The team of Solar Impulse 2 ("Si2"), the world’s first solar-powered airplane to fly around the world, is now preparing for its mission of an imminent attempt and an aviation first: flying for five consecutive days and nights from China to Hawaii with no polluting emissions.

For Solar Impulse’s Founders Bertrand Piccard, Initiator and Chairman along with André Borschberg, CEO, the Pacific crossing represents a testament to the 12 years of hard work that Solar Impulse has achieved since its inception.
This journey around the world, dedicated to inspire new generations and to shape a sustainable future (www.FutureIsClean.org), is bringing suspense and emotion at the heart of scientific adventure André Borschberg is ready to embark for the flight leg between Nanjing and Hawaii, while Bertrand Piccard will take the commands and fly from Hawaii to Phoenix, Arizona (USA).

Re-enacting great historic flying feats, but this time with solar energy. This flight is the most challenging leg of the endeavor. The pilot of the single seater aircraft will be exposed to extreme conditions, flying alone for up to 120 hours non-stop, living in the confinement of a 3.8m³ cockpit. They will be facing many human, technical and operational challenges which have been carefully researched, developed and simulated.

Main issues related to the experimental adventure were discussed to help better understand the challenges facing Solar Impulse:

- How the pilot will live in the small cockpit for 5 days in a row
- How he will operate the plane and interact with the team on the ground
- How he will stay alert throughout the crossing of the Pacific
- What nourishment is needed in order to sustain energy levels at high altitude
- Whose help the pilot will have when faced with difficult weather situations

An insight about the challenges of this first solar airplane with unlimited endurance, and limited endurance of human beings. A glimpse into the journey to demonstrate the reality, and sometimes the difficulty, that any pioneering and innovative spirit can encounter.

During the coming months, Swiss pilots Piccard and Borschberg will continue the Round-The-World Solar Flight and will stop in Midwestern United States, New York, Northern Africa or Southern Europe before attempting to return to Abu Dhabi having travelled 35,000 kilometers around the globe, accumulating 500 flight hours over 5 months to spread the message that clean technologies can achieve the impossible.

Stay tuned by visiting www.solarimpulse.com
Solar Impulse 2 (Si2) was built to achieve the First Round-The-World Solar Flight. This revolutionary single seater airplane powered by the sun will attempt a challenge that has never been done before: fly five consecutive days and nights crossing the Pacific Ocean without using any fuel.

This requires the optimization of new technologies and a drastic reduction in energy consumption, and Solar Impulse’s team of 80 engineers and technicians, have had to apply highly innovative solutions to make this happen. As a result, the Si2 is a real airborne technology lab with virtually endless endurance – a feat that has been perceived as impossible by industry experts.

How will the airplane fly day and night? During the day, Si2 will collect a maximum of energy from the sun allowing it to climb up to 28,000 ft (8,500 m) while simultaneously storing energy in the batteries. When it reaches the maximum flying altitude of 28,000 ft at the end of the day, the batteries are full. At sunset, the pilot will switch off the solar generator and start to descend to an altitude of 3,000 ft by gliding 4-5 hours, using minimal energy. The pilot will remain flying from the batteries at low altitude until the next sunrise when it will be able to produce energy again. This cycle is repeated each day of the crossing of the Pacific for 5 days and nights in a row.

How does the airplane work? The airplane captures all the energy it needs from 17,248 cells located on the aircraft’s wing (72 m), fuselage and the horizontal stabilizer. These cells with an efficiency of 22.7 %, convert the sun’s rays into electricity to be able to simultaneously power the engines and recharge the batteries.
The solar cells are just 135 microns thick— as thick as a human hair, and are encapsulated by a resin developed by Solvay which makes them UV resistant and waterproof.

How is the collected energy stored? The energy is stored in 4 high voltage batteries totaling 633 kg, or just over a quarter of the aircraft’s weight. The energy density of the batteries is optimized to 260 Wh/kg by Solvay’s chemical component research. Each battery feeds to its respective engine, powering the aircraft when there is no solar energy available.

