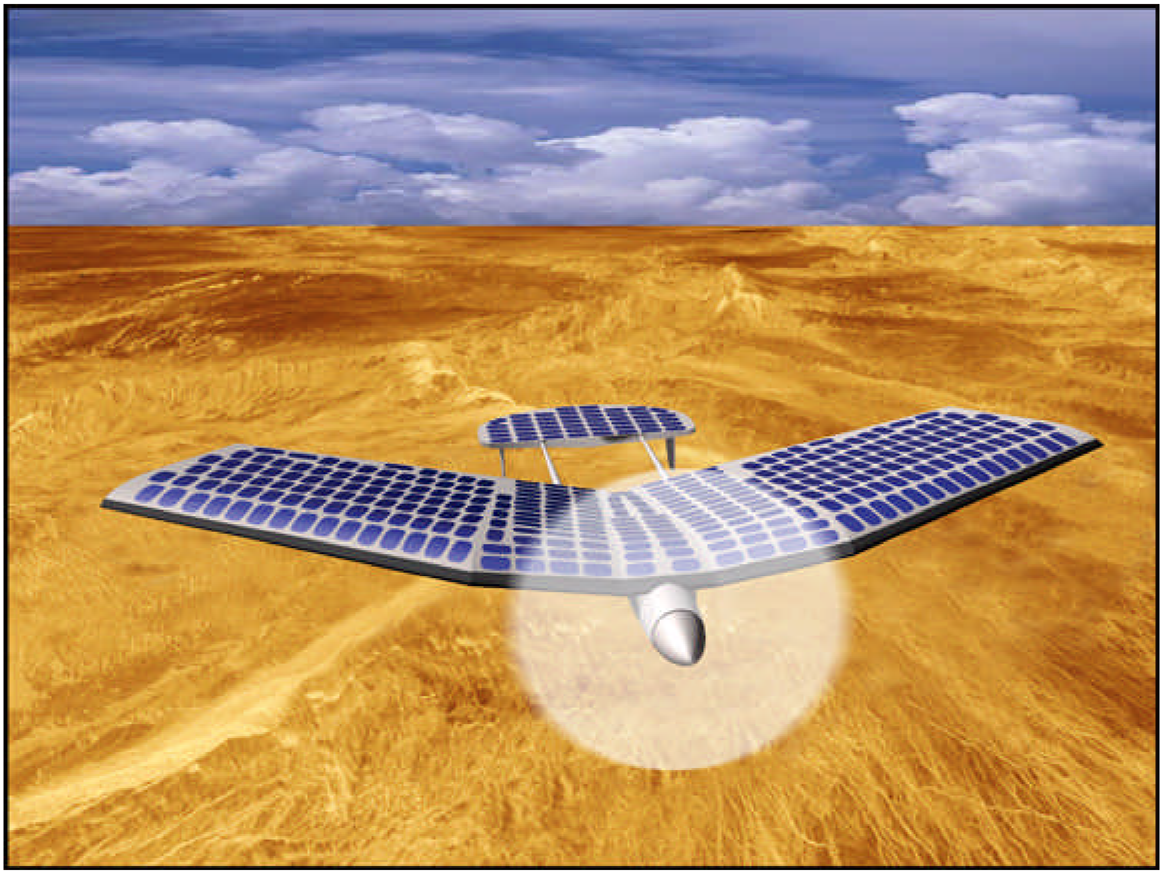
Solar Airplane Concept Developed for Venus Exploration



Solar-powered Venus airplane shown over a computer-generated radar image of the surface of Venus. (Artist's conception by Terence K. Condrich of InDyne, Inc.)
The surfaces of the wing and the horizontal tail are covered with solar cells

An airplane is the ideal vehicle for gathering atmospheric data over a wide range of locations and altitudes, while having the freedom to maneuver to regions of scientific interest.

Solar energy is available in abundance on Venus. Venus has an exoatmospheric solar flux of 2600 W/m^2, compared with Earth's 1370 W/m^2. The solar intensity is 20 to 50 percent of the exoatmospheric intensity at the bottom of the cloud layer, and it increases to nearly 95 percent of the exoatmospheric intensity at 65 km. At these altitudes, the temperature of the atmosphere is moderate, in the range of 0 to 100 °C, depending on the altitude.

A Venus exploration aircraft, sized to fit in a small aeroshell for a "Discovery" class scientific mission, has been designed and analyzed at the NASA Glenn Research Center. For an exploratory aircraft to remain continually illuminated by sunlight, it would have to be capable of sustained flight at or above the wind speed, about 95 m/sec at the cloud-top level. The analysis concluded that, at typical flight altitudes above the cloud layer (65 to 75 km above the surface), a small aircraft powered by solar energy could fly continuously in the atmosphere of Venus. At this altitude, the atmospheric pressure is similar to pressure at terrestrial flight altitudes.

For exploration at lower altitudes, the aircraft could glide down for periods of several hours and then climb back to higher altitudes, allowing the cloud layers to be probed. Analysis of a flight using battery storage shows that it is not feasible to keep the aircraft aloft on battery power during the passage across the night side of the planet.

The planet Venus has a number of fundamental scientific mysteries, both in its atmosphere and in its surface. An aircraft-based probe could measure the volatile inventory of Venus and the isotope ratio in the atmosphere, helping to determine whether early Venus once had an atmosphere and to determine the process and timing by which the planet lost its primordial inventory of water. The aircraft mission could also, by "sniffing" the sulfur content of the atmosphere as a function of position on the surface, determine whether the sulfur abundance in the atmosphere is correlated with specific surface features (such as volcanoes or fumaroles).

The atmospheric dynamics of Venus are also not yet understood. At the cloud tops, the atmosphere moves around the planet 60 times faster than at the surface. The mechanism that supports this atmospheric superrotation is not well understood. To address this problem, an aircraft would measure the infrared absorption and the horizontal and vertical components of atmospheric motion as a function of the altitude, latitude, and subsolar longitude. Detailed modeling of the atmosphere also will require knowledge of the atmospheric correlation, using two aircraft flying with a known separation. Even the nature of the absorbing particles in the clouds remains enigmatic. These could be characterized by chemical and physical sensors in the atmosphere.

The primary tool for aircraft-based investigation of the surface of Venus would likely be radar. Because the aircraft would observe the surface from a distance of 10's of kilometers, rather than the 100's of kilometers altitude of an orbiting probe, resolution will be improved by a factor of 10, and the required power will be reduced by a factor of a 100. Such an aircraft would also be able to circle over particular spots of interest, allowing detailed study of those areas, rather than uniformly covering all regions of the planet.

An aircraft such as the one analyzed here would be a powerful tool for exploration. By learning how Venus can be so similar to Earth, and yet so different, we will learn to better understand the climate and geological history of the Earth. The success of a prototype solar airplane could lead to the development of a fleet of solar-powered airplanes flying across the Venus cloud tops, taking simultaneous measurements to develop a "snapshot" of the climate across the face of the planet.

Venus airplane as it arrives at the atmosphere of Venus in a folded configuration, and unfolds its wings and tail to fly. (Artist's visualization by Terence K. Condrich of InDyne, Inc.)

The tail boom is hinged once, so that the horizontal tail can be folded over to the top of the wing. The wing has two hinges, so that the left and right wing panels are folded over on top of the center panel.

Find out more about this research: http://powerweb.grc.nasa.gov/pvsee/publications/

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Special recognition: ASM/AIAA Best Paper of 2002 award for best paper, atmospheric flight mechanics