ALLOCATION OF ORGANIC WORKLOAD FUNDING

RESOURCE ALLOCATION DECISION MODEL

ACKNOWLEDGEMENTS

ALLOCATION OF ORGANIC WORKLOAD FUNDING

Project B

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ABSTRACT

A United States Navy Program Manager for Acquisition (PMA) command, tasked with acquisition and life cycle support of aircraft support equipment, requires the services of Engineers, Logisticians and others in order to carry out his mission. These “people” resources are located at various Naval activities around the country that are generically referred to as Field Activities. The tasks are collectively referred to as “workload”. Each year a portion of the overall budget allocated to the PMA is forwarded to these Field Activities in order to fund the required effort. Downsizing within the Department of Defense has resulted in smaller budgets allocated for workload funding. As a result, not all tasks may be funded - thereby requiring evaluation of relative importance and identification of the most efficient utilization of limited dollars. Historically, each Field Activity’s yearly allocation has been a reflection (at a smaller overall percentage) of what was funded the previous year. Recognizing this may not be the best way to allocate funding, the leadership decided to attempt a bottom up review for fiscal year 1998. The focus of this review was on detailed tasks; efficiency of individual Field Activities was not considered. This model is an attempt to capture, at a macro level the differences and dynamics of individual Field Activities, based on the work done for fiscal year 1998 allocations. Specifically, the goal is to optimize the allocation of workload funding to each activity. The alternatives (nine Field Activities) are evaluated at various levels of funding against the primary objectives of maximizing Field Support Team, Engineering and Logistics services.

1.0 BACKGROUND

Overview of Environment

The Naval Air Systems Command (NAVAIR) is the U. S. Navy's agent tasked with the acquisition, procurement and life cycle support of the Navy's aviation related weapons systems and related support systems. The command is set up as a project oriented matrix organization. The command is divided into several PEOs (Program Executive Office) which in turn have multiple PMAs (Program Manager for Acquisition) reporting to them. The particular PMA which is the subject of this report (PMA-260) has an annual budget of well over 100 million dollars and is responsible for all aviation related support equipment, from complex Electro-Optic Automated Test Equipment used to repair sensitive Laser and Forward Looking Infrared systems to tiedown chains used for securing aircraft on the aircraft carrier flight deck. Throughout the acquisition process, from inception of a new system until the end of its operational service life, people are required to perform many and varied tasks. These include such things as design & manufacturing engineering, systems engineering for logistical analysis, fleet logistics support of fielded systems and field support engineering and technical services to work through operational issues. These support personnel are assigned to one of the many different Field Activities (which are directly responsible to NAVAIR) located across the country. Fundamentally, PMA-260 requires support services which fall into three general categories, Field Support Team (FST), Engineering and Logistics and employs nine of the various Field Activities.

Problem Description

Over the past five to ten years there has been a constant downward trend in the money available to fund the many Navy acquisition programs and the associated support infrastructure. The downward pressure has been exceptionally strong the last two to three years. In an effort to carry out planned acquisitions and provide continued support to deployed units, products and processes are continually re-evaluated to achieve maximum efficiencies. One aspect of this is allocation of funds to Field Activities in support of PMA goals. Significant budget reductions have been made in fiscal years 1996, 1997 and 1998 Field Activity funding levels. In anticipation of continued, downward budget pressure, energy is being directed at coming up with better, more efficient ways to allocate scarce dollars to accomplish required tasks at the minimum possible cost.

Decision Identification

The primary objective or goal of PMA-260 is to optimize the allocation of workload funding to Field Activities.

Impact/Significance of Decision

At the present time, the budget problem faced by PMA-260 is small when compared to DOD as a whole, or even as a percentage of the PMA's own total annual budget. However, in human terms, the difference of a couple million dollars spread across several different field activities means jobs and people's livelihood. At a national level, a wrong decision could lead to a possible reduction in military readiness on the front lines at some point in time. A repaired aircraft component not meeting its predicted mean time between failure, a system failure mode not anticipated, not enough spare parts at the right place at the right time all could result in an aircraft sitting on the ground, unable to do it's job, instead of in the air, performing the mission it was designed for.