How do the batteries still work at 28,000 ft when it’s -40 degrees outside? The batteries are insulated from the varying outside temperatures with polyurethane foam developed by Bayer MaterialScience that has very thin pores, high density and structural strength which protect the batteries from harsh elements.

The plane functions without technical maintenance during a 120 hour flight — how is this possible? The aircraft was designed and constructed to fly 5 days and 5 nights continuously. The key parts, such as the motors and propellers, along with the electrical systems have undergone rigorous test to ensure their endurance and viability. Additionally, Si2 is equipped with redundant safety systems in case of instrument or system failure.

What happens if one of the engines fails? Si2 has an energy dispatcher with bi-directional functionality to ensure that a battery can support another engine in the event that one fails. The energy dispatcher transfers the energy and redistributes it to functioning engines, allowing the plane to continue flying.

During the night, how does the pilot manage the available energy? To ensure the pilot reaches the next sunrise, he must carefully manage the plane’s energy consumption by flying slowly at a constant altitude of 3,000 ft (1,000 m). Mission engineers at the Mission Control Center will advise the pilot based on the monitored telemetric data (battery status, motor output), optimizing his flight route.
Flying alone for up to 120 hours non-stop, while piloting the single seater airplane in a tiny cockpit in extreme temperatures, with hardly any sleep makes for an intense challenge. This is a real test of endurance and alertness because, although the plane can technically "last" a long time in the air, the pilot needs to have a similar "lasting” capability as the pilot lives, sleeps and eats in the confinement of a 3.8m³ cockpit during 5 days and 5 nights.

**HUMAN CHALLENGES**

How does the pilot cope with living in such a limited space? Stretching exercises and yoga poses such as “shoulder bridge”, “spinal twist” or “knees to chest” have been designed for the pilot to practice in-flight, preventing thrombosis. André Borschberg has practiced yoga for many years and developed a routine specifically for long duration flights, which he introduced to Bertrand. The exercises increase blood circulation in vital organs and keep the pilot alert and concentrated on flying the airplane. The pilot is able to consult with a yoga teacher via Google Hangouts.
Can the pilot sleep during 5 days and 5 nights journey across the Pacific? Above the ocean, sleep will be allowed in the form of short naps lasting up to 20 minutes, 10-12 times a day. As a psychiatrist, Bertrand Piccard trained himself to only sleep for short periods by means of self-hypnosis – a technique used to dissociate the head from the body. Bertrand introduced this technique to André, which allows the body to regenerate into a very deep relaxation and keep the brain alert enough to check the instruments during the flight.

What techniques and instruments do pilots use to only sleep 20 minutes at a time during a flight that can last up to 120 hours? Deep breathing techniques and meditation support the vital upkeep of the pilot’s concentration while also reducing his need of sleep. The plane is equipped with an electronic system called a Stability Augmentation System that stabilizes the plane’s flight path and alerts the pilot in his sleep if there is a problem. Cloth armbands placed over the pilot’s arms are connected to an instrument developed by Omega that displays the bank angle of the plane. As soon as the bank angle goes beyond 5°, the armbands start to vibrate and an audible alarm wakes the pilot.

How does the pilot adapt to the extreme conditions? In the morning, when the sun heats the cockpit, the pilot is able to remove layers of clothing to be comfortable. While flying at high altitude and subsequently lower temperatures, the pilot can add layers to ensure he is warm. The high-tech pilot suit includes heated soles and gloves, and underwear that stimulates blood circulation. Everything is considered in order to optimize pilot comfort, even the bandana which holds the sensor close against the pilot’s head, indicating blood oxygen levels.

What does the pilot do during this long journey? And is he in contact with the ground? The pilot has a daily agenda scheduled with piloting duties which include resting, eating, and exercises. He doesn’t feel alone because he is always connected to the Mission Control Center via satellite communication to follow the pilot’s duties. The pilot can also communicate with the media and public through applications on his iPad such as Twitter.
HOW DOES THE PILOT LIVE IN THE COCKPIT FOR 5 DAYS IN A ROW?

