The Marine Corps Third Echelon Test System (TETS) A New Approach to ATS Acquisition

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Abstract - In June of 1994, Secretary of Defense William Perry directed that DoD acquisition should make maximum use of commercial standards to meet Automated Test Systems (ATS) performance specifications. In response, the Marine Corps began the process of re-evaluating the specifications to procure a ruggedized, forward-deployable test system based on Commercial Off-The-Shelf (COTS) technology that would be able to withstand the demanding environment in which the tester would be deployed.

This paper will describe the approach taken by the Marine Corps in the TETS procurement process to specify the ATS at a requirements level, with a stringent adherence to open commercial standards.

This paper will focus on a unique phase of the procurement and the bid sample period. As part of the procurement process, offerors for the TETS contract were asked to submit prototype units to the Marine Corps, prior to final contract award. The bid sample units were subjected to rigorous environmental testing, conducted by the Naval Research Labs (NRL) at Seal Beach, California, to ensure that the Marine Corps requirements could be met under worst-case conditions. This paper will also describe the post-award Field User Test (FUT) field training and evaluation period, where TETS underwent field testing at Camp LeJeune in Jacksonville, North Carolina.

In closing, the status of the TETS program will be presented along with an outlook for key milestones over the next phases of the program.

I. INTRODUCTION

If people in a work or home environment lose power briefly - it is an inconvenience. However, if an M1 tank or a satellite communications system goes down, it is not only an inconvenience, it could cost the lives of our fighting Marines and have a definitive impact on the outcome of the battle. During the Gulf War, the tactical vehicles in need of repair were forced to pull back to their support areas, forty to fifty miles behind the front. This clearly identified the need for electronic repair support on the forward edge of the battlefield, a need which will be filled by TETS. With TETS, weapon and communication systems will not have to be out of commission for that extended period of time. The purpose of TETS is to provide a portable maintenance capability that supports three Marine Corps maintenance roles:

a. TETS will fault isolate a wide variety of weapon and communication systems Line Replaceable Units (LRU) to the faulty Circuit Card Assembly (CCA) or Secondary Repairable Units (SRU).

b. TETS will perform CCA or SRU screening.

c. The components of TETS will operate as stand alone instruments when not being used in the automatic mode.

TETS will be able to provide support at the reserve troop staging areas and refueling points which are typically within ten to fifteen miles of the front lines. TETS is a highly mobile tester and can be operated from any tactical vehicle with a NATO slave connector. TETS does not require a controlled climate in which to operate and TETS can support a wide variety of weapon and communication systems.

The acquisition of TETS, which started out as a full military specification acquisition, was caught in the winds of change. The change was in both DoD acquisition policy and DoD interoperability of its automatic testing requirements. This paper will focus on the unique approach to the use of bid sample and field user's testing as a part of the acquisition process for TETS.

II. HISTORY

During the Gulf War, many of our fighting vehicles became incapacitated but the conflict was over so quickly no real effect was realized. Had we been engaged for a longer period of time, the loss of tactical vehicles and communication systems might have become a more serious issue.

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The TETS Program began in May of 1992 by LtCol Edward Lewis, then head of Marine Corps Systems Command (MARCORSYSCOM), Program Support, Test, Measurement, and Diagnostic Equipment (PM-TMDE). The Automatic Test Support (ATSU) Business Center, Marine Corps Logistics Bases, Albany, Georgia, was given the task of proving the concept of a system that could give the Marine Corps a portable maintenance capability that could operate from tactical vehicle power. The ATSU looked at the fielded Automatic Test Equipment (ATE) systems, such as the U.S. Army's Intermediate Family of Test Equipment (IFTE), the U.S. Navy's Consolidated Automated Support System (CASS), Pentastar's Direct Support Electrical System Test Set (DSESTS), and emerging technologies, such as virtual instruments (VI), instruments on a card (IAC) and VME Extensions for Instrumentation (VXI). The VXI solution appeared to be the most promising due to wide supplier participation in the VXI consortium and the fact that it provided a COTS solution.

After a Proof of Concept, research and development funds for the procurement of two prototype TETS were provided by PM-TMDE. A TETS System Specification was developed using a Contact Test Set Mission Needs Statement dated 21 January 1993 and a Digital Test Mission Needs Statement dated 1 October 1992. Test requirements for the DRAGON, TOW, MULE, LAV-25, and LAV-AD systems were used for this specification. The draft TETS System Specification, dated 1 July 1993, was published as the first Request For Information (RFI) to commercial offerors on 9 July 1993. Over seventy offerors requested a copy of the first RFI package. The first RFI contained the initial TETS System Specifications and was deemed by the respondents to be too vague.

