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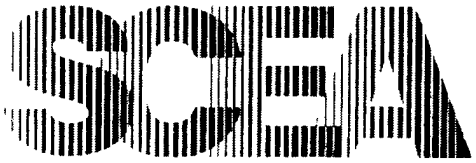

Military Operations Research Society

Society of Cost Estimating and Analysis

Mini-Symposium:

Emphasizing Cost in Cost and Operational Effectiveness Analyses

Fairfax Virginia
March 2 - 4, 1993

Donald E. Mixon, Chair

REPORT

Daniel A. Nussbaum, Editor

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DISCLAIMER

This Military Operations Research Society — Society of Cost Estimating and Analysis mini-symposium report faithfully summarizes the findings of a three-day meeting of experts, users, and parties interested in the subject area. While it is not generally intended to be a comprehensive treatise on the subject, it does reflect the major concerns, insights, thoughts, and directions of the authors and discussants at the time of the mini-symposium.

CAVEATS

The Military Operations Research Society does not make or advocate official policy.

Matters discussed or statements made during the mini-symposium were the sole responsibility of the participants involved.

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These proceedings record the results of a mini-symposium held on 2-4 March 1993. Four Working Groups, *Comparative Cost Analysis and Methodology*, *Uncertainty Analysis*, *Integrating Cost and Effectiveness*, and *Modeling Cost and Performance* convened to examine the role and methodology of cost analysis in the COEA process as well as the application of operations research techniques useful to the integration of both cost and effectiveness analysis.

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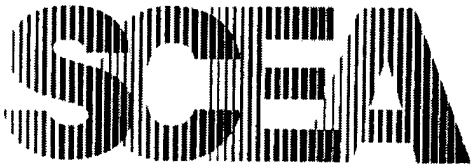

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The Military Operations Research Society (MORS)

The purpose of the Military Operations Research Society is to enhance the quality and effectiveness of classified and unclassified military operations research. To accomplish this purpose, the Society provides media for professional exchange and peer criticism among students, theoreticians, practitioners, and users of military operations research. These media consist primarily of the traditional annual MORS symposia (classified), their published proceedings and abstracts, special mini-symposia, workshops, colloquia special purpose monographs and other publications. The forum provided by these media is directed to display the state of the art, to encourage consistent professional quality, to stimulate communication and interaction between practitioners and users, and to foster the interest and development of students of operations research. In performing its function, the Military Operations Research Society does not make or advocate official policy nor does it attempt to influence the formulation of policy. Matters discussed or statements made during the course of its symposia or printed in its publications represent the positions of the individual participants and authors and not of the Society.

The Military Operations Research Society is operated by a Board of Directors consisting of 30 members, 28 of whom are elected by vote of the Board to serve a term of four years. The persons nominated for this election are normally individuals who have attained recognition and prominence in the field of military operations research and who have demonstrated an active interest in its programs and activities. The remaining two members of the Board of Directors are the Past President who serves by right and the Executive Vice President who serves as a consequence of his position. A limited number of Advisory Directors are appointed from time to time, usually a 1-year term, to perform some particular function. Since a major portion of the Society's affairs is connected with classified services to military sponsors, the Society does not have a general membership in the sense that other professional societies have them. The members of MORS are the Directors, persons who have attended a MORS meeting within the past three years and Fellows of the Society (FS) who, in recognition of their unique contributions to the Society, are elected by the Board of Directors for life.

MORS is sponsored by:

- The Deputy Under Secretary of the Army (Operations Research)
- The Director Assessment Division, Office of the Chief of Naval Operations
- The Director of Modeling, Simulation and Analysis, Deputy Chief of Staff, Plans and Operations, Headquarters, US Air Force
- Commanding General, Marine Corps Combat Development Command
- The Director of Force Structure, Resource and Assessment, The Joint Staff
- The Director Program Analysis and Evaluation, Office Secretary of Defense

The Society of Cost Estimating and Analysis (SCEA)

The purpose of the Society of Cost Estimating and Analysis is to further the effectiveness and efficiency of cost estimating and analysis and related disciplines in the public and private sectors by:

- Promoting and enhancing the profession of cost estimating and analysis.
- Fostering the professional growth of its members.
- Enhancing the understanding and appreciation of cost estimating, analysis and related disciplines throughout the general public.
- Promoting a common body of knowledge as a standard for individual excellence.
- Advocating a uniform code of ethics for the profession.
- Rewarding achievement through an appropriate program of recognition and certification.
- Providing forums and media through which experiences with the principles and techniques of cost estimating and analysis may be reported, discussed and published in furtherance of public interest.
- Fostering, promoting, and conducting research and educational programs.
- Developing and maintaining standards of proficiency and performance.
- Cooperating with other organizations and individuals, having common or related purposes, in furtherance of public interest.
- Providing an opportunity for government, industry and academia to collectively discuss and comment on related, proposed or suggested subjects of common interest.
- Establishing standards in the terminology, conduct and application of cost estimating and analysis.

Membership is open to all interested individuals in the cost estimating and cost analysis professions and related disciplines.

Members are from all levels of management, are experts, journeymen, and beginners from the government, private sector and academia.

PREFACE

This conference is the first conference jointly sponsored by MORS and SCEA. Both the operations research and cost communities have a mutual and overlapping interest in performing analysis required for COEAs. We, as communities, know how to do effectiveness analysis and we know how to do cost analysis. However, linking or integrating the two presents us with a unique challenge. It seemed only natural that our two communities should join forces to address the COEA costing topic, acknowledging and recognizing that we should work together to solve our common problems. It was apparent, from the other workshops and symposia on COEAs sponsored by OSD/PA&E, that integrating both types of analysis was an essential ingredient for successful completion, review and approval at the highest levels. Thus, the idea for this conference was born.

