Resource Allocation For Information Security IR&D Projects

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Section 1

Abstract

Every year, Principal Investigators develop excellent ideas for Internal (or Independent) Research and Development (IR&D) projects, the majority of which are worthy of being funded. However, limited available IR&D dollars eliminates many excellent ideas from coming to fruition.

This year, there are six IR&D projects competing for funds: Intrusion Detection, Advanced Capability Enhancement (ACE), Multi-Level Security Architecture, CORBA Security Project, Rule Engine, and Certificate Management System (CMS). Although all were worthy of funding, the amount required to fund all six projects far exceeds the $250K available. Resource allocation was performed in an effort to determine the most effective way to spend the available IR&D funding.

Section 2
Introduction

Internal (or Independent) Research and Development (IR&D) is defined as the cost of an effort which is neither sponsored by a grant, nor required in performing a contract, and which falls within any of the following four areas:

- Basic research,
- Applied research,
- Development, or
- Systems and other concept formulation studies.

BASIC RESEARCH is research directed toward increase of knowledge. The primary aim is knowledge or understanding of the subject, rather than a practical application.

APPLIED RESEARCH is the effort that 1) normally follows basic research, b) attempts to determine and exploit the potential of scientific discoveries or improvements in technology, and c) attempts to advance the state-of-the-art.

DEVELOPMENT is the use of scientific and technical knowledge to design, develop, test, or evaluate a potential new product.

SYSTEMS AND OTHER CONCEPT FORMULATION STUDIES are analyses and study efforts either related to specific IR&D efforts, or directed toward the identification of desirable new systems, equipment, or components, or modifications/improvements to existing systems, equipment, or components.

This paper concerns the IR&D projects of an Information Security department of Lockheed Martin. The mission of this department is to select the projects that best represent the goals of the department in being prepared to support new and ongoing business opportunities.

Project Goal

The Information Security department has $250K budgeted for IR&D expenditures for the upcoming fiscal year, and $343K worth of proposed IR&D projects competing for this funding. The project goal is to allocate the IR&D budget to projects that will provide a competitive advantage to the organization.

Section 3
Approach: Expert Choice's Resource Allocation

The software package *Expert Choice* contains a resource allocation feature that assists in selecting an optimal group of alternatives from a specified set of alternatives that are subject to budgetary constraints. The software can perform both Discrete and Activity Level resource allocation. Discrete Resource Allocation is used when there is only one activity per alternative, while Activity Level Resource Allocation is used when there are multiple levels per alternative that can be funded, but only one will be chosen. Since the IR&D projects in this allocation exercise must all be fully funded, the Discrete Resource Allocation was used.

The Resource Allocation feature of *Expert Choice* is accessed from the Data Grid. To perform the Resource Allocation, either Excel's Solver or *Expert Choice's* Advanced Optimization is used. As there are bugs in Excel's Solver, the software documentation recommends using the Advanced Optimization option. For the purposes of this project, Excel's Solver was used, and then the Advanced Optimization was employed to verify the results.

Section 4

Alternatives

The first step in the Resource Allocation process is to identify (or design) the alternatives. For this project, the alternatives are six proposed IR&D projects among which the department's budget must be allocated. Each alternative is detailed below.

Intrusion Detection

Intrusion Detection is a system designed to model attacks on our computer system, then detect and neutralize them. This simulation will model how an intruder could enter and navigate through the system. The System Monitor would go to a "red" condition to alert the System Operator that an intrusion was taking place. The System will then track the intrusion to see what is happening. At the same time, the System will advise the System Operator regarding possible alternatives to take. For example, the advice might be to simply watch for a while and see what the intruder was looking for. Or it might be to shut down all systems to prevent further intrusion.

The pros to this alternative are:

- Functions on multi-platforms.
- Of interest to both commercial and Government customers.

The cons to this alternative are:

- This is an expansion of a predecessor project that was not fully developed.
- Need to be certain that project is fully funded to completion.

