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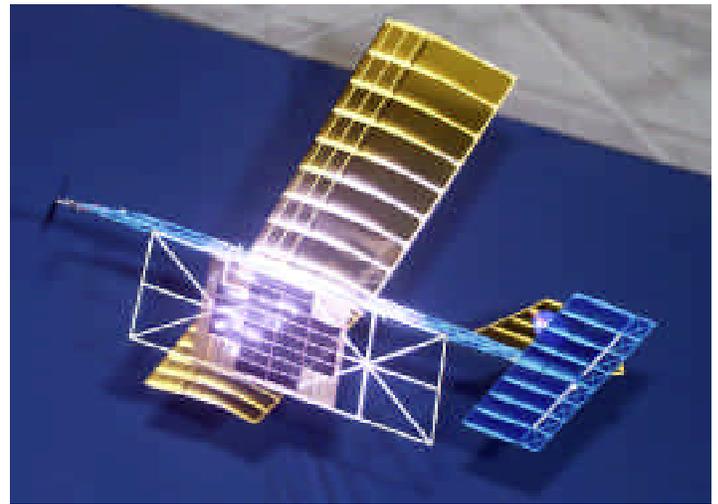
Beamed Laser Power For UAVs

Researchers at NASA's Marshall Space Flight Center, Huntsville, Ala., and Dryden Flight Research Center, Edwards, Calif., and the University of Alabama in Huntsville have flight-demonstrated a small-scale aircraft that flies solely by means of propulsive power from an invisible, ground-based infrared laser.

Flights of the lightweight, radio-controlled model airplane inside a large building at NASA Marshall are believed to be the first time that an aircraft has been powered only by laser energy. The demonstration was a key step toward the capability to beam power to an aircraft, allowing it to stay in flight indefinitely – a concept with potential for the scientific community as well as the remote sensing and telecommunications industries.

During the flight demonstration in September 2003, an engineer manually directed the 1 kw laser's energy from a central platform at a panel of infrared-sensitive photovoltaic cells mounted on the bottom of the aircraft to power its tiny six-watt motor as it flew circles inside the building. As a precursor to the laser beamed-power flights, a similar demonstration using a large theatrical spotlight was flown in the summer of 2002 at NASA Dryden, proving that beamed visible light could power the 11-ounce aircraft. The two lightweight model aircraft used for these demonstrations were designed and built in the NASA Dryden model shop, and were controlled using the same over-the-counter radio control instrumentation available to model aircraft hobby enthusiasts.

Two months after the initial laser-powered flight demonstrations, the team used the same laser system on a rotorcraft version that operated along guide wires. Several attempts were then made to fly the original aircraft, now modified with two motors for additional power, outside on a laser range on the U.S. Army's Redstone Arsenal near NASA Marshall. These attempts were not successful, due to the aircraft's light weight and low power being unable to overcome the effects of gusty winds.



With a laser beam centered on its panel of photovoltaic cells, a model makes the first flight of an aircraft powered by a laser beam inside a building at NASA Marshall.

NASA Photo ED03-0249-18.

History of Power Beaming

The concept of wireless transmission of electrical energy – or power beaming – is not new. The idea has been around for decades, proposed primarily for space-based solar farms to supply energy to Earth or the surface of another world, or for wireless power on Earth. The two technologies that appeared suitable for power beaming involved microwave or laser energy.

Researchers in several countries flew a variety of model aircraft using beamed microwave energy 20 years ago. However, the nature of the microwave beam causes it to spread out with distance, with a commensurate decrease in the power delivered to the target. While flight was easy to demonstrate at close distances with microwave beaming, flying an airplane at long distances would require a prohibitively powerful microwave beam to compensate for the energy loss as the beam spread. That left only lasers as a potentially viable option for practical power beaming.



NASA Dryden's Dave Bushman aims the optics of a laser device at a panel of solar cells during the first flight demonstration of an aircraft powered by laser light.

NASA Photo EC03-0249-36.

Until recently, however, laser technology had not advanced to the state where such applications could be possible. A key breakthrough to the potential success of power beaming is use of a new system of clustered tunable lasers conceived by laser scientists at the Lawrence Livermore Laboratory. Clustered lasers could provide similar efficiencies as high-power free electron lasers, whose development has not yet matured to the point of being practical for these applications.

