Military Operations Research Society

COEA in the Acquisition Process and the Role of Operations Research in Performing COEA

Naval War College
Newport, RI
9-11 March 1992

Edited By Alfonso A. Diaz
OASD(PA&E)

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DISCLAIMER

This Military Operations Research Society report summarizes the results of a meeting on the subject of COEA in the Acquisition Process and the Role of Operations Research in Performing COEA culminating with a workshop at the Naval War College on 9-11 March 1992. Each chapter is authored by the Chair or Co-Chairs of each of the working groups of the workshop and represents the view of that working group and not necessarily the view of the whole workshop. 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 authors and discussants at the time of the workshop.

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The OASD(PA&E) planned and organized a series of six Cost and Operational Effectiveness Analysis (COEA) conferences. The first of these occurred in April 1991 at the Defense Systems Management College and was attended by the senior leadership of all the military departments and the Office of the Secretary of Defense (OSD). At this conference key acquisition analysis issues were defined and used as the basis for the agenda and topics presented at later conferences. In May 1991, three "Military Action Officer" workshops were held at the MITRE Corporation. These conferences focused on what constitutes a COEA and how it fits into the new DoD acquisition management process. In June 1991, a COEA seminar, opened to the general Military Operations Research (MORS) community, was conducted in conjunction with the annual MORS meeting at the Naval Postgraduate School. Finally, in March 1992, a MORS sponsored mini-symposium was held. The proceedings herein record the results of that mini-symposium.

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The Military Operations Research Society

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, special mini-symposia, workshops, colloquia and special purpose monographs. 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 Director 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
- The Director of Force Structure, Resource and Assessment, The Joint Staff
- The Director Program Analysis and Evaluation, Office Secretary of Defense

PREFACE

The idea for this conference arose early in 1990 as the work of revising the Department of Defense 5000 series of acquisition regulations was underway. The impetus for the conference was a recognition within the Office of the Assistant Secretary of Defense for Program Analysis and Evaluation (OASD(PA&E)) that analysis to support acquisition decisions plays a significant role in weapon system reviews and that the acquisition community would be well served by a forum to explain and interpret the new analysis requirements.

The OASD(PA&E) planned and organized a series of six Cost and Operational Effectiveness Analysis (COEA) conferences. The first of these occurred in April 1991 at the Defense Systems Management College and was attended by the senior leadership of all the military departments and the Office of the Secretary of Defense (OSD). At this conference key acquisition analysis issues were defined and used as the basis for the agenda and topics presented at later conferences. In May 1991, three "military action officer" workshops were held at the MITRE Corporation. These conferences focused on what constitutes a COEA and how it fits into the new DoD acquisition management process. In June 1991, a COEA seminar, opened to the general Military Operations Research (MORS) community, was conducted in conjunction with the annual MORS meeting at the Naval Postgraduate School. Finally, in March 1992, a MORS sponsored mini-symposium was held. The proceedings herein record the result of that mini-symposium.

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ACKNOWLEDGEMENTS

The Military Operations Research Society COEA Mini-Symposium of March, 1992 was the result of the work and support of many individuals and organizations. Key to its success were the long hours put in by the organizing committee to do the advance planning and preparation. The General Chairman, Dr. Al Diaz (OASD(PA&E)), and the Deputy Chairmen, Mr. Ed Smith (IDA) and LtCol Dewey Tucker (OASD(PA&E)), were particularly dedicated to the task of putting on the conference. Mr. Dick Wiles and Ms. Natalie Addison from the MORS office made all conference arrangements and deserve credit for the smooth running of what turned out to be one of the largest MORS special meetings. Mr. Kevin Kelley, from the Naval War College, organized the host-organization support and provided various administrative services.

The organizations, whose significant and stead-fast support made possible this timely and effective conference, include the Land Forces Division in the Office of the Assistant Secretary of Defense for Program Analysis and Evaluation (Dr. Bill Lese, Director) and the National Security Decision Making Department in the Naval War College (Dr. Bill Turcotte, Department Head). In addition, the MORS sponsors gave unqualified support through their leadership and participation in conference activities and thus gave the meeting the high level of importance so vital for its success.

CHAPTER 1
INTRODUCTION
MORS MINI-SYMPOSIUM
COEA IN THE ACQUISITION PROCESS
AND THE ROLE OF OPERATIONS RESEARCH
IN PERFORMING COEA

1.0 EXECUTIVE SUMMARY The Military Operations Research Society (MORS) sponsored a mini-symposium in Newport, RI from March 9-11, 1992 on "COEA in the Acquisition Process and the Role of OR in Performing COEA." Two hundred and forty participants convened at the Newport Marriot to explore the COEA process and to identify how the application of operations research principles and techniques might improve decision making in DoD. Recurring themes at the conference included uncertainty in the security environment and the problems it generates, turbulence in the OR community as it organizes and prepares for a potentially new role, and recognition that the community must arrive at a consensus on its future direction.

The mini-symposium was the last in a series of COEA workshops sponsored by the ASD(PA&E) to assist operations researchers to transition to new analysis requirements promulgated by the revised DoD acquisition regulations. Previous workshops focused on explanations of new policies. The mini-symposium was aimed at initiating a dialogue among policymakers and practitioners on implementing the regulations.

The objectives of the conference were to promote understanding of the role of COEAs in the DoD 5000 Series acquisition regulations, to define the role of OR in the COEA process, to identify challenges and issues associated with conducting COEAs, to develop possible solutions or research initiatives for resolving issues, and to improve the collaborative framework for dealing with the COEA requirements.

The three-day mini-symposium began with a keynote address by Dr David Chu, ASD(PA&E). In his address, Dr Chu emphasized the growing importance of COEAs in supporting and documenting acquisition decisions. He noted that the community has a responsibility to ensure its collective work is consistent, credible, and independent. He also stressed the need to correlate COEAs with other supporting analyses and documents.

Representative Ron Machtley (R-RI), a member of the House Armed Services Committee, addressed the conference on congressional activities driving toward downsizing of military forces and exploiting the peace dividend. He provided excellent insights into current defense budget debates and discussed the general economic impact of going below current proposed budget levels. He stressed that a steeper defense drawdown would require very large additional reductions in manpower. Mr Machtley also sketched out a plan, to which he assigned a high congressional priority, for converting business from defense to commercial enterprise.

The mini-symposium included presentations by subject matter experts followed by question and answer sessions. The speakers and subjects for this meeting included:

1) Dr Bill Lese (OASD(PA&E)) - Milestone Decision Criteria
2) LtCol Gary Fauss (DIA) - Threats and Scenarios
3) Mr Sam Gardiner - Modeling and Tools
4) Mr Tony Brinkley (Teledyne Brown) - Operational Effectiveness Methodologies
5) Dr Dan Nussbaum (CNCA) - Cost Methodologies
6) Dr Pat Cassady (TRAC-WSMR) - Cost and Effectiveness Integration
7) LtCol Jim Feigley (USMC) - Managing COEA
8) Dr Bill Lese (PA&E), Dr Ernie Seglie (DOTE), and Dick Ledesma (DDR&E) - Linkage of Testing and COEA
9) Dr Al Diaz (OASD(PA&E)) - Coea Guidelines.

The mini-symposium also included six working groups, each chartered to consider and develop issues on various aspects (i.e. functional areas) of the COEA process. These groups were constituted from attendees pre-assigned by expression of interest or expertise in the functional area. The group chairmen and topics were:

1) Mr John Gehrig (ODUSA(OR) - Test and Evaluation
2) Col Charlie Cox (DIA) - Threat Assessments
3) Dr John Friel (RAND) - Effectiveness Methodologies
4) Dr Dan Nussbaum (CNCA) - Cost Methodologies
5) Col Don Bourdon (NWC) - COEA Management
6) Mr Mike Bauman (TRAC) - Future Direction.

A "synthesis" working group, chaired by Mr Clayton Thomas (USAFSA), was also functioning during the meeting. This group consisted of experienced MOR analysts whose purpose was to observe the mini-symposium proceedings and to identify, synopsize, and present issues meriting further investigation in future MORS meetings.

Finally, as key element of the mini-symposium, a panel of "Senior DoD Officials" discussed their views on the future direction of analysis. The panel included Dr Herb Puscheck (OASD(PA&E)), Mr Walt Hollis (DUSA-OR), MG Joe Ralston (USAF), RADM R. C. Allen (USN), and Mr Fred Bielan (HQ USMC). The panel was moderated by Dr Bill Lese (OASD(PA&E)). Each member of the panel presented a "Service" perspective on analysis issues and then fielded questions from the conferees.

1.2 General Chairman's Statement

Good morning ladies and gentlemen. As the general chairman for this meeting, I welcome all of you to Newport and to this MORS Mini-Symposium on COEAs. It is indeed a pleasure to see so many of you here because it is evidence of the importance that you attach to this topic and the work associated with it. I assure you that this topic is also of considerable importance in the Department of Defense. And, as active participants in the community of defense analysts, it is good that we take this opportunity to come together to discuss common problems, issues, and future directions for our business.

While it is true that the subject of COEAs is not new, there are many reasons why it is still a topic worthy of this assembly. Let me point out just a couple. First, the national security environment has changed. I will not belabor the point of what these changes are; most of you know them well. But with that change has come a need to consider how analysis, in general, and COEAs, in particular, also have to adjust. You here today are the leaders, teachers, and pathfinders, in government and industry, for identifying how analysis can make the transition. As a community, you must take that charge seriously, because if analyses, or analysts, do not support the new decision process, it and we both will be found dispensable.

Second, I submit to you that the nature of the requirement for analysis has changed. I do not pretend to know exactly how it has changed. But I would argue, that in the past, our community was focused on model building and the application of modelling methodologies in very standard types of problems, such as comparing weapon system alternatives using standard scenarios. Today, I believe, we are expected to focus on problem formulation and responsive problem solving for a broader set of defense issues such as force planning and design, affordability, and functional complementarity and redundancy of forces. The issues are changing too fast for old techniques to be supportive either in time or in scope. We have to find new approaches for today's problems.

The agenda we have for this meeting is a challenging one. We actually have two meetings in one.

The first is designed to communicate information to you by subject matter experts who hopefully will provoke your thinking and prove to be a good resource for you in your working groups. The second meeting is designed to elicit from you what *you* know. Your active participation in your working group is key for this purpose. I urge you to be involved. Contribute to your working groups. Make it a personal goal of yours that your contribution and your views will be reflected in the proceedings. If everyone does that, we will assure ourselves a very productive meeting.

– Alfonso A. Diaz
General Chairman

1.3 Host's Welcome Address

I welcome you to Newport. The Naval War College is pleased to host this MORS COEA mini-Symposium. I believe that, in this era of declining budgets, this is a topic of particular importance to the Defense analysis community. As you, no doubt, are acutely aware, the advent of tighter DoD budgets has brought with it the need for closer scrutiny of expenditures of taxpayers dollars. DoD, with Dr Chu's organization, PA&E, in the lead, wants the analysis community to contribute heavily to this process. Therefore, it has been seeking to institutionalize COEAs as an integral part of the DoD decision process leading to defense expenditures.

COEAs play a central role by helping to determine whether a system can provide needed capabilities at an acceptable price. They are intended to aid decision makers in dealing with complexities and uncertainties in weapons acquisitions. They are also intended to evaluate the cost and benefits of alternative courses of action that could be taken to meet recognized defense needs. They provide information on the sensitivity of acquisition alternatives to potential changes in key assumptions, variables and constraints, of both estimated costs and estimated benefits. As such, they provide critical inputs to decisions on major defense acquisitions and a sound analytical basis for evaluating decision alternatives.

This conference, the fourth in a series on this topic, but the first one open to the general defense analysis community, is being sponsored to help answer commonly asked questions about COEAs such as: How are they done? How do they play in the decision process? How should they be structured to best support decisionmakers? These are important questions that you as analysts and implementers of the new acquisition process must lead the rest of the defense community in answering. Your understanding of these issues will lead to better decisions and greater confidence that US security interests are being met effectively and economically.

Once again, welcome, and I wish you success as you tackle these important issues.

– RADM Joesph Strasser
President, Naval War College

CHAPTER 2
INVITED PRESENTATIONS
MORS COEA SYMPOSIUM
GENERAL SESSION TOPIC

2.0 Abstracts
Analysis Requirements For Milestone Review:

The acquisition of military weaponry and equipment is one of the basic functions of the Department of Defense (DoD). Accordingly, oversight and review of major acquisition programs has become a high management priority for the department's senior leadership. As new systems move from the drawing board through development and production, they are reviewed at regular intervals by decisionmakers within both the military departments and the Office of the Secretary of Defense (OSD). The purpose of these reviews is to assess the performance potential and costs of the systems, so as to determine whether they can provide needed capabilities at an acceptable price. Cost and operational effectiveness analyses, or COEAs as they are commonly called, play a central role in the review process.

COEAs are intended to evaluate the costs and benefits - operational effectiveness - of alternative courses of action that could be taken to meet a recognized defense need. They also should provide information on the sensitivity of acquisition alternatives to potential changes in key assumptions, variables, and constraints of both the estimated costs and the estimated benefits. Thus, they provide critical inputs to decisions on major defense acquisitions.

This presentation will provide an overview of the defense acquisition process and the role COEAs play in that process and will explain how COEA results are used by the Office of the Secretary of Defense.

Threat Assessments/STAR and Scenarios

The Defense Intelligence Agency (DIA) provides threat support to the Defense Acquisition Board (DAB), Joint Chiefs of Staff (JCS), and the Services. The DoD 5000 Series regulations require that DIA validate all threat information used to support DAB program decisions. DIA also validates the System Threat Assessment Report (STAR) and the threat portion of other program documentation, including the Cost and Operational Effectiveness Analysis (COEA). Validation of these documents ensures that the intelligence is complete, appropriate, reasonable, consistent, and logical.

The validated threat baseline for the COEA of major programs depends on where the program is in the acquisition cycle. Prior to Milestone I, a series of threat descriptions, by mission areas, are used. For Milestone I, a STAR focused on the threat environment expected for the specific program is prepared by the Service and validated by DIA. The STAR is updated prior to each milestone, or when a significant change occurs in the threat.

DoD Instruction 5000.2 states that scenarios for COEAs be based on the set of Defense Planning Guidance (DPG) scenarios. DIA assists OSD and JCS in the DPG process of developing these scenarios. Alternative scenarios may be considered in the COEA. In either case, DIA must review threat assumptions and data.

Since the promulgation of the DoD 5000 Series guidance, DIA has been more involved in the COEA process. DIA support will be ramped-up as requirements are levied. Validation of the threat models used in the COEA and requirements for more threat detail than is provided in the DPG and STAR are areas of concerns. As a result, DIA needs to be involved early in the COEA planning process. Coordination can be handled through the local intelligence support organizations, COEA steering groups, or threat working groups.

Modeling and Tools

The Wall. The Gulf War. New Doctrines. The disintegration of the Soviet Union. New weapons technologies. War and warfare will be very different. If analysis is going to contribute to an understanding of the future, it will have to be done in different ways. If analysis is going to contribute to the acquisition process, it will have to be done in different ways. It will have to have a different focus. It will have to have different components. This presentation will characterize the changes in the nature of war and warfare and will suggest the kinds of changes necessary

for productive analysis in the our world, the kind of analysis necessary for COEAs.

Operational Effectiveness Methodologies

Within the conduct of a Cost and Operational Effectiveness Analysis (COEA), the basic problem to be dealt with is the development and/or selection of an appropriate methodology to compare current and proposed material systems within an operational context. Operational effectiveness (the operational context) should not automatically imply a specific force level (i.e., joint/combined, theater, corps, brigade, etc.) at which comparative force-on-force analysis must be conducted to assess differences between forces equipped with current and future systems. Neither should operational effectiveness imply specific models or types of models to be used to support COEAs. Rather, COEA analytical methodologies should be developed or selected through rigorous, front-end analysis of specific issues and questions that must be answered to provide senior decisionmakers with the best possible information on which to base "go" or "no go" decisions. This front-end analysis of issues is a joint responsibility of the decisionmakers and those who do COEA. It should lay out clearly the depth and breadth constraints within which the operational effectiveness analysis will be conducted. Tailored analytical approaches and methodologies, linked to decision issues and to the time available, are significantly more useful and less resource demanding than adherence to a "cookbook" methodology. Likewise, responsive and transparent analytical tools and models should be preferred in many COEAs over the more complex, non-transparent "black boxes" so often selected to support these types of studies and analyses.

Cost Analysis in COEAs

The presentation addresses four questions associated with the cost analysis portion of conducting a COEA:

1) WHAT IS THE QUESTION? What are the terms for the requirement for a cost analysis in a COEA?

2) WHAT IS THE DELIVERABLE? What is it that the cost analyst owes to the COEA process, and in what format does it get presented?

3) WHO IS DOING COST ANALYSIS? Professional communities are often insular. The identification of the cost analysis organizations involved in COEAs must also show where they fit in their Service organizations.

4) WHAT ARE THE CURRENT ISSUES IN COST ANALYSIS. While there are a number of issues under intense debate within the cost analysis community, several of them earn the spotlight the COEA process:

- PRESENT VALUE ANALYSIS. What is it? Why do it? What are the choices? What research questions are open?
- RISK AND UNCERTAINTY ANALYSIS. The description of risk and uncertainty analyses differentiates between the two and provides recent, "live" examples of each.
- R&D COSTING. An approach to weapon system acquisition that has received recent attention is to do the R&D and then to put it in the shelf, delaying production to some indefinite future. What implications does this delay have for COEAs?

Cost and Effectiveness Integration

The analysts have estimated both effectiveness and cost for each alternative considered in the Cost and Operational Effectiveness Analysis (COEA). Their next task is to rank order the alternatives. Ranking the alternatives requires that the distinct attributes, cost and effectiveness, somehow be integrated. This presentation considers the integration problem from the viewpoint of multi-attribute or multiple criteria decision making. From this viewpoint, an individual decision maker's preferences and value trade-offs among multiple and often conflicting attributes can be explicitly modeled. This model can then be used to rank the decision alternatives. From existing literature, several possible techniques are identified. Two of the techniques are demonstrated in the context of an abbreviated COEA on the TOW Sight Improvement Program.

Managing COEA Development

The author's recent experience in putting together a COEA for a major weapons system will demonstrate the management process. Emphasis is placed on a practical approach to understanding what must be done, and on how to organize oneself and

others to accomplish it. Subjects include: what to do when initially tasked, how to identify what needs to be done, what are the most important elements of a COEA, how to organize senior leadership and working level resources, and (most importantly), what are the lessons learned from the entire experience. Principles, observations, and recommendations are made in such a way that they can apply to any program or weapon system.

Linking COEAs to OT&E

Current acquisition policy states that the cost and operational effectiveness analyses and test and evaluation are aids to decisionmaking. The COEA aids decisionmakers in judging whether any of the proposed alternatives are a cost effective approach to meeting an operational requirement. Test and evaluation aids decisionmakers in verifying that systems have attained their technical performance specifications and objectives, are operationally effective, and are operationally suitable for their intended use. The policies require that a linkage exist between COEAs and test and evaluation.

In order to implement this guidance consistently throughout the acquisition process, guidelines have been developed for COEA to include a measures of effectiveness (MOEs) that can be tested and show how other COEA MOEs can be derived from testable parameters. In addition, sensitivity analyses conducted as part of a Milestone II COEA should identify any critical sensitivities of system effectiveness to the stated test limitations. The Defense Acquisition Board (DAB) and the Defense Acquisition Executive (DAE) should be able to review the COEA results using test results to reaffirm the decision that the selected alternative continues to be a cost effective approach to satisfying the operational requirement.

In theory, linkage between the Mission Needs Statement (MNS), Operational Requirement Document (ORD), COEA, Acquisition Program Baseline (APB), and Test and Evaluation Master Plan (TEMP) in measures of effectiveness, measures of performance, and criteria seems obvious. So does ensuring that test results are used to "validate" the performance assumptions underlying the COEA results and that the premises for earlier acquisition decisions remain sound. In practice, this linkage is difficult to achieve and presents numerous analytical challenges. These challenges will be highlighted by the members of this panel.

The COEA in Support of the DoD Decision Process

This presentation describes elements and criteria for judging how well a COEA meets the new DoD 5000 Series acquisition regulations. It provides a framework for evaluating a COEA that is keyed to the analysis requirements incorporated into the regulations. Guidelines, while not necessarily comprising an exhaustive "checklist," are presented to identify general properties that characterize "good" COEAs. The guidelines are offered as a useful basis for achieving uniformity and consistency in doing COEAs and for enhancing the degree to which COEAs can support the DoD decision process. While the guidelines are offered primarily as an aid for implementing the acquisition regulations, it is hoped that they also will serve as a starting point for the analysis community to take up the greater challenge of defining what constitutes "high quality" COEAs.

PAPERS AND/OR

VIEWGRAPHS

MORS COEA
MINI-SYMPOSIUM
MARCH 9-11, 1992

COST AND OPERATIONAL EFFECTIVENESS ANALYSIS (COEA)

KEYNOTE ADDRESS
DR DAVID S. C. CHU
ASD(PA&E)

PURPOSE OF THE COEA MINI-SYMPOSIUM

- CLARIFY WHAT IS EXPECTED IN COEAs
- IDENTIFY AND DISCUSS PROBLEMS OF IMPLEMENTATION
- IMPROVE COLLABORATION IN SUPPORT OF ACQUISITION DECISIONS

THE DoD DECISIONMAKING CONTEXT

- COST-EFFECTIVENESS:
  A WELL- ESTABLISHED CRITERION
- BUDGETS:
  REFLECT THE END OF THE COLD WAR
- ACQUISITIONS REGULATIONS:
  SUBSTANTIALLY REVISED AND REJUVENATED

PURPOSE AND ROLES OF COEA

WHAT DO WE WANT?

NOT JUST CHECKING A BOX
NOR JUSTIFYING A DECISION

BUT

PART OF THE DECISION PROCESS...
AND PART OF THE RECORD ...
AND THE RATIONALE FOR CHOICE.

PURPOSE AND ROLES OF COEA

COEAs SHOULD:

FACILITATE COMMUNICATIONS:
- HELP IDENTIFY ALTERNATIVES EARLY
- MAKE ASSUMPTIONS AND VARIABLES EXPLICIT

AID DECISIONMAKING
- EXAMINE STRENGTH & WEAKNESSES OF PROG RATIONALE
- ILLUMINATE PROs & CONs OF ALTERNATIVES
- MAKE SENSITIVITIES EXPLICIT

DOCUMENT DECISIONS
- RECORD LOGIC & ANAL CONSIDERED BY DECISIONMAKERS
- PROVIDE BASIS FOR PROGRAM RATIONALE

PURPOSE AND ROLES OF COEA

NO SINGLE "COOKBOOK" SOLUTION

- CAPABILITY COUNTS
- DO NOT FORCE EQUAL COST OR EQUAL EFFECTIVENESS COMPARISONS

PROBLEMS AND CONCERNS
(1)

THE RATIONALE FOR A SYSTEM IS OFTEN NOT CLEARLY ESTABLISHED

- MISSION AREA ANALYSES
  - NOT DONE OR NOT AVAILABLE
- CAMPAIGN ANALYSES
  - NOT DONE OR NOT AVAILABLE.
  - YET THEY.....
    - HELP ENSURE CONSISTENCY
    - FOCUS ON OUTCOMES AND KEY CHARACTERISTICS
- SCENARIOS AND THREATS NOT KEPT CURRENT

PROBLEMS AND CONCERNS
(2)

- ALTERNATIVES
  - TOO NARROW - MINOR VARIATIONS ON A THEME
  - NOT DIRECTLY LINKED TO THE DECISION
- REQUIREMENTS TRADE-OFFS
  - NOT VISIBLE
  - COMBAT VALUE NOT SHOWN
- MEASURES OF EFFECTIVENESS
  - SHOW PERFORMANCE BUT NOT VALUE TO COMBAT OUTCOME
  - NOT LINKED TO BASELINE THRESHOLD
  - DO NOT SHOW IF SYSTEM AS TESTED IS COST-EFFECTIVE

PROBLEMS AND CONCERNS
(3)

- MODELS NOT ALWAYS CREDIBLE...
  NOR CAN RESULTS ALWAYS BE REPLICATED
- DATA NOT CONSISTENT WITH DATA USED IN OTHER ANALYSES
- COSTS
  NOT CONSISTENT WITH FIGURES BRIEFED TO THE CAIG
  NOT INCLUSIVE TO ALL COSTS INCURRED

PROBLEMS AND CONCERNS
(4)

- MANAGING COEAs
  INDEPENDENCE IS ESSENTIAL
  OSD SHOULD BE INVOLVED THROUGHOUT...
  NO SURPRISES
  COEA AND SSEB CONCLUSIONS NOT ALWAYS CONSISTENT

HOW CAN OPERATIONS RESEARCH HELP SOLVE THESE PROBLEMS ?

- FOCUS ON MILITARY OUTCOMES
- SPECIFY A BROAD RANGE OF ALTERNATIVES
- CHALLENGE "REQUIREMENTS"
- SCRUTINIZE SCENARIOS
- ENFORCE CONSISTENCY
- BE REALISTIC ABOUT COSTS

CONCLUSION

COEA

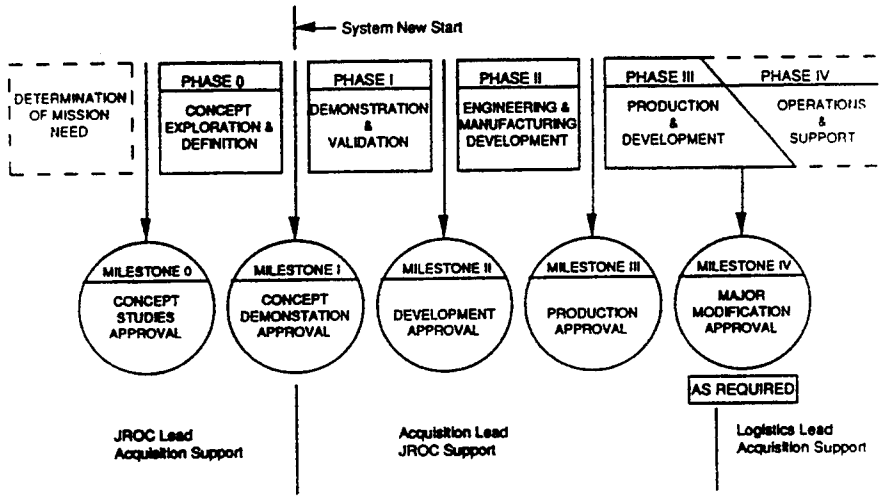
A GUIDE TO DoD DECISION

MORS COEA SYMPOSIUM

ANALYSIS REQUIREMENTS FOR MILESTONE REVIEWS

Dr Bill Lese
OASD(PA&E)

ACQUISITION MILESTONES & PHASES



MISSION NEED DETERMINATION

MINIMUM REQUIREMENTS

OBJECTIVE:

- IDENTIFY DEFICIENCIES AND/OR OPPORTUNITIES

ASSESSMENTS:

- THREAT
- MISSION NEED ANALYSIS
  (DEFINES DEFICIENCIES/OPPORTUNITIES)
- NON MATERIAL SOLUTION
  (EVALUATES DOCTRINE, OPERATIONAL CONCEPTS
  TACTICS, TRAINING & ORGANIZATION)
- MODS TO CURRENT US/ALLIED SYSTEMS

DOCUMENTATION

- MISSION NEED STATEMENT
  JROC VALIDATED
  JOINT PRIORITY ASSIGNED

MILESTONE 0 REVIEW

CONCEPT STUDIES APPROVAL

DAB DECISION ISSUE

- IS THE MNS ACCEPTABLE BASED ON
  * A VALIDATED THREAT
  * CONFIRMATION OF MATERIEL SOLUTION RQMT
  * MSN NEED BEING IMPORTANT ENOUGH TO STUDY

ANALYSIS NEEDS:

- THEATER LEVEL/ CAMPAIGN ANALYSIS

DAB RESULTS: AN ADM THAT SPECIFIES

- THE MIN SET OF MATERIEL ALTERNATIVE CONCEPTS
- WHAT STUDIES WILL BE AUTHORIZED
- DOLLARS AND FUNDING SOURCES FOR STUDIES

THEATER LEVEL/CAMPAIGN ANALYSIS
CHARACTERISTICS

- EVALUATES CROSS-SERVICE AND WITHIN SERVICE ALTERNATIVE CONCEPTS TO SATISFY IDENTIFIED DEFICIENCIES OR TO CAPATILIZE ON OPPORTUNITIES
- CONDUCTED IN CONTEXT OF JOINT OPERATIONS IN LARGE SCALE SCENARIOS.
- CAPTURES THE SYNERGISTIC EFFECTS OF CROSS-SERVICE SYSTEMS OVER EXTENDED PERIODS OF CONFLICT
- DEFINES THE CHARACTERISTICS REQUIRED OF A SYSTEM TO MEET IDENTIFIED DEFICIENCIES

MILESTONE I REVIEW
CONCEPT DEMONSTRATION APPROVAL

DAB DECISION ISSUES:
- IS A NEW PROGRAM START WARRANTED BASED ON
  - * A VALIDATED THREAT
  - * CONFIRMATION OF NEED BY STUDIES
  - * PROGRAM BEING AFFORDABLE VIS-A-VIS
    - LONG RANGE INVESTMENT PLANS
    - AVAILABILITY OF REQUIRED RESOURCES
      - (PEOPLE AND FUNDS
- IS CONCEPT BASELINE ACCEPTABLE BASED ON SPECIFIED
  - * COST, SCHEDULE & PERFORMANCE OBJECTIVES
  - * ORD THRESHOLDS

ANALYSIS NEEDS:
- COEA
- THEATER LEVEL/CAMPAIGN ANALYSIS
- AFFORDABILITY ANALYSIS

RESULTS (DOCUMENTED IN THE ADM)
- DEM/VAL GO-AHEAD
- CONCEPT BASELINE APPROVAL
- EXIT CRITERIA FOR PHASE I

PHASE I - DEMONSTRATION & VALIDATION

- COEA (MSII BEST ALTERNATIVE DESIGN APPROACH)
- REVALIDATED THREAT
- MAJOR COST, SCHEDULE & PERFORMANCE TRADE-OFF OPPORTUNITIES DEFINED
- DEVELOPMENT BASELINE ESTABLISHED
- DEVELOPMENTAL TEST RESULTS & ASSESSMENTS
- REFINED ACQUISITION STRATEGY
  - HIGH RISK AREAS
    RISK MANAGEMENT APPROACH
  - LRIP QUANTITIES
- ASSESSMENT OF INDUSTRIAL BASE CAPBILITY
- AFFORDABILITY AND LCC
- ADEQUATE RESOURCES PROGRAMMING
- PROPOSED EXIT CRITERIA FOR PHASE II
- POTENTIAL ENVIRONMENTAL CONSEQUENCES

MILESTONE II REVIEW

DEVELOPMENTAL APPROVAL

DAB DECISION ISSUES:

- SHOULD PROGRAM PROCEED TO EMD BASED ON
  - * A VALIDATED THREAT
  - * VALIDATED COST, SCHEDULE & PERF TRADE-OFFS
  - * PROGRAM BEING AFFORDABLE
- IS CONCEPT BASELINE ACCEPTABLE BASED ON
  - REFINED COST, SCHEDULE & PERF OBJECTIVES
  - REFINED ORD THRESHOLDS

ANALYSIS NEEDS:

- COEA
- STILL MEETING ORIGINAL REQUIREMENT
- AFFORDABILITY ANALYSIS

DAB RESULTS (DOCUMENTED IN THE ADM)

- EMD GO-AHEAD
- DEVELOPMENT BASELINE APPROVAL

PHASE II - EMD

- VALIDATED THREAT
- TEST RESULTS UNDER OPERATIONAL CONDITIONS
- LRIP THAT
  - VERIFIES ADEQUACY OF PRODUCTION PROCESS
  - CONFIRMS STABILITY & PRODUCIBILITY OF DESIGN
  - PROVIDES REALISTICS ESTIMATES OF PRODUCTION COST
- REFINED ACQUISITION STRATEGY & COST ESTIMATE
- REFINED PROGRAM COST, SCHEDULE & PERF OBJECTIVES
- PRODUCTION BASELINE
- SYSTEM CONFIGURATION BASELINE
- AFFORDABILITY AND LCC ASSESSMENT UPDATE
- SUFFICIENT PROGRAMMING RESOURCES
- POTENTIAL ENVIRONMENTAL CONSEQUENCES

MILESTONE III DECISION ISSUES

DAB DECISION ISSUES:
- SHOULD PROGRAM PROCEED TO PRODUCTION BASED ON
  - A VALIDATED THREAT
  - VALIDATED PERFORMANCE OBJECTIVES AND THRESHOLDS
  - OT SHOWING SYSTEM IS
    - STABLE
    - OPERATIONALLY ACCEPTABLE
    - LOGISTICALLY SUPPORTABLE
  - LRIP SHOWING SYSTEM CAN BE PRODUCED EFFICIENTLY
  - PROGRAM BEING AFFORDABLE
- IS PRODUCTION BASE LINE ACCEPTABLE BASED ON
  - REFINED COST, SCHEDULE & PERF OBJECTIVIES
  - REFINED ORD THRESHOLDS

ANALYSIS NEEDS:
- COEA UPDATE (IF THREAT OR COST CHANGES MUCH)
- AFFORDABILITY ANALYSIS

DAB RESULTS (DOCUMENTED IN THE ADM)
- PRODUCTION GO-AHEAD
- PRODUCTION BASELINE APPROVAL
- EXIT CRITERIA FOR PHASE III

PHASE II - EMD

- VALIDATED THREAT
- TEST RESULTS UNDER OPERATIONAL CONDITIONS
- LRIP THAT
  - * VERIFIES ADEQUACY OF PRODUCTION PROCESS
  - * CONFIRMS STABILITY & PRODUCIBILITY OF DESIGN
  - * PROVIDES REALISTICS ESTIMATES OF PRODUCTION COST
- REFINED ACQUISITION STRATEGY & COST ESTIMATE
- REFINED PROGRAM COST, SCHEDULE & PERF OBJECTIVES
- PRODUCTION BASELINE
- SYSTEM CONFIGURATION BASELINE
- AFFORDABILITY AND LCC ASSESSMENT UPDATE
- SUFFICIENT PROGRAMMING RESOURCES
- POTENTIAL ENVIRONMENTAL CONSEQUENCES

MILESTONE III DECISION ISSUES

DAB DECISION ISSUES:

- **SHOULD PROGRAM PROCEED TO PRODUCTION BASED ON**
  - * **A VALIDATED THREAT**
  - * **VALIDATED PERFORMANCE OBJECTIVES AND THRESHOLDS**
  - * **OT SHOWING SYSTEM IS**
    - **STABLE**
    - **- OPERATIONALLY ACCEPTABLE**
    - **- LOGISTICALLY SUPPORTABLE**
  - * **LRIP SHOWING SYSTEM CAN BE PRODUCED EFFICIENTLY**
  - * **PROGRAM BEING AFFORDABLE**
- IS PRODUCTION BASE LINE ACCEPTABLE BASED ON
  - REFINED COST, SCHEDULE & PERF OBJECTIVIES
  - REFINED ORD THRESHOLDS

ANALYSIS NEEDS:

- **COEA UPDATE (IF THREAT OR COST CHANGES MUCH)**
- **AFFORDABILITY ANALYSIS**

DAB RESULTS (DOCUMENTED IN THE ADM)

- **PRODUCTION GO-AHEAD**
- **PRODUCTION BASELINE APPROVAL**
- **EXIT CRITERIA FOR PHASE III**

PHASE III - PRODUCTION & DEVELOPMENT

- VALIDATED THREAT
- UPDATED CONFIGURATION BASELINE
- REFINE COST INFORMATION
- EXECUTION OF OPERATIONAL & SUPPORT PLANS
- IDENTIFICATION OF OPERATIONAL AND/OR SUPPORT PROBLEMS

MILESTONE IV DECISION ISSUES

DAB DECISION ISSUES:

- **SHOULD SYSTEM BE UPGRADED OR MODIFIED BASED ON**
  - **A VALIDATED THREAT**
  - **VALIDATED PERFORMANCE OBJECTIVES & THRESHOLDS**
  - **FIELD EXPERIENCE SUPPORTING THE NEED**
  - **ATTAINABILITY OF KEY TECHNOLOGIES & PROCESSES**
  - **PROGRAM BEING AFFORDABLE**
- IS NEW BASELINE ACCEPTABLE BASED ON
  - LEVEL OF RISK
  - AMOUNT OF RESOURCES COMMITTED

ANALYSIS NEEDS:

- **COEA (ONLY IF MAJOR CHANGES OCCURRED)**

DAB RESULTS (DOCUMENTED IN THE ADM)

- **DEFINE NEW SYSTEM "ENTRY" PHASE**
- **EXIT CRITERIA FOR PHASE IV**

PHASE IV - OPERATIONS
SUPPORT

- VALIDATED THREAT ASSESSMENT
- UPDATED CONFIGURATION BASSLINE
- ATTAINMENT/MAINTENANCE OF REQUIRED PERFORMANCE CAPABILITIES (PIPS)
- CONDUCT OF SLEPS AS APPROPRIATE

2.1.3 Threat Assessments/Star and Scenarios

Overview

The threat assessment process for Cost and Operational Effectiveness Analysis (COEA) begins with basic threat support and validation. Next, a threat baseline is defined for the COEA. Threat scenarios are then identified which place the threat baseline in the proper context. Threat analysis issues and coordination will be described and the paper will conclude with some recent experiences and concerns.

Threat Support and Validation

The Defense Intelligence Agency (DIA) provides threat support to the Joint Chiefs of Staff (JCS), the Office of the Secretary of Defense (OSD), Defense Agencies, the Services, and also U&S Commands. For major U.S. weapons programs, DIA supports the Defense Acquisition Board (DAB) oversight process. Support includes providing threat information; acting as a threat advisor to various DAB committees, other OSD working groups, and the Joint Requirements Oversight Council; and reviewing and validating threat information developed by DoD components. The DoD 5000 series regulations specifically require that "threat information, to include the target data base, must be validated by DIA for acquisition programs subject to review by the DAB..."

Initial efforts begin with DIA input and review of the Defense Planning Guidance (DPG). DIA assists OSD and JCS in the development of threat implications in the DPG and specifically the threat forces contained in the Illustrative Planning Scenarios (IPSs) which will be described later. As chairman of the Red Advisory Panel, DIA also coordinates Intelligence Community input, enemy order of battle, and threat actions in the JCS Joint Military Net Assessment process.

For the acquisition process, DIA reviews and validates threat sections of the Mission Need Statement, Operational Requirement Document, Integrated Program Summary, Integrated Program Assessment, Test and Evaluation Master Plan, and COEA. A major activity for a specific weapon program is DIA's validation of the System Threat Assessment Report (STAR), described later. Validation involves reviewing the proposed threat information with the following considerations:

(1) Is the full scope of applicable current and future threats considered?

(2) Are all threats shown appropriate?

(3) Are the threats reasonable, that is, are the treat systems, tactics, and force structure feasible?

(4) Is the threat information consistent with the latest defense and national intelligence position?

(5) Are extrapolations of future threat capabilities or technologically feasible options logical?

Threat Baseline

The validated threat baseline for COEAs will be a combination of the DPG and other documents depending on where the program is in the acquisition cycle. The DPG contains the overall threat scenarios. The underlying assumptions concerning the threat in the COEA should not conflict with the DPG. Prior to Milestone I, the initial threat will be found in a series of baseline threat documents prepared by the Services and validated by DIA or produced under DIA cover. These threat documents are normally developed by mission area. Examples include threats to undersea, airlift, space, and special operations forces. Both the Army's Battlefield Development Plans and Navy's Pyramid publications are being redone to reflect worldwide threats. The Air Force Threat Environment Descriptions (TEDs) also reflect this changed emphasis. The Pyramid publications and TEDs are now produced as formal DIA documents. In order to support long-range analysis, these generic documents project mission area threats out 20 years.

For Milestone I and beyond, a STAR is produced. The STAR focuses on the threat for a specific weapons program. The STAR projects the threat (weapons, targets, tactics, and order-of-battle) at the initial operational capability (IOC) and again at IOC + 10 years. It includes likely reactive threat changes due to premature disclosure about the program or actual deployment. The STAR is updated prior to each milestone or if a significant change in threat occurs. Since the COEA and STAR are being updated simultaneously before the milestone, it is important that

threat changes are carefully coordinated in the COEA to ensure consistency at the milestone.

Scenarios

Scenarios define how the available intelligence baseline is applied in the COEA. DoD Instruction 5000.2 requires that the COEA scenarios conform to the DPG scenarios discussed earlier. The current draft set of IPSs cover seven regional conflicts. DIA assists JCS (J-5) and the Under Secretary of Defense for Policy in the development of these scenarios. It is important to note that DIA does not drive the scenarios, but recommends threat force levels and capabilities. Further, DIA does not validate the scenarios; it validates the threat information in the scenarios. These scenarios are not predictions of the future, but as a set, help determine requirements for U.S. forces and capabilities.

The DPG scenarios are not detailed enough to conduct the COEA without additional assumptions regarding threat laydowns, composition of threat units, numbers and types of weapons, and weapon employment tactics and doctrine. Such assumptions may be drawn from the STAR and other DIA-validated sources or may be developed on a case-by-case basis. Alternative scenarios and threat excursions may be considered, but differences with the IPSs must be identified and addressed. DIA intends to develop a Threat Environment Projection document which provides expanded threat environments for each of the major DPG scenarios.

In the past, Service scenario developers, such as the Army Training and Doctrine Command, have taken the IPSs and expanded them to include unit descriptions, laydowns, and day-by-day descriptions of the movement of Red and Blue forces. Vignettes from these scenarios have also been used to establish detailed test and evaluation (T&E) criteria. On occasion, DIA has reviewed and approved these for use in COEAs and T&E. However, it is not DIA's intent to validate individual unit deployments, but rather require the Service certify that deployments have been accomplished in accordance with general military principles.

Threat Analysis and Coordination

DoD Manual 5000.2-M contains general guidance for threat analysis in the COEA. These guidelines cover: consistency with the DPG; consideration of the nature, size, and technical performance of threat forces; analysis in sufficient detail; implications of threat constraints; and the need for a range of plausible threats to allow for uncertainty. It is important to remember that there may be widely-varying confidence levels associated with much of the available information.

Coordination of these and other threat issues will be improved by involving DIA early in the COEA planning. DIA coordination may be handled differently depending on the size and nature of the COEA and the sponsoring Service. in addition to local intelligence offices, threat coordinating or working groups, with DIA participation, may be formed to review threat baselines and identify additional threat assumptions required to conduct the COEA. Formal DIA validation will probably be needed. Early coordination will help avoid delays and threat issues at the milestone.

Conclusion

Since the promulgation of the DoD 5000 series guidance, DIA has become more involved in the COEA process. Recent efforts include COEAs for the F-22, A-X, Global Protection Against Limited Strikes, and Joint Unmanned Aerial Vehicle programs. DIA has reviewed both digital threat models, as well as the input data for these models, as part of the validation effort. Review of man-in-the-loop simulators which input to a COEA is a particularly new challenge. DIA support will be ramped-up as requirements are levied. However, validation of threat models used in the COEA, and requirements for far more threat detail than is provided in the DPG and STAR, remain areas of concern. Validation, verification, and accreditation of models are areas that the Services and OSD, with support as required from DIA, need to resolve.

In summary, validation of threat assessments for COEAs are part of the threat support provided by DIA for major U.S. weapons programs. This support is based on a requirement levied by DoD for DIA validation of all threat information used in such programs. The COEA threat baseline is contained in the DPG and special mission area or system specific threat documents. COEAs should conform to the set of scenarios in the DPG. However, additional effort will be required to develop threat details for COEAs. As a result, DIA needs to be involved early in the COEA planning process to avoid problems and delays.

2.1.4 Modeling and Tools

Changes in War and Warfare:
New Demands for Analysis

Topic #3: Modeling and Tools

Sam Gardiner

MORS Mini-Symposium

COEA in the Acquisition Process and the Role of OR in Performing COEA

March 9, 1992

Figure 1: Changes in War and Warfare

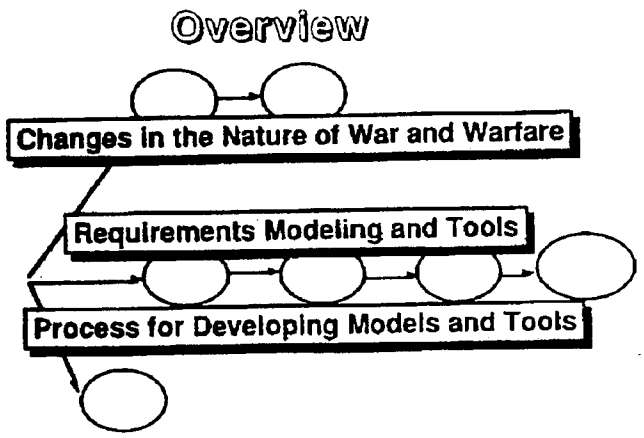


Figure 2: Overview

Trends	Level 1 Consequences (Trends)	Level 2 Consequences (Discontinuities)
Limited Objectives War Non-Forward Deployment Force Sizes	Information Content Campaign Fragility of Targets Assymmetrical Technologies Interchangability Tempo Density Fragility of Units	Deterrence by Punishment No Linkage Between Conventional and Strategic Character of War Termination Non-Continuous Combat Fragmented Battlefield Leverage (Maneuver Warfare)
Information Content Warfare Lethality Range of Systems		

Figure 3: Trends and Consequences

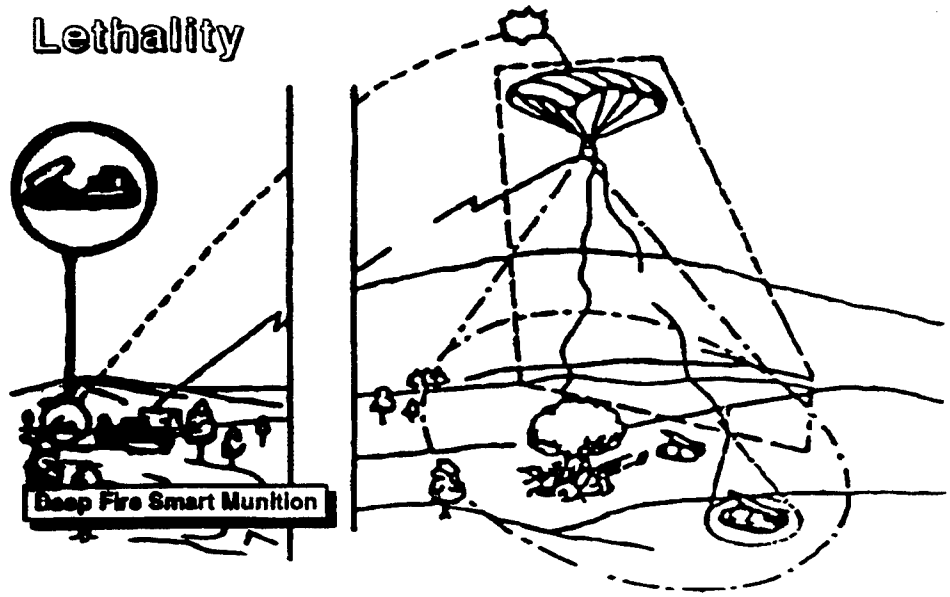
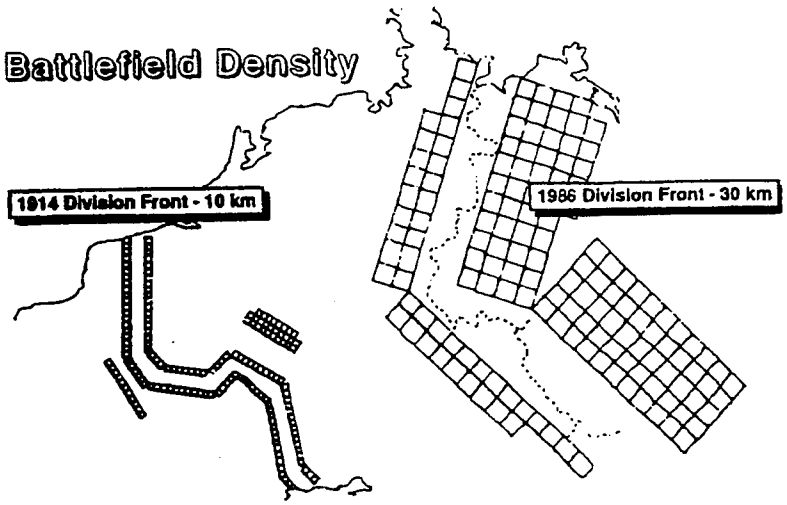


Figure 4: Lethality



This is from Chris Bellamy, The Future of Land Warfare

Figure 5: Battlefield Density

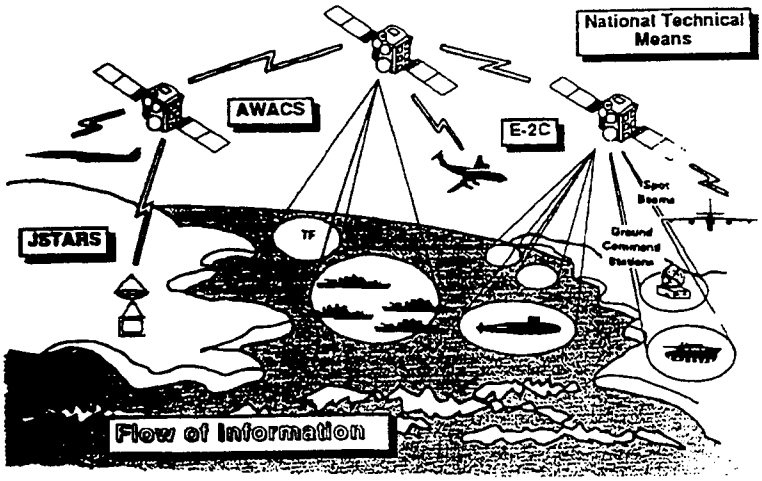


Figure 6: Flow of Information

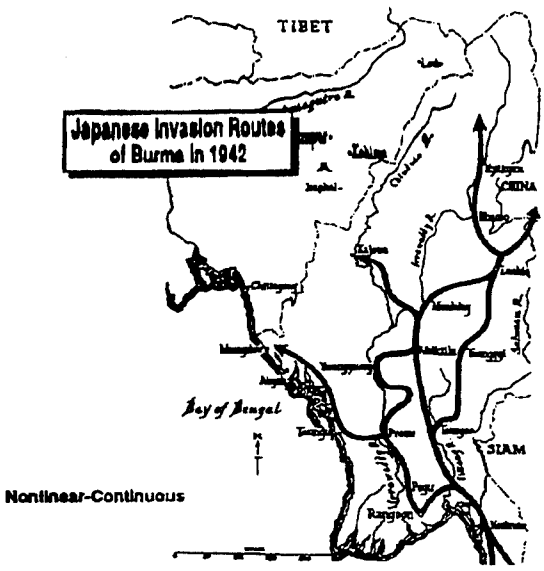


Figure 7: Nonlinear Continuous (1)

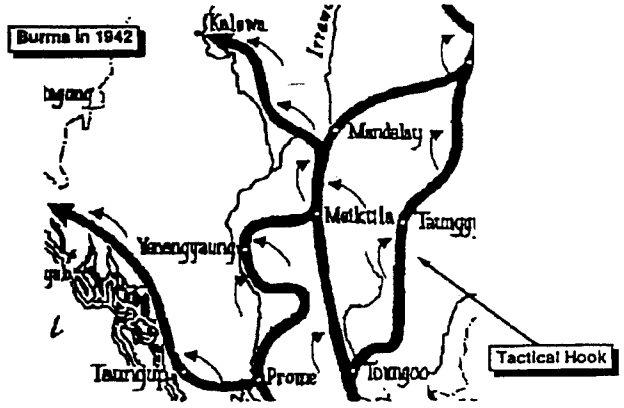


Figure 8: Nonlinear Contiuous (2)

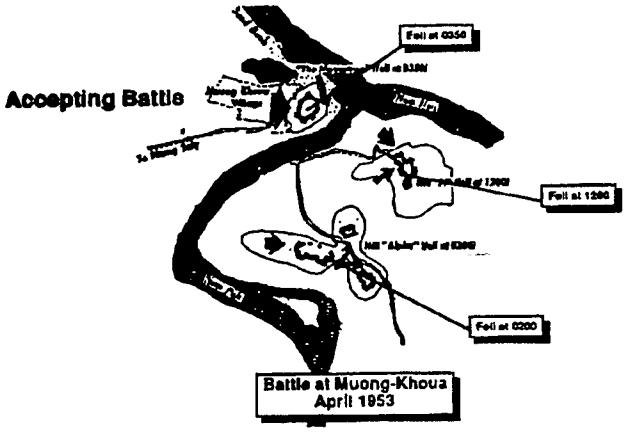


Figure 9: Refusing Battle

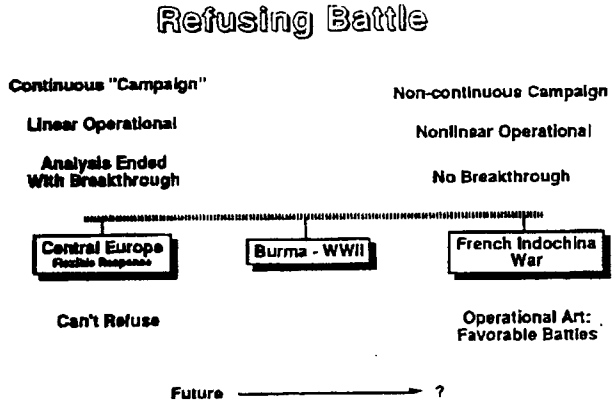


Figure 10: Refusing Battle

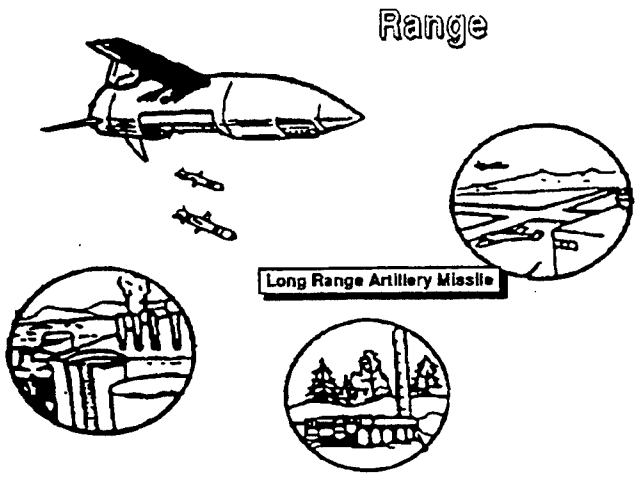


Figure 11: Range

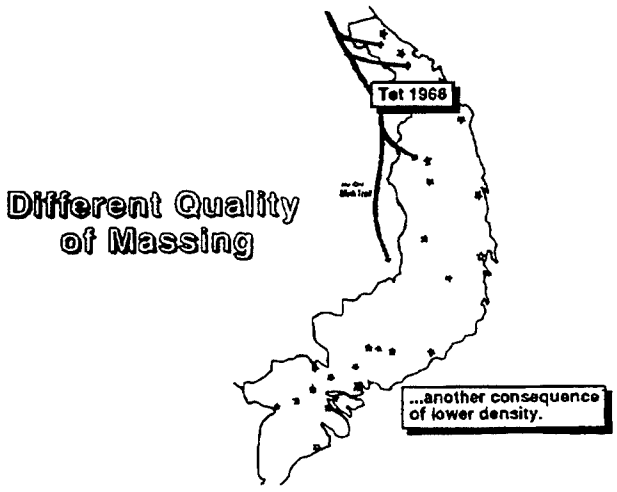


Figure: Different Quality of Massing

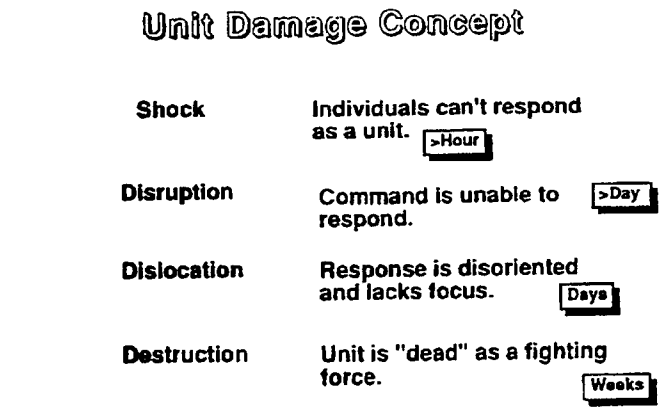


Figure 13: Unit Damage Concept

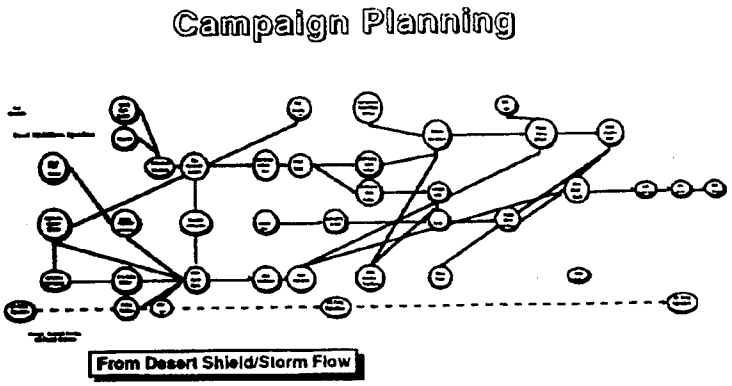


Figure 14: Campaign Planning

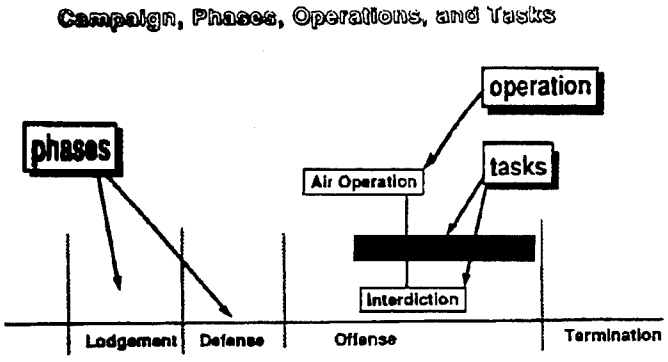


Figure 15: Campaign, Phases, Operations and Tasks

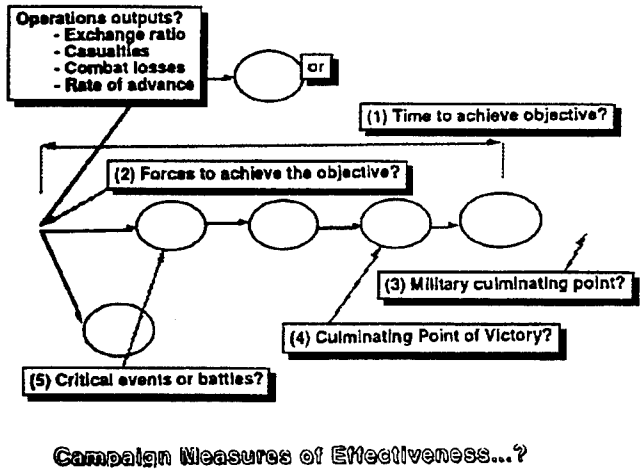


Figure 16: Campaign Measures of Effectiveness...?

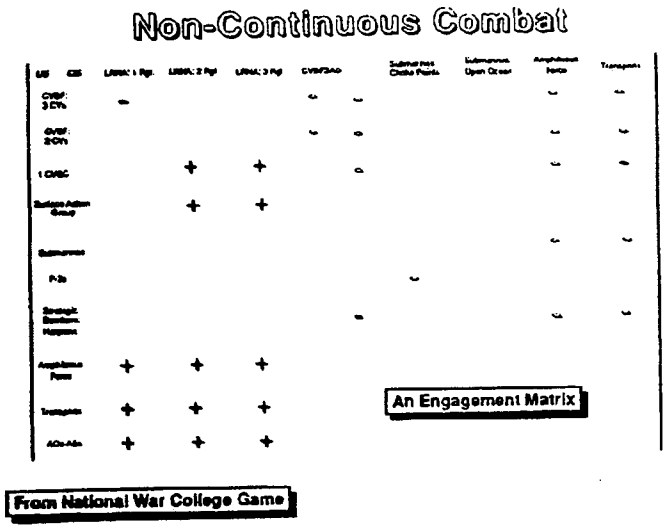


Figure 17: Non-Continuous Combat

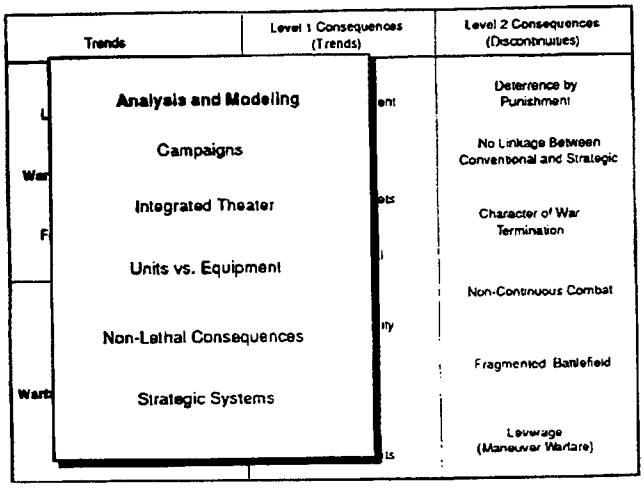


Figure 18: Analysis and Modeling

2.1.5 Operational Effectiveness Methodologies

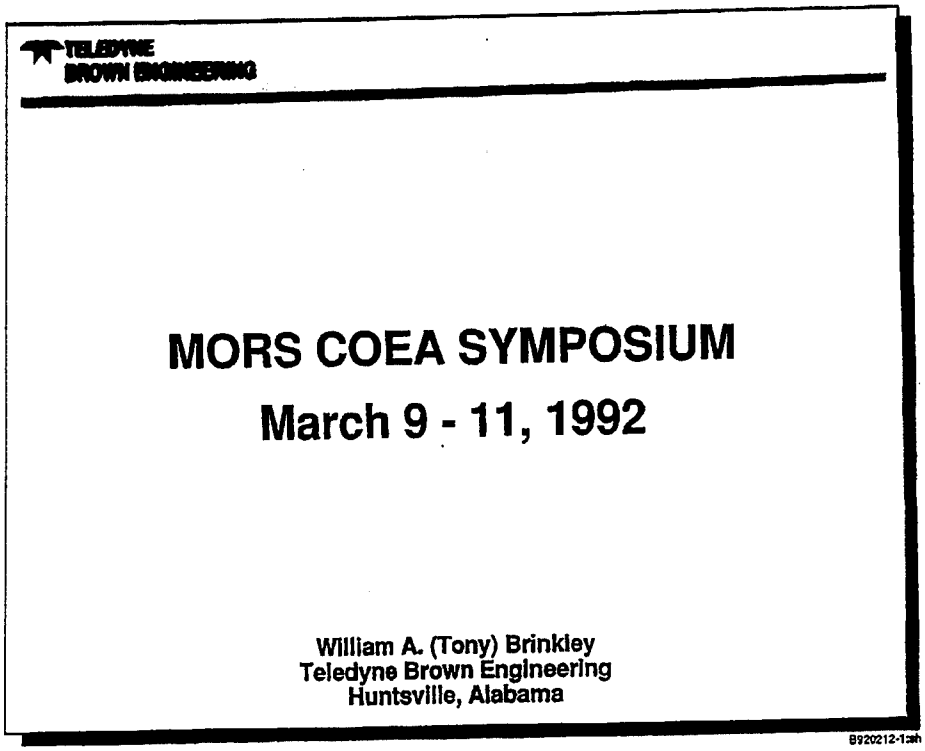


Figure 1: Introduction

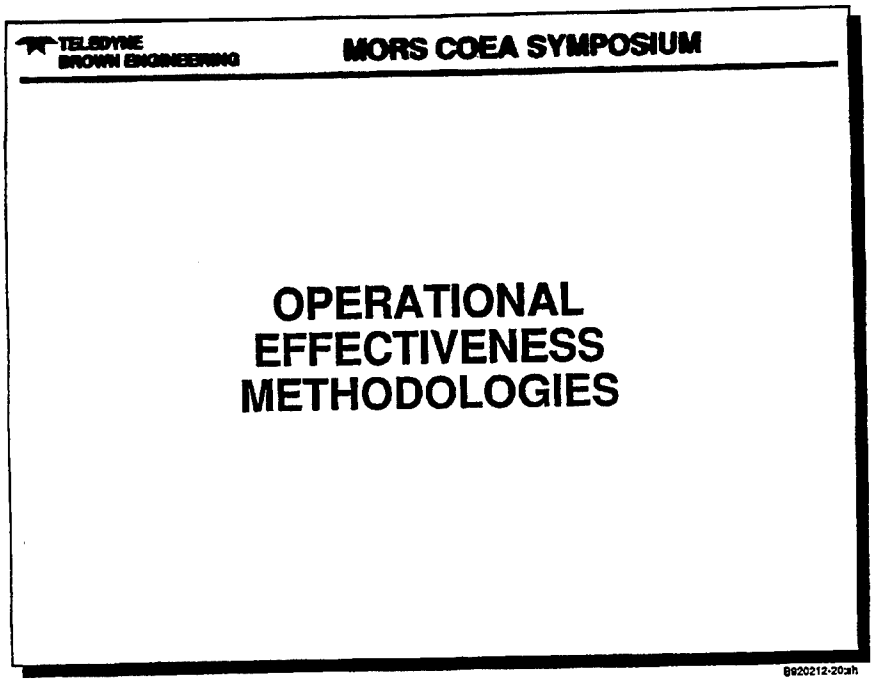


Figure 2: Operational Effectivenss Methodologies

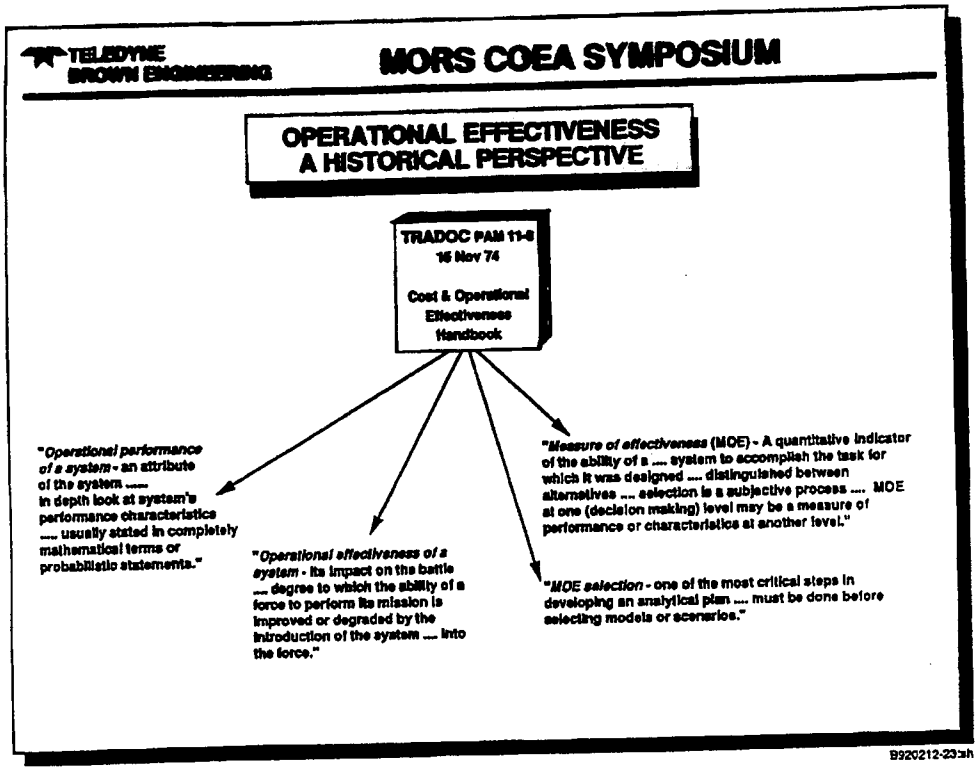


Figure 3: Operational Effectiveness--A Historical Perspective

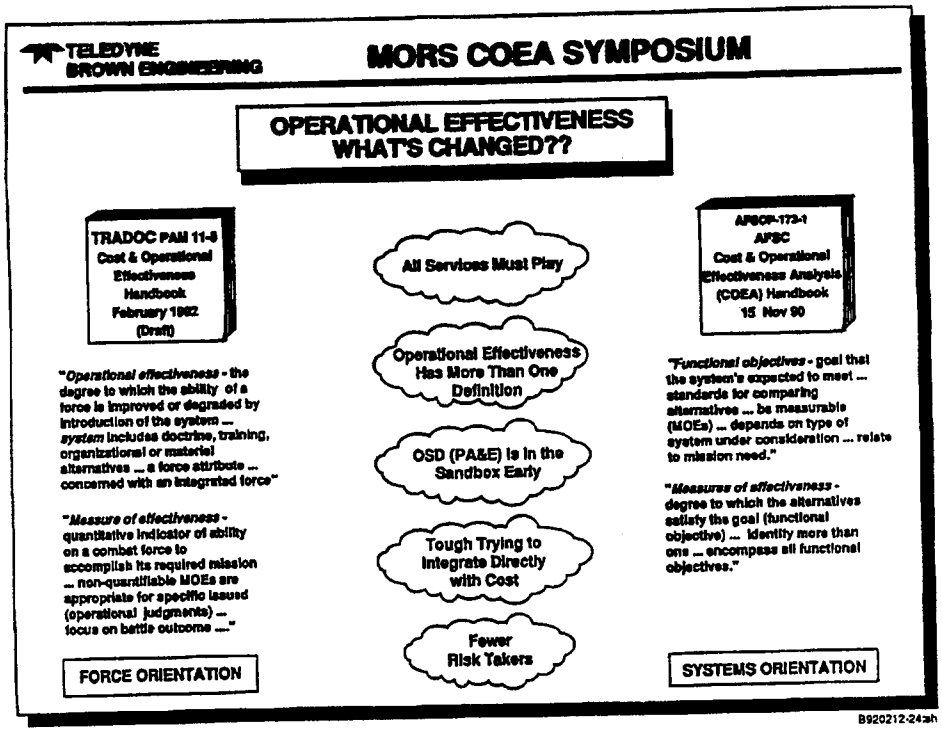


Figure 4: Operational Effectiveness--What's Changed?

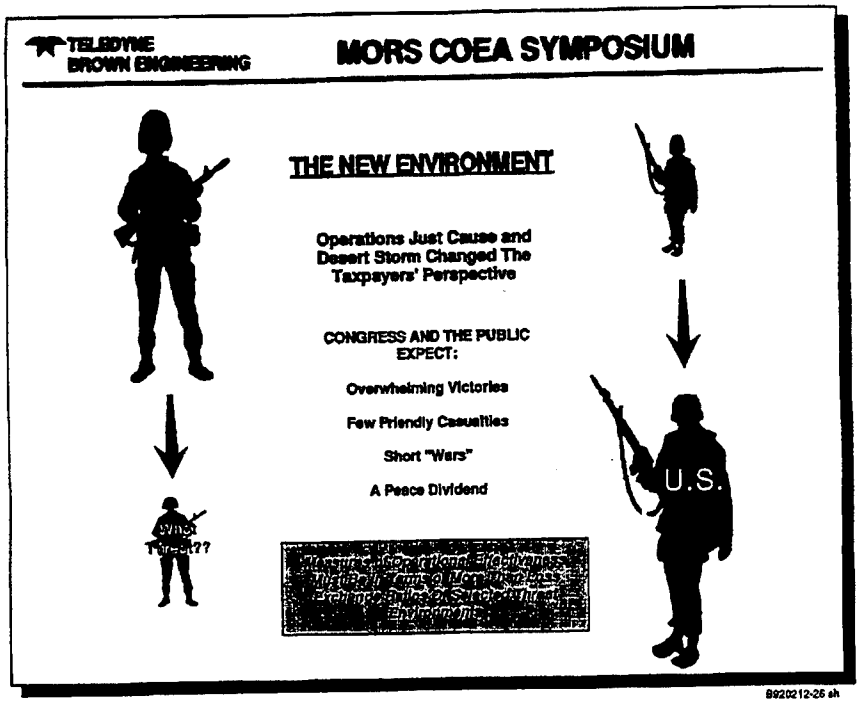


Figure 5: The New Environment

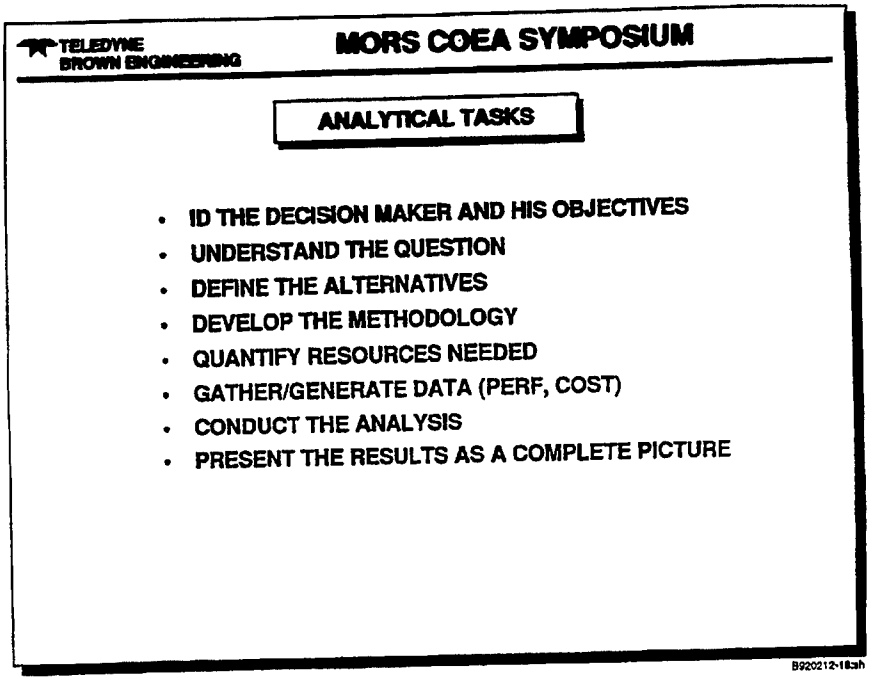


Figure 6: Analytical Tasks

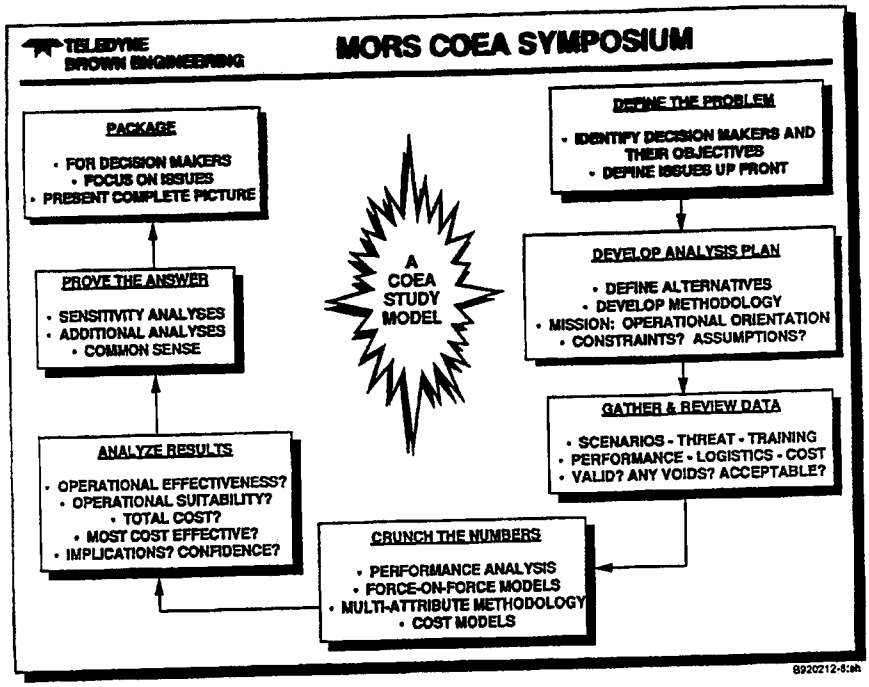


Figure 7: A COEA Study Model

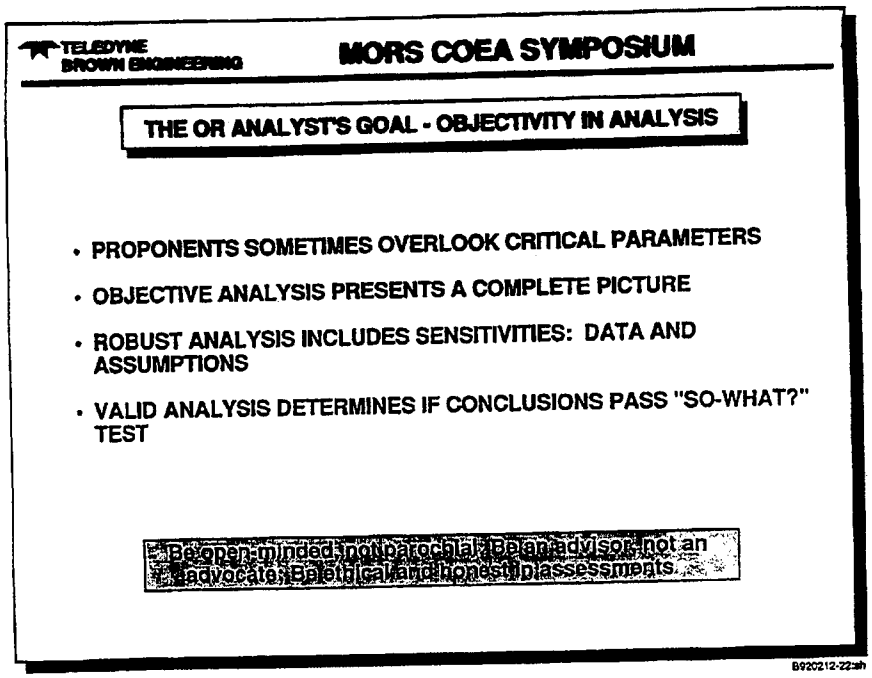


Figure 8: The OR Analyst Goal--Objectivity in Analysis

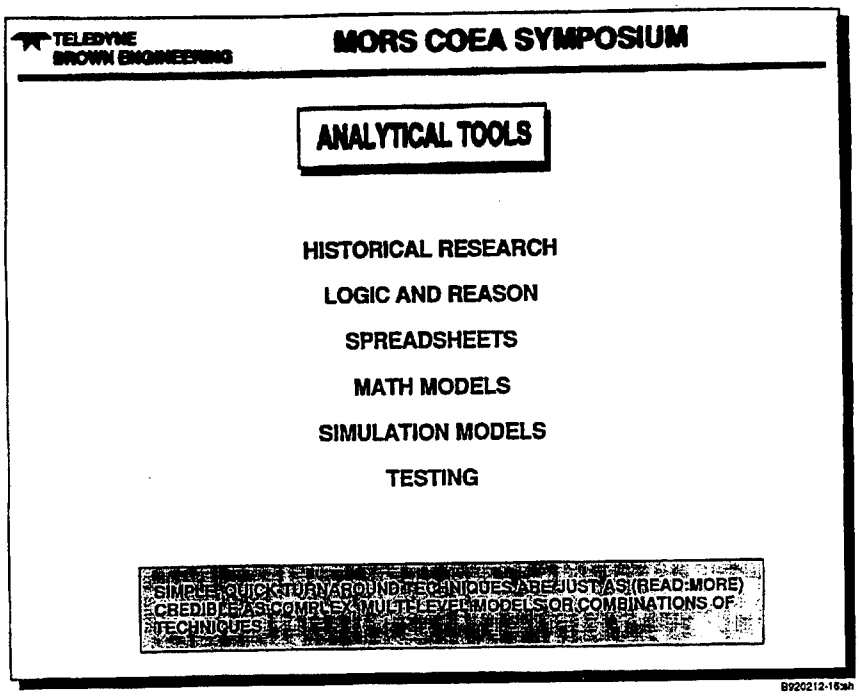


Figure 9: Analytical Tools

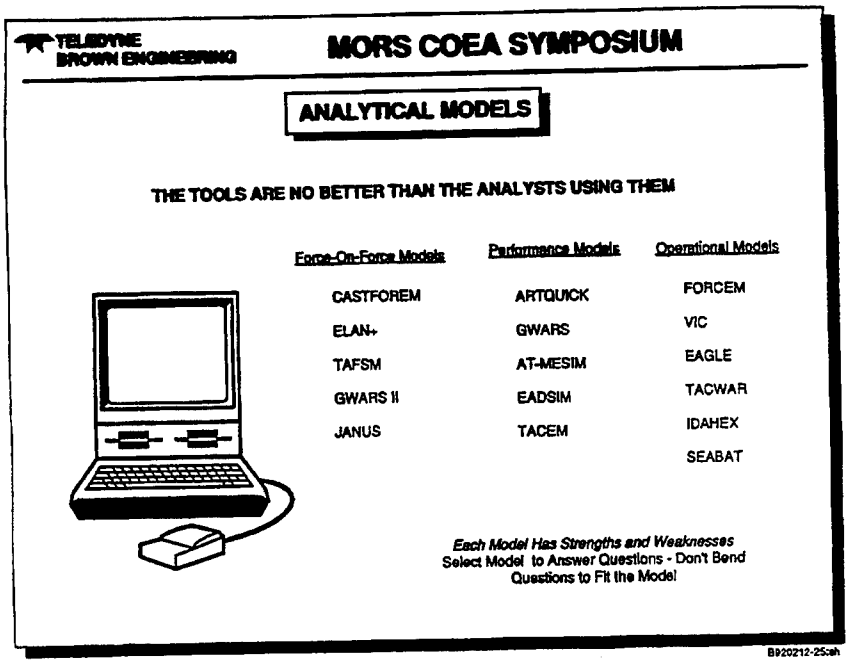


Figure 10: Analytical Models

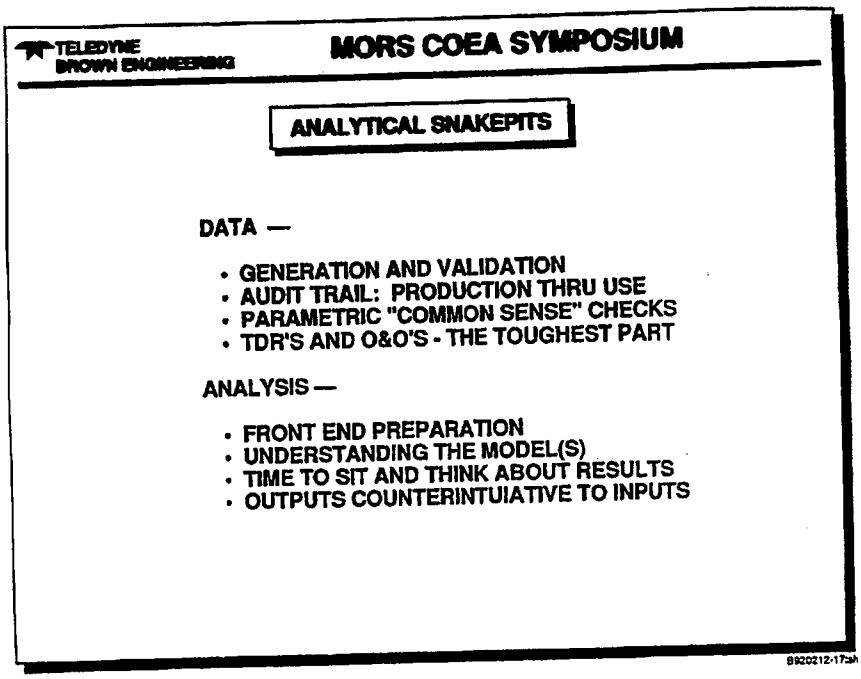


Figure 11: Analytical Snakepits

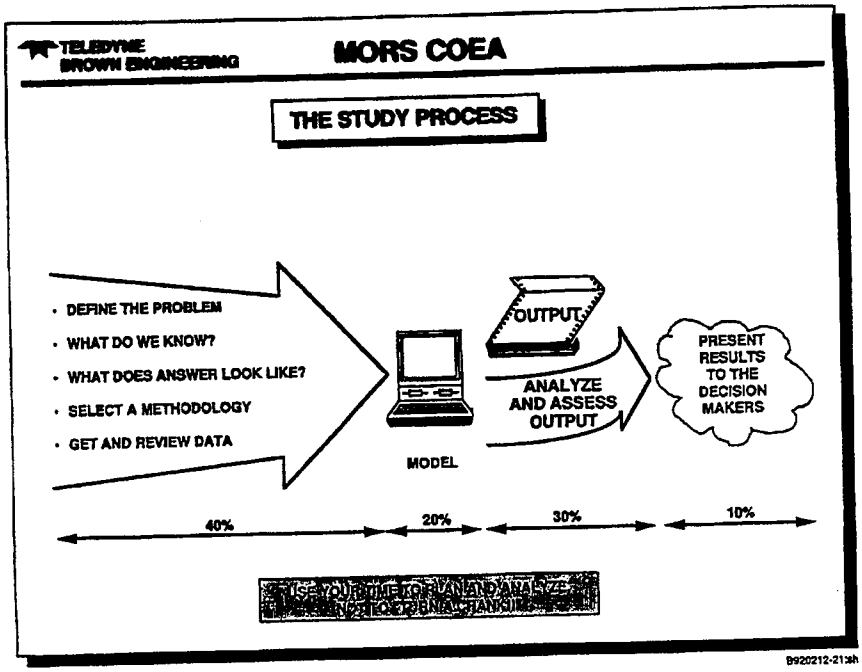


Figure 12: The Study Process

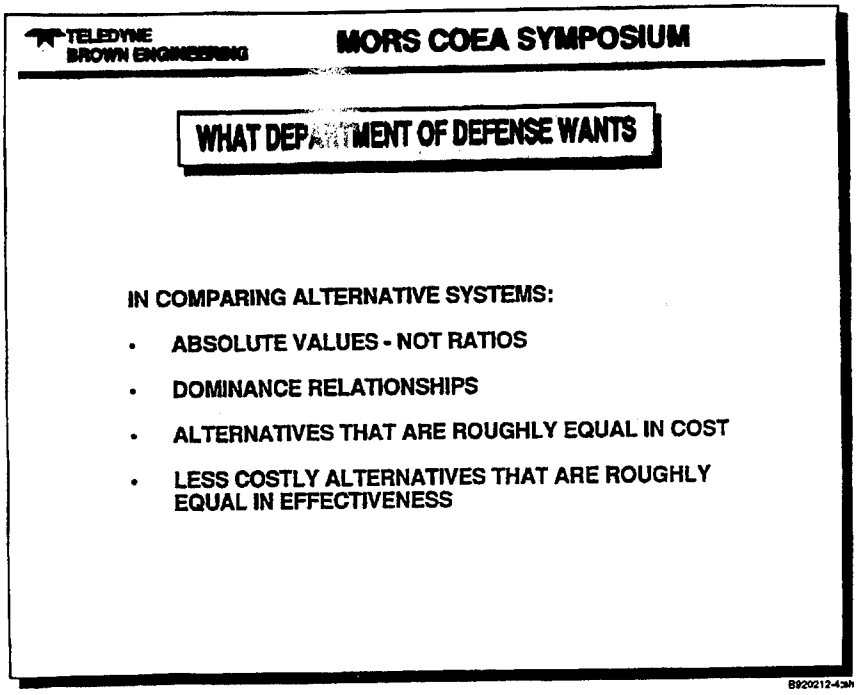
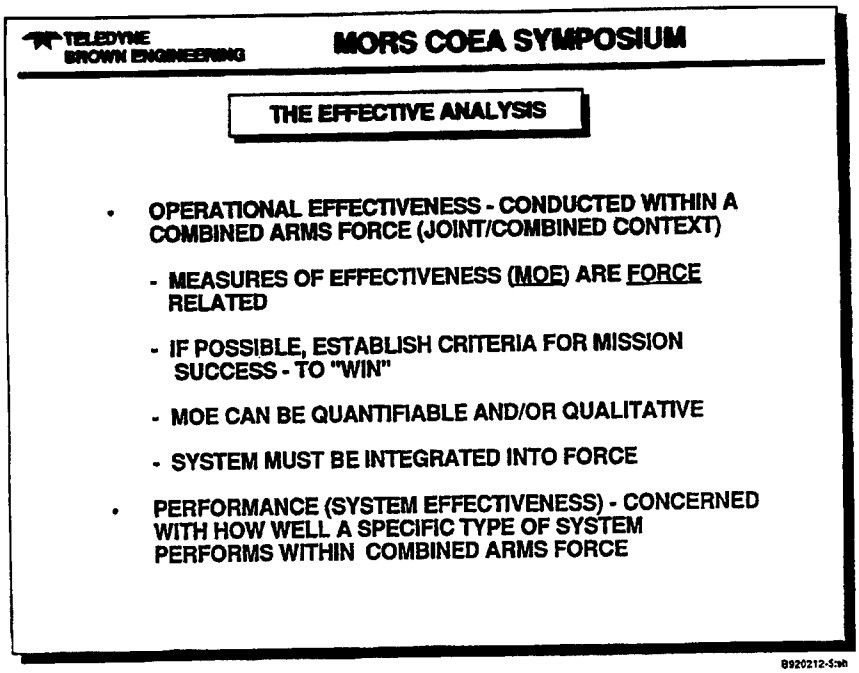


Figure 13: What Department of Defense Wants



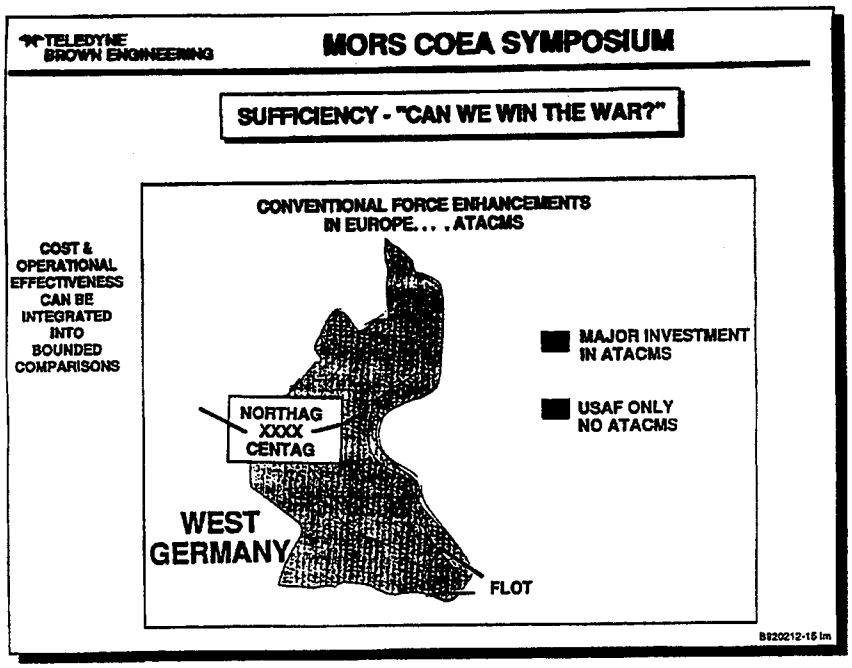


Figure 15: Sufficiency--"Can We Win the War?"