1. Introduction

1.1 BACKGROUND

During a time of rapid changes in the world and constrained resources, it is of the utmost importance that Department of Defense (DoD) decision makers be supported by pertinent and timely analysis. In an attempt to enhance and upgrade the level of analysis, the Director of Program Analysis and Evaluation, Office Secretary of Defense OSD(PA&E) developed and published Cost and Operational Effectiveness Analysis (COEA) guidelines as part of the then new 5000 Series Regulations to provide a framework for conducting COEAs.

A series of workshops was conducted to help explain the relationship of the COEA to the acquisition decision making process. The first workshop was held on 3 April 1991 at the Defense Systems Management College, Fort Belvoir, Virginia and included senior officials and analysts from DoD and the military departments. Seventy-two general officers, senior executive service civilians and others from all services met to discuss problems with current COEAs. Each workshop was opened by Dr. David Chu, ASD(PA&E). Short talks by subject matter experts were given with each followed by a brief discussion period. Each service, in turn, presented its unique problems and perceptions of the workshop.

Three "limited attendance" action officer workshops were held in May 1991, in McLean, Virginia at the MITRE Corporation with the MITRE Economic Analysis Center serving as host. Each workshop aimed to provide a forum for working level analysts to discuss methods for improving analyses associated with COEAs. Dr. Chu provided opening comments by stressing the need for better analyses. Workshop topics were presented, again by subject matter experts.

A tutorial concerning the PA&E workshops was presented at the 1991 Annual MORS Symposium at the US Military Academy in West Point, New York. The tutorial focused on the conduct of the workshops, on issues generated from the workshops and on trends or perceptions resulting from the workshops.

A two and one-half day mini-symposium focusing on COEAs in the acquisition process was held in March 1992 in Newport, Rhode Island, with MORS serving as sponsor. Dr. Chu presented the keynote address, once again expressing the need and importance of COEAs. Congressman Ron Machtley of Rhode Island provided the luncheon address noting, in particular, the need to develop an analytical basis for allocating scarce defense resources.

Results from all workshops were reported at the 1992 Annual MORS Symposium at the Naval Postgraduate School in Monterey, California. The need to focus on the costing aspects of COEAs was highlighted during these sessions. In all the workshops, tutorials and symposiums, interest from all segments of DoD and contractor personnel was high.

1.2 OBJECTIVES

The objective of the MORS/ SCEA mini-symposium was to examine the role and methodology of cost analysis in the COEA process as well as to examine the application of operations research techniques useful to the integration of both cost and effectiveness analysis. Exploring the broader aspect of affordability analysis is another one of the basic objectives of the mini-symposium. In particular, the goals were to:

- Understand the role of COEAs in the decision making process
- Examine the role of cost analysis in the COEA process
- Establish a set of common cost analysis issues and problems faced when performing COEAs
- Develop possible solutions or identify appropriate research areas common to those cost analysis issues and problems
- Improve the collaborative framework for dealing with COEA cost analysis requirements

1.3 ORGANIZATION

The mini-symposium covered a two and one-half day period and provided a forum for addressing the cost analysis issues and problems related to COEAs.

There were four major addresses, including a keynote speech by Dr. David Chu. There were two panel discussions — one a senior-level panel which addressed the general issue of cost estimating as part of the COEA process, with emphasis on the policy perspectives of the services and OSD, and the other a mid-level panel which placed emphasis on the implementation perspectives of the services. Finally, four working groups, each addressed a specific topic area.

1.3.1 Principal Speakers. The principal speakers were:

- Dr. David Chu, RAND and former Assistant Secretary of Defense (Program, Analysis and Evaluation) was the keynote speaker.
- Dr. David McNicol, Deputy Assistant Secretary (Resource Analysis), OASD (PA&E), and Chairman of the Cost Analysis Improvement Group;
- Mr. Frank Kendall, Chair, Conventional Systems Committee, Defense Acquisition Board;
- Mr. Robert Soule, Deputy Director, Acquisition Resources, Acquisition Policy and Program Integration.

1.3.2 Working Groups. Four working groups were convened to help explain the relationship of the COEA to the acquisition decision making process. Short talks by subject matter experts were given with each followed by a brief discussion period. The four working groups were: *Comparative Cost Analysis and Methodology*, *Uncertainty Analysis*, *Integrating Cost and Effectiveness* and *Modeling Cost and Performance*.

1.3.3 Panels. Two panels convened following Dr. Chu's remarks. The panels consisted of representatives from each of the services' cost organizations as well as

OSD(PA&E). The panels addressed the general issue of cost estimating as part of the COEA process. Particular emphases were on the policy perspectives of the services and OSD.

Senior Panel. The Senior Panel consisted of the senior person from each of the services' cost organizations as well as OSD(PA&E). The panel addressed the general issue of cost estimating as part of the COEA process. Particular emphases were on the policy perspectives of the services and OSD.

Each of the panel members provided a senior-level perspective on the cost issues resulting from institutionalizing COEAs.

Each of the service representatives raised similar concerns and echoed the others comments. They identified workload and personnel issues as one of their primary concerns with performing "quality and credible" COEAs. They also identified the Cost Analysis Requirements Document (CARD) as a useful document for facilitating COEA costing, provided it was completed in a timely manner.

From the OSD level, one of the primary issues was ensuring the services included sufficient alternatives to substantiate the COEA results. That is, "types of system alternatives" as well as "alternatives to meeting the requirement" other than a weapon system acquisition.

