

Low Cost Phased Arrays

PROBLEM/OBJECTIVE

Problem

Electronically scanned antennas offer numerous advantages in communication systems over conventional "fixed" reflectors. These include higher pointing speeds, no moving parts, graceful degradation and the capability of developing multiple independent beams from the same aperture. The historical obstacle to more widespread implementation has been the high cost of these arrays. Implementation has been limited to applications where performance requirements forced a phased array solution or in cases where the higher array costs actually minimized overall mission costs.

Objective

The primary objective of this effort was to develop and demonstrate an affordable phased array antenna architecture. The key aspect of this development was the development of a methodology that would yield an architecture that would be applicable to a broad range of frequencies and applications, not simply a point solution. As a proof of concept, the methodology was to be tested by developing a phased array with comparable performance to the Radio Access Point Array (RAPA). RAPA was selected as the target for this array because of the multiple successful Comm-On-The-Move performance demonstrations conducted using this array. The most recent, the JSCOPE demonstration held in June of 1999, where a 15 MB data link between a UAV and HMMWV mounted RAP array was demonstrated. The vehicle with the individual transmit and receive arrays are shown in the figure below.

The cost of the antenna system as fielded was in the \$500K range. The affordability objective of this program was to achieve a 10:1 cost reduction in the array without sacrificing any critical performance parameters.

ACCOMPLISHMENTS/PAYOFF

Accomplishments

The fundamental design concept for the DUAP arrays is the elimination of the individual T/R

modules and the use of a multi-layer printed wiring board (PWB) to make the digital and RF interconnections required. Numerous material trades were performed to establish a production methodology that made the maximum use of existing low cost manufacturing capabilities while still making allowances for the incorporation of emerging process, material & component technology. A key aspect of this architectural solution is to leverage commercial production methodology and commercial user volumes to drive the array costs down.

Both a transmit and receive array were developed using this module-less printed wiring board approach. These arrays were tested and found to provide the same or better performance, with less weight, smaller size and less power dissipation than the original RAP arrays. Furthermore, the arrays achieved the overall cost objective of a 10:1 cost reduction. The receive array with its radome removed is shown in the figure below.

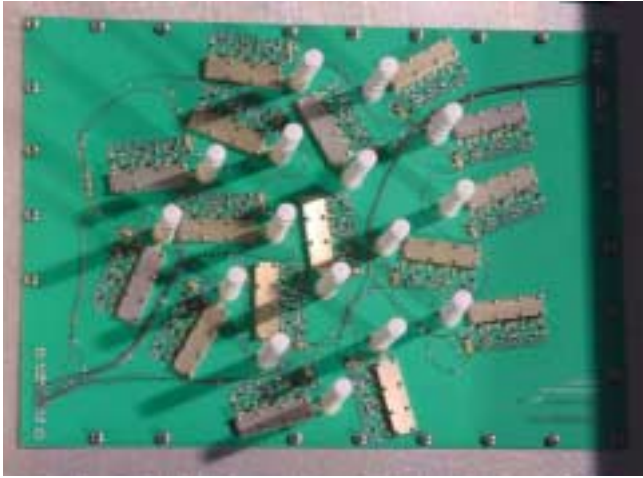


A comparison of the original RAP Rx array and the low cost array is provided in the table below.

Parameter	DUAP	RAPA
Size (inches)	22 x 22 x 1.5	22 x 22 x 11
Weight (lb)	35	85
Power Consumption (Watts)	50	828
G/T (Boresight) dB/°K	2.4	2.4
Loss @ Scan	$\approx 20\log(\theta)^{0.7}$	$\approx 20\log(\theta)^{0.8}$

A close up of the transmit array with its radome removed is shown in the figure below.

Low Cost Phased Arrays



A table comparing the original RAP array and the low-cost array is shown below

Parameter	DUAP	RAPA
Size (inches)	22 x 22 x 7.2	22 x 22 x 11
Weight (lb)	50	85
Power Consumption (Watts)	135	828
EIRP (Boresight)	49.9 dBm	50
Loss @ Scan	$\approx 20\log(\theta)^{0.5}$	$\approx 20\log(\theta)^{0.8}$

Payoff

Overall, the Program has met all of its objectives, providing a 10:1 cost reduction while maintaining key array performance objectives. Low cost transmit and receive arrays were designed, fabricated and tested. This development has demonstrated the viability of the multi-layer PWB concept for phased arrays. A layout approach has been refined that utilized the Cadence tool suite which allows schematic checking and design rule checking in most instances and the extraction of component placement data for the pick and place machines. In addition we have verified that multiple vendors have the capability to fabricate and test a majority of the board with standard PWB test equipment. Based on analysis and simulation the concept is directly applicable from frequencies below 1 GHz to frequencies in the 15 GHz range. In the range of 15 to 20 GHz higher levels of integration may be required depending on the amount of electronics to be associated with each element (e.g. the number of beams). Above 20 GHz, most applications will require higher levels of integration because of the relatively small element spacing. This higher frequency range will be the subject of evaluation for the new

DUS&T Agreement recently signed by Harris and CECOM.

Because of the sensitivity of total array cost to phase shifter cost, the effort to define a high performance low cost phase shifter will continue. The most likely near term candidate for low cost phase shifters is the thin film ferroelectric-based device. The first production ferroelectric phase shifters were just delivered to Harris by Agile Materials Inc. A photograph of one of the first production wafers is shown below. Initial results indicate the devices have comparable performance to MMIC devices at a significantly lower cost.

Expected Benefits:

The low cost array will allow the incorporation of antennas capable of Comm-On-The-Move at the unit of action level. Technology advances like the ferroelectric phase shifter offer even more dramatic cost reductions in the near future.

TIMELINE MILESTONES

Start Date: October 1998

End Date: June 2002

Initial Army Fielding:

Current plans call for the implementation in Harris' portion of the WIN-T Program and Block II of the FCS Communication System

Other Dates as Appropriate

The DUS&T Program is focused on the extension of this low cost technology to 20, 30 and 44 GHz. This program was awarded to Harris in May of 2002. The DUS&T program is schedule to run through the third quarter of CY 2005. Ferroelectric device development and production is anticipated during this program.

FUNDING

Total Funding: \$3,660K

Harris Funding Total: 2,200K

Army COSSI, ManTech, or RM&S Total: \$1,460

Other PE Funding Amount:

Cost Sharing: