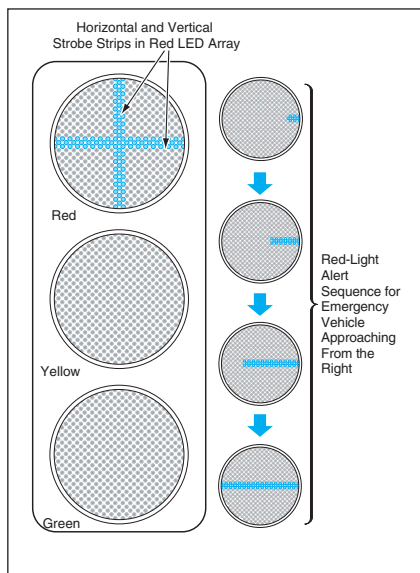


warning signs is potentially confusing to motorists. The strobe-enhanced traffic signals present less visual clutter.

In a given traffic-signal head, the strobe-enhanced traffic signal is em-



The LEDs in the Horizontal Strobe Strip are lit in sequence from right to left to indicate that an emergency vehicle is approaching from the right.

bedded in the red LED array of the “stop” signal. Two strobe LED strips — one horizontal and one vertical — are made capable of operating separately from the rest of the red LED matrix. When no emergency vehicle is approaching, the red LED array functions as a normal “stop” signal: all the red LEDs are turned on and off together. When the intersection is to be preempted for an approaching emergency vehicle, only the LEDs in one of the strobe strips are lit, and are turned on in a sequence that indicates the direction of approach. For example (see figure), if an emergency vehicle approaches from the right, the strobe LEDs are lit in a sequence moving from right to left.

Important to the success of strobe-enhanced traffic signals is conformance to city ordinances and close relation to pre-existing traffic standards. For instance, one key restriction is that new icons must not include arrows, so that motorists will not confuse new icons with conventional arrows that indicate allowed directions of movement. It is also critical that new displays like

strobe-enhanced traffic signals be similar to displays used in traffic-control systems in large cities. For example, Charleston, South Carolina uses horizontal strobes on red traffic lights to alert motorists and thereby help motorists not to miss red lights. The one significant potential disadvantage of strobe-enhanced traffic lights is initial unfamiliarity on the part of motorists.

*This work was done by Aaron Bachelder of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

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*Refer to NPO-30716, volume and number of this NASA Tech Briefs issue, and the page number.*

## Improved Timing Scheme for Spaceborne Precipitation Radar

**This scheme enables automated targeting and prevents pulse collisions.**

*NASA’s Jet Propulsion Laboratory, Pasadena, California*

An improved timing scheme has been conceived for operation of a scanning satellite-borne rain-measuring radar system. The scheme allows a real-time-generated solution, which is required for auto targeting. The current timing scheme used in radar satellites involves pre-computing a solution that allows the instrument to catch all transmitted pulses without transmitting and receiving at the same time. Satellite altitude requires many pulses in flight at any time, and the timing solution to prevent transmit and receive operations from colliding is usually found iteratively. The proposed satellite has a large number of scanning beams each with a different range to target and few pulses per beam. Furthermore, the satellite will be self-targeting, so the selection of which beams are used will change from sweep to sweep. The proposed timing solution guarantees no echo collisions, can be generated using simple FPGA-

based hardware in real time, and can be mathematically shown to deliver the maximum number of pulses per second, given the timing constraints.

The timing solution is computed every sweep, and consists of three phases: (1) a build-up phase, (2) a feedback phase, and (3) a build-down phase. Before the build-up phase can begin, the beams to be transmitted are sorted in numerical order. The numerical order of the beams is also the order from shortest range to longest range. Sorting the list guarantees no pulse collisions.

The build-up phase begins by transmitting the first pulse from the first beam on the list. Transmission of this pulse starts a delay counter, which stores the beam number and the time delay to the beginning of the receive window for that beam. The timing generator waits just long enough to complete the transmit pulse plus one re-

ceive window, then sends out the second pulse. The second pulse starts a second delay counter, which stores its beam number and time delay. This process continues until an output from the first timer indicates there is less than one transmit pulse width until the start of the next receive event. This blocks future transmit pulses in the build-up phase.

The feedback phase begins with the first timer paying off and starting the first receive window. When the first receive window is complete, the timing generator transmits the next beam from the list. When the second timer pays off, the second receive event is started. Following the second receive event, the timing generator will transmit the next beam on the list and start an additional timer. The timers work in a circular buffer fashion so there only need to be enough to cover the maximum number of echoes in flight.

When there are no more beams to transmit on the list, the build-down phase begins. In this phase, receive events begin when their respective timers pay off. When the timers have all paid off, the sweep is over and the instrument can begin a new sweep with a new list of beams.

Pulse collisions are avoided by the spacing of pulses during the build-up phase and by the order of the beams.