Overview of Decision Making Approach

This resource allocation problem follows a six-step process based upon the Analytical Hierarchy. These steps are described in Decision by Objectives (Forman, 1997, part I section D & H), and include:

1. Problem definition and research,
2. Identify alternatives
3. Decision model structuring in the form a hierarchy of objectives and sub-objectives,
4. Evaluation and prioritization of objectives and sub-objectives by use of pairwise relative comparisons,
5. Measure each alternative's contribution to each of the lowest level sub-objectives,
6. Documentation of decision for justification and control.

2.0 ALTERNATIVES

Overview

There are nine Field Activities, which the PMA currently funds to varying levels in support of his mission. They are:

- Lakehurst, NJ
- North Island, CA
- Jacksonville, FL
- Patuxent River, MD
- Point Mugu, CA
- Crane, IN
- Corona, CA
- Philadelphia, PA
- Cherry Point, NC

On the surface, Field Activities vary in size (number of personnel assigned), composition and capability. Additionally, there are differences in the quality and experience of people employed. At a macro level, allocation of funds is primarily based upon the equipment requiring support and the specific services needed. The various Field Activities are not so specialized that they may be referred to as "centers of excellence", but there is some degree of functional specialization that has evolved. The people resources assigned across the many Field Activities are organized in a matrix form in support of Naval Air's many different acquisition programs. It is not unusual for an individual to have multiple tasking. The majority of tasks funded are non-repetitive level of effort, as opposed to discrete or repetitive. Consequently, without reliable, well-defined estimates for task completion, potential funding levels are not discrete, but continuous. To provide flexibility in alternative funding strategies, each of the nine Field Activities was listed at four different funding levels: full, three quarter, one half and one quarter. These funding levels where picked arbitrarily. Not every Field Activity provides every type of service. Where sub-objectives did not apply, a not applicable (N/A) was used in place of intensity.

The Field Activities

Lakehurst, New Jersey:

> *Primarily provides logistics support, some development engineering and limited FST services (primarily equipment installations and site activations). They are the software configuration control management lead for all of the PMA's programs.*

North Island, California:

> *Primarily provides FST services, including installations, site activiations and on-sight troubleshooting. Also provides engineering investigation services, hardware configuration control management and reviews technical publications prior to Navy acceptance.*

Jacksonville, Florida:

> *The majority of their effort is spent on organic software development and production. Secondarily they provide some logistics analysis in the form of configuration management and sparring.*

Patuxent River, Maryland:

> *Engineering requirements analysis and design acceptance of hardware and software is their forte'. Second to that they provide significant FST services, primarily in the form of on-site technical assistance and troubleshooting.*

Point Mugu, California:

> *Provides primarily engineering services in the form of design review and acceptance.*

Crane, Indiana:

> *Their limited involvement is focused on engineering investigation support and some design review and production development.*

Corona, California:

Involvement limited primarily to hardware and software calibration issues, requirements analysis and design acceptance.

Philadelphia, Pennsylvania:

Limited to software engineering analysis and design acceptance.

Cherry Point, North Carolina:

Also mainly limited to software engineering analysis and design acceptance.

3.0 DECISION MODEL

Goal

The goal of this decision model is to optimize the allocation of scarce workload dollars to funded Field Activities.

Primary Objectives

In pursuit of the stated goal, the following were identified as the primary enabling objectives (see figure 3-1.):

Field Support Team (FST)	Provide user oriented, centralized and/or on-site technical and engineering services in support of fielded/deployed systems.
Engineering	Provide hardware, software and Test Program Set (TPS) engineering and support services for new acquisitions and fielded systems.
Logistics	Provide reliability and maintainability trend analysis, configuration control and spares management services.

These primary objectives are a roll up description of the lower level sub-objectives. The sub-objectives listed below are descriptions of actual tasks that have been funded in previous years.

