Why

• National Broadband Initiative (22 Feb 2012)
  – Repurposing of 1755 to 1850 MHz
  – Potential to lose 2200-2290 MHz

• Lower (4400-4940 MHz) and Mid (5091-5150 MHz) C-Band provide alternatives

• Initial Project funded by S&T SET in April 2012
  – 2.5 year effort
  – Compare TM performance between C-Band and S-Band
Test Series Overview
Objectives

• Assess end-to-end data link quality of C-band telemetry links from a missile test platform
  – Over land and over water
  – High altitude and low altitude
  – With and without Low Density Parity Coding (LDPC), Forward Error Correction (FEC)
  – Captive Carry & Live-Fire Test Flights

• Determine tracking loop performance of receiving antenna systems with multi-band feeds against a missile test platform
  – Acquisition with C-band vs. S-band
  – Tracking with C-band vs. S-band
  – Over land and over water
  – Low slew-rate tracking/high slew-rate tracking
Test Series Overview
Flight Tests

• Five Tests total accomplished over 6 events-
  1. Sea Range C-12
     • Low $E_b/N_0$
     • Low Grazing Angle
  2. Sea Range F-18 Captive
     • Various altitudes
  3. Land Range F-18 Captive (two events)
     • High and Low altitude
  4. Land Range F-18 Live-Fire
     • Track through launch to impact
  5. Land Range F-18 Captive 2
     • High Slew Rate
Two modified AN/DKT-89 Telemeters

- Two PRN-15 “data” transmitters
  - C-Band & S-Band at 10 Mbps, SO-QPSK, 5 watts
- JAMI TSPI Unit for captive and free-flight TSPI
  - Independent S-Band transmitter
  - combined into standard S-band antenna
- C-Band stream transmitted through AISD developed conformal strip-line antenna
  - Tuned to selected transmission frequency
  - Lower C-Band and Mid C-Band
Test Series Overview
Mounted onto Missile & F-18

Two missiles fabricated:

- TM units replaced warheads
- Electrically nulled guidance electronics
- “Dummy” AOTD
- Inert and live rocket motors
F-18 Captive Carry Flights

Summary of Results-

- LDPC Forward Error Correction (FEC) link outperformed uncoded link in terms of Link Availability
  - Adds link budget
  - Will not mitigate multipath

- General Tracking Performance
  - Comparable Performance between S-Band and C-Band
  - Some disparity between C & S at 500 ft. altitude from beach sites
    - C-Band had approximately 40% less link availability

- Operator Feedback
  - Experienced difficulties in C-Band during flight-line TM check
  - Difficulty to acquire track in C-Band
• Spectrum Selloff to Commercial Wireless Companies
  – 1780-1850 MHz
  – Verizon, AT&T, T-Mobile, Sprint…
  – Thousands of Contracts worth $46B
  – First of many auctions

• Spectrum Access Research & Development (SARD)
  – $500M Program
  – Support Government Test Ranges transition to C-Band
Conformal C-Band/Multi-band Antennas

• Follow on Project funded through Test Resource Management Center (TRMC)

• Consists of five subprojects identified as Technology Shortfalls in the CTEIP funded TSCRS (Tri-Service C-Band Roadmap Study) Report
  – Subproject #1: Broadband Conformal C-Band Missile Wraparound Antennas
  – Subproject #2: Beam Switching Array Antennas
  – Subproject #3: Multiband Conformal Antennas for Aircraft Applications
  – Subproject #4: High Altitude Coronal Efforts on Antenna Performance
  – Subproject #5: Small, Medium Gain Multiband Receive Antennas
• Conduct further studies with assets developed under previous C-Band TM S&T effort

• Additional test flights over the water will be conducted to further characterize the effects of multipath on C-Band TM reception

• Using data retrieved from these test flights flying close to the surface of the water, conduct Multipath Mitigation studies

• Conduct further 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
• This subproject will be advertised through the BAA process to fund Spectrum Consortium participant. Only entities registered in the Spectrum Consortium can submit proposals.

• In a rolling missile, it is desirable to be able to steer the beam to maximize gain and directivity.

• The benefit would be lower transmitter power and antenna gain requirement.

• Develop system to achieve TM beam steering with the following variable design parameters:
  – Missile Roll Rate
  – Missile Diameter
• Re-design the existing antenna panel on the top and bottom of the F-18 and replace them with a tri-band (L, S and C) TM antenna.

• Space Time Coding (as defined in RCC-106-15) will be used to address the issues of antenna nulling caused by the close proximity of the two panels.
• Technology Gap submitted by US Army (WSMR)
• Operating in C-Band will require increases in power requirements.
• Power increase will lead to unquantifiable coronal ionization discharges of RF/EMI prior to the RF energy radiating from antenna elements.
• Includes high altitude chamber tests to investigate the interaction of C-Band frequencies coupled to RF transmission components in the presence of low density gasses injected into a vacuum.
Subproject #5: Small, Medium Gain Multiband Receive Antennas

- Technical Gap submitted by (Aberdeen Proving Grounds)
- Small (2’-4’ in diameter) ground station antennas are desirable for surface vehicle weapons systems test.
- 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.
Summary

- Funding to arrive in the May 2016 timeframe.

- Due to time constraints, Subprojects #1 and #3 will be worked on during FY16 with the other three are set to commence during FY17

- Entire project is scheduled to last five years in duration