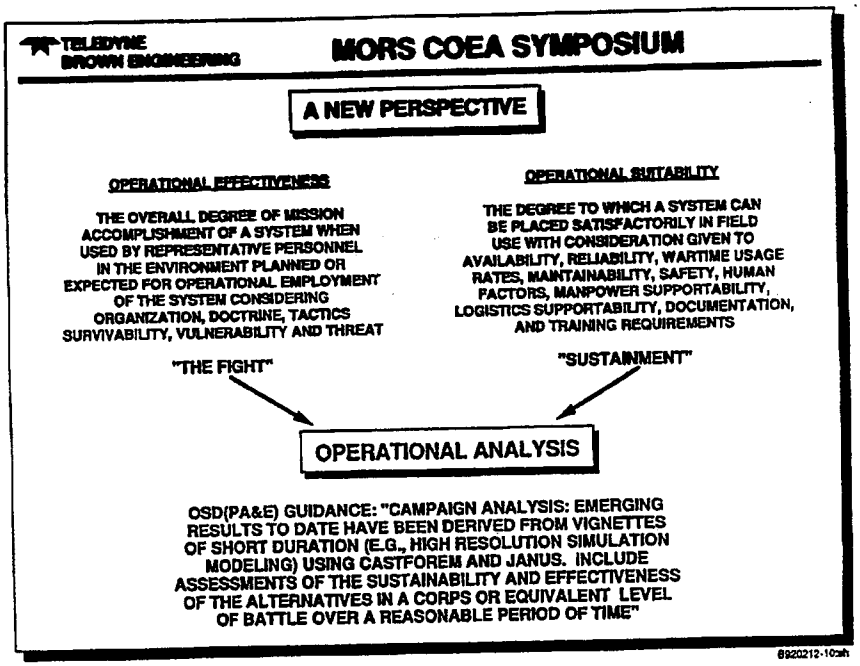


Figure 16: A New Perspective

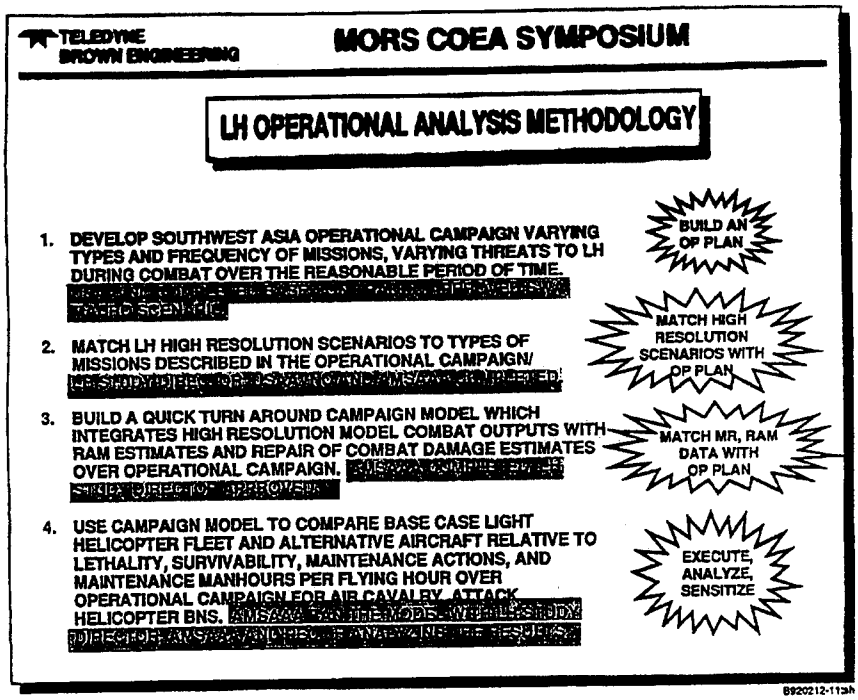


Figure 17: LH Operational Analysis Methodology

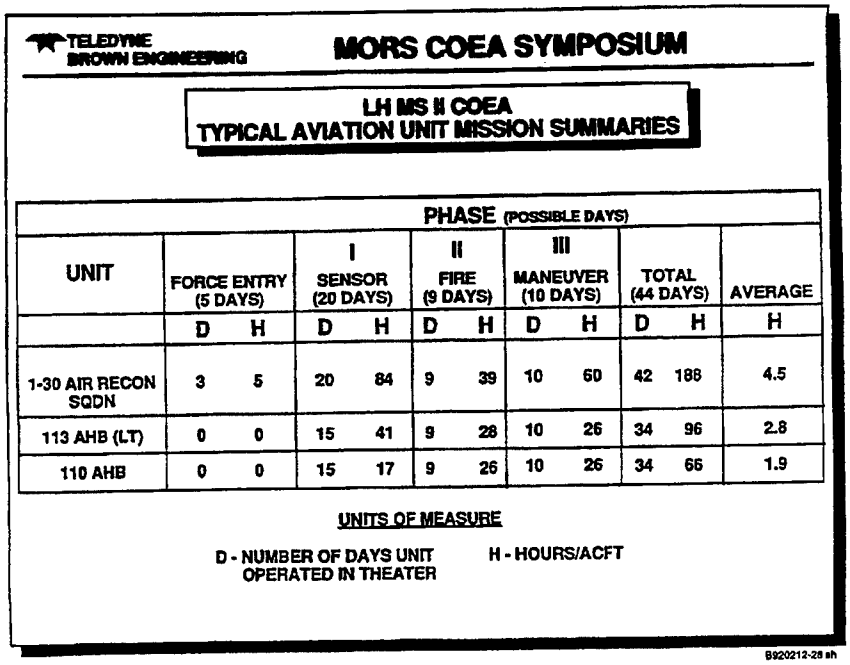


Figure 18: LH MSII COEA--Typical Aviation Unit Mission Summaries

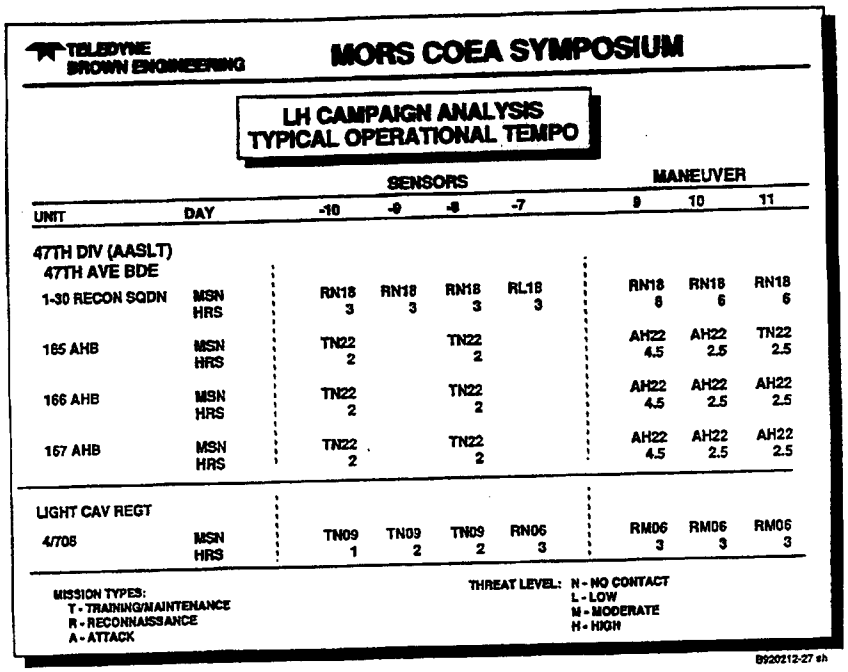


Figure 19: LH Campaign Analysis--Typical Operational Tempo

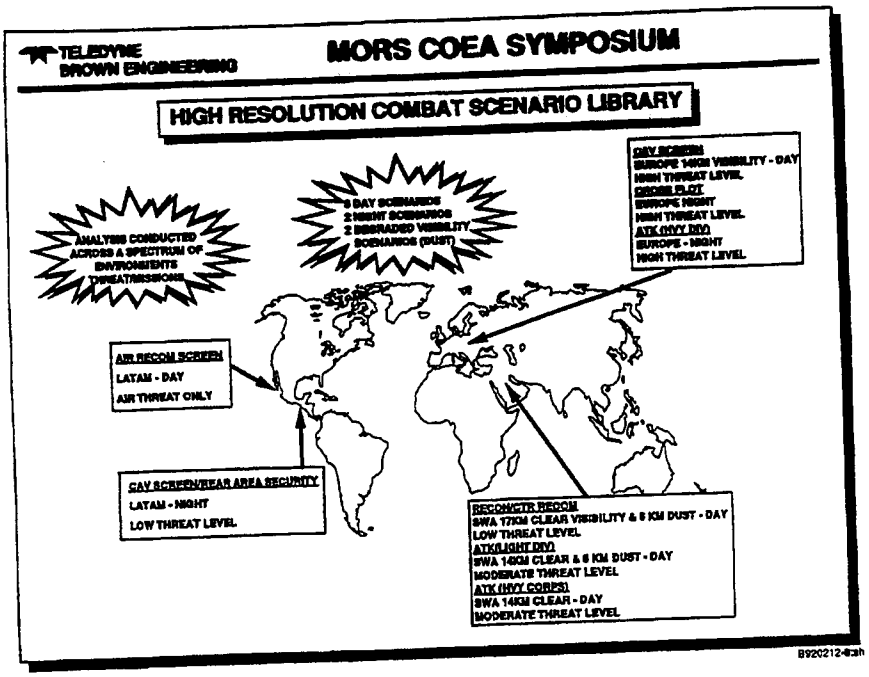


Figure 20: High Resolution Combat Scenario Library

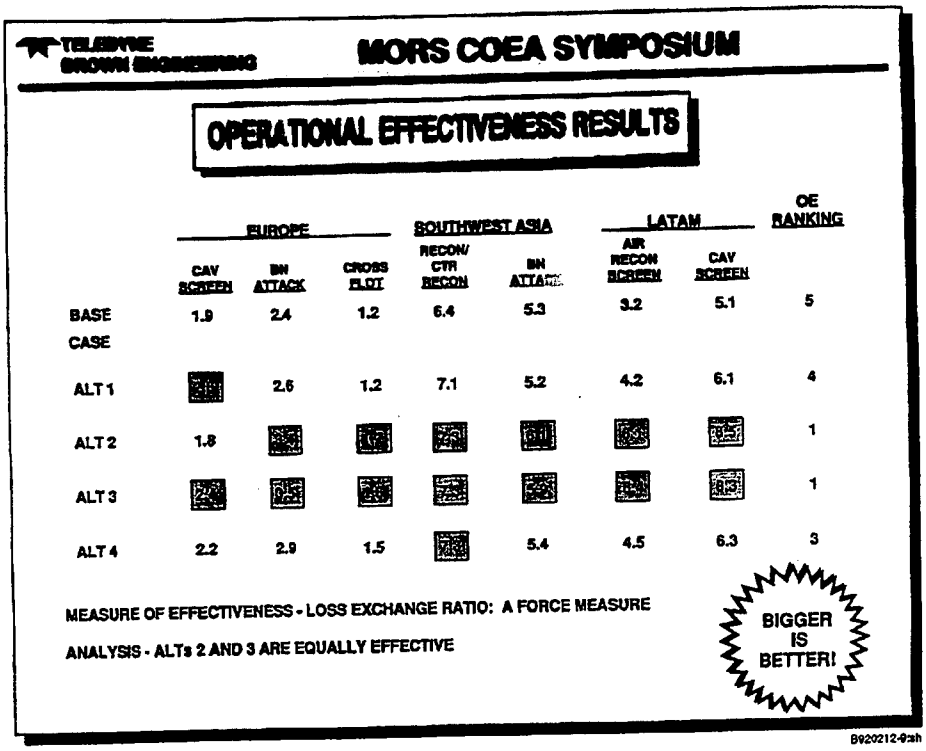


Figure 21: Operational Effectiveness Results

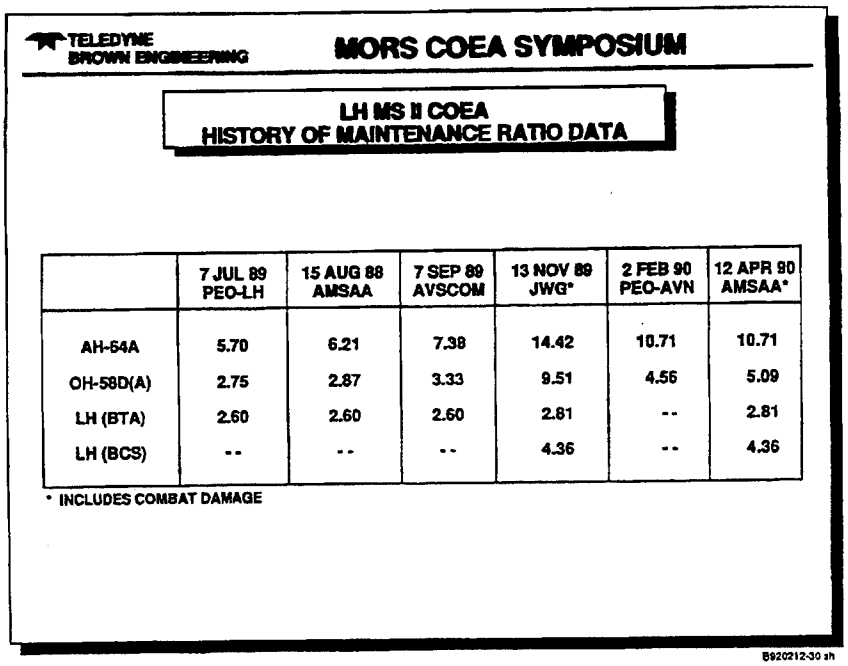


Figure 22: LH MSII COEA--History of Maintenance Ratio Data

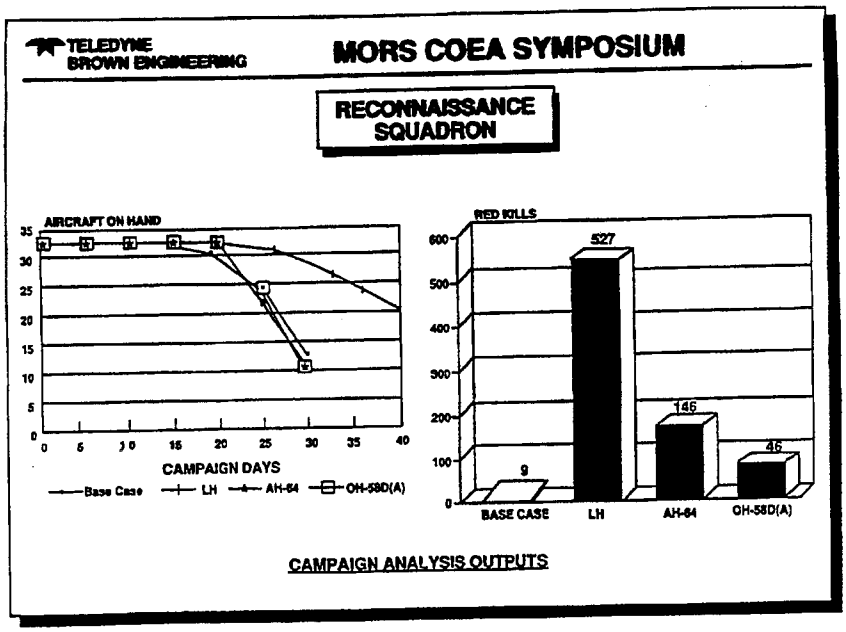


Figure 23: Reconnaissance Squadron

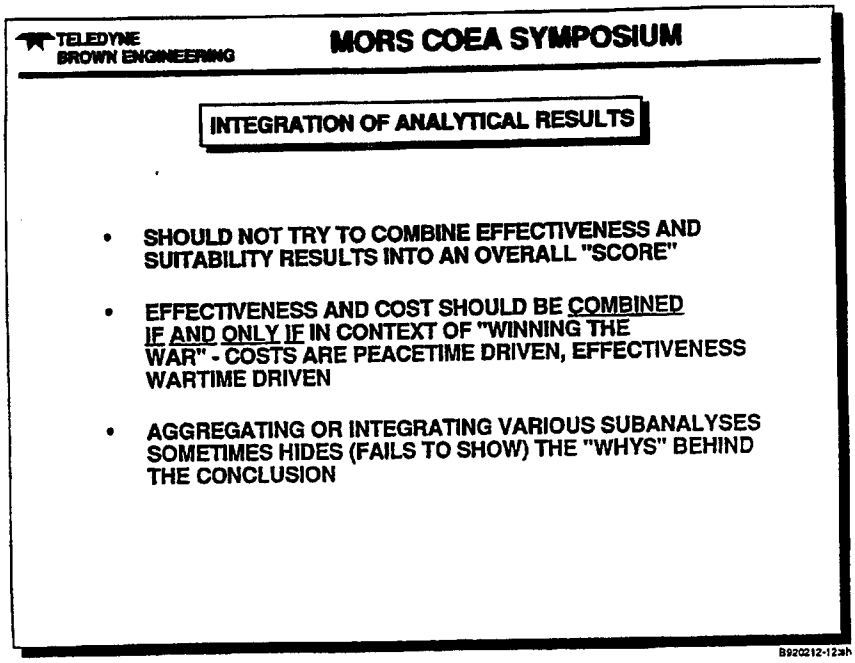


Figure 24: Integration of Analytical Results

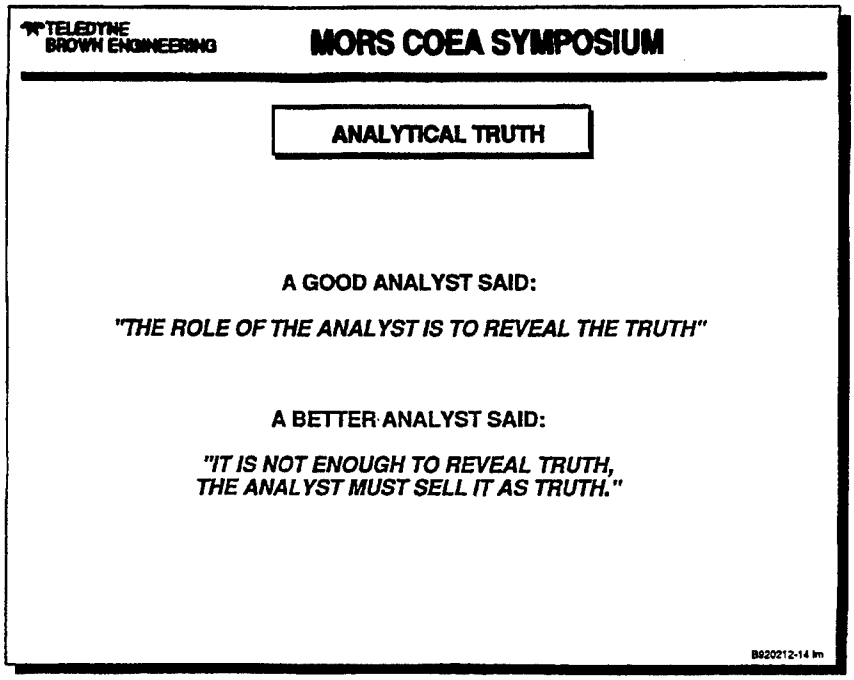


Figure 25: Analytical Truth

2.1.6

COST ANALYSIS IN COEAs

Introduction

Good morning. My name is Dan Nussbaum, and I am from the Naval Center for Cost Analysis.

I want to cover three topics related to the cost community that I think are important to the COEA process:

- Identifying the role of cost analysis in COEAs, including specifying the appropriate cost question and the deliverable from the cost analyst.
- Identifying the organizations, by Service, which are performing cost analysis to support COEA.
- Discussing two issues current in the cost analysis community that bear on how future cost estimates will be done: the treatment of risk and uncertainty in cost estimates and the estimation of R&D costs.

A short version of all this is that I want to address the issues of who we are, what we do, and some questions that are current within the cost analysis community.

The Role of Cost Analysis in COEAs

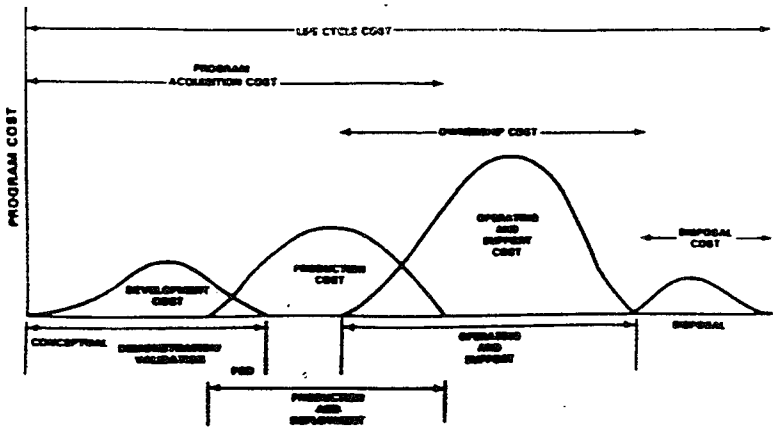
DoD 5000.2 states that there are three reasons for doing COEAs. These reasons are to aid in decision making, to facilitate communications, and to document acquisition decisions. My view is that it is the analyst's responsibility to give to the decision maker a "guided tour" of the decision space under discussion. That means that the analyst illuminates choices for the decision maker and consequences of those decision.

Whichever view one takes -- the DoD 5000.2 view or the "guided tour" view -- it is clear that we act in a support role.

The question often arises of "what are the proper costs to be considered in a COEA"? The answer is life cycle costs (LCC), which are usually defined as "the total cost (contractor and government) to the government for a system over its full life". While I have no intention, in this presentation, of doing a tutorial on cost analysis, the following remarks are pertinent and included for completeness:

- LCC covers all phases of the life cycle: development, procurement, operation and support, and disposal
- Each phase of the life cycle has its own work breakdown structure (WBS). Further, under each WBS element in each life cycle phase, there is a further refinement of the WBS.
- The usual WBS (as structured in MIL STD 881) is used for estimating costs of either weapon systems or automated information systems. There are other settings for cost estimating, including force structure issues, Defense Management Review initiatives, and personnel and logistics structure issues (e.g., unit-versus individual personnel rotation policies).

There is a standard picture of the phases of LCC reproduced below. It serves the purpose of showing the timing of life cycle phases, the relative magnitude of the costs incurred in each life cycle phase, and it provides some nomenclature. For these purposes, the chart is fine. There are, however, some aspects that are misleading:



- The peak of the O&S curve is higher than the peak of the Production cost curve. In fact, while total O&S costs are usually greater than total Production costs, the highest cost year for O&S costs is usually less than the highest cost year for Production costs,.

- For software projects, the correct relative magnitude for costs is: Development costs > O&S costs > Production costs

- Note also that the new nomenclature for the Full Scale Development (FSD) phase is now Engineering Management and Development (EM&D).

What are the products that you can expect from the cost analysis community -- the deliverables by cost analysts -- in a COEA? These deliverables include:

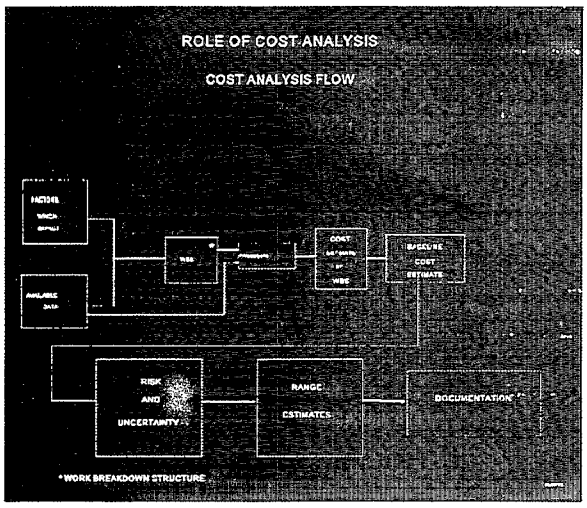
- LCC by appropriation for each alternative, done in constant $ and then year $

- Present value analysis for each alternative. While there are different viewpoints on the utility of present value analysis, it is my opinion that it is a useful analytical tool. Its value lies in the fact that it provides a single-valued discriminant across all the options that are under consideration.

- Risk and uncertainty analyses. These analyses represent excursions on relevant issues and provide to the decision maker a measure of the robustness of the preferred solution.

- Documentation. Not only does 5000 require it, but we want to document our analysis as part of the general documentation of the decisions. The essence of science is reproducibility, and it is that reproducibility of the COEA results, assembled and composed in the documentation, that permits later analysts to recreate our results. Documentation should be written to such a level that a journeyman analyst can reproduce the estimate.

I want to emphasize the point that cost analysis has to be involved early in the COEA process. Here is a flow of the cost analysis process.



I want to emphasize "factors which impact", because it makes an important point about how the cost analysis community operates. Among the factors which influence the cost estimate are:

- mission, technology required, special tooling and test equipment required, configurations for the system and its support, acquisition concept (sole source, buy-out, leader-follower), physical and performance characteristics, quantities, production rates, and logistics concept.

The point is that all those issues that are of interest to engineers at the early stages of a project are also of interest to the cost analyst. Three observations follow from this

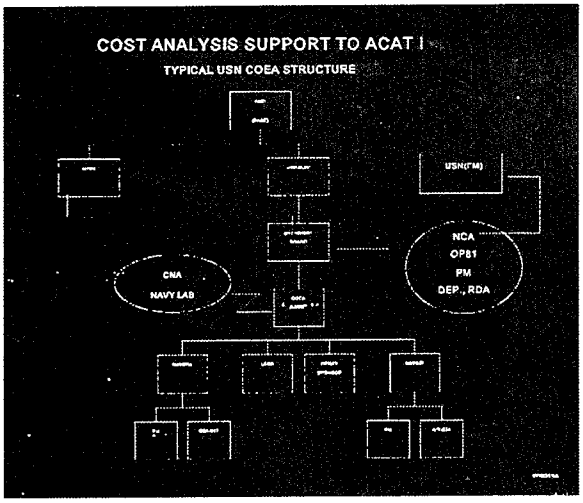
- There must be a baseline for the program, which identifies the details and specifications of the program.

- The baseline document is known as a Cost Analysis Requirements Document (CARD) and is called for in the new DoDI 5000.4. A CARD should be prepared for each alternative under consideration in the COEA.

- Cost analysis must be brought into the program at the earliest possible stage.

Organizational Location of Cost Analysis Capability

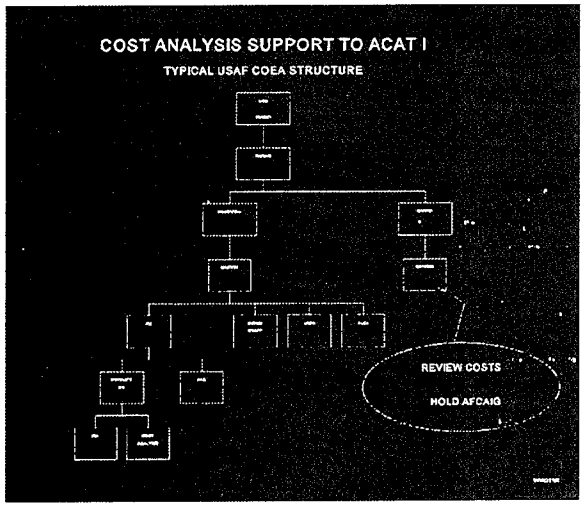
Only 10% of the attendees at this conference are in the formal cost analysis community, so for the sake of the other 90%, I want to identify the location of the Services' cost analysis capability. The truth is that the next three charts -- which purport to show the services' cost estimating organizations and where they are located in the bureaucracy -- are only roughly right. I am sure they are "precisely wrong". Still, they are approximately correct, and I think one of the goals of this conference is to get a good handle on these structures.



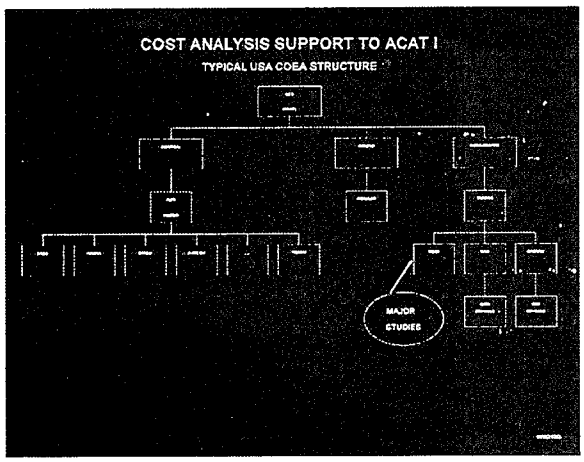
The cost analysis capability within the Navy resides in the Naval Center for Cost Analysis (NCA), the Systems Commands cost shops (AIR-524 and SEA-017), some of the Navy Labs, and the Center for Naval Analysis (CNA). The observations to make about the organization of the Navy's cost analysis capabilities are

- The capabilities are split between the Secretariat and the Blue Suit side of the house.

- NCA does milestone independent cost estimates, and by sitting on the COEA oversight board, provides for a consistency check on cost estimates.



The cost analysis capability within the Air Force resides in the Major Commands and within the Secretariat (SAF/FM). Within the MAJCOMs, the FM shops, the Air Logistics Centers and the cost estimating shops all have cost analysis capability. The observation to make about the organization of the Air Force's cost analysis capabilities is that it is a well-dispersed (organizationally) capability.



The cost analysis capability within the Army resides in the Army Cost and Economic Analysis Center (USACEAC), the Army Materiel Command (AMC) and AMC's Major Subordinate Commands (akin to the Navy's System Commands). The observations to make about the organization of the Army's cost analysis capabilities is that there is a dispersed cost analysis, and that the capabilities are split between the Secretariat and the Green Suit side of the house.

Current Issues in Cost Analysis

Now I want to turn my attention to some of the issues that are of high interest in the cost analysis community right now. I start with some slides about cost growth and schedule growth. My thanks to Mr. Dave Olsen of The Analytical Sciences Corporation for these slides. As you look at these slides, the salient points to recognize are that:

- Cost growth exists for private sector as well as public sector projects

- Schedule growth exists for private sector as well as public sector projects

- Weapons system cost and schedule growth compares favorably to cost and schedule growth experienced by non-weapon system projects, contrary to popular mythology.

The third chart, which provides descriptive statistics of the duration of life cycle phases for different classes of weapon systems, represents the beginning of research. In fact, from these data, we can model weapon system ph.. duration, and thereby have a basis from which to do risk analysis.

Now I want to turn to some basic definitions in risk and uncertainty . While these definitions are not universally held to, they do have some currency within the cost analysis community.

- "Risk" is about things that happen to the program, such as changes in program assumptions, performance, schedules, weight, acquisition strategy, or vendor business base. Usually, the impact of risk upon the cost estimate is handled by sensitivity analysis.

- "Uncertainty" is the embodiment of the statistical nature of cost estimating relationships (CERs). We can think of uncertainty as the "fog on my (cost estimator's) glasses" due to the statistical nature of CERs.

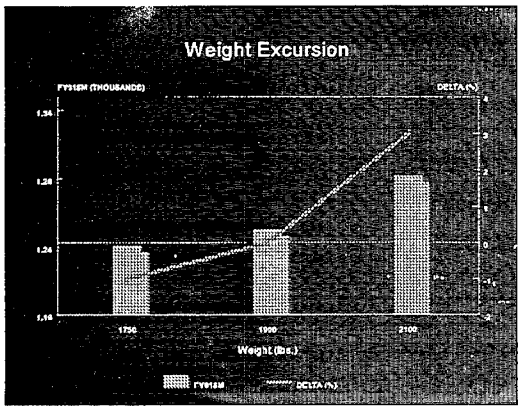
Everybody is interested in quality, including cost analysts who care about quality in their cost estimates. I think of uncertainty as the quality assurance of cost analysis.

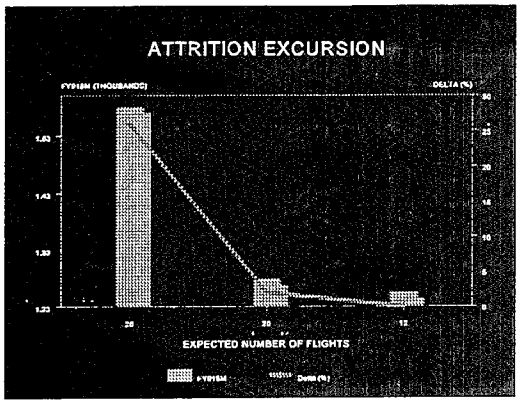
One of the issues that has always raged within the cost analysis community is the question of whether we better serve decision makers by producing point estimates or range estimates. Point estimates are attractive in that they conform to the input formats for both the DoD budget and congressional processes, and they are easy to deal with. Range estimates have the advantage that they conform to the uncertainty of the world, and they provide an explicit recognition of the statistical underpinnings of CERs.

Here is an example of the use of risk analysis in cost analysis. The estimation problem was to estimate the cost of an unmanned air vehicle (UAV). The base case for the analysis was a weight of 1900 pounds, and a life expectancy of 25 flights per MRUAV. There was technical risk that the true weight of the UAV -- once the vehicle was actually built -- could be as low as 1750 pounds or as high as 2100 pounds. There was also a technical risk that the life expectancy would more closely reflect the lower, historical experience in other, similar programs. Therefore, sensitivity excursions where run at life expectancies of 12, 20, and 25 flights. The following CER, relating the cost of the 100th UAV to its weight, was developed:

Cost of unit 100(FY89$K) = 233.6 + .201*(max weight)

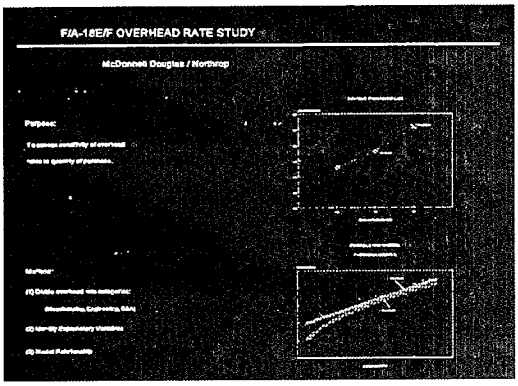
The following figures display the sensitivity of the cost estimate to these risk factors.





The lessons to be taken from Figures 5 and 6 are that the cost estimate is not sensitive too the weight variable, but that it is very sensitive to the attrition variable.

Another issue of importance in working to improve the quality of cost estimates is to measure the impact on a cost estimate of a change in production rate, especially drastic changes. The obvious problem is that the fixed cost at the manufacturing facility have to be spread over fewer manufactured units. We have a study in progress now to examine this problem in the case of the F/A-18E/F.



There is much to do in the area of cost estimating risk and uncertainty analysis. Here is a short list of risk and uncertainty operations research questions:

- identify appropriate distributions and models for
  - R&D schedule slippage
  - weight growth
  - business base implications
- determine correlations among cost variables

Now I want to transition to the new topic of current issues in R&D estimating.

As DoD budgets in general and Procurement budgets in particular are downsized, there may be an increased emphasis on R&D and concomitant deemphasis on procurement. From a cost estimator's perspective, the interesting question is what impact such an adjustment to procurement policy will have on current cost estimating models. Since current cost estimating models are built;t upon historical data, such a policy change would seem to undercut the validity these models.

A second important issue is that of measuring the impacts of having programs being done for more than one Service (Jointness). Many programs -- hardware as well as organizational support structures (e.g., finance and accounting) -- are now operating in a joint arena. The cost impact of this "purpling" of programs and services is yet to be characterized.

Here are some operations research questions in the area of R&D cost estimating:

- Should we over-weight R&D costs in COEA?

- What new techniques are needed to estimate R&D costs?

- What is the proper weighting of R&D costs in a COEA?

- What are the proper time-phased distributions for R&D costs?

- What comparisons can be drawn between the Development and Validation cost for a program developed by a single service compared to one developed in a joint environment?

- What are the costs to resurrect a shelved R&D program and to bring it into production status?

Finally, I want to make a plea for keeping open the cost data pipeline. Cost data from programs is the sine qua non of cost estimating, in the sense that CERs and cost factors are grounded in historical

experience (the past is prologue). In fact, data are needed at the WBS level, so that estimation may also be done there. These data are available from cost reports (CCDRs, CPRs and so forth). Cost analysts often hear the argument that cost reports are useless from FFP contracts since the contractor bears all the risk. The argument is specious (the A-12 and P-7 contracts dispel the myth), and in fact harmful to good program management.

Summary

A summary of what I have said in this presentation is:

- Involve cost analysts early in the project. Among the factors which influence the cost estimate are mission, technology required, special tooling and test equipment required, configurations for the system and its support, acquisition concept (sole source, buy-out, leader-follower), physical and performance characteristics, quantities, production rates, and logistic concept. The point is that all those issues that are of interest to engineers at the early stages of a project are also of interest to the cost analyst.

- Force a CARD for ACAT I programs. The baseline document is known as a Cost Analysis Requirements Document (CARD) and is called for in the new DoDI 5000.4. A CARD should be prepared for each alternative under consideration in the COEA. There must be a baseline for the program, which identifies the details and specifications of the program.

- Uncertainty is the QA of our business. Uncertainty is the embodiment of the statistical nature of cost estimating relationships (CERs). We can think of uncertainty as the "fog on my (cost estimator's) glasses" due to the statistical nature of CERs. Everybody is interested in quality, including cost analysts who care about quality in their cost estimates.

- Risk analysis provides texture and context to the results. Risk is about things that happen to the program, such as changes in program assumptions, performance, schedules, weight, acquisition strategy, or vendor business base. Usually, the impact of risk upon the cost estimate is handled by sensitivity analysis.

- R&D costs to gain in importance. As DoD budgets in general and Procurement budgets in particular are downsized, there may be an increased emphasis on R&D and concomitant deemphasis on procurement. From a cost estimator's perspective, the interesting question is what impact such an adjustment to procurement policy will have on current cost estimating models. Since current cost estimating models are built upon historical data, such a policy change would seem to undercut the validity these models.

2.1.7 INTEGRATING COST AND EFFECTIVENESS IN COST AND OPERATIONAL EFFECTIVENESS ANALYSES

INTRODUCTION. The analysts have estimated both effectiveness and cost for each alternative considered in the Cost and Operational Effectiveness Analysis (COEA). Their next task is to rank order the alternatives. Ranking the alternatives requires that the distinct attributes, cost and effectiveness, somehow be integrated. This paper considers the integration problem from the viewpoint of multiattribute or multiple criteria decision making. From this viewpoint an individual decision maker's preferences and value trade-offs among multiple and often conflicting attributes can be explicitly modeled. This model can then be used to rank the decision alternatives. From the literature several possible techniques are identified. Two of the techniques are demonstrated in the context of an abbreviated COEA on the TOW Sight Improvement Program.

Multiattribute Decision Making. The literature provides a wealth of possible multiattribute decision making techniques. Consideration is given to prescriptive techniques in contrast to descriptive techniques. Prescriptive techniques, largely the concern of operations research, seek to help people make better decisions. Such techniques are founded on compelling assumptions or practical decision criteria. On the other hand, descriptive techniques seek to describe decision making behavior. Primary references are Arrow and Raynaud, Chankong and Haimes, Hwang and Yoon, Keeney and Raiffa, MacCrimmon, and Saaty.

In a recent study Cassady and Goodwin reviewed multiattribute decision making techniques for possible use in COEA. Table 1 lists the techniques that they reviewed.

Based on their theoretical soundness, ease of use, data requirements, and prevalence, five of the techniques listed in Table 1 were found to be appropriate for general use in COEA. These five are listed in Table 2.

Table 1
Multiattribute Decision Techniques Reviewed

Dominance
Maximin
Maximax
Majority Rule
Koler's Ranking Technique
Conjunctive Technique
Disjunctive Technique
Stochastic Dominance
Lexicographic
Lexicographic with Minima
Key Attribute
ELECTRE
Permutation
Analytic Hierarchy Process (AHP)
Multiattribute Value Theory (MAVT)
Simple Additive Weighting (SAW)
Technique for Order Preference by Similarity To Ideal Solution (TOPSIS)
Cost-effectiveness ratios
Multiattribute Utility Theory (MAUT)

Table 2
Multiattribute Decision Techniques Appropriate for General Use in COEA

Dominance
Conjunctive Technique
Analytic Hierarchy Process (AHP)
Multiattribute Value Theory (MLAVT)
Multiattribute Utility Theory (MAUT)

The fact that a technique was not found appropriate for general use does not mean that it should never be considered for use. In particular simple ranking techniques such as majority rule and Koler's ranking technique have great potential. However, further research is required for a full understanding of their application in a COEA environment. On the other hand, techniques such as cost-effectiveness ratios or TOPSIS, were found not appropriate for general use in COEA because of their unique underlying assumptions. If these assumptions hold for a particular application then their use should be considered.

TSIP COEA. In their study Cassady and Goodwin demonstrated AHP and MAUT in conjunction with the recent TOW Sight Improvement Program (TSIP) Abbreviated Cost and Operational Effectiveness Analysis (COEA). This COEA was conducted to scrutinize alternative antiarmor capabilities in mechanized and light infantry.

The demonstration considered only a subset of alternatives from the mechanized infantry portion of the COEA. Mechanized infantry battalions include four mechanized infantry companies fielding Bradley Fighting Vehicles (BFV) firing TOW missile. In addition, the battalion contains an antiarmor company with improved TOW vehicles (ITV) also firing TOW. The TOW sight improvement program sought to replace the current TOW sight with a new sight. Table 3 lists the alternatives considered.

Table 3
Alternatives

	Mech Inv Co BFV TOW Sight	Anti Armor Co ITV TOW Sight
Alternative		
Base Case	**Current**	**Current**
Alt 1	**Current**	**New**
Alt 2	**New**	**Current**
Alt 3	**New**	**New**

Alternatives were compared by cost and effectiveness. Cost was assessed using twenty year life cycle cost in constant FY92 dollars. Effectiveness was assessed using loss exchange ratios (LER) from a high resolution combat simulation model. Three distinct combat scenarios were represented: European brigade meeting engagement (EUR MGT), European balanced task force defense (EUR DEF), and Southwest Asian brigade meeting engagement (SWA MGT). Figure 1 illustrates the COEA attributes in a hierarchical fashion.

Analytic Hierarchy Process. AHP proceeds with the decision maker scaling attributes and alternatives. Scale values are intended to capture the relative importance of an attribute or alternative in the hierarchy. Scale values are converted to comparable weights using an eigenvector method. The weights are then combined linearly up the hierarchy. Several commercial software packages are available for the application of AHP. The scale used to assess the pairwise importance of attributes or alternatives is illustrated in table 4.

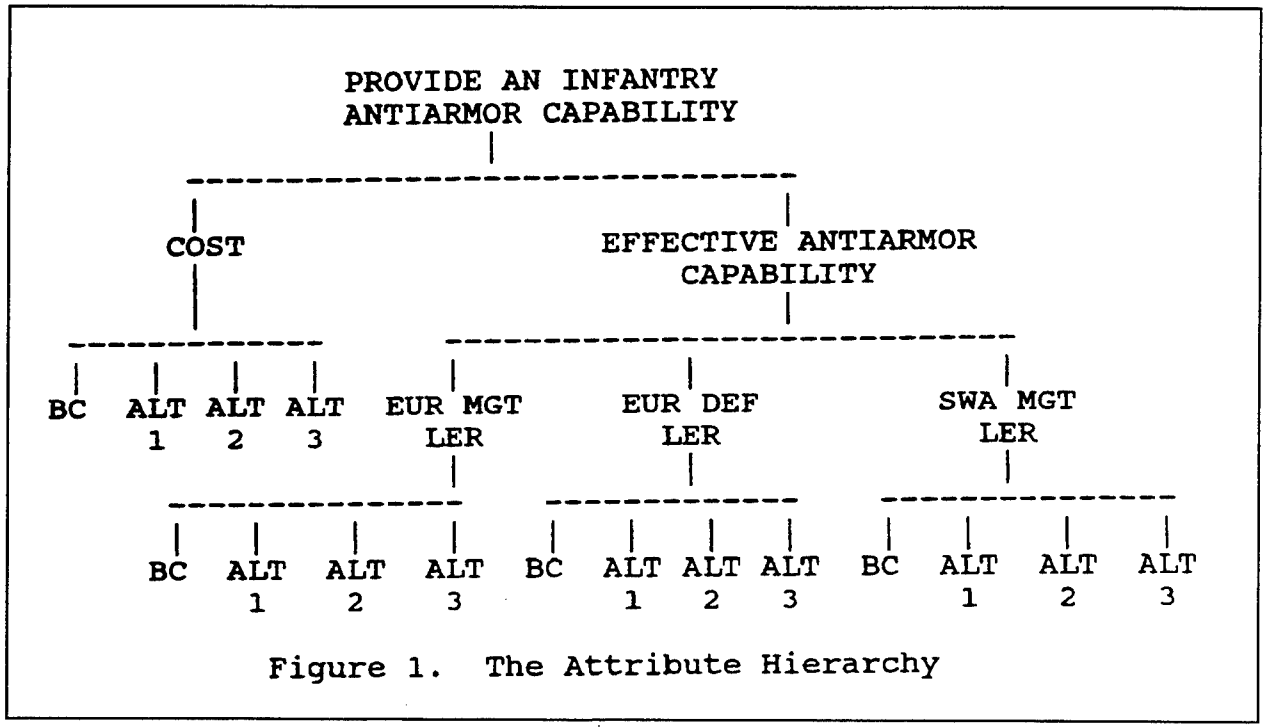


Figure 1. The Attribute Hierarchy

Table 4
AHP Scale of
Pairwise Importance

Importance of one factor over another	Value
Equal	1
	2
Weak	3
	4
Strong	5
	6
Very Strong	7
	8
Absolute	9

The AHP importance scale also makes use of the reciprocals of the values in Table 4. For example, if the pairwise importance of factor 1 over factor 2 is judged to be weak and valued at 3, the pairwise importance of factor 2 over factor 1 is valued at 1/3. The TSIP COEA hierarchy requires six distinct scalings. At the top the decision maker provides scale values on the relative importance of cost and effectiveness in meeting the overall decision criterion. Continuing down the hierarchy, the decision maker scales the relative importance of the three LER attributes in terms of their contribution to the effectiveness attribute. Next the alternatives are scaled in terms of their contribution to the cost attribute, the European meeting LER attribute, the European Defense LER attribute, and the SWA meeting LER.

For demonstration purposes hypothetical scale values are used. While it is hoped that these are reasonable values, no claim is made to their empirical validity. Table 5 gives the scale values and eigenvector weights for the relative importance of the contribution of cost and antiarmor capability to the decision. This choice of scale values weights cost and effectiveness equally.

Table 5
Pairwise Comparisons of
Cost and Antiarmor Capability

Capability	Cost	Anti Armor
Cost	1	1
Antiarmor Capability	1	1

Eigenvector weights - (0.50, 0.50)

Table 6 gives scale values, principal eigenvalue, and eigenvector weights for the relative importance of the three LER attributes in their contribution to the antiarmor capability. The scale values have been chosen so that the first two LER attributes are equally valued and the third is weakly more important.

Table 6
Pairwise Comparisons of
LER Attributes

	EUR MGT LER	EUR DEF LER	SWA MGT LER
EUR MGT LER	1	1	1/3
EUR DEF LER	1	1	1
SWA MGT LER	1	1	1

Eigenvalue - 3.00, Weights - (0.20, 0.20, 0.60)

The principal eigenvalue is a measure of the consistency of the scale values. Its value is at least as large as the number of factors scaled. Complete consistency occurs when this minimum value is obtained. In the present case the value of 3.00 indicates that the scale values are completely consistent.

Table 7 gives scale values, principal eigenvalue, and eigenvector weights for the cost of the alternatives. These scale values are derived from cost estimates (in FY92 constant million dollars). The scale values have been chosen so that the base case is valued strongly over alternatives one and two, alternatives one and two are equally valued, and alternatives one and two are valued strongly over alternative three. In addition the base case is valued absolutely over alternative three.

Table 7
Pairwise Comparisons of
Cost of Alternatives

	Base Case	Alt 1	Alt 2	Alt 3
Cost	**350**	**900**	**982**	**1344**
Base Case	**1**	**5**	**5**	**9**
Alt 1	**1/5**	**1**	**1**	**5**
Alt 2	**1/5**	**1**	**1**	**5**
Alt 3	**1/9**	**1/5**	**1/5**	**1**

Eigenvalue - 4.13, Weights - (0.64, 0.16, 0.16, 0.04)

A principal eigenvalue of 4.13 indicates that the scale values are highly consistent.

Tables 8, 9, and 10 give scale values, the principal eigenvalue, and the eigenvector weights of the alternatives for the LER attributes. These scale values are based on median LER estimates. In Table 8 the base case and alternative one are valued the same. Alternative two is valued strongly over the base case and alternative one. Alternative three is valued strongly over alternative two. Also alternative three is valued absolutely over the base case and alternative one.

Table 8
Pairwise Comparisons of
European Meeting LER Estimates

	Base Case	Alt 1	Alt 2	Alt 3
Median LER	**1.00**	**1.04**	**1.40**	**1.77**
Base Case	**1**	**1**	**1/5**	**1/9**
Alt 1	**1**	**1**	**1/5**	**1/9**
Alt 2	**5**	**5**	**1**	**1/5**
Alt 3	**9**	**9**	**5**	**1**

Eigenvalue - 4.13, Weights - (0.06, 0.06, 0.22, 0.66)

A principal eigenvalue of 4.13 indicates that the scale values are highly consistent.

In Table 9 alternatives one and two are equally valued. Alternatives one and two are valued weakly over the base case and alternative three is value weakly over alternatives one and two. Also alternative three is valued strongly over the base case.

Table 9
Pairwise Comparisons of
European Defense LER Estimates

	Base Case	Alt 1	Alt 1	Alt 1
Median LER	**2.29**	**2.44**	**2.38**	**2.57**
Base Case	**1**	**1/3**	**1/3**	**1/5**
Alt 1	**3**	**1**	**1**	**1/3**
Alt 2	**3**	**1**	**1**	**1/3**
Alt 3	**5**	**3**	**3**	**1**

Eigenvalue - 4.04, Weights - (8.08, 0.20, 0.20, 0.52)

A principal eigenvalue of 4.04 indicates that the scale values are highly consistent.

