn't that be great? The SolarStratos project is working to demonstrate that sustained, solar powered flight is possible at high altitude in regions where fossil energy burning devices are not operable. This is especially relevant as energy sourced from the sun presents a virtually limitless supply that could serve for billions of years, while fossil-based energy not only negatively impacts the environment, its supply is finite.

Through the Solarstratos initiative, the intention is to demonstrate that solar energy, represents not only sustainable, clean energy, but also that this can be used in exciting ways, creating jobs while improving lives on this planet.

The project represents a combined human and technical adventure. To share this adventure as widely as possible, the aircraft has the ability to transmit real time imagery back to earth. The transmissions are accessible through numerous informational and social media formats allowing the viewer to follow and engage with the experience and excitement of solar flight as it flies above the clouds, ascending further towards the stratosphere, to where the curvature of the earth becomes visible as well as the vast expanse of darkness of space.

To fly in these regions the pilot needs to be protected. The outside temperatures are below minus 50°C and the atmospheric pressure reaches extremely low levels. The aircraft is not pressurized and the flight will take place above the Armstrong limit line which is a measure of altitude above which atmospheric pressure is sufficiently low that water boils at the normal temperature of the human body. As a result, no human can survive in this environment without pressurization. The single pilot has a specially designed space suit that has also been engineered to operate via solar energy.

MAIN CHARACTERISTICS OF THE SOLARSTRATOS AIRCRAFT

- MTOW = 600 kg
- Wingspan of 25 m – 10 m long
- Double engine (single axis) driving single propeller, 2 × 19 kW
- Retractable landing gear for record flight
- 22 m² of solar cells
- 60–120 kg of Li Ion batteries
- Un-pressurized cabin, pilot will wear Sokhol space suit (Soyouz launch and re-entry suit)

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Aircraft with view of earth's curvature. (Photo Solarstratos 2015. Computer generated image by Creatorz Dietz.)

View of lightweight aircraft. (Solarstratos photo, Canada, Martin Lachambre.)

TECHNICAL CHALLENGES

Weight

The cell and wings need to be strong enough to allow flight in the very thin atmosphere and resist the different aerodynamic forces that can act upon its structure with up to a 3.5 g acceleration.

Every kilogram that can be shaved off the aircraft improves the maximum reachable altitude. To achieve optimal flight conditions a very light-weight composite structure has thus been chosen, so that as minimal weight as possible is carried, while remaining very strong. A similar sized standard glider would be greater than double the weight of the Solarstratos aircraft.

Flutter problems in this very thin atmosphere require special attention. Stable flight will only be possible in a range of about 100 km/h at speeds of 250–350 km/h in order to create the same dynamic pressure than at ground level.

Electrical power train

A special project optimizes an electrical power train from the best available solar cells, their encapsulation, wiring, MPPT's (max. power point trackers), batteries and their management system, engine controller, engines and propeller in order to get the best possible overall efficiency.

Special attention is given to the flight profile so as to maximize the solar energy received by the cells. The flight routes and trajectory will be mapped to a 50 km cylinder above the airfield which have been designed to guarantee the best possible angle of the solar incidence on the cells (as close as possible to 90°C at each moment).

Physics work in our favor as the flight gains altitude and reaches colder atmospheric regions as the efficiency of PV cells increases as the temperature decreases.

Pressure suit

The pressure suit is a key element for the project and will serve to keep the pilot alive above 12–14 km. The suit itself was based on the well-known SOKHOL space suit worn by every Soyuz cosmonaut as a launch and re-entry suit during launches and subsequent re-entry and landing from the Baikonour Cosmodrome the largest spaceport which is located in southern Kazakhstan.

The LSS (life support system) is adapted from the Russian Orlan suit and is integrated into the SolarStratos fuselage, together with the necessary oxygen supply and back-up system.

Image of Solarstratos in flight, view of solar cells along wings. (Photo Solarstratos 2015. Computer generated image by Creatorz Deitz.)

Life support system adapted for the SolarStratos aircraft.

Raphaël Domjan in the pressurized space suit. (Solarstratos photo Moscow.)

The LSS will also operate on solar energy only, so it needs to use as little electricity as possible.

Heat management

The cockpit of the aircraft will not be insulated and the space suit will provide only limited insulation and heating (which otherwise would require too much electrical power), to overcome this challenge in the minus 50 to minus 60 degree environment, use of the almost $1'400 \text{ W/m}^2$ of sun power on the canopy of the cockpit will be made. Also, the engine and electronics need to be cooled and heat transferred to the cockpit via a special heat transfer system, pure convection cooling/heat transfer is not an option in the low-pressure environment.

WHERE WE ARE TODAY

The aircraft made its maiden flight in May 2017 and has since been taken through a thorough flight test program with a professional test pilot. This year, 2019 should take us up to the 10 km mark, thus setting a new record for solar aircraft. The first ever solar sky dive and free fall is also planned, with

Eco Explorer Raphaël Domjan, who is the initiator, founder and pilot of the aircraft. It is planned that he will jump out of the solar plane making a parachute, pinpoint landing in front of our partners and media.

By 2020 the first flight with the un-inflated pressure suit is projected, followed by a flight with a fully suit pressurized. Later the record flight into the stratosphere — to the edge of space is anticipated.

POTENTIAL COMMERCIAL DEVELOPMENTS

Later developments will include HAPS (High Altitude Pseudo Satellites) meaning drones flying above 20 km to deliver earth observation, imagery, telecom and other services.

The SolarStatos aircraft will also serve as a test bed to further develop electric and solar powered aircraft, leading eventually to 30–50 passenger aircraft flying solar-electric on short-haul routes.

For this aircraft, we are developing cutting edge technology and combining that with more traditional, off the shelf systems into a unique product and experimental aircraft.

Eco-explorer Raphaël Domjan, initiator founder and pilot of aircraft with space suit and Solarstratos aircraft. (Photo Solarstratos Ali Eichenberger and Zeppelin.)

Pilot training and monitoring for anticipated flight to the stratosphere.

Roland Loos, CEO of Solarstratos with Jean-François Clervoy, ESA astronaut and member of the team at Zvezda/Moscow. (Solarstratos January 2019.)

Awaiting takeoff during its maiden flight. (Solarstratos.)

First flight, Revillard Rezo.ch.

Solarstratos aircraft in 3D. (Photo Solarstratos 2015. Computer generated image by Creatorz Deitz.)

ACKNOWLEDGEMENTS

Such an adventure is obviously only possible with a highly dedicated and professional team of engineers and technicians, supported by many other specialists.

The communications team plays an important role as well, our presence in the press and on social media

and networks is key to the project and to spreading our message.

It is funded by our partners who are proud to be part of this unique adventure, we are very grateful to them.