The Marine Corps was well aware of the investment required by the offeror for the bid sample, as we have also built two prototypes ourselves. Originally, we were proving to the Marine Corps that VXI technology was the best technology to use for TETS. The first system we built was configured primarily with equipment from a single vendor who, at the time, had the most equipment of this type available. After development of the first prototype, we developed a second prototype system that had a variety of instruments from a variety of manufacturers, as this would probably be the composition of the instrumentation in TETS. The actual porting of the TPS from one system to another was a great success. During the development of the prototypes, there was no such thing as a DC powered VXI chassis and the ruggedized chassis, as a viable commercial product, was just coming onto the market. These prototypes were demonstrated at AUTOTESTCON '93 in San Antonio, Texas and won the "Best Technical Presentation Award" for military displays.

The second RFI was released on March 30, 1994, it contained the compilation of Critical Item Product Function Specifications (C2a per MIL-STD 490) for each instrument in TETS, and it was deemed by prospective offerors to be too specific.

From the time of the release of the first RFI to the release of the final Request For Proposals (RFP), two significant events affected the TETS program and contract documentation. The first event was the establishment in April 1994 of an Executive Agent for the Office of the Under Secretary of Defense to review new requirements for DoD ATS. The TETS program was the first to go through reviews by the branches of the service that already had established DoD Families of ATS. These reviews were designed to insure that the requirements of the new ATS could not be met by one of the existing DoD testers. The second event was the release of Secretary of Defense William Perry's Memorandum on Specifications and Standards in June of 1994. In essence, this memorandum directed a review of contract documentation to replace as many military specifications and standards as possible with commercial standards and practices. The effect this had on the TETS requirements documentation was to reduce the military standards and specifications in the TETS Statement of Work and Purchase Description (PD) from 43 to only 16. Of the sixteen military standards referenced, only three required waivers. Those three standards were MIL-STD-461D and 462D dealing with electromagnetic interference (EMI) testing and MIL-STD-100E which dealt with the drawings for the system.

An Operational Requirements Document (ORD) was developed for TETS by the Requirements Division of Marine Corps Combat Development Command in Quantico, VA. The ORD defines requirements such as the operational concept, mission need, system performance, wartime mission scenarios, survivability, natural environmental factors

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and many others. The ORD for TETS was adopted on 31 October 1994. In all there are 34 different requirements in the ORD that TETS must meet.

The draft RFP was released for industry comment on November 28 1995.

On April 2, 1996, the Contracts Directorate at MARCORSYSCOM released the final RFP for TETS, this was a "Best Value" Contract. Eighty-one companies requested a copy of the RFP. A Pre-Bidders Conference was held at MARCORSYSCOM to answer any questions from the RFP. Of the 81 companies, five submitted proposals for TETS contract. The written proposals were evaluated from 2 June 1996 to 19 July 1996. After evaluation of the written proposals, three offerors were chosen to submit a sample of their proposed systems. These systems were then scheduled to undergo bid sample testing.

III. BID SAMPLE TESTING

The bid sample testing began on 19 April 1997 and was completed on 30 June 1997. Testing was conducted by NRL at the Naval Surface Weapons Center in Seal Beach, California and monitored by members of the TETS evaluation team. The TETS evaluation board included representatives from the TMDE Business Center in Albany, GA, the Quantico program office, and field representation. The bid sample method of evaluation was chosen to validate the strategy the offering companies proposed in their written response and to determine the amount of risk inherent in each proposed system. When using commercial equipment to fulfill ruggedized requirements, it is in the best interest of the intended user to insure that the system will remain operational in an environment that in some cases may exceed the original manufacturer's specifications. The bid sample testing was divided into four segments: physical, electrical, EMI, and environmental. In the event that a bid sample system experienced a failure, five of which were allowed for each offeror, the company was contacted and representatives of the company had five working days from the time of notification to arrive at the testing site. Once the representatives arrived, they had 72 continuous hours to effect repairs.

The physical testing included a system inventory, a workmanship review, a size and weight verification, and a review of the setup configuration. The system size objective was 30.47 ft^3, with dimensions of 33 inches high, 42 inches wide, and 38 inches deep [33" x 42" x 38"] [83.82 cm x 106.68 cm x 96.52 cm]. The size threshold was 38.5 ft^3, with dimensions of 33 inches high, 42 inches wide, and 48 inches deep [33" x 42" x 48"] [83.82 cm x 106.68 cm x 121.92 cm]. The maximum weight of the system was to be no more than 650 lbs., with no one box weighing more that 130 lbs. The objective weight for each component in the system was 88 lbs. During physical testing, some significant architectural differences in the three systems were noted. One difference was the distribution of the required Basic and optional RF instruments between the Primary and Secondary chassis, along with the means by which the instruments were connected to the receiver interface. Different approaches were also shown in the integration of the power distribution unit, which can affect the total number of transported components.

