Optimize Use of Limited In-house Development Staff

David Bolon
Lisa Panek
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Table of Contents

Table of Figures

Abstract

The Enterprise Products Company monitors and operates natural gas and liquids pipelines throughout the United States. The company uses a computerized system called Supervisory Control and Data Acquisition (SCADA) to monitor and operate these pipelines. The software developers within the company are responsible to ensure that the SCADA system is functioning properly and also to enhance the system when the need arises. The developers have found that they cannot implement all the requested changes within an allotted two month window of development time. The developers have also found that it is quite difficult to determine what work should be completed in the immediate update and what work can be delayed until more resources are available. Therefore, the developers have decided to use Expert Choice[1] to help them identify what work should be prioritized for completion with the next release. We will be looking at how this was accomplished and the outcome of this resource allocation effort.

Background

The Enterprise Products Company, whose main focus is to monitor and operate pipelines throughout the United States, has a control center staff which consists of 30 controllers, 3 operations staff and 3 software developers. The developers are responsible for ensuring the company's SCADA system runs accurately and conforms to regulations and guidelines that are mandated either from company policy, state or federal agencies. This means that the developers must determine what bug fixes and/or enhancements will go into current and future releases that would be the most beneficial to the organization. This can be a very trying task when there are an over abundance of upgrades that need to be completed within a timely manner.

In the past the developers used the method of assigning each of the tasks with a high/medium/low ranking. But they found that this method was not satisfactory because of the disagreements over what was truly high priority to all individuals. A common problem was encountered where, because of disagreements between the developers, the majority of the updates were assigned a high priority ranking. When too many updates were labeled high priority (more than could be implemented by the small team of developers), the simple ranking system was not sufficient to define which updates were to be included in the next release.

The developers decided that they would try a different method to prioritize and select what subset of updates would be in the upcoming release. They invoked the software application, Expert Choice and implemented a true resource allocation process to help in making those decisions.

Approach

Expert Choice has a capability that helps in determining how to best accomplish a certain amount of work in light of one or more scarce resources. In this study, the certain amount of work to be accomplished is the large number of requested updates to be implemented in the SCADA system and the scarce resources are the software developer's time. The overall goal is to *optimize the use of a limited in-house development staff.* The following is a brief overview of the process used by the development staff:

1. The overall objectives of the users of the system were defined
2. The objectives were prioritized by the users of the system
3. The current set of requested updates were imported into the Expert Choice package for evaluation
4. A rating scale was developed to help with rating each of the requested updates
5. The developers then rated each of the alternatives
6. A subset of the alternatives were identified for implementation based on the allotted funding (this study uses developer time instead of funding/dollars)

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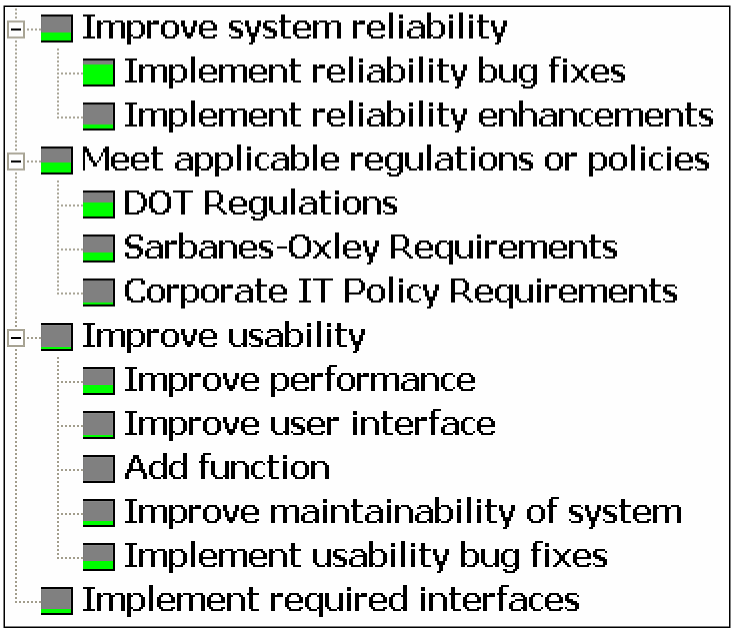
[1] Expert Choice is a software package that implements the Analytical Hierarchy Process. More information is available at the website of Expert Choice, Inc. (www.expertchoice.com)

7. "What-if" scenarios were run to determine what could be done if more or less developers were available to perform this work.

