RESOURCE ALLOCATION MODEL FOR NAVAL AVIATION COMMON GROUND EQUIPMENT

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ABSTRACT

Common ground equipment is an integral subset of Naval Aviation's common support equipment (CSE). Common ground equipment ranges from "yellow gear" such as tow tractors, cranes, and hydraulic generators, to avionics test boxes, which help maintainers test various sophisticated aircraft systems and subsystems. Without the proper type and amount of common ground equipment, Navy and Marine Corps maintenance personnel cannot adequately maintain and repair their aircraft. Deficits in the inventory of this equipment, could have a direct negative impact to the readiness of Naval Aviation's aircraft.

During the recent "build-up" of the Fiscal Year 2000 budget (POM-00), the requirements officer for common support equipment was tasked by his resource sponsor to perform a *10% plus-up "drill" of the common ground equipment's six year budget profile (FYDP). Working with the common support equipment program office (PMA-260), the requirements officer must identify the Fleet's highest support equipment priorities that will fit within the 10% plus-up, while optimizing the allocation of these resources. During plus-up drills in past years, there was little need or focus in having a methodical or objective basis for prioritizing unfunded requirements and optimizing resource dollars. Throughout the 1980's, new and/or unfunded requirements were easily justified because of the significant growth in defense spending. However in the 1990's, with the end of the Cold War and the Nation's desire of having a balanced budget, defense spending has steadily decreased. Because of this, requirements below the funded line have substantially increased, making the decision of prioritization and what to fund during plus-up drills, very complex. The goal of this paper will be to optimize the plus-up allocation for common ground equipment. The Analytic Hierarchy Process (AHP) and Expert Choice software will be used to give positive structure to the current decision making process, allowing for a better understanding of objectives and alternatives in relation to the overall goal.

10% plus-up drills are common during the planning and programming portion of the budget. By inserting an additional 10% into a budget line, resource sponsors attempt to get a clear picture of high priority requirements that fall just below the funded line; and to also prepare for potential congressional plus-ups.

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BACKGROUND

Environment Overview

The resource sponsor for Navy and Marine Corps CSE is the Chief of Naval Operations, Air Warfare Division N881 (a Navy Captain). N881 and his principle advisors, the aircraft maintenance working group N881C, establish the planning, policy, and fleet support for all aviation maintenance issues for the Navy and the Marine Corps. The working group primarily focuses on monitoring and defending scarce resource dollars, which buy aircraft depot maintenance, engine improvements, weapons maintenance, supply support, and CSE. The requirements officer for the CSE funding line, which includes common ground equipment, is a Navy Commander.

Requirements officers are responsible for ensuring Fleet requirements are adequately funded through the use of the Department of Defense's (DODs) Planning, Programming, and Budgeting System (PPBS). The PPBS is a six year budget plan, which uses the Program Objectives Memorandum (POM) to enable resource sponsors to submit and justify their needed requirements. During the development of the POM, allocations are based upon competing requirements for the resources available in the Future Years Defense Plan (FYDP). It is within this development stage in which the 10% plus-up drill occurs. For this scenario with common ground equipment, the plus-up will be for 10% of the total common ground equipment budget line over the entire FYDP. Therefore the plus-up will be a total of $90 million.

After each resource sponsor within the Navy has submitted his requirements (through the Sponsor Program Proposal), the Department of the Navy will submit its unified POM to the Secretary of the Defense for the detailed application of resources. Upon completion of analyses and adjustments, the Secretary of Defense submits the DOD budget (as part of the President's budget) to Congress for approval. During congressional review, congressional plus-ups to individual programs may occur.

Problem Scenario

With the declining DOD budget, Naval Aviation must now acquire nearly all requirements within its existing budget. Because of this, there are far less opportunities for plus-ups within the Department of the Navy’s budget, or from congress. However, as part of the POM development process and the rare occurrence of a plus-up within the organization or from congress, requirements officers must be prepared to state and justify plus-up requirements. With fewer resource dollars to fund all programs, requirements officers and their program offices are finding more and more requirements are falling below the funded line. The ability to prioritize, choose, and allocate resources among these numerous requirements has become tedious and frustrating work for the requirements officer and the program office. By having a well structured and simplified process that optimizes selections, requirements officers have a far greater chance of successfully justifying and defending budget lines that receive plus-ups during the POM process.

