# The Advanced Multifunction RF Concept (AMRFC) Test Bed

G.C. Tavik
*Radar Division*
I.D. Olin
*SFA Inc.*

**Introduction:** A glance at any Navy fighting ship underscores the goal of the technology being developed and demonstrated in this multidivision, multilaboratory program, sponsored and inspired by the Office of Naval Research. Today, single system antennas increasingly clutter our ships. Over just the ten-year 1980-1990 period, many ship classes that initially had fewer than 100 antennas needed nearly 150. Mutual signal interference, ship's signature, manning, spares, and life cycle costs all point to the need for a multifunctional concept in which systems are defined by their functions and by software that drives the electronics of a single antenna suite. In this program, hardware and software that emulate Emission Control, Normal, and Combat scenarios have been successfully combined in an active Proof of Principle demonstration at NRL's Chesapeake Bay Detachment (CBD).

**System Flexibility Enables a Broad Spectrum of Functionality:** The test bed operates over 6-18 GHz with functions broadly grouped: Communications, Electronic Warfare, Radar, and Calibration. Many functions within these groups have been selected for demonstration. Others that can be defined in terms of the apertures, hardware, and test bed software can be added later. Currently, Communications include line-of-sight using the Ku-band Tactical Common Data Link (TCDL) as well as satellite communications, both commercial Ku-band and a military link at X-band. Within Electronic Warfare, Electronic Attack (EA) provides noise and deceptive jamming. Electronic Surveillance (ES) fulfills High Probability of Intercept (HPOI) and Precision Direction Finding (PDF). A surface navigation function is demonstrated within the Radar function. Array and subsystem calibration, functional characterization, and diagnostics—all critical to dynamic maintenance of test bed operation—are part of the Calibration group. Other shipboard functions can now be added by using the hardware and software developed in this program.

The cornerstone for this work is the flexibility engendered by broadband dual-polarized phased array antennas that operate under the control of common system resource allocation manager (RAM) software. Together with a real-time control network, all the functions are defined. Figure 1 illustrates the receiver array partitioned (independently controlled parallel receive array channels, or ports, are shown separately

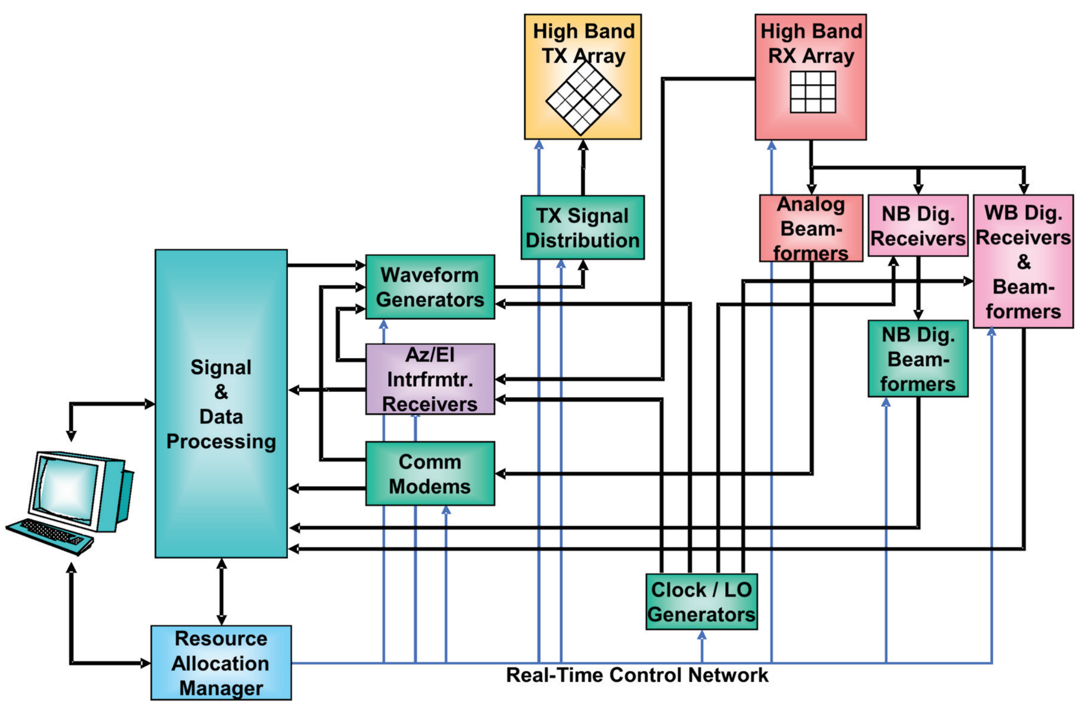


**FIGURE 1**
AMRFC receive array and transmit array, illustrating selectable partitioning to support RF functions. Difference in angle orientation reflect individual contractor's approach.