Objectives

The objectives defined in this decision model are defined from the perspective of the end users of the system. The controllers and their management are one group that uses the SCADA system in their day-to-day monitoring of the pipelines. Another group is the support staff that updates and maintains the SCADA system on behalf of the controllers. This group performs such activities as: add the scanning of new field computers or troubleshoot minor problems with the system. Together, these two groups identified the following major objectives and sub-objectives.

Figure 1 - Objectives



The objectives groupings are discussed below:

<u>System reliability</u> – this reflects the need to have a system that will not repeatedly fail during use. The controllers identified two sub-objectives of implementing reliability bug fixes and implementing reliability enhancements. A bug fix is necessary to correct a problem that exists today; something that is impeding system reliability. An enhancement will increase the reliability to a higher level than it nominally is today.

<u>Regulations or policies</u> – this set of objectives reflects the need to be in compliance with various governing bodies that have jurisdiction over the system. Three sets of regulations have been identified as being applicable: the Department of Transportation SCADA advisory notices, the Sarbanes Oxley law, and the internal corporate information technology policies.

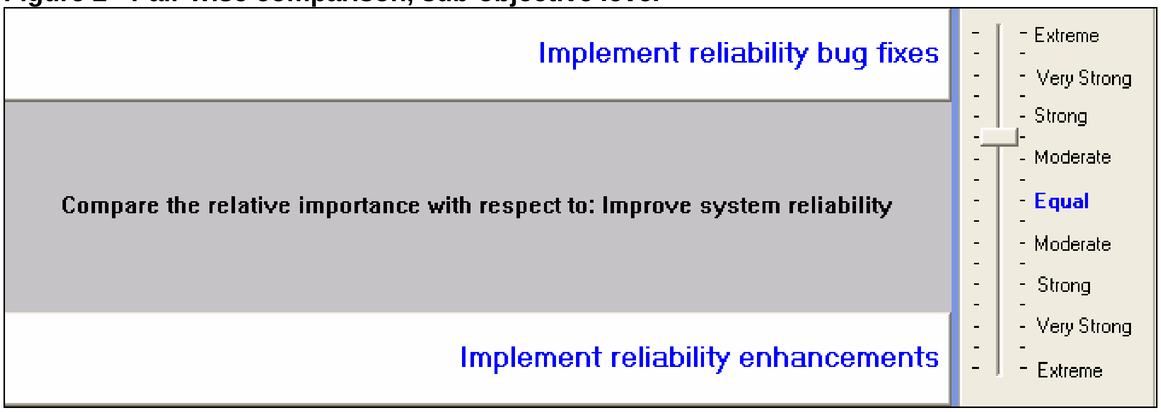
<u>Usability</u> – this set of objectives reflects all the various features that end users encounter as they operate a system. Controllers are most interested in the system performance, the usability of the various features, making sure their additional function requests are incorporated in the system, and in the bug fixes affecting usability. System operators are interested in the updates which will improve the maintainability of the system.

<u>Required interfaces</u> – this objective derives from the fact that the SCADA system must supply or accept data from other corporate systems.

Priorities of Objectives

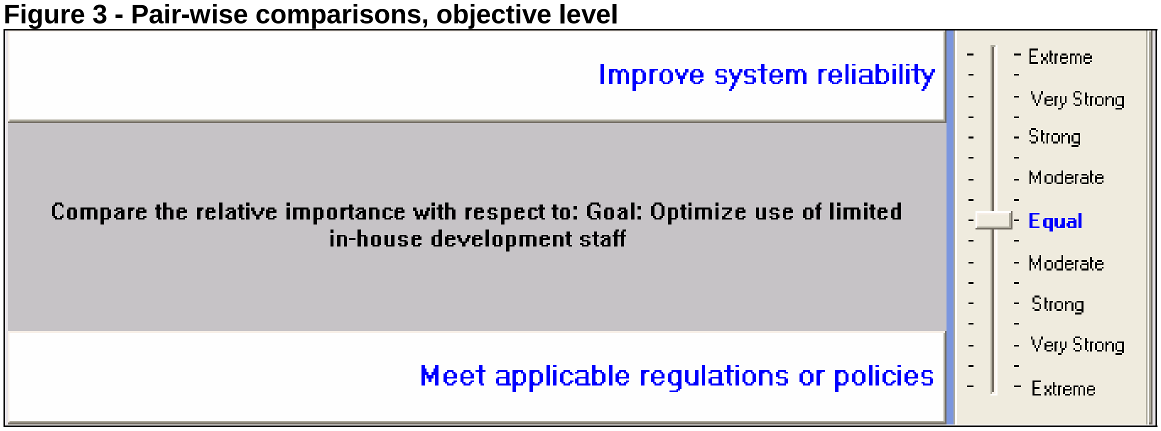
The priorities of the objectives were established by performing a series of pair-wise comparisons between the objectives within a cluster. For example, the following two sub-objectives were compared: *implement reliability bug fixes* and *implement reliability enhancements*. Figure 2 shows the comparison and the fact that the end user preferred *implement reliability bug fixes* by a moderate to strong level over *implement reliability enhancements*.