Decision Identification

The primary focus of the requirements officer will be to optimize the $90 million plus-up allocation for common ground equipment.

Significance of Decision

This decision can have significant impact to the readiness of Naval Aviation aircraft. Lost opportunities in acquiring common ground equipment that is needed by maintenance personnel, could lead to the inability to conduct certain repairs and upkeep maintenance, or cause injury to personnel or unnecessary damage to an aircraft.

Decision Making Approach

Currently, the requirements officer and the program office do not have an established methodological process for the prioritization, selection, and allocation of plus-up candidates. Prioritization and selection are generally made by choosing the top items off of the *support equipment APN-7 buy list. Allocation of resources are accomplished by simply going down the buy list and "fitting" dollars into candidate programs. During this process, there is no stated goal or objectives, although it is assumed because the programs are on the buy list, they must meet the goal and criteria for plus-ups. Under the current budget environment, the resource sponsor can no longer assume that the decisions made are in fact in the best interest of the maintenance working group as a whole. In this scenario of the plus-up, if the alternatives selected do not adequately meet the criteria and goal of a plus-up, perhaps some of the funds allocated for common ground equipment could be better spent in another section, such as depot maintenance. Today's environment has created far more complex and unstructured (non-routine) decision problems for the decision maker than in past years.

**The support equipment APN-7 buy list is a prioritized list of Fleet CSE requirements, which contains both funded and unfunded requirements. It is derived annually from inventory data from the Support Equipment Resource Management Information System (SERMIS), acquisition data from the Automatic Support Equipment Resource Document system (AUTOSERD), and input from the Fleet's Support Equipment Controlling Authorities (SECAs). Although this appears to be an effective means of establishing priorities, and a good baseline for choosing candidates for plus-ups, it has proven to be inflexible and inadequate in the current unstructured and cost conscious budget environment. Although the buy list could benefit from the use of the AHP and Expert Choice, the limited scope of this project restricts the author to focus solely on the plus-up scenario.*

In this scenario of optimizing the plus-up allocation for common ground equipment, the Analytical Hierarchy Process (AHP) and Expert Choice (a software application based on the AHP) will be used to bring rationality to the decision problem. Rationality enables the decision maker to meet the organization's purpose through the achievement of objectives. By using the framework of the AHP, a complex scenario such as resource allocation will be capable of being modeled. By modeling the problem, the decision maker will have a better understanding of the problem, its criteria, and possible choices. The hierarchical structure of the AHP consists of an overarching goal, objectives (criteria), sub-objectives, and alternatives (see figure 1).

