more cost effectively without sacrificing sensor performance or the aircraft time on station.

The results of the initial analysis and numerical design indicated strong potential for an antenna array that would satisfy all of the design requirements for a replacement HIRAD array. Multiple common aperture antenna methodologies were employed to achieve exceptional gain over the entire spectral frequency band while exhibiting superb VSWR (voltage standing wave ratio) values.

Element size and spacing requirements were addressed for a direct replacement of the thicker, lower-performance, stacked patch antenna array currently employed for the HIRAD application. Several variants to the multiband arrays were developed that exhibited four, equally spaced, high efficiency, "sweet spot" frequency bands, as well as the option for a high-performance wideband array. The 0.25-in. (≈6.4-mm) thickness of the antenna stack-up itself was achieved through the application of specialized antenna techniques and meta-materials to accomplish all design objectives.

This work was done by John Little of Spectra Research, Inc. for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-33005-1.

Complementary Barrier Infrared Detector (CBIRD) Contact Methods

NASA's Jet Propulsion Laboratory, Pasadena, California

The performance of the CBIRD detector is enhanced by using new device contacting methods that have been developed. The detector structure features a narrow gap adsorber sandwiched between a pair of complementary, unipolar barriers that are, in turn, surrounded by contact layers. In this innovation, the contact adjacent to the hole barrier is doped n-type, while the contact adjacent to the electron barrier is doped p-type.

The contact layers can have wider bandgaps than the adsorber layer, so long as good electrical contacts are made to them. If good electrical contacts are made to either (or both) of the barriers, then one could contact the barrier(s) directly, obviating the need for additional contact layers. Both the left and right contacts can be doped either n-type or p-type. Having an n-type contact layer next to the electron barrier creates a second p-n junction (the first being the one between the hole barrier and the adsorber) over which applied bias could drop. This reduces the voltage drop over the adsorber, thereby reducing dark current generation in the adsorber region.

This work was done by David Z. Ting, Cory J. Hill, and Sarath D. Gunapala of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47042

Autonomous Control of Space Nuclear Reactors

Autonomous operation and safety are addressed simultaneously.

John H. Glenn Research Center, Cleveland, Ohio

Nuclear reactors to support future robotic and manned missions impose new and innovative technological requirements for their control and protection instrumentation. Long-duration surface missions necessitate reliable autonomous operation, and manned missions impose added requirements for failsafe reactor protection. There is a need for an advanced instrumentation and control system for space-nuclear reactors that addresses both aspects of autonomous operation and safety.

The Reactor Instrumentation and Control System (RICS) consists of two functionally independent systems: the Reactor Protection System (RPS) and the Supervision and Control System (SCS). Through these two systems, the RICS both supervises and controls a nuclear reactor during normal operational states, as well as monitors the operation of the reactor and, upon sensing a system anomaly, automatically takes the appropriate actions to prevent an unsafe or potentially unsafe condition from occurring. The RPS encompasses all electrical and mechanical devices and circuitry, from sensors to actuation device output terminals.

The SCS contains a comprehensive data acquisition system to measure continuously different groups of variables consisting of primary measurement elements, transmitters, or conditioning modules. These reactor control variables can be categorized into two groups: those directly related to the behavior of the core (known as nuclear variables) and those related to secondary systems (known as process variables). Reliable closed-loop reactor control is achieved by processing the acquired variables and actuating the appropriate device drivers to maintain the reactor in a safe operating state. The SCS must prevent a deviation from the reactor nominal conditions by managing limitation functions in order to avoid RPS actions.

The RICS has four identical redundancies that comply with physical separation, electrical isolation, and functional independence. This architecture complies with the safety requirements of a nuclear reactor and provides high availability to the host system. The RICS is intended to interface with a host computer (the computer of the spacecraft where the reactor is mounted).

The RICS leverages the safety features inherent in Earth-based reactors and also integrates the wide range neutron detector (WRND). A neutron detector provides the input that allows the RICS to do its job. The RICS is based on proven technology currently in use at a nuclear research facility. In its most basic form, the RICS is a ruggedized, compact data-acquisition and control system that