Spectrum Access R&D (SARD) Program:
An Update on the Conformal C-Band/Multi-band Antenna Project

Scott Kujiraoka, Russell Fielder, Maxim Apalboym and Michael Chavez
NAVAIR-Point Mugu and China Lake, California

ABSTRACT

In September 2016, work was initiated on the subprojects which comprise the Conformal C-Band/Multiband Antenna project: SARD #1: Broadband Conformal C-Band Missile Wraparound Antennas; SARD #2: Beam Switching Array Antennas; SARD #3: Multiband Conformal Antennas for Aircraft Applications; SARD #4: High Altitude Coronal Efforts on Antenna Performance; and SARD #5: Small, Medium Gain Multiband Receive Antennas. A brief status of each of them will be discussed and detail the technology areas being developed by each.

KEY WORDS

C-Band Telemetry, Conformal Wraparound Antennas, Spectrum Access, Spectrum Selloff.

BACKGROUND

The Spectrum Access Research and Development (SARD) Program is a $500 million Program created by the Federal Government selloff of frequency spectrum to commercial wireless companies such as Verizon, AT&T, Sprint and T-Mobile. The funding is used to support the augmentation of telemetry operations at Government Test Ranges to operate in the C-Band frequency range. Since this project is mainly related to Telemetry Operations, it is being managed out of the Test Resource Management Center (TRMC).

BROADBAND CONFORMAL C-BAND MISSILE WRAPAROUND ANTENNAS

The initial increment of funding was received at NAWC-WD, however it is was so small that it provided for only minimal support. Additional funding has now been received so all efforts can fully commence. Below are the efforts that will be developed under this project.

Further studies will be conducted with the assets developed under the previous C-Band Telemetry (TM) S&T effort. These studies would include conducting additional test flights over the water to further characterize the effects of multipath on C-Band TM reception. Contrary to the original theory that the multipath effects operating at C-Band would be less disruptive than at S-Band; initial flight data while taxiing on the flight line prior to takeoff showed that the multipath interference was greater at C-Band to the point of not receiving C-Band TM data until the test asset was airborne. Using data retrieved from these additional test flights flying close to the surface of the water, studies will be conducted to mitigate the effects of multipath on TM data reception.

Once again taking assets from the original C-Band TM S&T effort, continue the development on the C-Band TM antenna to cover the entire frequency range (4400-5150 MHz) as well as stabilize the antenna gain over this frequency range. The original design will be optimized to simplify the fabrication of the antenna and to increase the operating frequency range of the antenna. Some design tradeoffs may have to be done such as stabilizing the antenna gain at the expense of decreasing the operational bandwidth of the antenna.

BEAM SWITCHING ARRAY ANTENNAS

In a rolling missile, in order to maximize gain and directivity, it is desirable to be able to steer the beam to always be pointing in the direction the TM receiving stations. By accomplishing this feat, the benefit would be the need for lower transmitter power and antenna gain. This would partially alleviate the overheating issue within the TM unit as well as simply the TM antenna design. In addition, the developed system needs to maintain the ability to track a spinning five inch diameter missile with a Roll Rate in the range of 10-30 Hz.

This subproject was awarded to Georgia Tech Research Institute (GTRI). For their initial design, a fractal antenna was used to achieve the broadband antenna performance. Multiple elements were combined to cover 60 degrees around the circumference of the missile. This design included a microprocessor design to control a switch matrix to turn on and off antenna elements. This involves the use of an Inertial Measurement Unit (IMU) to determine the location of each antenna element as it was spinning. Currently there are issues locating a reasonably inexpensive IMU which can track Roll Rates as high as 30 Hz. A more detailed discussion of this topic is covered in another paper presented at this Conference entitled "Steered Conformal Array for the Rotating Airframe Missile".

MULTI-BAND CONFORMAL ANTENNAS FOR AIRCRAFT APPLICATIONS

In order to support the augmentation of C-Band TM operations in Navy jets, the existing upper (Door 4) antenna panel has to replace the existing S-Band TM antenna with a tri-band (L, S and C-Band) one. This subproject has been awarded to Toyon Corporation (Goleta, CA). They are currently awaiting the finalization of the requirements document in order to be fully engaged in the development effort. Originally Space Time Coding (as defined in RCC-106-15) was to be used to address the issues of antenna nulling caused by the close proximity of the two panels. However it has since been dropped from the Requirements Document.

HIGH ALTITUDE ANTENNA PERFORMANCE UNCERTAINTY

Like all of the other subprojects, this Technology Gap called out in theTri-Service C-Band Roadmap Study (TSCRS see Reference [1]) was submitted by the US Army at the White Sands Missile Range (WSMR). Due to increased atmospheric losses of operating in C-Band and other effects, these TM operations will require an increase in the power requirements. As a result, TM operations in C-Band will lead to unquantifiable coronal ionization discharges of RF/EMI prior to the RF energy radiating from antenna elements. In order to characterize this issue, high altitude chamber tests are planned to investigate the interaction of C-Band frequencies coupled to RF transmission components in the presence of low density gasses injected into a vacuum. It should be noted there were no bidders in the original Call for Proposals. The personnel at WSMR have re-edited the solicitation announcement so that the Request for Proposals (RFPs) will be resubmitted during the next phase of the SARD Program.

SMALL, MEDIUM-GAIN MULTI-BAND ANTENNAS

This Technical Gap from the TSCS Report (Reference [1]) was submitted by Aberdeen Proving Grounds (APG). They had required a small (2'-4' in diameter) ground station antennas for surface vehicle weapons systems test. This requirement came from the need to have high slew rate tracking antennas for close in surface test flights. Vendors claim comparable performance to single band tracking antenna systems, however actual testing of multi-band antennas have shown degraded performance in the lower L-Band. APG's lack of commercially available small, medium-gain (15-25 dBi) multi-band tracking antennas has driven the requirement for this effort. This subproject was also awarded to Georgia Tech Research Institute (GTRI). They are also using a Fractal Broadband Antenna to cover the three frequency bands (L, S & C Band). In addition, they are using an in-house design to support the 8:1 Combiner Design which will be used in the Digital Beamforming Network.

FOLLOW ON THOUGHTS

The original business model of SARD was to send all $500M to Picatinny Arsenal for contract award. Unfortunately, they did not anticipate that use of 'in-house' government resources to perform some of the development work. As a result it has been extremely difficult having funding sent directly to Government Field Activities. Hopefully in the Follow-on $500M Program, many of these funding issues can be straighten out.

REFERENCES

[1] Tri-Service C-Band Roadmap Study (TSCRS): Gap Analysis and Technology Shortfalls Report (dated 24 September 2014).