Figure 2 - Pair-wise comparison, sub-objective level



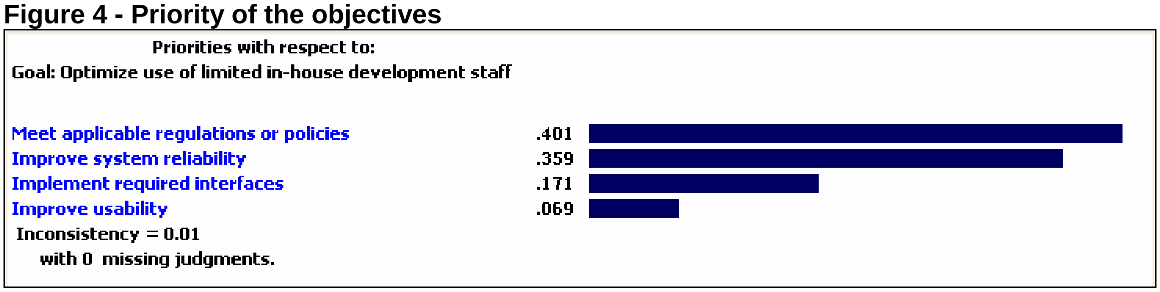
Pair-wise comparisons were also done at the objective level. Figure 3 shows a comparison between *improve system reliability* and *meet applicable regulations*. The verbal comparison shows that the end users assigned equal importance to these two objectives.

Figure 3 - Pair-wise comparisons, objective level



After all the pair-wise comparisons were completed, priorities were derived for the objectives and sub-objectives. The priorities for the objectives are shown in Figure 4:

Figure 4 - Priority of the objectives



The objective, *meet applicable regulations or policies*, has the highest priority among the set. This fits with common sense in that a system which does not meet the baseline regulations for the industry will expose the company to possible fines or other penalties. The second most important objective is *improve system reliability*. This also fits with intuition in that the controllers and their management wants a system that will operate without failure so they can concentrate on operating a safe pipeline. The third most important objective is to *implement required interfaces*. This reflects the set of changes that are required to either supply or receive data from another system. Finally the objective, *improve usability*, is the least important objective.

This graphical view (Figure 4) of the priority of the objectives with respect to the goal of optimizing the use of the limited in-house development staff visually represents the importance of the objectives to the users of the system. The fact that these are ratio scale numbers allows us to understand that the highest prioritized objective is nearly six times as important as the lowest prioritized objective. (.401 / .069 = 5.8) Other facts are equally apparent in Figure 4; for example it can be seen that the most important objective of *meet applicable regulations or policies* is more important than *improve system reliability* but only by a relatively small amount compared to the rest of the objectives. *Meet applicable regulations or policies* is 1.17 times (.401 / .359 = 1.17) as important as *improve system reliability.* This ratio was discussed with the end users of the system and found to be in agreement with their intuition. Ratio scale numbers provide much more valuable insight into the relative importance of the objectives versus using a simple ordinal scale to rank the objectives.

Alternatives

The alternatives are the open set of change requests that users, operators, and developers of the SCADA system have entered into an external change management application. The change requests are entered into the change management application along with supporting documentation and explanatory material. The development team reviews the change request and adds information that indicates how much time is required to implement the change. This developer’s time (entered in labor months) is a reflection of the cost of implementing the change. The next step in the process is a review by the change control board which either approves or disapproves the change for implementation.

At this point in the change control process, a set of approved changes are ready to be evaluated to determine what set of changes should comprise the next release (or upgrade) of the SCADA system. Using the data grid feature of Expert Choice, the approved changes (title and labor hours) were imported into Expert Choice for evaluation and optimization. This process of importing the approved changes can be performed in a cyclical manner as each release is defined. The strength of the process is that the evaluation can take place with a current snapshot of the approved change requests in a very quick manner.

Figure 5 shows a portion of the data grid with the change request title and cost (labor months) shown. There are a total of 30 alternatives being considered in this decision model, only a subset is shown for space savings reasons.

Figure 5 - Alternatives and cost

Alternative	Costs
"Event History" Tool	1.5
3,000 Unused Tags in PIMS MR Table	0.5
Ablility to download all screens etc.	2
Ack All On Startup is Flakey	0.5
Alarm display order	0.25
Alarms Are Missing.	0.25
Any update services to not hardcode drive	0.5
Auto Rename of History	1.5
Color Change for MAOP Alarms	1
Computer Migration - Loss Of Data	0.5
Daily averages are from 9-9 - liquids needs	1.5

Rating scale

A rating scale was developed for use in evaluating how much each alternative contributes to the objective. Intensity names were defined; then pair-wise comparisons between the different names were conducted to determine the ratio scale measures seen below. From this scale it can be seen that an alternative rated *excellent* contributes slightly more than four times as much to the objective as an alternative rated *very good* contributes. Similarly, when an alternative is rated *excellent*, this indicates that it contributes almost 28 times (1.0 / .036) more than an alternative that has a rating of *minimal*. If a typical ordinal scale had been used, then an alternative that was rated *excellent* would only be six times more preferable than one that was rated *minimal*.

Figure 6 - Intensity rating scale

Intensity Name	Priority
Excellent	1.000
Very good	.248
Good	.131
Marginal	.077
Weak	.047
Minimal	.036

Priorities of alternatives

Once the alternatives have been entered into Expert Choice, an evaluation of the alternatives against the various covering objectives can be performed. The covering objectives are the lowest level sub-objectives in the hierarchy of objectives. Each alternative is rated against the scale for each covering objective. A subset of the results of this rating is shown in Figure 7. Note that this rating was performed by the developers of the system, as they had the most expertise to determine if a change request was applicable to any of the covering objectives.

Figure 7 - Alternative ratings

Alternative	Costs	Improve system reliability Implement reliability bug fixes	Improve system reliability Implement reliability enhancements	Meet applicable regulations or DOT Regulations
"Event History" Tool	1.5		Minimal	Excellent
3,000 Unused Tags in PIMS MR Table	0.5		Marginal	Minimal
Ablility to download all screens etc.	2	Marginal	Good	
Ack All On Startup is Flakey	0.5	Excellent		Good
Alarm display order	0.25	Marginal	Weak	Weak
Alarms Are Missing.	0.25	Excellent		Excellent
Any update services to not hardcode drive	0.5	Good	Very good	
Auto Rename of History	1.5	Good	Good	
Color Change for MAOP Alarms	1		Minimal	Excellent
Computer Migration - Loss Of Data	0.5	Excellent		Excellent
Daily averages are from 9-9 - liquids needs	1.5		Very good	Very good

