USING COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS (CRADA) TO REDUCE THE TRANSITION TO PRODUCTION RISK OF A MISSILE TELEMETRY SECTION

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ABSTRACT

The Joint Advanced Missile Instrumentation (JAMI) Program's main thrust has been the integration of Global Positioning System (GPS) tracking technology into the Department of Defense (DoD) Missile Test Ranges. This technology could be used for Time, Space, Position, and Information (TSPI), Flight Termination (FTS), or End Game Scoring purposes. However the Program's main goal is to develop Proof-of-Concept components only. Transitioning Missile technology developed by the Government to Private Industry, so that it can be economically mass produced, has been quite a challenge. Traditionally, private industry has had to bid on proposals without much detailed information on how these components have been designed and fabricated. These unknown risks, Non-Recurring Engineering (NRE) and Missile Flight Qualification costs, routinely have significantly increased the price of these procurement contracts. In order so that the Fleet can economically utilize these components in the field, Cooperative Research and Development Agreements (CRADA) between the Government and Private Industry have been used to successfully transition Government developed technology to mass production. They can eliminate the NRE and flight qualification costs to provide for an economical and low risk method of providing the Fleet with the latest advances in GPS Tracking Technology. This paper will discuss how this is currently being accomplished in the development of a conformal wraparound instrumentation antenna for a five-inch diameter Missile Telemetry (TM) Section.

KEY WORDS

Global Positioning System (GPS); Time, Space, and Position Information (TSPI); Flight Termination, Missile Telemetry, Cooperative Research and Development Agreement (CRADA).

BACKGROUND

JAMI is a Central Test and Evaluation Investment Program (CTEIP) sponsored by the Office of the Secretary of Defense (OSD). CTEIP's main charter is to develop Proof-of-Concept products that can eventually be transitioned to the field. JAMI is tasked with developing a suite of GPS and FTS components that are approved for use in any weapons system currently fielded. The list of components includes GPS based devices for Time, Space, & Position Information (TSPI); Range Safety; and End Game Scoring applications. The purpose of the AIM-9X TM development effort is to demonstrate the use of all of these capabilities in a single package for a small diameter missile that can be tracked on a Government Missile Test Range.

The design requirements are to:

1) Provide data analysts with missile telemetry data that is compatible with the current telemetry systems.
2) Provide GPS based tracking for TSPI and Range Safety purposes.
3) Provide facilities to implement an approved flight termination system for the AIM-9X missile at a later date.

Design objectives include:

1) Improve bandwidth efficiency by implementing SO-QPSK modulation techniques.
2) Provide field-selectability of frequencies from 2200.5 MHz to 2289.5 MHz.
3) Provide post flight trajectory analysis capability for End-Game Scoring.

TRI-BAND ANTENNA

Developed in-house by the Weapons Instrumentation Division at Pt. Mugu, the AIM-9X/JAMI TM system employs a single-piece, conformal wrap-around antenna that contains three separate antenna systems: a TM transmit antenna, a GPS receive antenna, and a FTS receive antenna.

The FTS antenna has two separate feeds - one for the primary flight termination receiver (FTR) and another for the secondary FTR. The Wilkinson Power Divider is incorporated within the antenna substrate, which eliminates the need for an externally mounted one. Likewise, a Notch Filter is also contained within the Feed Network Board to prevent the TM output signal from the transmitter from coupling into the GPS Receiver. The Limiter & Low Noise Amplifier for the GPS Receiver are active devices embedded within the antenna substrate as a space saving measure, which receives its power from a DC bias voltage applied to the RF signal input to the receiver.

ANTENNA DEVELOPMENT CHALLENGES

Due to the tight radius of curvature (5”) and thickness of the antenna (0.150”), single antenna boards have cracked during the lamination process. As a result, initially a six antenna-board stack has been implemented (i.e. a stack of thinner boards had to be used instead of one thick board) for the JAMI Effort. In addition, to accommodate the narrow bandwidth of the FTS antenna, stiff RT/Duroid 6002 material had to be used instead of more pliable RT/Duroid® 5870 material. Traditionally the 5870 material had been used for GPS and TM applications due to its ease of conformability to missile shapes. However the dielectric constant (which affects the operating frequency of an antenna) has been known to be relatively unstable over temperature. Since the FTS antenna has such narrow bandwidth (because of its low operating frequency), the 6002 material needs to be used for its stable dielectric properties. When the prototype JAMI/AIM-9X antennas were constructed for both the JAMI Configuration #7 Flight and JAMI/AIM-9X Captive Carry Flight, a special tool had to be constructed to install the stiff antenna onto the Telemeter Housing. It should be noted that this installation procedure would be cumbersome in a production environment.

In addition to the stiffness issues, the current Proof-of-Concept JAMI antenna design has the following shortcomings.

- The TM antenna elements have to be manually tuned.
- The existing bandwidth (65 MHz) does not satisfy the required TM bandwidth (90 MHz).
- The locations of the four antenna connectors, the antenna element feeds, and the FTS antenna shorting-wires are extremely difficult to solder reliably.
- During the Captive Carry Flight, one of the antenna ports failed. The failure was traced to a cold solder joint, and the vibration of the captive carry flight more than likely caused the failure.

MITIGATION

In order to minimize the impact of the demise of the one-piece antenna design, a Creative Research and Development Agreement (CRADA) has been established with TECOM Industries to split the existing one-piece tri-band JAMI antenna into two-pieces (GPS/TM and FTS). The CRADA has been approved by both NAWC-WD and TECOM Industries. The Agreement establishes a means for NAWC-WD to transition the design of the antennas (GPS/TM and FTS) for the AN/DKT-89 Telemeter to TECOM for production purposes. Under the agreement, NAWC-WD would provide the design expertise and TECOM would provide the manufacturing processes expertise. Both parties would share in the development and design qualification duties. After the completion of the CRADA, the government will have a qualified source for the procurement of these antennas. This should save the government money, since TECOM is able to competitively price the antennas due to the fact that most of the risk of development (no NRE required) and qualification has been eliminated by the use of the CRADA.

CURRENT EFFORTS

The lessons learned from the Captive Carry Flight will be implemented in the new version of the antenna. The splitting of the antenna allows for ease of installation of the connectors since they would be located at the forward edge of the antenna. The number of antenna boards required would decrease. The axial length would decrease causing a reduction in the force needed to install the antenna onto the housing. The TM elements have been simulated to achieve a larger bandwidth. Rivets will be added to securely attach the contact between the antenna connector and antenna board. This is the same method that has successfully been used on several Army projectiles that are launched with much higher launch shock levels. In addition, the feeds on the antenna board will provide for better connection reliability.

CRADA Meetings are being held on an on-going basis. There still is one main issue that needs to be resolved before the antenna can be mass produced. The issue is whether or not the amplifier and limiter should be installed directly onto the substrate of the antenna or if a drop-in board, that contains these components, should be used. The drop-in board may streamline the production of the antenna; however there still are possible mechanical issues with attachment (i.e. during vibration). A study is currently being conducted to address all of the advantages and disadvantages of the two approaches.

SUMMARY AND FUTURE PLANS

The current developmental status of the conformal wraparound instrumentation antenna to provide TM & GPS tracking capability to the AIM-9X Missile has been discussed. The use of a CRADA should provide for a smooth transition from development to production of the antenna. If this is successful, the same strategy will be used for the FTS antenna as well.