Participants in the panel were:

- **Moderator** — Dr Stephen Balut, Director, Economic Analysis Center, Institute For Defense Analyses.
- **OSD** — Dr David McNicol, Deputy Director (Resource Analysis) OSD(PA&E) and Chairman of the Cost Analysis Improvement Group (CAIG).
- **Army** — Mr. Robert Young, Director, US Army Cost and Economic Analysis Center.
- **Navy** — Captain Richard S. Coleman, Director, Naval Center for Cost Analysis.
- **Air Force** — Mr. Lee Baseman, Deputy Assistant Secretary of the Air Force (Economic Analysis)

Mid-level panel. The panel addressed issues of cost estimating as part of the COEA process. Particular emphases were on the implementation perspectives of the services. Each of the panel members provided a senior-level perspective on the cost issues resulting from institutionalizing COEAs.

Participants in the panel were:

- **Moderator** — Maj Sylvia Wardley-Niemi, Office of the Assistant Secretary of the Air Force (Financial Management).
- **Navy** — Ms. Noreen Bryant, Director of Cost Analysis, Naval Air Systems Command.
- **Army** — Dr. Herb Fallin, Director, Assessment and Evaluation, Office of the Assistant Secretary of the Army (RDA).
- **Air Force** — Mr. Jack Graser, Office of the Assistant Secretary of the Air Force (Financial Management).
- **OSD** — Mr. Lance Roark, Office of Deputy Director (Resource Analysis), OSD(PA&E).

2. Working Group I
Comparative Cost Analysis and Methodology

Dr Daniel A. Nussbaum, Naval Center for Cost Analysis, and Mr. Leonard S. Freeman, Office Chief of Naval Operations (OP-81)

2.1 GOALS AND ISSUES

Cost estimating is important and adds value to the acquisition process. In fact, the cost estimating process enhances understanding of the program by forcing greater clarity in program definition. Early involvement by the cost estimating community is critical for credible and useful COEAs. At the previous MORS mini-symposium on COEAs, everyone agreed that special emphasis should be placed on the fact that the first letter in COEA is a "C", and it stands for Cost. Without proper and early attention to cost, the COEA process is fatally flawed. The purpose of the Comparative Cost Analysis Working Group was to identify the commonly perceived problems, as well as the thoughts of the costing part of the COEA world.

This working group addressed the following issues:

- The validity of cost estimating relationships (CERs) — There is a constant need to update data bases in order to reflect current technology and acquisition environments.
- Updating cost tools — This is a continuous process requiring people and funds. Cost estimating tools are perishable as the acquisition environment changes (e.g., business base, acquisition strategy, etc.)

2.2 SUMMARY

There were 10 presenters in the working group. They represented all the services in DoD and the FAA. Each speaker had actually done the cost analysis for the COEA they were presenting. The speakers provided a short overview of the COEA — the options, who did the work, and the results — and then addressed the set of common questions.

A common set of questions was discussed by each presenter, to act as a focusing agent on the working group issues.

Following the presentations, the working group analyzed the central tendency of the papers. These coalesced into a set of four issues:

- The independence of the cost estimate
- The need for a cost validation authority
- The need for an oversight board
- A gauge of the appropriate effort to be put into a COEA.

We take these four issues up, in turn, below.

The independence of the cost estimate — DoDI 5000.2 provides guidance on doing COEAs, and it requires that the cost estimates in the COEA be "consistent" with the cost estimates presented at the program's

milestone review. The working group participants believe that this consistency requirement makes it inevitable that the cost estimates that the COEA analysts use will come from the PM, and that they will be indistinguishable from the most recent POM/budget inputs from the program office. The concern of the working group participants is that consistency has replaced validity as the driving criterion.

The need for a cost validation authority — Concern about the validity of the cost estimate led to a recognition that there has to be a validating authority analogous to the independent cost estimate (ICE) required at a milestone review. Is there a validating mechanism in the Services? What we found was that:

- The Army produces an Army Cost Position (ACP), which is the result of a review of the costs in the COEA and any other cost estimates for the program. By the ACP, the Army does validate the COEA cost estimate.
- The Air Force validates its COEA cost estimates by filtering the estimates through the Air Force Cost Analysis Improvement Group (AFCAIG). In this way, the Air Force formally validates the COEA cost estimate.
- The Navy has no formal validating process. It is true that the Naval Center for Cost Analysis (NCA) serves as the Navy's independent cost estimator for milestone purposes, and sits on the Navy COEA oversight Boards (in an advisory capacity only), and from that perch can advise on proper cost estimating standards. Nevertheless, there's no formal process in the Navy to validate the cost estimate in the COEA.

The need for an Oversight Board (OB) — Each Service has a group whose function is to oversee the accomplishment of the COEA. The Army calls it a Study Advisory Group (SAG), the Air Force calls it a COEA Advisory Board (CAG), and the Navy calls it a COEA Oversight Board (COB). Whatever it is called, almost every speaker in the working group avowed the importance of the Oversight Group, and made the following points:

- Early involvement of the OB is important to the success of the COEA.
- Active participation of the OB is very important.
- A Study Plan, briefed to and approved by the OB, is indispensable to the success of the COEA. Two of the sections of the Study Plan that were emphasized by the working group speakers were:
  - Resource section, identifying the resources (time, dollars, schedule,...) needed for the COEA.
  - Cost section, identifying the relevant cost issues to be addressed in the COEA.

A gauge of the appropriate effort for a COEA — A number of speakers emphasized the importance of making sure that the effort put into the COEA is commensurate with the problem at hand. In particular, the number of options,

paying attention to the milestone decision, and relative versus absolute costs are thought to be important issues. COEAs should be tailored to the circumstances.

3. Working Group II
Uncertainty Analysis

Dr Richard Trainor, US Army Cost and Economic Analysis Center

3.1 Goals and Issues

Trade-offs between alternatives offering varying levels of effectiveness vis a vis different costs are specifically addressed by the COEA. The choice between competing alternatives is often aided by using uncertainty analysis. Uncertainty in the context of the symposium refers to the major factors that can be expected to adversely impact the accuracy of future cost estimates and thereby undercut the credibility of the resulting COEAs.

The working group attempted to identify these factors, describe their impact on cost analysis accuracy, identify actions required to reduce future cost analysis uncertainty and address ways of applying uncertainty analysis to COEA cost analysis.

3.2 Summary

Due to the rapidly changing nature of the world, it was decided to treat the subject of uncertainty analysis in a broadly based geo-political context rather than in its more conventional mathematical orientation. Therefore this working group focused mainly on how cost analyses 10-15 years in the future will be affected by changing world events. The changes will occur gradually. However, their cumulative effect is nearly certain to be major over the long term.

Seven papers were presented in the Uncertainty Analysis Working Group. They represented the views of the Army, Navy, NASA, and both profit and non-profit analysis organizations. The content of the papers covered wide ranging topics as was appropriate to this study group.

Of the many problem areas that can be expected to cause future cost uncertainty, five were highlighted in this working group. These problem areas are the data base, the industrial base, acquisition policies, availability of CERs and the COEA workload.

The availability of a robust, applicable data base is fundamental to sound cost analyses. However, as we produce fewer weapon systems and in smaller quantities the data base shrinks accordingly. More effort is required, to include more inter service cooperation, to assure that maximum use is being made of the shrinking data base.

As the military budgets are reduced in size, we can expect to see an increasing need to assess the impact of non-recurring costs and semi-variable costs. These cost categories can be expected to attain increasing importance since companies in aerospace industry base can be expected to have difficulties in directing their talents to the development and production of "plowshares."

Emerging acquisition policies such as "silver bullets" and developing weapon systems and then "putting the technology on the shelf" may have merit. However, the emerging acquisition policies have cost implications and not all of these are obvious at first glance. The cost analysis community should take the lead to ascertain the full cost consequences of key emerging acquisition policies.

The final major problem discussed in this work group was the COEA workload. As the Department of Defense shrinks in size we can expect fewer COEAs. However, this reduction will occur very slowly, probably not as fast as reductions in the size of cost analysis staffs. Therefore, the surviving cost analysts can expect an increasing workload. Moreover, future COEAs will focus increasingly on analyses that occur during the Milestone 0 to Milestone 1 period. During this period the alternatives are poorly defined. There is no Cost Analysis Requirements Document (CARD) and top management wants the results yesterday. This dilemma, if it is to be solved, will require an entirely new cost analysis methodology. This new methodology hopefully will result in top level CERs that will allow the cost analysis community to participate in these important, but fast moving decision processes. A major research effort will be required to determine whether such top level CERs can be developed. Such research should be given a high priority within OSD and by each military department.

4. Working Group III
Integrating Cost and Effectiveness

Mr. Wilbur C. Hogan and Ms. Mary Henry, US Army Training and Doctrine Command (TRADOC)

4.1 Goals and Issues

The purpose of this working group was to examine various methods of integrating cost and effectiveness and to discuss their respective merits and faults. This working group was also to address how the Cost Analysis and Operations Research professions are successfully integrating cost and effectiveness analysis such that decision makers can understand and use the analysis to make decisions.

DoD 5000.2M states "there is no magic formula for combining cost and effectiveness measures to identify a preferred alternative." Accordingly, the services have been striving to come up with acceptable methods.

This working group examined those methods and discussed their merits and faults. A series of papers was presented as food for thought on different approaches to accomplishing this critical task. One series of two papers looked at Value-Added Analysis as a means of comparing two or more COEAs dealing with different means of overcoming the same deficiency or meeting the same requirement. The co-chairs presented a paper dealing with accepted methods currently used in COEAs.

4.2 Summary

There were nine presentations in this working group including representatives from the Defense Systems Management College, The MITRE Corporation, RAND, and various Army analysis organizations.

There were two central issues identified throughout the sessions. First, methods for integrating cost and effectiveness are still evolving, and second, there is "no single best method" for integration.

5. Working Group IV
Modeling Cost And Performance

Dr. John G. Honig, Management Analysis Incorporated (MAI)

5.1 Goals and Issues

Cost performance analysis (as differentiated from cost effectiveness analysis) is a critical factor in design trade-off analysis of weapon systems and support equipment. A relationship of performance parameters to cost and effectiveness needs to be understood and can frequently be modeled.

This working group addressed the modeling of performance parameters and their relationship to cost and effectiveness. It was arranged into five topical sessions, which dealt with an Introduction and definition of context, Macroeconomics, Case studies, Design-to-Cost, and a General discussion session on the whole working group topic. A summary report on the working group was delivered in a final general session. In addition, at least one-half hour was set aside in each session to discuss the particular topic, and the time was generally used constructively with many working group attendees participating.

5.2 Summary

Not all "COEAs" are truly "COEAs." The early COEAs identified by Mr. Kendall are required to select the best approaches. If more than one Service can perform the mission who is the "honest broker" that defines missions, measures of effectiveness correctly and reviews that study results evenly? Rough system definitions will produce rough operational effectiveness estimates and rough cost estimates.

Requirements documents specify performance parameters that should be met for a system to achieve a given operational effectiveness. As the operational assumptions which are the basis for the operational effectiveness change, who is responsible for analyzing the impact of the system's inherent performance on the new operational effectiveness?

As technological changes and cost constraints impact the performance parameters of a system under development, who analyzes the impact of those performance changes on operational effectiveness?