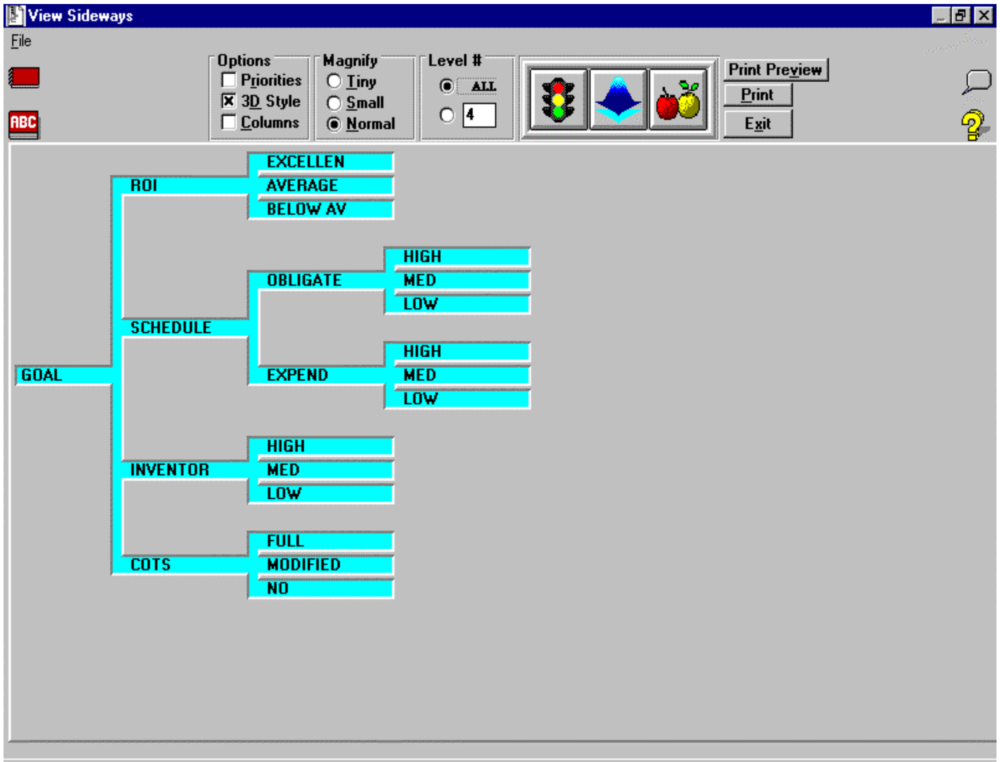

Figure 1. Hierarchical Structure

In order to obtain rationality, the AHP uses the following process:

1. Problem definition and research- Problem identification (statement of goal), identification of objectives and alternatives, and research of alternatives.
2. Discarding of infeasible alternatives.
3. Building the decision model in the form of a hierarchy (goal, objectives, sub-objectives, and alternatives).
4. Evaluating and prioritizing objectives and sub-objectives through use of pairwise relative comparison, using both factual data when available and intuition when not.
5. Measuring the alternative's contribution to each of the lowest sub-objectives.
6. Documenting the decision for justification and control.

The user-friendly design of Expert Choice will enable the user to easily build the AHP model and perform pairwise comparisons. Judgments that are both hard data and intuition may be inputted. The software will synthesize the decision maker's priorities in order to obtain overall priorities and ranking of the alternatives. Optimization of the alternatives will be conducted through the use of Microsoft Excel and its solver function. The optimization combines the relative ranking order (Expert Choice priority ranking) of each alternative with available funds, eventually giving the user the most optimal choices possible with given dollars. This process is very flexible, and by conducting several iterations, the decision maker can get a true feel of making the best decision possible under the current circumstances.

ALTERNATIVES

Nine alternatives, totaling nearly $125 million in APN-7 dollars, were selected by the program office (from the APN-7 buy list) as the best candidates for the $90 million plus-up over the current six year FYDP. They are as follows:

<u>Gas Detector</u>
The Gas Detector is utilized for the detection and monitoring of explosive vapors, oxygen, and toxicity levels during fuel cell maintenance operations. The existing Fleet detector is the GasTech 1314, which does not detect toxicological exposures. The current inventory objective is for 638 units. The Gas Detector will be used to support the following aircraft and drop tanks: AV8, C130, C2, C9, E2, E6, F14, FA18, H1, H2, H3, H46, H53, P3, S3, T2, T45, and V22.

<u>Shorebased De-Icer</u>
The TM1800 De-Icer is a shorebased, truck mounted, self-propelled unit with an enclosed cab for the operator. It is used in winter situations that require de-icing/anti-icing prior to an aircraft launch. The TM1800 will be used on the C130, C9, E6, and P3 aircraft, and will be replacing the legacy Trump D-40D model. The current inventory of D-40Ds cannot met current Fleet requirements due to parts obsolescence and increasing rework costs. There is an inventory objective of 35 units.

<u>SETS</u>
The Standard Engine Test System (SETS) is a fully automated, intermediate level engine test system for testing aircraft engines (out of airframe), which will replace the entire inventory of Navy engine test systems. The existing test systems, most of which are 20 to 30 years old, are manually operated and require long run times to acquire data, establish power settings, and to calculate performance data. The SETS will consolidate over 20 unique configurations and 180 end items to a single configuration capable of testing multiple Navy and Marine Corps propulsion systems. The inventory objective is 81 units. SETS will support the following aircraft engines: F18EF, AV8B, T45, F14B, S3A, EA6B, T2, V22, HIW, P3, C130, E2C, CH46, SH60B, and various auxiliary power units and small gas turbines.

<u>Crane Replacement</u>
The crane replacement is the 8-1/2 Ton Hoist Maintenance Crane, which is a shorebased crane used to remove and replace aircraft components in support of scheduled and unscheduled maintenance. These components include engines, transmissions, propellers, engine modules, and rotor blades on fixed and rotary-wing aircraft. Existing Pettibone cranes are approaching the end of their life cycle, which is resulting in high rework costs and associated supply support problems as replacement parts become obsolete. The inventory objective is 87 units. The replacement crane will be used on the P3, C130, H53, H46, AV8, and V22 aircraft.

Universal Engine Installation/Removal Trailer
The universal engine trailer provides a single configuration trailer to perform organizational and depot level engine installation and removal for various types of aircraft engines. Two types of trailers are currently being utilized by the Fleet for the installation/removal and handling of aircraft engines; they are the 4000 and ETU-110/E models. The 4000 trailer is large, is unable to transport engines, and is costly to maintain due to obsolete parts and materials. The ETU-110/E has a high failure rate, with high costs and unavailability of replacement parts. The inventory objective is 597 units. The trailer will be used support the F18, F18EF, F14, S3, E2, C2, and P3 aircraft.

Frequency Converter
The shipboard frequency converter is a solid state frequency converter that replaces the MMG-1A converter. It primarily supports the E2C aircraft, however has the ability to support various Naval Aviation aircraft. It is used in conjunction with the Deck Edge Power, and the shipboard MEPP electrical unit. Current MMG-1A units have experienced significant corrosion problems onboard aircraft carriers. This has lead to significant down time of units and costly high maintenance man hours. Modifications to prevent corrosion on the MMG-1A has been deemed impractical through the use of cost benefit analysis. Inventory objective is set at 48 units.

COAST
The Common Organizational level Armament Support Tester (COAST) is a planned joint program with the Air Force. It is designed to perform operational and system integrity checks to verify that the input/output signals at the weapons carriage interface are correct, accurate and within tolerance. The COAST will enable the Navy to eliminate twelve separate pieces of support equipment presently being used. The inventory objective is for 450 units. This tester will eliminate existing parts obsolescence issues on legacy testers, and will provide the latest in state of the art equipment to ordnance technicians. The COAST will be used on the F18, AH1, P3, H60, and AV8B aircraft.

ABE
The Advance Boresight Equipment (ABE) will allow for the boresighting of Naval Aviation aircraft while aboard and underway on a carrier, and while other maintenance is being conducted. This unit will reduce the time and manpower requirements currently needed to support the existing boresight unit because of its smaller size and maintenance friendly procedures in comparison to the large and complex legacy system . The inventory objective is for 57 units. The ABE will support the following aircraft: F18, F18EF, AV8B, V22, AH1W and various joint service requirements.

Universal O-Level Tester
The universal organization level tester or LINK-4A/C Data Link System is designed to support the Automated Carrier Landing System (ACLS), which gives aircraft the capability to perform “hands off landings”. The universal tester will replace the SM-511/511A and the ID-1956 testers. These legacy testers have been susceptible to high failure rates, and long turnaround times in repair due to parts obsolescence. The current inventory objective is for 197 units.

DECISION MODEL

Goal
The goal of this decision model is to optimize the plus-up allocation for Naval Aviation’s common ground equipment.

Primary Objectives
The following primary objectives were identified to be the most relevant in regards to the decision goal (see figure 2)

- ROI — Anticipated Return On Investment for the program.
- Schedule — Ability of the program to reach specified scheduled budget events.
- Inventory — Delta in obtaining an inventory objective of 85%.
- COTS — Program's potential for Commercial Off The Shelf applicability.

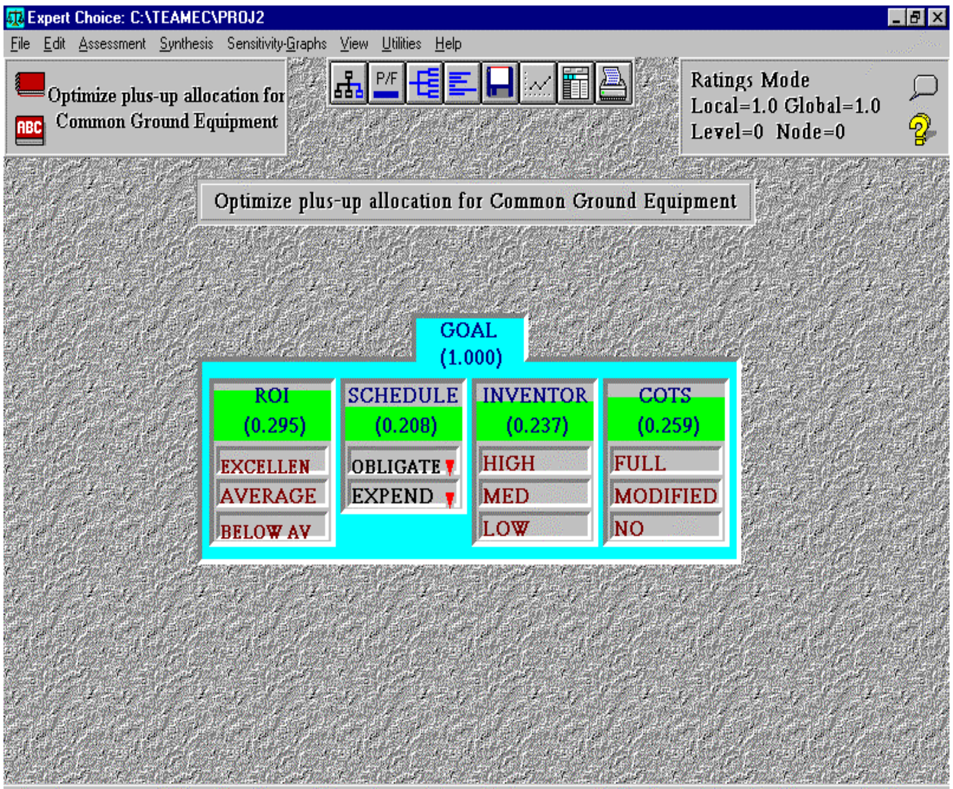

Figure 2. Decision Model

Sub-objectives
The following sub-objectives will be used for the below named objective.

SCHEDULE
- Obligation- Ability to secure a contract with the manufacturer in a timely manner.
- Expenditure- Ability of a program to fully expend dollars allocated to it.

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Ratings/Use of Intensities

In instances where there are numerous alternatives, such as the resource allocation scenario in this paper, a ratings approach is used. At the decision model's lowest level (objective or sub-objective), a scale of intensities was made so that each of the alternatives could be rated or measured. Like the objectives and sub-objectives, weights were derived to identify the relative preference for each level of the scale. The following scale of intensities will be used:

ROI
- Excellent
- Average
- Below Average

SCHEDULE/Obligation and Expenditure
- High
- Medium
- Low

INVENTORY
- High
- Medium
- Low

COTS
- Full
- Modified
- No

SYNTHESIS AND ANALYSIS

Weighting of Objectives

Through the use of the graphical pairwise comparison function in Expert Choice, weights were derived for the four primary objectives of ROI, schedule, inventory, and COTS, giving the decision maker priorities for the stated criteria.

