Army Embedded Global Positioning System Receiver (AEGR)

Congressional Mandate Impetus for New, Innovative Army Program

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Public Law 66 legislates, as documented in the Congressional Record, H9194, Nov. 10, 1993:

"Limitation on procurement of systems not GPS-equipped: After September 30, 2000, funds may not be obligated to modify or procure any Department of Defense aircraft, ship, armored vehicle, or indirect-fire weapon system that is not equipped with a Global Positioning System receiver."

As a result of Public Law 66, Army officials managing the Abrams Tank M1A2 Systems Enhancement Program (SEP) determined in December 1995 that in order to comply with the directive, while simultaneously meeting the already demanding requirements of the Abrams SEP, they must embed Global Positioning System (GPS) functionality. By integrating GPS performance characteristics along with the existing, on-board Position/Navigation (Pos/Nav) inertial navigation unit, the Army stood to gain a major combat power enhancement. Further facilitating GPS integration was the fact that the current navigation unit was already dynamically interactive with other on-board subsystems.

Critical challenges to the Army Embedded GPS Receiver (AEGR) program were fourfold:

- The SEP program was already off and running, but less than one year remained on the program schedule for contract solicitation and award; design and development; and generation of prototype hardware without adversely impacting the tank program's schedule.
- A budget-constrained process, the SEP's critical focus was digitization.
- The Vetronics architecture[1] of the tank was already designed and allocated; due to existing constraints and Preplanned Product Improvement (P3I) requirements, only one slot, in the Mission Processor Unit (MPU), was reasonably available.
- GPS was "new" scope, and a contracting vehicle had to be found quickly.

HTI-Based Approach

Army Lt. Col. George Patten, Product Manager, M1A2 Abrams, realized immediately that effectively integrating GPS into the existing navigation unit, while simultaneously exercising sound risk management in several areas, called for a creative solution. Patten and Army Col. Christopher Cardine, Abrams Project Manager, were convinced only an innovative, Horizontal Technology Integration or HTI-based approach would meet the challenges posed by the AEGR program, yet still allow the program to remain within cost, on schedule, and within acceptable performance risk parameters. Together, they determined HTI was the key to satisfying administrative and contractual prerequisites, as well as the Quality Assurance and Logistical demands of SEP's testing and fielding plans.

Patten had to make fast, yet well-informed decisions. Seeking advice from other Weapon System program offices, he contacted Army Lt. Col. Bob Buckstad, Product Manager Avionics, U.S. Army PEO Aviation, who already had experience embedding GPS in the Army's aviation fleet as part of his work with joint programs. Their mutually beneficial exchange of information included GPS contracting options, technical insights, HTI opportunities, and cost information.

Although HTI has several beneficial characteristics—reduction of duplicative nonrecurring engineering efforts, economy-of-scale savings in procurement, and life cycle sustainment benefits—still its implementation routinely runs into programmatic obstacles—chiefly *control*.

- Lead Weapon System Office—The lead weapon system office(s) must "share" control; HTI requires more in-depth, front-end analyses; the "perception" persists that some design compromises may be necessary.
- Trailing Weapon System Office—The trailing weapon system office(s) "feel" that they are giving up some control and funds; they may not get all the