At Milestone 0 the approaches are so poorly defined that performance measures are difficult to specify. How few performance parameters is the analyst willing to accept to produce a rough estimate?

Decision makers would like to have macro parametric models that estimate costs related to performance parameters. Given the instability of CERs and the absence of good, homogenous data bases is such a process feasible?

The importance of cost analyst involvement as early in the process as possible was emphasized. The cost analyst needs to be part of the alterna-

tives definition process to assure that enough parameters are defined to be able to cost the system.

Design-to-cost will be increasingly important as budgets get tighter and each development competes with many others for scarce resources. It is important that the impact of performance changes, driven by budget constraint, on operational effectiveness be evaluated rapidly. That is, it is important to determine whether an aircraft with speed or maneuverability degradation of 15% is still operationally effective compared to the aircraft it replaces.

The cost analyst needs to work closely with the design engineers to provide responsive feedback on the impact of design changes on cost. Once a design is complete, it is sometimes difficult to incorporate changes required to lower the system's cost.

Measures of Effectiveness are parameters of the degree of accomplishing specified missions. These are operational measures of achieving the mission objective. These measures are a function of operational parameters to include a selection of missions to be accomplished, operational scenarios, enemy threat characteristics and tactics, strategies and tactics involved in the use of the system being analyzed and others. Operational scenarios include consideration of offensive or defensive action, daylight or night operations and others that impact the success of accomplishing a mission.

Measures of Performance are parameters that are intrinsic to a system, based on its design and manufacture. These characteristics are generally measurable, e.g., air speed, altitude, cross country speed, target detection range, hit probability, etc. These measures are relatively independent of the operational scenario in which they are employed. These measures are also the ones used by engineers to design a system and, consequently are used by cost analysts to cost a system. Cost analysts do not cost operational effectiveness, they cost performance.

As operational contexts change, for example, with the demise of the Soviet threat, operational effectiveness is said to change. In reality, "effectiveness" does not change, but utility of the system changes as the threat disappears. "Operational effectiveness" can, therefore, be considered a utility measure.

As the threat changes the inherent characteristics of systems, their performance does not change, and consequently their acquisition cost does not change. If the systems utility is decreased presumably the systems operational tempo (usage) will decrease, and in a life cycle cost sense, the operating and support costs will decrease.

A key issue, that was not discussed in detail, but is an overriding factor in this discussion is the relationship between effectiveness and performance. It was stated above that the operational effectiveness changes with operational parameters. It is important to select representative operational parameters that lead to a determination of the desired performance parameters. In the test and evaluation process the performance parameters are generally measured, rather than the operational effectiveness,

although the effectiveness is considered qualitatively during the evaluation in an operational sense.

There is a corollary to this issue. As budget constraints increase severely, cost and performance tradeoffs must be analyzed. For example, how much savings can be expected if a less capable tank engine is used, decreasing cross-country speed by 15%. Someone needs to analyze the impact of this lesser speed on the operational effectiveness of the future tank.

A statement found in DoDD 5000.2, Part 4, Section E, Paragraph 3.a.(5) is:

"To judge whether an alternative is worthwhile, one must first determine *what it takes to make a difference. Measures of effectiveness* should be defined to measure operational capabilities *in terms of engagement or battle outcomes. Measures of performance,* such as weight and speed, should *relate* to the measure of effectiveness such that the effect of a change in the measure of performance can be *related* to a change in the measure of effectiveness."

In order to get insight on how cost and effectiveness are integrated Mr. Hogan, TRADOC, provided a talk on the subject. It was the same talk he also gave in his working group. His bottom line was that there is no good way of integrating cost and effectiveness. He discussed in some detail problems with determining effectiveness. He arrived at the concept of sufficiency, i.e., what is the system being analyzed supposed to accomplish, but he found no consistent methods for determining sufficiency. The further question still remains of how to translate sufficiency into performance parameters.

Mr. Dennis, SPARTA, discussed the influence of scenarios on performance. He illustrated his talk with examples from the Strategic Defense Initiative context. He discussed the impact of attack parameters on such measures as timeliness, engagement leverage and cost per intercept. He concluded, based on his analyses, that "scenario selection can drive costs to meet requirements, by unequal focus on performance attributes."

Macroeconomics. The first talk was by LTC Loerch, US Army Concepts Analysis Agency, who presented his concept for a Value Added Analysis (VAA). He defined:

"Value Added: The incremental return on investment as measured using explicit effectiveness values and implicit effectiveness values as compared to cost.

"Explicit Measures of Effectiveness: Objective factors that measure the worth of the system/program in terms of its contribution to overall force effectiveness (e.g., combat simulation results).

"Implicit Measures of Effectiveness: Subjective factors (e.g., political risk) that affect the decision making process."

This concept was clearly and cogently presented, and is certainly useful in the overall decision making process. However, since this working group was primarily concerned with performance rather than effectiveness, and it was already stated that cost really relates to

performance, the question remains how well differences in performance of individual weapon systems, e.g.. reduction in cross-country speed impact the results of VAA. Differences in performance can result from technological improvements, manufacturing difficulties and cost constraints, for example. How sensitive is the VAA methodology to analyzing alternatives with different performance characteristics.

Another comment should be made regarding the omission of operating and support costs in the optimization process. It was indicated that this estimate was difficult to arrive at because of uncertainties in estimating operating and support costs of developmental systems. On the other hand, it is well known that operating and support costs represent a major portion of the life cycle cost. Therefore estimates of operating and support costs are provided to the decision maker as information, but these costs are not included in the optimization model.