In Table 10 the base case and alternative one are equally valued. Alternative two is valued weakly over the base case and alternative one. Alternative three is valued weakly over alternative two and strongly over the base case and alternative one.

Table 10
Pairwise Comparisons of
SWA Meeting LER Estimates

	Base Case	Alt 1	Alt 2	Alt 3
Median LER	**1.34**	**1.37**	**1.49**	**1.62**
Base Case	**1**	**1**	**1/3**	**1/5**
Alt 1	**1**	**1**	**1/3**	**1/5**
Alt 2	**3**	**3**	**1**	**1/3**
Alt 3	**5**	**5**	**3**	**1**

Eigenvalue - 4.04, Weights - (0.10, 0.10, 0.24, 0.56)

A principal eigenvalue of 4.04 indicates that the scale values are highly consistent.

The final step in the AHP is to aggregate the separate weights into an overall weight for each alternative. The following linear format is used.

AHP Weight = 0.5 * (Cost Weight)
+ 0.5 * 0.2 * (EUR MGT LER Weight)
+ 0.5 * 0.2 * (EUR MGT LER Weight)
+ 0.5 * 0.6 * (SWA MGT LER Weight)

Table 11 gives the overall AHP weight for each alternative.

Table 11
AHP Weights of Alternatives

Alternative	Weight
Base Case	**0.36**
Alt 1	**0.13**
Alt 2	**0.20**
Alt 3	**0.31**

The base case ranks first followed by alternative three. The greater effectiveness of alternative three is offset by its greater cost. This results in part from valuing the importance of cost and effectiveness equally. Had effectiveness been valued just very weakly over cost the scale values of Table 5 would be replaced by those of Table 12 below.

Table 12
Revised Pairwise Comparisons of
Cost and Antiarmor Capability

	Cost	Antiarmor Capability
Cost	**1**	**1/2**
Antiarmor Capability	**2**	**1**

Eigenvector Weights - (1/3, 2/3)

With these new weights for cost and effectiveness the overall weights of the alternatives become those of Table 13.

Table 13
Revised AHP Weights of Alternatives

Alternative	Weight
Base Case	**0.27**
Alt 1	**0.12**
Alt 2	**0.21**
Alt 3	**0.40**

In this case alternative three ranks first followed by the base case. A simple computation shows that if effectiveness is valued at 1.21 over cost the base case and alternative three tie for the first rank with equal weights.

Multiattribute Utility Theory. The application of MAUT proceeds in three steps: modeling the decision maker's utility over the attributes, developing probability distributions for outcomes of alternatives, and integrating utility with the distributions. Several commercial software packages are available for the application of MAUT.

To simplify the modeling of utility for the demonstration it is assumed that the multiattribute utility function decomposes as a sum of products of single attribute utility functions. It is also assumed that the decision maker is risk neutral with regard to

Table 14
Single Attribute Utilities

Attribute	Range	Utility	Scaling Constant
Cost	200 to 1500	UC(c) = (1500-c)/1300	KC
EUR MGT LER	0.25 to 4.0	UM(x) = 4(x-0.25)/15	KM
EUR DEF LER	0.25 to 4.0	UD(y) = 4(y-0.25)/15	KD
SWA MGT LER	0.25 to 4.0	US(z) = 4(z-0.25)/15	KS

Using the four scaling constants introduced in Table 14 the utility function, U(c,x,y,z), decomposes as

$$
\begin{aligned}
U(C,x,y,z) = {} & KC*UC(c) + KM*UM(x) + KD*UD(y) + KS*US(z) \\
& + K*[KC*KM*UC(c)*UM(x) + KC*KD*UC(c)*UD(y) + \\
& \quad KC*KS*UC(c)*US(z) + KM*KD*UM(x)*UD(y) + \\
& \quad KM*KS*UM(x)*US(z) + KD*KS*UD(y)*US(z)] \\
& + K*K*[KC*KM*KD*UC(c)*UM(x)*UD(y) + \\
& \quad KC*KM*KS*UC(c)*UM(x)*US(z) + \\
& \quad KC*KD*KS*UM(c)*UD(y)*US(z) + \\
& \quad KM*KD*KS*UM(x)*UD(y)*US(z)] \\
& + K*K*K*[KC*KM*KD*KS*UC(c)*UM(x)*UD(y)*US(z)]
\end{aligned}
$$

each single attribute. As a consequence the single attribute utility functions are linear. Formal checking of these assumptions would be required in practice. Their failure to hold would require more complex techniques. Table 14 gives the single attribute utility functions which are scaled from 0 to 1 over their range.

Next the four scaling constants, KC through KS, are determined. This requires detailed and complex assessment sessions with the decision maker. Software such as IDEA can be useful in simplifying this assessment. After the four scaling constants, KC through KS, are determine, the constant K is determined numerically as the solution of a polynomial. Table 15 gives hypothetical values for the scaling constants. The scaling constants, KC through KS, have a utility interpretation at the extreme values of the attributes. They are not to be interpreted as the relative importance of an attribute, i.e., KC is not the relative importance of the cost attribute.

Table 15
MAUT Scaling Constants

Constant	Utility Equivalent	Value
KC	U(200,0.25,0.25,0.25)	0.200
KM	U(1500,4.0,0.25,0.25)	0.300
KD	U(1500,0.25,4.0,0.25)	0.300
KS	U(1500,0.25,0.25,4.0)	0.400
K	None	-0.409

The next step is to develop probability distributions for outcomes of alternatives. It is assumed that the attributes for any particular alternative are independent. Formal checking of this assumption would be required in practice. Its failure to hold would require more complex techniques. Because of the assumptions of independence and of risk neutrality only the means of the distributions of outcomes are required. Table 16 gives the necessary values.

Table 16
Means of Outcomes

	Attributes			
Alternative	COST	EUR MGT LER	EUR DEF LER	SWA MGT LER
Base Case	350	1.06	2.35	1.30
Alt 1	900	1.08	2.46	1.40
Alt 2	982	1.45	2.36	1.52
Alt 3	1344	1.81	2.78	1.63

The final step is to combine the decision maker's utility with the probability distributions. This is done by integrating the multivariate utility function with the probability distributions to yield the expected utility for each alternative. The alternatives are then ranked by their expected utility. Because of the assumptions of independence and risk neutrality the expected utility of an alternative may be computed by substituting the appropriate mean values from Table 16 into the utility function U(c,x,y,z). Table 17 gives the expected utilities for each alternative.

Table 17
Expected Utilities

Alternative	Expected Utility
Base Case	0.483
Alt 1	0.428
Alt 2	0.447
Alt 3	0.465

As was the situation with AHP the base case ranks first followed by alternative three. If the value of KC, which equals U(200,0.25,0.25,0.25), were decreased from 0.20 to 0.15, the expected utilities of Table 17 would be replaced by those of Table 18.

Table 18
Revised Expected Utilities

Alternative	Expected Utilities
Base Case	0.451
Alt 1	0.413
Alt 2	0.435
Alt 3	0.466

Now alternative three ranks first followed by the base case. A simple computation shows that with KC valued at 0.172, the base case and alternative three tie for the first rank with equal expected utilities.

Conclusion. DoD guidance from 5000.2M, Part 8, on the use of integration techniques in COEA includes:

Analysis of Alternatives. There is no magic formula for combining cost and effectiveness measures to identify a preferred alternative. Judgments and perceptions about the relative importance of competing needs are important in the final choice of a course of action. A cost and operational effectiveness analysis can assist in making that choice by providing a solid framework for evaluating the alternatives, and by highlighting the implications of alternative choices. In that regard, it is essential to:

Never use schemes in which several measures of effectiveness are weighted and combined into an overall score. Weighting schemes can sometimes be helpful, but they must be clearly explained in the analysis so that their results can be interpreted correctly.

While there is no "magic" formula there are formulas that can capture a decision maker's judgments and perceptions for the relative importance of conflicting attributes. These formulas, or techniques, may be based on reasonable assumptions and may be relatively easy to apply. All practical techniques, however, require some degree of participation by the decision maker. Whether this participation is to be accomplished as part of the

COEA or subsequent to it becomes an important operational question.

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MORS COEA SYMPOSIUM

MANAGING COEA DEVELOPMENT

LtCol JIM FEIGLEY
US MARINE CORPS

MANAGING A COEA IS NOT UNLIKE RIDING THE LUGE. THERE IS OFTEN A SENSATION OF ROARING DOWN AN ICY MOUNTAIN.... PRONE AND SPREAD EAGLE!

Anonymous Marine Officer

AAA OVERALL STUDY PROCESS

- COEA ANALYZED 13 ALTERNATIVES
  - AMPHIBIOUS VEHICLES
    - FAST AND SLOW
    - NEW AND EXISTING
  - NON-AMPHIBIOUS VEHICLES
    - NEW AND EXISTING
  - NON-VEHICLES
    - HELICOPTERS
    - SUBMERSIBLES
- TWO PHASED STUDY APPROACH
  - PERFORMANCE ANALYSIS
  - OPERATIONAL EFFECTIVENESS ANALYSIS

MISSION AREA ANALYSIS

- WHERE THE NEED FOR A COEA REALLY BEGINS
- BECOME FAMILIAR WITH

  THE THREAT USED
  THE MODEL(S) USED
  THE DOCTRINE & TACTICS USED
  THE EQUIPMENT ANALYZED
  THE DEFICIENCIES IDENTIFIED

- DEFICIENCIES BECOME REQUIREMENTS

  THE PURPOSE OF THE COEA IS TO FIND THE BEST WAY(S) TO RESOLVE THEM

PRE-MILESTONE-0 "TRADE-OFF" PROCESS

- THOROUGHLY UNDERSTAND WHY:

  CHANGES IN DOCTRINE, TACTICS, TRAINING OR ORGANIZATION DIDN'T WORK.

- READ EVERY STUDY OR PAPER ASSOCIATED WITH THE INVESTIGATION.

- REASON:

  GIVES YOU INSIGHT INTO THE THREAT AND HOW YOU MUST "FIGHT" THE SYSTEM.

MILESTONE-0 PRODUCTS YOU MUST HAVE

- MISSION NEED STATEMENT
  - BEGINS TO DEFINE THE "UNIVERSE" OF POTENTIAL ALTERNATIVES
- JROC PRESENTATION AND ENDORSEMENT
  - THRESHOLDS AND GOALS
- ACQUISITION DECISION MEMORANDUM
  - EXIT CRITERIA
- IN EACH CASE;
  - GO REVIEW THE DOCUMENTS WITH THE PEOPLE WHO WROTE THEM.

STEP ONE: IDENTIFY THE MAJOR ELEMENTS OF A COEA

- POLICY (OSD AND SERVICE)
- THREAT DATA
- ALTERNATIVE CONCEPTS
- DOCTRINE & TACTICS TO BE USED
- SCENARIOS
- ASSUMPTIONS
- MODELS
- MOEs
- METHODOLOGY & STUDY PLAN
- COST ESTIMATES
- "INTERESTED PARTIES"

STEP TWO: ORGANIZE THE SENIOR LEVEL LEADERSHIP

- ESTABLISH A GENERAL/FLAG LEVEL ADVISORY BOARD VIA YOUR SPONSOR
- CRITICAL TO GETTING RESOURCES AND AUTHORITY TO DO THE JOB
- SERVES AS THE QUALITY CONTROL CHECK YOU WILL NEED
- SAVES A LOT OF HEARTACHE LATER IF THEY PROGRESS ALONG WITH YOU
- PREVENTS MISINTERPRETATION OF DATA AND PROMOTES CONSISTENCY IN THE SERVICE POSITION

NEW DON POLICY OVERSIGHT BOARD

- PROGRAM SPECIFIC
- NOT A FINAL DECISION FORUM
  RAISES/FORMS ISSUES FOR ASN (RD&A)/CMC/CNO DECISION WHEN CONCENSUS NOT REACHED
- BOARD REVIEWS:
  COMPLIANCE WITH OSD GUIDANCE
  ASSUMTIONS (VALID/COMPLETE)
  ALTERNATIVES, MOEs, THREAT, SCENARIOS, ETC.
- OVERALL QUALITY CONTROL:
  DOES IT MAKE SENSE?
  ARE CONCLUSIONS REASONABLE?

STEP THREE: ORGANIZE YOUR WORKING LEVEL RESOURCES

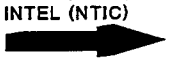
- BASED ON WHAT THE MAJOR ELEMENTS IMPLY
- IF YOU DON'T HAVE THE AUTHORITY TO TASK AND PRIORITIZE....
  GO GET IT
- IDENTIFY WHAT COMMANDS, AGENCIES, LABS, ETC. YOU NEED TO ACCOMPLISH THE MAJOR ELEMENTS OF A COEA
  GET A WORKING LEVEL REP FROM EACH
  OBTAIN A WRITTEN MISSION FOR THE GROUP
  CALL IT A STUDY ADVISORY GROUP.....
  IF YOU LIKE

NEW DON POLICY: STUDY DIRECTOR/TEAM

- STUDY DIRECTOR
  PLANS AND SUPERVISES COEA
  COORDINATES FUNDING
  ESTABLISHES TEAM MEMBERSHIP
- MUST HAVE
  ANALYSIS BACKGROUND
  TECHNICAL & OPERATIONAL BACKGROUND
  BE INDEPENDENT FROM PMs
- STUDY TEAM GENERALLY INCLUDES WORKING LEVEL REPS OF OVERSIGHT BOARD MEMBERS
- DIRECT LIAISON WITH OSD IS AUTHORIZED FOR TECHNICAL DISCUSSIONS

AAA COEA MANAGEMENT ORGANIZATION

ESTABLISHED	CHARTERED	TASKED
FLAG OFFICER REV GRP	STUDY ADVISORY GRP	ANALYSIS AGENCY
DIR, OPNs DIV (HQMC) DC/S RQMT/PRG (HQMC) CG, MCRDAC DIR, WARFIGHTING CTR DACNO,SURFACE WARFARE ASN(RD&A) EXP FORCES DRPM-AAA	REPs FOR EA FLAG OFF PLUS... REP OASD(PA&E) REP OUSDA(A) TECH ADVISORS: ENGR (DTRC) INTEL (NTIC)	CENTER FOR NAVAL ANALYSIS



ANALYSIS PLAN

GUIDANCE

ANALYSIS PRODUCTS

REPORTING

GUIDANCE REVIEW

MAJOR ACTIVITIES OF THE AAA SAG

- DEVELOP INITIAL STAR THRU INTEL REP
- SELECT SPECIFIC SCENARIOS THRU USER REP
- IDENTIFY SYSTEM ALTERNATIVES THRU SAG
- DEVELOP ALTERNATIVES "DESIGN" BOOK THRU ENGINEERING AND PM REPS
- CONDITIONALLY DEVELOP/APPROVE STUDY PLAN & METHODOLOGY...
  - ASSUMTIONS
  - MOEs
  - MODELS

PHASE I: PERFORMANCE ANALYSIS

- PURPOSE: TO SCREEN MORE CAPABLE SYSTEMS FROM THOSE LESS CAPABLE:
  GUIDES THE USE OF RESOURCES ON THE MOST REASONABLE ALTERNATIVES
- EACH CANDIDATE'S PERFORMANCE WAS ANALYZED BASED ON THEIR
  - SHIP-TO-SHORE MOVEMENT; I.E.
    - BUILD-UP RATE OF COMBAT POWER ASHORE
  - MOBILITY ASHORE IN VARIOUS TERRAINS
    - SLOPE CLIMBING
    - MAXIMUM SPEED
    - VCI
    - DRAW BAR PULL
  - SURVIVABILITY
    - PROBABILITY OF BEING HIT
    - PROBABILITY OF BEING DAMAGED
  - LETHALITY
    - ACCURACY AND ARMOR PENETRATION

PHASE II: EFFECTIVENESS ANALYSIS

- PURPOSE: TO SCREEN SYSTEMS AND GUIDE USE OF RESOURCES ON MOST LIKELY ALTERNATIVES
- CONDUCTED ON 7 OF 13 ALTERNATIVES
- USED TWO DIFFERENT SCENARIOS
  - LOW/MID INTENSITY COMBAT
  - MID/HIGH INTENSITY COMBAT
  - NO RUSSIANS
- USED TWO DIFFERENT SIZED UNITS
- PRINCIPAL MOE's
  - LOSS EXCHANGE RATIOS
  - FORCE MOVEMENT
  - PERCENT OF SURVIVING FORCE
  - FORCE RATIO
  - SHIP-TO-SHORE MOVEMENT TIMED
- INCLUDED SENSITIVITY ANALYSIS
  - ON SEA MINE THREAT
  - ENEMY ARRIVAL TIMES
- COSTED ONLY 7 UNSCREENED ALTERNATIVES

MANAGING A COEA
LESSONS LEARNED

- DESIGN A PROCESS THAT CAN ACCOMMODATE CHANGES
- YOU CAN'T START TOO EARLY TO DEVELOP/VALIDATE THE THREAT
- MAKE SURE YOUR SCENARIO THREATS (EQUIPMENT, OOB, DOCTRINE, ETC) ARE IN THE STAR
- MAKE SURE YOUR ASSUMPTIONS ARE LOGICAL, DEFENDABLE, WELL DOCUMENTED AND AGREED TO BY EVERYONE
- ESTABLISH AN EARLY RELATIONSHIP BETWEEN ALL THE PM-"COSTERS" AND "ICE PEOPLE" IN THE CAIG
- DON'T "COOK THE BOOKS" ON SCENARIOS - PARALLEL THE REAL WORLD, CONSIDER USING MORE THAN ONE, AND APPLY THE "MOST LIKELY" LITMUS TEST.
- PICK THE RIGHT KIND OF MODEL, UNDERSTAND ITS LIMITATIONS AND GET A "SEAL OF APPROVAL" FOR IT
- PICK MOE's THAT HAVE MEANING TO WARFIGHTERS

MANAGING A COEA
LESSONS LEARNED (CONT)

- KEEP THE SAG SMALL, ENSURE THAT IT HAS AUTHORITY TO MAKE ROUTINE DECISIONS, INCLUDE OSD REPS
- BE EVENT ORIENTED WHEN CALLING FOR A SAG MEETING
- DOCUMENT EVERYTHING SAID OR DONE
- KEEP ALL YOUR LEADERSHIP INFORMED AND UP TO DATE
- DON'T WAIT UNTIL THE END TO PUBLISH RESULTS
- DON'T EXPECT THE COEA TO PROVIDE "THE ANSWER"

MORS COEA SYMPOSIUM

LINKING
COEA TO OT&E

Dr Bill Lese
OASD(PA&E)

ACQUSITION POLICY

- STATES THAT BOTH COST AND OPERATIONAL EFFECTIVENESS ANALYSES AND TEST AND EVALUATION ARE AIDS TO DECSIONMAKING

ALSO

- STATES THAT LINKAGE SHOULD EXIST BETWEEN COEAs AND TEST AND EVALUATION

ACQUSITION POLICY

DoDI 5000.2/4/E/3.a(5)(c)

MEASURES OF EFFECTIVENESS SHOULD BE DEVELOPED TO A LEVEL OF SPECIFICITY SUCH THAT A SYSTEM'S EFFECTIVENESS DURING DEVELOPMENTAL AND OPERATIONAI TESTING CAN BE ASSESSED WITH THE SAME EFFECTIVENESS CRITERIA AS USED IN THE COST AND OPERATIONAL EFFECTIVENESS ANALYSIS. THIS WILL PERMIT FURTHER REFINEMENT OF THE ANALYSIS TO REASSESS COST EFFECTIVENESS COMPARED TO ALTERNATIVES IN THE EVENT THAT PERFORMANCE AS DETERMINED DURING TESTING, INDICATES A SIGNIFICANT DROP IN EFFECTIVENESS (I.E., TO OR BELOW A THRESHOLD) COMPARED TO THE LEVELS ASSUMED IN THE INITIAL ANALYSIS.

ACQUSITION POLICY
DoDI 5000.2/4/E/3.a(5)

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 MEASURES 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...

ACQUSITION POLICY

DoDI 5000.2-M/8/2.a(5)

A COMPREHENSIVE TEST AND EVALUATION PROGRAM IS AN INTEGRAL FACTOR IN ANALYZING OPERATIONAL EFFECTIVENESS, SINCE IT WILL PROVIDE TEST RESULTS AT EACH MILESTONE DECISION POINT THAT GIVE CREDENCE TO THE KEY ASSUMPTIONS AND ESTIMATES THAT MAY HAVE BEEN MADE IN THE CURRENT OR EARLIER COST AND OPERATIONAL EFFECTIVENESS ANALYSES.

COEA - T&E RELATIONSHIP

THE LINKAGE BETWEEN COEA AND T&E IS COMPLICATED BY:

- COEA AND T&E BEING EXECUTED BY DIFFERENT AGENCIES.
- MOE AND MOP BEING DEVELOPED INDEPENDENTLY
- THE OT ENVIRONMENT DIFFERING SIGNIFICANTLY FROM THAT ASSUMED IN THE COEA.
- THE COEA BEING "PUT ON THE SHELF" AT MS II AND THE RATIONALE FOR DECIDING WHETHER A SYSTEM WAS A COST-EFFECTIVE APPROACH TO MEETING THE OPERATIONAL REQUIREMENT BEING FORGOTTEN.

COEA - T&E RELATIONSHIP (CONTINUED)

THE REMEDIES LIE IN:

- EARLY COORDINATION BETWEEN THE AGENCIES RESPONSIBLE FOR THE COEA, T&E, AND THE DEVELOPMENT OF REQUIREMENTS.
- IDENTIFICATION OF MOEs FOR BOTH COEA AND T& E THAT ARE DERIVED FROM THE MISSION NEED STATEMENT AND REFLECT OPERATIONAL UTILITY AND A CLEAR DEMONSTRATION OF THE RELATIONSHIP BETWEEN MOEs AND MOPs.
- UNDERSTANDING OF THE REASON FOR AND MAGNITUDE OF THE DIFFERENCE ANTICIPATED BETWEEN TEST AND ANALYTIC RESULTS.
- ABILITY TO REVIEW THE COEA USING TEST RESULTS TO REAFFIRM EARLIER DECISIONS.

COEA - T&E RELATIONSHIP GUIDELINES

- DoD COMPONENTS, IN THE PROCESS OF PERFORMING MS-1 COEA SHOULD IDENTIFY THE MOEs TO BE USED IN THE COEA AND SHOW HOW THESE MOEs ARE DERIVED FROM THE MNS.
- COEA SHOULD INCLUDE MOEs REFLECTING OPERATIONAL UTILITY THAT CAN BE TESTED. THESE AND OTHER MOEs THAT CANNOT BE TESTED SHOULD BE DESCRIBED IN TERMS OF TESTABLE PARAMETERS OR MOPs (I.E. SHOW HOW CHANGES IN THESE PARAMETERS RELATE TO CHANGES IN THE COEA MOEs.)
- THESE MOEs, MOPs, AND THE ASSOCIATED CRITERIA SHOULD BE INCLUDED IN THE ORD, AND THE KEY MOEs SHOULD ALSO BE INCLUDED IN THE APB.
- CONSISTENCY SHOULD BE MAINTAINED BETWEEN ALL THE ACQUISITION MANAGEMENT DOCUMENTATION.

COEA - T&E RELATIONSHIP GUIDELINES (CONT)

THERE SHOULD BE THE ABILITY TO REVIEW THE COEA AT MILESTONE DECISON POINTS AND OTHER ACQUISITION REVIEWS USING TEST RESULTS (DEVELOPMENTAL/OPERATIONAL AS APPROPRIATE) TO REAFFIRM THE DECISIONS MADE EARLIER

- SELECTED ALTERNATIVE IS STILL COST EFFECTIVE
- OPERATIONAL REQUIREMENTS ARE MET

IF THE ORIGINAL COEA ASSUMPTIONS ARE NOT SUPPORTED BY TEST RESULTS OF THE THRESHOLDS IN THE ORD ARE NOT MET, COEA SENSITIVITY ANALYSES SHOULD BE AVAILABLE TO ASSIST THE DECISIONMAKERS IN DETERMINING WHETHER

- THE SYSTEM IS STILL COST EFFECTIVE
- DOT&E IS ABLE TO CONFIRM THAT THE SYSTEM IS OPERATIONALLY EFFECTIVE AND SUITABLE

COEA - T&E RELATIONSHIP GUIDELINES (CONT)

FOR A VARIETY OF REASONS (EG. AFFORDABILITY, AVAILABILITY OF TEST RESOURCES, SAFETY CONSTRAINTS) THE PROPOSED OPERATIONAL ENVIRONMENT OFTEN DIFFERS SIGNIFICANTLY FROM THAT ASSUMED IN THE COEA

- PROPOSED OPERATIONAL SCENARIO AND THREAT REPRESENTATION
- SAFETY AND OPERATING RESTRICTIONS
- DIFFERENCE BETWEEN TEST ARTICLE AND THE SYSTEM AS REPRESENTED IN THE COEA (EG. MATURITY & LEVEL OF MATURITY)

IF AS A CONSEQUENCE, TEST RESULTS ARE EXPECTED TO SIGNIFICANTLY DIFFER FROM COEA ASSUMPTIONS , THE COEA SHOULD ASSESS THE MAGNITUDE OF THE IMPACT AND THE EXTENT TO WHICH TEST AND ANALYTIC RESULTS WOULD BE EXPECTED TO VARY

MORS COEA SYMPOSIUM

LINKING
COEA TO T&E

Mr Richard R. Ledesma
OUSD(A) (T&E)

COEA RELEVANCE TO TEST & EVALUATION

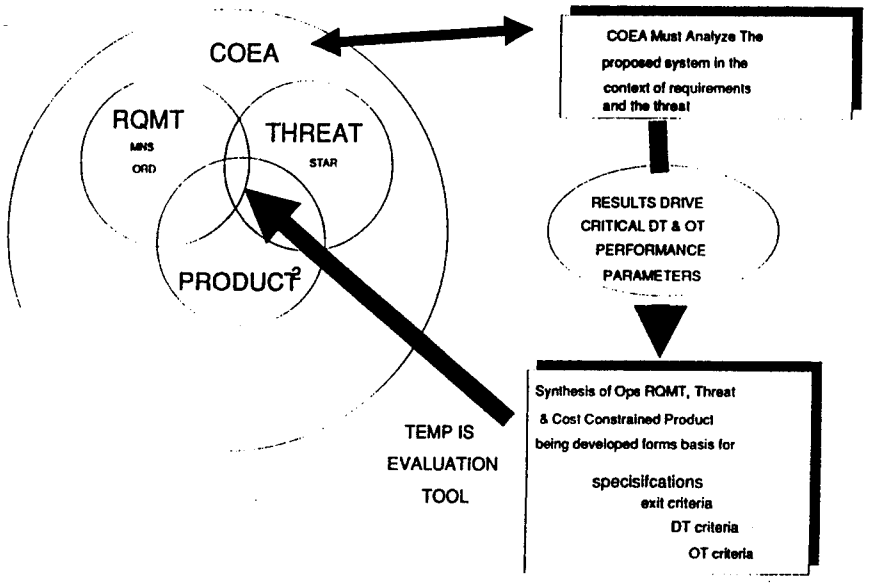
- AN ANALYSIS TOOL
- PROVIDES SYSTEM FOCUS ON THE BASIS OF REQUIREMENTS INCLUDING FEASIBILITY TO MEASURE PERFORMANCE AND THREAT
- SYNTHESIZES REQUIREMENTS, THREAT AND COST TO FORM A BASIS FOR A DT & OT PERFORMANCE PARAMETERS.
- NOT AN EVALUATION TOOL - BUT PROVIDES A FRAMEWORK FOR T&E

DT CONTRIBUTION TO T&E - COEA LINKAGE

- ASSISTS COEA IN DERIVING APPROPRIATE MOE/MOP
- ESTABLISHES FEASIBILITY OF ACHIEVING MOE/MOP
  - ** MEASURABLE
  - ** ACHIEVABLE (I.E. EXCHANGE RATIO)
- PROVIDES T&E RESULTS INPUT TO LATER COEA

  QUANTIFIES MEASURE OF TECHNICAL PERFORMANCE
- CERTIFIES MODELING & SIMULATION AS TESTING ADJUNCT
- PROVIDES UPDATES & MEANS TO REFINE MOE/MOP DURING DEVELOPMENT
- PROVIDES EARLY INSIGHT INTO ACHIEVABLE OPERATIONAL PERFORMANCE

COEA - TEMP LINKAGE



DT/COEA RESOURCE IMPLICATIONS

- EARLY INTERACTION TO ADDRESS TESTING AND RESOURCE ISSUES.
- WHAT IF RESOURCES ARE NOT AVAILABLE ?
  - ** DON'T PROCEED?
  - ** ACCEPT INADEQUATE TESTS?
  - ** LOOK FOR ALTERNATIVES?
- WHEN? BETWEEN MS-0 AND MS-1

COEA/T&E LINKAGE COULD PROVIDE FIRST OPPORTUNITY TO ADDRESS THIS ISUE

2.1.10 The COEA In Support of the DoD Decision Process

Introduction

Cost and Operational Effectiveness Analysis (COEA) and, more generally, systems analysis are well established methodologies used by the Department of Defense (DoD) to allocate scarce resources. The methodologies were introduced into the decision-making process along with the "systematic" Planning, Programming and Budgeting System (PPBS) in the early sixties. Yet while the PPBS in DoD has been from its earliest days generally well received, systems analysis, including COEAs, is often highly controversial. COEAs are alternately viewed with hostility or favor. When their results support a "defense consensus," COEAs sail through the bureaucracy. But woe the COEA that challenges an "obvious" defense need or supports a "turkey" of a system. It is puzzling, indeed, that an enterprise whose fundamental strength is "objectivity" can evoke such reactions. Yet, in spite of several attempts over the years to diminish the role of analysis, the Office of the Secretary Of Defense (OSD) continues to place high emphasis on COEAs and other analytical studies. Guided by the principles that decision-making can be improved by analysis and that it is always desirable to examine the cost-effectiveness of alternatives to meet requirements, the DoD has integrated COEAs into its new acquisition regulations (the so called 5000 series regs). From the DoD perspective, a COEA always serves a valuable function for even when it does not definitively resolve all issues, it promotes a logical presentation of information and provides a rational basis for evaluating alternative courses of action. Because a COEA underpins very difficult decisions with analysis, it will continue to play a significant role in the OSD decision-making machinery.

The OSD and the Services have developed elaborate organizations of people, models and methodologies to do COEAs, making considerable investments in studies for each cycle of acquisition and for program reviews. The Army, for example, the service most heavily invested in analysis, not only develops each year a comprehensive study program (the AR 5-5 Study Program) but also maintains entire organizations devoted to executing it. The Navy, on the other hand, where analysis traditionally has been dispersed and more "targeted," is currently setting up an organizational structure to integrate the COEA "process" into overall decision making. The Air Force is likewise revising its analysis structure, reallocating responsibility for COEAs to the major commands where the studies can be appropriately integrated into
Air Force decisions. OSD, of course, depends mainly on "outside" or contractor support for its studies but it is no less committed to the COEA process. In all cases, money is being allocated to support new study initiatives. Given that, a COEA, as a rule of thumb, takes from six to twelve man-years and costs between two and five million dollars, the continued reliance by all parties on quantitative evaluations is a clear indication of the value attached to such work.

It is worth noting that COEAs ideally should be neither shields nor swords in the fight for defense resources but rather merely tools for enlightened decision-making. In their pure essence, they are most useful and productive when helping decision-makers to formulate problems, choose appropriate objectives and alternatives, compare and test alternatives in realistic environments and assist in setting priorities and reaching decisions. COEAs do not "give the best solution" but provide the vehicle for decision-makers to make tough choices with objective clarity.

Why Focus on COEAs

COEAs are important for two reasons: they are the primary tools for resolving resource allocation issues concerning the discretionary part of the DoD budget; and they provide analytical justification for selected courses of action.

It has been argued (Hitch) that the basic problems of defense are economic. That is to say, most defense issues eventually devolve to a choice of alternative means for satisfying objectives within cost or other resource constraints. It is not uncommon, therefore, that defense problems spill over to the general federal budget arena since, as defense competes within the broader set of federal expenditures, choices made in defense can impact the nation's general economy and vice-versa. Moreover, the impact of defense choices can in fact be larger than just the magnitude of defense expenditures themselves (nominally about 25-30% of the Federal budget) because a large fraction (nearly 68% and growing as apparent in Figure 1) of the federal budget is "mandatory", i.e. non-discretionary, spending.

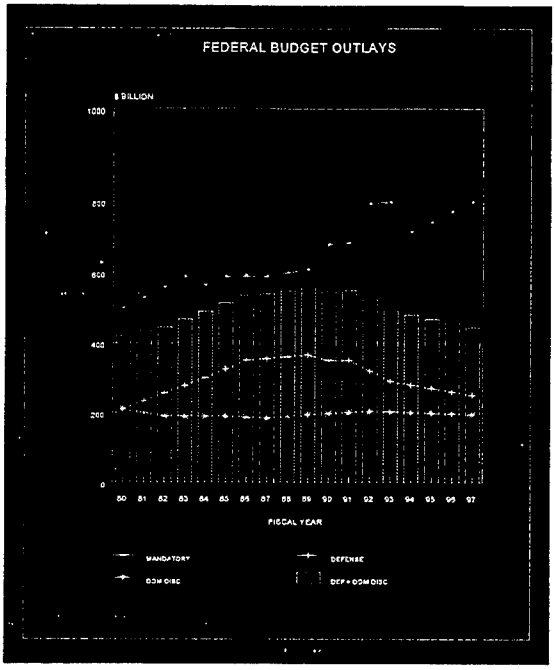


Figure 1

Hence in the fight for resources, the pie over which the national priorities battle takes place is mostly defense. In fact, nearly 70% of federal discretionary funds are defense dollars (Figure 2).

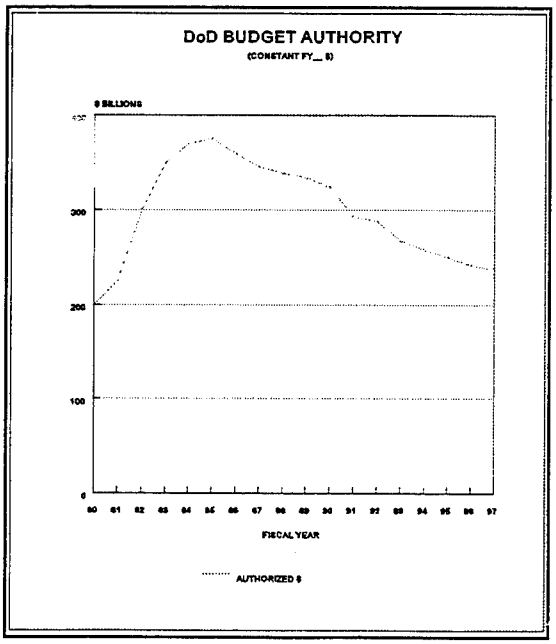


Figure 2

Defense spending, as viewed from the federal budget perspective, is all discretionary.

There is no denying that in both relative and absolute terms, the amount of money authorized for defense is huge (Figure 3).

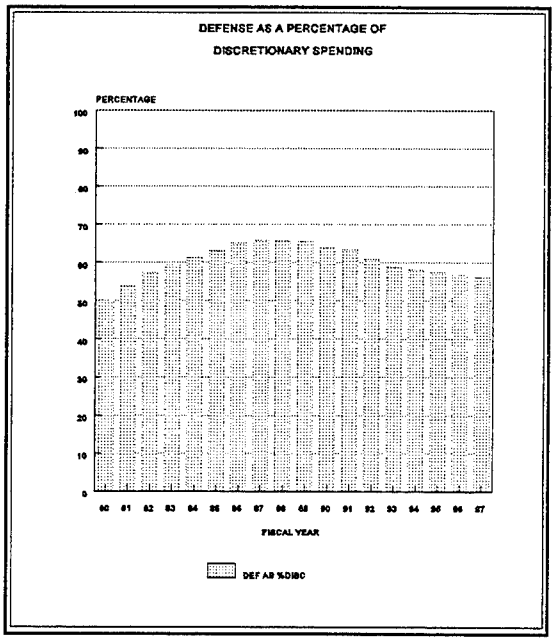


Figure 3

However, when viewed strictly from a defense perspective, the entire defense budget is not discretionary. For all intents and purposes, once a force structure is established, the money to support that force itself becomes mandatory, covering such items as personnel pay, quality of life and operations and maintenance. None of these can be "raided" with impunity without serious consequence for total force capability. Furthermore, in recent years, the DoD has placed great emphasis on avoiding a "hollow" force, meaning that funds for these three "mandatory" areas enjoy high priority. The current Annual Report of the Secretary of Defense makes this clear (page 24), noting that defense priorities place people, quality of force and readiness at the top of the list. The net result is that the discretionary portion of the defense budget essentially

defaults to the Research and Development (R&D) and Procurement accounts. An additional small amount, about 3% of the total DoD budget, allocated for military construction, can also be included in this pot. Together these moneys, are referred to as the "investment" account. In recent years, this account has averaged about 35% or $95 Billion, no small change to be sure.

In effect, therefore, the basic economic problem for defense is how to allocate DoD investment account funds or how best to invest in modernization and improvement, (i.e. acquisitions) for our forces. Considerable effort has been expended by the DoD in recent months to address this problem. General initiatives to improve the acquisition process have been well-publicized. But a more technical initiative has also been launched with the publication and implementation of the 5000 series acquisition regulations. Included in these regulations as an integral and recurring part of the new process is the COEA. According to these regulations, a COEA provides the only comparative analysis for evaluating alternative acquisitions and is a key document for establishing alternative preferences. The COEA performs three functions as part of this process. It;

1) aids decision makers; it presents and uncovers relative advantages and disadvantages of alternatives and provides a measure of the relative sensitivity of the alternatives to changes in underlying assumptions;

2) facilitates communications; it identifies feasible alternatives and promotes open debate concerning their reasonableness, efficacy and suitability for given objectives, assumptions and limitations;

3) documents acquisition decisions; it provides the historical written record of the rationale for selected courses of action so it can be reexamined later, perhaps under different circumstances and by different players.

The acquisition process requires numerous studies and voluminous documentation. It is complicated, time consuming, and demanding. No doubt, this drives much of the effort to underpin decisions analytically. However, of the analyses that are required, only one type evaluates alternative courses of action in terms of cost-effectiveness. That is to say, although much analysis is done leading up to the point of identifying a materiel solution to meet a DoD requirement, most of this analysis deals with requirements evaluation or with the execution of the acquisition process itself, not with the problem of economic choice. The COEA alone addresses the matter of "military worth" vis-a-vis cost.

The cost-effectiveness tradeoff is far from a trivial concern. In DoD, the fundamental issue is how to choose doctrine, weapons, and/or equipment to get the most "defense" for the dollars available. The issue is not how to maximize effectiveness or how to minimize cost. It is neither a chauvinistic appeal to getting the "best for our boys" nor a scrooge-like denial to make do with the worst possible systems. It a matter of weighing the value or utility of an alternative against the cost of implementation. This problem exists because resources are always limited and what is used for one purpose decreases the amount available for another. The COEA gives decisionmakers a framework for assessing these choices. To the extent that it is the only such decision support tool in the acquisition process, the COEA is essential.

In addition, examining the new acquisition process reveals that only one type of analysis recurs: the COEA. Requirement studies are initiated once, acquisition and implementation plans once (and adjusted thereafter); and concept studies once. The COEA, however, is done or updated at each milestone of the process. In this sense, it is a dynamic evaluation of choices and serves, at each point, to confirm that the solution being pursued remains viable. The COEA, therefore, is the thread that weaves all procurement justifications together. Consequently, it is as much forward looking as it is backward looking. That is, it emphasizes the evaluation of current alternatives but it does so by asking whether the original requirement is still valid. For this reason, sometimes it can be a "show-stopper" but always serving the decision-maker by asking whether "the gain is still worth the cost." No responsible official would fail to ask that question at key review points and it follows that the COEA would always be important for making that judgment. In effect, the COEA in its replications provides the continuous justification to proceed with an acquisition.

What is a COEA

A COEA is, first and foremost, an aid to the decision-maker. It provides a framework for comparing alternative courses of action using a structured quantitative approach. It addresses head on the basic allocation problem of defense which, in simplest terms, is either to get the most "defense" for a given level

resources (i. e. the classical "bang for buck" problem) or, equivalently, to achieve a given level of defense at the least cost. While these perspectives are conceptually easy to grasp, they are difficult to execute. Frequently, there are either too many choices or the context for choice is extremely complicated. The COEA helps clarify the pros and cons of complex decisions and guides the decision-maker in asking the right questions and uncovering uncertainty by steering his thinking; the COEA provides the decision-maker with confidence that the solution is a product of a rational decision process.

In DoD, a COEA is defined as:

> a comparative analysis of given alternatives (one of which is a basecase) intended to meet specified requirements in an operational context and using comparative life cycle cost estimates to establish alternative preferences based on cost-benefit measures.

This definition embodies several key concepts for analysis. First, a COEA is comparative in nature, implying that "relative measurement" is the desired analysis framework. In particular, this means that the COEA analyst must identify and highlight the critical distinguishing characteristics of the alternatives. In general, a COEA is of little value in absolute terms. This is a distinguishing feature of most COEAs and is the reason that COEA comparisons often remain valid even as underlying assumptions in the study change. Unlike "absolute" analyses, in a COEA only differences among alternatives are ever quantified. Thus, the critical questions when assumptions change are "does the relative ranking of the alternatives also change" and "is the delta between alternatives now small enough to reverse the cost-effectiveness preferences"? The answers to these questions are frequently in the affirmative.

Second, the typical COEA accepts alternatives as inputs. In other words, alternatives are given. This does not preclude, however, the consideration of additional alternatives even as a COEA is being executed. Rather, as new alternatives are identified, whether prior to or during a COEA, they must be introduced at the beginning of the COEA methodology. Normally, the COEA methodology will not give rise to conceptually different alternatives, although variations on a theme frequently do arise. The definition of the alternative set is made outside the COEA framework, sometimes as a matter of policy - as for example when a foreign system is (or is not) decreed to be considered in the analysis. More often, however, alternatives enter naturally as the decision issues are developed. Further, since one of the alternatives must be the basis for comparison, the "basecase" alternative, (also called the "status quo" or "default"), must be included. In general, therefore, alternatives are defined prior to starting a COEA. But as with all external COEA parameters, inputs can drive outputs. So caution must be exercised to avoid excluding potential solutions by assumption. After all, the point of doing a COEA is to see whether cost-effective improvement can be obtained over the status quo. An alternative set that is not broad enough to cover the decision issues defeats that purpose. A COEA that is short on alternatives will not justify the economic value of substituting something new for something on-hand. And, it certainly will not aid the decision-maker.

Third, a requirement for a materiel acquisition is presumed to have been established prior to initiating a COEA. By the time the COEA starts, a "Mission Need Analysis (MNA)" should have been completed. Such an analysis should have established that a specified requirement can be met only by a materiel solution. A COEA will not provide a basis for determining whether a requirement is valid or whether a deficiency is real. This is beyond the scope of the methodology. The COEA will, of course, raise questions about requirements as differences in alternatives are quantified and rationalized. In this respect, the COEA can and should complement early conceptual studies of requirements and, more importantly, should have a link back to them so that any such questions can be resolved as part of the "requirements validation" at each acquisition milestone.

Probably the most mature concept of a COEA, as it is done in the DoD, is that of operational effectiveness analysis. It is this concept that distinguishes DoD analysis from general economic analysis. It may also be the reason why other government agencies have had difficulty in applying it to their operations. Notionally operational effectiveness says that, when comparing alternatives, the issue is not how well an individual system performs but rather how well it contributes to mission accomplishment. The former perspective is almost inconsequential to a COEA (except as an input) because in most cases from this perspective the answer is usually obvious: new is better, bigger is better, advanced is better. However, from the mission

completion perspective, the issue is one of "force-level" effectiveness. It is a team concept, if you will, where the value of a system is measured in terms of its integral contribution to an overall effort by an organization. Capability that contributes to this goal is of value while that which does not, no matter how flashy from an individual perspective, does not count. This is the reason that DoD has spent enormous energy in developing combat models and conducting operational tests. It is through simulation, modeling, and testing at the force-on-force level that alternatives can be assessed for their mission accomplishment value. A properly executed COEA will, therefore, show how well one alternative does as part of a military team conducting realistic missions in an integrated, combined-arms battlefield.

It is an acknowledged fact that the cost of systems exceeds the cost of acquiring them for the cost of maintaining and supporting systems must also be included. Moreover, history has shown that these latter costs are the most significant. Taken together, the cost of acquisition including R&D, and operations and support, constitutes the life cycle cost of a system or the entire cost of "ownership." The only proper basis for comparing COEA alternatives therefore is Life Cycle Cost (LCC). In DoD, the typical term for LCC estimates is 20 years. However, in order to compare alternatives, it is not sufficient to develop only 20 year life cycle cost estimates for each one for there would be no way to account for the "phasing in" of an alternative. That is to say, there is a cost associated with each alternative, beyond its life cycle cost, for bringing it into the inventory. Depending on the alternative, these costs could be substantial and if ignored could lead to an erroneous indication of the true cost of an alternative. In order to get a true comparative cost basis, all COEA alternatives should be synchronized relative to their phasing-in schedules. The costs associated with phasing-in plus the life cycle cost comprise the "comparative" LCC, the proper basis for comparing the costs of COEA alternatives.

The integration of cost and effectiveness is the last key concept in a COEA and the hardest part to execute. Notionally, the idea is simple: combine the two attributes, cost and effectiveness, into a single measure - perhaps a ratio or a weighted sum. But as is well known, ratios can distort differences and weighted averages can inject bias. So while the problem is easy to conceptualize analytically, it is a difficult decision-theoretic problem to solve. Many techniques have been developed to address this problem, including cost-effectiveness and relative worth ratios, multi-attribute utility theory, and the more recent pairwise comparative methods like the analytic hierarchy process. Nevertheless, the problem of identifying alternative preferences using strictly quantitative methodologies remains unsolved though considerable research effort continues.

Analytical difficulties not withstanding, preference and choice are still the objectives in a COEA. Thus, if it is to serve its purpose, a COEA must clearly identify the criterion of choice while conceding that unquantifiable policy or judgmental aspects affect the choice process. Decision-makers like to have an "intuitive" sense that the decisions they make are valid. Therefore, they must be given the opportunity to "assimilate the raw data" themselves. This is especially critical for those alternatives that are characterized as ones that "yield more but cost more." Preference in this situation is a very judgmental thing and circumstances and risks usually affect the decision. The best approach, therefore, is to give the decision-maker both effectiveness and cost numbers and let him use his own judgement guided by analytics.

Where Does a COEA Fit In the DoD Management System

The new acquisition regulations establish a DoD management system (Figure 4) that consists of three separate but supporting decision processes: Requirements, Acquisition and PPBS.