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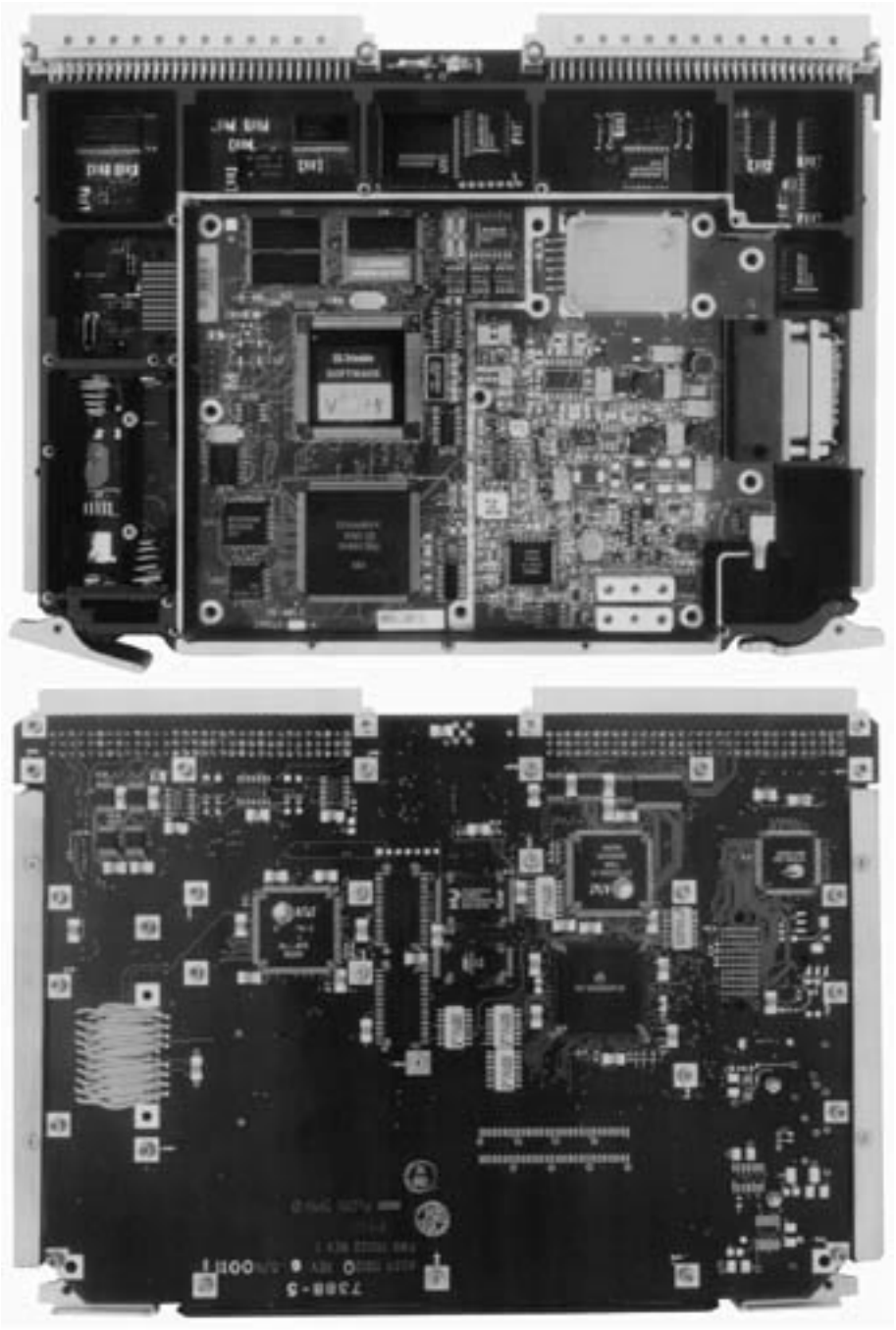
attention they expect; moreover, their program may incur "additional risk," depending upon delivery of the Government Furnished Equipment/Contractor Furnished Equipment item(s).
- Contractor — Further, prime contractors on all sides, often accused of using any disruption in the HTI program as the cause of any internal perturbations, may have wanted to keep the business in-house.

The AEGR program overcame these obstacles with a combination of strong leadership from the top, and continuous communication and cooperation among the players.

The Plan

During the 1995 Christmas holidays, an innovative program plan was born. It required the support and cooperation of numerous agencies to plow new ground and set new standards. All eyes focused on the successful achievement of the objective, rather than suffering the oppressive inertia of "business-as-usual."



AEGR Top & Bottom Views

Photos by Darell Libby, Assurance Technology Corporation

Integrated Product Team

Based on information gleaned from a variety of contacts and sources, Patten concluded that formation of an informal Integrated Process/Product Team (IPT) was the next step. Although the membership would not have all the "traditional" contractual relationships, Patten concluded they would still require mutual responsiveness and support. Toward that end, he devised a membership that included: the Abrams PM; the Abrams Prime contractor; General Dynamics Land Systems (GDLS); the GPS Joint Program Office (JPO); and the Army PM, GPS, as a source for GPS engines. Also needed were an HTI representative; a contracting agency with an existing contract; and a contractor with experience in Systems Engineering, the rapid prototyping of leading-edge technologies for weapon systems, and GPS technology.

Although the AEGR was designated a Government Furnished Equipment item, the IPT process created a mutually beneficial environment for all involved. Several outstanding professionals contributed to the success of the program:

- GDLS — Rich Dinges, Director of Tank Programs appointed special engineers with expertise on the MPU and the Vetronics Architecture. Tom Yestrepski, MPU Engineer, provided all necessary documentation as well as critical insights to the Systems Engineering Process. He also scheduled M1A2 SEP Systems Integration Laboratory time to support the AEGR effort.
- GPS JPO — Air Force Col. James Armor, System Program Director, Navigation Satellite Timing and Ranging (NAVSTAR) GPS Joint Program Office, provided critical support from his office. Air Force Col. Stephen Opel, Chief of User Equipment, dedicated essential security engineers to the project. Mike Dash and Bob Cook, JPO Principal Investigators from ARINC Corporation, attended all AEGR reviews; arranged for JPO-GPS authorization and scheduling of GPS security

modules for release; and identified variances in, and provided changes to, the GPS Datums. Together, they conducted a Baseline Design Review and an Intermediate Design Review to verify and validate design of GPS engine security within the AEGR, in accordance with CZE-93-105.[2] Cook and Dash also conducted a site survey of the production process and facility, thus expediting the approval process for the implemented security measures.

