In addition to the basic frequency-band and low-noise requirements, the initial design problem included a requirement for capability of operation in a closed-cycle helium refrigerator at a temperature ≤ 4 K and a requirement that the design be mechanically simplified, relative to prior designs, in order to minimize the cost of fabrication and assembly. Previous attempts to build 32-GHz traveling-wave masers involved the use of metallic slow-wave structures comprising coupled transverse electromagnetic (TEM)-mode resonators that were subject to very tight tolerances and, hence, were expensive to fabricate and assemble. Impedance matching for coupling signals into and out of these earlier masers was very difficult.

A key feature of the design is a slow-wave structure, the metallic portions of which would be mechanically relatively simple in that, unlike in prior slow-wave structures, there would be no internal metal steps, irises, or posts. The metallic portions of the slow-wave structure would consist only of two rectangular metal waveguide arms. The arms would contain sections filled with the active material (ruby) alternating with evanescent-wave sections. This structure would be transparent in both the signal-frequency band (the aforementioned range of 31.8 to 32.3 GHz) and the pump-frequency band (65.75 to 66.75 GHz), and would impose large slowing factors in both frequency bands. Resonant ferrite isolators would be placed in the evanescent-wave sections to provide reverse loss needed to suppress reverse propagation of power at the signal frequency.

This design is expected to afford a large gain-bandwidth product at the signal frequency and efficient coupling of the pump power into the paramagnetic spin resonances of the ruby sections. The more efficiently the pump power could be thus coupled, the more efficiently it could be utilized and the heat load on the refrigerator correspondingly reduced. To satisfy the requirement for operation over the 0.5-GHz-wide signal-frequency band, the paramagnetic spin resonances would be broadened by applying a magnetic field having a linear gradient along the slow-wave structure. The gradients in the two arms are offset in order to compensate for the gaps of the evanescent sections.

The two arms of the slow-wave structure would be connected into a U-shaped assembly. At the base of the U (at the right end in the figure) there would be a cavity that would be simultaneously resonant in the TE_{301} mode at the signal frequency and in the TE_{403} mode at the pump frequency. The pump power would be injected into this cavity from two dielectric-filled waveguides that would be beyond cut-off at the signal frequency. The dielectric-filled waveguides would be excited from the two output arms of an electric-field-plane T junction. The signal power would enter and leave via WR-28 waveguides connected to opposite ends of the U-shaped assembly. Impedance matching would be effected by means of dielectric-filled (sapphire) sections of the waveguide arms near their input and output ends.

This work was done by James Shell and Robert Clauss of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). ***NPO-41273***

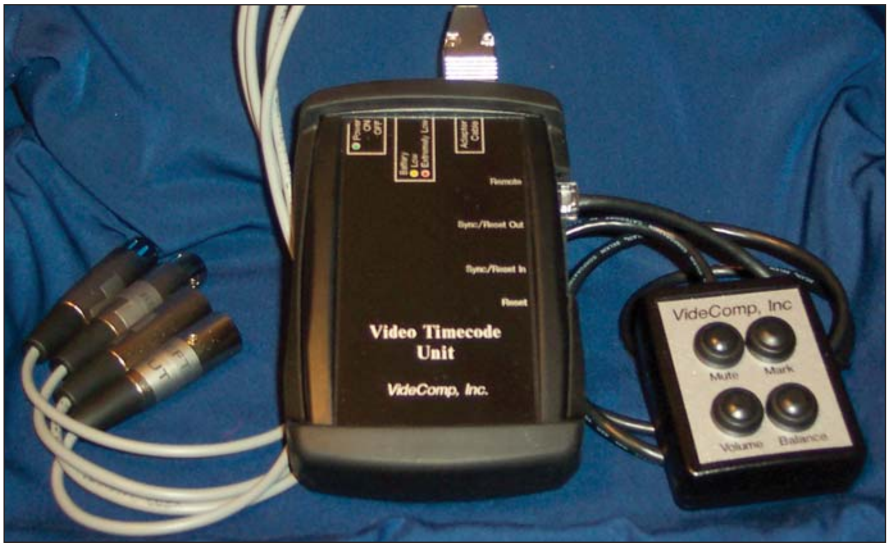
System Synchronizes Recordings From Separated Video Cameras

A large, immobile timing infrastructure is not needed.

Stennis Space Center, Mississippi

A system of electronic hardware and software for synchronizing recordings from multiple, physically separated video cameras is being developed, primarily for use in multiple-look-angle video production. The system, the time code used in the system, and the underlying method of synchronization upon which the design of the system is based are denoted generally by the term "GeoTimeCode™." The system is embodied mostly in compact, lightweight, portable units (see figure) denoted video timecode units (VTUs) — one VTU for each video camera. The system is scalable in that any number of camera recordings can be synchronized. The estimated retail price per unit would be about $350 (in 2006 dollars).

The need for this or another synchronization system external to video cameras arises because most video cameras do not include internal means for maintaining synchronization with other video cameras. Unlike prior video-camera-synchronization systems, this system does not depend on continuous cable or radio links between cameras (however, it does depend on occasional cable links lasting a few seconds). Also, whereas the time codes used in prior video-camera-synchronization systems typically repeat after 24 hours, the time code used in this system does not repeat for slightly more than 136 years; hence, this system is much better suited for long-term deployment of multiple cameras.



This **Mockup of a VTU** is based on a prototype VTU circuit powered by a standard 9-volt battery. To the extent possible, production VTUs would be made of low-power, precision electronic components that are already commercially available.