Advanced Capability Enhancement (ACE)

Advanced Communication Enhancement (ACE) is a knowledge-based system. It functions as an intricate Date Miner to ferret out information in various databases. In addition, it can do so in multiple languages. For instance, if you wanted to search for

Osama Bin Laden, you would enter that name (in various languages, if you wanted) and the system would proceed to search for anything that contained that information. It also provides a linked report showing the sources of that data.

The pros to this alternative are:

- Timely product.
- Strong application for Government clients.

The cons to this alternative are:

- There are several similar products available on the market.
- Must find the niche where this is the most applicable.

Multi-Level Security Architecture

Multi-Level Security is a study to examine various commercial off-the-shelf (COTS) products available to provide security to computer systems. The goal will be to find and integrate the best software and hardware products that are available at the most advantageous costs, into a multi-layered architecture to protect the Computer System.

The pros to this alternative are:

- Has both internal and external applications.
- Of interest to both commercial and Government customers.

The cons to this alternative are:

- Have not yet identified any external customers.
- Do not yet have a project manager.

CORBA Security Project

The CORBA Security Project is an advanced study to determine the needs of our company and customers regarding current and future CORBA needs. This will involve documentation of requirements and identification of security needs that are not being met. Then a system will be designed to meet these needs and requirements. Several current customers utilize CORBA, so resale potential is good.

The pros to this alternative are:

- Increasingly popular with our current customer base.
- Several areas of potential resale currently identified.

The cons to this alternative are:

- Requires a reliable security system.
- CORBA is not mature and implementation varies.

Rule Engine and Certificate Management System (CMS)

The final two IR&D programs, Rule Engine and Certificate Management System (CMS) relate to a unit identified as a SafeKeyper. A SafeKeyper is a crypto module designed to support certification authorities and other applications that employ digital signatures. Constraints in the unit are defined by rule sets which are bound to specific certification authorities; there is one rule set signer for each certification authority.

The Rule Engine IR&D task will define the structure of the rules and rule sets for a particular certification authority, which are then loaded into the SafeKeyper. This task will define procedures and request/response formats for rule management, and will design the rule engine and any utilities needed to convert rule formats. The CMS IR&D task will enhance the CMS software to support the latest versions of SafeKeyper (allowing the latest version of the rule engine to be incorporated), including software engineering, testing, and documentation.

Both of these tasks will advance work on the SafeKeyper, which will better position the company for additional work from the client. However, there is a small uncertainty as to the future of SafeKeyper.

Section 5

Objectives

The next step in the Resource Allocation process is to identify and structure the goal and objectives, because all decisions, including resource allocation decisions, must be made on the basis of achieving objectives. These objectives will be the basis of the resource allocation. It is also best to include broad sub-objectives in the hierarchy. Then the relative importance of the objectives and sub-objectives is established to allocate resources.

Of the IR&D projects included herein, three are new projects (Intrusion Detection, Rule Engine, and CMS), while the remainder (ACE, Multi-Level Security, and CORBA Security Project) are existing projects. The objectives and sub-objectives are summarized below.

Long-Term Benefits of New Projects

New IR&D projects must have long-term benefits. For example, the department can perform research/developmental work in advance of receiving an RFP or submitting an unsolicited proposal in order to gain an edge in receiving the work, or to enhance their reputation with their client. Therefore, future salability and enhanced reputation are sub-objectives of this objective.

Added Value to Existing Projects

Sometimes IR&D is performed to add value to existing projects. The same sub-objectives identified for the first alternative (future salability and enhanced reputation) are also applicable here.

Project Parameters

Finally, project parameters are important. Since the funding allocation is only for one fiscal year, the time to the completion of the IR&D project is critical. Also important is if additional funding will be required to complete the IR&D project. Specifically, will separately funded phases be required in order for the project to be successful, or will the current funding request be sufficient?

Figure 1 is the *Expert Choice* decision hierarchy, showing the objectives and associated sub-objectives with respect to the goal.