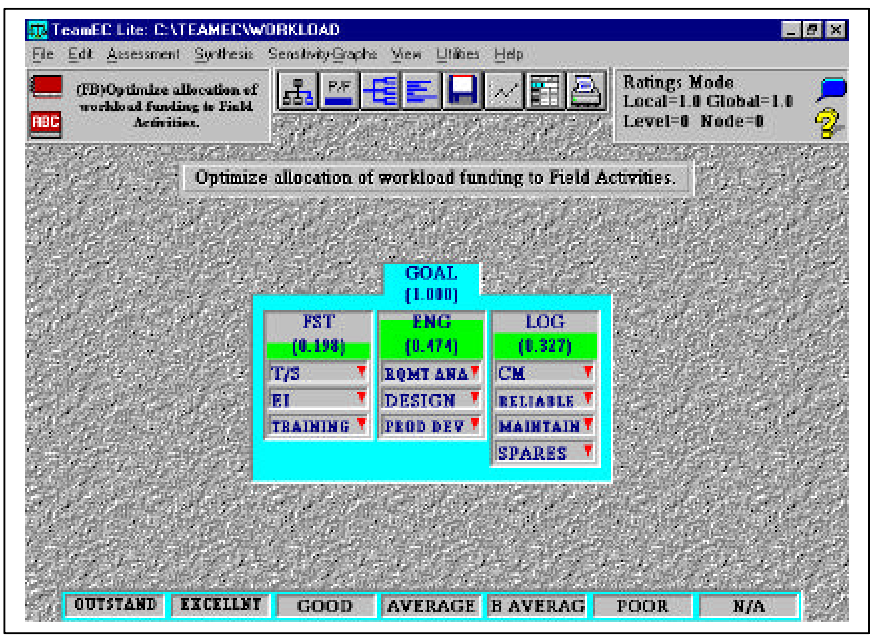

Figure 3-1. Workload Model.

Sub-Objectives

For each of the primary objectives the following sub-objectives apply and further define each type of service:

Field Support Team (FST)

- No fielded system is ever deployed with all possible failure modes or short comings identified in advance and reworked or corrected. Inevitably, the crucible of operational use brings these discrepancies to light. It is the job of the FST to work through these issues and come up with work arounds, initiate equipment modifications and/or identify and outline additional training requirements.

  1. Troubleshooting – Provide troubleshooting services for fielded systems, frequently including on-site evaluation on deployed ships or aircraft.
  2. Engineering Investigations – Perform engineering investigations and root cause analysis as required to correct equipment discrepancies and identify potential manufacturing defects.
  3. Training – Provide advanced operator and maintainer technical training upon request.

Engineering

- A critical element in the acquisition and life cycle support of complex or advanced equipment is the engineering effort applied to validate the operational application driving the requirement, review and evaluation of the proposed design to meet the requirement and the on-going product support essential to equipment maturation.

  1. Requirements Analysis – Analyze and evaluate required operational capability and projected operating environment to identify/validate detailed equipment specifications.
  2. Design Review – Perform systems design review prior to government acceptance. Verify proposed design will meet critical item specifications, is logistically supportable and reflects good engineering practices.
  3. Product Development – Provide product development services for fielded systems. Synthesize operational "lessons learned" to determine potential corrections, modifications or additions to baselined equipment in order to take fullest advantage of inherent capabilities and improve mission support.

Logistics

- Adequate support of fielded systems is a difficult and crucial aspect of an equipment's life cycle. Control of the equipment's configuration, ongoing analysis of its reliability & maintainability and ensuring proper support with spare parts help ensure successful deployment.

  1. Configuration Management – Control equipment configuration for fielded systems. Ensure no unauthorized changes are made to product baseline in order to prevent potential conflict between unknown system or equipment configurations and the logistical support structure's ability to repair or replace failed items.
  2. Reliability – Perform reliability and trend analysis in support of fielded systems in order to facilitate continuous improvement and maturation.
  3. Maintainability – Perform ongoing maintainability analysis on fielded systems. Explore and evaluate potential changes to the level of repair analysis in order to facilitate the cheapest and most expeditious method of support.
  4. Spares – Using the Level of Repair Analysis, determine and maintain the optimum level of spare parts to support fielded systems.

