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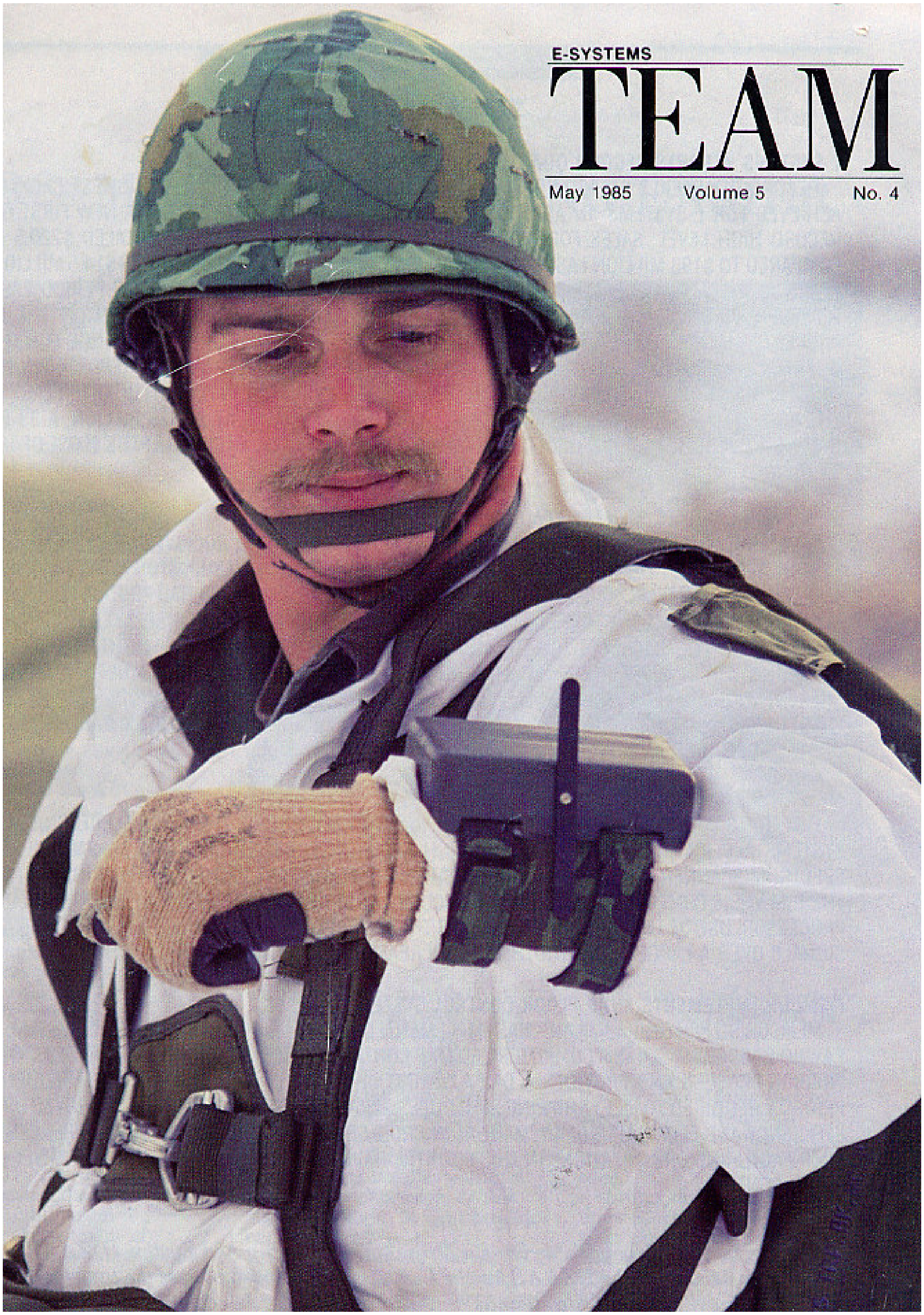

NEW RESEARCH LAB LEADS TO UNIQUE RADIO RECEIVER

**by Space Systems Technology Group, Garland Division*

Necessity does indeed lead to invention. A group of Garland E-Teamers had to create an ultra-fast data processor, configured as a digital radio receiver, because their large general purpose computer was too slow to run a promising new radio signal processing technique being developed in an R&D project. Experts who have seen it — customers, consultants, associate contractors — all agree that the new digital computer based receiver, called the Software Radio, has the potential to revolutionize the field of processing very complex radio signals.

* **The Software Radio** is the first sellable product produced in the new Digital Signal Processing Laboratory (DSP Lab) of Garland's Space Systems Department. The primary goal of this Lab is to provide research personnel the capability to develop and test advanced receiver processing concepts for signals of interest to Space Systems — signals received at such low levels that they are literally buried in radio noise. Many of these signals have such poor quality that traditional signal processing receivers provide little, if any, useful information. The new DSP Lab will also be used as a signal analysis facility to process and extract the transmitted information from other radio signals which have been received under adverse conditions by various customers and sent to the lab on magnetic tape. Wideband signals received at signal strengths as low as -20dB can be processed.

This unique Lab was established in an Independent Research and Development project by a team of Space Systems scientists and engineers. The team was led by Russell McKown and included Phil Evans, John McKown, Gary Breaux, Tom Summers and Dillard Lane. Over $500,000 of E-Systems capital equipment was integrated to create the first phase of the DSP Lab last August. This new signal processing concept quickly attracted widespread attention and the Lab is now being expanded in a customer-funded project to develop and demonstrate a full scale Software Radio.