Which equipment is necessary in the 3.8m³ cockpit?
The cockpit volume provides enough space on board for oxygen supplies, food, survival and pilot equipment, while also meeting the optimal ergonomic requirements for flights lasting several days.

What is special about the functions of the pilot’s multi-purpose seat?
Built into the back of the seat is a survival kit consisting of a parachute and life raft for use in case of emergency. The multi-purpose seat can recline, allowing the pilot to perform physical exercises. It allows more legroom and has an ergonomic inflatable cushion, however, the pilot cannot move freely in the cockpit because he is not allowed to disengage the safety harness. The pilot’s seat can be converted into a bed and even a toilet! Concealed under the front part of the seat is an opening that serves as a toilet, protected by a sealed bag. Once used, the bag is sealed again and stored until the next landing.

How is the pilot’s health ensured during long flights?
To anticipate any potential health issues, a team of doctors and specialists closely monitor the pilot by implementing a check-up before each flight leg. Brainwave (electrical activity of brain), electrocardiogram (electrical activity of the heart), blood tests, and ultrasounds are performed to verify that the pilot’s health status. Health checks are routinely performed throughout the flight and if the pilot doesn’t feel well, there is a first-aid kit on board equipped with medications, ECG and blood pressure measurement.

When at high altitude of 8,000 meters, there is immense strain on his system because he has less oxygen available for use, and the effect is comparable to climbing Mount Everest. Because the cockpit is unpressurized, the pilot will wear an oxygen mask above 3,600 meters to alleviate symptoms associated with high altitude sickness. Along with the varying temperatures, food and rest, the pilot must regulate the oxygen that is required to breathe. The complex challenge is to repeat the management of all three factors to ensure he is sustainable for the duration of the flight.
WHAT NOURISHMENT IS NEEDED IN ORDER TO SUSTAIN ENERGY LEVELS AT SUCH HIGH ALTITUDE AND EXTREME SITUATIONS FOR THE HUMAN BODY?

What does the pilot eat while in the cockpit?
The pilot’s daily intake is 2.4 kg (5.2 lbs) of food, 2.5 l (84.5 oz) of water, and 1 l (33.8 oz) of sports drink per day, during the Pacific Ocean crossing. The pilot will eat 11 meals and snacks each day, most of which is dehydrated or fresh food developed by Nestlé Research Center. Heating food on board presents a problem in itself as adding water to dry food was not possible due to the risk of water spilling on the electronic instruments in the cockpit. However, the pilot can use a self-heating pouch in which an exothermic reaction subsequently heats the food inside the bag. All the food will be kept in a special food box, to preserve it from temperatures ranging from -20 degrees Celsius to +30 degrees Celsius inside the aircraft.

The nutritional composition of the food will fluctuate with the altitude and temperature because the pilots require more energy while flying at higher altitudes, even though the elevation decreases their appetites. At high altitude, the meals will be higher in carbohydrates, whereas when the pilot is flying below 3,500 meters, he will consume meals higher in protein. The custom made menu includes mushroom risotto, quinoa tabbouleh, rice and chicken with summer vegetables, as well as carrot, chicken, leek and potato soups.
MISSION CHALLENGES

Up until this point during the First Round-The-World Solar Flight, the most challenging route for Solar Impulse is to plan and prepare the Pacific Crossing. The Mission Control Center (MCC) must accurately predict the weather forecast one week in advance which would allow for a safe landing in Hawaii. Unlike the previous flight legs that incorporate take-off, route, and landing over a time period of just one day, this flight planning must extend to accommodate the 5 day spread, thus, making it a complex task.

Which aspect of weather forecasting is critical?
The wind factor is crucial for take-off and landings as well as along the route. Due to its immense size and low weight, the aircraft is sensitive to turbulence on the ground. During the Pacific Crossing, the wind pattern has to be predominately tailwind to support the flight lasting 5 days and 5 nights.