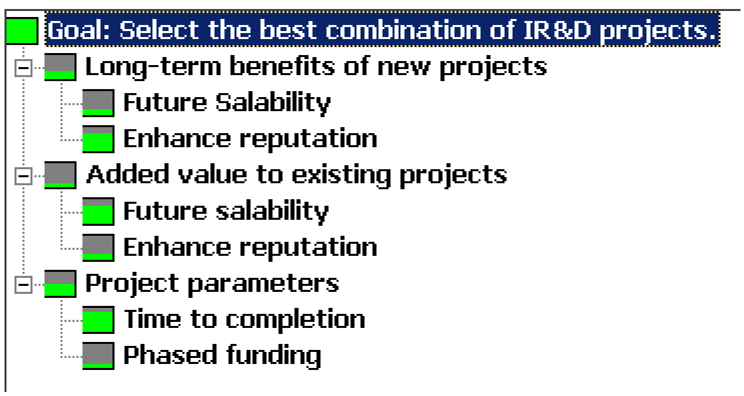

Figure 1. *Expert Choice* Decision Hierarchy

Section 6

Resource Allocation

Pairwise Comparisons

The AHP process involves structuring a hierarchy in order to evaluate objectives. The primary objective is the goal. Secondary objectives are identified, which can in turn be further divided into sub-objectives. Alternatives are identified; in this case the alternatives are the specific IR&D projects. Once the hierarchy is established, pairwise comparisons are performed. These pairwise comparisons are performed using two factors at a time; either of the two objectives is compared on the basis of the importance in achieving the goal, or alternatives are compared on the basis of preference relative to the objectives.

Using pairwise comparisons, the priorities of the objectives were derived (see Table 1). The project parameters objective was judged to be the most important, followed by long-term benefits of new projects, then added value to existing projects. The derived priorities are ratio level, so it is known that the priority of project parameters is 1.39 times the priority of the second most important objective, and 2.88 times the priority of the third most important objective.

Objective	Priority
Long-Term Benefits	0.349
Added Value	0.168
Project Parameters	0.484

Table 1. Objective Priorities

Intensities

Next, intensities for each of the objectives were also prioritized via pairwise comparisons. As shown in Figure 2, a “Highly Preferred” IR&D project will receive a priority of about 2.62 times that of an IR&D project that is only “Preferred”. While the intensities and their scales can be different for each of the objectives in the hierarchy, for the purposes of this project, the authors used the same intensities and rating scale for each of the objectives.

Intensity Name	Priority
Highly Preferred	1.000
Moderately Preferred	.627
Preferred	.382
Somewhat Preferred	.232
Not Preferred	.148

Figure 2. Intensities

After the objectives and the intensities were prioritized, each alternative IR&D project was rated with respect to each of the lowest level objectives. The results are shown in Figure 3. The columns with the "Ratings" headings show the intensities of the objectives. The "Cost" column shows the funding requirement of each of the alternative IR&D projects, and the "Total" column shows the ratio scale measure of the total contribution that each IR&D project will make to the department's objectives.

Ideal mode			RATINGS	RATINGS	RATINGS	RATINGS	RATINGS	RATINGS
Alternative	Total	Costs	Long-term benefits of new proj Future Salability (L:.250)	Long-term benefits of new proj Enhance reputation (L:.750)	Added value to existing projec Future salability (L:.750)	Added value to existing projec Enhance reputation (L:.250)	Project parameters Time to completion (L:.800)	Project parameters Phased funding (L:.200)
Intrusion Detection	.312	50000	Highly	Moderately				Moderately
ACE	.315	75000			Highly	Highly	Preferred	
Multi-Level Security	.095	40000			Preferred	Somewhat		Preferred
Rule Engine	.574	55000	Highly	Preferred			Highly	
CMS	.703	60000	Moderately	Highly			Highly	
CORBA Security Project	.282	23000			Somewhat	Somewhat	Moderately	

Figure 3. Combined Ratings

Solver

Initially, Excel's Solver was used to perform the Discrete Resource Allocation. A budget of $250K was entered; results are shown if Figure 4. The results show that ACE, Rule Engine and CMS will all be funded, for a total cost of $230K, and a benefit of 1.44 (out of a potential maximum benefit of 1.918 if all projects could be funded)