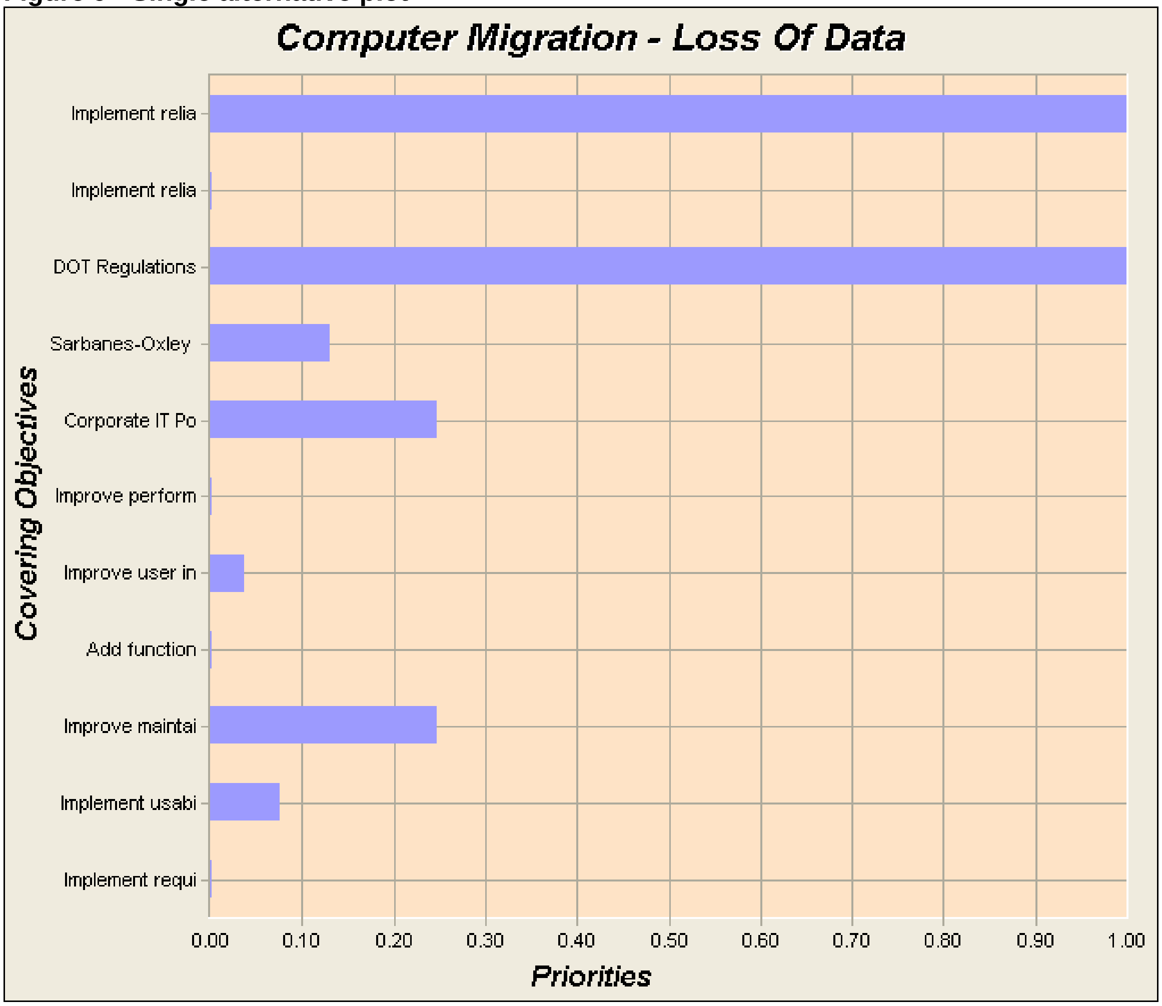
Once all the alternatives were rated against the covering objectives (11 in this model), a total score for each alternative was derived by Expert Choice. This total score represents the contribution that particular alternative will make toward the objectives. Figure 8 includes the total score for the subset of alternatives shown (again a subset is shown to conserve space). In this figure the totals have been normalized to indicate the "percent of maximum" with the highest prioritized alternative at the top of the list and the alternatives shown in descending total order. This view gives a clear indication of which alternatives contribute the most to the objectives and sub-objectives, and how much they contribute. For example the highest prioritized alternative is *Computer Migration – Loss of Data*, with the alternative *Need to provide Plant Operators Control Ability* contributing less than 50% as much benefit as the highest prioritized alternative.

Figure 8 -Alternative prioritization

Alternative	Total	Costs
Computer Migration - Loss Of Data	1.000	0.5
Alarms Are Missing.	.992	0.25
Fail Over Procedures Documentation Procedures	.853	2
Did not display all stale/old alarms on failover	.679	1.5
Does not sort correctly on initialization	.627	0.25
Ack All On Startup is Flakey	.624	0.5
Multiple records showed up in AlarmsWatcher for the	.624	0.5
"Event History" Tool	.589	1.5
linepack calc wont calc stale/old input tags	.585	0.5
Memory Leak	.583	0.5
Daily records should only be kept for 3 years	.571	0.5
Database Additions - need to trim off any blank spaces	.539	1
Move calculations from Gateway to PIMS	.524	0.5
Need to provide Plant Operators Control Ability	.493	1.1

A useful feature to understand why an alternative is prioritized as it is, is to use a graphic that shows a single alternative and the rating assigned for each covering objective. Figure 9 shows the alternative *Computer Migration – Loss of Data* in such a graph. In this one graphic it is possible to visually see why an alternative was prioritized as highly (or as low) as it was. In this case, the alternative was rated excellent applicability for *implement reliability bug fixes* and *meet applicable regulations* (which are some of the higher priority objectives).