in the diagram) and grouped in several different ways; partitioning of the transmitter array into four quadrants is also shown. The receive array also includes a set of nine elements for an interferometer that supports the HPOI and PDF functions and two auxiliary elements for use in the EA function. Although the arrays operate in close proximity, the design of the installation provides greater than 100 dB isolation. This arrangement allows simultaneous use of both arrays, an important requirement for multifunction operation. It also suggests that offboard cooperative transmitters could be used to enhance ship stealth. Figure 2 is a high-level block diagram of the test bed. Receive array, receivers, and digital beamformers have been developed by Lockheed Martin, transmit array by Northrop Grumman, and analog beamformers by Raytheon. Other hardware and software (shown in green) were developed by employees of the Radar Division, Tactical Electronic Warfare Division, and Space Systems Department at NRL; Dahlgren Naval Surface Warfare Center; Patuxent River Naval Air Warfare Center; and Digital System Resources. All work leading to the design of these equipments was the result of an extensive review and critique process by an all-Navy team. Component specifications, such as transmitter modules and receiver components, were guided by the functional requirements selected for testing and others that may be needed in the future. A modular open-system software architecture was designed to accommodate new RF functionality, new hardware resources, and upgrading. This includes RF functional software, core operational software, and the test bed operating system.

**AMRF Concept Successfully Demonstrated at CBD:** Figure 3 is a view of the test site at CBD. The radomes and integrated antenna arrays are mounted on a 15-deg slope, emulating a shipboard deckhouse installation. Equipment packaging uses seven converted 20-ft shipping containers to protect equipment and to enable relocation to other sites or aboard ship. The CBD test site also provides an overwater test range with some receiver and transmit instrumentation located about 17 km across the bay at Tilghman Island.

Initial testing began in the summer of 2004. Functions in the Communication group demonstrated data links via two satellites, Telstar-11 and DSCS WLANT. Significantly, measured signals differed from predicted values by only 0.5 dB. It also included demonstration of Ku TCDL, including two simultaneous high-quality video feeds and full duplex voice communications, and tracking of air platforms to over 37 km and sea platforms to over 18 km. Detection ranges of the Radar function, operating over a 7-16 GHz band with a low-power single-pulse waveform, exceeded predictions. The Electronic Attack function, generated range gate pull off and multiple false targets countermeasures. It also successfully responded to four missile seekers and three targeting radars. Exercise of

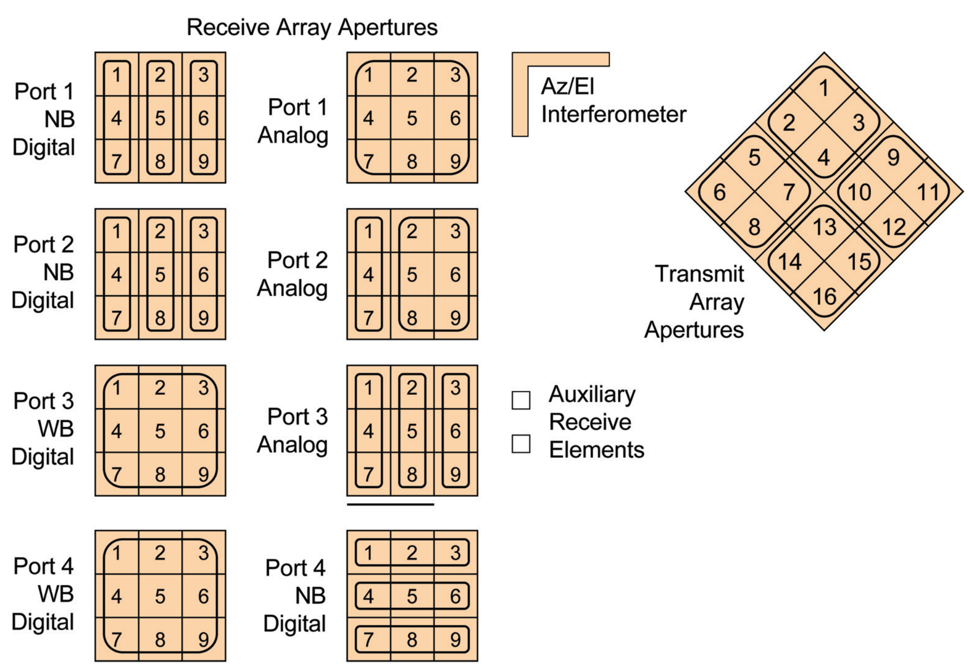


**FIGURE 2**
Test-bed functional block diagram of the major subsystems.


**FIGURE 3**
AMRFC test-bed at NRL's Chesapeake Bay Detachment Test facility.

the antenna polarization diversity, a part of this function, was also successful. The Electronic Surveillance function successfully demonstrated digital channelized receivers for each of the array embedded elements. Emitters of opportunity, including those aboard a P-3 aircraft, an NRL boat, and Tilghmann Island navigation radars, were successfully detected. The Calibration function is critical to the dynamic maintenance of the test bed operation. To date, it has provided initial function calibrations and implemented a transmit calibration mode.

The success of our contractor and Government team in fulfilling the goals of this program and in the various aspects of the design, hardware, software, and testing emphasize the recurring theme that the AMRFC test bed is dealing with various *functions*, rather than *systems*. The former implies flexibility; the latter reflects increasing proliferation of special above and below decks equipments.

[Sponsored by ONR]