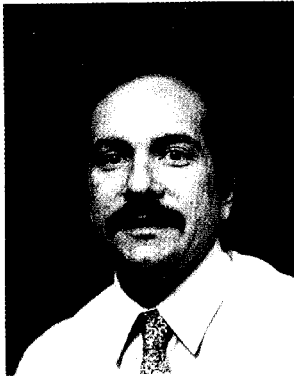


## VALUE ENGINEERING - HARDWARE TECHNOLOGY INSERTION IMPLEMENTATION OF A "NON-TRADITIONAL" VECP



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### ABSTRACT

This is an explanation of the insertion of new technology early in the development of the ALQ-156A missile warning system.

technology insertion.

In 1992, under the Navy's Integrated Defensive Avionics Program (IDAP), Sanders proposed a technology insertion VECP for the ALQ-156A Missile Warning System. The ALQ-156A is a third generation pulse Doppler missile warning radar, under development since 1985 for the A-6E Special Weapons Improvement Program.

### INTRODUCTION

The Value Engineering (VE) process is generally applied to military products that are in production to reduce overall cost without impairing essential performance, reliability, quality, or safety requirements. With a little creativity, VE can also be applied to preproduction or Engineering and Manufacturing Development (EMD) programs. In 1992, Lockheed Sanders was the recipient of the Navy's Outstanding VE Achievement award. Sanders used the VE process as a vehicle for hardware technology insertion in the AN/ALQ-156A Missile Warning System. This Value Engineering Change Proposal (VECP) was considered "non-traditional" because of its implementation during the EMD program phase. Significant life cycle cost savings would not have been maximized if the VECP had been implemented during the production phase of the program.

The ALQ-156A is a Weapons Replaceable Assembly (WRA) within the IDAP Electronic Warfare suite that detects the closing of a hostile missile on the host platform. The design evolved from its predecessor, the ALQ-156(V1)/(V2) developed by Lockheed Sanders in 1977 for U.S. Army rotary wing and transport aircraft.

The proposed missile warning solution for the IDAP was to simply expand ALQ-156(V1)/(V2) architecture to provide the increased performance demanded by tactical aircraft. The expansion was done by increasing the number of crystal filters to provide extended Doppler frequency coverage for the higher velocity platform. These crystal filters have been used in the ALQ-156 family of systems since 1972. This conservative, low risk approach is analogous to improving the range of a motor vehicle by increasing the holding capacity of the gas tank. It was the best technical solution at the time, not necessarily the most cost effective.

VE is the formal technique by which contractors either 1), voluntarily suggest methods for performing more economically and share in the resulting savings or 2), are required to establish a program to identify and submit to the Government methods for performing more economically. One such method is

### BACKGROUND

EMD programs are being extended because of funding constraints and reduced requirements. Concurrently, technology is continuously evolving at a rapid pace, leading to greater VECP opportunities

for hardware technology insertions. In 1988, the IDAP was effectively delayed for two years due to lack of funding. During this delay, two emerging technologies, Monolithic Microwave Integrated Circuits (MMIC) and High Speed/High Dynamic Range, Analog to Digital Converters were identified as ideal technologies for insertion into the ALQ-156A. The following describes the impact of each technology on system architecture and the benefits provided.

MMIC

The pre-VECP missile detector incorporated a centralized power amplifier (PA) approach as shown in the ALQ-156A Functional Block Diagram of Figure 1. However, a major drawback to centralized architecture is the loss of RF energy through long cables (cable loss) between the Receiver/Transmitter (R/T) WRA and system antenna. Cable loss is compensated by increasing PA output power. This requires higher power components within the PA and duplexer, and drives efficiency down. An optional preamplifier was provided to improve system noise figure when cable loss could not be tolerated. A more desirable method is to generate the required power locally at each antenna combining the preamplifier function into a single transmit/receiver (T/R) module. Previously, this was not possible because the module was too heavy and large to fit where the antennas are located on the host platform.

With advances in MMIC technology, Sanders was able to combine the functions into a single T/R module, eliminating the centralized PA. The PA within the T/R module was a simpler design than the centralized PA because cable loss no longer had to be compensated. High power components within the duplexer were eliminated. Improvement in system power efficiency led to a 40% reduction in power supply size. Extensive built-in test within the T/R module eliminated the need for organizational level (O-level) support equipment.

A/D Converter

Signal processing in the pre-VECP missile detector (Figure 1) is accomplished by down converting the radar's return signal to baseband for signal detection by the RMS and Doppler processors. Separation of signal return from clutter is done in the second Intermediate Frequency (IF) by using high Q crystal filters before final down conversion to baseband. The second IF and its associated circuitry accounted for 30% of the R/T's volume and 20% of its weight. The second IF was one of two assemblies within the R/T that drove system Mean-Time-Between-Failure (MTBF) below design goals. Procurement experience had shown that the frequency matched crystal filters required 12-18 months lead time. Supplier yields were poor which extended out deliveries. To eliminate the second IF would require an alternate signal processing technique.