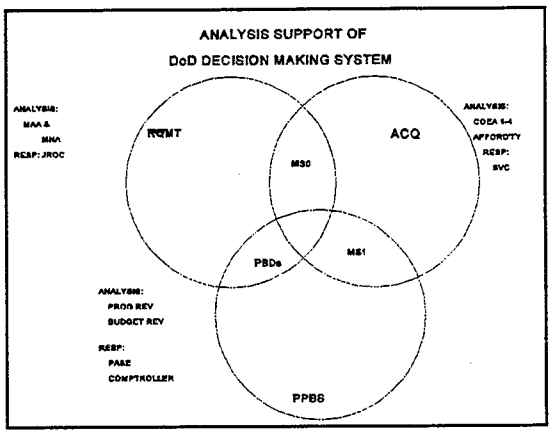


Figure 4

Each process supports a different aspect of DoD activity and in turn each is supported by certain types of

analyses. The requirements process, for instance, is supported by Mission Area Assessments (MAA) and Mission Needs Analysis (MNA). An MAA identifies deficiencies given current force structures, mission requirements and threats. A MNA takes these deficiencies and confirms that a materiel solution is the best way to cover them. The MNA, therefore, justifies an acquisition "new start." Requirements evaluation is the responsibility of the Joint Requirements and Oversight Council.

The Acquisition process is supported directly by Affordability Analyses and by COEAs (referred to as COEA 1-4) at each of the four acquisition milestones (Figure 5).

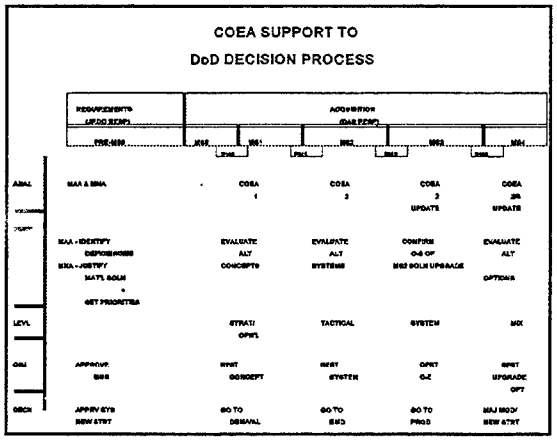


Figure 5

The purpose of these COEAs is discussed more fully below. Acquisition is the responsibility of Under Secretary of Defense for Acquisition [USD(A)] and is overseen and managed by three acquisition committees and by a Defense Acquisition Board.

The PPBS does not require pre-specified analyses. However, as it is executed to evaluate service programs, embodied in the Program Objective Memorandum (POM), PPBS usually relies on a complex of studies, issue examinations, quick analyses, special-purpose studies and COEAs. PPBS is executed in two parts: program review and budget review with the various analyses supporting these two parts. Program review is the responsibility of the Assistant Secretary of Defense for Program, Analysis and Evaluation [ASD(PA&E)] while budget review is driven by the Assistant Secretary Of Defense (Comptroller) (ASD(C)). The result of PPBS is the president's budget.

The various analyses noted above support and complement each other as a way of interfacing the three DoD decision processes. For example Requirements and Acquisition interface at milestone zero (MS0). This is the "new start" milestone. Thus analyses to justify requirements and to identify deficiencies occur prior to MS0 but feed into the MS0 review. In order for a system to begin its acquisition path, the mission need statement must be supported by an MAA and an MNA. The strength of the MS0 decision, therefore, is based on the quality of the MAA and the MNA done during pre-MS0 evaluations. At milestone zero, the studies and the alternatives for COEA-1 are established. Clearly, the scope of COEA-1 also depends on the level of effort reflected in the MAA and MNA.

The interface between PPBS and Acquisition is at MS1. This is a key milestone in that the decision at this point is a "whole enchilada" decision. The regulations make it clear that proceeding on the basis of funding wedges, partial programs, or promises to fund programs at a later time will not be acceptable. Hence, newly-required affordability analysis is particularly important because it makes the trade-off in a given function area to see whether proposed programs are affordable within total fiscal guidance. The COEA plays a relatively minor role here since affordability is strictly a cost assessment. But the COEA can support this analysis by providing effectiveness measures in a given mission area as a way of assessing risks in proceeding.

The COEA supports the DoD management system in different ways. It is best, therefore, to view a COEA as a process rather than as a product. The COEA begins with the successful passage of MS0 since it is one of the studies, arguably the primary study, initiated immediately after MS0. The alternatives for this COEA are defined during the MS0 review. The COEA for MS1 is an evaluation of alternative concepts. That is to say, it examines the different ways a job can be done or a mission carried out. The alternative set at this stage should include conceptually different approaches to meet the requirement and should not be simply a variation on a single theme. Preferably, the COEA-1 should be done at the strategic or operational level based on a broad notion of mission accomplishment. The objective of this COEA is to screen out those approaches that do not "work" and to narrow the set of system options.

COEA-2 should focus on a comparison of systems for accomplishing a mission. This analysis should deal with alternative hardware designs or, in the case of non-developmental items, actual systems. Prototypes developed during Phase 1 and performance estimates from them should be used as the basis for estimating the combat effectiveness of the alternatives. The best level of evaluation here is tactical where the particular performance features of a system can be assessed. Since the decision to be made at this point is on the best hardware configuration, the highest possible level of a combined-arms battle that still draws out hardware differences is the best approach. In practice, this frequently turns out to be the battalion or brigade level for Army systems.

COEA-3 occurs on an exception basis. In particular, it is done only if substantial changes have developed either in the configuration of a system, its cost or the threat. Even in this case, however, the question to be answered is whether the change is drastic enough to invalidate previous cost-effectiveness rankings and preferences not whether cost-effectiveness estimates are different. This COEA is done at the system level since the objective is to certify the cost-effectiveness established by COEA-2. In general, COEA-3 simply updates COEA-2 using better performance data obtained from engineering or test results. Unfortunately, in practice, so much time passes between MS1 and MS2 that a COEA-3 is usually required. While this may seem by analysts as an unnecessary burden, from a management viewpoint it is essential because the decision to be made here is usually a "big-bucks" one, namely, should the system go into production. At this stage, there is rarely little alternative to a no-go decision except terminating a program. Thus, the certification of cost-effectiveness by COEA-3 is a critical component of the decision.

COEA-4 is also optional. It closes the loop on the acquisition cycle. At MS4 the issue is whether to upgrade a system that is already fielded or to initiate a new system acquisition. Upgrade options are the main focus in the alternative set for this COEA. Additionally, replacement systems, existing as well as new, are also included as these options can potentially drive the issue back to the requirements phase and a subsequent MS0. The context for this COEA is mix of assumptions and conditions with emphasis ranging from future to near-term and from specific systems to general concepts. The level of this COEA is likewise a mix from detailed tactical situations to large scale operations. The real utility of this COEA is as a tool to determine whether there is a need for something new or whether improvements to current systems will suffice. COEA-4 serves the gut modernization issue in DoD.

Generic COEA Methodology

A generic methodology for doing a COEA is shown in Figure 6. The key inputs are at the top, the key processes are in ovals and the key outputs are noted by heavy arrows.

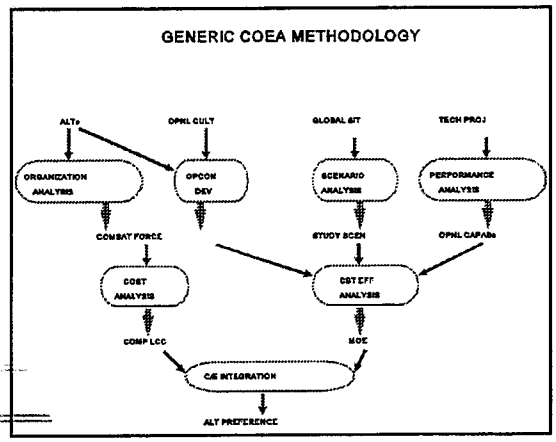


Figure 6

Inputs: External to the COEA are the alternatives, the operational culture, the global situation and technology projections. Alternatives are defined either through outside analyses or policy decisions. The COEA begins with a set of alternatives, including a basecase, and seeks to identify the one preferred from this set. Obviously, unless an alternative is included in the input set it will not be recommended at the end. Therefore, a crucial consideration at the beginning of the COEA is the makeup of this set. It should be as comprehensive as possible but allowances should also be made to expand it later as additional alternatives surface.

Since the COEA is an operational evaluation, the underlying culture of the "operators" enters in through the development of an "operational concept" for the study. Simply stated, this says that what one believes about how to do a job determines what approaches one takes to doing it. For example, due to different operational cultures, the operational concept for providing point air defense will differ among the services. While the Army might rely on guns and missiles on mobile platforms at relative short ranges,

the Air Force might emphasize long-range missiles and manned interceptors and the Navy mid-to-long range air and missiles. Thus, a key outside determinant of a COEA is the accepted operational culture reflected in the "way to fight" as trained for and practiced by the services.

The COEA must be meaningful within a realistic context. This context is set by assumptions regarding the global situation and leads to the specification of the combat scenarios that are the basis for a COEA. Until now, the global context was relatively stable and rigid. For the most part it implied a land battle scenario in Europe emphasizing the heavy armor battle. Of course, this is now changed. New scenarios, therefore, must be developed which accommodate the new assumptions about the global situation and which can be used to drive the combat effectiveness assessments in COEAs.

Since a COEA is mainly an analysis that supports the acquisition process, its end product is the identification of systems that can potentially be added to the force structure. Consequently, the availability of technology becomes an important aspect of defining alternative systems. However, technology projections are outside the scope of the COEAs. They are external inputs which determine not only alternatives that should play but also the level of performance that is achievable. Realistic projections of technology are important if the alternative set and the corresponding performance parameters are to be credible. A highly optimistic projection will cause near term systems to look unduly bad while a pessimistic one will preclude taking advantage of real opportunities.

Processes: In its most general form, a COEA is a collection of subanalyses tied together in such a way that data generated by one is used by another. The first level of processes are ones that look at organization, concept of operations, scenario development, and performance analysis. These processes translate the external inputs into analytical formats for later COEA processes. Organization Analysis and Operational Concept Development consider each of the alternatives and using the operational culture, develop an organizational structure that will function militarily to carry out a mission. This activity involves defining not only the best organization for conducting combat operations with an alternative but also the quantities of and support required by each system. The product of these processes is a "combat force" that may be considered a microcosm of the total force that would exist if that alternative is selected. This combat force might, and probably will, be configured differently for each alternative. It is not simply the case where the same strucuture is used and alternative systems substituted. Also, the combat force will include support systems along side the alternative systems since it must be fully mission capable. This force is sometimes referred to as a "slice" of the total force structure.

Scenario analysis generates realistic combat situations to use as study scenarios. It generates these at various levels from low-resolution, theater level operations down to high-resolution, small-scale tactical situations. The level depends on the COEA being done. Regardless of level, however, the study scenarios are defined in the following terms: the composition of the friendly force (i.e the combat force), the opposing force (i.e. the threat), the mission to be accomplished (i.e. the military objective), the timing or chronology to be followed (i.e. the battle dynamics) and the environment in which the operation will occur. All of these components must be specified in order to drive the combat models used later in the methodology. Additionally, the complete COEA uses more than one study scenario. The spectrum of scenarios should include some that are stressful, non-stressful, likely, worst case and best case. At all costs, however, study scenarios should not be contrived and, if possible, they should relate back to the Defense Planning Guidance. In general, a broad spectrum of scenarios is desirable since the point of the analysis is to determine the best alternative under a variety of conditions.

The heart of the COEA is the Cost Analysis and the Combat Effectiveness Analysis. In cost analysis, comparative LCC estimates are developed for each alternative. The two critical aspects of this analysis are realism and completeness. Realism is attained by using the latest, most accurate data about each of the alternative. It is achieved by having cost analysts work closely with and, ideally, even live with system designers and developers. Also, since cost analysts usually work either parametrically, bottoms-up or by analogy, extensive (in terms of scope and history) data bases are essential. The operative concept is that a cost analyst without a good data base is a cost analyst not to be believed. Completeness is attained by including all factors that contribute to the cost of an alternative. This means that the life cycle cost estimate should include more than just the "big five" cost components of procurement, R&D, Military Construction, Personnel and Operations & Support. Other costs, such as sunk

and phase-in costs, should also be included. An estimate with costs hidden or omitted will lead to an erroneous basis for comparison. The COEA will only be as good as the "comparative " life cycle cost estimates of each alternative.

Combat effectiveness analysis is a measure of an alternative's ability to meet established mission requirements in an operational environment. It is to be distinguished from performance analysis which is a measure of how well a specific system accomplishes an assigned task. Operational effectiveness is a force attribute; performance is a system attribute. In a COEA, combat effectiveness is quantified through "force level" measures of effectiveness (MOE). The ideal MOE will measure mission accomplishment. However, since in many cases this is hard to quantify, lower order MOE are used as surrogates and supplemented with judgment. Often these surrogates focus on casualties, both enemy and friendly, and are quantified as ratios. Typical among them are Loss Exchange Ratios (LERs) and Force Exchange Ratios (FERs). Combat effectiveness is usually quantified via simulation or tests. Simulations, whether of the Man-In-The-Loop or closed-form variety, seek to measure combat outcome. They play through a battle as defined by the scenario, and evaluate battle outcome in terms of casualties or objectives achieved, based on performance, tactics, and environment. At the tactical level, these models tend to be complex stochastic simulations used as the vehicle for executing an experiment design. Numerous replications are made to achieve statistical stability and the model results are reported at given confidence levels. At the operational or higher level where representing individual platforms is not critical, simulations are normally of the deterministic type and not infrequently lanchester-equation based. In these models, the critical part of the analysis is obtaining estimates of attrition coefficients. Once coefficients are known, however, results are quantified in one pass, i.e. one replication of the model. Confidence levels for model results in this case are determined primarily by the confidence level of the inputs. In either type of model, high or low resolution, the key is to play an integrated battlefield. Meaningful combat effectiveness analysis requires a combined-arms battle situation so that the value of a system is determined while taking into account the synergistic effects of all combat force elements.

Since combat effectiveness analysis is essentially a computer experiment, analysis of model output should be done using sound statistical principles. In essence, the study is an experiment and one model replication is an observation. The analyst's job is to define the experimental design to answer specified questions (called the essential elements of analysis (EEA)). The design, usually defined as a "runs matrix," must account for the limitations of the model and must also provide for sufficient collection of data to meet given confidence levels. Model execution should not be strictly a number crunching exercise as the dynamics of the battle must reflect both experience and the real world if the results are to be believed. Operational effectiveness analysis is partly an art form but it is one that any serious analyst can learn and use meaningfully in decision-making.

The integration of cost and effectiveness results is the most difficult of the COEA processes. This problem is at once analytical and political. Sophisticated techniques, ranging from simple ratios to complex multi-attribute techniques to the more recent analytic hierarchy process, can be applied to identify alternative preferences . However, the more complicated these techniques are, the less visibility the decision-maker has into them and the less he will rely on them to make his choices. This suggest that the analyst should strive to implement the tools but should also make the data available to the decision-maker so he can make his own assessments.

A discussion of the methodology of a COEA is not complete without a few comments on judgment. There are several kinds of judgment that enter into completing a COEA: one is the judgment that comes from being an experienced analyst, another from being experienced in military operations and a third from being politically wise. The first kind of judgment allows one to know when analysis tools are functioning as intended. It is not an uncommon COEA failing for models to run (i.e execute) but to do so without producing useful output. Analysis judgment is the only thing that reveals this problem. It is also analytical judgment that allows one to suspect that input data is wrong. The inexperienced analyst will usually carry on, not even knowing there is a problem; the experienced analyst will stop and check. Military judgment is equally important in COEAs. Through it comes recognition of the "worth" of a mission; i.e whether the job is worth doing in order to accomplish the military objective. Only one with military experience can judge whether a mission is a reasonable one. Military judgment also enters into knowing when or to what degree a mission has been accomplished. Trite as it may sound, only the experienced combat

analyst can truly judge when a battle is over. Finally there is "political" judgment which comes to bear when the results of COEAs are not clear cut. In the really interesting decision problems, alternatives that are decisively good or bad are the exception. The typical defense "choice problem" is one where there is gain but there is cost. In this case the decision-maker is expected to exercise his intuition, take the risk if appropriate, and move the process forward as efficiently as possible. No analysis is ever going to replace judgments. A truly good analysis, therefore, will provide information to make these judgments sounder. That is the true value of a COEA.

How Is A COEA Evaluated For Quality?

There are certain elements and criteria that can be used to make quality judgments about COEAs. While it is unreasonable to develop a checklist for quality, it is possible to identify characteristics which make a good COEA. The following list serves this purpose. It poses questions to check whether a COEA has omitted or abused some aspect of the analysis requirement or procedure. Note that there are no right or wrong answers. The questions serve only to guide the judgment of whether the COEA has covered all the elements and if so, whether it has done so comprehensively. Note also that the assumption for these guidelines is that a MS0 has been successfully passed since the first time a COEA is required is after this has happened.

The guidelines are given in terms of various components or "elements" of a COEA (Table 1).

COEA ANALYSIS ELEMENTS

IN THE 5000 REGS	NOT IN THE 5000 REGS
Mission Needs Analysis	Issues & Essential
Threat	Elements of Analysis
Operational Environments	Study Plan
Constraints & Assumptions	Related/Sub-analyses
Operational Concepts	Scenarios
Functional Objectives	Methodology
Alternatives	
Models	
Data	
Measures of Effectiveness	
Costs	
Trade-off Analyses	
Analysis of Alternatives	
Conclusions	

Table 1

This partition is a matter of convenience but it serves the purpose of organizing a quality check on the analysis. Also, for reference, the elements are identified as either being explicitly addressed in the acquisition regulation or not. This carries no connotation of their relative importance and is noted only for reference.

Element: Mission Needs Analysis

Guidelines:

1. Is the MS0 justification still valid? In particular,
   a. are the study scenarios still suitable ones for the operational analysis?
   b. are the weapon systems in the combat mini-force still the same ones or is there a difference in the synergistic effects represented by the analysis?
   c. is the time frame of the analysis still the same or has there been a change in schedules for the availability of equipment on either side?
2. Is a new level of analysis (i.e degree of resolution) required? In particular
   a. has there been any change in the basis of issue for the item under investigation?
   b. have new tactics or doctrine been introduced to change the "way to fight" assumptions?

Element: Threat

Guidelines:

1. Is the assumed threat consistent with intelligence assessment? In particular,
   a. has the threat been validated by the Defense Intelligence Agency?
   b. is the validation recent enough, relative to known world changes, to accept it at face value?
2. Is the threat defined in a way that is consistent with realistic operational constraints? In particular,
   a. is the threat reasonable for the time, place and type of operation so that it is neither 10 feet tall or a pushover?
   b. has a reasonable level of intelligence been given to the threat force so that it is neither too dumb nor too all-knowing?

Element: Operational Environment
Guidelines:

1. Have contributions from supporting forces, either from sister services or allies, been accounted for so that the proper integrated perspective is reflected?
2. Has the right timeframe (i.e. season) of the operation been setup?
3. Have realistic assumptions concerning the availability of support or resources (personnel and funding) been made?
4. Are the assumptions about the availability, quantity, distribution and readiness of the equipment item realistic?

Element: Study Constraints and Assumptions
Guidelines:

1. Are the alternatives appropriate for the level of analysis: concepts at MS1, designs at MS2, systems at MS3 and upgrade options at MS4?
2. Is the alternative set broad enough or is it simply a list of narrow variations on the same theme?
3. Have reasonable alternatives been eliminated simply by assumption about environment or performance?
4. Are projections dealing with the availability, reliability, capability, etc of force, equipment, technology and funds realistic?

Element: Operational Concept
Guidelines:

1. Is the employment doctrine (i.e the how to fight assumptions) feasible and valid vis-a-vis training?
2. Does the assumed force structure reflect realistic plans or proposals for the overall composition of the US force?
3. Have alternative employment doctrines been considered to ensure effectiveness does not suffer from poor utilization?
4. Has field or test experience been folded into the analysis so that untried theoretical procedures are not included?

Element: Functional Objectives
Guidelines:

1. Has a task list been specified for each alternative that reflects the operational concept for it?
2. Have tasks been defined in such as way as to permit the quantification of accomplishment or completion?
3. Have key performance parameters for alternative systems been captured by the tasks defined for the operation?
4. Are the measures of system performance measurable and testable?

Element: Alternatives
Guidelines:

1. Has the study basecase been identified?
2. Does the alternative set cover a good spectrum of choices? In particular,
   a. are current systems included? Have they been "undersold"?
   b. are product improvements to current systems included?
   c. are prospective near-term and far-term systems included?
   d. are conceptual or "paper" systems included? Have they been "oversold"?
3. Have alternatives that vary only tactics or doctrine been considered?
4. Have alternatives that represent "a different way to do the job" been included?

Element: Models
Guidelines:

1. Do the models applied in the study quantify the defined measures of effectiveness (MOE), performance (MOP) and costs?
2. Has the result of the combat effectiveness been done on a force-on-force (i.e an integrated combined-arms) basis?
3. If the study model is a man-in-the-loop type, has the human "bias" been eliminated or identified from the results?
4. If the study model is extant, does it apply directly to the problem or has it been properly modified to fit?
5. If the study model is new, has it been certified as representative of the scenario and systems under investigation?
6. Are the model process transparent and explainable at reasonable levels of analytical sophistication?
7. Has the study model been "tested" by
   a. running a known system (often the basecase) and checking for "reasonableness"?
   b. running a case that uses current friendly systems opposed by current enemy systems and comparing with other "net assessments"?

Element: DATA
Guideline:

1. Are the study data current?
2. Are the study data accurate or is there a known level of precision for it?
3. Are the data technically sound, derived by rigorous engineering analyses or are they "anecdotal"?
4. Have the data been verified by (or collected from) relevant developmental or operational tests?
5. Do the data accurately reflect assumptions about tactics and doctrine?

Element: Measures of Effectiveness (MOE)
Guidelines:

1. Are the study MOE quantifiable, directly or indirectly from the model outputs?
2. Do the MOE discriminate among the alternatives?
3. Are the MOE force-level measures?
4. Do the MOE measure battle outcome or mission accomplishment?
5. If the MOE are "aggregated" from other measures using weights or ratios, do they distort the relative comparisons?

Element: Cost
Guidelines:

1. Is the cost estimating technique used valid for the type and level of analysis?
2. Are the quantities and schedules used to make the estimates valid?
3. Are the input data used to make the cost estimates current?
4. Is the input data valid? In particular,
   a. do they conform with the operational concept?
   b. have hey been properly collected?
5. Has a comparative life cycle cost estimate been developed for each alternative so that comparison is on the same basis?
6. Are the cost estimates consistent with other estimates, especially, the baseline cost estimate (BCE) and the independent cost estimate (ICE)?

Element: Trade-off analyses (sensitivity and uncertainty)
Guideline:

1. Has the study considered "analysis excursions" in the following areas: a) threat capabilities, b) friendly capabilities, c) environmental conditions, d) countermeasures, e) availability or level of support (either combat service support or complementary combat systems), f) availability or level of funding?

Element: Analysis of alternatives
Guidelines:

1. Has a comparison been given on an equal-cost or equal-effectiveness basis and, if so, does it reflect alternatives on bases consistent with the operational concept and scenario?
2. Have absolute values of the MOEs been given?
3. If a composite (i.e. weighted) MOE is used, are the weights explained in a meaningful sense?
4. If ratios are used, are they unambiguous in meaning?
5. Have all MOE been shown?
6. If some form of multi-attribute or decision analysis technique is used, have the inputs to it been given to the decision-maker also?
7. Have the alternatives been ranked and a preference indicated?
8. Have the alternatives been grouped by cost? by effectiveness?
9. Have the alternatives been further examined for conditions that would weaken or overturn its preference order?

Element: Conclusions
Guidelines:

1. Are the study conclusions exclusively supported by study results or are study results being complemented by outside information or knowledge?
2. Are the study conclusions responsive to the study issues?

Element: Issues or Essential Elements Of Analysis (EEA)
Guidelines:

1. Is the study responding to the current decision issue or has time rendered it irrelevant or peripheral?
2. Does the study respond to relevant "Acquisition Decision Memorandum" of the regulations?
3. Do the essential elements of analysis of the study properly reflect the decision issues?
4. Are the EEA comprehensive vis-a-vis the issues?

Element: Study Plan
Guidelines:

1. Has the plan been coordinated at all levels of review up to and including OSD?
2. Has the plan been properly resourced in terms of time, people, and money?

Element: Scenarios
Guidelines:
1. Does the study include more than one scenario?
2. If several scenarios are used, are they a good spectrum? In particular, do they include
   a. a stressful one?
   b. a light one
   c. a likely one?
   d. a worst/best case?
3. Is the scenario "contrived" to show an alternative as favorable?
4. Can the scenario be traced back to the Defense Planning Guidance?
5. If the scenario is not traceable to the DPG, has it been validated by the appropriate "warfighters"?

Element: Methodology
Guidelines:
1. Does the COEA methodology answer all the Study EEA?
2. Does the methodology include enough flexibility to allow mid-course corrections? Does it identify decision "points of no return"?
3. Does the methodology allow for periodic progress reports and especially a final report?

Element: Related/Sub-analyses
Guidelines:
1. Have all studies supporting the same acquisition action as the COEA been synchronized with respect to timeframe, operational concept, scenario, technology, performance data, etc.
2. Has the linkage to operational tests, development of requirement documents and program baseline been made explicit?

Summary

COEAs in support of the acquisition process are an established way of doing business in DoD. Decision-makers expect sound analyses at each milestone to assist them in making the tough choices. COEAs clearly fulfill this requirement now. In the future, perhaps modified to respond to the changing security environment and issues, they will continue to play a significant role in DoD analysis efforts.

REFERENCES

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2. Annual Report of the Secretary of Defense (Washington, DC: DoD 1992)
3. Charles J. Hitch, Decision-Making for Defense (Berkeley: University of California Press, 1965)
4. Department of Defense Directive 5000.1 and 5000.2 (Washington, DC: DoD 1991)

MORS COEA
MINI-SYMPOSIUM
MARCH 9-11, 1992

FUTURE DIRECTIONS
SENIOR SERVICE PANEL

MODERATOR
Dr. BILL LESE
OADS(PA&E)

FUTURE DIRECTIONS
OSD

- COEAs ARE INCREASINGLY KEY TO DECISIONS
- MORE THOUGHTFUL LINKAGE ACROSS PROCESS
- RELATED TO MISSION AREA ANALYSIS
- CLEARER RATIONAL FOR JOINT AND INTERNATIONAL PROGRAMS
- USED IN EMERGING AFFORDABILITY ASSESSMENTS
- CLOSER LIAISON ACROSS DoD

FUTURE DIRECTIONS
ARMY

FOUR CHALLENGES:

- DETERMINING ARMY MISSION NEEDS IN A JOINT OPERATIONAL CONTEXT THAT ADEQUATELY REPRESENTS THE CAPABILITIES OF OTHER SERVICES.
- DEVELOPING A CLEARER DEFINITION OF REGIONAL THREATS AND MILITARY CAPABILITIES REQUIRED TO MEET THE GOALS ESTABLISHED BY THE NATIONAL MILITARY STRATEGY.
- DEVELOPING A CLEARER DEFINTION OF DECISIVE FORCE AS A BASIS FOR ESTABLISHING REQUIRED CAPABILITIES.
- DEVELOPING A CLEARER PICTURE OF OUR ACQUISITION STRATEGY, ESPECIALLY THE POTENTIAL FOR MOVING FEWER SYSTEMS FROM THE R&D STAGE TO FULL SCALE, HIGH RATE PRODUCTION.

PRESENTED BY MR. HOLLIS

FUTURE SITUATION
AIR FORCE

EXPECT DECREASING RESOURCES

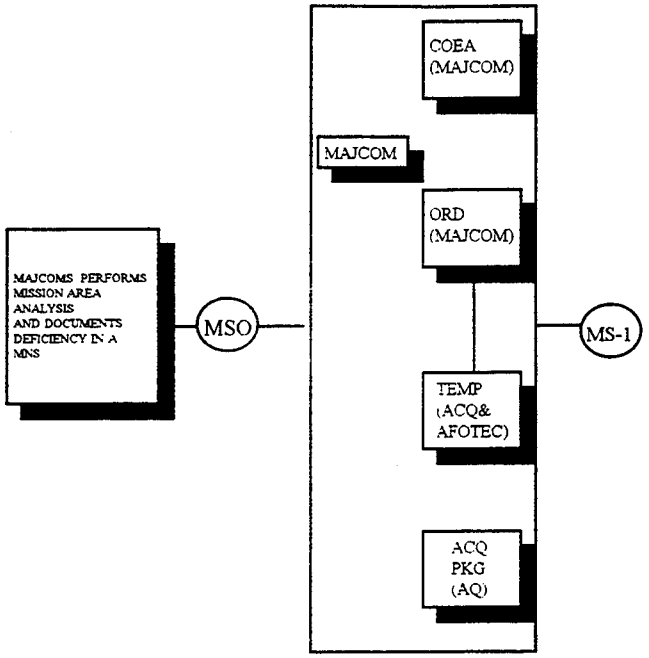
EXPECT INCREASED SCRUTINY AND OVERSIGHT

FOR FUTURE STARTS (MILESTONE 1) AND OTHER ACQUISITION MILESTONES, WE WILL NEED:

- STRONGER AND MORE COHERENT RATIONAL
- BETTER SUPPORTING ANALYSIS

PRESENTED BY MAJ GEN J.W. RALSTON

OVERALL PROCESS



MISSION AREA ASSESSMENT
MISSION NEED ANALYSIS

(MAA/MNA)

- THE MAA/MAN IS A CONTINUING ACTIVITY INITIATED AND CONTROLLED BY THE MAJCOM

- MAA/MNA IDENTIFIES DEFICIENCIES REINFORCES THE NEED FOR INCREASED EMPHASIS ON AN OPERATIONAL OBJECTIVE

ENHANCED THROUGH USE OF CAMPAIGN AND ENGAGEMENT LEVEL MODELS AND ANALYSES

MISSION NEED STATEMENT

- THE MAJCOM WRITES AND ISSUES A MISSION NEED STATEMENT
- THE MISSION NEED STATEMENT STATES THAT A PARTICULAR OPERATIONAL OBJECTIVE NEEDS INCREASED EMPHASIS AND WHY
- THE MNS IS VALIDATED BY THE JOINT REQUIREMENTS OVERSIGHT COUNCIL (JROC)

MILESTONE 0
(AN EVENT)

DIRECTION TO COMMENCE CONCEPT EXPLORATION

USING MAJCOM RESPONSIBLE FOR THE PROCESS

- THE MAJCOM - SUPPORTED BY DEVELOPERS - FORMULATES, DEFINES AND EVALUATES VARIOUS OPERATIONAL CONCEPTS TO ENHANCE OUR ABILITY TO ACHIEVE THE STATED OPERATIONAL OBJECTIVE
- THE PROCESS IS SUPPORTED BY A "CONCEPT EXPLORATION ANALYSIS" (CEA)

ENHANCED THROUGH USE OF CAMPAIGN, ENGAGEMENT AND ENGINEERING LEVEL MODELS AND ANALYSIS

COST AND OPERATIONAL EFFECTIVENESS ANALYSIS (COEA)

THE MAJCOM BASED ON THE ANALYSIS IS RESPONSIBLE FOR A COEA WHICH DESCRIBES

- THE RELEVANCE OF ACHIEVING OPERATIONAL OBJECTIVES (AND ACCOMPLISHING ATTENDANT TASKS)
- THE OPERATIONAL CONCEPTS SELECTED AND WHY
- THE COST EFFECTIVENESS OF EACH SYSTEM CONSIDERED TO IMPLEMENT THE RELEVANT OPERATIONAL CONCEPT
- THE SELECTED SYSTEM AND WHY IT WAS CHOSEN

ENHANCED THROUGH USE OF CAMPAIGN, ENGAGEMENT AND ENGINEERING LEVEL MODELS AND ANALYSIS

FUTURE DIRECTION
NAVY

- COEA IS A PROCESS RATHER THAN A PRODUCT
- STRUCTURE TO ACCOMPLISH THE PROCESS
  - COEA EXECUTIVE COMMITTEE
    - PRINCIPAL DASN(RD&A)
    - DIR, PROGRAM RESOURCES APPRAISAL DIV
- STUDY DIRECTOR AND STUDY TEAM
- COEA OVERSIGHT BOARD
  - ASN(RD&A)
  - OP-08 OR OP-07
  - OPNAV
  - ADDITIONAL ORGANIZATIONS AS APPROPRIATE
- JOINTNESS REVIEW THROUGH COEA OVERSIGHT BOARD

PRESENTED BY RADM R. ALLEN

OEA EXECUTIVE COMMITTEE

NAME	TITLE/ORGANIZATION
MRS MCBURNETT	PRINCIPAL DEPUTY ASST SECNAV (RD&A)
RADM DANTONE	DIR, PROGRAM RESOURCES APPRAISAL DIV
RADM OLIVER	DIR, GEN PLANNING & PROGRAMMING DIV
RADM ALLEN	ASST DEP, CH OF NAV OPS (NAVAL WARFARE)
RADM HOULEY	DEP DIR, NAVY TEST & EVAL & TECHNOLOGY
MGEN GARDNER	DEP CH OF STAFF (RQMTS & PROG), USMC
RADM WISELY	DIR, WARFARE SYS ARCHITECTURE, SPAWARSYSCOM
MR R. PERKINS	DIR, SYS ALTERNATIVES DIV, NAVAIRSYSCOM
MR D. MATTEO	EXEC DIR, SUBMARINE DIV, NAVSEASYSCOM

COEA PROPOSAL TO INITIATE ACTION

FOR ACAT I PROGRAMS, PREPAREED BY ASN (RD&A DASN) IN COORDINATION WITH PROGRAM SPONSOR, PROGRAMMANAGER AND THE APPROPRIATE SYSCOM/PEO

FOR ACAT II & III PROGRAMS, PREPARED BY PROGRAM SPONSOR IN COORDINATION WITH PROGRAM MANAGER AND/OR APPROPRIATE SYSCOM/PEO

CONTAINS RECOMMENDATIONS FOR
- CO-CHAIRS OF COEA OVERSIGHT BOARD
- ORGANIZATIONS REPRESENTED ON THE OVERSIGHT BOARD
- STUDY DIRECTOR
- ORGANIZATIONS TO PROVIDE STUDY TEAM MEMBERS
- SCHEDULE

APPROVED BY OP-08 AND ASN (RD&A)

STUDY DIRECTOR AND STUDY TEAM

STUDY DIRECTOR:
- PLANS AND SUPERVISES COEA STUDY
- COORDINATES FUNDING THROUGH PROGRAM MANAGER
- ESTABLISHED STUDY TEAM MEMBERSHIP
- MUST HAVE
  - STRONG ANALYSIS BACKROUND
  - TECHNICAL AND OPERATIONAL CREDIBILITY
  - INDEPENDENCE FROM PROGRAM MANAGER

STUDY TEAM MEMBERS DRAWN FROM:
- APPROPRIATE DASN
- OPNAV SPONSOR
- SUPPORTING SYSCOM
- PEO/DRPM
- PROGRAM OFFICE
- OP-08, OP-07, OP-091, OP,092
- FIELD ACTIVITIES AS RQD

DIRECTOR & TEAM MEMBERS MUST BE CHOSEN TO AVOID CONFLICT OF INTEREST IN FOLLOW-ON EFFORTS RESULTING FROM ANALYSIS

COEA OVERSIGHT BOARD

PROGRAM SPECIFIC

NOT A DECISION FORUM
- RAISES AND FRAMES ISSUES FOR ASN (RD&A) AND OP-08 DECISION WHEN CONSENSUS NOT READILY OBTAINED

SENIOR AND EXPERIENCED INDIVIDUALS

BOARD REVIEWS:
- COEA STUDY PLAN
- STUDY FOR COMPLIANCE WITH OSD GUIDANCE
- ASSUMPTIONS ARE VALID AND COMPLETE
- ALTERNATIVES TO BE CONSIDERED
- PROPOSED MOEs
- SCENARIOS
- THREAT CHARACTERISTICS

CONCLUSIONS ARE REASONABLE
FINAL BRIEFING ACCURATELY REFLECTS RESULTS
MOEs RELATE TO TEST & EVALUATION MASTER PLAN

COEA OVERSIGHT BOARD MEMBERSHIP FOR ACAT I & II

CO-CHAIRED
- ASN (RD&A) - PDASN OR DASN
- OP-08 (PROGRAM PLANNING) OR OP-07 (NAVAL WARFARE)

MEMBER FROM OPNAV
- OP-07 OR OP-08 (WHOEVER IS NOT A CO-CHAIR)
- OP-091 (TEST & EVALUATION)
- OP-092 (NAVAL INTELLIGENCE)
- SPONSOR

MEMBERS FROM ASN (RD&A)
- PEO
- PM
- DIRECT REPORTING PM (IF APPLICABLE)
- SUPPORTING SYSTEM COMMAND
- ASN (RD&A) SCIENTIFIC ADVISOR (EX-OFFICIO)

OTHER ORGANIZATIONS AS APPROPRIATE (NCS, USMC, ETC)

FUTURE DIRECTIONS
USMC

MOSTLY SMALL PROGRAMS
- ACAT III & IV
- AAA IS ONLY ACAT I

USMC FOLLOWING DON POLICY
- OVERSIGHT BOARDS
- STUDY DIRECTORS
- EMPHASIS ON USER-ACQUISITION TEAMWORK

PROCESS IS TAILORED TO PROGRAM SIZE

HEADED BY HQ USMC R&P AND DEPUTY EFP
- IN-HOUSE SUPPORT FROM MCCDC, MARCORPSYSCOM AND OTHER HQ ELEMENTS
- FFRDC AND OTHER OUTSIDE SUPPORT

PRESENTED BY MR. BELEN

CHAPTER 4
WORKING GROUP REPORTS

4.1 Working Group Charter

Working Group 1: Test & Evaluation

Objective: Define and report on the role of operations research in the COEA process; issues, problems, and research areas, and the future directions for military operations research analysis to support COEAs as it relates to this working group.

Suggested Issues:

- What analytic techniques can be developed to:
  - Help COEA MOEs, scenarios, and TEMPS be consistent?
  - Relate "real world" data to COEA model validation?
  - Relate developmental test data to COEAs?
  - Relate operational test data to COEAs?
  - Relate live fire test data to COEAs?
- What simulation techniques can be used to support tests and COEAs?

Working Group 2: Threat Assessments and Scenarios

Objective: Define and report on the role of operations research in the COEA process; issues, problems, and research areas, and the future directions for military operations research analysis to support COEAs as it relates to this working group.

Suggested Issues:

- What is the relationship of threat assessments and scenarios, the COEA process, and operations research?
- What problem areas are evident in the above relationship?
- How can a COEA be executed as the "threat" evolves during the timeframe of the COEA?
- What is the best way to analytically represent a regional/contingency threat scenario?
- What spectrum of scenarios brings out the versatility of a system for comparison?(High, Mid, Low)(Day, Night) (High, Hot) (Low, Cold)
- How can scenario development be integrated into the COEA process?
- How do you set up study scenarios to address the spectrum of conflict in models and simulation?
- How do scenarios cover the scope to accommodate all phases of operations from pre-deployment on?
- How do you avoid stacking the deck through scenario selection?
- What is the appropriate level of scenario detail at each milestone?

Working Group 3: Effectiveness Methodologies

Objective: Define and report on the role of operations research in the COEA process; issues, problems, and research areas, and the future directions for military operations research analysis to support COEAs as it relates to this working group.

Suggested Issues:

- Models/Data
  - What are the spectrum of ways to simulate warfare/battles?
  - What are the characteristics of combat/cost models/simulations to conduct the COEA?
  - How is models/data credibility achievable?
  - What are the unique modeling requirements to address campaign analyses?
  - What is the value of a DoD clearing house for models/data?

- How can Operational Utility Evaluations relate to COEAs?

- How do we integrate cost parameters and effectiveness measures?

- How can effectiveness methodologies evolve to accommodate the increased emphasis in deployment, sustainment, and campaigns?

- How do we model the evolving high technology battlefield?

- How can sensitivity analyses be incorporated into the COEA?

    - What tools are available to accomplish the sensitivity analysis?

- Measures of Effectiveness

    - How do we show or measure the impact of non-attrition systems: Command & Control, Reconnaissance, Intelligence Collection, etc.

- Value added Methodologies?

    - Statistical comparisons

    - Design of experiments

    - Others?

Working Group 4: Costing Methodologies

Objective: Define and report on the role of operations research in the COEA process; issues, problems, and research areas, and the future directions for military operations research analysis to support COEAs as it relates to this working group.

Suggested Issues:

- How can it be ensured the costs for the preferred option on the COEA match the costs briefed to the Cost Analysis Improvement Group?

- Affordability -- What is the linkage between affordability considerations in COEAs and in POMs?

- Affordability -- How should affordability be addressed at Milestone reviews?

- What techniques are available to perform affordability analysis?

- How do we integrate cost parameters and effectiveness measures?

- What is the best way to provide cost analysis support to the decision maker?

- What role should life cycle costing, decision costing, and present value analysis play in COEAs?

- How do we ensure consistency between the COEA, Independent Cost Estimate (ICE), Independent Cost Analyses (ICA), and Baseline Cost Estimate(BCE)?

- How can sensitivity analyses be incorporated into the COEA?

    - What tools are available to accomplish the sensitivity analysis?

- Are current costing methodologies adequate to compare the alternatives in a COEA?

- What costing methodologies should be developed to advance the state of the art in COEA?

Working Group 5: COEA Management

Objective: Define and report on the role of operations research in the COEA process; issues, problems, and research areas, and the future directions for military operations research analysis to support COEAs as it relates to this working group.

Suggested Issues:

- What are the roles of the service, Program Manager, contractor, and Federally Funded Research and Development Centers (FFRDCs) in COEAs?

- How do you structure a Study Advisory Group (SAG) to support the COEA process?

- What should be the role of SAGs in COEA development?

- Should SAGs be monolithic (one SAG with all players) or tiered (several SAGs at Service, OSD, etc.)?

- How do we coordinate the efforts of the contributors including threat, data, modelling, cost, tests, and others?

- How do you make the COEA responsive to the changing evolution through the acquisition milestone phases?

- How can the Senior Service Colleges/Universities (NWC, AWC, NDU, etc.) contribute to the acquisition process by enhancing military analysis education?

- Contractor support
    - What is the role of FFRDCs in COEAs?
    - Should contractors do COEAs?
    - Should vendors/bidders do COEAs?

- Management Techniques?
    - PERT
    - POAMS
    - TQM

- Who should sponsor/fund COEAs?

- Which organizational structure best facilitates the COEA process?

Working Group 6: Future Directions

Objective: Define and report on the role of operations research in the COEA process; issues, problems, and research areas, and the future directions for military operations research analysis to support COEAs as it relates to this working group.

Suggested Issues:

- What are the requirements for operations research techniques to support future COEAs:
    - Models (Effectiveness/Cost)
    - Man-in-the-loop simulation
    - Data
    - Cost Effectiveness Integration

- Milestone Decision Criteria
    - What analytical techniques are appropriate for each Milestone analysis?
    - How does the COEA support the definition of exit criteria?

- Contractor support
    - What is the role of FFRDCs in COEAs?
    - Should contractors do COEAs?
    - Should vendors/bidders do COEAs?

- What additional analysis bear on:
    - Pre-Milestone 0 analysis
    - Campaign analysis
    - Tests

- Linkage to other program documents: MNS, COEA, ORD, TEMP, etc.

- Incorporating sensitivity analyses into the COEA:
    - What tools are available to accomplish the sensitivity analysis?

- How do you make the COEA responsive to the changing evolution through the acquisition milestone phases?

4.2 Report of the Test and Evaluation Working Group

Issue: How can the OR community help to establish consistency among the COEA MOE/MOPs, ORDs and the TEMP and relate (Real World, DT and OT) data to the COEAs?

Discussion: A principal issue in the acquisition process which involves the T&E community is how can consistency among the COEA MOE/MOPs, ORDs and the TEMPs be ensured. An equally important question is how can pertinent ("real world," DT and OT) data be related to the COEAs. To date, there are too many inconsistencies and lack of collaboration in preparating acquisition documents. In addition, problems frequently arise in trying to incorporate test results and cost and threat changes into updating COEAs.

No major methodology development is envisioned in order to establish and solidify this process. Rather, what is required to ensure an effective and consistent process is a realignment of currently available resources and possibly a reorganization of personnel.

In regards to policy implications, what is required is a collaborative approach which will establish a standardized process allowing for interaction among all players. While this process should be specifically laid out, it must be flexible and certainly adaptable to a changing environment. To ensure that this process does, in fact occur for systems, it should be incorporated into the DoD 5000 series andimplemented via individual Service guidance.

An investigation should be made of the feasibility of creating linkages within the COEA, TEMP and ORD documents which ensures crosswalks exist between these documents. Event-driven updates of the COEA throughout the acquisition process should be implemented. Although the DoD 5000 series currently incorporates COEA updates, if required, at each milestone review, a significant change, e.g. "threat," could demand an update of the COEA between milestones. A formal procedure should be established to provide the necessary feedback of changes to threat, cost, etc, and test results to all participants.

An immediate step should be taken to structure the process within each of the Services to ensure that consistency exists among the COEA MOE/MOPs, TEMP, and ORD documents. It is clear that in the future much pressure will exist to achieve consistency among the four Services.

The actions needed to attain consistency are 1) encouraging a feedback process, 2) setting up a Test and Analysis Integration Group to foster and oversee this process and 3) obtaining the sanction and support of OSD and Service Principals.

Issue: How can Modeling and Simulation techniques be used to support tests and COEAs?

Discussion: As defense budgets decline, and more confidence is required to make early Milestone decisions, one approach that may allow us to increase confidence to an acceptable level is by an increased use of certified modeling and simulation (M&S).

Many M&S tools and techniques have been used by the defense community during the past decades, including linear programming, queueing theory, Markov chains and a variety of Monte Carlo simulations. In recent years newer techniques have been developed that have potential to increase the range and fidelity of modeling and simulation efforts. Some of these include distributed interactive simulations (eg., SIMNET) and a number of man and/or machine in the loop techniques, (e.g., TACCSF).

Using these and other tools, we can augment data obtained from testing by using M&S to interpolate between testing data points and extrapolate into areas that cannot be tested (as when only subcomponent tests are available during early DT.) As examples, M&S can gather data on operational concepts, reliability, availability, maintainability, and sustainability. M&S can also shed light on logistics and training requirements and strategies, as well as generate information on notional systems that do not yet exist. Finally, M&S can examine the integration of subsystem components during DT, thereby fulfilling the COEA requirement to assess system effectiveness during DT with the same effectiveness criteria as in the COEA.

These advancements in modeling and simulation now enable us to organize models into a hierarchy where lower resolution models feed higher resolution models in nearly a transparent manner. However, in order to make full use of this advancement we must also support and adopt the Defense modeling

standardization efforts in the area of protocols and data elements.

The impact of modeling and simulation on COEA and T&E is to provide a wider exploration of the "state space." In addition to enabling us to test concept systems that don't exist, M&S also allows us to explore conditions and scenarios that are either impossible, unsafe, too costly, or too numerous to test. This does, however emphasize the importance of model verification, validation and accreditation, ie. certification.

We feel that the increased use of M&S techniques makes the new acquisition strategy possible. As the new acquisition policy is being formulated, it seems clear that early-on, there will be a more and stronger reliance on the use of M&S. This should not be construed as reduced testing or necessarily a substitution of modeling for testing, but rather a complementary program of testing and M&S that will ultimately reduce risk in the acquisition process.