Intensities

For each of the lowest-level sub-objectives a scale of intensities was defined against which each alternative could be measured or rated. The weights for these intensities were derived, just as for the objectives and sub-objectives, to identify the relative preference for each level of the scale. The scale was structured with seven levels (see figure 3-2) in order to provide sufficient granularity in the event that two alternatives were close in total score. The intensities and their definitions are:

Outstanding – Superior to all others.
Excellent – Better than most.
Good – Better than average.
Average – Average.
Below Average – Below or less than average.
Poor – Worse than most.
N/A – Not applicable.

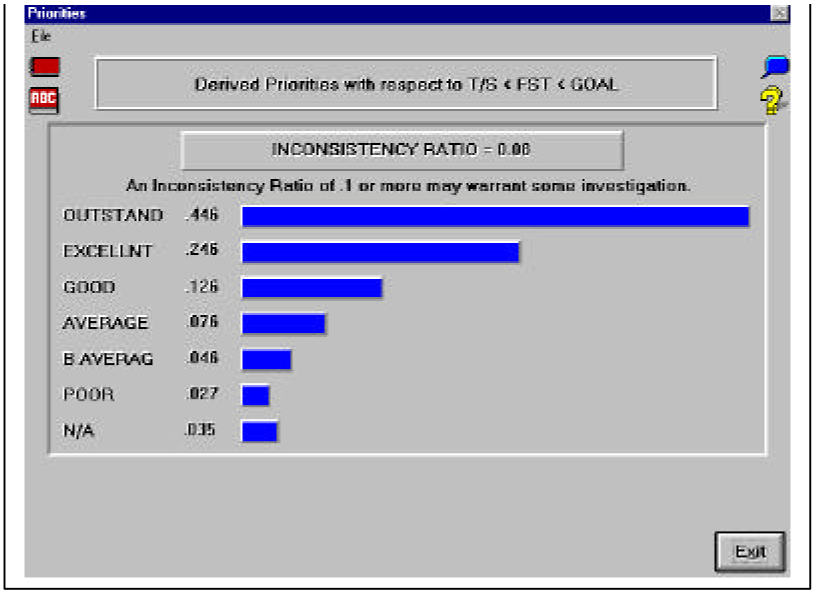

Figure 3-2. Intensities.

4.0 JUDGEMENTS

Methodology

Overview of Expert ChoiceÔ Software
The Expert Choice™ software program was used to facilitate the development of the decision model described in the last section. This software provides several methods for structuring the decision hierarchy, entering information into the decision model, assigning weights to the various decision objectives and sub-objectives and coming up with intensities.

Pairwise Judgments
Pairwise judgements were made for each of the objectives, sub-objectives and intensity scales defined in the decision model. A pairwise judgement is one in which two unlike elements can be measured against some criterion to identify how they relate, relative to that criterion. There are several methods (see Figure 4-1) to make pairwise judgements as described below.

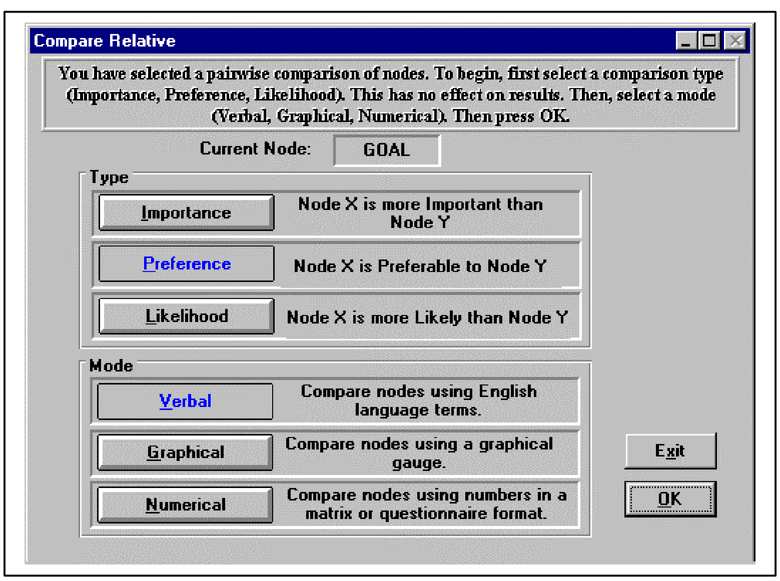

Figure 4-1. Selection of type of pairwise judgement.

Verbal Judgements
The verbal judgement mode is used to compare items or nodes using English language terms. This mode is often preferable when making qualitative judgements because it does not require the user to enter precise numerical information. For example, consider the judgement of temperature; it is often easy to say that today was warmer than yesterday, or that even that it was moderately or strongly hotter today than yesterday. However, it is far more difficult to say that it was 2 degrees warmer than yesterday. How do you know it was 2 degrees versus 2.5 or 1.7 degrees? The verbal mode allows the user to enter judgements into the model using terms that are easier to make and articulate than quantitative measures. Figure 4-2 depicts the Expert Choice™ screen for making verbal comparisons for decision objectives and alternatives.

Numerical Judgements
The numerical judgement mode is used to compare items or nodes using a numerical scale of 1.0 to 9.0. This mode is often preferable when making judgements when there is quantitative data available to support the comparison of the items. For example, when purchasing a car, consider the judgement of price when evaluating alternatives. Using the numerical mode, one could normalize the actual sticker prices of the cars to fit into the 1.0 to 9.0 scale, and thereby develop an accurate and consistent judgement as to the relative ranking of the cars based upon price. The numerical mode judgements can be entered in either of two modes (see Figures 4-3 and 4-4), the matrix mode or the questionnaire mode. The scale is the same in both approaches, but the presentation differs. It is the user's choice as to which method to enter judgements.

Graphical Judgements
The graphical judgement mode is used to compare items or nodes using a relative visual scale. Dragging one of the two bars representing the compared nodes enters the judgement, so as to describe how much more important, preferable, or likely the one node is to the other. A pie chart also depicts the relationship as the bars are resized (see Figure 4-5). Users may find the graphical mode preferable to both the verbal and numerical modes since it presents judgements visually. Often users will find words too imprecise and numbers too constraining when making their judgements. However, they find the graphical mode much easier to manipulate in order to reflect their views.

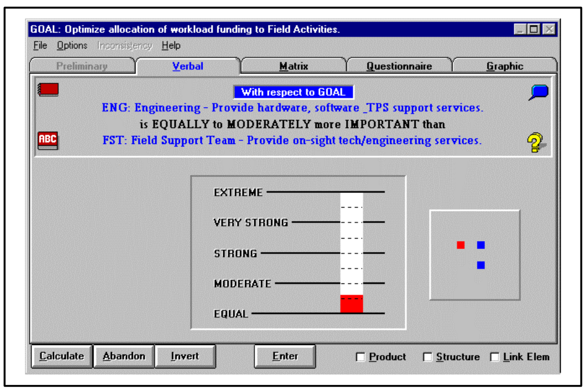

Figure 4-2. Verbal pairwise judgement mode.

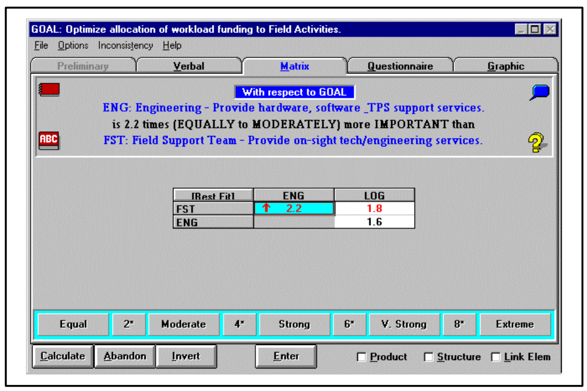

Figure 4-3. Numerical matrix pairwise judgement mode.