- Cardine assigned Natalie Dunbar the Team Leader, with support from all branches of the Abrams office. Chris White, PM Abrams, served as Lead Engineer for the MPU and acted as the main conduit among players, facilitating exchange of information and resources. Additionally, Dave Busse from the HTI division of PM ASI worked to optimize AEGR's application to other Ground Combat and Support Systems.
- Army PM GPS — Army Lt. Col. Joe Lofgren included the AEGR program in the Army GPS IPT and spearheaded, within the GPS community, the rising demands of the combined arms ground combat team, a relatively new (but clearly the largest) GPS customer base — most of whom use, as a standard form factor, the Versa Module Europa circuit card assembly.
- Naval Research Laboratory (NRL) assigned Neil Russell as the AEGR Principal Investigator and David DeRieux as the Lead Technical Engineer. Russell allocated the GPS design, development, and integration tasks to Assurance Technology Corporation, which has experience in embedding GPS and leveraging HTI initiatives.

IPT Actions

The key to success was not just in what the IPT did, but rather how they went about it. Yes, several innovative technological applications emerged, but more importantly, a pro-active, forward-thinking attitude characterized the team's day-to-day efforts. Close communication and cooperation thrived, as the IPT worked doggedly to avoid or eliminate obstacles. A success-oriented atmosphere permeated the program, and not even the slightest perception of bureaucratic inertia or "business-as-usual" survived!

Since delivery was a mere nine months away, the IPT went straight to work. GDLS carefully delineated the Abrams SEP systems-level specification, performance characteristics of the Pos/Nav system, and the requirements for the AEGR. In addition, GDLS delineated Interface Control Documents (ICD) for the MPU and the 1553 bus management[3] for the core architecture of the SEP. Assurance Technology Corporation, in close coordination with GDLS, published an A-Specification for the AEGR.

The company also conducted a market survey to identify the best possible GPS engine candidate based on cost, schedule, performance, and P3I features for the impending Navigation Warfare (NAVWAR) requirements. Eventually, Assurance Technology selected the Trimble Force 2 engine. Trimble provided a significant economy-of-scale discount to the AEGR program since a pre-existing open production order with HTI-quantity options was already in place and supplying engines to other embedded systems among the Services. Trimble, a significant contributor to the NAVWAR program, assured PM Abrams and Assurance Technology that the footprint of its new engine allowed for optimum P3I upgrade without altering the AEGR base module. All changes would be handled through software revisions at the open interfaces of the GPS receiver.

Since only one slot remained available in the MPU, Assurance Technology used its successful experiences in Space and Aerospace development and production to design a creative AEGR program. Using the available pins on the existing MPU backplane, their architecture integrates the engine as a mezzanine board and densely compacts a host of functions (to interoperate with other tank subfunctions), using advanced technology like a Ball Grid Array processor. Assurance Technology also leveraged its team of longstanding, highly responsive, "Best Value" vendors to provide key components out of sequence. Together, Assurance Technology and GDLS conducted final testing of the card to assure full functionality. Its final design facilitates the physical P3I process as a repair action by automated "Pick & Place" machines.

The Results

The AEGR card was successfully developed, fabricated, integrated, tested, and delivered in nine months. The architect of the AEGR, Lou Palecki, Director of Engineering, Assurance Technology, met and exceeded the "only-one-slot-available" challenge by first identifying key specifications the card had to meet: hosting a GPS engine; extracting and managing Position, Velocity, and Timing data; distributing data to the various weapon system subfunctions; providing numerous supporting and growth functions and the requisite diagnostics; and upgrading paths. To do this, Palecki identified and applied numerous innovative engineering solutions.

For example, most of the energy in an embedded system is traditionally spent at the box level, re-engineering the Printed Wiring Board interfaces to validate and perform. Rather than changing the entire card, and incurring the bother and expense of box-level certification and testing, the more innovative designer can leave the interface as is and keep the new receiver isolated from the weapons platform. This, essentially, is how AEGR is designed.

Under the AEGR program, designers isolated the change element, the receiver, from the Host MPU. The Host MPU does not detect installation of a new receiver because the AEGR core board translates data to the host's language. Adding a new NAVWAR receiver is simply a matter of removing the older receiver, inserting the new one, closing the unit, and porting the new software. No changing of ICDs or external features is required.