Figure 9 - Single alternative plot



Optimization process

The optimization process involved taking all the prioritized alternatives and determining the subset that would meet the budget constraint while providing the most benefit. The budget constraint is defined in terms of labor months available to implement the next release. In this case, the timeframe (budget) allotted to develop the next release is 2 calendar months which is equivalent to 6 labor months. The benefit is measured by the total score for the set of alternatives.

Using the optimization feature of Expert Choice, the alternatives were evaluated and the following set of change requests was identified as the optimal set for the next release (optimal meaning providing the most benefit for the identified budget). The alternatives in the yellow shading are the ones that should be funded for the next release.

Figure 10 - Alternative optimization (all alternatives shown)

Alternative	Funded	Benefit	Cost
Computer Migration - Loss Of Data	YES	1.000	0.50
Alarms Are Missing.	YES	.992	0.25
Fail Over Procedures Documentation Procedures	NO	.853	2.00
Did not display all stale/old alarms on failover	YES	.679	1.50
Does not sort correctly on initialization	YES	.627	0.25
Multiple records showed up in AlarmsWatcher for the same alarm	YES	.624	0.50
Ack All On Startup is Flakey	YES	.624	0.50
"Event History" Tool	NO	.589	1.50
linepack calc wont calc stale/old input tags	YES	.585	0.50
Memory Leak	YES	.583	0.50
Daily records should only be kept for 3 years	YES	.571	0.50
Database Additions - need to trim off any blank spaces	NO	.539	1.00
Move calculations from Gateway to PIMS	YES	.524	0.50
Need to provide Plant Operators Control Ability	NO	.493	1.10
Database Interfaces	NO	.472	1.50
Color Change for MAOP Alarms	NO	.448	1.00
MAOP Tags	YES	.448	0.50
Get PIMS working on Citrix for swing migration	NO	.339	1.00
Midstream today using PIMS	NO	.325	2.00
DR table population issue	NO	.317	1.00
Daily averages are from 9-9 - liquids needs daily averages	NO	.226	1.50
Auto Rename of History	NO	.190	1.50
Any update services to not hardcode drive letters	NO	.138	0.50
Need standard "phone number" tool across all desks	NO	.112	3.00
Need to identify & delete unused tags.	NO	.110	1.00
Make popup dialogs appear in correct location	NO	.098	0.50
Ablility to download all screens etc.	NO	.087	2.00
Alarm display order	NO	.082	0.25
3,000 Unused Tags in PIMS MR Table	NO	.070	0.50
Don't show acked alarms on AWatcher sub-tabs	NO	.056	0.75

It is also possible to determine the percent of maximum benefit that will be achieved by this alternative set. Figure 11 (also from the same optimization tool in Expert Choice) shows that 56.69% of the total possible benefits available will be implemented by selecting and implementing this set of change requests. The *budget limit* field shows that 6 labor months are used in this evaluation. The *benefits* field shows the total amount of benefits to be achieved with this budget, and the *base case maximum* field shows the total amount of benefits possible if all alternatives are selected for inclusion.

Figure 11 - Benefit analysis

Budget Limit	Benefits		%
6.	7.257	=	56.69
Funded Cost	Base Case Maximum		
6.	12.801		