Power Beaming for Uncrewed Aircraft

The development of prototype lightweight, solar-electric powered remotely operated aircraft such as the Pathfinder-Plus and Helios Prototype under NASA sponsorship led to a renewed interest in laser power beaming. With an adequate system to provide supplemental energy at night when solar energy is not available or is minimal at high latitudes in winter, a solar-electric aircraft has the potential to be able to fly day and night for weeks or possibly months without landing. This ability to fly continually would be a breakthrough in aviation, with such high-altitude, long-endurance, aircraft able to serve as "atmospheric satellites" on surveillance or telecommunications relay missions.

Laser power-beaming was considered as one option, along with regenerative or non-regenerative fuel cell systems or improved rechargeable batteries, to provide supplemental electrical energy to power such aircraft. Power beaming could help recharge a fuel cell- or battery-based energy storage system on a solar aircraft, and also could provide significantly more power to a payload than solar

power alone.

Although inclement weather poses a severe limitation on power beaming to an aircraft, several ground stations could be located so that one should be able to beam power while the primary site is in the rain. Careful selection of the laser wavelength could permit the laser station to compensate for atmospheric and weather-related losses. Another possible solution would be to beam the power down from a laser power station in space that can always see the aircraft above the clouds.

Other Potential Applications

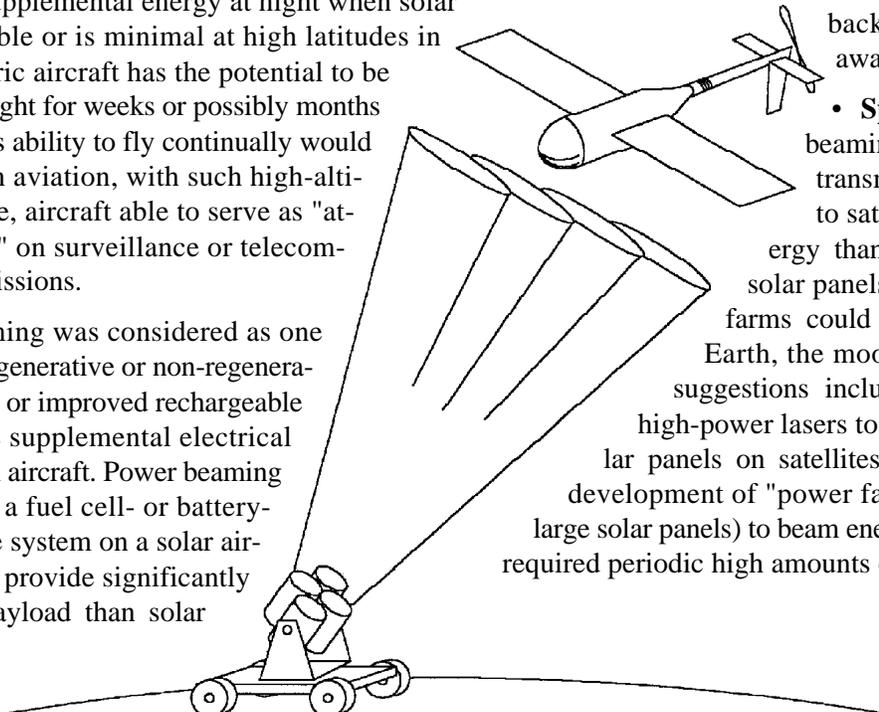
- **High-altitude airships:** Beaming power to high-altitude airships for the same role as high-altitude, long endurance uncrewed airplanes has also been proposed, although the technology to allow a dirigible or blimp fly at high altitude has yet to be demonstrated.

- **Extra-terrestrial robotic rovers and aircraft:** Laser power-beaming could energize ground-based robotic rovers on the moon and Mars or power a small airplane in the Martian atmosphere, with electricity beamed from an orbiting satellite.

- **Small or swarming unmanned aircraft:** Small, low-altitude scout aircraft that could fly guard duty over a military combat area, or fly in front of a convoy to warn against an ambush could be periodically recharged with a laser beam so they could stay aloft as long as needed.

- **Power transmission:** In locations where it is not practical to run power transmission lines, power beaming could "close the gap" by beaming the energy across the open distance. Power could even be beamed to a special aircraft or satellite that would then send the energy back to Earth a great distance away.

- **Space applications:** Power beaming has been proposed to transmit power from the ground to satellites to provide more energy than they could absorb from solar panels alone. Space-based solar farms could beam power directly to Earth, the moon or other planets. Other suggestions include using specially tuned high-power lasers to "rejuvenate" damaged solar panels on satellites to extend their life, and development of "power farms" (satellites with very large solar panels) to beam energy to another satellite that required periodic high amounts of energy.



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