Using Decision Analysis Tools in Selecting Alternate Engineering Design Projects

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Introduction

This article is intended to help Engineering Managers make better decisions regarding how to proceed on the projects they have at hand, whether they are for a development or a production tester or some other project to be undertaken. The process can be generalized to assist in making any general business management decision.

What is a Decision Analysis?

No process can make a business decision for a manager, but there are several ways to assist a manager in making better decisions. Utilizing a formal process is a significant improvement over the decision by the "seat of your pants." These tools assist in making a much better and reasoned decision. In the end, though, the manager is often faced with deciding with insufficient information to make a final decision. These tools, as a class, are known as "Decision Analysis Tools." They assist in making a decision when many of the needed facts are uncertain.

There are many good places to get a more in-depth understanding of such tools. Several of these have been collected on my website at https://www.angotti.com/docs/analyisistools.pdf . So, if you are curious about the background of this article, check out a few of these.

The general concepts of making uncertain decisions are based upon several items, the factor under consideration, the relative significance, and the relative impact on the outcome of the decision. On a general level, if one assigns say one to five weights for importance and impact of a factor, then the score of a particular factor is computed as:

(relative significance of a factor) times (impact of a factor) = total score for a factor

Each of these scores can be added to a total. Then, these can be summed to yield a total score for a particular decision.

Now alternate decisions can be compared with each other, and a selection can be made among them. These scores are not just immediately acted upon, just because of the numbers. Instead, after this, the decision-maker looks at the results and judges whether the outcome ranking makes much sense. Often the outcomes are pretty close together, so only slight changes in the analyses can change a ranking. Perhaps the earlier factor analyses need to be reviewed; then, the weights might be changed to create a new analysis. This review points out where the critical factors lie, and that assists strongly in the final decision.

What are Outcome Factors in Making a Reasoned Judgement?

These weightings represent the factors, or short descriptions, of what might be considered in making a decision. These depend upon what is known by the decision-makers and what they have on hand or might be easily obtained via research or internal data gathering. As an example, it might be the "total project cost" with 5 = very high relative cost and one = a very, very low relative cost. 3 might be a modest cost. Of course, these are all judgments in themselves, but the cost consideration helps decide this particular factor's value.

The Criticality Factor Explained

These weighting factors represent a judgment based upon past knowledge of how critical a factor is in making the decision. Again, as an example, if budgets are very tight, this might be assigned a value of 5, for very important, or a 0 for not crucial if cost isn't as critical a factor as other factors might be.

The Impact of a Factor Explained

These weightings represent how a factor might affect a decision. They are all judgment calls. Will this particular factor affect the final project's future outcome or affect the company's future in a significant way? If so, it would be given a value of 5 to represent very impactful or one as hardly impactful at all. A factor of 1 would have a meager impact on the decision.

Creating and Using a Simple Analysis Tool

An illustration of how such an analysis might work is presented here. The decision involves choosing a Production Test design. The choices are:

1) A more inexpensive and easier to develop manual one
2) A mid-cost semi-automatic one
3) A higher cost and more challenging to develop fully automatic tester

This particular company is a mid-sized one with a modest budget. The devices to be tested cost about $100 each to fabricate and assemble. The volume produced is estimated at 100 per month. The life of this product is expected to be five years into the future. For this situation, the life cycle value of the tester is $100 per unit X 100 Units per month X 60 months, or $600,000. In this situation, if product tester development costs are planned to not add significantly to the unit production cost, these might amount to adding 5% to the final tested cost allowing $30,000 for such a development.

Example of the Factors that Make up the Decision

In all cases, the future significance or impact of these factors of often highly unknown. For this analysis, some of the factors <u>may be reversed</u> in their order of criticality. For some factors, a 1 has high criticality, while a 5 has low criticality. The analysis intends that a higher total score favors an Automatic Tester, and a lower one favors a Manual Tester.

