The Advanced Amphibious Assault Front End Analysis Process: An Approach to Balance Design and Ownership Requirements

Dr. David J. Daly, Mr. Mack Perry,
Dr. Charles A. Beagles,
Naval Training Systems Center
Orlando, Florida
and
LtCol James Feigley
U.S. Marine Corps

ABSTRACT

One of the primary goals of any major acquisition program is to achieve the best possible balance between performance, risk, schedule, and cost. Early consideration of life cycle cost and manpower, personnel and training (MPT) issues is critical to the achievement of this objective. Historically, operating and support (O&S) and MPT support requirements have not been adequately considered during the early phases of weapon system development. Consequently, O&S requirements have become the unaltered by-products of initial engineering decisions and in some cases have become a logistics support/MPT burden on the user community.

This paper presents one promising technique for the incorporation of O&S forecasts into the engineering requirements analysis process. This design to ownership approach requires concurrent and interdependent front end analysis. O&S predictions are generated by economic modeling of baseline and new system concepts. These early O&S forecasts lead to the generation of engineering design approaches and specific design rules to offset future support requirements.

INTRODUCTION

This concurrent engineering approach is being used for an acquisition category (ACAT) I program during the concept phase when historically engineering decisions account for 70% of a system's life cycle cost. The purpose of this paper is to explain this design to ownership process and to present some preliminary findings. The lessons learned from this acquisition should apply to both future weapon system and training system procurements.

The Management Problem. The critical issue to be addressed by program managers in today's declining budget environment is:

> With increasing weapon system complexity, how can we develop an *affordable* system which optimizes *total system* (man & machine) performance?

As indicated by Table 1, human integration issues are often bypassed by technical design and schedule priorities. As a result, system performance and O&S requirements have been significantly impacted.

The initial estimates of manpower (IEM) for complex weapon systems have often been significantly understated.
The maintenance demands for complex weapon systems have often been understated.
Operators have been required to remember too many steps to find targets and fire weapons.
System performance has been degraded by the demanding physical requirements placed on the user.
System performance has often been degraded because training of key collateral skills was not recognized as important.

Table 1. Past Ownership Problems

<u>**The Program Manager's Concerns**</u>. Marine Corps management recognized the magnitude of the potential ownership problem for the new vehicle, the Advanced Assault Amphibian Vehicle (AAAV). The AAA Program Manager requested assistance from NAVTRASYSCEN in analyzing the O&S and MPT requirements of the new system. Table 2 presents the program's manager's assessment of the situation.

Force Level Reductions are a Certainty.
Lessons Learned from the "Tech Base" show a high probability of greater technical complexity.
Maintenance of the Current System is taxing the Logistics and Training Support System.
New Systems do not necessarily eliminate "Old" problems.
Long term trends in Defense Spending will increase the emphasis on reducing the "Cost of Ownership" of New Systems.

Table 2. Program Concerns

NAVTRASYSCEN was included on the AAA team addressing AAAV procurement issues in 1988 prior to the initiation of the Concept Exploration Phase. This early involvement permitted the evolution of a systematic approach to the O&S problem. Tasks leading up to the concept study included:

- the implementation of training situation analyses which addressed the operational manpower, personnel and training constraints of the current system as well as current supportability problems.

- selection of an economic model to support conceptual design trade-off analysis.

- the development of a HARDMAN Supplement for the AAAV RFP which included development of three HARDMAN (Hardware vs Manpower) data item descriptions (DIDS).

- the development of an integrated front end analysis approach to include O&S/MPT considerations in the early design phases of the AAAV.

- the development of a Manpower, Personnel, Training, and Safety (MPTS) Plan for Defense Acquisition Board (DAB) Milestone Review.

THE DESIGN TO OWNERSHIP SOLUTION: CONCURRENT FRONT END ANALYSIS

The design and development of the new weapon had to fit the total affordability and supportability constraints of the Marine Corps. To address this goal, the AAAV RFP required that systems engineering, human integration, and logistics analysis be interdependent. As indicated by Figure 1, the selected approach also required the use of economic modeling to support that interdependency.

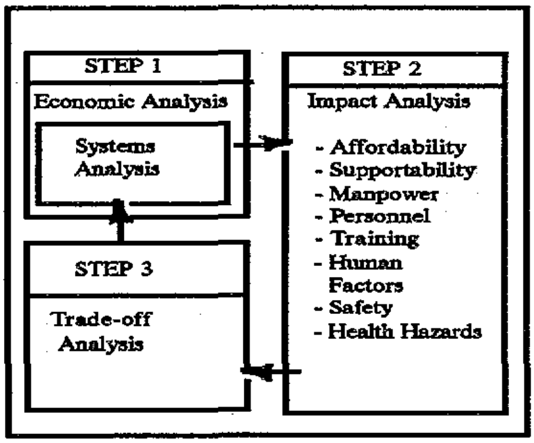

Figure 1. The Front End Process

Each step (Systems Analysis, Impact Analysis, and Trade-off Analysis) is presented in detail in the Army's HARDMAN Comparability Methodology. The AAA Program's addition to this process will be further described. The two key aspects of the approach which fostered interdependent design analysis are the use of past problems and economic modeling.