Mr. Daigle, US Army Tank and Automotive Command, discussed Analysis of Residual Value, Military Usefulness, Economic and Military Useful Life. Mr. Daigle is in the Tactical Wheeled Vehicle Fleet Planning Office and is concerned with the replacement of truck and other support vehicles. He has developed mathematical algorithms to determine the useful life of a vehicle based on cumulative maintenance costs and the investment of replacing the aging vehicle with a new vehicle of the same kind. He determined residual value and economic or militarily useful life based on operating and support costs and age characteristics of the vehicle to be replaced.

It would appear that the applicability of Mr. Daigle's analyses are somewhat unique to his office. In his commodity are a number of critical things that do not change significantly. The missions of a truck in support of Army units, and the scenario in which they operate are rather fixed. Technological advances are generally not radical. The replacement vehicle will probably not differ significantly from the aging vehicle being replaced. It probably would be useful to analyze the feasibility of extending the basic concept to a wider variety of commodity classes.

Case Studies. Mr. Denelsbeck, Frontier Technology, Inc., lead a discussion on "Cost Architecture for Advanced Design (CAFAD)." CAFAD is an engineering-based cost architecture used for design-to-cost, tradeoffs among design alternatives, pre-Milestone 0 level costing. Its objective is to arrive at the best performance within a cost constraint. It is an automated system, uses an interdisciplinary approach, and relies on a close working relationship between the design engineers and cost analysts. It permits direct feedback when trading off performance goals and can, therefore, directly link enhanced or reduced performance to cost.

In the pre-Milestone 0 environment the designer works largely off the MENS which is frequently very general and includes performance parameters which are frequently not based on hard analyses. The relative accuracy of the cost estimates depends on the accuracy of the design parameters based on the MENS.

Mr. Denelsbeck discussed in some detail the approach that was taken to develop this cost architecture. It is based on an overall system executive routine, made up of concept, input/output and cost executive routines. Further details of each of these routines as well as the input data requirements were discussed.

In the final analysis, the model should be capable to link engineering buildups to specific engineering parameters that drive costs. The model will therefore provide costs for advanced concepts from level 0 to level 3. Cost drivers will be identified early in the process, data will be provided to support investment strategy decisions, full weapon system design and technology are inserted at the subsystem level, and the lab-wide investment planning process will be supported.

Mr. Harmon, Cost Analysis and Research Division, Institute for Defense Analyses, examined the relationship between performance and cost for various methods of integrating avionics in the next generation of tactical aircraft. The two principal methods that were compared was the traditional federated architecture of combining building blocks consisting of various electronic functions on the one hand, and a fully integrated set of avionics that incorporates the same functions in a single system on the other hand.

In the integration process decreased hardware life cycle costs are traded off against increased software life cycle costs resulting from increases in functionality. Integration will result in lower airframe and engine life cycle costs and potential increases in weapon system effectiveness resulting from software improvements. On the cost side, the integrated system costs are due more to increased software capacity and complexity. It is expected that development costs, integration costs and support costs will all increase.

Hardware life cycle cost savings were estimated based on cost estimating relationships developed for processor weights over time (historical data), and estimating the weight of federated system architecture and the integrated system, as well as the impact of those weight differences on aircraft weight and thrust. Hardware life cycle cost savings could then be estimated.

Cost estimating relationships and other relationships were used to estimate the development cost, the integration cost and operating and support cost for integrated software. Costs were derived for physical integration (traditional federated architecture) and three levels of functional integration.

Design-To Cost. Design-to-cost was defined in DoDD 5000.28(encl. 2) as:

"Design to Cost (DTC). An acquisition management technique to achieve system designs that meet stated requirements for life cycle cost (LCC) elements. Cost is a key system consideration that is addressed on a continuing basis as an inherent part of the development and production process. The technique embodies early establishment of realistic but rigorous cost objectives, goals, and thresholds and a determined effort to achieve them".

Furthermore, the same document states that:

"The achievement of DTC parameters shall be considered as important as achievement of performance, schedule, manpower, and supportability requirements."

The above document has been superseded by a number of later publications, and DTC was finally incorporated into DoDD 5000.2. Nowhere have the above quotations been restated as clearly in later documents. However, DoDD 5000.2, Part 6, Section K, states:

"These policies and procedures establish cost as a design constraint early in the acquisition life cycle."

With increasingly tighter budget constraints, the need to develop future systems within tight cost constraints will become very important. This requires not only the capability to trade off cost and performance, but again requires understanding of how performance degradation impacts operational effectiveness.

Mr. Covert, TECOLOTE, discussed a Survivability Cost Estimating Model (SCEM), and then proceeded to demonstrate the computer model to the working group. SCEM was developed using Cost Engineering Integrated Tools (CEIT). A key factor in making this model work is a close integration of the design and cost analysis process. The latter is considered an integral part of the systems engineering process. Rather than being handed a system to cost, after having been completely designed, the cost analyst works with the engineer every step of the way.

In the application shown, SCEM was applied to Javelin. Hardening techniques to counter nuclear and laser threats were examined. Each subsystem had a suite of hardening options that could be selected, and each selection had performance, weight and cost impact. By modeling these factors explicitly the impact of design changes could be readily determined. By combining system design logic with cost estimating technologies the decision maker could make cost-conscious decisions concerning each hardening technique on an element-by-element basis.

General Discussion. The last session provided an opportunity for spirited discussion among many of the working group attendees. It became evident that not all COEAs are "true COEAs". Mr. Kendall, in his luncheon speech pointed out the need for more "COEA" prior to milestone 0. This brought out a number of issues.

If the mission has the potential of being performed by more than one Service who is responsible for a Super-COEA, who assures that each of the Service candidates are analyzed on a comparable basis, performs an independent risk analysis, and measures that the costs are comparable?