Some examples of factors that might be considered in the analysis are:

- Factor 1 - Experience with Building Similar Testers, 5 = Lots, 1 = Very Little, Lots favors the use of automatic testing, 3 favors semi-automatic testing
- Factor 2 - Est. Final Cost of UUT, 5 = Higher, 1 = Lower, 3 = middle cost. A higher cost generally favors automatic testing
- Factor 3 - Volume Level of Nominal Build, 5 = Higher, 1 = Much lower, higher volume favors automatic testing, etc.
- Factor 4 - Volume Level of Est Life Cycle Build Total, 5 = Higher, 1 = Much lower, higher volume favors automatic testing, etc.
- Factor 5 - Funds Available for Tester Project, 5 = Relatively High, 1 = Much lower, more funds available favors automatic testing, etc.
- Factor 6 - Est. Cost to Build Tester and Write software or Test Procedures, 5 = Relatively High, 1 = Relatively lower, more funds available favors automatic testing, etc.
- Factor 7 - Skill Level of Test Operator, in this case, a 5 = Lower Skill and 1 = Higher Skill. Cost is highly dependent on the operator's skill in running the testing. High volume favors automatic testing, etc.
- Factor 8 - Likelihood of Field Failure, in this case, a 1 = Lower Probability and 5 = Higher Probability, higher probability means to incur higher lifetime maintenance cost. Higher cost favors the quality of automatic testing, etc.
- Factor 9 - Cost of Field Failure, a 1 = Low cost and 5 = High Cost. Field failures are likely high if it is costly to troubleshoot a failure in the field. In this case, the High cost of Field Failures favors the quality of automatic testing, etc.

The above illustrates the value of the significance of a factor to a decision. Similarly, each factor impacts the decision, such as impacting the ability to market the product or the impact on the company’s future success due to loss of funding. For example, a significant impact favors automatic testing, while a small one makes the score for that factor favor manual testing as sufficient in a particular instance. In this case, 5 = very impactful, and a 1 would have a relatively much lower impact.

The table below illustrates how these factors are used to decide on whether to design a fully automatic, semi-automatic, or manual tester to test a particular board or system.

Table 1 Example Spreadsheet

Evaluation Checklist for Test Equipment for a Build Decision

Factors	**Decision Factors**	**Value of Factor (1 to 5)**	**Impact of Factor (1 to 5)**	**Factor Calculated Value**
Factor 1	Experience with Building Similar Testers	2	3	6
Factor 2	Est. Final Cost of UUT	4	4	16
Factor 3	Volume Level of Nominal Build	3	4	12
Factor 4	Volume Level of Est Life Cycle Build Total	2	4	8
Factor 5	Funds Available for Tester Project	2	4	8
Factor 6	Est. Cost to Build Tester and Write software or Test Procedures	3	4	12
Factor 7	Skill Level of Test Operator	3	3	9
Factor 8	Liklihood of Field Failure	3	3	9
Factor 9	Cost of Field Failure	4	5	20
Factor 10	N/A	N	N	0
Factor 11	N/A	N	N	0
	Sum of Computed Value of All Factors			**0.444**

Normalized Computed Value Ranges:				
All Max Value			1	**Definitely Auto Tester**
All Mid Value			0.36	**Likely Semi-Automatic Tester**
All Min Value			0.04	**Definitely Manual Tester**

No. of Active Categories	9

See Notes for Description of the Value of Factor and the Impact of a Factor

You can obtain an Excel spreadsheet that has these computations embedded in it. Your factors can be added or altered to satisfy your needs. It is obtained by sending an email to carl@angotti.com with the subject “Send Decision Matrix Spreadsheet.” It will be returned to you via email.

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List of sources for Decision Analysis Information

https://www.mindtools.com/pages/article/newTED_03.htm - Discussion of the use of spreadsheet analysis to make a decision

https://pestleanalysis.com/decision-analysis/ -- Excellent discussion of many business analysis techniques

https://home.ubalt.edu/ntsbarsh/business-stat/opre/partIX.htm - An academic discussion of Decision Analysis in the face of uncertainty

https://creately.com/blog/diagrams/decision-making-techniques-tools/#Root_Cause_Analysis – Another excellent site for understanding the many tools that might be used for decision analysis

https://hbr.org/2013/11/deciding-how-to-decide - "How to Decide" - A great article from Harvard Business Review on decision analysis