The Lab became a necessity because of advances in signal processing techniques. Here is the story.

Space Systems scientists have devoted considerable research effort over the past four years to the development of higher performance digital receivers. The emphasis of the research to date has been directed toward the processing of frequency-modulated and phase-modulated digital signals (signals in which the information is pulse coded into a string of ones and zeros), which are received in the presence of severe radio interference. The present set of receiver designs in Space Systems is based on an E-Systems proprietary concept called Adaptive Digital Demodulation and Synchronization (ADDS). This method uses digital matched filters which automatically adapt to the characteristics of the incoming signal environment to synchronously demodulate complex signals embedded in very heavy interference.

Although they had obtained impressive performance for ADDS based receivers before last year, the team had measured this performance using idealized computer simulations which operated at a small fraction of the full rate of the wideband signals. Further ADDS development would require testing at computational rates available heretofore only in specially designed high speed hardware processors. They would have to design and build an engineering prototype receiver. However, although ADDS based receivers enjoy a performance/cost ratio that is significantly better than for competing designs, a hardware prototype development effort would still require considerable time and IR&D funding. Hence the idea for the DSP Lab with a software processor operating in relatively low cost commercially available high speed computers.

The Lab consists of three basic equipment groups: tape and disk recorder equipment, control/monitoring and analysis equipment, and digital processing equipment. Signals to be processed are introduced from wideband analog or digital tape recorders into the digital processors under control of the operator's monitoring console. Processed signals are stored on the magnetic disk for examination on the analysis equipment or for forwarding to a general purpose computer for off-line analysis.

The processing horsepower of the Lab is supplied by a bank of sixteen FPS 5430 Array Processors — very high speed but special purpose digital computers. The heart of the Lab, the device which permits a single stream of data to be partitioned into parallel array processors and then successfully reunited, is a DPS 2400 Dimensional Processor, a special input/output controller with memory. Together, the DPS 2400 and the FPS 5430s provide the high speed data transfers and computational power which permit the functions of a high performance digital receiver to be executed at full speed in a software implementation. This means that the DSP Lab's Software Radio is programmable, like any other computer. Unlike special purpose hardware processors, it can be quickly converted to perform different processing functions on received signals having different formats or different noise environments.

The DSP 2400 contains 24 Megabyte/sec internal data bus and mass memory system and a series of programmable 12 Megabyte/sec data interfaces. The FPS 5430 is an integrated package of four array processors which offers a computational rate of 60 million floating point operations per second — 60 Megaflops. (An "operation" is an arithmetic multiply or add.) Both units have high-level software development packages and extensive assembly code libraries which can be hosted on Space System's VAX 11/780 computer using the VMS operating system.

* **With the DSP Lab,** new ADDS based receiver designs can be conveniently implemented as full speed software processors and then be realistically tested. This not only provides a proof-of-concept demonstration (always required by prospective customers) but also produces a saleable digital signal processor. These software based digital receivers are capable of complete end-to-end processing of signals which cannot be successfully handled by existing hardware based receiver designs.

Dillard Lane (seated) and Gary Breaux at the operator's console of the DSP Lab, use the software radio to search for an unusual signal in a heavy interference spectrum.

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4950TH TEST WING

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The ARIA fleet consists of seven four-engine EC-135 jet aircraft. Efforts are currently underway to convert four C-18 (Boeing 707) aircraft to ARIA, replacing four of the older EC-135s. The first of the converted C-18s, designated EC-18B when configured for the ARIA mission, was unveiled Jan. 4, 1985, following a 30-month modification effort by members of the Test Wing's Aircraft Modification Division. It will join the ARIA fleet in mid-1985 after extensive ground and flight testing.

The ARIA were developed in 1968 to receive, record, and retransmit telemetry data and voice conversations between astronauts and Houston Control during the Apollo program. They presently are used to support various NASA and DoD missions including unmanned space launches, cruise missile tests, Army and Navy ballistic missile tests, and the Space Transportation System (Shuttle) program.

Externally, the most obvious difference between the ARIA-configured craft and standard C-18 and C-135 aircraft is the large bulbous nose — a nine-foot radome that houses the world's largest airborne steerable antenna. The antenna itself is a seven-foot dish used for telemetry reception. In addition to the droop nose, the ARIA have a probe antenna on each wing tip.

Internal modifications include sophisticated state-of-the-art prime mission electronic systems and facilities for crew members who operate the equipment. The crew for an ARIA mission ranges from 16 to 24 people, depending on the complexity and duration of the mission.

Future modifications for the EC-18s, which have more cargo room for mission equipment and more fuel efficient engines than the EC-135s, include the addition of a Sonobuoy Missile Impact Location System that pinpoints test missile impacts on test ranges.

Currently, the Greenville Division is actively involved in this program, having recently received an ASD contract for modification of the first EC-18 (phase one). In phase two, the phase one design and documentation will be updated and three modification kits will be furnished to the 4950th.

The Greenville Division is also responsible to the Air Force Logistics Command for phased depot maintenance and logistic support of the C-18 aircraft assigned to the Wing.

—JOHN SUTTON

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