Research & Development (R&D) Contracting Innovations — AEGR

The Naval Center for Space Technology (NCST, Code 8100) of the NRL made

available an existing, competitively won contract, with an applicable Statement of Work (SOW). Other Army platform Project/Product Managers had experienced past success with the NCST contract vehicle. Most importantly, the NRL team had extensive knowledge of GPS, dating back to the early Cesium TIMATION satellites (the experimental predecessors of GPS) and first NAVSTAR launches. Currently, NRL is also involved with the GPS JPO's NAVWAR project, the technological response to the GPS Congressional mandate.

NCST used a competitive approach to contracting for non-specific hardware builds through innovative general purpose contract vehicles, the use of which they freely offer to other Services. The NCST support team is made up of more than 30 specialty engineering companies, with thousands of collective man-years of experience on the toughest problems. A customer PM need only identify the required hardware, software, or analytical profile required; negotiate a SOW and price; and move the money to begin. By competitively pre-selecting a large cadre of domain experts, combining them with the in-house, national treasure of more than 2,000 scientists and engineers, NRL can tackle and deliver solutions in the same amount of time it normally takes just to initiate and implement a dedicated, competitive contract instrument.

At the time of the AEGR program effort, NCST was already supporting U.S. Army PEO Aviation's navigation efforts. Since members of the U.S. Army Tank-automotive and Armaments Command Acquisition Center enjoyed a cooperative relationship with the U.S. Army Aviation & Troop Command (ATCOM) and NRL Acquisition Centers, they collaborated to leverage aviation experiences. Cardine was able to send Military Interdepartmental Purchase Request funds from PM Abrams to the NRL. The IPT then quickly drafted an AEGR SOW to ensure the NCST team – PM Abrams and the Abrams Prime contractor, GDLS – carefully defined all areas of responsibility. The AEGR scope was performance-oriented and incorporated all applicable Acquisition Reform initiatives.

GPS Engine

Trimble had an existing contract with HTI-quantity options, and the sponsor allowed Assurance Technology to secure the proper quantity for the R&D effort. Trimble also provided a considerable HTI economy-of-scale discount for the production quantities.

Abrams Tank

The SEP program had sufficient systems engineering scope to support the integration of the AEGR. Although no formal contractual instrument existed between GDLS and Assurance Technology, a "partnership" was formed to ensure seamless physical and functional integration of AEGR.

Production Contracting Innovations — Alpha Contracting

The TACOM Acquisition Center met with Assurance Technology Corporation to negotiate an Alpha contract for production. Government representatives from PM Abrams Engineering (Dunbar) and Procurement (Army Maj. Fred Roitz); the TACOM Armament & Chemical Acquisition and Logistics Activity (Tim Donohoe, Jim Thomas); and the Armament Research, Development and Engineering Center (Tony D'Agosto, Yui Lung, and Ka Yuen) spent two days at Assurance Technology's corporate headquarters and production facilities. This small team of negotiators was expert in program management; pricing and auditing; engineering, quality assurance and documentation; and contracting.

ALPHA contracting was a new experience for Assurance Technology Corporation. The contractor's team of negotiators realized every action was not only happening quite rapidly, but also permanently. They had to be fully empowered and fully prepared. They would continue to exercise the HTI economy-of-scale rates for the GPS engines, via a subcontract with Trimble. Using computer models, they drafted an SOW outline and cross-referenced it to a table of possible deliverables and a detailed Basis of Estimate, formulated with the Defense Contract Audit Agency-approved labor and materiel rates/scales. This way, contractors have speed and flexibility working for them as they interact confidently with the government team.

A mere two days later, the scope, specifications, terms and conditions, and deliverables were finalized. The draft contract consisted of a fixed price Contract Line Item Number (CLIN) for production of the AEGR cards, a parts supply CLIN, and a Time and Materials CLIN (cost plus) for engineering services. The PMO and Assurance Technology jointly created the contract to their mutual acceptance and agreement, and within two weeks, government procurement authorities ratified it.

A familiar cliché says, "Necessity is the Mother of Invention," but in this case, a better proverb might be "Hard Work is the Creator of Innovation." The right people with the right attitudes and a common goal found innovative solutions to numerous challenges. Undeniably, the keys to success, for this program, are Horizontal Contracting initiatives, Horizontal Technology Integration initiatives, and Acquisition Reform in support of good leadership and focused motivation.

Editor's Note: The author welcomes questions or comments concerning this article. Contact him at **barbara@assurtech.com.**

REFERENCES

1. Vetronics are the electronic instrumentation, software, and control equipment used on ground-based vehicles and some weapons systems.

2. *Security Requirements for Use of Precise Positioning Service (PPS)*, CZE 93-105 (June 6, 1993).

3. An electronic bus is the electronic medium used to interconnect a number of circuit boards or electronic assemblies.