<u>The Use of Predecessor and Generic Amphibious Problems.</u>
As indicated by Table 3, new designs were assessed with regard to affordability and supportability, as well as by all the MANPRINT (i.e., manpower integration) domains.

For the AAAV analysis, past amphibious problems were input into the "Systems Analysis" because these problems drain O&S resources. Table 3 presents examples of the problems and lessons learned utilized from a review of training situation analyses, lessons learned reports, task listings and training device studies.

Industry's requirement was to analyze past user problems and to develop measurable design solutions. Each of the past problems identified were listed with an identification of potential design solutions. For instance, the need for an excessive amount of tools could potentially be reduced by requiring standard connectors in the new design. In this case, the requirement for a design to use "no more than seven tools" is a proposed design rule for further evaluation.

Logistics Number of Tools Required Amount of Test Equipment Required Time Required to Access Damaged Equipment
Manpower Number of People Required
Personnel Skill Levels Required
Training Sustainment of Gunnery Skills Sustainment of Troubleshooting Skills
Human Factors Complexity of Turret Operation Procedures Visibility when Buttoned Up
Safety Malfunction of Heater Unexpected Hatch Closure
Health Hazards Exhaust Fumes

Table 3. Past Vehicle Problems

Table 4 presents a list of design rules being evaluated by industry in their new design concepts. If a design rule adversely impacts the feasibility of the engineering concept, then a trade study or economic analysis can be run to support a decision on the design rule. The output of this analysis is a listing of potential design rules and an audit trail of problems and proposed solutions.

O&S Issue	Design Rule
Workload	
Tools	- *No More than 7 Tools Required for Onboard Maintenance.*
Test Equipment	- None Required for Onboard Maintenance.
Test Equipment	- No Growth of Test Equipment over Current System.
LRU Replacement	- All Lowest Replaceable Units (LRUs) of the same type shall be interchangeable. - All LRUs must be easily repaired and replaced while wearing NBC/Cold *Weather Clothing.* - All Fasteners must be Captive. - LRUs will be designed for replacement in uncontrolled (ie., moisture, dust, electrical) environments.
Accessibility	- There shall be no requirement to remove other equipment or parts to gain access to an LRU.
Adjustment	- *Electrical adjustment will be automatic.* - Mechanical Interface will require alignment features such as precision mounting surfaces and alignment guide pins. - Track adjustment will require no more than 2 people in 10 minutes.
Affordability	
Maintenance Ratio	- The Ratio of the Cumulative Number of Corrective and Preventative Maintenance Man-hours expended in Direct Labor and the Cumulative Number of End Item Operating Hours shall not exceed an 8 to 10 Ratio.
Human Factors	
Operating Procedures	- Operators will not have to remember more than 7 Steps in a sequence to perform any procedure.
Training	
Skill Sustainment	- Operators will be able to Perform Driving, Gunnery, and Repair & Replacement Procedures to 90% accuracy one month after training.
Safety & Health Hazards	
Crash Padding	- There shall be padding & back support for each Crew and Troop Position.
Hazardous Fumes	- There shall be No Fumes in the Crew and Troop Compartment.

Table 4. Typical Design Rules being Evaluated for Implementation

The use of Economic Analysis. Economic analysis was used to analyze the life cycle cost and MPT support requirements associated with the current and proposed vehicle. An initial objective was early identification of "high drivers." The intent was to translate these high drivers into engineering challenges and thus integrate O&S issues into the systems design process. The ultimate end product would be a more cost and operationally effective vehicle design.

An additional objective of the economic analysis was to support the trade-off analysis process by projecting the relative life cycle cost of alternative system designs. The Equipment Designer's Cost Analysis System (EDCAS) was selected as the economic model because of its sensitivity and trade-off analysis capabilities as well as its capability to project life cycle cost based upon preliminary design parameters. The use of the model will be described further in more detail.

Task 1: Economic Modeling to Determine where to Place Design Emphasis. Design contractors were initially required to model the current system, the Landing Vehicle Track-7A1, and a baseline system representing new technology. The resulting life cycle costs and manpower requirements were then analyzed by subsystem and ranked in terms of importance as demonstrated by the Pareto chart depicted in Figure 2.

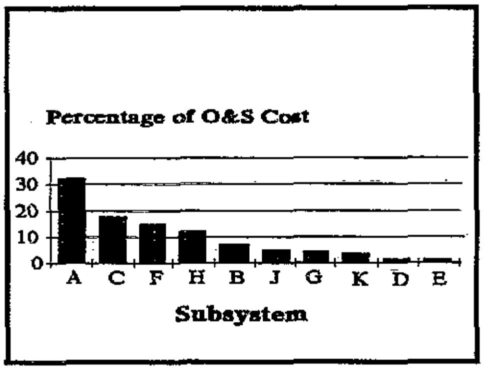

Figure 2. "High Driver" Subsystems

Using the results of the economic modeling, the engineering team could prioritize their design approach to minimize O&S impact. For example, the O&S requirements identified with the top four "high driver" subsystems in Figure 2 represent 65% of the total O&S cost and would naturally be given design priority.

