path of the wire-grid combiner. The first vane polarizer would be oriented with its vanes at 45° with respect to the polarization of the combined input beam, so that the output of the first vane polarizer would be circularly polarized. The second vane polarizer would convert the circular polarization to linear and would be oriented to place the final output polarization at a desired, standard angle. Fixing the polarization at a standard angle would facilitate the assembly of multiple stages to combine power from more than two sources.

Proper phasing is essential to the success of the proposed scheme. The phasing problem is somewhat more complex than in the case of a simple equal-power combiner because propagation through and between the vane polarizers introduces additional phase shift. However, this is not a serious problem because the majority of the phase shift is a predictable function of the positions and orientations of the vane polarizers, and each power-combining stage could be designed to incorporate an adjustable phase shifter for fine-tuning. There is also an analog of this combining technique in waveguide.

This work was done by Bruce Conroy and Daniel Hoppe of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-44532

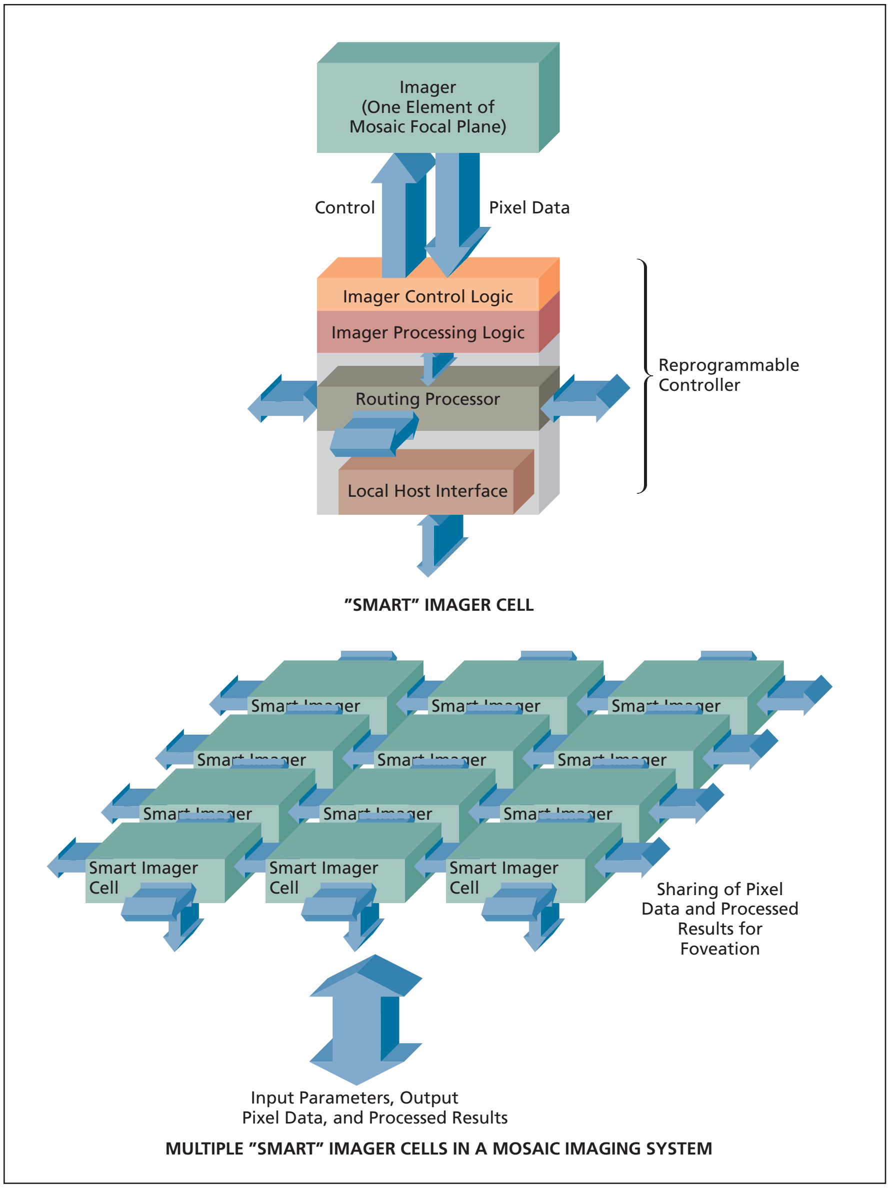
Synthetic Foveal Imaging Technology

Gigapixel images are analyzed in real time using multiple foveae.

NASA's Jet Propulsion Laboratory, Pasadena, California

Synthetic Foveal imaging Technology (SyFT) is an emerging discipline of image capture and image-data processing that offers the prospect of greatly increased capabilities for real-time processing of large, high-resolution images (including mosaic images) for such purposes as automated recognition and tracking of moving objects of interest. SyFT offers a solution to the image-data-processing problem arising from the proposed development of gigapixel mosaic focal-plane image-detector assemblies for very wide field-of-view imaging with high resolution for detecting and tracking sparse objects or events within narrow subfields of view. In order to identify and track the objects or events without the means of dynamic adaptation to be afforded by SyFT, it would be necessary to post-process data from an image-data space consisting of terabytes of data. Such post-processing would be time-consuming and, as a consequence, could result in missing significant events that could not be observed at all due to the time evolution of such events or could not be observed at required levels of fidelity without such real-time adaptations as adjusting focal-plane operating conditions or aiming of the focal plane in different directions to track such events.

