implement such application-specific, real-time processes as digital filtering and data compression. To afford additional operational flexibility and to enable use of a receiver in other applications, the design also includes a provision for an additional "drop-in" circuit board containing analog amplification and filtering circuitry. Such boards, which are relatively simple and inexpensive, can be easily exchanged by the user to modify center-frequency, bandwidth, and signal-level parameters.

The digital receivers can be configured to operate in a stand-alone mode, or in a multichannel mode as needed for DBF. In the multichannel/DBF mode, the receivers are made to take turns in transmitting sampled data onto the bus. The bus port on each receiver adheres to the FPDP-II standard, which supports an aggregate data rate of 400 MB/s. While the primary role of the FPDP bus is to transmit sampled data from receivers to a data-storage unit, the bus can also be used to transmit configuration data to the receivers. The bus also enables the receivers to communicate with one another — a capability that could be useful in some applications. Each receiver is also equipped with an RS-232 interface, through which configuration data can be communicated.

The data on the bus are aggregated and then sent to a data-acquisition (DAQ) subsystem by means of a serial FPDP interface that, like each receiver, contains an FPGA that serves partly as a FIFO memory and partly as a control unit. The DAQ subsystem stores the data onto a hard-disk array for postprocessing. In its role as a control unit, this FPGA sends timing and configuration information to each of the 16 receivers.

Although band-pass sampling is a widely applied technique, heretofore, it has been little used in radar systems. The use of band-bass sampling in the present receiver design is what makes it possible to achieve compactness: Band-pass sampling makes it possible to feed, as input to the ADC, signals having higher frequencies than could otherwise be utilized. In so doing, band-pass sampling enables elimination of an additional down-conversion stage that would otherwise be needed, thereby reducing the design size of the receiver. This design approach also eases filtering constraints and, in so doing, reduces the required sizes of filters.

The customizability of the receiver makes it applicable to a broad range of system architectures. The capability for operation of receivers in either a stand-alone or a DBF mode enables the use of the receivers in an unprecedentedly wide variety of radar systems.

This work was done by Delwyn Moller, Brandon Heavey, and Gregory Sadowy of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45539

Two-Camera Acquisition and Tracking of a Flying Target

An unanticipated moving target can be automatically spotted and tracked.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method and apparatus have been developed to solve the problem of automated acquisition and tracking, from a location on the ground, of a luminous moving target in the sky. The method involves the use of two electronic cameras: (1) a stationary camera having a wide field of view, positioned and oriented to image the entire sky; and (2) a camera that has a much narrower field of view (a few degrees wide) and is mounted on a two-axis gimbal. The wide-field-of-view stationary camera is used to initially identify the target against the background sky. So that the approximate position of the target can be determined, pixel locations on the image-detector plane in the stationary camera are calibrated with respect to azimuth and elevation. The approximate target position is used to initially aim the gimballed narrow-field-of-view camera in the approximate direction of the target. Next, the narrow-field-of view camera locks onto the target image, and thereafter the gimbals are actuated as needed to maintain lock and thereby track the target with precision greater than that attainable by use of the stationary camera.

Figure 1 shows a prototype of the apparatus. The stationary, wide-field-of-view camera includes a fish-eye lens that projects a full view of the sky (the full 360° of azimuth and the full 90° of elevation) onto a 512×512-pixel image detector of the active-pixel-sensor type. The gimballed narrow-field-of-view camera contains a charge-coupled-device (CCD) image detector. The apparatus also includes circuitry that digitizes the image-detector outputs and a computer that processes the image data and generates gimbal-control commands.

The stationary, wide-field-of-view camera repeatedly takes pictures of the sky. In processing of the image data for each successive frame period, the immediately preceding frame is subtracted from the current frame, so that all that remains in the image is what has changed between the two successive frames. Hence, if there is a moving luminous target, it