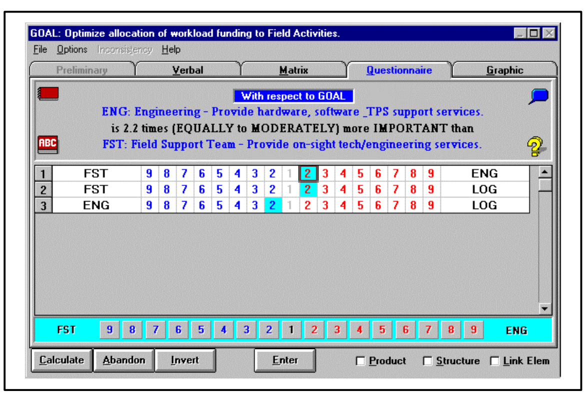

Figure 4-4. Numerical questionnaire pairwise judgement mode.

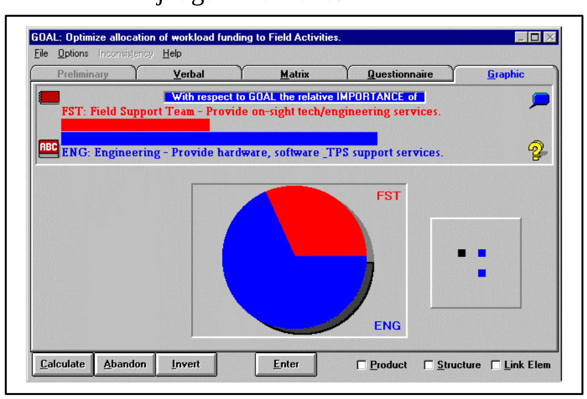

Figure 4-5. Graphical pairwise judgement mode.

The verbal mode was used for weighting the objectives and sub-objectives. The verbal mode was also used for deriving the intensities, however if after calculating the values the intensities did not seem to match intuitive judgement, the graphical mode was used for fine tuning the pairwise judgements.

Inconsistency Ratio
The inconsistency ratio is a measure of how consistent you have been in your judgements. This is a useful tool to understand when making redundant judgements whether or not you have been able to compare multiple, related items to each other in a consistent manner. Generally, an inconsistency ratio of no more than 10% is considered reasonable. It is important to recognize that consistency does not guarantee the right answer, since one can be consistently wrong. Therefore, accuracy in judgements is actually more important than consistency. A consistency ratio of greater than 10 % should be used to indicate a possible.

The judgements tended to be fairly consistent (i.e., within 1%). There were a few instances wherein the consistency was off. This was resolved by re-visiting the comparisons in question. In one case it was a problem of erroneously recording a judgement.

Ratings
The Analytical Hierarchy Process is based upon cognitive studies that have proven that humans, on average, cannot remember or organize more than seven, (plus or minus two) things at one time. Therefore, AHP does not allow more than nine nodes within any one level or more than nine alternatives within the hierarchy. Expert Choice™ does, however, provide a method to compare more than nine alternatives. This capability is provided through the rating module as depicted in Figure 4-6.