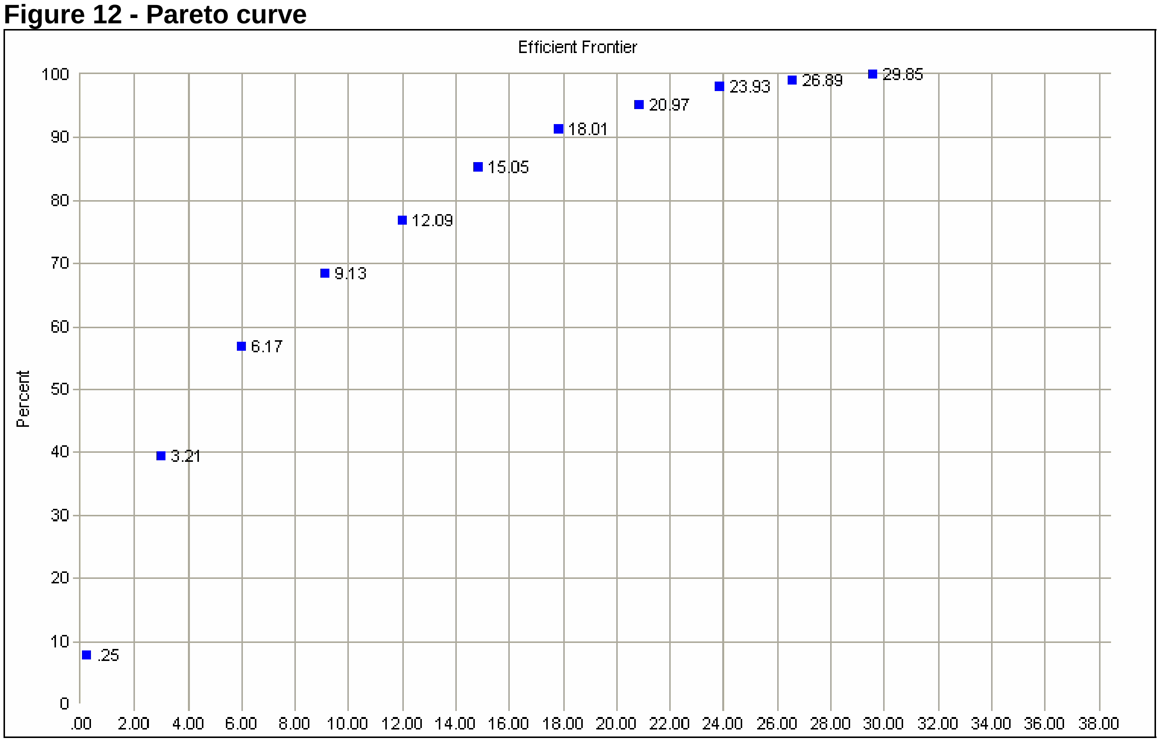
Alternate portfolios

One interesting capability of Expert Choice is to present a portfolio of work that can be implemented for any given cost. The value of the portfolio of work is expressed in terms of the benefit derived from implementing that set of change requests.

In Figure 12, a Pareto curve is plotted showing the increasing costs (labor months on X axis) that it takes to achieve an increasing amount of benefit (percent of maximum on Y axis). One interesting observation that is immediately apparent is that it would take approximately 30 labor months to implement all the change requests and receive 100% of the available benefits. Another interesting observation is that there is a case of diminishing returns associated with this body of work. Because many of the change requests with the highest benefit are implemented first, the remaining change requests do not provide as much benefit for the associated cost – therefore the Pareto curve shows a diminishing return. The optimization process does not simply choose the alternatives with the highest benefit for inclusion; the process determines the best mix of alternatives that will provide the highest overall benefit within the cost constraint. For example, some alternatives with high benefit and high cost may not be initially included because this would not provide the optimal solution. This is most likely the case with the alternative "Fail Over Procedures Documentation"; see Figure 11.

Also, the Pareto curve can be used to graphically answer the question, how much more benefit will I gain if I add one or two more developers to the project? Likewise, how much benefit will I lose if one of the developers is assigned elsewhere? These questions can be answered graphically with this figure, or they can also be answered using Expert Choice to show the benefit to be derived for a given budget, along with the exact set of change requests to be implemented.

Figure 12 - Pareto curve



Summary and Conclusion

This case study has identified a set of alternatives to be implemented within the next release of the SCADA system. The streamlined process began with a set of objectives defined and prioritized by the end users of the SCADA system. From there, a set of alternatives were evaluated to determine which alternatives would contribute the most toward accomplishing the end user's set of objectives. After a set of alternatives were prioritized using a rating scale, an optimization step was undertaken to identify the set of change requests that would provide the maximum benefit given a constrained budget. From start to finish, the process is focused on understanding the priorities of the end users and defining a set of updates which provide the highest benefit for them, given a constrained resource.

This study effectively identified the set of change requests that will be implemented in the next update of the SCADA system used by the Enterprise Products Company. The previous process of ranking each change request with a high/medium/low priority had drawbacks because the developers began to assign a high priority ranking to most of the change requests. Far more change requests were ranked high priority than could be implemented within the two month calendar window allotted for the next release. A subset of the change requests had to be selected, yet there was no effective mechanism to determine which ones were the best set to choose.

