LONG RANGE LASER TRAVERSING SYSTEM

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In December 1968, the U.S. Forest Service approached Goddard Space Flight Center to see if NASA-developed laser technology could be applied to the problems involved in surveying land in areas where the direct line of sight between property corners located on one mile centers is obscured by various types of obstacles, such as terrain or vegetation. As an indication of the magnitude of this requirement, the U.S. Forest Service controls 270,000 miles of property lines consisting of more than 1,000,000 property corners, the majority of which are located on one mile centers. Maintaining these property lines requires a never-ending program of land survey. The Forest Service estimates that an instrument with a range capability of one mile and an azimuth accuracy of ±1 minute of arc will support 95 percent of their surveying requirements at a savings in excess of $100.00 per mile in cost.

In support of the U.S. Forest Service request, a study was carried out to determine if the concept of detecting optical scatter from a vertically oriented laser beam with a portable receiver system located up to a mile away was theoretically feasible, and if feasible, could a laser transmitter and receiver be built that would be man-portable and meet our theoretical requirements such as power output and receiver detectability. The results of the study verified the feasibility of a system which would be both man-portable and capable of detecting the optical scatter due to molecular and aerosol constituents of the atmosphere from a vertical laser beam.

Figure 1 shows the basic concept of the system. The laser transmitter, located up to one mile from the receiver, is aligned to the local gravity vertical by the use of precision bubble levels attached to the unit. The receiver is set up on a reference corner, leveled, and pointed in the direction of the laser beacon specified by compass data. The receiver is elevated to clear terrain obstacles and the transmitter is commanded to fire either upon command of the receiver operator via a radio link or in a continuous 1/5-s mode. The receiver then begins an azimuth search until the beacon is detected. The receiver is then aligned to the laser beacon using the azimuth sensing capability built into the receiver system.

Figure 2 shows the laser transmitter and receiver units of our prototype surveying system. The laser vertical beacon consists of a ruby laser system with an energy output in excess of 150 mJ and an angular divergence of less than one mrad. The narrowness of the laser beam is basic to our azimuth accuracy. This laser divergence represents a beam width of 30.5 cm at an altitude of 457.5 m. The unit is powered by a 28-V battery pack at a maximum rate of one pulse every five seconds.

The receiver system is a modified DKM-3A astronomical theodolite with a basic instrumental accuracy of less than 0.5 arc seconds. The unit has a 2.83 arc-second optical aperture and a 50.8-cm focal length. The unit shown has an acquisition field of ±20 arc minutes and an azimuth sensing accuracy of ±0.5 arc minutes at a range of one mile and a receiving elevation angle of 45 deg.

The system shown in Figure 2 has been operated in the field under a variety of daylight conditions. The tests were run with the beacon and receiver separated by approximately one mile. The system was consistently able to detect the laser signal regardless of background conditions.

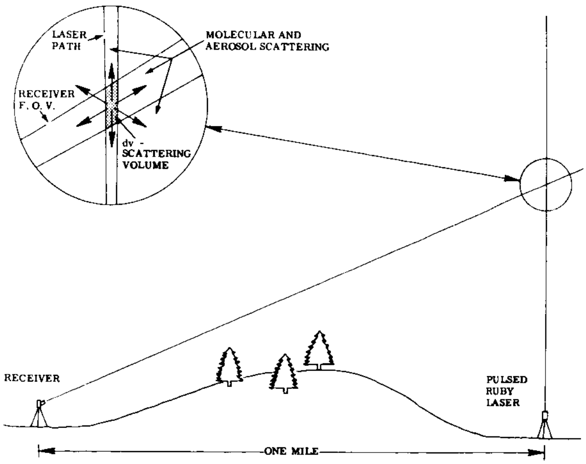
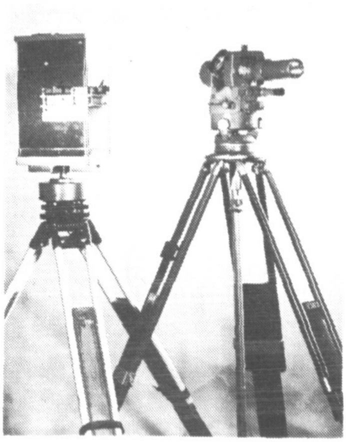


Figure 1—Laser traversing system.



LASER TRANSMITTER

POWER OUTPUT	0.15 J
OPTICAL WAVELENGTH	6943Å
PULSE LENGTH	≤20 ms
PULSE RATE	12/min MAX
DIVERGENCE	0.75×10^{-3} rad
POWER INPUT	28 V dc
WEIGHT–LASER	10.80 kg
BATTERIES	6.75 kg
TRIPOD	10.35 kg
TOTAL	27.90 kg

RECEIVER

OBJECTIVE APERTURE	2.83″
FOCAL LENGTH	50.8 cm
ACQUISITION FOV	40′
OPTICAL BW	8Å
SENSITIVITY OF LEVELS	10″/mm
INSTRUMENT ACCURACY	0.5′
WEIGHT–RECEIVER	11.25 kg
ELECTRONICS	4.50 kg
BATTERIES	6.75 kg
TRIPOD	9.00 kg
TOTAL	31.50 kg

Figure 2–Prototype surveying system.