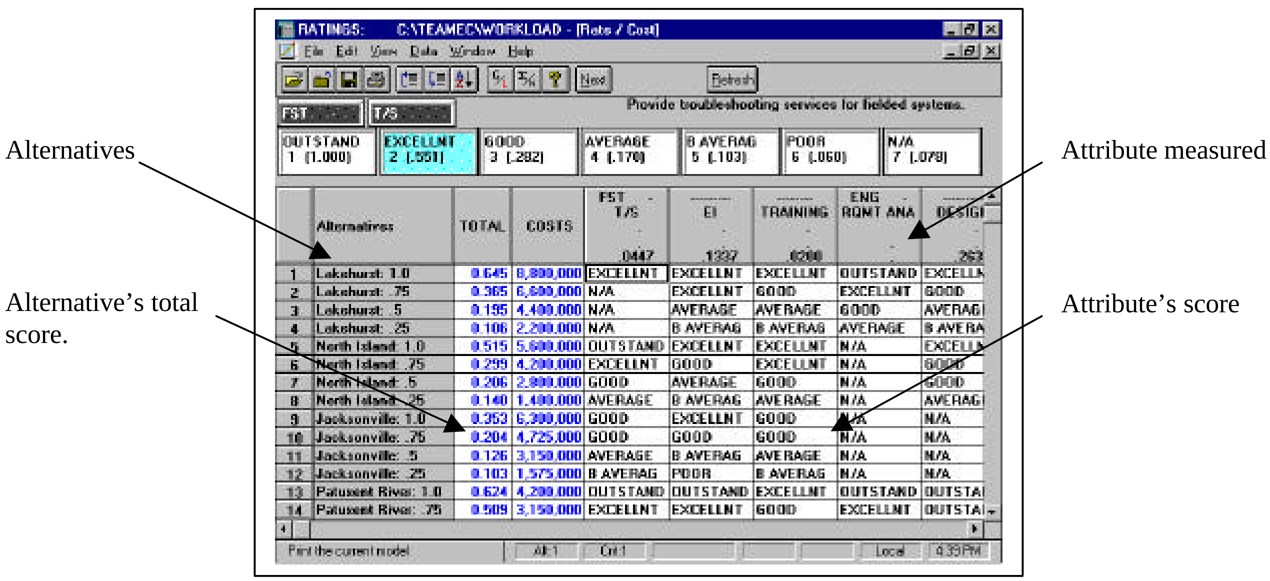

Figure 4-6. Ratings model for ranking more than nine alternatives.

The rating model was used to enter judgements for each of the Field Activities at each of the designated funding levels. Four individual funding levels where set for each Field Activity (100%, 75%, 50% and 25%) in order to provide a basic level of granularity and to facilitate maximum funds disbursement.

Weights and Ratios
A pairwise comparison was performed on the objectives, sub-objectives and intensities. The resultant weights for the objectives can be seen in figure 3-1. The weights for the sub-objectives are listed in table 4-1. The weights for the intensities are listed in figure 3-2.

Object-ive	T/S	EI	Train-ing	Reqs Analys	Design	Prod Dev	CM	Reli-able	Main-tain	Spares
Weights	.0447	.1337	.02	.0653	.2639	.1451	.087	.0322	.0202	.1879

Table 4-1. Weights for sub-objectives.

5.0 SYNTHESIS/PRELIMINARY RESULTS

The problem was divided into its component parts, organized by levels of importance and then set up as a decision hierarchy. Each of the alternatives (four different funding levels for each Field Activity) were rated in importance against the objectives (goals) and sub-objectives. An optimization was then performed using an Excel spreadsheet. The optimization (table 5-1) combines the relative rank ordering of each alternative, Field Activity Costs, along with available budget and suggests an optimum choice of funding levels to maximize use of available dollars. This optimization represents an assessment of only one possible combination of alternatives. An initial funding level cap of $14.1 million was used for our purposes.