With advances in A/D technology, direct processing of the IF became feasible through a digital signal processing technique. Sanders developed a digital receiver consisting of four digital circuit card assemblies (CCA) to replace the second IF, Doppler processor, and RMS processor. The digital receiver was less expensive and more reliable. The RS-422 and synchronizer CCAs were combined into one to interface with the digital receiver.

Combined Benefits

During the VECF program, Sanders redesigned 80% of the missile detector, keeping only the FMO and first IF from the original design. This redesign is shown in Figure 2, ALQ-156A VECF Functional Block Diagram. The ALQ-156A realized a 23% reduction in system weight, 44% increase in system MTBF and 250% improvement in detection range. Predicted Operation and Support (O&S) costs were lowered because of the increase in system MTBF and elimination of O-Level support equipment. With the elimination of five CCAs and 20 RF cable assemblies, significant savings in acquisition costs were also realized.

Reductions in size allowed for a common tri-service missile warning system which enhanced program viability. This made the Sanders ALQ-156A more competitive while providing the Government savings on future procurements.

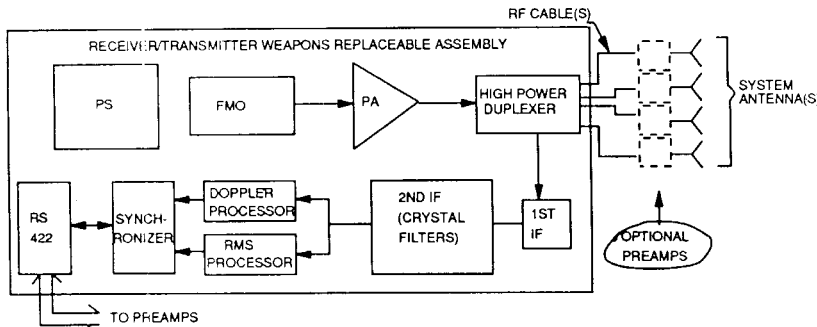


Figure 1. Functional Block Diagram of ALQ-156A

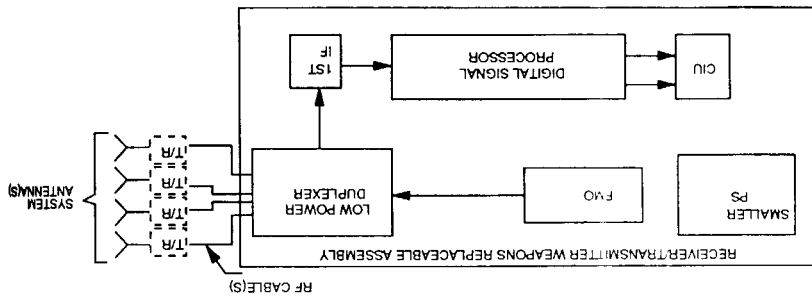


Figure 2 . Functional Block Diagram of ALQ-156A VECP

PROBLEM

To implement a VECP during an EMD program creates numerous programmatic challenges. The contractor must develop a robust plan that addresses the technical, schedule, and funding vehicles. To be successful, the contractor must be prepared to go through extraordinary lengths and considerable risks to successfully implement the VECP.

VECP PLANNING

Planning for a technology insertion VECP should be concurrent with the technology development. As the technology matures, the contractor must 1), continually update the plan, addressing elements of acquisition cost savings, O&S cost savings, implementation cost, and schedule and 2), continually brief the Government Program Management Office and VE Manager. Teamwork is essential; the Program Manager, VE Manager, and Contractor must all work together to successfully implement the VECP.

Sanders submitted the ALQ-156A VECP in September 1991. The EMD Program was 90% complete. All hardware had been delivered and the program was approaching Contractor qualification testing beginning in 1992. Concurrent with contractor qualification testing, the Government had scheduled a series of risk reduction flight tests for the fourth quarter of 1992 to mitigate risk before entering into Development Test and Evaluation (DT&E). DT&E had been scheduled to begin in 1993 followed by Operational Test and Evaluation in 1994.

Sanders approach showed that significant savings could occur if the VECP was incorporated during the EMD phase. If

production, Government DT&E and Contractor qualification testing would have to be repeated, negating the savings. Timeliness of the VECP made sense, and the benefit in life cycle cost savings significantly outweighed program risk.