As long as the range (delay) never decreases there will always be enough time between any 2 transmit pulses for the receive window and it can occur at its optimal time. The solution is shown by simulation to average 90-percent efficiency in that the instrument is transmitting or receiving (but never both) 90 percent of the time. This can be shown to be optimal, given the constraint that the number of echoes in

flight needs to be constant over a sweep. This timing solution is the heart of an onboard processor/controller board for the second generation of Global Precipitation Mission.

*The work is being done by Andrew Berkun and Mark Fischman of Caltech for NASA's Jet Propulsion Laboratory, with cooperation from consultant Ray Andraka. Further information is contained in a TSP (see page 1). NPO-30560*

## Concept for Multiple-Access Free-Space Laser Communications

Multiple terminals at lower altitudes would be tracked by optomechanical and optoelectronic means.

NASA's Jet Propulsion Laboratory, Pasadena, California

A design concept for a proposed airborne or spaceborne free-space optical-communication terminal provides for simultaneous reception of signals from multiple other optical-communication terminals aboard aircraft or spacecraft that carry scientific instruments and fly at lower altitudes. The concept reflects the need for rapid acquisition and tracking of the signals coming from the lower-altitude terminals as they move across the field of view.

As shown in the upper part of the figure, the optical train of the terminal would include a telescope aimed at the scene below via a gimbaled flat mirror, which would be used to scan the field of view over a wide angular range. The lower part of the figure schematically depicts some of the optical and electronic channels used in the reception of data signals from, and the transmission of a beacon signal to, the lower terminals. This scheme is based on an architecture that provides for imaging of a small portion of the transmitted beam on a focal-plane array of photodetectors. Equipped with fast-read-out circuitry, the focal-plane array would be used in simultaneous acquisition and tracking.

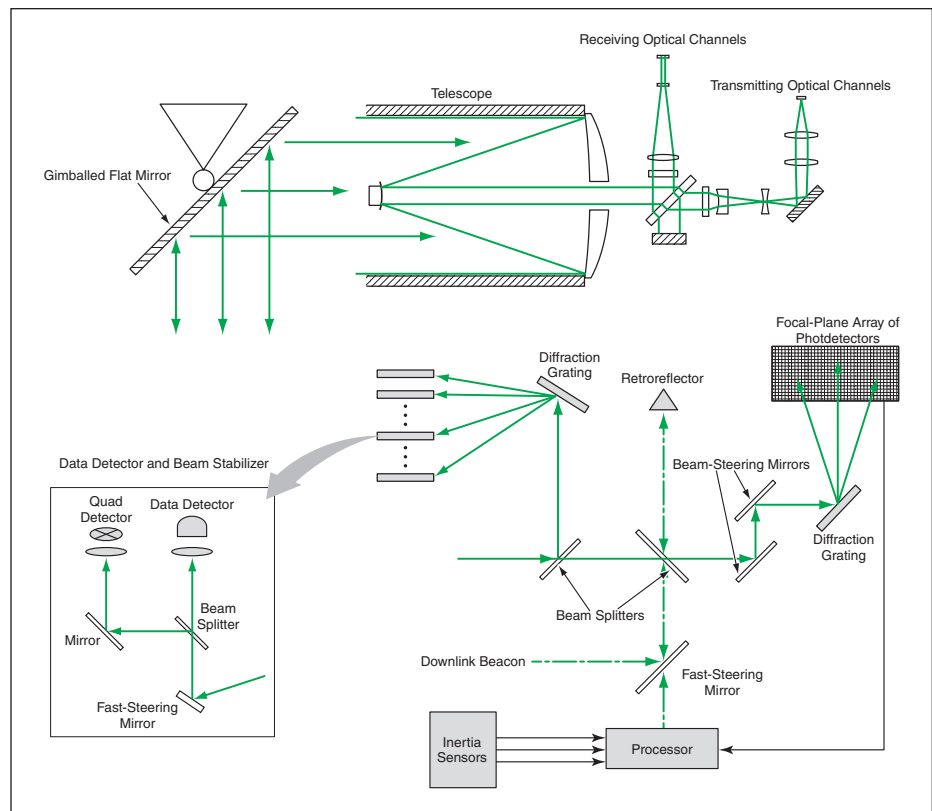
The design concept includes an operational scenario in which each lower terminal would be assigned a unique uplink wavelength for its transmitted laser beam, which would serve as both its uplink communication beam and its beacon. An optical link would be initiated by a lower terminal, which would transmit a wide beam up to the higher terminal. The lower terminal would then await an

acknowledgement of acquisition of its signal by the higher terminal before proceeding with a "handshake" and subsequent communications.

In the higher terminal, the uplinked beams from the lower terminals would be split between a data and a tracking channel, most of the beam power going to the data channel. In the tracking channel, the beams would then pass with minimal attenuation

through a dichroic beam splitter and onto two electronically actuated beam-steering mirrors, which would reflect the beams onto a diffraction grating that would separate the beams by wavelength. The beams would then impinge on separate spots on the focal-plane array of photodetectors.

The downlink beam would be reflected by a fast-steering mirror, which would be driven to correct for vibrations measured



The **Optics and Electronics** in a higher optical-communication terminal would maintain communication with multiple lower terminals within its field of view.