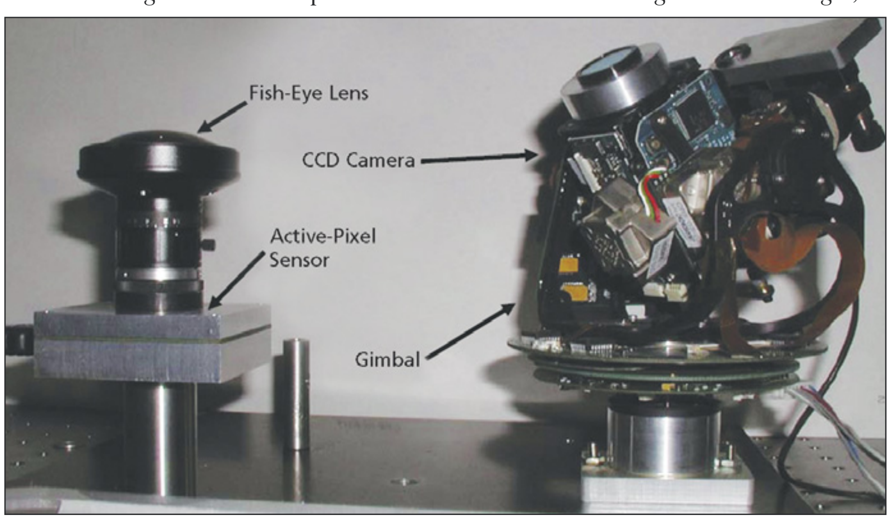

Figure 1. This **Prototype Apparatus** was built and tested, yielding the images shown in Figure 2.

ALL-SKY IMAGE BEFORE FRAME SUBTRACTION
The ISS is concealed by glare from the horizon

ALL-SKY IMAGE AFTER FRAME SUBTRACTION
The ISS is clearly visible. The bright patch at the left is from trees moving in wind near light sources

IMAGE IN GIMBALLED NARROW-FIELD-OF-VIEW CAMERA

Figure 2. **Images of the International Space Station** (ISS) were acquired by the prototype apparatus and used to track the ISS as it moved across the sky.

manifests itself in the processed image as a bright spot on a dark background (see Figure 2). The moving target is detected computationally as a spot of pixels brighter than a set threshold level. The location of the target is determined, to within a fraction of a pixel, as a brightness-weighted average pixel location. By use of a straightforward transformation that utilizes the image-detector-plane calibration, the target location is converted to azimuth and elevation coordinates, then by use of another calibrated transformation, the azimuth and elevation coordinates are converted to gimbal commands for initial aiming of the narrow-field-of-view camera.

Once the narrow-field-of view camera has been initially aimed and has acquired an image of the target, the apparatus switches into a tracking mode. In this mode, the gimbal commands are formulated to move the image of the target toward the center of the CCD image plane.

This work was done by Abhijit Biswas, Christopher Assad, Joseph M Kovalik, Bedabrata Pain, Chris J. Wrigley, and Peter Twiss of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). *NPO-45237*

Visual Data Analysis for Satellites

Stennis Space Center, Mississippi

The Visual Data Analysis Package is a collection of programs and scripts that facilitate visual analysis of data available from NASA and NOAA satellites, as well as dropsonde, buoy, and conventional *in-situ* observations. The package features utilities for data extraction, data quality control, statistical analysis, and data visualization.

The Hierarchical Data Format (HDF) satellite data extraction routines from NASA's Jet Propulsion Laboratory were customized for specific spatial coverage and file input/output. Statistical analysis includes the calculation of the relative error, the absolute error, and the root mean square error. Other capabilities include curve fitting through the data points to fill in missing data points between satellite passes or where clouds obscure satellite data. For data visualization, the software provides customizable Generic Mapping Tool (GMT) scripts to generate difference maps, scatter plots, line plots, vector plots, histograms, timeseries, and color fill images.

This program was written by Yee Lau, Sachin Bhate, and Patrick Fitzpatrick of the GeoResources Institute at Mississippi State University for Stennis Space Center.

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Refer to SSC-00266-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

A Data Type for Efficient Representation of Other Data Types

Some obstacles to programming of parallel computers are removed.

NASA's Jet Propulsion Laboratory, Pasadena, California

A self-organizing, monomorphic data type denoted a sequence has been conceived to address certain concerns (summarized below) that arise in programming parallel computers. ["Sequence" as used here should not be confused with "sequence" as the word is commonly understood or with "sequence" as used elsewhere to denote another, polymorphic data type that is also relevant to computer programming.] A sequence in the present sense can be regarded abstractly as a vector, set, bag, queue, or other construct. A sequence is defined in terms of the behavior of the operators that can be applied to it without any foreknowledge of the underpinnings of its representation or particular implementation.

Heretofore, in programming a parallel computer, it has been necessary for the programmer to state explicitly, at the