Which factors need to be considered to find the optimal route?
The simulation team has to ensure the aircraft is able to fly the energy optimized profile for the flight path by searching for the perfect compromise between maximum tailwind and minimum cloud coverage above the aircraft make sure enough solar energy is collected. The clouds impede the collection of solar energy and the tailwind minimizes the airplane’s energy consumption.

Why does the plane need to reach the maximum altitude before each sunset?
By climbing up to 28,000 feet, Si2 will have stored maximum potential and electric energy in the batteries before the sun sets for the day. When night falls, the motors of the engine are stopped and the airplane glides down to low flying altitude of 3,000 feet before repeating this flight cycle.
During the night, how does the pilot manage the available energy?
To ensure the pilot reaches the next sunrise, he must carefully manage the plane’s energy consumption by flying slowly at a constant altitude of 3,000 feet (1,500 meters). Mission engineers will advise the pilot based on the monitored telemetric data (battery status, motor output), optimizing his flight route.

What is the challenge for Mission Control Center team?
The MCC has an overview of the complete flight, but as soon as new weather information is available, the team needs to adjust accordingly. If necessary, they need to derive a flight plan, make new routings and coordinate logistics.

The mission engineers constantly monitor the aircraft’s energy performance to make sure the pilot can make throughout the night. Additionally, they must regulate the pilot’s resting and health status to allow him to be sustainable during the 5 days and 5 nights while communicating the project’s message to the world.

How does the MCC team organize themselves?
Knowledge transfer amongst colleagues is critical because the flight across the Pacific will last 5 consecutive days. Working in shifts within the team is how this challenge is met. Mission engineers will work a 12 hour shift which includes being briefed by a colleague 1 hour prior to starting work, as well as briefing the subsequent colleague at the end of the shift, so as to not lose momentum with the status and workload of the flight.

When does the Round-The-World crew leave Nanjing to be able to be ready for the landing in Hawaii?
The Solar Impulse team is deployed after passing the point of no return to Hawaii. The logistics team needs to be ready to support any unforeseen changes or modifications to ensure ground crew is ready for Si2’s arrival and prepare the mobile hangar.

What is the mobile hangar?
The light weight of Si2 requires appropriate protection from adverse weather conditions at all times, a requirement that is difficult to satisfy at every airport along the 2015 Round-The-World Flight itinerary. This is why the mobile hangar, designed especially for the Si2, is a solution to shelter the aircraft anywhere in the world with rapid deployment when there is no hangar like it was the case in Mandalay, (Myanmar) and is the case in Hawaii. For the Si2, it was important to find a material that can withstand the elements and protect the aircraft as it is rip-stop, fire proof and waterproof. The hangar’s fabric comes from the sailing industry and is transported in the cargo plane which follows the aircraft, carrying all material including spare parts. To assemble it, it requires 4-5 hours to be ready, 6-7 hours to completely close it.
What is the MCC?
The Mission Control Center (MCC) is the entity that manages Solar Impulse 2 flights from the preparation until the safe landing at destination. Based in Monaco, thanks to the support of the Prince Albert II of Monaco Foundation it remains operational 24/7 during each flight.

Who is part of the MCC team?
The MCC team is composed of air traffic controllers (ATC), weather experts, engineers and mathematicians under the supervision of the Mission Director. It has its own unofficial Cartesian motto: cogito ergo circumvolat (we think, therefore he flies around!).

How does the MCC team prepare a flight?
Weather experts study in detail the weather pattern, cloudiness and wind at the take-off and landing locations but also along the route. The ATC team looks at the air space constraints as well as take-off and landing slot. These parameters are forwarded to the mathematicians of the simulation team, who integrates them in an extremely precise, predictive routing system which also considers the energy performance of the aircraft. This tool called "Platoo" will cross all the parameters and will be able to find the optimal flight strategy and define the best route among thousands of possibilities.

When is the final decision of take-off taken?
The route is carefully analyzed during the daily flight briefing with the MCC team and pilots, who then collectively decide with the Mission Director to confirm the chosen flight strategy. As the weather could change quickly, the meteorologists are studying every day their data and the route is constantly recalculating to confirm the decision. Therefore, the final go is given the day before departure.