Alternative	Benefits	Costs	DVS	F. Benefits	F. Costs	B/C	Musts	Musts Nots
Intrusion Detection	0.194	50000	0	0.000	0.0	0.38800	0	1
ACE	0.555	100000	1	0.555	100000.0	0.55500	0	1
Multi-Level Security	0.095	40000	0	0.000	0.0	0.23750	0	1
Rule Engine	0.606	95000	1	0.606	95000.0	0.63789	0	1
CMS	0.281	35000	1	0.281	35000.0	0.80286	0	1
CORBA Security Project	0.187	23000	0	0.000	0.0	0.81304	0	1
				1.442	230000.0			
					250000.0			

Figure 4. Solver Results

Next, the authors optimized for increasing budgets. This feature allows the user to view the additional IR&D projects that will be funded if the budget allocation is increased. The “insure that funded alternatives remained funded as the budget increases” box was checked for ACE, Rule Engine and CMS prior to optimizing for increasing budgets. The results show that, predictably, this was only guaranteed once a minimum amount of funding of in excess of $230,000 (the combined cost of the three projects) is available.

Alternatives/Budget	23000	57300	91600	125900	160200	194500	228800	263100	297400	331700	366000
Intrusion Detection			Funded							Funded	Funded
ACE							Funded	Funded	Funded	Funded	Funded
Multi-Level Security						Funded			Funded		Funded
Rule Engine				Funded	Funded	Funded	Funded	Funded	Funded	Funded	Funded
CMS	Funded	Funded	Funded		Funded	Funded		Funded	Funded	Funded	Funded
CORBA Security Project	Funded			Funded	Funded	Funded	Funded	Funded	Funded	Funded	Funded
Cost, Funded	23000	35000	85000	118000	153000	193000	218000	253000	293000	303000	343000
Benefit, Normalized	9.7497	14.6507	24.7654	41.3452	55.9958	60.9489	70.2815	84.9322	89.8853	95.0469	100
Benefit, Funded	0.187	0.281	0.475	0.793	1.074	1.169	1.348	1.629	1.724	1.823	1.918

Table 2. Optimizing for Increasing Budgets

Advanced Optimization

Once the Solver Resource Allocation is complete, the Advanced Optimization Resource Allocation feature was executed. Results are shown in Figure 6.a and are identical to those shown earlier in Figure 4. Optimizing for increasing budgets showed similar results.

Solution		Status	Min	Max	Obj	Costs
	1) Intrusion Detection	4			0.194	50000
1	2) ACE	4			0.555	100000
	3) Multi-Level Security	4			0.095	40000
1	4) Rule Engine	4			0.606	95000
1	5) CMS	4			0.281	35000
	6) CORBA Security Project	4			0.187	23000
1.442	Min					
Tot Ben	Max					250000
						230000

Figure 5. Advanced Optimization Results

Section 7

Conclusions

In past years, IR&D projects selected were selected during a long, drawn out meeting, where the manager responsible for allocating the available IR&D funding and those Principal Investigators who were requesting funding for their project ideas would discuss and argue until only the strongest and loudest were left standing. Prior to using this resource allocation method, the authors knew that ACE had to be funded, but were unsure as to which remaining IR&D projects should be funded. The results show that that funding ACE, Rule Engine and CMS will best meet the department's objectives.

The above results were shown to the manager responsible for allocating the available IR&D funding. The authors explained the Expert Choice resource allocation feature, and discussed the results with her. Since the model showed ACE as funded, she was pleased with the results, and felt that additionally funding the Rule Engine and CMS efforts would be quite beneficial for two new efforts that are expected to be of interest to the Government. This model and analysis provided a new way to avoid some of the difficulties in selecting which projects would best benefit the company. This new approach was not embraced as the absolute answer to circumvent some of the discussions that inevitably take place, but there is interest in using this process to support the traditional discussions, and perhaps bring the decision process to closure sooner in the future.