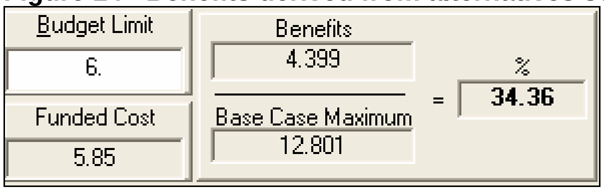
A comparison is presented in Figure 13 to show the set of change requests that *would have been implemented using the previous method*. In this scenario, the high priority change requests were marked as "must", while the low priority change requests were marked as "must not". As stated previously, more change requests were marked with the high priority category than could be implemented within the short two month window. The developers often used a BOGSAT (bunch of guys sitting around talking) to determine the subset of the high priority items to be included in the next release. This subset is shown in Figure 13 as items that "must" be included.

Figure 13 - Alternatives selected using previous process

Alternative	Funded	Benefit	Cost	Must	Must Not
Computer Migration - Loss Of Data	YES	1.000	0.50	☑	☐
Alarms Are Missing.	YES	.992	0.25	☑	☐
Fail Over Procedures Documentation Procedures	NO	.853	2.00	☐	☐
Did not display all stale/old alarms on failover	YES	.679	1.50	☑	☐
Does not sort correctly on initialization	NO	.627	0.25	☐	☐
Multiple records showed up in AlarmsWatcher for the same alarm	NO	.624	0.50	☐	☑
Ack All On Startup is Flakey	NO	.624	0.50	☐	☐
"Event History" Tool	NO	.589	1.50	☐	☐
linepack calc wont calc stale/old input tags	NO	.585	0.50	☐	☐
Memory Leak	NO	.583	0.50	☐	☐
Daily records should only be kept for 3 years	NO	.571	0.50	☐	☐
Database Additions - need to trim off any blank spaces	NO	.539	1.00	☐	☐
Move calculations from Gateway to PIMS	NO	.524	0.50	☐	☐
Need to provide Plant Operators Control Ability	YES	.493	1.10	☑	☐
Database Interfaces	NO	.472	1.50	☐	☐
Color Change for MAOP Alarms	YES	.448	1.00	☑	☐
MAOP Tags	YES	.448	0.50	☑	☐
Get PIMS working on Citrix for swing migration	YES	.339	1.00	☑	☐
Midstream today using PIMS	NO	.325	2.00	☐	☐
DR table population issue	NO	.317	1.00	☐	☐
Daily averages are from 9-9 - liquids needs daily averages	NO	.226	1.50	☐	☐
Auto Rename of History	NO	.190	1.50	☐	☐
Any update services to not hardcode drive letters	NO	.138	0.50	☐	☐
Need standard "phone number" tool across all desks	NO	.112	3.00	☐	☐
Need to identify & delete unused tags.	NO	.110	1.00	☐	☐
Make popup dialogs appear in correct location	NO	.098	0.50	☐	☐
Ablility to download all screens etc.	NO	.087	2.00	☐	☑
Alarm display order	NO	.082	0.25	☐	☐
3,000 Unused Tags in PIMS MR Table	NO	.070	0.50	☐	☑
Don't show acked alarms on AWatcher sub-tabs	NO	.056	0.75	☐	☐

The benefits to be derived from this set of change requests are indicated in Figure 14. Several interesting facts can be seen from this comparison. First, the total benefit derived from implementing this set of alternatives is 34.36% of the maximum possible. This is substantially lower than the benefits derived from using the entire process (including prioritizing the alternatives with the rating scale). The optimal set of alternatives yielded 56.69% of the maximum benefits, this is nearly a 65% increase in benefits ((56.69 – 34.36) / 34.36). Secondly, and related to the first observation, the change requests selected for implementation using the high priority ranking and BOGSAT approach were not really the most important change requests for the end users. It can be seen in Figure 13 that many of the change requests selected for implementation were further down the list in terms of importance or benefit provided to the users.

Figure 14 - Benefits derived from alternatives selected using previous method



This study has shown a better method to determine the specific work that should be implemented by the in-house development staff. This resource allocation method, based on the Analytical Hierarchy Process, identified a 65% more beneficial set of updates to be included within the next release of the SCADA system. This allows the Enterprise Products Company to truly optimize the use of a limited in-house development staff.

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