Test Instrumentation Workshop (TIW)

Conformal C-Band/ Multiband Antenna Project

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Background (Initial S&T Project)

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

Test Series Overview
Test Articles

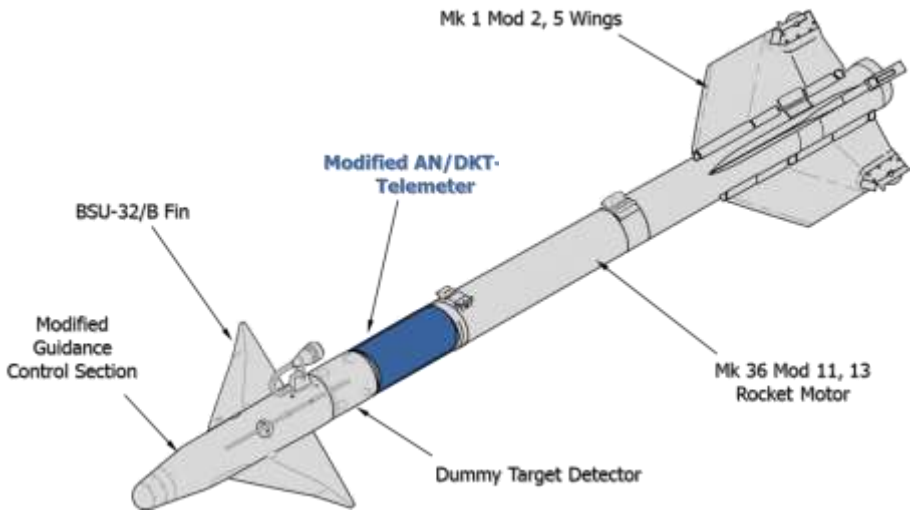
Two modified AN/DKT-89 Telemeters

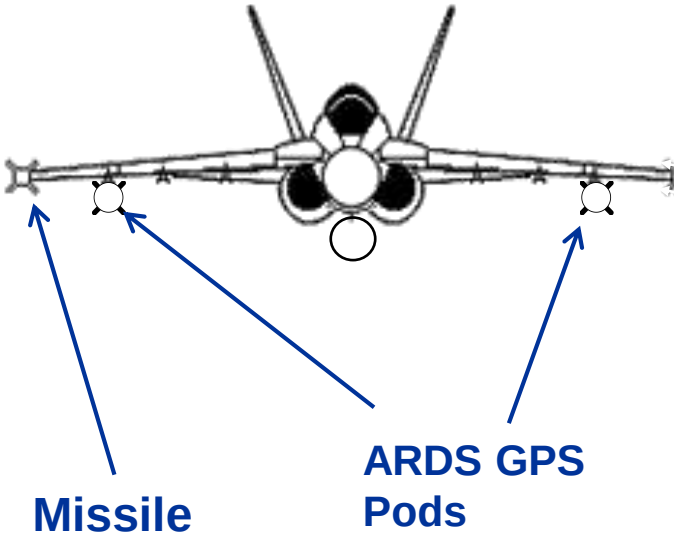
- **Two PRN-15 “data” transmitters**
  - **C-Band & S-Band at 10 Mbps, SO-QPSK, 5 watts**
- **JAMI TSPI Unit for captive and free-flight TSPI**
  - **Independent S-Band transmitter**
  - **combined into standard S-band antenna**
- **C-Band stream transmitted through AISD developed conformal strip-line 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**

Background (SARD Program)

- **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**

Subproject #1:
Broadband Conformal C-Band Missile Wraparound 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**

Subproject #2:
Beam Switching Array Antennas

- **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**

Subproject #3:
Multiband Conformal Antennas for Aircraft Applications

- **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.**

Subproject #4:
High Altitude Coronal Efforts on Antenna Performance

- **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.**
- **Lack of commercially available small, medium-gain (15-25 dBi) multi-band tracking antennas.**

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**