Electrical testing included testing the instruments to the specifications as stated in the PD and to the tolerances that the offerors stated for increased instrument capability. Even though the individual system components may have had increased capabilities that the offerors were hoping to receive best value consideration for, the electrical testing validated that these increased instrument capabilities were present at the system interface. Since TETS is to have one hardware interface plane, this is where all tolerances needed to be validated.

As per the PD, the offerors only had to have the basic components of the system, (i. e., the Digital Multimeter, Function Generator, and so forth) in the proper form, fit and function. All offerors chose to supply all instruments VXI solution. The testing of the switches proved to be a challenge. There was some confusion on exactly how to check the isolation of the switch paths. After contacting the offerors, a method of grounding the switches was devised and demonstrated to the evaluation team. The electrical testing ran continuously for nine days.

EMI testing included conducted emissions, conducted susceptibility, radiated emissions, and radiated susceptibility tests. It was determined to use the EMI testing as a benchmark to determine how much effort would be required to bring the system into conformance for First Article Test when the system must meet all requirements to the PD. The EMI testing took 14 days to

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complete for all systems and at times involved around the clock, rotating crews of personnel to perform and monitor the testing.

The environmental testing consisted of loose cargo bounce, functional shock, transit drop, and temperature and humidity variation tests. Environmental testing was performed, per MIL-T-28800E and MIL-STD-810E over a total of 22 days for all systems. The first of the environmental tests to be performed was the loose cargo bounce. This test consisted of each transit case being put inside a wooden frame attached to a vibration table.

The functional shock test consisted of verifying the systems were operational prior to the test. After the verification of operation, each transit component was mounted onto a shock table. The shock table was raised to a predetermined height in order to achieve a maximum shock of 30 Gs. Each transit component was dropped on each side of the transit case three times. After all components were shocked, a visual inspection was performed to look for obvious damage prior to the systems being powered up. The last step was to connect and power up the systems and run the confidence test.

The transit drop test was used to verify that the system can withstand transit drop without degradation. After the verification of operation, each transit component was put into a sling and raised to eight inches above a wooden deck. Insuring that there was no swing to the transit case, it was released on to each face and each corner three times. Upon completion of the test, each transit case was visually inspected and the system was cabled together and the confidence test performed.

Next was the temperature and humidity testing that was to run for a minimum of six consecutive days per MIL-T-28800E. The testing was to be non-condensing. The PD calls for -10° C to +55° C for the system, but the manufacturer's specification for many of the instruments is 0° C to +50° C. Though, it may not seem to be a major leap in meeting the PD temperature requirement, it was determined that even +5° C can make a difference in instrument performance.

The bid sample repair procedure proved to be a challenge not only to the offerors, but to the Government as well. As stated before, the offerors had five working days after notification of a failure and 72 continuous hours to effect repairs. Which would allow time for the offerors to investigate what might have caused the malfunction. The offerors were not limited to who they brought with them to effect repairs. To expedite the repair actions, the offerors had access to telephone and facsimile. Some repairs only took a few hours to complete and others took up to 70 hours before the systems were turned back over for testing.

IV. FIELD USERS TEST

As a requirement for obtaining a Production Decision on TETS, Major General Carol Mutter, then commander of MARCORSYSCOM, directed that a FUT be conducted. The purpose of the FUT was to validate that the TETS Program (i.e., ATE, Test Program Set Development software, and Test Program Sets) met the needs of the Marine in the field and to validate the TETS ORD. The FUT allows the program office and the user to validate the ORD and to submit changes or updates to the ORD as necessary to meet the needs of the Marines. The test data and information provided by the FUT were also discussed at the TETS Critical Design Review.