Field Activities	Priority	COSTS	DVs	F. Benefit	F. Cost	
Lakehurst: 1.0	15.023	8,800,000	0	0.00	0	
Lakehurst: .75	8.794	6,600,000	0	0.00	0	
Lakehurst: .5	4.704	4,400,000	0	0.00	0	
Lakehurst: .25	**2.548**	**2,200,000**	**1**	**2.55**	**2,200,000**	
North Island: 1.0	12.402	5,600,000	0	0.00	0	
North Island: .75	**7.19**	**4,200,000**	**1**	**7.19**	**4,200,000**	
North Island: .5	4.953	2,800,000	0	0.00	0	
North Island: .25	3.38	1,400,000	0	0.00	0	
Jacksonville: 1.0	8.494	6,300,000	0	0.00	0	
Jacksonville: .75	4.911	4,725,000	0	0.00	0	
Jacksonville: .5	3.029	3,150,000	0	0.00	0	
Jacksonville: .25	**2.482**	**1,575,000**	**1**	**2.48**	**1,575,000**	
Patuxent River: 1.0	15.017	4,200,000	0	0.00	0	
Patuxent River: .75	**12.254**	**3,150,000**	**1**	**12.25**	**3,150,000**	
Patuxent River: .5	7.121	2,100,000	0	0.00	0	
Patuxent River: .25	4.221	1,050,000	0	0.00	0	
Point Mugu: 1.0	**8.846**	**750,000**	**1**	**8.85**	**750,000**	
Point Mugu: .75	4.537	562,500	0	0.00	0	
Point Mugu: .5	2.857	375,000	0	0.00	0	
Point Mugu: .25	1.848	187,500	0	0.00	0	
Crane: 1.0	**6.246**	**620,000**	**1**	**6.25**	**620,000**	
Crane: .75	4.148	465,000	0	0.00	0	
Crane: .5	2.625	310,000	0	0.00	0	
Crane: .25	1.912	155,000	0	0.00	0	
Corona: 1.0	**9.177**	**191,000**	**1**	**9.18**	**191,000**	
Corona: .75	3.489	143,250	0	0.00	0	
Corona: .5	2.067	95,500	0	0.00	0	
Corona: .25	1.733	47,750	0	0.00	0	
Philadelphia: 1.0	**12.397**	**180,000**	**1**	**12.40**	**180,000**	
Philadelphia: .75	5.141	135,000	0	0.00	0	
Philadelphia: .5	2.781	90,000	0	0.00	0	
Philadelphia: .25	1.673	45,000	0	0.00	0	
Cherry Point: 1.0	**12.397**	**190,000**	**1**	**12.40**	**190,000**	
Cherry Point: .75	5.141	142,500	0	0.00	0	
Cherry Point: .5	2.39	95,000	0	0.00	0	
Cherry Point: .25	1.82	47,500	0	0.00	0	
			Totals:	**73.54**	**13,056,000**	**14,100,000**
						Available

Predetermined funding levels, uniformly set for each Field Activity.

Constraints to assure one and only one level for each Alternative:

Lakehurst	**1**
North Island	**1**
Jacksonville	**1**
Patuxent River	**1**
Point Mugu	**1**
Crane	**1**
Corona	**1**
Philadelphia	**1**
Cherry Point	**1**

Table 5-1. Excel Optimization.

6.0 CONCLUSIONS

Significance of Results and Process Followed
The benefits of following a structured process such as AHP and using the Expert Choice software to allocate scarce workload dollars has the potential to change a previously subjective process into one that is primary objective in nature. When dealing with decisions and issues potentially involving national security, politics and people's livelihoods, using an entirely intuitive approach or one based on what's been done in the past leaves the decision maker in a very vulnerable position. Unfortunately, the timing of the annual budget drills precluded the chance to exercise this model for the FY98 workload allocation. However, the opportunity exists to experiment with this model next year.

Alternative Approaches to Decision
Over the past two to three years the process used for allocating workload dollars has been strictly based on previous year's funding levels for each activity. As the realities of a shrinking defense budget have forced consistent reductions in such things as available dollars to fund Field Activity workload, the drill has been to "reduce last year's budget by X%". This does a poor job of matching changes in actual work to be performed with corresponding levels of funding. An alternate line of thought considered of late for making these funding allocation decisions has been down the Work Breakdown Structure path. This has proved to be very time consuming and still will not take into consideration the intuitive pluses and minuses of the different Field Activities. Ideally, this approach could be rolled into an Expert Choice model and combined with the model presented here, resulting in a highly effective process, flexible enough to account for changes in both people and tasks.

Summary
In summary, the use of the Analytical Hierarchy Process and Expert Choice Software have opened a new way in which to structure, analyze, and present recommended workload funding alternatives. The AHP process ensured that the primary objectives (Field Support Team, Engineering and Logistics) were all factored into the various alternative levels of funding for Field Activities. The alternatives were rated against the primary objectives and sub-objectives and a synthesis was performed to determine the optimum allocation of dollars - given a fixed amount of money available for workload. The scope and complexity of the task (allocation of workload dollars) was too great to thoroughly address within the confines of one semester. However, this has opened the door to a potentially significant change in the way we may do business next year.

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