The basic concept of foveal imaging is straightforward: In imitation of a natural eye, a foveal-vision image sensor is designed to offer higher resolution in a small region of interest (ROI) within its field of view. Foveal vision reduces the amount of unwanted information that must be transferred from the image sensor to external image-data-processing circuitry. The aforementioned basic concept is not new in itself: indeed, image sensors based on these concepts have been described in several



A **Mosaic Imaging System According to SyFT** would be built from "smart" imager cells, each of which would contain a focal-plane image sensor and a reprogrammable controller.

previous *NASA Tech Briefs* articles. Active-pixel integrated-circuit image sensors that can be programmed in real time to effect foveal artificial vision on demand are one such example. What is new in SyFT is a synergistic combination of recent advances in foveal imaging, computing, and related fields, along with a generalization of the basic foveal-vision concept to admit a synthetic fovea that is not restricted to one contiguous region of an image.

The figure depicts a mesh-connected SyFT architecture as applied to a focal-plane mosaic of homogeneous or heterogeneous image sensors. The architecture provides a networked array of reprogrammable controllers for autonomous low-level control with on-the-fly processing of image data from individual image sensors. Each image sensor in the mosaic focal plane is mapped to one of the controllers so that taken together the reprogrammable controllers constitute a conceptual (though not necessarily a geometric) image-processing plane corresponding to the mosaic focal plane. The controllers can be made versatile enough to control and to process pixel data from both charged-coupled-device (CCD) and complementary metal oxide/semiconductor (CMOS) image sensors in the mosaic focal plane. The image sensors can also have multiple pixel data outputs where each output has dedicated processing circuitry in its associated controller to achieve high throughput with real-time processing for feature detection and processing.

Each controller includes a routing processor to implement the network protocol and define the network topology for real-time transfer of raw pixel data and processed results between controllers. The network protocol and the capability to implement it are essential to realization of the capability for synthetic foveal imaging across the entire mosaic focal plane. The processing and networking capabilities of the controllers will enable real-time access to data from multiple image sensors, with application-level control of one or more ROI(s) within the mosaic focal plane array for sharing of detected data features among controllers. These capabilities will effectively facilitate the equivalent of rewiring and reconfiguration with different sensors in the mosaic, with scalability to different mosaic sizes dictated by application requirements. Consequently, the mosaic focal plane is treated as an integrated ensemble of synthetic foveal regions that can traverse the entire mosaic for autonomous intelligent feature detection and tracking capability. Unlike the current state-of-the-art in image sensors, "SyFTing" enables intelligent viewing through vast amounts of image data by treating a mosaic focal plane of sensors as an integrated ensemble rather than a collection of isolated sensors.

This work was done by Michael Hoenk, Steve Monacos, and Shouleh Nikzad of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

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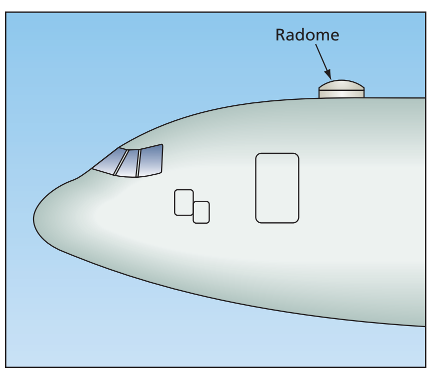
Airborne Antenna System for Minimum-Cycle-Slip GPS Reception

The antenna is kept pointing upward as the airplane banks.

Goddard Space Flight Center, Greenbelt, Maryland

A system that includes a Global Positioning System (GPS) antenna and associated apparatus for keeping the antenna aimed upward has been developed for use aboard a remote-sensing-survey airplane. The purpose served by the system is to enable minimum-cycle-slip reception of GPS signals used in precise computation of the trajectory of the airplane, without having to restrict the airplane to maneuvers that increase the flight time needed to perform a survey.

"Cycle slip" signifies loss of continuous track of the phase of a signal. Minimum-cycle-slip reception is desirable because maintaining constant track of the phase of the carrier signal from each available GPS satellite is necessary for surveying to centimeter or subcentimeter precision. Even a loss of signal for as short a time as a nanosecond can cause cycle slip. Cycle slips degrade the quality and precision of survey data acquired during a flight.



The **Radome Atop the Fuselage** of the NOAA hurricane-hunting airplane houses the present minimum-cycle-slip GPS antenna system.

The two principal causes of cycle slip are weakness of signals and multipath propagation. Heretofore, it has been standard practice to mount a GPS antenna rigidly on top of an airplane, and the radiation pattern of the antenna is typically hemispherical, so that all GPS satellites above the horizon are viewed by the antenna during level flight. When the airplane must be banked for a turn or other maneuver, the reception hemisphere becomes correspondingly tilted; hence, the antenna no longer views satellites that may still be above the Earth horizon but are now below the equatorial plane of the tilted reception hemisphere. Moreover, part of the reception hemisphere (typically, on the inside of a turn) becomes pointed toward ground, with a consequent increase in received noise and, therefore, degradation of GPS measurements.

To minimize the likelihood of loss of signal and cycle slip, bank angles of remote-sensing survey airplanes have generally been limited to 10° or less, resulting in skidding or slipping uncoordinated turns. An airplane must be banked in order to make a coordinated turn. For small-radius, short-time coordinated turns, it is necessary to employ banks as steep as 45°, and turns involving such banks are considered normal maneuvers. These steep banks are highly desirable for minimizing flight