In 2015 Bertrand Piccard and André Borschberg plan on flying around the world in a solar powered aircraft. During the flight, the temperature profile inside the cockpit is submitted to great variations causing the water to freeze. This prevents the pilot from drinking and preparing meals based on dehydrated food. Two distinct problems are faced: keep a volume of water from freezing and thus drinkable and heat another one up to 70°C, so as to provide a hot meal for the pilot. The following solutions are based on core equations of heat transfer, Matlab® simulations and experiments to verify the accuracy of the models and hypothesis made, with an emphasis on lightweight design.

« Heating up the water for hot meals »

The solution chosen to heat up the water works on the principle of a Solar Plate. In a few words, it is an insulated water tank with double glazing, that collects solar radiation.

**Model**

In order to calculate the temperature of the water, a Matlab® simulation was made. Figure 2 provides an illustration of the simulated solar plate.

**Validation**

A prototype was built in order to validate the simulations. Since there is a small layer of air next to the absorber, that is not included in the simulation, the simulated temperature is slightly lower than the measured one. See figure 3.

**Results**

Two distinct solutions were developed: a first one providing hot water for 20 hours. The period of 20 hours was made possible by including a Phase Change Material (PCM). It absorbs a lot of energy without increasing its temperature, at 80°C.

The second one, which focuses on the weight efficiency, provides hot water for a device-weight of only 150 grams. Every compromise between these two extremes is possible.

**Conclusion**

It is shown that it is possible to heat up the water with solar radiations. Two renewable solutions are suggested to supply the pilot with hot water for the meals.

« Preventing the water from freezing »

During the nocturnal part of the flight, the temperature drops down to -20°C, rendering the aircrafts main water supply inaccessible. In order to provide the pilot with drinking water during this time, 400ml are to be stored in an insulated bottle. A model was established to assess the temperature profile inside this bottle.

**Model**

The model considered for the bottle is of a cylindrical shape. Heat conduction occurs through the walls and convection along the walls. Equation (1) is the core equation on which the simulations are based.

\[
m \cdot C_p \frac{dT(t)}{dt} = Q_{in}(T(t)) - Q_{out}(T(t))
\]

The bottle was fitted with a removable insulation to reduce heat loss. Polystyrene was chosen as the insulator, both for its low density and low thermal conductivity. The whole was then implemented in a Matlab® simulation.

**Insulated bottle simulation**

The purpose of this simulation is to find the insulation thickness which prevents the water in the bottle from freezing.

According to Figure 2, a 20mm polystyrene insulation is enough to prevent the water from freezing.

**Experiment to validate the simulation**

An experiment was conducted in order to provide data to which the simulations could be compared.

The experiment led to the conclusion that the models are fairly accurate. The results deducted from the simulations can therefore be considered as trustworthy.