Each VTU contains a free-running, extremely stable clock, based on a 32,768-Hz (2^{15}-Hz) quartz-crystal oscillator. The clock begins a binary count up from zero when reset and continues counting up until reset again (or until it automatically restarts from zero when the time code repeats after more than 136 years). Each VTU also contains digital and analog audio circuitry required for synchronization of video recording.

The GeoTimeCode is a variant of the Inter Range Instrumentation Group B (IRIG-B) time code, which is widely used in the aerospace industry. The GeoTimeCode can easily be converted to other standard time codes, including the Society of Motion Picture and Television Engineers (SMPTE) time code. The GeoTimeCode is similar enough to the IRIG-B time code that software can easily be adapted to read either code.

A VTU can be synchronized to a Universal Time source (e.g., an Internet time server or a radio time signal) or to other, possibly distant VTUs by use of a computer equipped with the appropriate software and ancillary electronic hardware. Optionally, without using a computer, multiple VTUs can be synchronized with each other by temporarily connecting them together via standard patch cables and pressing a reset button. At the instant when synchronization is performed, the synchronization is accurate to within less than a millisecond. Synchronization can be done either before or after a video recording is made; the clock in a VTU is stable and accurate enough that as long as synchronization is performed within about 8 hours of recording, timing is accurate to within 0.033 second (a typical video frame period).

A portion of the time code is reserved for a serial number that identifies each VTU and, hence, the camera from which each recording is taken. Another portion of the time code is reserved for event markers, which can be added manually during recording by means of a pushbutton switch. Each event marker includes an event number from a counter that is incremented for each event. The serial numbers and event markers can be used to identify specific image sequences during post processing of video images by editing software.

This work was done by William "Bud" Nail, William L. Nail, Jasper M. Nail, and Duong T. Le of Technological Services Co. for Stennis Space Center.

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Refer to SSC-00253, volume and number of this NASA Tech Briefs *issue, and the page number*

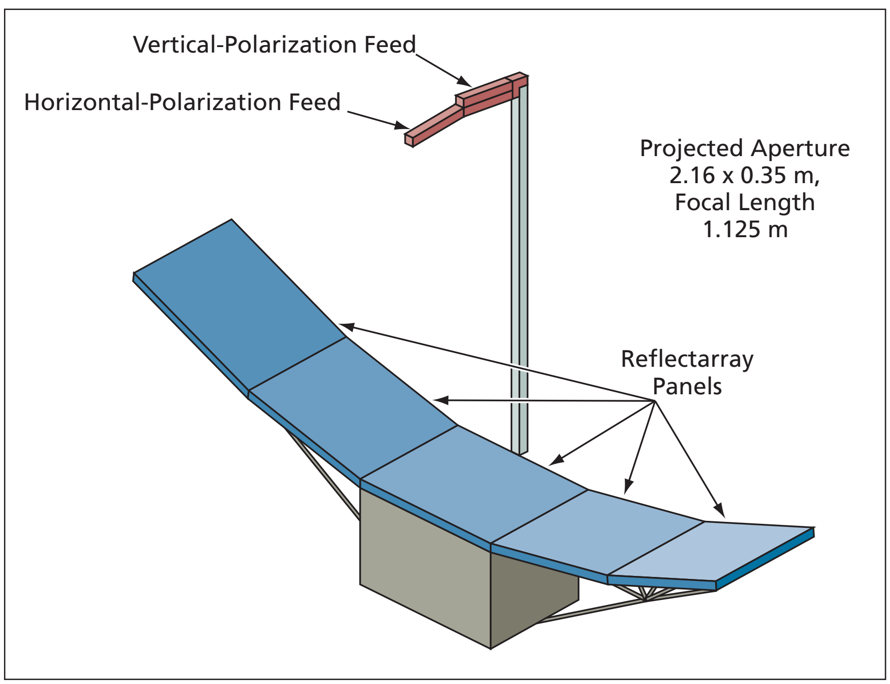
Piecewise-Planar Parabolic Reflectarray Antenna

Performance is equalized in horizontal and vertical polarizations.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure shows a dual-beam, dual-polarization Ku-band antenna, the reflector of which comprises an assembly of small reflectarrays arranged in a piecewise-planar approximation of a parabolic reflector surface. The specific antenna design is intended to satisfy requirements for a wide-swath spaceborne radar altimeter, but the general principle of piecewise-planar reflectarray approximation of a parabolic reflector also offers advantages for other applications in which there are requirements for wide-swath antennas that can be stowed compactly and that perform equally in both horizontal and vertical polarizations.

The main advantages of using flat (e.g., reflectarray) antenna surfaces instead of paraboloidal or parabolic surfaces is that the flat ones can be fabricated at lower cost and can be stowed and deployed more easily. Heretofore, reflectarray antennas have typically been designed to reside on single planar surfaces and to emulate the focusing properties of, variously, paraboloidal (dish) or parabolic antennas. In the present case, one approximates the nominal parabolic shape by concatenating several flat pieces, while still exploiting the principles of the planar reflectarray for each piece.



Five Flat Panels are arranged in a piecewise-planar approximation of a parabolic reflector surface. Each panel is a reflectarray designed to emulate the corresponding part of the parabolic reflector.

Prior to the conception of the present design, the use of a single large reflectarray was considered, but then abandoned when it was found that the directional and gain properties of the antenna would be noticeably different for the horizontal and vertical polarizations. The reason for this difference in per-