Milestone 0 analyses lead to specification of operational effectiveness and performance parameters. In most cases there may only be very few of these performance parameters and they are based on little analysis. Even the effectiveness analyses are macro, yet the expectations of the cost estimate are of a valid, tight estimate. A key issue facing the cost analyst is, on the basis of how

few performance parameters, will he be willing to put a cost estimate on paper. He must also consider that costs have a life of their own, and whatever assumptions he makes may be forgotten when the costs are quoted in the *Washington Post.*

A related subject deals with relative cost estimates. Early in the design cycle it may only be possible to have rough estimates of the relative cost of various approaches. This may be adequate to chose an alternative, but it is not adequate to determine its affordability. It may be that none of the alternatives are affordable with serious redesign within DTC constraints.

If technological or cost risks find an alternative to be too risky and has to be redesigned, who will reassess the operational effectiveness of the degraded performance system? Who determines that, given this degradation, how the rank ordering of the alternatives changes?

The 1992 COEA conference identified the following methodological issue:

"Better Macro Level Parametric Cost Models are Needed."

The same item continues:

"Parametric Macro Cost Models — Performance Parameter Based — are needed to allow cost trades."

The answer proposed was to "develop quick response methodologies, new macro level models with performance parameters available by acquisition phase, and by commodity class."

There was no more discussion about the desirability of such models than the desirability of motherhood. However, there was little consensus about even the feasibility of such models with a reasonably acceptable degree of uncertainty.

It is evident that development of such macro models requires cost estimating relationships that continue to be valid over time and that are based on reasonably homogeneous data bases. There was consensus that neither of these are in existence, nor likely to be happening. With rapidly advancing technologies and irregular trend lines, extrapolating CERs based on historical data is speculative at best.

Greg Staley, Air Force ASC/XRE, discussed his organization's cost engineering process, whereby design and cost estimates are developed simultaneously. He discussed the advantages of a joint Air Force-Industry Life Cycle Cost Engineering Working Group. He also emphasized the importance of performance impact on operating and support costs. He also emphasized the importance of XR working with the using command to refine the requirement to have designable/costable parameters.

Appendix 1
Agenda

2 March 1993

0730-0830	Registration (Coffee, Pastries, Juices)
0830-0845	Welcome / Introduction of Keynote Speaker
0845-0930	KEYNOTE ADDRESS — Dr. David Chu, RAND Corp; formerly Assistant Secretary of Defense, Program Analysis and Evaluation
0930-1000	BREAK
1000-1200	SENIOR-LEVEL PANEL DISCUSSION — "OSD CAIG and Military Departments Response to COEA Costing", moderated by Dr. Steven Balut, Institute for Defense Analysis
1200-1330	LUNCHEON with SPEAKER (Dr. McNicol)
1330-1530	GENERAL SESSION: MID-LEVEL PANEL DISCUSSION — "Issues in COEA Cost Analysis"
1530-1600	BREAK
1600-1700	GENERAL SESSION: AFFORDABILITY ANALYSIS — Robert Soule, Office of the Assistant Secretary of Defense, Acquisition.

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0800-1000	CONCURRENT WORKING GROUPS Comparative Cost Analysis and Methodology (Dr. Nussbaum and Mr. Freeman) Uncertainty Analysis (Dr. Trainor) Integrating Cost and Effectiveness (Mr. Hogan and Ms. Henry) Modeling Cost and Performance (Dr. Honig)
1000-1030	BREAK
1030-1200	CONCURRENT WORKING GROUPS
1200-1330	LUNCHEON With SPEAKER (Mr. Frank Kendall III)
1330-1500	CONCURRENT WORKING GROUPS
1500-1530	BREAK
1530-1700	CONCURRENT WORKING GROUPS

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0800-1000	CONCURRENT WORKING GROUPS
1000-1030	BREAK
1030-1200	CONCURRENT WORKING GROUPS
1200-1300	LUNCH
1300-1500	WORKING GROUP REPORTS
1500-1530	CLOSING REMARKS

Appendix 2
TERMS OF REFERENCE

BACKGROUND

During a time of rapid changes in the world and constrained resources, it is of the utmost importance that Department of Defense (DoD) decision makers are supported by pertinent and timely analysis. In an attempt to enhance and upgrade the level of analysis, OSD/PA&E developed and published COEA guidelines as part of the new 5000 Series Regulations to provide a framework for conducting COEAs.

A series of workshops was conducted to help explain the relationship of the COEA to the acquisition decision making process. The first workshop was held on 3 April 1991 at the Defense Systems Management College, Fort Belvoir, Virginia and included senior officials and analysts from DoD and the military departments. Seventy-two general officers, senior executive service civilians and others from all services met to discuss problems with current COEAs. The workshops were opened by Dr. David Chu, ASD(PA&E). Short talks by subject matter experts were given with each followed by a brief discussion period. Each service, in turn, presented its unique problems, and perceptions of the workshop.

Three "limited attendance" action officer workshops were held in May 1991, in McLean, Virginia with the MITRE Corporation serving as host. Each workshop aimed to provide a forum for working level analysts to discuss methods for improving analyses associated with COEAs. Dr. Chu provided opening comments by stressing the need for better analyses. Workshop topics were presented, again by subject matter experts.

A tutorial concerning the PA&E workshops was presented at the 1991 Annual MORS Symposium at the US Military Academy in West Point, New York. The tutorial focused on the conduct of the workshops, on issues generated from the workshops and on trends or perceptions resulting from the workshops.

A two and one-half day mini-symposium focusing on COEAs in the acquisition process was held in March 1992 in Newport, Rhode Island, with MORS serving as sponsor. Dr. Chu presented the keynote address, once again expressing the need and importance of COEAs. Congressman Ron Machtley of Rhode Island provided the luncheon address noting, in particular, the need to develop an analytical basis for allocating scarce defense resources.