What are the MCC’s responsibilities during a flight?
During the flight, the MCC team is providing the pilot with optimal support to get him safely to the destination. They play the key role of “co-pilot” from the ground and are in permanent contact via satellite communication developed by Swisscom, the official telecom partner of Solar Impulse. Mission engineers are monitoring the aircraft performance and behaviour through the telemetry system but also the general state of the pilot through health checks. They are also following the daily agenda and remind the pilot to rest, exercise and eat when permitted. Air traffic controllers are coordinating the route in collaboration with the local Air Navigation Services. The simulation team recalculates the route twice a day in accordance to the updated weather data.
WHAT IF?

HUMAN ASPECTS:
WHAT IF

What if one of the two pilots is unable to go on the next flight? In a case like this, the pilot who has flown the previous leg will also go on the next one, with a rest period of a few days during the stop.

What if there are not enough oxygen reserves? Without oxygen, the pilot cannot fly above 12,000 feet. Therefore he will have to maintain a low flight altitude, which will mean he cannot continue on a day and night cycle with the plane.

What if the pilot has to bail out over the sea? In the event of an emergency jump over an ocean, the pilot has a parachute and an inflatable life raft, which he can activate at any time. Once in the sea, he must wait aboard the life raft until help arrives, which might take several days, the time needed to send a ship to his location. In preparation for this eventuality, the pilots received pre-flight training from specialists in sea rescue.

What if the plane crashes? Beyond the risk to yourself, doesn’t that stop the momentum for what you are trying to accomplish? We have taken the utmost care to minimize the chance of any accident from happening on this journey. But aviation, especially pioneering aviation, has always entailed risk. We have never let that stop us. As an aviation community, we learn from these challenges and develop something even better than before the next time around.

OPERATIONAL ASPECTS:
WHAT IF

What if a part on the plane fails? If one of the 4 motors breaks down for example, the plane would operate with the other 3 remaining motors. The battery supplying the faulty motor would then be used for the adjacent motor. Most of the systems on board the plane are duplicated. If one were to fail, another would take over.

What if solar cells are damaged during flight? It is possible for a solar panel to become detached during flight. In that case, the motor will have less energy because supply will be reduced and the batteries will not be as fully charged. This could be a concern if a night flight cycle is to be undertaken.

What if there aren’t enough reserves of energy in the batteries when night falls? Without enough energy in the batteries a night flight is impossible. The plane would have to make an emergency landing. That would be possible if it is flying over land, but if it is over the sea, the pilot could be electrocuted when the plane enters the water. The pilot would be obliged to bail out.

What if there are cumulonimbus clouds or turbulences during the night? If the plane encounters turbulences stronger than the aircraft can handle (2m/s), or is struck by lightning and runs into a thunderstorm, it would be destroyed. Therefore, it is important for the Solar Impulse expert meteorologists to forecast the weather conditions. Thanks to radar and satellite weather images, the team is able to detect these challenges.

What if the ground crew cannot get to the meeting point? The pilot is capable of landing on the runway on his own, but the crew needs to be there on the ground to maneuver the plane, put it in its hangar, service it, and prepare it for the next flight. Forty people are needed on the ground for this adventure to happen. If the ground crew is not there, the Round-The-World Flight cannot continue.

What if Solar Impulse crosses the path of another aircraft? Air traffic controllers monitor their radar screens and ensure that aircraft do not come too close to each other. Turbulence created by large aircrafts are dangerous for Solar Impulse. The airplane is fitted with a transponder, which transmits a signal allowing it to be identified on radar screens.

What if the plane has to make a U-turn? This has already happened twice with Si1 due to bad weather, in Brussels and Rabat in Morocco. If the wind is too strong and the plane cannot turn round, then it must make an emergency landing at an alternative airport. As the logistics team flies in an accompanying aircraft and the second pilot joins the solar airplane at each stop, the accompanying aircraft must change its flight plan and head for where Si2 will actually land.

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