In the area of M&S research, we recognized the need for development in these areas:

- C3I (including information management)
- Dismounted infantry (some work has been done in this area)
- Artillery suppression
- Countermeasures (battlefield smokes & obscurants and battlefield electronics)
- Inclusion of smart weapons into battlefield scenarios
- Logistics models need to provide the capability for design/cost tradeoff
- Continued development of new S&/S techniques.

Actions: We need to continue to develop distributed interactive simulations and other research tools. We need to establish a standardized and accessible database and protocols. We need to continue to be flexible and proactivS.

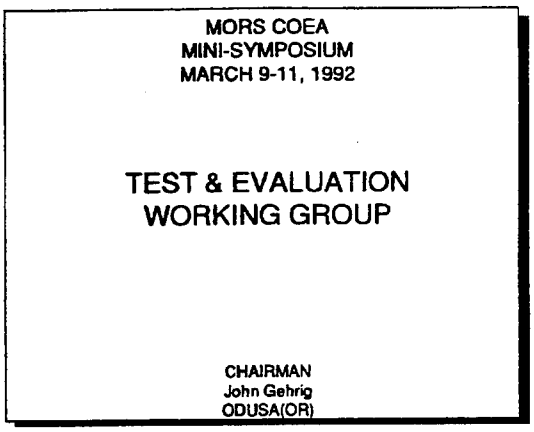


Figure 1: Test & Evaluation Working Group

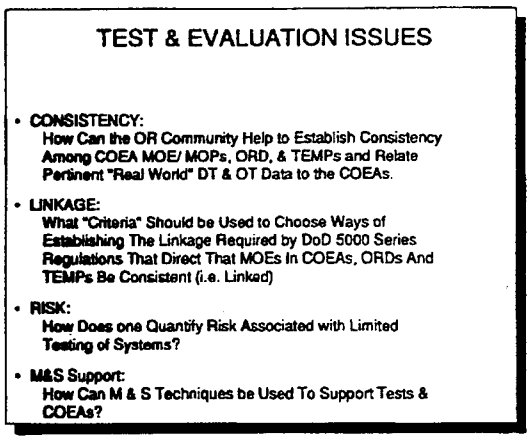


Figure 2: Test & Evaluation Issues

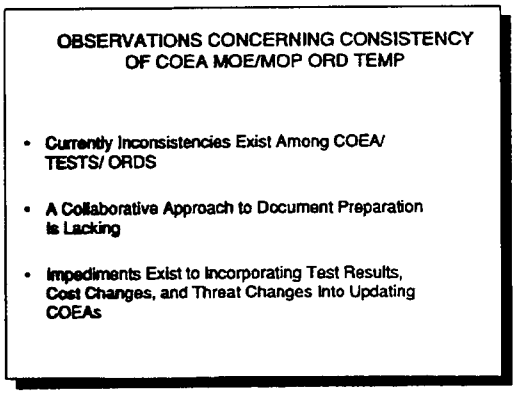


Figure 3: Observations

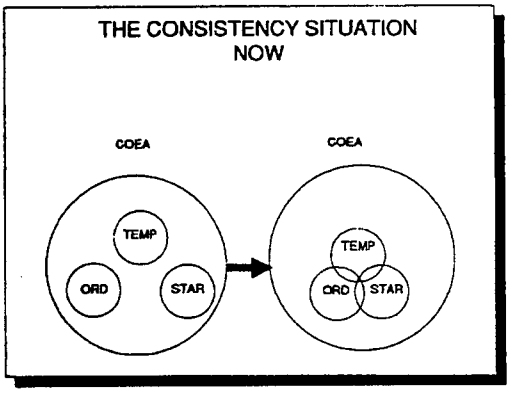


Figure 4: Consistency Situation

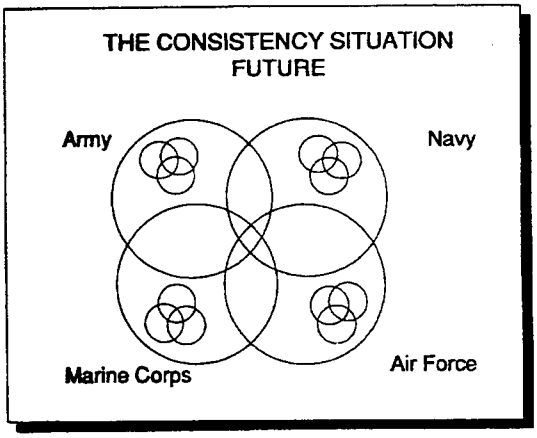


Figure 5: Consistency Situation Future

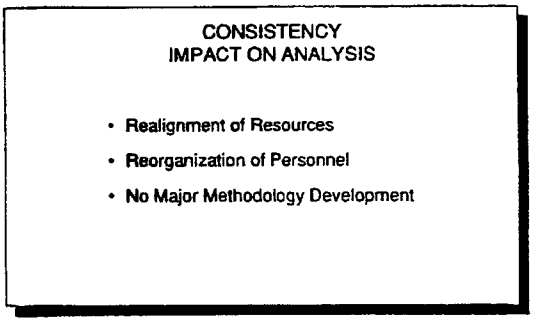


Figure 6: Consistency Impact

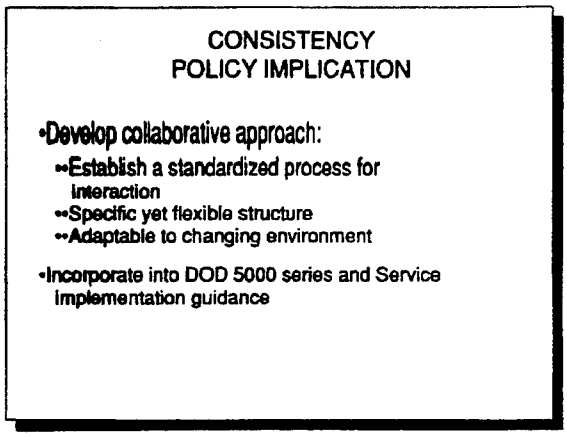


Figure 7: Policy Implication

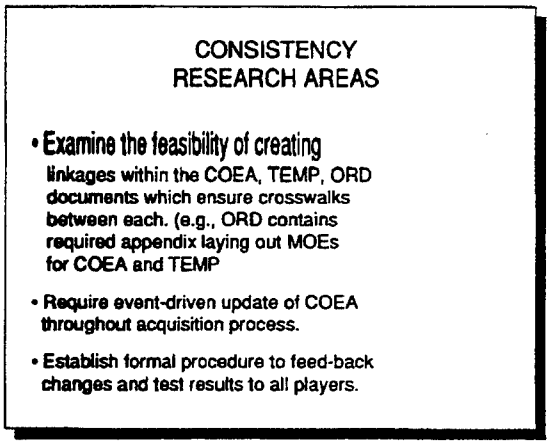


Figure 8: Research Areas

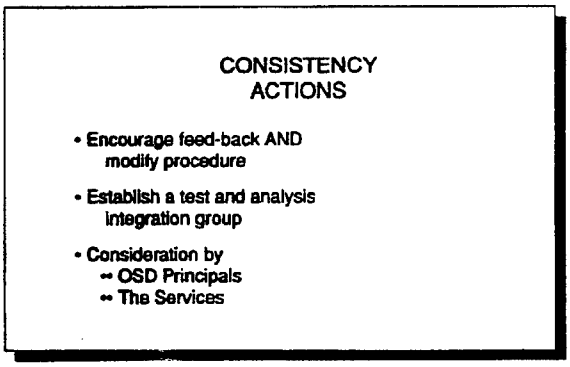


Figure 9: Consistency Actions

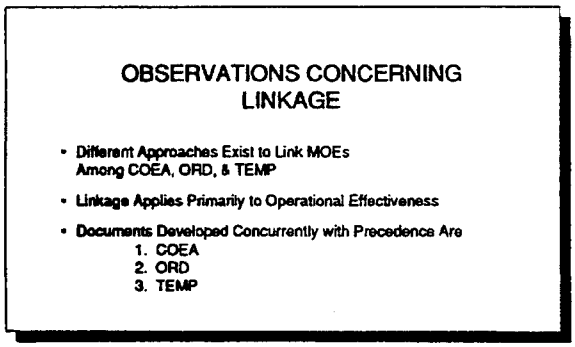


Figure 10: Observations

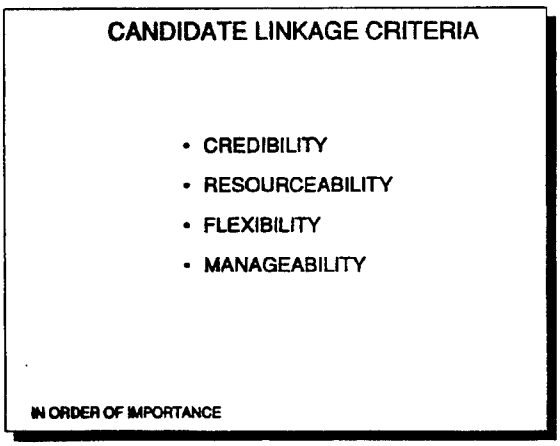


Figure 11: Candidate Linkage Criteria

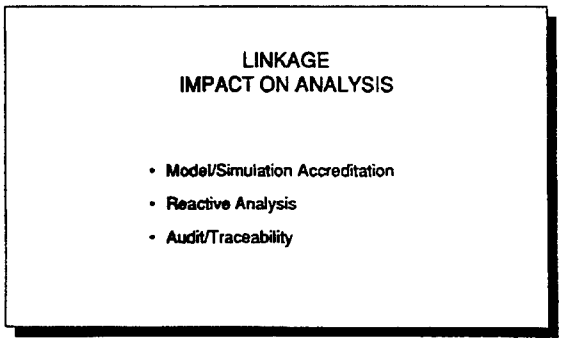


Figure 12: Linkage Impact on Analysis

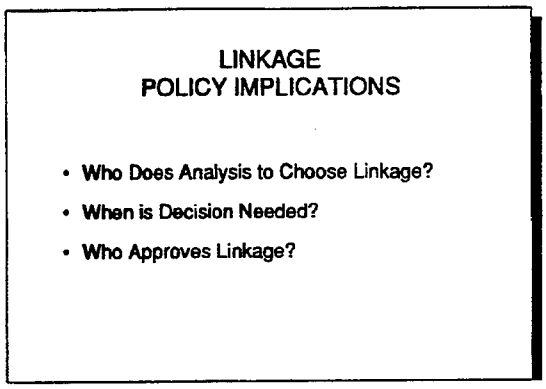


Figure 13: Linkage Policy Implications

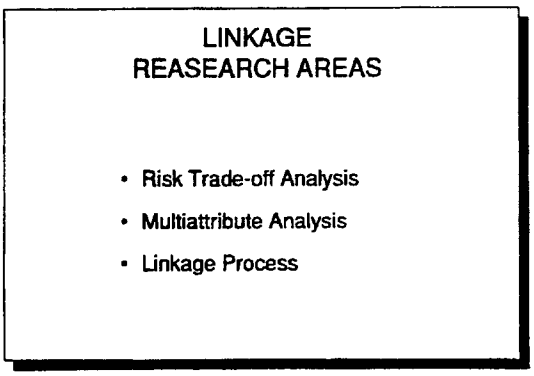


Figure 14: Linkage Research Areas

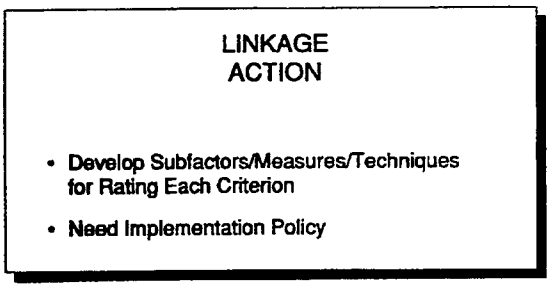


Figure 15: Linkage Action

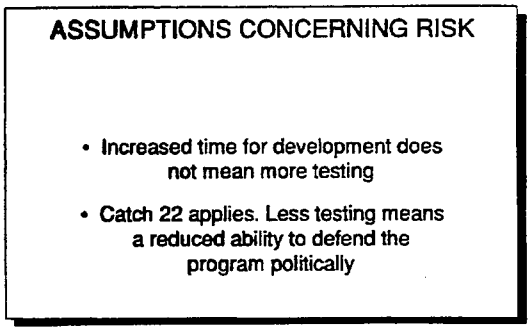


Figure 16: Assumptions Concerning Risk

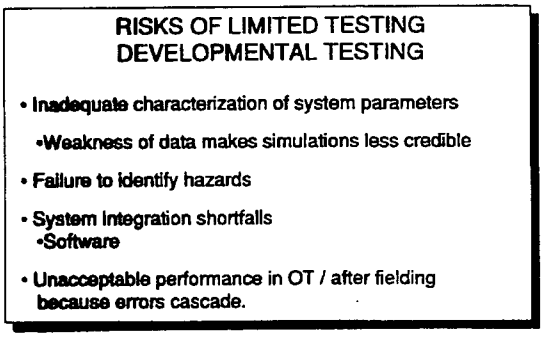


Figure 17: Risks of Limited Testing Developmental Testing

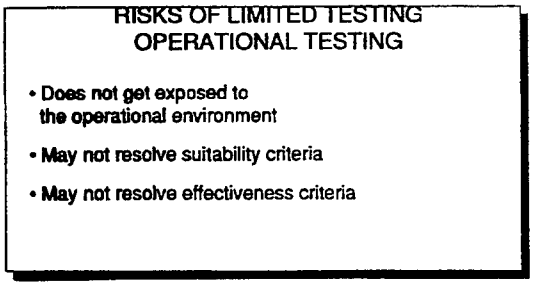


Figure 18: Risks of Limited Testing Operational Testing

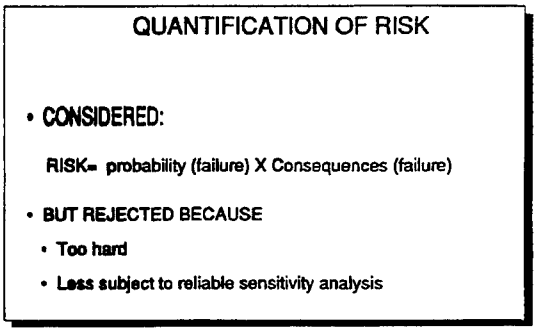


Figure 19: Quantification of Risk

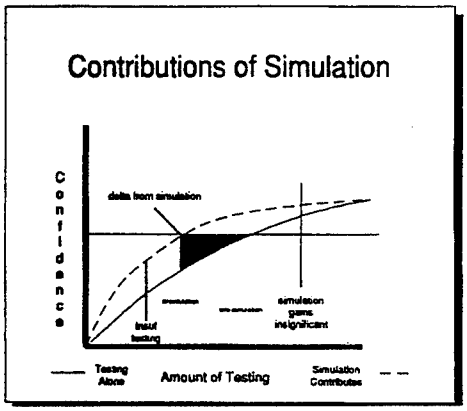


Figure 20: Contributions of Simulation

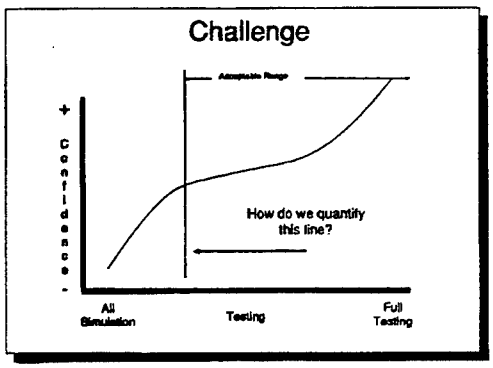


Figure 21: Challenge

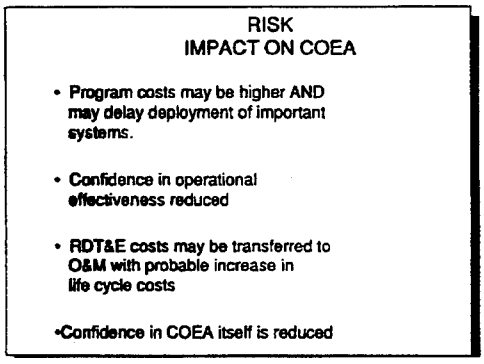


Figure 22: Risk Impact on COEA

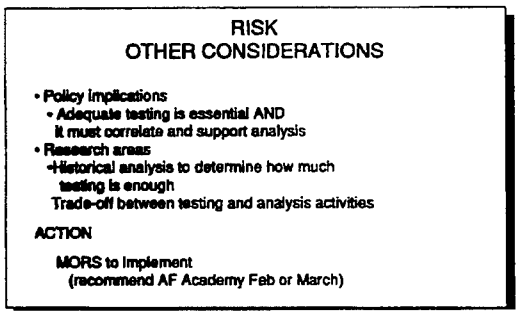


Figure 23: Other Considerations

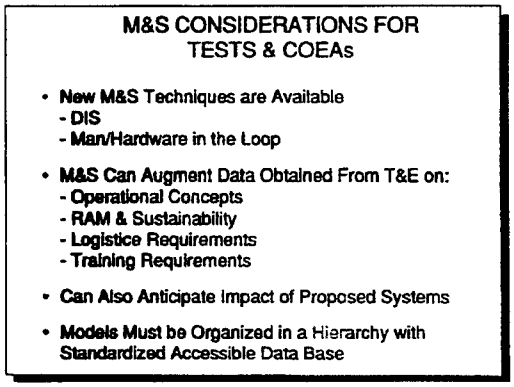


Figure 24: M&S Considerations

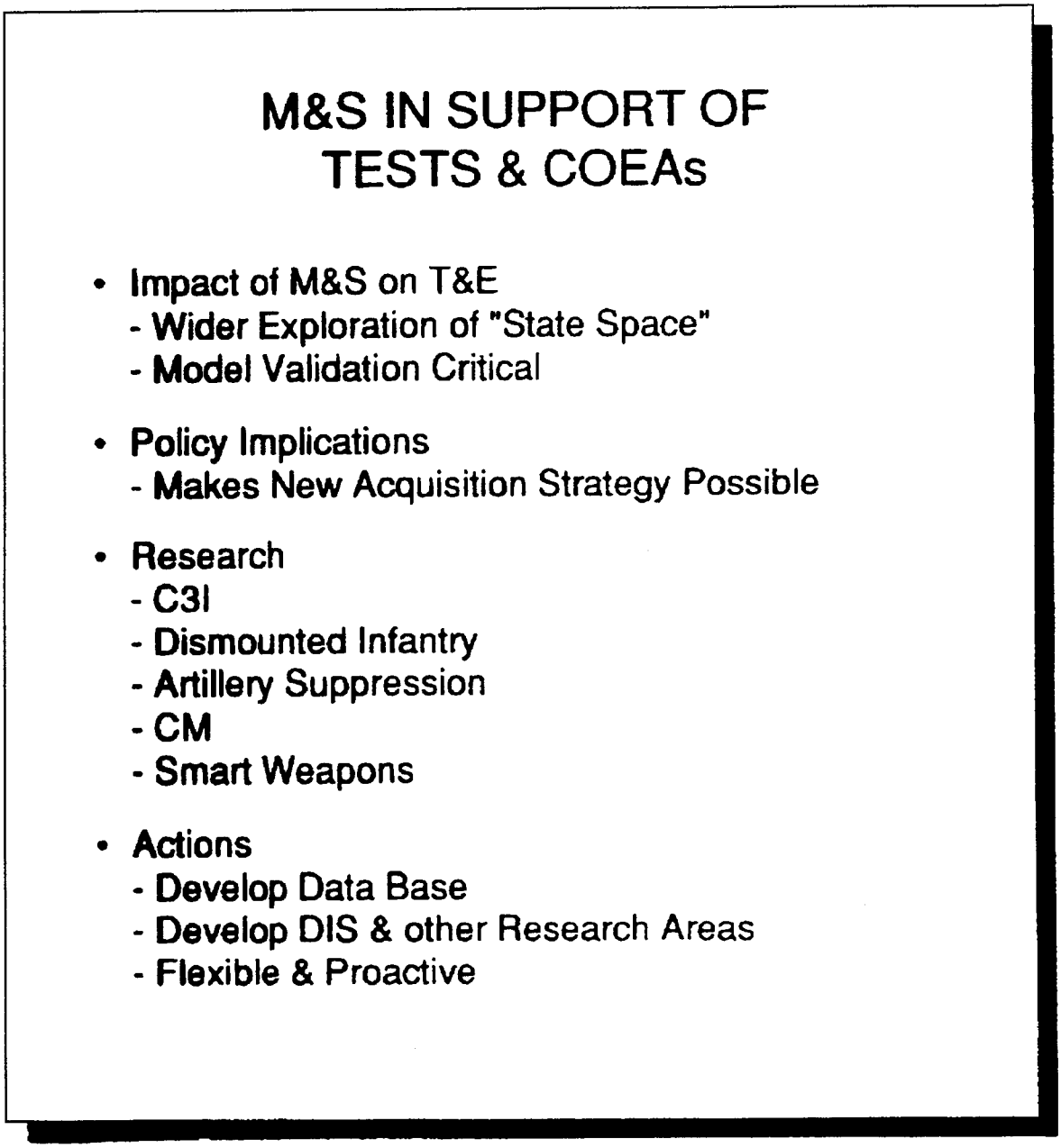


Figure 25: M&S in Support of Tests & COEAs

4.3 Report of the Threat Assessments and Scenarios Working Group

Overview

The backdrop or background to the Defense Acquisition Board process is the threat environment in which a proposed weapon system will operate. During the development cycle, the threat will change, predictions of future threats will change and what we think we know about the threat will change. Threat assessments, scenarios, the COEA process and the operations research community must react and respond to these changes to present the effectiveness and capabilities and vulnerabilities of the weapon system as accurately as possible. There are measures one can take to minimize and respond to changes during the acquisition process.

Issues

Working Group 2: *Threat Assessments and Scenarios* discussed and chose to address three issues or areas of concern: the dynamic threat, level of detail, and analysis of operational effectiveness with scenarios. We have highlighted impacts on analysis and impacts on research. This area is a broad, diverse area and we provide some general guidelines and suggestions for your consideration.

Dynamic Threat

In today's environment, we may expect the threat to continue to change. These changes may not be as dramatic as the changes that have occurred over the past two years. However, the threat is dynamic, and change is inevitable. Threat changes may occur at any time, either during the drafting of a COEA or after the completion of a milestone COEA. If the changes to the threat are significant, the validity of a COEA may be called into question.

To account for rapid threat changes during the COEA development, COEA analysts are faced with a number of possible decisions. First, the COEA analyst may react to changes by making rapid modifications to the COEA while continuing to meet the schedule. This "scramble and panic" mode is all too often representative of many of today's COEA processes. Second, if the changes in a threat are considered to be sufficiently small, localized, or insignificant to warrant a major COEA update. In addition, "freeze the threat" is an option to consider. While such a freeze may make the COEA dated, if the COEA analyst were to document his/her rationale then the COEA may still serve as a useful historical document. Third, if critical threat information is unavailable or is subject to frequent change, then COEA analysts must conduct sensitivity analyses and parametric studies to determine the impacts of threat changes on COEA results. In all cases, sensitivity analysis and parametric studies add to flexibilitiy in a COEA.

COEAs need to plan for change. Due to threat and other changes, COEA planning should be flexible to incorporate changes. New tools, methodologies, and techniques need to have flexibility designed into them up-front. To ensure flexibility and responsiveness, periodic in-progress reviews should be conducted throughout the COEA process.

Threats may also change after a milestone decision has been made. In this case, the change must be reconsidered under the above criteria (impact size, localization, and significance) to see if an update is warranted. If warranted, an updated COEA should be produced expeditiously and results should be provided to principle decision makers as soon as possible. The original COEA should be treated as a baseline for future comparisons. If an updated COEA is warranted, then that COEA should incorporate the complete set of changes that have been identified to date -- including, threat, requirements, scenarios, etc.

Level of Detail

Due to the nature of the COEA process, the level of detail which needs to be considered increases for successive milestones. The emphasis for Phase 0 is to be flexible enough to encompass the attributes of multiple concepts which may negate the operational deficiencies identified in the mission needs statement. For phase 1, the COEA must be more detailed so as to identify performance differences between specific solutions identified as being capable of meeting the mission needs statement operational shortfalls. Updates of the COEA may be needed during phase 1 or later phases to account for changes in understanding of the threat, advances in US technology base, and/or later cost data.

The specificity of the mission needs shortfalls require a matching level of threat input parameters.

Therefore, a mission needs statement which addresses a very specific need may require a more detailed threat definition early.

Current US military and political viewpoints suggest that the COEA utilize an integrated analysis to take into account the effect of proposed systems on the outcome of the joint campaigns. The effectiveness of the proposed systems should be analyzed by examining all aspects of joint operations.

Analyze Operational Effectiveness With Scenarios

Initially, basic assumptions contained in the COEA must be clearly defined. These would include assumptions about the threat and operational concepts. This will form a baseline for understanding future milestone objectives and changes. The scenarios must be analytically broad enough to address requirements of the Mission Need Statements and to explore the range of conflicts or environments. Include aspects of joint operations in which a weapon system may be employed. The range and scope of these scenarios need to be tailored and will probably be unique to each COEA. Scenarios should be sufficiently robust to capture the differences in effectiveness and the cost implications of each alternative. The scenarios should also allow exploration of technology, employment, and tactics of opposing systems, either as excursions or in sensitivity analyses.

Impact on Analysis

Scenarios must be able to withstand the "what if" challenge. They must challenge the alternatives being considered.

The analyst should be careful to avoid focusing on what he understands versus what is critical. This kind of bias can ignore critical aspects.

Robustness is necessary in threat analysis, in the derived scenario, and in the model. A valid test of robustness is achieved when variations in threat and model parameters result in consistent and predictable results that do not alter the preference rankings of the alternatives.

The models often require more specific detail than is generally available - the question is, how do we get it? Threat details should be supplied by the intelligence community. Other details need to be created by the analyst, within reasonable bounds and while maintaining credibility. Study teams help bring a level of credibility and rationality to this process.

Campaign scenarios should address plausible deployment and employment timelines. For many weapons systems, the ability to respond rapidly to a theater commander's needs is as important as its capability in combat. Similarly the ability to conduct sustained operations over time - the logistics and reliability dimensions of a candidate weapons system is a necessary measure of capability. Considering all phases of a theater operations will allow you to accomplish this dimension.

Analytical resources need to be allocated to explore the sensitive and/or interesting facets of the theater operation timeline. This may require extreme detail in some areas while giving cursory analysis to the less relevant. If this is the case, insure you have documented the logic for your methodology.

The analyst's dilemma: designing flexibility into a scenario is a problem because of the continuous changes in the threat environment. Scenarios must be designed so as to accomodate changes in the threat throughout the evolution of the developing system. This flexibility should be included so that to the greatest extent possible, the scenario retains those attributes which derived the original requirements for the system.

To assure that the needs of various communities within the acquisition process are recognized, and that the capabilities of these various communities to contribute to the COEA process are exploited, it is critical that close working relationships among the communities be established early in the COEA effort.

Impact on Research

There is an increased requirement for assessments of a historical, current, and projected nature. A shift from a European conflict to a variety of regional conflicts necessitates assessing a host of new potential conflicts and technologies. This should be done in an historical/current context in order to make reasonable projections regarding potential operational environments, capabilities, and intentions.

There is a need to expand the data base to address more fully the characteristics of Blue, Red, and Gray systems. In this context, blue refers to US

systems; red to systems in the inventory of hostile forces; and gray systems normally non-US systems available to both potentially hostile as well as coalition forces.

On-line availability of these data would improve currency and completeness of the effectiveness analysis.

There is also a need to develop methods of comparing the results of different models used to analyze different alternatives. Especially as more emphasis is placed on joint operations. For example, in evaluating the contributions of alternative ground-based and air-based systems may require the integration or comparison of results from various models.

There is a need for a certified listing of models, databases and scenarios for use in COEAs. This will ensure a thread of commonality and consistency when comparing COEA results. This allows decision-makers a reasonable logic trail for program trade-offs.

There is a need for distributed/networked analysis capability between centers of expertise or excellence. This will result in broader, more detailed, credible, and consistent analytic results. It will help reduce redundancy, save resources, improve quality, and facilitate time-savings.

MORS COEA
MINI-SYMPOSIUM
MARCH 9-11, 1992

THREAT ASSESSMENTS & SCENARIOS WORKING GROUP

CHAIRMAN
COL Charlie Cox
DIA

OVERVIEW

- ISSUES/ DISCUSSION POINTS
- IMPACT ON ANALYSIS
- IMPACT ON RESEARCH

ISSUES

- DYNAMIC THREAT
- LEVEL OF DETAIL
- ANALYZE OPERATIONAL EFFECTIVENESS WITH SCENARIOS

DYNAMIC THREAT

- THREAT CHANGES DURING IN PROGRESS COEAS
  - FREEZE THE THREAT
  - FLEXIBILITY
    - DESIGN IN UP FRONT
    - HOLD IN PROGRESS REVIEWS
  - SENSITIVITY ANALYSIS
  - UPDATE COEA (TIMELINES)
- THREAT CHANGES AFTER MILESTONE
  - UPDATE COEA
  - ORIGINAL WORK IS BASELINE
  - INCORPORATE ALL CHANGES (THREAT, REQUIREMENTS, SCENARIOS, ETC)

LEVEL OF DETAIL

- DETAILS WILL INCREASE FOR SUCCESSIVE MILESTONES
  - PHASE 0 COEA FLEXIBLE (MULTIPLE CONCEPTS)
  - PHASE 1 COEA MORE DETAILED (SPECIFIC SOLUTION(S))
  - UPDATES WILL REMAIN DETAILED
- MISSION NEED DRIVES DETAILS
- INTEGRATED APPROACH/ JOINT CAMPAIGN ANALYSIS
  - EXAMINE ALL ASPECTS OF JOINT OPERATIONS

TESTING OPERATIONAL EFFECTIVENESS WITH SCENARIOS

- THE OPERATIONAL EFFECTIVENESS OF A SYSTEM IS BEST EXAMINED THROUGH A SERIES OF SCENARIOS
- SCENARIOS MUST ADDRESS THE RANGE OF PLAUSIBLE, POTENTIAL CONFLICT ENVIRONMENTS
  - EXPLORE HIGH, MEDIUM, AND LOW INTENSITY CONFLICTS (QUANTITY/ QUALITY)
  - THE APPROACH WILL BE UNIQUE TO EACH COEA

REGIONAL/ CONTINGENCY THREAT SCENARIOS

- CLEARLY DEFINED BASIC ASSUMPTIONS
- IDENTIFY POLITICAL AND ECONOMIC FACTORS
- EXPLORE TECHNOLOGY LEVEL OF OPPOSING SYSTEMS
- JOINT CAMPAIGN ANALYSIS
  - SYNTHESIS/ EXAMINE ALL ASPECTS OF JOINT OPERATIONS
- ROLE OF BLUE FORCES
  - EXPLORE ALTERNATIVE OUTCOMES

BROAD ANALYTICAL SCENARIOS

- SHOULD BE CAPABLE OF BEING MODELED ANALYTICALLY
- NEED TO ADDRESS MISSION NEEDS STATEMENT REQUIREMENTS
- INITIALLY DETAILED AND EXPANSIVE; NARROW LATER
- BE ABLE TO CAPTURE DIFFERENCES AND ALTERNATIVES
- TAILOR TO MEET COEA OBJECTIVES
- NOT GEOPOLITICALLY ORIENTED
- SCENARIOS SHOULD ADDRESS ALL NECESSARY PHASES OF OPERATIONS

IMPACT ON ANALYSIS

- ASSESS ABILITY OF SCENARIOS TO ADDRESS QUESTIONS
- FOCUS ON CRITICAL ASPECTS OF SCENARIOS
- INCLUDE EXCURSIONS TO BETTER EVALUATE ROBUSTNESS
- SPECIFY DETAIL/ DATA REQUIRED FOR BOTH RED AND BLUE
- DECIDE WHICH PHASES OF OPERATION ARE REQUIRED
- DO PHASES AT REQUIRED LEVEL OF DETAIL
- DESIGN IN FLEXIBILITY (I.E. SENSITIVITY ANALYSIS)
- DEVELOP CLOSER WORKING RELATIONSHIPS

IMPACT ON RESEARCH

- INCREASED REQUIREMENT FOR ASSESSMENTS OF A HISTORICAL, CURRENT, AND PROJECTED NATURE
- DATA DEVELOPMENT WILL ADDRESS BLUE/RED/GRAY SYSTEMS
- MEANS TO COMPARE RESULTS FROM DIFFERENT MODELS TO COMPARE DIFFERENT ALTERNATIVES
- DATABASE OF CERTIFIED MODELS, APPROVED THREATS AND SCENARIOS
- DISTRIBUTED/ NETWORKED JOINT/ INTEGRATED ANALYSIS CAPABILITIES - CENTERS OF EXCELLENCE

ANALYZE OPERATIONAL EFFECTIVENESS WITH SCENARIOS

- CLEARLY DEFINE BASIC ASSUMPTIONS
- BROAD ANALYTICAL SCENARIOS NEEDED TO ADDRESS MNS REQUIREMENTS
  - EXPLORE RANGE OF CONFLICTS/ ENVIRONMENTS
  - UNIQUE TO EACH COEA
- CAPTURE DIFFERENCES OF ALTERNATIVES
- EXPLORE TECHNOLOGY OF OPPOSING SYSTEMS
  - EMPLOYMENT TACTICS

4.4 Report of the Effectiveness Methodologies Working Group

Working Group 3 was charged with looking at issues, problems, and research topics within the area of effectiveness methodologies. This area was viewed as having two components: precursor activities (front end analysis) and effectiveness tools. The "front end" of the effectiveness analysis must clearly define the problem, establish the approach, and select the appropriate set of metrics. Knowing where you are going and how to get there is both challenging and critically important to a successful COEA.

SETTING UP THE ANALYSIS

Defining the Problem

Each COEA has a unique set of concerns that the ultimate decision makers require the analysts to address. Defining the problem is the process by which these unique concerns are identified, described, and understood. The process must enable the COEA team to internalize the decision maker's needs, where the program is in the acquisition process, and the decisions to be made.

Defining The Approach

Once there is a through understanding of the problem, the team should define and establish the overall approach. Included within this step is a group of interrelated and iterative activities. One activity is the identification of alternatives which may be given to the team by the sponsor or expanded by the team to consider all appropriate solutions. The approach selected must identify and consider key analysis questions, the essential elements of analysis (EEA). The EEA represent that set of questions, which when answered, will completely address the issues associated with the COEA decision. Lastly, the approach definition step must settle issues of methodology, assumptions, and constraints.

Selecting Metric

The level of analysis is a function of the phase of the acquisition process. At each stage, the decision maker has a defined, evolved, set of missions/objectives that must be satisfied. The metrics need to assess how well the alternatives achieve those objectives. Qualitative and quantitative metrics should be examined. The metrics selected must be meaningful to the audiences to which the COEA must answer. These audiences include not only the DOD Programmers, but also the Congress, the Executive Branch, and the CINCs.

Process Issues

A well understood and accepted COEA process must be institutionalized to ensure consistent results in the face of changing leadership, issues and tools. Relying upon the personality of connections of an individual study director is a hit or miss proposition at best and does not capture the processes required to ensure a good analysis effort. Communication between the decision maker and the producer of the COEA document that supports the decision making process is inadequate.

Formal communication is provided as a result of an ADM followed by a rather lengthy period (18 months) with no formal communication. This makes the COEA dependent on the Study Director's capabilities in seeking informal guidance. This can cause wide variance in the COEA's usefulness to decision makers. Typically the COEA team is both physically and organizationally remote from the decision makers. This impacts on the study directors access to decision makers for in process review. This impact manifests itself as intermediate command guidance on the questions the COEA is to address, and a screening of COEA team requests for guidance from the decision makers. No direct paths exists between the COEA team and the decision maker (or his representative) to keep the COEA properly focused. Recent experience demonstrates that over the normal COEA time frame that the environment changes rapidly for some programs. Leadership and environmental changes affect National goals and policies. These in turn result in changes in military objectives and the content of programs needed to accomplish these objectives. These changes must be incorporated in the COEA process to enable the decision maker to make valid decisions.

Lessons Learned

Currently the procedures to learn how to conduct a COEA are not imbedded either in the service academies processes or in the informally supported

methods characterized by lessons learned from media, symposia, etc. The inclusion of an exit report from the director of the study into and accessible data base to preserve institutional memory for future study directors would be and approval. Included should be the methodology that was followed and any that were considered and disregarded. Rationale as to why a specific procedure was used as opposed to another needs to be included. Measures used to establish the merit of subjects of study should be captured and summarized for potential future use. A "Roadmap" needs to be established to enable the COEA to achieve a better chance of success. All the services train for success in war, they also need to train for success in the peacetime warfare associated with doing a COEA. Positive feedback to current study doers is a useful procedure to reinforce successful efforts. A mechanism to do this needs to be included in the COEA process.

Continuity

Timeliness involved with the COEA cycle, to include the updates involved at different milestones stretch the ability of the study doer to maintain continuity of effort. Recent changes in Europe are evidence of the changing context in which COEA efforts are coordinated. Along with the threat implications, the services have doctrinal, strategic and operational issues that change over time. These often need to be reflected in the study proceeding or just ended. Accomplishing the task requires initial planning flexibility to absorb the additional requirements, changes in direction or evaluation of sensitivity analysis that was originally not anticipated.

Research Issues

A second set of issues deals with areas in which the tools available to support effectiveness analysis are inadequate. This area naturally suggests research to improve existing tools or develop new ones.

The first area focuses on the approaches available to the OR community and their relevance and transparency to the ultimate consumer -- the decision maker. Many of the tools available may be so esoteric that they are either not understood by or not accepted by the decision makers. On the other hand, many analysts do not appreciate fully either the issues the decision makers need to address or their perspective/logic. A key need in developing the approach is to assure that the methodology selected focuses on the criteria to be used in making the decision.

The second area deals with the whole issue of the identification and selection of appropriate measures. In the changing threat and budgetary environment, it may well be that the traditional measures (attrition, FLOT movement, exchange ratios, etc.) no longer apply. There is a need to develop agreed upon measures for non-attrition warfare, indeed, for the full range of conflicts most likely in the future. There is also the need to develop a hierarchy of measures that allow you to relate campaign outcomes to MOEs and MOEs to MOPs. It is the MOPs, at the system level, that provide the linkage between the analysts and the testers.

Finally, many of the problems will be qualitative in nature and therefore there is a need to develop an agreed upon set of qualitative measures. We expect fewer weapon systems new starts and more supporting systems, including C3I and mobility enhancements, new starts. Measures are needed to allow us to address the performance, effectiveness, and combat contributions of these latter systems. Even in the case of weapon systems, qualitative measures are often appropriate and meaningful to the decision makers.

The OR community is the logical venue to develop new tools, not only to resolve recognized deficiencies but also to take advantage of new techniques, theories, and approaches.

KEY RECOMMENDATIONS

Take advantage of modern technology to improve the inadequacies of the COEA process. Teach the COEA community how to do a successful COEA.

We need to create a program to resolve the COEA process issues as they occur. This can be implemented in three ways. First, create an interactive library/data base of COEA lessons learned. This data base contains metrics that describe successful and unsuccessful COEAs. Next, continue with COEA symposia to get lessons learned out to the COEA community. Finally, establish networks of specialists/identify leadership.

We need to research innovative methods to bring OR decision making methods to the decision

makers. We have to make the process and results more understandable to the decision maker. We can do this by making use of modern technology to involve the decision maker in the analysis process. This may require working with the decision maker.

We need to do research to define types of measures that are appropriate for the emerging conflict environments. The past will not necessarily be a good predictor of future measures. We are moving toward Joint Service and Combined Allied operations. Also, non-weapon systems can be key to influencing the outcome of the conflict. Campaign analysis in the future will probably involve limited objectives and may require different measures than the past, more traditional conflicts.

EFFECTIVENESS METHODOLOGIES

Introduction

The challenge facing this working subgroup was significant for it accepted the task of defining and outlining future COEA effectiveness methodologies. As expected, however, most of the discussions focused on member's experiences using current tools and methods in addressing COEA issues. When asked to extend their experiences to future requirements the real challenge surfaced. In order to produce a useful product in the short time allotted at the symposium the subgroup limited its discussions to the following two topics;

(1) Develop insight into future methodologies through review of the decision making process and issues for COEA effectiveness modeling.

(2) Provide insights into practical "campaign analysis" modeling techniques.

General

The concept of COEA effectiveness analysis is not new but the current climate of military decision making does present an environment different from the past decade. COEA effectiveness analyses are now used within a decision making environment with several new characteristics which places considerable strain on many of the current modeling tools. For the past several decades the following model environmental parameters have been reasonably stable; a dominant threat, analytical requirements focused on single service priorities and acquisition dollars were sufficient to allow each service several major programs. As a result of significant changes in all of these parameters the analytical community is faced with the challenge of developing modeling tools for this new era. All of these factors imply a demonstrative change in modeling tools to effectively address future effectiveness issues.

COEA work of the future will take a joint and possibly combined perspective and cover a broader set of scenarios and issues. The focus of "campaign analysis" is designed to extend traditional COEA analysis into a more general and useful process for the service and OSD decision maker. A caution must be sounded because of the tendency to link COEA effectiveness analyses with affordability and programmatic issues. The subgroup as well as the senior analyst panel felt that these two sets of issues, effectiveness and affordability, should remain separate. These two sets of issues are closely related and must be complementary but not so dependent that they lose their distinction. A close examination of the measures of performance and essential elements of analysis in each of these two arenas shows that there are distinctive dynamics in each and that effectiveness should not be dependent upon affordability issues.

Modeling Environment

It is critical to start the model development process at the beginning! Discard preconceived notions of appropriate techniques and methods and allow the systems analysis process and the problem statement to develop appropriate tools and techniques. This paradigm will be the key to future modeling developments. With this thought the subgroup first examined the environment in which effectiveness methodologies will be used. Immediately, the subgroup saw that the problem, COEA effectiveness analysis and associated campaign analyses, is not sufficiently defined to focus directly on one modeling technique. What are COEA decision issues? Are they identical to campaign analysis decision issues? Are one set of issues and requirements a subset of the other? How dependent should the COEA analysis be upon the campaign analysis? (Prof Hughes offers his opinion on this last question in his comments.) Additionally, it was difficult to forecast either the military scenario and forces associated with either a COEA or the more robust campaign analysis. Effectiveness measures of past COEAs may satisfy some future issues, but there is a strong likelihood that new issues will arise.

The old axiom; don't make the tool fit the problem rather let the problem define the appropriate tool, should now be restated for we may tend to select the method of solution before we know the problem/issue. To be most effective the methodology, and model if one is used, should address the decision issues as directly as possible. It's because of this single facet of the future analytical environment, uncertainty in issues and scenarios, that a single modeling technique may fall well short of satisfying future modeling requirements. Uncertainty both in model requirements and analytical issues forces the analyst to remain flexible in his approach to COEA problem solving. It is ill advised to presume that a single model designed with rather severe limitations in scope and flexibility will serve future COEA analytical needs.

Despite uncertainty the characteristics and nature of future modeling requirements do provide useful guidance in developing appropriate tools and methods. What are characteristics of future issues and what are the factors that will influence scenario development? There are several factors that influence and strengthen the need for a flexible and tailored process; shorter analytical cycles, broad spectrum analysis, non-threat based scenario analysis and non-attrition based effectiveness measures are all factors to be accommodated in future modeling requirements.

Review of likely future issues provides more weight to the notion that flexibility will be the key to future effectiveness and trade-off analyses. Programmatics will play a larger role than ever in acquisition decision issues. Effectiveness and programmatic concerns must remain separate but complementary processes must be developed to aid the decision maker. If this is to be accomplished, separate and complementary, then focus on the development of separate and complementary modeling processes. This is a simple view, but start simple and build in difficultly as the particular decision issue warrants. With programmatic and affordability issues uncertainly lies in the area of budgets, force structure levels and plausible scenarios but weapon system effectiveness issues deal with service doctrine and system performance within defined forces and doctrine.

We have done little more than review the environment of future modeling and it appears that several traits must be reflected in our next generation of modeling. Without these traits it seems that modeling will poorly serve the decision makers. If we understand the impact and critical nature of these model traits/characteristics we will be much more informed about the appropriate techniques and tools to apply. (Specific tools are discussed below.)

The subgroup developed the following three critical characteristics of future COEA effectiveness models;

(1) COEA modeling support will have to deal effectively with more than one service and over long time periods.

(2) COEA modeling must be sensitive to the decision issues, i.e. tailored to system issues and decision maker issues for the specific COEA. Interoperability, lethality, supportability, deployability and sustainability may be equally weighted COEA issues.

(3) A mix of tools and models will likely be used to produce a thorough analysis, because no one model or technique can effectively address such a wide range of issues.

There exists strong evidence that this approach to COEA related modeling works because of three examples of past COEAs. In the LH, KE-ASAT and BLK-III COEAs the study director used unique modeling tools to address the critical issues of the COEA. In the case of the LH and BLK-III a unique, not previously used, mathematical model was developed specifically for the study. In the case of the KE-ASAT COEA a unique war game seminar was conducted to serve as the medium for concept development and COEA issue analysis. These COEA analytical models were effective in dealing with the issues of their specific acquisition process. Their efforts relied heavily on data derived from our current set of high and low resolution simulations but the current set of models and simulations were used as support elements only. In each case data from current models was used as a driver, an emulator or stimulator for a more specialized model focusing on specific COEA issues. Using our current set of models and data as a foundation, or backdrop, for a new and more flexible set of tools is an evolutionary approach to dealing with this difficult problem.

What effectiveness methodologies serve the analyst, and decision maker, given the changing conditions and diversified issues presented above? No one approach to effectiveness analysis can be adopted

since the environment is too uncertain and tomorrow's issues are just too varied, essentially undefined. Don't draw upon the last two decades of effectiveness analysis, threat based and attrition dependent, to develop your future model criteria. Listed below are several analytical methods, modeling techniques, which are well suited to the decision making and modeling environment of the future;

1. AHP
2. Utility theory
3. Mathematical programming (linear, goal, non-linear)
4. War gaming
5. Unique mathematical modeling
6. State space modeling techniques

The first four techniques are well documented and provide tremendous flexibility in dealing with effectiveness issues. Each must be tailored to address specific issues and this is the task of the analyst. Unique mathematical modeling could include the elaborate combat simulation models we have grown accustomed to over the years, but the trend will likely be towards more specialized math models similar to the LH COEA model. It is important to note that our current models serve a significant role in all of the above mentioned techniques, especially the high resolution model. The aggregated nature of most of these techniques relies heavily on a fundamental understanding of the dynamics of the specific analytical issue. In this regard the current high resolution model may play an even more crucial role as a data provider, driver, emulator or stimulator for the more aggregated form of modeling. There appears to exist a fundamental requirement for high resolution modeling to address system performance concerns for the warfighter, fightability and trainability, but the next level of issues seems to rest in very aggregated perspectives and expected performance for forces over long time periods, a military campaign. The challenge of the military analyst is to develop modeling techniques to use high resolution insights within a campaign.