Task 2: Economic Modeling to Support Trade-off Analysis. As the conceptual design matured, each subsystem was analyzed by varying the input design parameters (unit cost, scheduled maintenance, mean time between failure, mean time to repair, etc.,) to evaluate each design variable's impact on life cycle cost. Industry used this sensitivity analysis to identify the variables which had the greatest influence on life cycle cost. Figure 3 presents a "generic" representation of the relationship of design parameters to life cycle cost. Using the economic model in this context, logistics and MPT support requirements are quantifiable and thus are able to become an integral part of the trade-off decision process.

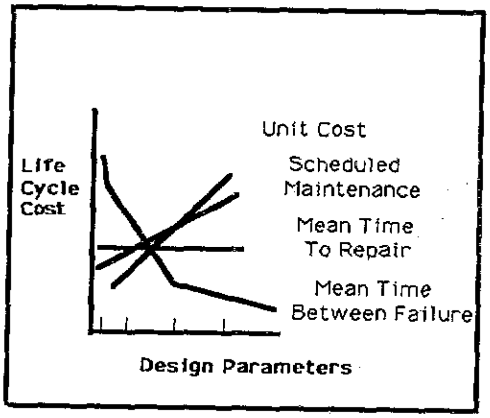

Figure 3. Sensitivity Analysis

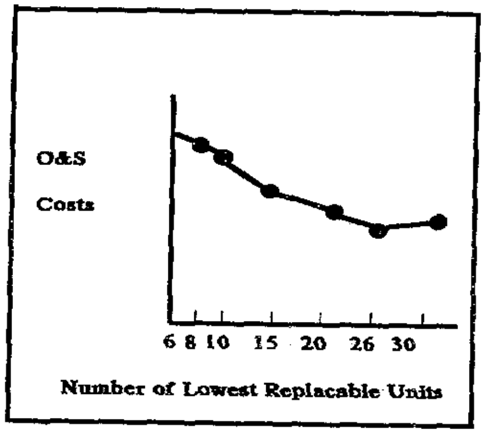

Figure 4. Partitioning Analysis

Task 3: Economic Modeling to Support the Development of Modularization Goals. In addition to sensitivity analysis, industry teams conducted partitioning analysis to determine the relative life cycle savings which could be obtained through modularization. From a supportability standpoint, it is often cheaper to break equipment in smaller and lighter lowest replaceable units (LRUs).

Figure 4 illustrates a generic partitioning analysis graph. For the AAA Program, industry was required to develop a partitioning design goal for each subsystem design. In this case, the typical starting point would be for a design range from 20 to 26 LRUs. This would maximize the savings accrued through modularization. Next, a trade study would typically be run to determine what specific number of LRUs is feasible from an engineering perspective.

DISCUSSION

In the AAA Program, O&S impacts have influenced several key design decisions through the use of this type of concurrent engineering. In some cases, a design alternative requiring the least expensive support requirement was selected. In other cases, the use of specific design goals and modularization goals are being used to reduce the ownership cost of "high driver" subsystems.

CONCLUSION

This process represents a major departure from past practices. For the AAA program, the economics of the new system's ownership costs are driving the design, instead of the design driving the ownership costs.

ABOUT THE AUTHORS

LTCOL JAMES M. FEIGLEY is currently the Assistant Direct Reporting Program Manager for the Advanced Amphibious Assault (AAA) Program. He has served as a platoon and company commander and battalion operations officer in the 1st Amphibian Tractor Battalion, 2nd Assault Amphibian Battalion, and 1st Tracked Vehicle Battalion. He is a graduate of the Amphibious Warfare School; Marine Corps Command and Staff College; Project Managers Course, Army Logistics Management Center, Fort Lee, Virginia; and the Program Managers Course, Defense Systems Management College, Fort Belvoir, Virginia.

DR. DAVID J. DALY is managing the Advanced Amphibious Assault HARDMAN Analysis. He has most recently been involved in industry with weapon system developments integrating economic, logistics, and HARDMAN analyses. He holds a Ph.D. degree from Indiana University in instructional systems technology.

MR. MACK PERRY is currently an Operations Research Analyst within the Performance Assessment Group of the Naval Training Systems Center (NTSC). He has fifteen years of experience with NTSC and PM TRADE conducting cost and economic analyses. He holds a M.S. degree from Rollins College Crummer School of Business.

DR. CHARLES A. BEAGLES is Deputy Program Director for the Special/Combined Operations Directorate, Naval Training Systems Center (NTSC). He has worked in training analysis and design since 1976. Prior to joining NTSC, he worked at the Center for Needs Assessment and Planning, Florida State University. Dr. Beagles is a former Marine Corps Captain and served as a Rifle Company Commander in Vietnam. He holds a Ph.D. degree from Florida State University in educational psychology.