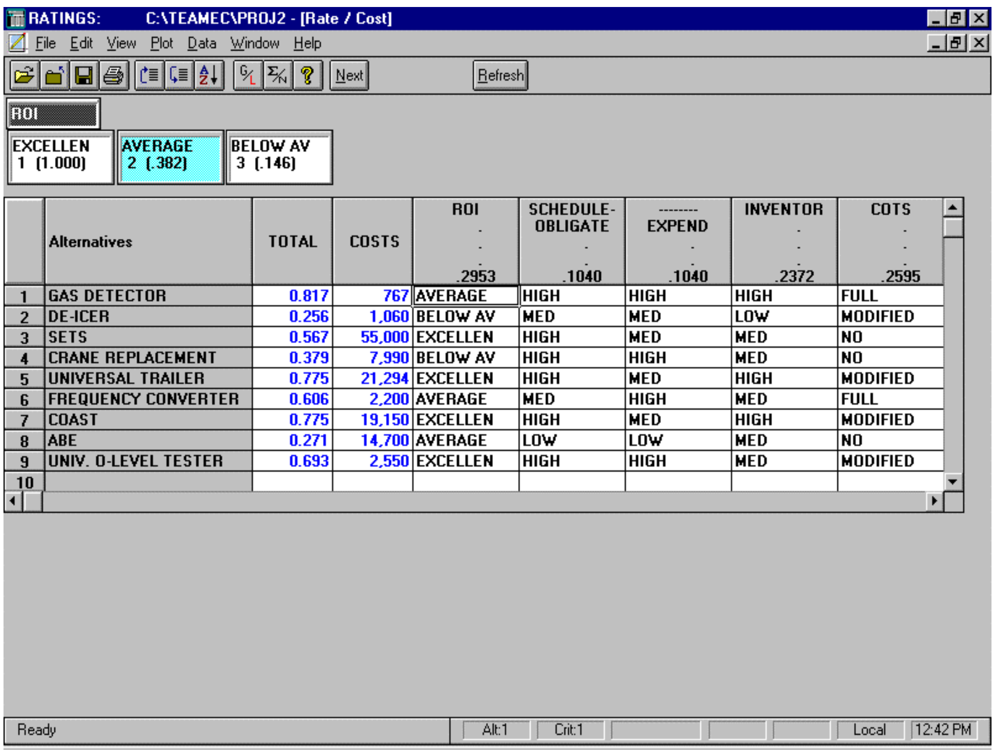
- ROI- .295
- Schedule- .208
- Inventory- .237
- COTS- .259

With the current budget environment, ROI was weighted by the requirements officer to have the highest priority among the four stated objectives. During the development of the budget, those programs which have high ROI will undoubtedly have a better chance of surviving the scrutiny of senior leadership. COTS was weighted as having the second highest priority. With the DOD push on acquisition reform and the emphasis on using

COTS technology whenever feasible, any alternative chosen must be screened for COTS applicability. Following COTS was the objective, inventory. During past budget development meetings (Flag Boards), those programs that could articulate or state the needed quantity of assets to reach an inventory objective of 85% were more successful in their ability to justify requirements. Although an important topic, the lowest prioritized objective was schedule. Once a program is allocated dollars, it is constantly monitored by budget analysts at all levels of the government (program, Navy, DOD, Congress) for its ability to obligate and expend within stated goals. Failure to reach these goals could mean the loss of scarce program dollars.

<u>Alternatives, Costs, and Priorities</u>

Using the weighted objectives above, the following priorities in Figure 3 were derived for all listed alternatives. Stated also is the total cost of the individual program, and the rating used to prioritize individual objectives in relation to the specified alternative.



	Alternatives	TOTAL	COSTS	ROI .2953	SCHEDULE-OBLIGATE .1040	-------- EXPEND .1040	INVENTOR .2372	COTS .2595
1	GAS DETECTOR	0.817	767	AVERAGE	HIGH	HIGH	HIGH	FULL
2	DE-ICER	0.256	1,060	BELOW AV	MED	MED	LOW	MODIFIED
3	SETS	0.567	55,000	EXCELLEN	HIGH	MED	MED	NO
4	CRANE REPLACEMENT	0.379	7,990	BELOW AV	HIGH	HIGH	MED	NO
5	UNIVERSAL TRAILER	0.775	21,294	EXCELLEN	HIGH	MED	HIGH	MODIFIED
6	FREQUENCY CONVERTER	0.606	2,200	AVERAGE	MED	HIGH	MED	FULL
7	COAST	0.775	19,150	EXCELLEN	HIGH	MED	HIGH	MODIFIED
8	ABE	0.271	14,700	AVERAGE	LOW	LOW	MED	NO
9	UNIV. O-LEVEL TESTER	0.693	2,550	EXCELLEN	HIGH	HIGH	MED	MODIFIED
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Figure 3. Alternatives, Costs, and Priorities