State space modeling techniques, a general form of the Markov model, present another powerful set of modeling tools that has seen limited use in DOD combat modeling. The Air Force has used this technique for limited theater level analysis as well as B-52G upgrade effectiveness analysis and F-16 mission performance analysis. Flexibility and transparency are two traits of state transition modeling. It unlike several other techniques can deal directly with uncertainty by modeling expectations and likelihood of units performance. Considerable work has been accomplished at the Naval Postgraduate School in applying this particular modeling methodology to a host of military effectiveness issues.

CAMPAIGN ANALYSIS

The ambiguity of campaign analysis creates difficulty in adopting an appropriate modeling technique. As outlined above COEA related campaign analysis will be tailored to COEA requirements therefore methodologies used to satisfy the modeling requirement will likely be defined by the COEA. The above discussion focused on the applications of models to a specific weapon system COEA, but is there a need for a broader more general model application that transcends a specific weapon system requirement and functions as an "omnibus" model for force effectiveness issues? Although the subgroup had little time to discuss this issue there is without a doubt a need for some form of omnibus campaign analysis methodology. Interestingly though, the rational for flexibility and transparency for COEA related campaign analysis should hold true for a more general campaign analysis tool or tools. It is within the context of more general force effectiveness issues and affordability issues that omnibus campaign analysis adopts a distinctive character from that of COEA related campaign modeling. Within COEA analyses the general focus of the analysis is on "which system is better suited" for the force. The service has decided to commit to the acquisition and has conducted analyses to justify its application within their mission. However, affordability and omnibus issues generally focus on "how much is enough." So long as there is potential for services to compete for national defense missions the "how much is enough" analysis should lie outside the purview of the COEA (see Prof Hughes' comments). From an effectiveness methodologies viewpoint these are not totally independent processes but don't presuppose that one modeling methodology will satisfactory address each concern.

The best example for a candidate methodology for omnibus campaign analysis is exhibited in the KE-ASAT COEA. A war game seminar provides a robust and dynamic forum for the investigation of concepts and critical issues as well as generation of meaningful quantitative data.

The following section is a commentary by Professor Wayne Hughes from the Naval Postgraduate School. Professor Hughes was asked by Dr. Peter Purdue, a subgroup member, for his thoughts on campaign analysis. Prof Hughes is very familiar with the campaign analysis issues and military modeling methodologies.

Campaign and Theater Level Analysis for COEA

"A campaign analysis is a low resolution, quantitative examination of heterogeneous forces operation over a large geographic area in a series of engagements over time. It is the analytical equivalent of military campaign executed under an operations plan that defines a series of operations by integrated forces. Its conduct is as distinctive from a detailed systems analysis of the new system as the conduct of a campaign is distinctive from the handling of forces in a battle.

In general, campaigns may be studied with mathematical models, computer simulations, and war games. Each of these three forms has its advantages and disadvantages, depending on the operation or analytical purpose. In general, a combination of all methods is superior, so that each form complements the others. A family of campaign analyses, each of which is done with a specific aim (which aim may or may not have a procurement orientation), will in the aggregate provide a foundation for studies with many aims, among which is that of a COEA.

A campaign analysis is at the apex of a hierarchy of engagement analyses of weapon and sensor performance and command and control. It is a synthesizing structure which presupposes analysis in detail and considerable prior aggregation of results.

Because of the almost limitless possibilities and variations in detail, is particularly well to remember the If-Then nature of every model. A campaign analysis is a stylized set of inputs and dynamic relationships (the model) from which flow results. Because of the tenuous grasp of detail at the campaign level in advance of actual military operations, successful and utilitarian campaign models to assist with procurement decisions have tended to be highly abstract, flexible, and transparent, with reproducible results, involving many alternative situations and cases. Thus, while computer simulations and war games serve many purposes in general, relatively concise mathematical expressions of aggregated interactions are usually best for COEA in particular.

Mathematical structure often suggests some form of optimization algorithm to derive a "best" solution. When a mathematical optimization is possible, it should not be dismissed out of hand. But it is far more important when dealing with campaign analyses to emphasize their value for exploratory computations, in which diverse points of view are examined and in the best of worlds the analysis assists in a convergence and unity of perspective regarding the strategic environment and the place where candidate systems performs its mission.

Moreover, insofar as a COEA is concerned, a single, new, entirely original campaign analysis is insufficient. The productive role of campaign analysis is achieved when there is already in hand a reasonably well understood sequence of studies and analyses of the theater in question for existing and future forces, both enemy and friendly, into which the new system in question may be inserted.

Specifically with regard to the Phases of the Acquisition Process, the following comments apply:

1. Preliminary to Phase 0: The acquisition process envisions the determination of mission need. If the need is to fulfill a new mission, as is commonly the situation that has existed in the armored forces since around 1989, then only a campaign or theater framework can serve to test the efficacy of the new mission, the candidate weapon, sensor or other system to fulfill it, and the possible alternatives.

If, for example, the umbrella mission is to safeguard the movement of goods, military or commercial, at sea, a prominent sub-mission has been to protect against submarines. The many questions about the nature of the present submarine threat illustrate the most basic Pre-Phase 0 issue. Given that campaign analysis has narrowed these diverse points of view and the future threat variations are sufficiently agreed, then the issue becomes the strategy to defeat submarines. Until recently, a long series of campaign analyses, other more detailed studies, and many at sea exercises had evolved an "offensive strategy," which is to say to new submarines threat characteristics may upset that strategy. The degree of upset and need, if any, to devise a new strategy is almost exclusively in the campaign analysis domain.

It is possible that the need for a new system or technology to repair a bankrupt strategy may be uncovered in this way. It is more common that the need will be adumbrated--this is, sketched out and publicized--by campaign analysis. This arises the consciousness of new missions, or a new strategy within a mission, Usually the adumbration is accompanied by a candidate solution, as for instance, a new ASW submarine or a new multipurpose submarine with several mission capabilities.

The thrust of these comments are to emphasize that anything more than a superficial and unconvincing understanding of new mission or strategic requirements come from a strong foundation of continuing campaign studies at the theater, that is, strategic and operational, levels of thought.

2. Phase 0: Concept Exploration and Definition: For most acquisitions a new version of an old system is proposed to perform a longstanding mission. The new one is justified on the basis of (a) a threat upgrade, (b) a new technology breakthrough, (c) a replacement as preferable to a SLEP, or (d) a combination of the three. At such a juncture, it is reasonable to ask whether an entirely different system might be superior. For instance, if a replacement submarine class is proposed for ASW, a fair question is whether an ASW aircraft, mines, or even Air Force aircraft might be preferable. A campaign analysis is the preliminary methodology to describe the way the alternative system would fulfill the mission.

But such a campaign analysis can do no more than establish the feasibility of the alternative. If it is thought that some type of mines could substitute for a new submarine class, then a vast amount of analysis must follow. In addition, it is not practical to assign the burden of proof to the submarine advocate that the submarine is preferable to any and all alternatives. For one thing, this leads to an endless series of explorations, rather like a judge demanding the proof of innocence of the accused. For another, the submarine advocate will not likely grasp or express the advantages of the competing system. A proposed replacement in kind may be justified on the basis of threat, technology, and cost, but the burden of demonstrating (to some preliminary degree) the superiority of an alternative system such as a mine lies with the proponent of the alternative. The advocacy of competing systems may be carried out by the advocates, but the campaign analysis of mission needs entails a neutral, objective team.

3. Phase 0 Campaign/Theater Level Analysis: Let us postulate that there is the required foundation of existing campaign studies of, for example, the protection of shipping and military forces at sea which includes the role of ASW submarines. Let us further postulate that we allow the advocate of a new ASW submarine class to proceed with concept studies. The constructive role of campaign analysis is at that juncture highly efficacious. The "approved" settings (or scenarios) exist, as do the base of existing friendly forces, their capabilities and their employments. The threat, including future trends, is in hand.

The primary purpose of the COEA-specific campaign analysis is to place the new submarine capabilities in operational context with one or more intelligent employment variations. If the change in submarine capabilities is radical, other force employments may have to be rearranged, but that is an attainable goal. A utilitarian campaign analysis will elucidate the proper measure of force effectiveness (MOFE).

It is not likely, however, that the cost-effectiveness of the new system can be deduced from a campaign study. The analysis is too coarse-grained (low resolution) to infer system performance on the margin. Often a simpler, straightforward, proxy measure of effectiveness (MOE) can be deduced and agreed. For example, it is usually accepted that safeguarding the arrival of cargo is the true aim of ASW forces, and that two robust MOFEs of the ASW campaign are percentage of ships lost (for early and critical cargo) and exchange ratio of ships lost per submarine sunk (for an extended campaign). Conjecture that a new ASW submarine's campaign employment kills, but does not deter or suppress, enemy submarines. If so, we know from the campaign analysis that a suitable proxy MOE for the ASW submarine is the probability that a transiting submarine is killed under scenario conditions specified by the campaign setting. The campaign analysis also established the value, vis-a-vis the MOFE, of every level of kill (MOE) attainment. The campaign analysis describes the types of enemy submarines and the proportion of each to be engaged by the ASE submarine. Finally, the campaign analysis will probably reveal the extent to which the sub-on-sub exchange rate is a decisive factor in the analysis.

In this way the COEA-related campaign analysis defines the setting for a subsequent system analysis, which must be conducted in great detail,

including tactics by which the enemy is detected, classified, closed, engaged, and killed, and the associated probabilities for each enemy type variant. The detailed cost and effectiveness studies--the systems analysis proper--can then, and only then, proceed with confidence that kill probability is an adequate MOE and that the specific systems analysis setting (scenario) is robust and well-defined. Finally, if the analysis suggests that the sub-on-sub exchange ratio is going to be unexpectedly high, then the campaign analysis will have revealed whether or not this is a problem that requires a review of the MOE, and indeed the entire strategy.

In conclusion, a whole series of past campaign analyses is a necessary antecedent to serve as the foundation for a specific, simple, focused, reproducible campaign analysis to support the COEA. The focused campaign analysis is a necessary antecedent of the detailed systems analysis of the system at issue, to determine its cost-effectiveness. The general campaign study foundation, the COEA-specific campaign analysis, and detailed cost-benefit systems analysis are three distinguishable efforts that cannot be combined."

MORS COEA
MINI-SYMPOSIUM
MARCH 9-11, 1992

EFFECTIVENESS METHODOLOGIES WORKING GROUP

CHAIRMAN
John Friel
RAND

EFFECTIVENESS METHODOLOGY
SETTING UP THE ANALYSIS

•DEFINING THE PROGRAM

- -DECISION MAKERS' NEEDS
- -WHERE IN ACQUISITION PROCESS
- -DESCRIBE THREAT, REQUIREMENTS, ISSUES

•DEFINING THE APPROACH

- -ESTABLISH ALTERNATIVES
- -IDENTIFY ESSENTIAL ELEMENTS OF ANALYSIS
- -SELECT METHODOLOGY, ASSUMPTIONS, CONSTRAINTS

•SELECTING METRICS

- -APPROPRIATE TO DECISION
- -QUALITATIVE AND QUANTITATIVE
- -MEANINGFUL TO WARFIGHTERS

KNOW WHERE YOU ARE GOING AND HOW TO GET THERE

SETTING UP THE ANALYSIS
PROCESS ISSUES

POOR COMMUNICATIONS BETWEEN CONSUMERS AND PRODUCERS

- ANALYSIS TEAM FAR REMOVED FROM DECISION MAKERS
- NO DIRECT PATH
- ENVIRONMENT CHANGES OVER DURATION OF ANALYSIS

NOT STRUCTURED TO LEARN LESSONS FROM OTHER COEAs

- SUCCESSFUL METHODOLOGIES AND MEASURES
- EXAMPLE ROADMAPS
- FEEDBACK ON PERFORMANCE

DIFFICULT TO MAINTAIN CONTINUITY OVER DURATION OF COEA

- ENVIRONMENT CHANGES
- PLAYERS CHANGE
- POLICY/GUIDANCE EVOLVES

IMPROVING THE PROCESS WILL IMPROVE THE PRODUCT

SETTING UP THE ANALYSIS
RESEARCH ISSUES

DIFFICULT TO STRUCTUE APPROACH DECISION MAKERS CAN USE

- DECISION MAKERS NOT COMFORTABLE WITH OR NUANCES
- ANALYSTS DO NOT UNDERSTAND DECISION MAKERS THINKING
- HOW TO RELATE ANALYSIS TO OTHER DECISION CRITERIA

INSUFFICIENT CRITERIA TO SELECT APPROPRIATE MEASURES

- METRICS WITH MEANING IN TODAY'S DECISION ENVIRONMENT
- METRICS FOR EVOLVING WARFARE NOT DEFINED
- HOW TO RELATE CAMPAIGN METRICS WITH MOEs AND MOPs

NO CONSENSUS ON QUALITATIVE MEASURES

- MOST MEASURES APPLY TO WEAPONS SYSTEMS
- MEASURES FOR INFORMATION/DECISION SYSTEMS NOT DEFINED

OR COMMUNITY NEEDS TO DEVELOP NEW TOOLS

SETTING UP THE ANALYSIS
KEY RECOMMENDATIONS

•CREATE A PROGRAM TO ADDRESS ONGOING COEA ISSUES

-MAINTAIN A LIBRARY OF COEA LESSONS LEARNED
-CONDUCT "OUTREACH" ACTIVITIES
-DEVELOP NETWORK OF SPECIALISTS

•RESEARCH TO DEVELOP INNOVATIVE DECISION MAKING SUPPORT

-INFORMATION DISPLAY
-INSIGHT INTO ANALYTIC PROCESS AND CONTENT
-DECISION MAKER INTERACTION

•DEFINE METRICS FOR EMERGING CONFLICT ENVIRONMENTS

-JOINT/COMBINED OPERATIONS
-NON-WEAPON SYSTEMS
-CONTINGENCY AND LIMITED OBJECTIVE WARFARE

APPLY MODERN TECHNOLOGY TO IMPROVE THE PROCESS

EFFECTIVENESS METHODOLOGIES
COMPARATIVE MODELS

OBJECTIVE:

•TO IDENTIFY:

- ISSUES/PROBLEMS
- RESEARCH AREAS
- FUTURE DIRECTIONS

THAT APPLY TO THE EFFECTIVENESS
PORTION OF THE COEA PROCESS

EFFECTIVENESS MODELS PROBLEMS/ISSUES

- SHORTCOMING - CHARACTERIZATION OF NON-QUANTITATIVE EFFECTS
- MANY CURRENT MODELS ARE NOT ROBUST ENOUGH TO HANDLE THE CHANGING THREAT ENVIRONMENT
- USE OF CONTRACTOR PROPRIETARY MODELS
- TRADE OFF BETWEEN EFFICIENCY AND FIDELITY

EFFECTIVENESS MODELS RESEARCH AREAS

- MODEL EVALUATION CRITERIA
- DEFINITION AND ACCEPTABILITY OF MODEL CATEGORIES/HIERARCHY FOR USE IN COEAs
- VARIABLE RESOLUTION METHODOLOGY

EFFECTIVENESS MODELS FUTURE DIRECTION

- USE OF WARGAMING IN COEA PROCESS
- JOINT ANALYSIS
- DISTRIBUTED INTERACTIVE SIMULATIONS
- FLEXIBLE/MODULAR MODELS
  - RAPID PROTOTYPING
  - DATA DRIVEN

CAMPAIGN ANALYSIS

- NEED GUIDANCE TO THE SERVICES
- HARD TO DEFINE THE PROBLEM
- SCOPE: "LIMIT TO COEA USE"

CAMPAIGN ANALYSIS PURPOSE

- TO DETERMINE THE FORCE LEVEL IMPACTS OF INDIVIDUAL SYSTEMS
- TO DETERMINE FORCE LEVEL IMPACTS OF FUNCTIONS OF:
  - LOGISTICS
  - SUPPORTABILITY
  - DEPLOYABILITY

CAMPAIGN ANALYSIS MODEL REQUIREMENTS

- SHOW SENSITIVITY TO DECISION ISSUES
- EASILY TAILORABLE
- DEAL WITH UNCERTAINTY (MORE DIRECTLY)
- JOINT
- NOT FOCUSED ON
  - ATTRITION
  - THREAT

CAMPAIGN ANALYSIS
METHODOLOGIES

- BUILD UPON CURRENT INVENTORY
- UNIQUE MATHEMATICAL MODELS (LH COEA)
- WARGAMING SEMINARS (KE-ASAT)
- LIBRARY TYPE DATA SUPPORT (OBJECT ORIENTED THINKING)
- STATE SPACE MODELING

CAMPAIGN ANALYSIS
(KE-ASAT EXAMPLE)

	CAMPAIGN ANALYSIS	OPERATIONAL ANALYSIS	SYSTEM ANALYSIS
MS I	EEAs/MOEs Alter concepts Threat defined Reqmnt Trade-offs Scenarios Military value	Operational value of system defined	Compare concepts Sense Anal
MS II	Refine MS I	same as MS I	same as MS I

TOOLS

Analytical Wargame	Force level Model	System level Model

CAMPAIGN ANALYSIS
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EFFECTIVENESS METHODOLOGY
SUMMARY

- VARIOUS ISSUES AND PROBLEMS IDENTIFIED
- MORS COMMUNITY IS THE LOGICAL GROUP TO ADDRESS THEM

"THIS MAY MEAN THAT YOUR WAIT WILL BE A SLIGHT BIT LONGER THAN ELSEWHERE, BUT LIKE ALL FINE THINGS TIME AND CARE ARE ESSENTIAL COMPONENTS OF THE FINISHED PRODUCT"

HARP DONNELLY'S NEWPORT GRILL
NEWPORT, RHODE ISLAND
MARCH 10, 1992

4.5 Report of the Costing Methodologies Working Group

We had vigorous discussion by 45 participants who represented OSD, Major Commands, Laboratories, the academic community and hardware vendors. The success of the working group depended on all of them, with special thanks to LtCol Ray Baker of the Navy War College for administrative and logistical support and to Don Mixon of the MITRE Corporation for organizational support.

Everyone agreed that special emphasis should be placed on the fact that the first letter in COEA is a C, and that it stands for COST. Without proper and early attention to cost, the COEA process is fatally flawed.

The rest of this report is keyed to the attached briefing slide.

Service Cost Estimate Linkage

There had been a concern among the participants in the working group over whether each Service has a process to support the various cost estimates that have to be prepared for program manager's estimates, COEAs, and independent cost estimates (ICEs). We decided that there is, within each service a process and/or organization which prepares these various cost estimates. Further, as the chart shows, the processes and organizations differ from one service to the next, but that the lack of organizational uniformity is not worrisome.

Consistency In Cost Estimates

The new DODI 5000 series requires that there be consistency among the various cost estimates that have to be prepared for program manager's estimates, COEAs, and independent cost estimates (ICEs). There was concern that there were not processes in place within the Services to ensure that consistency. After discussing the issue within the Working Group, we decided that there is, for each service, a consistency filter.

- For the Army, USACEAC participates in the creation of the Army Cost Position, so it is in the position to ensure consistency among the various cost estimates.

- The Air Force holds its own internal CAIG, and this forum permits enough insight into the various cost estimates to provide the requisite consistency check.

- For the Navy, the Naval Center for Cost Analysis (NCA) generates the ICE, reviews the PM's estimate, and serves on the COEA Oversight Board. This "triple-threat" by the NCA provides the Navy with a consistency filter. [Now I get to tell my boss, the Director of the Naval Center for Cost Analysis, of this newly-discovered mission of the organization.]

Cost Approaches In Support Of Acquisition Phases

We discussed the cost analysis methodologies that exist and their use in the various milestone phases. As a program moves from Milestone I to II to III, the specificity of program definition increases (and uncertainty decreases), but the uncertainty is embedded in the programmatics, rather than in the CERs that are used for the cost estimate. We concluded that the advent of COEAs does not alter this matrix or this observation. We also observed that the validity of CERs is like cheese -- it has a perishable shelf life; As the underlying data base ages and obsolesces, so does the validity of the CER decline. There is a constant need to update data bases in order to reflect current technology and acquisition environments.

If, for example, DoD enacts an acquisition policy is enacted that fosters development of technologies but forgoes their incorporation into production units, then R&D costs will, arguably, rise significantly, and R&D CERs will have to be updated to reflect this new acquisition environment.

Source Of Estimating Risk And Uncertainty

Risk and uncertainty are major issues in cost estimation. Of the four sources of estimating risk and uncertainty, three of them (uncertainty in requirements, uncertainty in the ultimate design solutions and uncertainty in the timely availability of appropriate technology) are program-related, while one (the inherent uncertainty in statistically based estimating methods) has to do with the adequacy of cost estimating tools. The working group concluded that the cost analysis community has to be involved in the analysis process from the earliest possible time, and its involvement should continue throughout the analysis process.

Summary

The items on this chart summarize the important items from the working group.

- Linkage and consistency among cost estimates is important, and seems to be in hand.
- Risk and uncertainty cannot be ignored. Program risk should abate as a program moves through its milestone process.
- Updating cost tools is a continuing process, which requires people and funds. Cost estimating tools are perishable as the acquisition environment (e.g., business base, acquisition strategy, etc.) changes.
- Early involvement by the cost estimating community is critical for credible and useful COEAs. 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.

MORS COEA
MINI-SYMPOSIUM
MARCH 9-11, 1992

COSTING METHODOLOGY WORKING GROUP

CHAIRMAN
Dr. Dan Nussbaum
NCCA

THE FIRST WORD IN COEA IS...

COST

SERVICE COST ESTIMATE LINKAGE

ARMY	PM	COEA	ICE	ACP
NAVY	PEO/AMC	TRADOC	CEAC	CEAC (PM/COEA/ ICE)
	SYSTEM COMMAND	SYSTEM COMMAND	NCA	
USAF	PRODUCT DIVISION	OPERATIONAL COMMAND	PRODUCT DIVISION/ SAF(FM)	

BOTTOM LINE: THREE DIFFERENT PROCESSES ALL SEEM TO WORK

CONSISTENCY IN COST ESTIMATES

- HOW DO WE ENSURE CONSISTENCY BETWEEN THE COEA AND SERVICE COST ESTIMATES PREPARED FOR THE DAB?
- ENSURED BY SERVICE COST REVIEW
  - ARMY COST POSITION
  - NAVY COEA OVERSIGHT BOARD
  - USAF CAIG REVIEW

COST APPROACHES IN SUPPORT OF ACQUISITION PHASES

MILESTONE / COST TOOL	0	I	II	III	
PARAMETRIC	X	X	X		
ANALOGY		X	X		
BOTTOM UP			X	X	X

TIME - - ► DEFINITION INCREASES
UNCERTAINTY DECREASES

- - ► TOOLS/CERS NEED UPDATING AND IMPROVEMENT

CHALLENGE: ADJUST HISTORICAL DATA TO REFLECT FUTURE TECHNOLOGY AND ENVIRONMENT (THIS COSTS $$)

EXAMPLE: R&D WILL INCREASE "SIGNIFICANTLY" IF POLICY TO PUT SYSTEMS ON THE SHELF PREVAILS

SOURCES OF ESTIMATING UNCERTAIN RISK

- REQUIREMENTS (THREAT)
- DESIGN SOLUTIONS
- TECHNOLOGY AVAILABILITY
- ESTIMATING METHODS

SOURCES OF ESTIMATING & ANALYSIS OF ALTERNATIVES

- ESTABLISH LINKAGE/CONSISTENCY WITH DESIGN AND REQUIREMENTS PROCESS
- EXPLORE TRADEOFFS BETWEEN COST AND MILITARY UTILITY (THRESHOLDS/OBJECTIVES)
- ADDRESS RISK AND UNCERTAINTY
- SENSITIVITY ANALYSIS
- IDENTIFY COST DRIVERS (BOUNDS)
- RANK ORDER AND BOUNDED ESTIMATES FOR DM

  - COMPLETED IN COEA

COST ANALYSIS APPROACH

- BASELINE (CARD)
- ASSUMPTIONS & GROUND RULES] CONSISTENCY LINKAGE
- WBS
- MODEL
- ESTIMATES
- SENSITIVITY ANALYSIS
- EVALUATION

SUMMARY

- LINKAGE/CONSISTENCY AMONG COST ESTIMATES IS IMPORTANT
- RISK & UNCERTAINTY CANNOT BE IGNORED
- UPDATING COST TOOLS IS A CONTINUING PROCESS AND REQUIRES PEOPLE AND FUNDS
- EARLY COST COMMUNITY INVOLVEMENT IS CRITICAL
- COST FORCES PROGRAM DEFINITION AND CLARITY

4.6 Report of the COEA Management Working Group

Issue #1: Role of Contractor in the COEA

- Similar to that of current program support or SETA efforts
- Impacts are:

  1) ability to provide professional, skilled resource pool-continuity,

  2) availability of unique, specialized analytical tools, and

  3) direct cost to service/program office
- Use of contractor requires careful screening for both capability and ensuring independent/objective work (contractor accepting such work must be willing to exclude the company/corporation from other work on the program)
- Independent/objective work is not likely if contractor "answers" to PM. Best management technique is to have contractor responsive to COEA oversight committee, or similar group.
- OSD could provide list of desirable skills to help in preparation of RFP and contractor selection
- Draft RFP requirement statements may help
- Team stopped short of recommending OSD list of "approved" or "recommended" contractors for COEA support services

Issue #1a: Role of FFRDC in COEA

- FFRDCs best suited for general COEA support, not work related directly to a specific COEA.
- Rationale: FFRDCs usually not responsive to hard deadlines, not well-suited to represent service interests in COEA. FFRDC talent is better suited to study more general subject related to COEA such as policy implications, the development or analysis of COEAs models, the development or analysis of COEA models, the development of new analysis techniques, etc.
- OSD may recommend services establish policies consistent with the FFRDCs role in COEA
- COEA model development COEA policy analysis (Research areas)
- Action: MORS recommend process improvement and modeling and analytical techniques

Issue #2: Structure of COEA Oversight Board

- Establish with experienced/senior individuals from key involved organizations both user and acquisition who can contribute to successful conduct of the COEA.
- This oversight board will enhance the credibility of the analysis.
- Allows for a good, viable method to include sister service input.
- Builds consensus support for the COEA.
- Provides authority for the study director.
- Core members of oversight body: user/combat developer, acquisition executive/system developer, intel rep., T&E rep., Materiel developer/systems command rep., cost estimating rep. Departmental resource allocation manager, i.e., AF/PE, DA (PA&E), OP-80 for affordability expertise), other service representatives, OSD (observer).

Issue #3: Role of COEA Oversight Board

- Define and focus the COEA on key decisionmaker issues.
- Recommend approval of the COEA study plan.
- Assist in definition of COEA issues.

- Conduct periodic reviews of COEA progress.
- Recommend approval and release of COEA findings.
- Provide advice and council to study direction in planning and executing COEA.

Issue #4: Support and/or Assistance to the Study Director

- Establish an Advisory Working Group (AWG) chaired by the study director.
- AWG represented by each organization on the oversight board and other COEA participants.
- AWG assists in the formulation of the COEA study plan.
- AWG members assist COEA execution.

Issue #5: Coordination of Contributors (threat, data, modelling, cost, tests, and others)

- In reality, this is not an OR issue, but instead is a management issue. As in the case of any effort involving a variety of talents and organization, the smart move is to coordinate efforts via a plan. This plan contains elements pertaining to schedule, tasking, requiring resources and expected output(s).
- Inherent in formulation of the plan are inputs from the subordinate organization that will support production of the final product. This insures that supporting organizations have some sense of having bought into the plan.
- As a final element, the plan must be approved at an appropriate level of seniority such that the approved plan is effective.

Issue #6: Responsiveness of COEA to the Changes

- Impact: By not designing the initial COEA to be responsive to future changes, the next (follow-on) COEA may be just as hard and resource intensive as the original study; and we may have to restart at MS 0, or even could jeopardize the entire program.
- Action: Structure one's initial COEA broad enough via parametric bounding to look at "ranges" of threats, scenarios, effectiveness and cost.

Issue #7: Contribution of Senior Service Colleges/ Universities Through Enhancement of Education

- Impact: Obviously, senior colleges/universities can have little role in performing COEA, due to timeliness, schedule, and accountability issues. However, they can contribute immeasurably to educating senior folks as to COEA processes and issues.
- Policy implication: No direct impact upon policy.
- Research Applications: Primary issue would be general PME regarding COEA processes and issues. Might also become involved in tool/process building.
- Action: Include COEA case studies in PME. Examine tool applicability including but not limited to wargaming and simulations.

Issue #8: Focus on the Service Role in COEA Development

- PM involvement becomes more focused past MS I.
- Essential that developer be involved in pre MS I analysis.
- Impact: Service is best qualified in operations environment and links requirements and programming functions. PA&E interface.
- Problem areas are: service only perspective and questions on objectivity.
- Full integration of joint programs and theater level analysis.
- Oversight and guidance: Policy implication of senior lead, who funds effort and accomplishes analysis, differences in service procedures, who decides what is correct.
- Research Areas: Review different processes for COEA effectiveness, need for joint

modelling, development of campaign analysis at theater level.

- Actions: Examine different processes, development of flexible tools, can the process be streamlined, joint service modelling.
- Assumptions: PM (Developer) has to be involved throughout the process with role increasing as program matures.
- Contractor support is dependent on value added capability.
- Warfighters are ultimately responsible for efforts.

Issue #8a: Role of the Program Manager in COEA

- Impact: PM participation in COEA is critically important but participation must be balanced by equally critical participation of "user" or "warfighting" service representatives. Role of PM is service dependent and also dependent on program maturity {PM role changes as program matures}. PM is best source for system capabilities, realistic program schedules, developmental costs, etc. PM influence may need to be controlled in earliest stages of program development to permit objective consideration of widest range of options
- Policy: PM role is service controlled. Service-run, COEA oversight committees are probably best suited to make the best use of PM's contribution.
- Research Area: Unknown
- Action: Use PM wisely.

Issue #9: Potential Management Techniques at the Study Director Level

- Must be tailored to issue/program.
- Capability required.
- Time/Resources available.
- Study director (SD) has latitude to select.
- Cost may direct size/scope available.
- SDs basic management/leadership style.

Issue #10: Funding and/or Sponsorship of COEA

- MS 0/1, service HQs. (see viewgraph)
- Remember reasons for new capability, to correct a deficiency, and exploit an opportunity.
- Resources for studies at risk.

Issue #11: Best Organizational Structure to Facilitate COEA Processes

- See viewgraph for organizational structure answer.

Closing Statement

Active participation of <u>both</u> user and acquisition communities is essential to successful completion of a COEA!

MORS COEA
MINI-SYMPOSIUM
MARCH 9-11,1992

COEA MANAGEMENT
WORKING GROUP

CHAIRMAN
LtCol Don Bourdon
NAVAL WAR COLLEGE

COEA MANAGEMENT

OVERSIGHT BOARD CORE MEMBERSHIP

- WARFIGHTER/USER
- ACQUISITION/DEVELOPER
- TEST AND EVALUATION
- INTELLIGENCE COMMUNITY
- COST COMMUNITY
- PPBS/PROGRAMMING

COEA MANAGEMENT

DECISION MAKER ISSUES THAT MUST BE ADDRESSED BY A COEA

- WHY IS A NEW START ACQUISITION REQUIRED (ANALYTICAL UNDERPINNINGS)?
- WHAT DRIVES EFFECTIVENESS?
- WHAT DRIVES COST?
- WHAT DRIVES THE ACQUISITION MILESTONE DECISION SCHEDULE?

COEA MANAGEMENT

FUNDAMENTAL ISSUES IN COEA MANAGEMENT (CONTINUED)

- DEVELOPING SIMULATION MODELS/TOOLS TO PERMIT TIMELY, COST EFFECTIVE, CREDIBLE ANALYSIS OF JOINT CAMPAIGN LEVEL ISSUES IS A PRIORITY NEED
- BUILDING A TRUSTING RELATIONSHIP BETWEEN THE WARFIGHTER, THE ACQUISITION COMMAND, AND OSD NECESSITATES FULL AND OPEN DISCUSSION AS COEA PROCEEDS

COEA MANAGEMENT

FUNDAMENTAL ISSUES IN COEA MANAGEMENT (CONTINUED)

- ESTABLISHING AN OVERSIGHT BOARD/ SENIOR ADVISORY GROUP TO PROVIDE ADVICE AND COUNSEL TO STUDY DIRECTOR IS VITAL
- ESTABLISING A WORKING LEVEL STUDY TEAM/ADVISORY GROUP TO SUPPORT THE STUDY DIRECTOR IN THE EXECUTION OF THE COEA FACILITATES TIMELY STUDY COMPLETION

COEA MANAGEMENT

•ISSUE: WHAT SHOULD BE THE ROLE OF THE OVERSIGHT BODY IN THE DEVELOPMENT AND CONDUCT OF A COEA?

•IMPACT: THE OVERSIGHT BODY SHOULD ASSIST IN THE DEFINITION

DECISION MAKER ISSUES

EXAMPLES

- IS A NEW START WARRANTED?
- WHAT DRIVES SYSTEM EFF.?
- WHAT DRIVES COST?
- WHAT DRIVES THE MS DECISION SCH.?

STUDY PLAN EXAMPLES

- ALTERNATIVES
- SCENARIOS/MODELS
- THREAT CAPABILITY
- MOEs
- ASSUMPTIONS
- TASKING AUTHORITY
- APPROACH/METHODOLOGY

• IN EACH CASE, WHAT TRADE-OFFS SHOULD BE INVESTIGATED?

•POLICY: None •RESEARCH AREA: N/A •ACTION: N/A

COEA MANAGEMENT

ACTIVE PARTICIPATION OF BOTH USER AND ACQUISITION COMMUNITIES IS ESSENTIAL TO SUCCESSFUL COMPLETION OF A COEA!

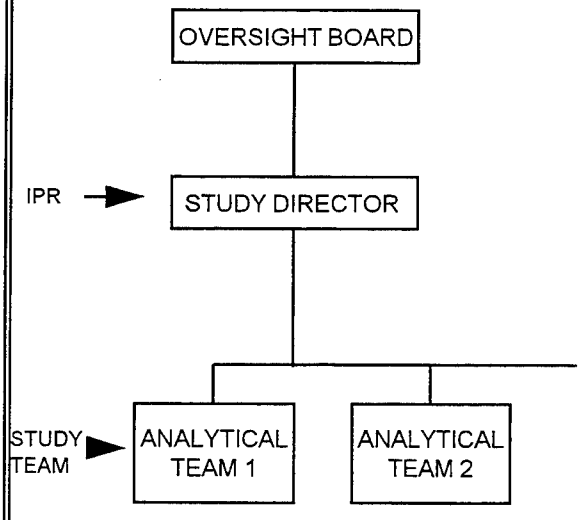
COEA MANAGEMENT

- ISSUE: How to make COEA responsive?
- IMPACT:
  - -May make follow-on COEA as extensive as predecessor (unnecessarily spend resources, $$, people, time)
  - -May have to restart/cancel program
- POLICY: N/A
- RESEARCH AREA: N/A
- ACTIONS: Structure original COEA broadly enough via parametric bounding--look at:
  - -ranges of threat and scenarios, levels of effectiveness

COEA MANAGEMENT

- ISSUE: How to coordinate COEA contributors?
- IMPACT: Lack of coordination could...
  - -Answer wrong questions
  - -Make analysis hard to sell
  - -Allow one to use wrong inputs/data
  - -Not co-opt contributors
- POLICY: N/A
- RESEARCH AREA: N/A
- ACTIONS: COEA Management should have an approved study plan, SAG (SMEs), and frequent IPRs

COEA MANAGEMENT



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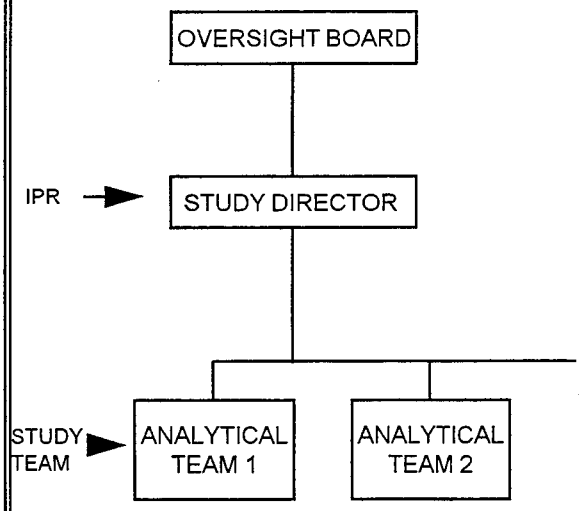

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MORS COEA MINI-SYMPOSIUM MARCH 9-11, 1992

FUTURE DIRECTIONS WORKING GROUP

CHAIRMAN
MIKE BAUMAN
US ARMY TRAC

ISSUE:

SHOULD COEA BE AVAILABLE TO SOURCE SELECT AUTHORITY

POINTS:

- SS CRITERIA CONSIDER PGM FACTORS BEYOND COST EFF
- IF COEA IS SS CRITERIA, MUST BE RELEASED TO BIDDERS (SUBJECT TO LEGAL INTERPRETATION)
- COEA MAY CONTAIN PROPRIETARY/COMPETITION SENSITIVE INFO, WHEN SANITIZED, LIMITS COEA UTILITY

IMPACT ON COEA:

- MAY COMPLICATE EXECUTION (BIDDERS REVIEW M&S)
- POTENTIALLY EXPANDS SCOPE BEYOND COEA ISSUES

POLICY IMPLICATIONS: N/A

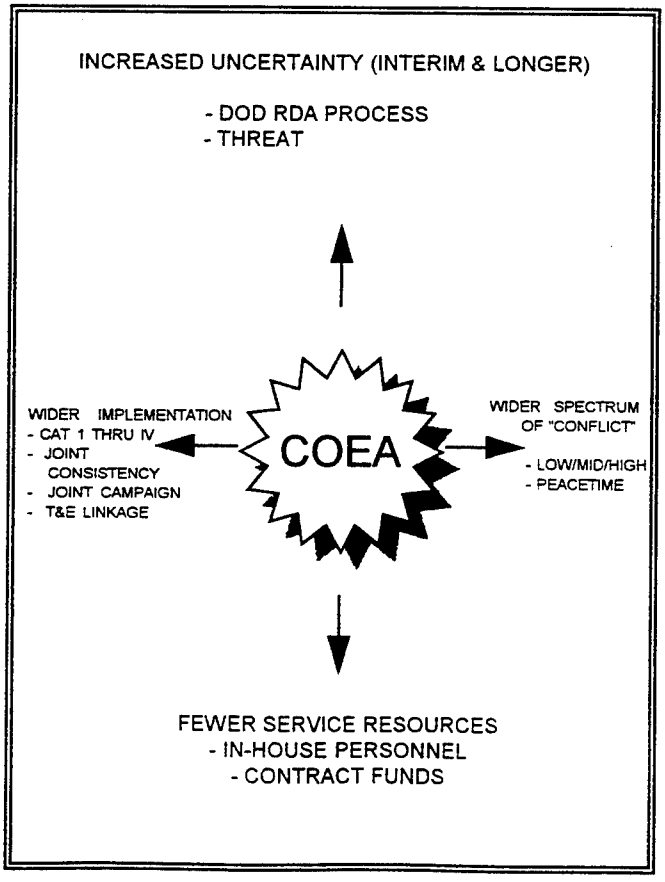
RESEARCH TOPICS: N/A FOR OPERATIONS RESEARCH

REQUIRED ACTIONS:

- LEGAL RULING AS TO WHETHER COEA (W/PROPRIETARY INFO) CAN BE PROVIDED TO SSA W/O MANDATORY RELEASE TO BIDDERS OR W/O SANITIZING (LEAD: SERVICE DEPT HQ)

MILITARY ENVIRONMENT

THEN	NOW (& FUTURE?)
BI-POLAR WORLD	MULTI-POLAR WORLD
MONOLITHIC THREAT	DIFFUSED THREATS
CONTAINMENT	CRISIS RESPONSE
EUROPE-SOVIETS	REGIONAL-GLOBAL ADVERSARIES
FORWARD-BASED	CONUS-BASED
ATTRITION WARFARE	PRECISION WARFARE
STRUCTURED FORCES	TAILORED FORCES
28 DIV-36 WINGS-600 SHIPS	SMALLER BASE FORCES (MUCH SMALLER?)
STRATEGIC NUKES	REGIONAL NUKES



VARIETY OF CONCERNS

- GROWING UNCERTAINTIES - BUT ANALYSIS NOT EVIDENT
- REQ'D ORIGINALITY NOT EVIDENT - TOOLS INADEQUATE
- FLEXIBILITY/TRAINING MUST BE RECONCILED WITH NEED FOR ACCEPTANCE/CREDIBILITY
- MORE REQUIREMENTS - BUT FEWER RESOURCES !
- SHOULD DO MORE JOINT COEA - POOL RESOURCES ?
- ALL PARTIES WITH VESTED INTEREST MUST GET CHANCE TO PARTICIPATE
- WHAT'S IMPACT OF "NON-PROCUREMENT" ON COEA ?
- WHAT'S PROPER ROLE FOR CONTRACTOR IN COEAs ?
- SCOPE LIMITED - E.G., NO "WHAT IFS" ABOUT DEPLOYMENT ?

VARIETY OF CONCERNS (CONT)

- THREAT ? THREAT ?? THREAT ???
  - LONG RANGE ESTIMATE
  - HOW DO WE BUILD REQ'D DETAIL IN BROAD ESTIMATE?
  - HOW DO WE GAIN CONSENSUS ON THE COEA THREAT?
- HOW DO WE APPLY "CAT I/CAT II PROCEDURES" TO III/IV?
- COEA CONTEXT FOR NON-THREAT DRIVEN SYSTEMS
- SHOULD COEA ADDRESS AFFORDABILITY? IF YES, HOW?
- HOW DO WE CONVINCE DECISION MAKERS THAT LEVEL OF DETAIL MUST DECREASE?
- WHAT ARE PITFALLS OF COEA PROCESS AND HOW AVOIDED?

VARIETY OF CONCERNS (CONT)

- HOW DO WE ADDRESS MIL-POLITICAL ASPECTS OF LESS INTENSE REGIONAL CONFLICTS? METHODS? MOE?
- SHOULD SOURCE SELECTION DECISIONS USE COEA? IF YES, WHAT ARE IMPEDIMENTS - HOW ELIMINATED?
- MDR IV SHOULD BE DISCOURAGED, EXCEPTION ONLY.
- HOW TO MINIMIZE ORGANIZATIONAL BIASES THAT UNDERMINE CREDIBILITY? E.G., PM PAYING FOR COEA
- HOW TO RECONCILE TREND TOWARD STANDARDIZATION WITH NEED FOR INNOVATION, ORIGINALITY AND TAILORING?

ISSUE:

- UNDER WHAT CONDITIONS, AND HOW, TO DO JOINT COEA?

POINTS:

- TWO TYPES OF JOINT: CONTEXTUAL AND MULTI-SERVICE TEAM
- SERVICES DIVERSITY OF MODELS, SCENARIOS, & DATA BASES
- SERVICE PAROCHIALISMS ARE AN IMPEDIMENT
- JOINTLY AGREED REQM'TS MAY HAVE CONFLICTING PRIORITIES
- CONSENSUS ON COEA RESULTS MAY BE BIGGEST HURDLE

IMPACT ON COEA:

- EXECUTION COMPLEXITIES MAY INCREASE COST & SCHEDULE
- MGMT AND OVERSIGHT MAY BE COMPLICATED AND ONEROUS

POLICY IMPLICATIONS: NEED ONE TO BEGIN WITH

RESEARCH TOPICS:

- JOINT REVIEW/APPROVAL PROCESS
- POTENTIAL USE OF FFRDC AS JOINT COEA AGENCY

REQUIRED ACTIONS: OSD(PA&E) - "GO FIGURE"

ISSUE:

- WHAT ROLE, IF ANY, SHOULD CONTRACTORS PLAY IN COEA?

POINTS:

- CONTRACTORS MAY PARTICIPATE IN ALL ASPECTS OF COEA, BUT:

- PROGRAM COMPETITORS (BIDDERS) SHOULD NOT
- CONT'R AFFILIATED W/ OR SUPPORTING BIDS SHOULD NOT
- CONT'R SHOULD DISQUALIFY FROM FUTURE PGM INVOLVEMENT

- COEA RECOMMENDATIONS ARE EXCLUSIVE DOMAIN OF GOV'T
- JOINTLY AGREED REQM'TS MAY HAVE CONFLICTING PRIORITIES
- PM MAY FUND, BUT BE COMPLETELY DIVORCED FROM CONTROLS (NOT COR/COTR)

IMPACT ON COEA:

- LEVERAGE SPECIALIZED EXPERTISE
- READILY AVAILABLE, FEWER COMPETING PRIORITIES THAN GOV'T

POLICY IMPLICATIONS:

- RISK NONCOMPLIANCE W/O ADEQUATE RESOURCE-PEOPLE/FUNDS

RESEARCH TOPICS:

1. ROLE FOR UNFUNDED CONTRACTOR STUDIES IN COEA?
2. RQM'TS FOR TASK-ORDER TYPE CONTRACTORS, MASTERS & SPECIA
3. IMPROVE ACCESSIBILITY OF COEA RELATED INFO TO INDUSTRY

REQUIRED ACTIONS

1. USD(A); PA&E, OSD GEN COUNSEL, SERVICES
2. USE(A) LEAD; PA&E, GAO, SERVICES
3. USD(A) LEAD; OSD GEN COUNSEL, SERVICES, INDUSTRY

ISSUE:

- HOW SHOULD THREAT BE ADDRESSED IN FUTURE COEA?

POINTS:

- A SPECIFIC THREAT IS NO LONGER CLEAR, NOW AMBIGUOUS
- NEED LIMITED # PLAUSIBLE THREATS & SPECTRUM OF CONFLICTS
- MUST CONSIDER:
- HOW FORMIDABLE (SIZE, MODERN, DOCTRINE, CAPABILITY)?
- HOW FAR FROM U.S. FORCES?
- HOW LIKELY?

IMPACT ON COEA:

- SCOPE AND TIME EXPANDED
- TRANSITION FROM SINGLE THREAT-BASED TO RANGE OF CAPABILITIES BASED ON SPECTRUM OF THREAT

POLICY IMPLICATIONS: N/A

REQUIRED ACTIONS:

- DEVELOP MEANS TO ENSURE AVAILABILITY OF JOINT THREAT
- OSD(PA&E) LEAD; DOD AND SERVICE INTEL AGENCIES
- STATEMENT (DETAILED DESCRIPTIONS USING DPG AS VEHICLE)

ISSUE:

- HOW SHOULD FUTURE COEA ADDRESS NEW: (1) CONFLICT OBJECTIVES, AND (2) PEACETIME OBJECTIVES?