Recognizing that the VECP would not immediately be approved created schedule risk. Therefore, Sanders, under Independent Research and Development funds, retrofit the digital receiver into an existing ALQ-156A Missile Warning System to support Government risk reduction testing. The T/R module was not implemented because it was considered low risk in comparison to the digital receiver.

In December of 1991, Sanders and the Government agreed in principle to proceed with the VECP - with the proviso that a VECP Missile Warning System would be available to support Government DT&E in 1993. This required Sanders to develop and deliver a VECP system within one year. If hardware was not delivered on time, testing of the IDAP suite would be delayed, causing a negative cost impact to the Government. To mitigate risk, Sanders developed the ALQ-156A VECP to be form, fit, and functionally interchangeable with the pre-VECP Missile Warning System. This allowed the Government the flexibility to use pre-VECP hardware to complete DT&E on the IDAP suite if VECP hardware was not delivered on time. Overall nonrecurring implementation cost was reduced because there were no changes to aircraft installation scheme. This resulted in a small penalty in hardware nonrecurring cost.

To meet VECP system deliveries within one year required Sanders to use commercial parts. The Government, through a waiver, authorized the use of commercial parts. However, the Government did not relieve Sanders from meeting the qualification requirements, which put Sanders at great risk; failures during qualification testing would require corrective action at no additional cost to the Government. During VECP Missile Warning System development, all contractor qualification testing was deferred - awaiting successful completion of the VECP system development. Again, this helped reduce the non-recurring implementation cost.

NET ACQUISITION COST SAVINGS

no ongoing production, there also exists no negotiated production prices. To establish production pricing for the pre-VECP configured hardware and the VECP hardware, the Government and the contractor must agree on the anticipated/future production quantities. This will account for economies of scale (learning/material cost/support labor). Once a proposal is established for each configuration, a net acquisition savings value can be calculated.

The contractor must provide an estimate of cost savings when submitting the VECP. An obvious method is to perform a detailed auditable cost proposal for acquisition costs. During this process, the contractor must establish assembly standards and performance factors, obtain material quotes, and estimate support costs typically not well established during an EMD program for production hardware. Although this approach is the most accurate, it may not be the preferred approach because of the significant investment required by both contractor and Government before a VECP decision can be made. Unfortunately, internal strawman models or similar tools commonly used by the contractor to determine nonrecurring or production costs are estimating tools generally not approved by the Government.

Computer aided parametric cost estimating is the widely accepted approach. This method produces results quickly with little cost investment. A parametric tool such as the Martin Marietta Price (Parametric Review of Information for Costing and Evaluation) system is accepted by the Government.

Sanders used the Martin Marietta Price-H model to determine acquisition cost savings. Based on a production quantity of 450 systems, Sanders demonstrated a net acquisition cost savings of \$8.7 million. The significant cost savings was directly related to implementing the VECP in the EMD program before starting Government and contractor qualification testing. In addition, the interchangeability of the VECP system with the pre-VECP system minimized changes to Special Test Equipment and Factory Acceptance Equipment. Intermediate and depot level support equipment had been identified, but not developed.

Once the VECP was approved, a detailed cost proposal in accordance with FAR 15.804 was

submitted for both configurations. Costs associated with preparation of the cost proposals were included as part of the non-recurring implementation cost.

#### O&S COST SAVINGS

Similar savings were identified for Operation and Support (O&S) costs, using the U.S. Navy's Level of Repair (LOR) model, Microlora Plus. Results of LOR analysis showed an O&S cost savings of \$35 million over a 15 year period. As previously noted, major contributing factors included a 44% improvement in system MTBF, overall reduction in CCAs and 23% reduction in system weight. Improvements in MTBF decreased spares requirements and increased operational availability. Elimination of CCAs reduced the number of spares required and the associated support equipment test program set. Reductions in system weight decreased packaging, handling, and storage cost and decreased organizational level removal and replacement task personnel requirements from two persons to one person.

#### VECP FUNDING

When a VECP is identified, it should be implemented as soon as possible to achieve maximum cost savings. Estimates of nonrecurring implementation cost (negative instant contract savings) must be briefed to the Customer early during Technology Development to identify additional funding requirements. For the ALQ-156A VECP, an unexpected consolidation in the Customer's organization delayed the formal acceptance of the VECP and subsequent funding for seven months. Since schedule was the primary risk, any delay in implementation would most likely result in VECP disapproval; therefore, Sanders initiated the VE change with company private funds. During the seven month period, Sanders incurred costs of \$2.5 million. Preincurred costs were ultimately recognized as allowable cost once the VECP was approved.

Lack of available funding can delay implementation of a VECP. With contractor initiative and courage, a VECP can move forward while programmatic issues are being resolved.