

Application of the laser energy transmission technology to drive a small airplane

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A small flying object (kite plane) was successfully driven by using the laser energy transmission technology. A demonstration test was done in a large baseball dome stadium. A long-time flight of a kite plane flying at an altitude of 50 m and with a circulating radius of 10 m has been accomplished. It has been shown that the technology is applicable to practical use such as a reconnaissance flight in natural disasters.

OCIS codes: 350.4600, 140.2020, 080.2740.

Small flying objects such as airplanes or helicopters are considered very useful for a reconnaissance flight at the time of natural disasters such as flood, earthquake etc. to collect necessary information from area where man cannot access. Right now, they are driven by an electric battery or liquid fuel. For a practical use, however, the limit of operation time shall be critical and continuous energy supply is needed.

Our objective is to establish the laser energy transmission technology developed for a rover in the lunar exploration^[1] to drive a small airplane to a practically applicable level.

The system configuration is shown in Fig. 1. A kite plane developed by Atrim Inc. has been used. As a small flying object, any object is possible. Among them, the kite plane is expected to be strong to bad weathers.

Underneath the plane a solar panel is attached. The laser is irradiated from a fiber-coupled continuous-wave (CW) laser diode (LD) light source on the ground and the light energy is converted to the electricity using a solar panel to drive the plane. The plane is tracked by a tracking system (Fig. 2).

A long-time flight test was done at the baseball stadium of "Osaka dome". The dome has a ceiling height of 60 m and no appreciable wind is there. A kite plane (length: 789 mm, width: 1360 mm, height: 560 mm, weight: 800 g) is used. A solar panel of 30 cm in diameter

is placed underneath the plane. It consists of 30 small GaAs solar cells (3×6 (cm)), 10 cells connected in series and 3 in parallel, and it is directly connected to the propeller motor. The maximum output power is about 42 W when it is irradiated by a 300-W laser.

A small corner cube is set in the center of the panel to reflect a part of the laser beam to the transmitter. This is used for the laser beam to track the kite plane. A small Li-polymer battery (7.4 V, 480 mA, 36 g) is used in parallel to maintain the necessary power during the take-off from the ground. It can only sustain the kite plane flight less than 5 min. A small TV camera (15 g with small battery and transmitter) is on board to observe the landscape below.

Two fiber-coupled 200-W LD transmitters are used. The wavelength is 808 nm and the light beam comes out from a fiber whose core diameter is 400 μm and the cladding diameter is 480 μm with the numerical aperture (NA) of 0.22. 15 V, 39 A are required for 200-W laser output. One of the LDs is cooled by a couple of Peltier cooling unit (cooling capability is 255 W each) and the other is water-cooled.

Two fibers are set on the tracking system and two lenses of focal length of about 8 cm are used to focus the laser beam on the solar panel on the kite plane. The control of the light beam axis is done not in θ - ϕ directions, but the north-south and east-west directions are varied independently so that the laser beam can track any motion of the kite plane above the head. Two rotation stages are used.

The requirement of the tracking includes the following aspects. 1) Accuracy: less than 1 cm with respect to the center of the solar panel ($D = 33$ cm); 2) speed: it shall respond to the kite plane velocity of 10 m/s at an altitude of 50 m; 3) dynamic range: the kite plane flies within a circle of 10 m in radius at an altitude of 50 m.

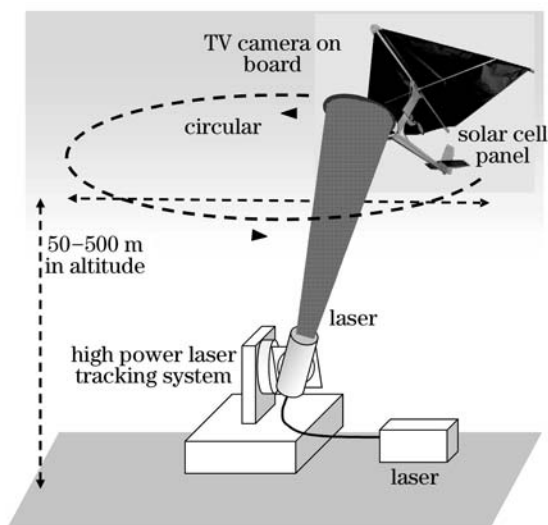


Fig. 1. System configuration of a kite plane driven by a laser energy transmission.



Fig. 2. Tracking system.

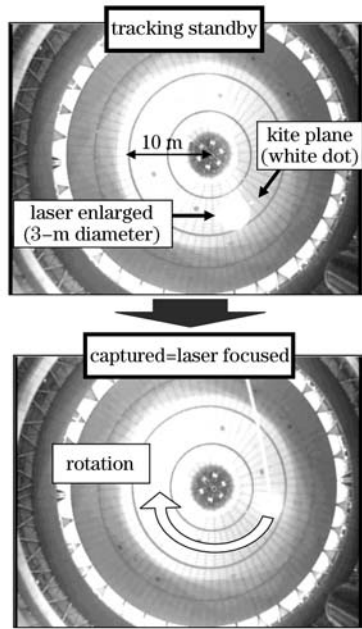


Fig. 3. Process of the kite plane being captured by the laser beam.

The tracking control is done as follows. A corner cube is placed in the center of the solar panel and the reflected light from the corner cube on the solar panel is detected

by a 4-element diode through a lens. If the solar panel is in the right center of the laser beam axis, the image of the corner cube is in the center of the 4-element diode. The deviation of the focused spot from the center is reflected to feed back to move the laser beam axis to the right direction.

The capture of the kite plane is done in the following way. The laser beam is enlarged to 10 times as large as the panel size and the tracking system waits until the kite plane enters in the beam area. Then the laser beam is focused to the panel size, as shown in Fig. 3.

The test in the dome was done twice in early 2006. In both cases, a long-time stable flight operation was successfully realized (more than 1 hour in each case). The time was limited by the availability of the dome. It is shown that the laser energy technology to a small flying object is well within a practical application.

This work was conducted as the major program in the Open Research Center Project GEMDAT in 2005 fiscal year supported by the Ministry of Science and Education of Japan. N. Kawashima's e-mail address is knobuki@ele.kindai.ac.jp.

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