POINTS:

- NON-TRADITIONAL CONTEXT AND CONSIDERATIONS
- NEW OBJECTIVES RELATED TO: (1) CIVILIAN CASUALTIES, COLLATERAL DAMAGE, ENVIRONMENTAL DAMAGE, MILITARY CASUALTIES, CAPTURE AVOIDANCE; AND (2) INDUSTRIAL BASE READINESS/RECONSTITUTION, COUNTER-NARCOTICS, NATION-BUILDING, POLITICAL GOALS

IMPACT ON COEA:

- REQUIRED RADICALLY NEW MOE's
- ORIGINALITY AND INNOVATION IS A PREREQUISITE
- MAY BE DIFFICULT TO SELL; CREDIBILITY WILL BE ISSUE

POLICY IMPLICATIONS:

- INTERPRET TO ENCOURAGE FLEXIBILITY, RECOGINITION OF NON-TRADITIONAL MOE
- FOSTER EXCHANGE OF IDEAS THRU COEA DIST; MORS SYM

RESEARCH TOPICS: NEW MOE's

REQUIRED ACTIONS: OSD(PA&E); MORS

CHAPTER 5
REPORT OF THE
SYNTHESIS WORKING GROUP

Clayton J. Thomas

This report of the Synthesis Group (SYNGRP) to the COEA Mini-Symposium at Newport represents the combined views of all twelve group members. Each of us is a military operations research analyst and we circulated around the sessions looking for military OR issues. This is a summary of our findings:

I introduced the synthesis group concept and our membership. Jerry Goldschmidt, Navy Sponsor's representative to MORS, summarized effectiveness issues including those bearing on the linkage of test and evaluation (T&E) to COEAs. Gerry McNicols, CEO of Management Consulting and Research, summarized cost analysis issues. Finally, Gene Visco, Army Sponsor's representative to MORS, presented integration issues that are tied to both cost and effectiveness estimation. He also included ideas for future directions in the performance of COEAs.

SYNGRP Outline

I'll explain the purpose of the synthesis group, its membership and the three issues we focused on: effectiveness, cost and integration.

SYNGRP Purpose

The purpose of the SYNGRP was to focus on MOR issues. Administrative aspects of COEAs were not of direct interest. Of special interest were examples that pointed to a need for new OR methodologies or better use of existing techniques.

SYNGRP Members

The members of the SYNGRP are listed here. Among these members there is a depth of MOR experience in cost and effectiveness estimation and in service and agency perspectives. Half of the SYNGRP had served in a similar capacity at a previous mini-symposium.

SYNGRP Posts

We positioned our members to sample as many discussions and perspectives as possible. We had at least one member in each of the working groups and in three working groups there were two. Additionally, three SYNGRP members were in rotating posts. Thomas followed the Topic 1, 6, and 7 experts. Visco shadowed Topic 2, 5, and 9 experts. Goldschmidt followed Topic 3, 4, and 8 experts.

Effectiveness Issues

Joint COEAs reflect joint operations and/or consider options from more than one service. We have experienced many difficulties in evaluating options that involve more than one component of a single service. These are compounded and intensified in joint COEAs limitations of current service models, data bases, and experience, suggest that joint COEAs may require contributions from joint staff and/or more than one service.

New technology, such as "DIS" (Distributed Interactive Simulation) permits greater operational realism and flexibility in military simulations. To derive full benefits from such technological advances and to permit sharing of separate data bases, we must establish suitable standards and protocols, and DMSO — The Defense Modeling and Simulations Office — can help in this.

Guidance for COEAs emphasizes several "linkages." First is linkage of measures of engineering performance (MOPS) to intermediate measures of "encounter" effectiveness (MOES) to high level campaign measures of operational outcomes (MOOS). We can test MOPS and sometimes MOES but very often we can evaluate MOES and almost always MOOS, only through some kind of simulation. Second is linkage of effectiveness measure estimates and cost estimates to ensure that they apply to the same system.

Much recent guidance for COEAs deals with requirements for campaign analysis. Even defining these poses difficulties and accomplishing them leads to many more. If they could be well performed and adequately reflect a commander's operational art, they would greatly enhance the values of COEAs. Some current efforts hold promise, but many further steps are needed to achieve potential.

Cost Issues

Cross training of effectiveness analysts and cost analysts could help those in each community, but especially effectiveness analysts. Now, e.g., many effectiveness analysts see the need to carefully define the parameters of their estimates, but may ask "what is the cost" without regard to quantity, constant or then-year dollars, force or system content, etc. Thus cost is often the forgotten half of cost-effectiveness analysis.

Better macro level parametric cost models would permit quick reaction cost tradeoffs in early stages of analysis and the quick evaluation of enough options to better ensure the identification of better alternatives.

Better risk and uncertainty analysis models would lead to better identification of cost drivers to robust COEAs and thus to better decision support.

A new acquisition strategy, putting systems "on the shelf" after development, will require cost estimating methodologies to put more weight on R&D costs vs life cycle costs.

Different speakers in the mini-symposium disagreed on how to couple cost and effectiveness estimates in COEAs. Research is needed to develop definition or new approaches as a basis for clarifying policy.

For a cost estimate, a cost analyst currently writes a "card" (cost analysis requirement document) to define/specify the system or force under study. Should a COEA always require such a CARD and should effectiveness analysts also play a role?

Integration Issues

It is trite to note the culture shock of dramatic threat changes, burgeoning technology, and shrinking budgets, but the shock is nonetheless real. The analytic community has tremendous opportunities but faces unprecedented challenges; integrating these is issue one.

Meeting the challenges requires true thought and defies "cookbook recipe." In particular, we must see models as tools and not as panaceas. We must resist those who misuse "models" as an icon, to the neglect of a concern for data and well structured analysis.

The challenges include not only the linkage of measures and of cost to effectiveness but also higher level questions of affordability and sustainability. The question of affordability transcends a COEA for a single system and involves consideration of multiple systems competing for scarce dollars but may be painfully relevant to system acquisition. Sustainability may refer to troops on a battlefield or a nation's industrial base but each is essential to support of national strategies and therefore an essential consideration in system and force decisions.

More use of joint and combined forces, the changing density of engaged troops and the new technologies all require new techniques and development in decision art and science.

To some of us, this implies more use of traditional interdisciplinary teams and increased interrelationships among analysis groups and institutions.

EFFECTIVENESS ISSUES

Potential OR Problems

As Clayton Thomas just noted, our group focused on effectiveness and T&E issues. We also followed modeling and tools (Sam Gardiner), operational effectiveness methodologies (Tony Brinkley), and linkage of performance effectiveness (Lese, Ledesma and Seglie). We focused on effectiveness methodology and linkage. We developed four issues based on a combination of what participants in this mini-symposium articulated and our own personal views.

EFfectiveness Issue 1

Our first issue deals with jointness in effectiveness analysis. The future directions working group made excellent comments on this issue and raised the problem of how to oversee and provide oversight. We have similar concerns.

By "joint COEAs" we are referring to COEAs that reflect operations and that consider options from more than one service. We have seen problems within single services with respect to options that consider more than one component of the service and recognize that this is a difficult thing to do. We believe some thought should be given to how well a single service can do a joint COEA and what role, if any, JCS and the

CINCs might have with respect to joint COEAs. We also believe current service models may not be adequate to consider jointness because most of them focus on single service operations. And, jointness is related to the issues of campaign analysis because campaign models must reflect joint operations.

We see several long range impacts related to proper consideration of jointness in our COEA effectiveness analysis. These include potential for cheaper solutions, potential for more operational capabilities, better ties between the acquisition process and how we fight, and more inter-service analyst exchanges similar to the CAA/AFSA exchange mentioned by Walt Hollis. As RADM Allen noted yesterday, if people don't get on board (with respect to jointness) they will be left behind.

Effectiveness Issue 2

Our second issue deals with the use of new technology to improve modeling. Today, we can do things we would not have dreamed of ten years ago. For example, today DIS allows us to conduct simulations that include widely dispersed participants, including operational units from several services, thereby leading to more operational realism in these joint operations. We also believe that by establishing standards and protocols, it will allow us to address specific issue thereby allowing us to deal with uncertainty in a much better fashion than we can today. It is also important to develop our systems so we can share data bases. Finally, we must work with the DMSO on these issues because they are heavily involved with this issue and if these items are not properly defined, they could be counter productive.

We see the potential for significant impact from the proper use of new technologies in the areas of increased flexibility, reduced costs, enhanced efficiency and more operational realism.

Effectiveness Issue 3

The T&E working group made excellent comments on the issue of linkage between COEAs and T&E. It noted that we must develop criteria to establish this linkage to ensure that modeling and simulation techniques used for COEAs also support the T&E for the system as it is developed.

As analysts involved in COEAs, we must interface with the T&E community to develop an understanding of the types of tests they will conduct so the methodologies developed and used for COEAs and T&E are comparable and estimate the same MOEs. Further, the methodology must establish relationships between the MOEs/MOPs used for T&E so that it is possible to show how changes in lower level measures drive the higher level measures (e.g., aircraft losses) that often cannot be measured through T&E because of cost or loss of life. These relationships can then be used by the T&E community to examine sensitivities of variables they cannot measure to other variables to determine which ones have a major impact on operational outcomes. These results can be used by the T&E community to select appropriate variables for testing.

We see the potential for significant impact from the proper linkage between COEAs and T&E through more credible and consistent COEAs and testing and systems which serve warfighting needs.

Effectiveness Issue 4

The effectiveness working group made excellent comments on the issue of campaign analysis. We agree that it is tough to define campaign analysis. Guidance is needed.

First, campaign analysis means different things to different people. We must develop a common definition. Second, we develop guidance regarding when analyses are appropriate. We clearly saw their value in conducting mission area analysis (MAA) to determine requirements, but did not see a clear value in the later milestones for system development. Other questions that must be answered include who does them, how do we establish credibility and what are the proper MOEs.

We also heard comments on this issue from two of our senior panel members. MG Ralston noted that linking models to campaign output is a weak area. Mr. Hollis noted that we need new tools and methods to allow us to conduct campaign models properly.

We see the potential for significant impact from proper use of campaign analysis through more consistent COEAs, better focus on military outcomes and better rationale.

Cost Issues

Let me note that some cost analysts believe they have divine guidance by quoting the New Testament verse: LUKE 14:28.

We identified the following six cost issues:

1) cross-training,

2) the need for better macro level parametric cost models,

3) the need for better risk and uncertainty analysis models,

4) the lack of a methodology to properly weight and cost R&D if systems are "put on the shelf" after development as the potential new acquisition strategy may require,

5) the need for new techniques for cost effectiveness comparison and coupling,

6) the need for and use of a cost analysis requirements document (and who should develop it).

Cross Training

Most effectiveness analysts will not answer the question "what is the effectiveness" without asking for clarification, e.g., at what altitude, dive angle, intervelometer setting, etc. But, they will then ask "what is the cost" without regard to quantity, constant or then-year dollars, force or system content, etc. Thus cost is typically the forgotten half of cost-effectiveness analysis.

Often the cost analysis is not brought into the early stages of COEA planning, yet cost issues could be anticipated, and the cost team could begin developing relevant data bases if they were "in at the beginning."

Impact on Analysis: The key impact on the analysis is that the costing is not of high quality when hurried. In addition, design trades by the cost team may lead to useful and better alternatives which can be added to the COEA.

Impact on Policy: None

Research Areas: The development of a cost methodology training course useful to all COEA participants.

Actions: An executive overview training course should be developed which would be used to familiarize all COEA team participants with cost, technical, and test issues relevant to the COEA. Initial team training should be an integral part of the COEA startup. A joint education conference between MORS and the Society of Cost Estimating and Analysis (SCEA) should be held.

Macro Level Parametric Cost Models

Cost analysis is often required very late or very early in the COEA process. There is typically insufficient time to apply detailed costing methodology.

In addition, parametric cost models which are performance parameter based are needed to allow various cost tradeoff analyses to be performed.

In the effectiveness side, measures of performance (MOP) have to relate to measures of operational output (MOO). It would be useful to have measures of cost (MOC) to relate to both of these. Such measures might include flyaway cost, weapon system, cost, acquisition cost, program cost, unit cost, cost per kill, etc.

Impact on Analysis: More macro level models would allow quick reaction cost tradeoffs to be conducted in the early stages of analysis to reduce the number of alternatives or to permit more "analysis" of costs rather than being spent on cost estimate generation.

Impact on policy: None

Research Areas: Development of macro level parametric cost models.

Actions: Develop new "quick response" methodologies or models with performance parameters. These would have to be sensitive to acquisition phase and be unique for each commodity class.

Risk And Uncertainty Models

A critical methodology problem is to identify the key "cost drivers" for each alternative. Such cost drivers should relate to the system performance or physical parameters. Each cost driver, however, is

subject to risk and uncertainty. Probability distributions can be developed and these can be aggregated to obtain a total cost uncertainty. New models to handle such uncertainty are needed. The analytical methodology exists.

Impact on Analysis: COEA would be more robust if uncertainties were explicitly handled.

Impact on Policy: Determining how such uncertainties in both cost and effectiveness should be treated.

Research Areas: The key research needed is to review the appropriate methodologies in the literature and develop new models to incorporate it.

Actions: Development of quick response methodologies and new risk models useful to the acquisition phase and commodity class. Standard presentation formats are needed to illustrate the importance of uncertainty in evaluating the selection of alternatives.

Costing And Weighing R&D

New techniques to estimate R&D are needed. The current "cost drivers" of research and prototype development are time and level of engineering effort (eg., size of engineering team). Current R&D cost data bases are poor, particularly with many recent firm fixed priced contracts allowing little or no cost visibility. It is also expensive to startup or reopen a cold production line since prototype systems may have been built with "soft" vs "hard" tooling. This could even result in the disappearance or production lines altogether.

Impact on Analysis: The analysis would be based on a cost different from life cycle cost.

Impact on Policy: The policy change would be to revise the LCD requirement in 5000.2

Research Areas: New, robust methods for determining R&D costs are needed.

Actions: The required actions are to develop new data bases and then new methodologies and models from this data.

Coupling Cost And Effectiveness

There was some confusion during the conference as to the proper comparisons. For example, one speaker said do not combine cost and effectiveness, but treat them separately. Another said use the analytical hierarchy process or utility theory. Dr. Chu said not to be artificially constrained to equal cost or equal effectiveness alternatives. The Army commonly uses force cost comparisons while the Air Force and Navy use systems and/or comparisons. Speakers talked about using "decision cost" versus life cycle cost comparisons and noted the consistency issue with baseline cost estimates (BCE) or independent cost estimates (ICE). Others noted that cost is peace-time driven while effectiveness is wartime driven.

Impact on Analysis: Define "upfront" what the assumptions and ground rules are for COEA.

Impact on Policy: A policy issue is to clarify what "decision costs" are relevant.

Research Areas and Actions: Research needs to be conducted to develop the appropriate definitions, clarifications or new approaches.

Developing Cards

For a cost estimate, a cost analyst currently writes CARD, but should the effectiveness analyst write CARD for the COEA. Should a COEA have a CARD which is currently only required for an ICE/BCE/POE?

Impact on Analysis: Specification and definition of alternative systems/forces is critical to the costing exercise.

Impact on Policy: A guidance document for a COEA would be a policy addition.

Research Areas/Action: Write a directive specifying the structure and contents of a CARD equivalent document.

INTEGRATION

Culture Shock

During the last two days, the synthesis group has observed the collective sense of culture shock invading the analysis community. Our traditional, well-

understood and well-analyzed threat has been uncooperative. Great technological opportunities loom for the future (eg SDI, non-lethal weapons), concurrent with these new forces, resources (money and people) are seriously reduced.

Related to these new forces, the Department of Defense is adopting new management techniques (e.g. TQM) and processes (e.g., systems acquisition, DMR, CMI) to increase efficiency in providing for the national defense.

The analytic community faces unprecedented demand and challenges to its capabilities.

Models Not Synonymous With Analysis

There has been much talk about the tools and materials of the analyst — the models and the data bases that feed them. One position holds that we need more campaign analyses while another argues against the time and expense involved in analyzing increasing numbers of scenarios. The latter group demands more quick-turnaround tools and top-down thinking.

Above all, it is important to remember that the emphasis here is on analysis — thinking to help the decision maker. However, much we may desire it, there will not be a cookbook solution to the varied and multifaceted problems we will confront. The ingredients and the utensils for each will be different; our job is to make the finished product palatable or at least edible.

We therefore strongly advise our colleagues to focus on that heavy investment (40% of the total study time) upfront for study planning, formulating the problem, obtaining the data, gathering the tools... and reacquainting ourselves with existing applicable techniques such as experimental design, sensitivity analyses and decision science to reduce uncertainty and deal with the risk increasing importance to our analysis.

Analytic Challenges

The new challenges are illustrated most emphatically by what has been termed here as linkage, the most obvious and familiar linkage is cost with effectiveness. Another is effectiveness to system measures that can be tested and translated to operational outcomes on the battlefield. A third (that many would prefer to ignore) is that of system effectiveness to allocation decisions — a vitally needed linkage. And, we have the problem of linkage in time — the problem of reconstitution, both of our industrial base in the event of major war in the future and of forces on the battlefield in the sense of tactical or operational levels.

The community must focus on the decisionmakers and the way to effectively provide them with information , which may be a lesson in decision science. There are "tactical" challenges also, for example, developing better understanding of the nonlinearaities of the battlefield or the changed densities (a challenge that seems to be a continuous one).

All the forgoing implies, to some of us at any rate, a return to the past; greater use of the true, traditional interdisciplinary teams; increased interrelationships among analysis group and institutions; further centralization of analysts.

Future Responsibilities

Despite present capacities to overcome difficult obstacles (to the present time, at least), we acknowledge the need for improvement. The multi-disciplinary communities must work together. In some ways there are many opportunities unfolding; the OSD initiative on modeling and simulations has a potential for improving linkage, at least in communications among and between the services, the Joint Staff and OSD and possibly influencing standards.

As pointed out, models and simulations are not substitutes for analysis — They are only particular tools. The military operations research community must improve its credibility with decision makers. One small step is to increase the transparency of our analysis, particularly the analysis that relies heavily or exclusively on computer models. Another contribution to credibility comes from improvements in verification, validation and accreditation process through events like the MORS Simval series of special meetings.

Improvements can not come solely from the efforts of the Services and the analysts regulations and guidelines must be carefully thought through. One recommendation the synthesis group makes is that an independent study be commissioned to define how the systems acquisition and resource allocation processes should work in this unprecedented era; perhaps an FFRDC could be charged with the responsibility.

MORS COEA
MINI-SYMPOSIUM
MARCH 9-11, 1992

SYNTHESIS WORKING GROUP

CHAIRMAN
Clayton Thomas
HQ USAF AFSAA

SYNTHESIS GROUP

PURPOSE

MEMBERS

EFFECTIVENESS ISSUES

COST ANALYSIS ISSUES

INTEGRATION ISSUES

SYNTHESIS GROUP PURPOSE

IDENTIFY MILITARY OPERATIONS RESEARCH ISSUES TO COEA ACCOMPLISHMENTS...

-- BY USING WORKING GROUP

-- PRESENTATION & DISCUSSIONS

AND

-- SYNTHESIZING

SYNTHESIS GROUP MEMBERS

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USA MISMA

SYNTHESIS GROUP OBSERVATION POSTS

POSTS	OBSERVERS
WG 1, TEST AND EVALUATION	GUSTAFSON
WG 2, THREAT ASSESSMENTS	SCHNURRPUSCH
WG 3, EFFECTIVENESS METHODS	BEXFIELD & KAYS
WG 4, COSTING METHODS	McNICOLS & RHODE
WG 5, COEA MANAGEMENT	BETTENCOURT
WG 6, FUTURE DIRECTIONS	HENNINGSEN & SMITH
TOPICS:1 (LESE), 2 (CASSADY), 3 (FEIGLEY)	THOMAS
TOPICS:2 (FAUSS), 5 (NUSSBAUM), 9 (DIAZ)	VISCO
TOPICS:3 (GARDNER), 4 (GARDNER), 8 (LESE, LEDESMA, SEGLIE)	GOLDSCHMIDT

EFFECTIVENESS ISSUES

JOINT COEAs

NEW TECHNOLOGIES:

- **DISTRIBUTED INTERACTIVE SIMULATION**
- **DATA SHARING**
- **STANDARDS**
- **DMSO**

LINKAGE:

- **MOPs/MOEs/MOOs, EFFECTIVENESS AND COST**

COMPAIGN ANALYSIS

COST ANALYSIS ISSUES

CROSS TRAINING: EFFECTIVENESS & COST ANALYSIS

BETTER MACRO-LEVEL PARAMETRIC COST MODELS

BETTER RISK & UNCERTAINTY ANALYSIS MODELS

MORE WEIGHT ON R&D COSTS FOR "PUT ON SHELF"

NEW WAYS TO COUPLE COSTS & EFFECTIVENESS

COST ANALYSIS RQMTS DOCUMENTS FOR COEAs

INTEGRATION ISSUES

CULTURE SHOCK:
THREAT, TECHNOLOGY, BUDGET

MODELS DO NOT AN ANALYSIS MAKE

CHALLENGES:
LINKAGES: MEASURES, C&E, AFFORDABILITY, SUSTAINABILITY

CHANGING BATTLEFIELD: JOINT, COMBINED, NON-LINEAR

DECISION ART AND SCIENCE

INTERDISCIPLINARY TEAMS
&
AGENCIES INTERRELATIONSHIPS

SYN GROUP: COST ISSUES

LUKE 14:28 **"FOR WHICH OF YOU, INTENDING TO BUILD A TOWER, SITTETH NOT DOWN FIRST, AND COUNTETH THE COST, WHETHER HE HAVE SUFFICIENT TO FINISH IT."**

OBJECTIVE: **IDENTIFY PROBLEMS IN ACCOMPLISHING COEAs WHERE ADVANCES IN MILITARY OPERATIONS RESEARCH METHODOLOGY OR PRACTICE ARE MOST NEEDED OR HIGHLY DESIRABLE.**

PRACTICE

ISSUE: CROSS TRAINING (E.G. COST AWARENESS TRAINING FOR EFFECTIVENESS ANALYSTS)

DISCUSSION:
- COST IS TYPICALLY THE FORGOTTEN HALF OF COST EFFECTIVENESS
- CONCENTRATION ON EFFECTIVENESS MODELS AND COMPLEXITY OF EFFECTIVENESS SCENARIOS OFTEN LEADS TO INSUFFICIENT TIME TO COST ALTERNATIVES
- COST TEAM SOMETIMES NOT INVOLVED IN EARLY STAGES OF ANALYSIS DEVELOPMENT SO AS TO ANTICIPATE COST ISSUES

IMPACT ON ANALYSIS: INSUFFICIENT TIME FOR QUALITY COSTING, DESIGN TRADES FOR COSTS (BETTER ALTERNATIVES) MAY BE LOST

IMPACT ON POLICY: NONE

ISSUE: PRACTICE CONTINUED

RESEARCH AREAS: COST METHODOLOGY TRAINING COURSE FOR COEA PARTICIPANTS

ACTIONS:

- DEVELOP EXECUTIVE OVERVIEW TRAINING COURSE COVERING ALL ELEMENTS OF ANALYSIS
- CONDUCT INITIAL "TEAM" TRAINING AT THE START OF A COEA
- HOLD JOINT EDUCATION CONFERENCE BETWEEN MORS AND SOCIETY OF COST ESTIMATING AND ANALYSIS (SCEA)

METHODOLOGY

ISSUE: BETTER MACRO LEVEL PARAMETRIC COST MODELS NEEDED

DISCUSSION:

- COST ANALYSIS IS OFTEN REQUIRED VERY EARLY AND VERY LATE IN THE COEA PROCESS WHERE INSUFFICIENT TIME IS AVAILABLE FOR DETAILED COSTING METHODOLOGY
- PARAMETRIC MACRO COST MODELS - PERFORMANCE PARAMETER BASED - ARE NEEDED TO ALLOW EARLY COST TRADES
- MEASURES OF PERFORMANCE (MOP) ARE TO RELATE TO MEASURES OF EFFECTIVENESS (MOE) AND MEASURES OF COST (MOC) OUGHT TO RELATE TO BOTH

IMPACT ON ANALYSIS: QUICK REACTION TRADEOFFS WOULD PERMIT MORE "ANALYSIS" OF COST VERSUS GENERATION

IMPACT ON POLICY: NONE

METHODOLOGY CONTINUED

RESEARCH AREAS: DEVELOP PARAMETRIC MACRO MODELS

ACTIONS:

- **DEVELOP QUICK RESPONSE METHODOLOGIES, NEW MACRO LEVEL MODELS WITH PERFORMANCE PARAMETERS AVAILABLE BY ACQUISITION PHASE, AND BY COMMODITY CLASS**

- **HOLD JOINT EDUCATION CONFERENCE BETWEEN MORS AND SOCIETY OF COST ESTIMATING AND ANALYSIS (SCEA)**

METHODOLOGY

ISSUE: BETTER RISK AND UNCERTAINTY ANALYSIS NEEDED

DISCUSSION:

- COST ANALYSIS TEAM NEEDS TO IDENTIFY KEY "COST DRIVERS" WHICH RELATE TO SYSTEM PERFORMANCE OR PHYSICAL PARAMETERS

- THESE "COST DRIVERS" ARE SUBJECT TO RISK OR UNCERTAINTY (THIS IS DIFFERENT FROM SENSITIVITY ANALYSIS)

- APPROPRIATE DISTRIBUTIONS AND AGGREGATION MODELS ARE NEEDED

IMPACT ON ANALYSIS: BETTER UNDERSTANDING IN COSTS

IMPACT ON POLICY: HOW SHOULD UNCERTAINTY IN COST AND EFFECTIVENESS CALCULATIONS BE TREATED?

METHODOLOGY RISK (CONT)

RESEARCH AREAS:

- DEVELOP APPROPRIATE METHODOLOGY AND MODELS

ACTIONS:

- DEVELOP QUICK RESPONSE METHODOLOGIES, NEW RISK MODELS BY ACQUISITION PHASE, AND BY COMMODITY CLASS
- DEVELOP STANDARD PRESENTATION FORMATS TO ILLUSTRATE IMPORTANCE OF UNCERTAINTY TO ALTERNATIVE SELECTION

METHODOLOGY

ISSUE: METHODOLOGY TO COST AND PROPERLY WEIGHT R&D COST (vs LCC) IF SYSTEMS PUT "ON SHELF" AFTER DEVELOPMENT (POTENTIAL NEW ACQUISITION STRATEGY)

DISCUSSION:

- NEW TECHNIQUES TO ESTIMATE R&D COST NEEDED
- CURRENT "COST DRIVERS" OF R&D IS TIME (SYSTEMS ENGINEERING EFFORT), SIZE OF RESEARCH TEAM, ETC...
R&D COST DATA BASES POOR, FFP CONTRACT HAVE LITTLE OR NO COST VISIBILITY
- STARTUP OR REOPENING COLD PRODUCTION LINE
- COSTLY (HARD TOOLING vs SOFT TOOLING) - COULD RESULT IN DISAPPEARANCE OF PRODUCTION LINES

IMPACT ON ANALYSIS: DIFFERENT COST THAN LIFE CYCLE COST

IMPACT ON POLICY: REVISE LCC REQUIREMENT IN 5000.2

METHODOLOGY
R&D COST (CONT)

RESEARCH AREAS:

ROBUST METHODS FOR DETERMINING R&D COSTS

ACTIONS:

- **DEVELOP NEW DATA BASES**
- **DEVELOP NEW METHODOLOGY**

METHODOLOGY (CE COMPARISON)

ISSUE: DEVELOP NEW TECHNIQUES FOR COST EFFECTIVENESS COMPARISON OR COUPLING

DISCUSSION:

- ONE SPEAKER SAID: "DO NOT COMBINE COST EFFECTIVENESS"
- ANOTHER SAID: "USE ANALYTICAL HIERARCHY PROCESS, UTILITY THEORY, ETC...TO COMBINE"
- DR CHU SAID "DON'T ARTIFICIALLY FORCE EQUAL COST OR EQUAL EFFECTIVENESS COMPARISON"
- ARMY USES FORCE COST COMPARISONS WHILE AIR FORCE/NAVY USES SYSTEM/PLATFORM COMPARISONS
- DECISION COST vs LCC (ICE OR BCE) SCOPE OF COST MAY BE DIFFERENT THAN COEA-CONSISTENT

IMPACT ON ANALYSIS: NEED TO DEFINE UP FRONT WHAT COST GROUND RULES AND ASSUMPTIONS ARE

IMPACT ON POLICY: NEED TO CLARIFY WHAT "DECISION COSTS" ARE RELEVANT

METHODOLOGY
CE COMPARISON (CONT)

RESEARCH AREAS AND ACTIONS:

DEVELOP APPROPRIATE DEFINITIONS, CLARIFICATIONS, NEW APPROACHES E.G. MATHEMATICAL PROGRAMMING

PRACTICE
CARD

ISSUE: CAN A COST ANALYSIS REQUIREMENTS DOCUMENT (CARD) BE DEVELOPED FOR COEA? WHO SHOULD DEVELOP?

DISCUSSION:

- COST ANALYST CURRENTLY WRITES CARD, BUT SHOULD EFFECTIVENESS WRITE COEA EQUIVALENT?
- CARD IS FOR ICE/POE/BCE NOT COEA

IMPACT ON POLICY: GUIDANCE DOCUMENTS FOR COEA COULD BE POLICY ADDITION

RESEARCH AREAS/ACTIONS: WRITE DIRECTIVE SPECIFYING STRUCTURE AND OF CARD EQUIVALENT DOCUMENT

INTEGRATION
CULTURE SHOCK

DISCUSSION

- CHANGING THREAT
- NEW WEAPON & TECHNOLOGY OPPORTUNITIES
- DECLINING RESOURCES
- NEW MANAGEMENT TECHNIQUES
- NEW ACQUISITION PROCESSES

IMPACT

- INCREASING "DEMAND" FOR ANALYSIS
- DECLINING ANALYTIC RESOURCES

INTEGRATION

ANALYTIC THINKING

- POINT ESTIMATES vs RANGES: SENSITIVITY ANALYSIS
- OVERARCHING SCENARIO vs MULTIPLE OPTIONS: EXPERIMENTAL DESIGN APPLIED TO MODELING
- QUICK LOOK vs CAMPAIGN ANALYSIS: INTEGRATED HIERARCHY OF MODELS
- COOKBOOK FOR COEAs vs ONE-OF-A-KIND COEAs: PROCEDURAL CONSISTENCY & ANALYTIC METHODOLOGY FLEXIBILITY

IMPACT

- REQUIREMENT FOR GREATER EMPHASIS ON CREATIVE THINKING IN ANALYSIS
- DE-EMPHASIS ON "COOKBOOK SOLUTION"

INTEGRATION

DISCUSSIONS

- REQUIRED LINKAGES: MEASURES, C&E, AFFORDABILITY, FORCES (PRESENT&FUTURE), RECONSTITUTION (BATTLEFIELD/INDUSTRIAL BASE)
- CONSIDERATION FORM MILITARY SCIENCE: HISTORY, NON-LINEAR BATTLEFIELD, JOINT/ COMBINED INTERAGENCY OPERATIONS, SPECTRUM OF CONFLICT
- USING DECISION SCIENCE: STRUCTURING DECISION OPTIONS, INTEGRATION METHODS, PRESENTATION

IMPACT

- DOD MOVING TO EMPHASIS COMMONALITY: REQUIREMENTS, INTERRELATIONSHIPS OF METHODS, CENTRALIZATION OF RESOURCES
- MOR COMMUNITY FORCED TO RETURN TO ITS INTER-DISCIPLINARY FOUNDATION

INTEGRATION

IMPROVE

- COMMUNICATIONS: BETWEEN/WITHIN COMMUNITIES
- PRACTICE: TRANSPARENCY, VV&A
- IMPLEMENTATION: FINE TUNE REGULATIONS AND UNDERSTAND THE PROCESS

IMPACT

- SUPPORTS NEED FOR FUTURE MORS SPECIAL MEETINGS

NEED

- IN-DEPTH STUDY OF ACQUISITION & RESOURCE ALLOCATION PROCESS
- EXTENSIVE OR INVOLVEMENT IN DISTRIBUTED INTERACTIVE SIMULATIONS INITIATIVES

POTENTIAL OR PROBLEMS IN SUPPORT OF COEAs

TOPICS INCLUDE:
- **EFFECTIVENESS METHODOLOGIES**
- **LINKAGE**

SYNTHESES TEAM PARTICIPANTS
- **MR JIM BEXFIELD**
- **MR JERRY GOLDSCHMIDT**
- **MR RON GUSTAFSON**
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ISSUES ARE A COMBINATION
- **WHAT PARTICIPANTS ARTICULATED**
- **OUR PERSONAL VIEWS**

EFFECTIVENESS ISSUE NO. 1

ISSUE: JOINTNESS IN EFFECTIVENESS ANALYSIS

DISCUSSION:
- CULTURE SHOCK - "JOINT COEAs"
- SINGLE SERVICE
- JCS/CINSs
- CURRENT MODELS MAY NOT BE ADEQUATE
- RELATED TO ISSUE OF CAMPAIGN ANALYSIS

IMPACT:
- POTENTIAL FOR CHEAPER SOLUTIONS
- POTENTIAL FOR MORE OPERATIONAL CAPABILITY
- BETTER TIES BETWEEN ACQUISITION PROCESS AND HOW WE FIGHT
- MORE INTER-SERVICE ANALYST EXCHANGES

EFFECTIVENESS ISSUE NO. 2

ISSUE: NEW TECHNOLOGY TO IMPROVE MODELING

DISCUSSION:
- DISTRIBUTED INTERACTIVE SIMULATION (SIMNET)
- STANDARDS AND PROTOCOLS
- SHARING DATA BASES
- ROLE OF DMSO

IMPACT:
- INCREASED FLEXIBILITY
- REDUCED COSTS
- ENHANCED EFFICIENCY
- MORE OPERATIONAL REALISM

EFFECTIVENESS ISSUE NO. 3

ISSUE: LINKAGE BETWEEN COEAs AND T&E

DISCUSSION:
- COMPARABLE METHODOLOGIES
- ESTABLISH RELATIONSHIPS BETWEEN COEAs AND MOEs/MOPs
- EXAMINE SENSITIVITIES TO IDENTIFY KEY TEST VARIABLES THAT INFLUENCE OPERATIONAL OUTCOMES

IMPACT:
- MORE CREDIBLE & CONSISTENT COEAs AND TESTING
- SYSTEMS WHICH BETTER SERVE WARFIGHTING NEEDS

EFFECTIVENESS ISSUE NO. 4

ISSUE: CAMPAIGN ANALYSIS

DISCUSSION:
- WHAT DO WE MEAN BY CAMPAIGN ANALYSIS?
- WHEN ARE THEY APPROPRIATE?
- WHO DOES THEM?
- HOW DO WE ESTABLISH CREDIBILITY?
- WHAT ARE THE PROPER MOEs?
- ARE THE OLD ONES ADEQUATE?
- HOW DO WE CAPTURE UNCERTAINTY?
- RELATION TO MAA?

IMPACT:
- MORE CONSISTENT COEAs
- BETTER FOCUS ON MILITARY OUTCOMES
- BETTER RATIONALE

ANNOUNCEMENT

MINI-SYMPOSIUM: COEA IN THE ACQUISITION PROCESS AND THE ROLE OF OPERATIONS RESEARCH IN PERFORMING COEA

DATE: 9-11 MARCH 1992
LOCATION: MARRIOTT NEWPORT
NEWPORT, RHODE ISLAND

MORS is the professional association of military operations research analysts and users of military operations research from both the military and civilian sector. MORS is sponsored by:

- The Deputy Under Secretary of the Army (Operations Research)
- The Director of Program Resource Appraisal, Office of the Chief of Naval Operations
- The Director, Directorate of Programs and Evaluation, Headquarters U.S. Air Force
- The Director of Force Structure, Resource and Assessment, The Joint Staff
- The Assistant Secretary of Defense (Program Analysis and Evaluation)

Under the Contractual Sponsorship of:

- The Office of the Chief of Naval Research

The Proponent for this mini-symposium is the Assistant Secretary of Defense (Program Analysis and Evaluation).

Co-Proponents are:

The Deputy Under Secretary of the Army (Operations Research)
The Director of Program Resource Appraisal, Office of the Chief of Naval Operations
The Director, Directorate of Programs and Evaluation, Headquarters U.S. Air Force

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BACKGROUND

One of the Secretary of Defense's major initiatives was to streamline the acquisition process. Accordingly, the Defense Acquisition process was realigned in the new DoD 5000 Series Regulations to establish a disciplined management approach for acquiring systems and materiel that satisfy the operational user's needs. During a time of rapid changes in the world and constrained resources, it is of the utmost importance that military decision makers within the acquisition process are supported by pertinent and timely analysis. These new regulations now contain general guidelines and place greater emphasis on the Cost and Operational Effectiveness Analyses (COEA) which help decision makers select the best systems from among alternatives. The COEA is an important document in the acquisition decision making process to support both effectiveness and affordability assessments and program milestone decisions.

In an attempt to enhance and upgrade the level of analytical expectation, OASD(PA&E) developed and published COEA guidelines which were incorporated into the new DoD 5000 Series Regulations. Although the requirement for COEA previously existed, the regulations now contain a clearer framework to conduct COEA. Recognizing the importance of COEA, PA&E determined that a series of workshops, explaining the relationship of the COEA to the acquisition decision making process, was appropriate and timely. PA&E viewed the workshops as a way to start improving the overall analysis support for acquisition decisions. By bringing all the services and acquisition activities together to discuss COEA, common problems could be addressed and resolved. PA&E also felt that a workshop would help clarify what is expected in a COEA and would also help establish a more collaborative framework within the DoD structure for dealing with COEA requirements in the future.

A workshop for senior officials and analysts from DoD and the military departments was held on 3 April 1991 at the Defense Systems Management College, Fort Belvoir, Virginia. Seventy-two general officers, senior executive service civilians and others attended. The workshop was opened by Dr. David Chu, ASD(PA&E) who discussed the problems with current COEA. Short talks by subject matter experts were then given, each followed by a brief discussion period. At the end of the day each service presented its unique problems and perceptions of the value of the workshop.

Three "limited attendance" action officer workshops were held in May 1991, with the MITRE Corporation serving as host. Each workshop lasted two days. Dr. Chu opened each workshop by again stressing the need for better analysis as he had done at the Senior Officer Workshop. Workshop topics were presented, again by subject matter experts.

A tutorial concerning the PA&E workshops was presented at the recent Annual MORS Symposium. The tutorial focused on the conduct of the workshops, on issues generated from the workshops and on trends or perceptions that came from conducting and observing the workshops.

In all the workshops and tutorials, interest from all segments of DoD has been much higher than anticipated. Numerous requests to hold additional workshops for DoD as well as contractor personnel have been received.

OBJECTIVE

The overall objective of the mini-symposium is to explore the COEA process and identify how the application of operations research principles and techniques might improve the information available to decision makers. In particular the goals are to:

- understand the role of COEA in the DoD 5000 Series Acquisition Regulations
- define the role of operations research in the COEA process
- identify challenges and issues associated with conducting COEA and identifying those challenges that could best be addressed by operations research
- develop possible solutions or identify appropriate research areas to those operations research problems and issues
- improve the collaborative framework for dealing with COEA requirements

SCOPE

The mini-symposium will cover a three day period. Dr. David Chu will be the keynote speaker. Another senior DoD or Congressional official will also make a presentation on a significant analysis issue of the day. The mini-symposium will provide an opportunity for MORS sponsors and members to discuss their views concerning both the COEA process and the role of operations research in performing COEA. After the last presentation a panel of senior DoD personnel will discuss the future direction of COEA. Subject matter experts will be invited by the chairman to present a series of papers on the following topics:

(1) Milestone Decision Criteria

(2) Linkage of Performance Effectiveness

(3) Threat and Scenarios

(4) Operational Effectiveness Methodologies

(5) Costing Methodologies

(6) Cost and Effectiveness Integration

(7) Modeling and Tools

(8) Managing COEA

(9) COEA Guidelines

Each presentation will last twenty-five minutes. After every three presentations the audience will be divided into three sections. Each section will then enjoy a twenty-five minute Q&A session with each presenter. The audience will be divided into six working groups. Symposium attendees will be pre-assigned to a working group to ensure that each working group contains representatives from the various segments of the operations research community. The working groups will focus and report on the following six topics:

(1) Test and Evaluation

(2) Threat Assessments

(3) Effectiveness Methodologies

(4) Costing Methodologies

(5) COEA Management

(6) Future Directions

The mini-symposium chair will select a chair for each working group. The group chairs should provide a breadth of experience and collectively represent the various sponsors and organizations that either conduct COEA or use COEA in decision making. The working group chairs are responsible for guiding their working group discussions, and insuring their group develops a set of issues and problems, potential solutions to those issues and problems, and a presentation of the working group results to the entire body. A panel consisting of six chairs (one from each working group) will be held in a general assembly to discuss each group's issues and perceptions.

A synthesis group will observe the mini-symposium's general and working group sessions to identify issues that merit investigation in future MORS special meetings. The synthesis group members will have prior knowledge of the role of COEA in the acquisition process.

PARTICIPATION

Attendance will be limited to a maximum of 200 attendees. The goal is to get a mix of people with various levels of COEA experience but more importantly each attendee should be currently involved with COEA and should come prepared to participate in an active role as recorder, moderator, or discussion leader. The symposium, similar to the PA&E workshops, will be held at the unclassified level.

LUNCHEON SPEAKER

A luncheon will be held at the Marriott Hotel on Tuesday, 10 March 1992. A presentation will be made by a Member of Congress on topics relevant to the symposium theme. The luncheon cost is included in the registration fee.

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PRODUCTS

The presenters will be asked to provide a paper on their topic to form the basis for a proceedings. Dr. Chu's talk and the reports from each working group will also be included as part of the proceedings. Additionally the synthesis group's report will be included as part of the proceedings and will serve as the basis for planning future MORS special meetings.

In addition, the achievements of the meeting will be reported in a presentation to the General Session of the 60th MORSS and in a *PHALANX* article.

LOGISTICS

The Marriott Hotel in Newport, Rhode Island will be the site for this mini-symposium. The daily rate is $93 including tax. Call (401) 849-1000 for reservations and mention that you are a participant in the MORS Mini-Symposium. Reservations must be made by 16 February 1992. The address is: Newport Marriott, 25 America's Cup Avenue, Newport, Rhode Island 02840. The closest Airport is T.F. Green in Providence, Rhode Island.

FEES

The Registration Fee is $180.00 for Federal Government and $330.00 for other personnel. The Fee includes $20.00 for a luncheon (with speaker) on Tuesday and $10.00 for a working lunch on Wednesday.

CAVEATS

The Military Operations Research Society does not make nor advocate official policy.

Matters discussed or statements made during the symposium are the sole responsibility of the participants involved.

All attendees and participants are expected to submit requisite attendance forms and to pay the normal registration fees unless specifically waived by the MORS President. There is no waiver or discount for short-period attendance or participation.

The Society retains all rights regarding final decision on the content of the Mini-Symposium Report.

Vernon M. Bettencourt
President

Approved:

Jerome X. Goldschmidt
Contracting Officer's Technical Representative

MORS COEA Symposium

Meeting Agenda for March 9-11, 1992

MONDAY, 9 MARCH 1992

0800-1000 Registration

1000-1015 Opening Remarks
Al Diaz, Chairman

1015-1030 MORS Welcome
Vern Bettencourt, MORS President

1030-1045 Host Welcome
(Naval War College Representative)

1045-1145 Keynote
David Chu, Assistant Secretary of Defense (Program Analysis and Evaluation)

1145-1245 Luncheon

1245-1455 GENERAL SESSION
(25 min) Topic #1: Milestone Decision Criteria
(25 min) Topic #2: Threat and Scenarios

1335-1430 Hon. Ron Machtley

(25 min) Topic #3: Modelling and Tools

1455-1515 Break

1515-1630 QUESTION & ANSWER SESSIONS

(25 min)	WGs 1&2: Topic #1	WGs 3&4: Topic #2	WGs 5&6: Topic #3
(25 min)	WGs 1&2: Topic #2	WGs 3&4: Topic #3	WGs 5&6: Topic #1
(25 min)	WGs 1&2: Topic #3	WGs 3&4: Topic #1	WGs 5&6: Topic #2

1630-1730 WORKING GROUP SESSION

1800-1900 Hors D'oeuvres at Marriott Hotel

TUESDAY, 10 MARCH 1992

0800-0915 GENERAL SESSION
(25 min) Topic #4: Operational Effectiveness Methodologies
(25 min) Topic #5: Costing Methodologies
(25 min) Topic #6: Cost and Effectiveness Integration

0915-1030 QUESTION & ANSWER SESSIONS

(25 min)	WGs 1&2: Topic #4	WGs 3&4: Topic #5	WGs 5&6: Topic #6
(25 min)	WGs 1&2: Topic #5	WGs 3&4: Topic #6	WGs 5&6: Topic #4
(25 min)	WGs 1&2: Topic #6	WGs 3&4: Topic #4	WGs 5&6: Topic #5

1030-1045 Break

1045-1200 GENERAL SESSION
(25 min) Topic #7: Managing COEA
(25 min) Topic #8: Linkage of Performance Effectiveness
(25 min) Topic #9: COEA Guidelines

1200-1330 Lunch

1330-1445 QUESTION & ANSWER SESSIONS

(25 min)	WGs 1&2: Topic #7	WGs 3&4: Topic #8	WGs 5&6: Topic #9
(25 min)	WGs 1&2: Topic #8	WGs 3&4: Topic #9	WGs 5&6: Topic #7
(25 min)	WGs 1&2: Topic #9	WGs 3&4: Topic #7	WGs 5&6: Topic #8

1445-1500 Break

1500-1700 Panel on Future Direction

1700-2100 WORKING GROUP SESSIONS

WEDNESDAY, 11 MARCH 1992

0800-1200 WORKING GROUP SESSIONS
Working Groups 1 through 6: Topic - Define and report on the role of operations research in the COEA process; issues, problems, and research areas, and the future directions for military operations research analysis to support COEAs.

1200-1300 Working Lunch for Working Groups

1300-1400 GENERAL SESSION (REPORTS TO THE ASSEMBLY BY WORKING GROUP CHAIRMEN)
(20 min each) Working Groups 1 through 3

1400-1415 Break

1415-1515 GENERAL SESSION (REPORTS TO THE ASSEMBLY BY WORKING GROUP CHAIRMEN)
(20 min each) Working Groups 4 through 6

1515-1545 Synthesis Group Feedback

1545-1600 WRAP-UP/CLOSING

INVITED SPEAKERS

SPEAKER	TOPIC
Dr Bill Lese (OASD(PA&E))	Milestone Decision Criteria
LtCol Gary Fauss (DIA)	Threats and Scenarios
Mr Sam Gardiner	Modeling and Tools
Mr Tony Brinkley (Teledyne Brown)	Operational Effectiveness Methodologies
Dr Dan Nussbaum (CNCA)	Cost Methodologies
Dr Pat Cassady (TRAC-WSMR)	Cost and Effectiveness Integration
LtCol Jim Feigley (USMC)	Managing COEA
Dr Bill Lese (PA&E) Dr Ernie Seglie (DOTE) Mr Dick Ledesma (DDR&E)	Linkage of Testing and COEAs
Dr Al Diaz (OASD(PA&E))	COEA GUIDELINES

WORKING GROUP LEADERS

Working Group	Chairman	Moderator
Costing Methodologies	Dr Dan Nussbaum (CNCA)	LtCol Ray Baker, USAF (NWC)
COEA Management	LtCol Don Bourdon (NWC)	Cdr Ed Berry, USN (NWC)
Effectiveness Methodologies	Mr John Friel (RAND)	Cdr Indy Crowley,USN (NWC)
Future Directions	Mr Mike Bauman (TRAC)	Cdr Scott Ensminger,USN (NWC)
Threats & Scenarios	Col Charlie Cox (DIA)	Cdr Chuck Sipe, USN (NWC)
Test & Evaluation	Mr John Gehrig(ODUSA(OR)	LtCol John Sergeant, USMC
Synthesis Group	Mr Clayton Thomas (USAFSA)	Professor Steve Fought (NWC)

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