The FUT was conducted from 23 March through 7 April 1998. Four of the LRIP systems were sent to Camp LeJeune to be used in the field by the Marines who are targeted to receive TETS. The Marines were trained to operate and perform maintenance on the systems. The testing was performed both in the permanent maintenance facility and in the field environment. The operational testing included: system setup, daily preventive maintenance, General Purpose Electronic Test Equipment (GPETE) emulation, LRU/SRU fault detection, LRU fault isolation, system shutdown, and system pack-up. Maintenance testing involved performing operator and intermediate level maintenance actions that included system fault detection and isolation, component replacement, and repair verification. There were 18 different ORD requirements validated during FUT some of those 18 included:

- Operation from a Variety of Power Sources
- TPS Reconfiguration Time
- Operational Availability
- Technical Manuals
- Transportation
- Manpower
- Portability
- Facilities
- Shelters
- Safety

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The FUT assures the higher echelon approving authorities that TETS does meet the needs of the Marine in the field and that it meets the ORD requirements tested, and as such, was a valuable indicator to the procuring office. The true measure of the system came when the Marines loaded TETS in the back of three High Mobility Multi Wheeled Vehicles (HMMWVs) as loose cargo. The Marines took the systems through training areas that are only accessible using unimproved roads to challenge the TETS equipment with potholes and mud puddles. On the completion of the ride, the evaluators met the program office personnel at a remote site and conducted the same testing that was performed back in the controlled environment (garrison). As each system came to life and passed the confidence tests, LRU and stand-alone instrument testing was conducted. The Marines, some of whom were initially skeptical about the usefulness of TETS, were visibly impressed as the systems capably performed their routines. At the conclusion of the FUT, the Marines were asked to comment on the system. The majority stated they would definitely use the system as soon as it is provided. Two comments that stand were, "The systems need to be strapped down in the tactical vehicles," and, "the ability to view the technical manual on CD-ROM has changed me forever, I don't ever want to use a paper manual again." All of the ORD requirements will be tested and recorded again during the TETS First Article Testing process.

V. CONCLUSIONS

Due to the unique needs of the ATS to be ruggedized and to be used in any environment, the Marine Corps was best served by requiring a two-step bidding process: paper proposal and bid sample. In addition, the FUT, which may be a uniquely Marine Corps process, demonstrated its value to both the users in the field and the program office.

Some of the lessons learned in the procurement process will be helpful in future procurement efforts. Prior to the final RFP, there were two RFIs and a Draft RFP that were released during the procurement period. There was also a prebidder's conference held at MARCORSYSCOM approximately three weeks after the RFP was released. In order to cut down on time between reviews, it is recommended that one RFI and the RFP with a pre-bidders conference would be sufficient. In this reduced process, the Government and potential bidders would not incur such a significant draw on resources for a prolonged period of time.

During repair actions, the offerors were given five working days to respond to system failures. After the five days, the offerors were given 72 hours to repair the system. If the failure fell on the right day, say for instance 4:00 p.m. on Friday, the offeror actually had seven days to respond with an additional 72 hours to effect repairs. During this whole time, the system was out of the testing cycle for at most ten days, or one third of the originally planned testing cycle. Granted that the Marine Corps was a little optimistic with a 30 day Bid Sample test but, ten days to effect repairs seems a little excessive. In the future, it would be recommended that offerors be given four calendar days to respond, with an additional 48 hours to effect repairs.

The requirement for a paper proposal was standard in Government procurements at the time of the RFP release. Now there are some alternatives to the paper proposal that are being investigated by the Government. It was the intent of the Marine Corps to use the paper proposal evaluation to gauge how well the offerors understood the requirements for TETS. It was initially believed that ALL offerors would go through Bid Sample process.

The Marine Corps used the bid sample process to reduce its risk in the acquired system, and to view the preliminary design of the proposed system. In the proposal, the Marine Corps sought answers to questions about power utilization, ruggedization, and RF capability. The bid sample provided interesting solutions to those questions.

The changes in attitude of those Marines conducting the FUT showed us the value of the FUT requirement. As systems designers, we can try to understand the Marine Corps requirement and make judgment calls that we feel have merit. Only by putting the system in the hands of its ultimate users in their working environment can we be certain that we have achieved our goal. The Marine Corps ATS Program office has been successful during all phases of development of TETS in having user representation in the decision-making process. This includes those Marine officers and enlisted men at the program office who are responsible for the contracting issues, as well as those enlisted Marines attached to the ATSU Business Center who participated in the TETS development, performed the technical evaluations, and monitored the testing. For the Marine Corps, FUT insured

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that the TETS developers had not lost sight of the ORD requirements or the needs of the ultimate users.

Overall, the acquisition of TETS will have taken six and a half years. During this time many new policies and procedures have been established for DoD acquisition and the procurement of ATE, for the military in particular. Taking into consideration the amount of time spent to formalize these new procedures and policies, the actual time spent on the acquisition was closer to four and a half years. The TETS acquisition has shown that a system composed of COTS and modified COTS equipment, and some commercial practices, can be used to meet military requirements. First article testing will be the final formal test to insure that COTS equipment and procedures meet the needs of the Marine Corps. When TETS completes this final formal test, in September 1998, this will have been one of the fastest procurements for a major ATS.

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