Results from all workshops were reported to the 1992 Annual MORS Symposium at the Naval Postgraduate School in Monterey, California. The need to focus on the costing aspects of COEAs was highlighted during these sessions. In all the workshops,

tutorials and symposia, interest from all segments of DoD and contractor personnel has been high.

OBJECTIVE

The objective of the mini-symposium will be to examine the role and methodology of cost analysis in the COEA process as well as the application of operations research techniques useful to the integration of both cost and effectiveness analysis. Exploring the broader aspect of affordability analysis is another one of the basic objectives of the mini-symposium. In particular, the goals are to:

- Understand the role of COEAs in the decision making process;
- Examine the role of cost analysis in the COEA process;
- Establish a set of common cost analysis issues and problems faced when performing COEAs;
- Develop possible solutions or identify appropriate research areas common to those cost analysis issues and problems;
- Improve the collaborative framework for dealing with COEA cost analysis requirements.

SCOPE

The mini-symposium will cover a two and one-half day period and will provide a forum for addressing the cost analysis issues and problems related to COEAs. Dr. David Chu will be the keynote speaker. In addition, there will be a high-level government panel comprised of the Chairman of the OSD Cost Analysis Improvement Group (CAIG) and the senior cost analysis officials from each of the three services. The panel will address "OSD CAIG and Military Department response to COEA Cost Analysis." Each official will give a fifteen to twenty minute presentation, followed by a fifteen to twenty minute period of questions.

Working groups on special topic areas will be conducted in which presentations will be given by practitioners within the operations research and cost analysis communities. The working groups will be held on the morning of the second day of the symposium and repeated during the afternoon of the same day to give attendees an opportunity to participate in more than one working group session.

The mini-symposium chair will select co-chairs from each services' cost centers as well as co-chairs of the working groups for the special topic areas. The co-chairs will in turn, solicit speakers to give presentations on each of the special topic areas in working groups. The speakers will themselves be experts within their respective areas and will

present areas to explore and discuss the COEA issues facing cost analysis practitioners. The special topic areas to be explored are:

- Issues in COEA Cost Analysis
- Methodology for Comparative Cost Analysis
- Uncertainty Analysis
- Integrating Cost and Effectiveness
- Modeling Cost and Performance

Issues in COEA Cost Analysis

This general session will serve, to some extent, as an overview to the more detailed working group sessions which will take place on the second day of the mini-symposium. Hence, this special topic area will be addressed before the entire mini-symposium audience. Speakers from OSD and each of the three services will explain which government organizations are doing cost analysis for COEAs and will discuss their approaches, issues and problems.

Methodology for Comparative Cost Analysis

Cost estimating is important and adds value to the acquisition process. In fact, the cost estimating process enhances understanding of the program by forcing greater clarity in program definition. Early involvement by the cost estimating community is critical for credible and useful COEAs.

At the last MORS mini-symposium on COEAs, everyone agreed that special emphasis should be placed on the fact that the first letter in COEA is a "C", and it stands for Cost. Without proper and early attention to cost, the COEA process is fatally flawed.

This working group will address the following issues:

- The validity of cost estimating relationships (CERs) — There is a constant need to update data bases in order to reflect current technology and acquisition environments.
- Updating cost tools — This is a continuous process requiring people and funds. Cost estimating tools are perishable as the acquisition environment changes (e.g., business base, acquisition strategy, etc.)

Uncertainty Analysis

Trade-offs between alternatives offering varying levels of effectiveness vis a vis different costs are specifically addressed by the COEA. The choice between competing alternatives is often aided by using uncertainty analysis. Uncertainty in the context of the symposium refers to the major factors that can be expected to adversely impact the accuracy of future cost estimates and thereby undercut the credibility of the resulting COEAs.

This working group will attempt to identify these factors, describe their impact on cost analysis accuracy, identify actions required to reduce future cost analysis uncertainty and address ways of applying uncertainty analysis to COEA cost analysis. This working groups will involve four speakers.

Integrating Cost and Effectiveness

DoD 5000.2M states "there is no magic formula for combining cost and effectiveness measures to identify a preferred alternative." Accordingly, the services have been striving to come up with acceptable methods.

This working group will examine those methods and discuss their merits and faults. A series of papers will be presented as food for thought on different approaches to accomplishing this critical task. One series of two papers will look at Value-Added Analysis as a means of comparing two or more COEAs dealing with different means of overcoming the same deficiency or meeting the same requirement. The co-chairs will present a paper dealing with accepted methods currently used in COEAs.

Modeling Cost and Performance

Description still to come.

PARTICIPATION

Attendance will be limited to a maximum of 300 people. The goal is to get people currently involved in costing, analyzing and modeling activities associated with COEAs and those responsible for providing oversight of the COEA and its analytical methodologies. The symposium will be at the unclassified level.

DATE AND LOCATION

The mini-symposium will be held March 2-4, 1992 at the Fairview Park Marriott Hotel, Falls Church, Virginia.

LUNCHEON SPEAKER

A luncheon will be held at the Fairview Park Marriott Hotel on each day of the symposium. A high-level Government official will be invited to address the attendees on the theme of the symposium or other pertinent topic relative to the symposium theme.

PRICE

The registration fee for the mini-symposium will be $150.00 for Government personnel and $300.00 for non-government personnel.

PRODUCT

The product from this mini-symposium will include the abstracts from the papers presented during the special-topic working groups prepared by the presenter. It will also include a summary of each working group and general session done by the session chair. Each presenter will prepare the abstract to be included in the published proceedings jointly published by MORS and SCEA.

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