<u>Optimizing the Selection of Alternatives</u>

In this resource allocation scenario of selecting common ground equipment for the working group plus-up, the requirements officer wants to make the decision of whether to fully fund or not fund a program. Specifically, he wants to get the “biggest bang for the buck” since it is evident that resource dollars are tight, and that the working group can only afford to fund those programs that meet the stated objectives. In order to get the biggest bang for the buck, an optimization must be performed. Optimization is a method used in resource allocation problems that looks for those combination of alternatives that will maximize the total benefits without exceeding a given budget. Figure 4 shows one iteration of an optimization performed by Microsoft Excel Solver.

Alternatives	Priority	Costs (k's)	DV's	F. Benefits	F. Costs
GAS DETECTOR	0.159	767	1	0.159	767
DE-ICER	0.05	1,060	1	0.05	1060
SETS	0.11	55,000	0	0	0
CRANE REPLACEMENT	0.074	7,990	1	0.074	7990
UNIVERSAL TRAILER	0.151	21,294	1	0.151	21294
FREQUENCY CONVERTER	0.118	2,200	1	0.118	2200
COAST	0.151	19,150	1	0.151	19150
ABE	0.053	14,700	1	0.053	14700
UNIV. O-LEVEL TESTER	0.135	2,550	1	0.135	2550
			Totals:	0.891	69711

Figure 4. Optimization of Alternatives

If an optimization had not been conducted, the decision maker would have most likely chosen the highest prioritized alternatives until all funds ($90 million) were exhausted. However, after optimization, one can see how the information provided can have a profound change to the decision being made. In the iteration ran by Solver in Figure 4, the 1's listed in the DV (Decision Variable) column means that the alternative should be funded. The 0, recommends no funding. As it turns out, the alternative selected for no funding is the highest costing program, SETS. Of the $90 million available in plus-up, just under $70 million is maximized in relation to the stated objectives. Therefore, approximately $20 million of the plus-up funding could be better spent in another area within the working group (i.e. depot maintenance). Resource allocation is a dynamic and iterative process. Use of Excel Solver with Expert Choice, gives the decision maker the flexibility needed to perform several *iterations which may be graphed. By doing so, the decision maker has a clearer understanding of all potential options, making for better overall decisions.

**It is important to note the need to iterate when a solution is obtained, especially when it appears to be counter intuitive. Examples of a counter intuitive result includes when several alternatives are selected in one particular program, and not in another, or when all the lower cost alternatives are funded and no high cost alternatives are funded. The end solution should be intuitively acceptable to the decision maker, and justifiable in regards to the stated objectives. If this is not the case, more objectives and sub-objectives or intensity levels can be added in order to obtain a more robust hierarchy.*

CONCLUSION

With the end of the Cold War and the Nation's desire to balance the national budget, there is no longer an abundance of defense dollars to fund all stated requirements. Because of this, the task of prioritizing and selecting programs (within a defined budget) during budget plus-up drills has become painstakingly complex. Use of the AHP process and Expert Choice gives the decision maker the structure needed to model complex scenarios such as the common ground equipment problem discussed in this paper. Without a well defined process for prioritizing and selecting candidates for plus-ups, the requirements officer and program office were unable to choose, with confidence, those programs which truly deserved funding. Through the use of Microsoft Excel Solver, optimization of the prioritized alternatives was conducted, giving the decision maker flexibility and enhanced understanding of how to get the "biggest bang for the buck" during allocation of resources.

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