Cost of Failure?

A Model for Determining a Course of Action

by

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Introduction

While we normally calculate the cost of a project or activity, we seldom consider the cost of inaction in any detail. We do that for a variety of reasons, not the least of which is that it can be very time consuming to make good economic decisions. As a result, we sometimes end up making decisions based on sound experience but minimal data. And we may overlook options that might better serve our needs and budgets in the process.

The following outlines a simple comparative option that has been used for asset management. Yes, it is a simplified benefit to cost comparison, but one that is straight forward and can help explain your rationale to both your elected officials and your citizens. It can be applied in both our construction and maintenance operations just as easily, and data needs and use can be kept pretty simple.

Model

The model may be outlined as:

<table>
<thead>
<tr>
<th>Estimate the cost of an action</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate the probability of failure (of the action or inaction)</td>
<td>Pf</td>
</tr>
<tr>
<td>Estimate the cost of failure (direct and assured indirect costs)</td>
<td>Cf</td>
</tr>
<tr>
<td>Multiply the probability times the cost of failure to get a risk cost</td>
<td>Rc=Pf x Cf</td>
</tr>
<tr>
<td>Compare the Cost of Action to the Risk Cost for a B/C ratio</td>
<td>BC=Rc/ Ca</td>
</tr>
</tbody>
</table>

If BC > 1.0, then it's very probably an economically wise decision.

Model Application

Obviously economics are not always the only factor in deciding how to respond to a particular issue, but it is an excellent way to begin the discussion as this model can be used to place values on some of the less obvious factors. All factors should be considered when their impacts and probably or actual costs are
clearly identifiable and quantifiable. Identification and quantification may be accomplished through a variety of means, but should include conversations with impacted land owners and groups.

The following provides general guidance on the factors you may use in determining the probability and costs of failure. Certainly there are other factors that may be considered, and you should feel free to quantify and add those factors into the model.

**Cost of Action**

All costs that will be necessary to carry out an action should be included. In the event of inaction, there may well be associated costs with that choice, but may also be no direct associated costs.

The level of accuracy is not necessarily that of an engineering estimate for a contract, but should have a reasonable degree of confidence.

1. **Labor** -- direct labor cost to carry out the selected activity.
2. **Materials** -- direct materials cost to carry out the selected activity.
3. **Equipment** -- direct costs of equipment used to carry out the selected activity.
4. **Overhead** -- fixed business expenses such as office and benefits.
5. **Right-of-Way** -- costs of acquiring rights-of-way or easements, including displacement and relocation costs.
6. **Business Costs** -- costs to affected businesses, such as temporary relocation; reduction in customers due to limited access or other factors.

(The following are often difficult to identify, quantify and place a value on, but doing so is key to obtaining a fair evaluation.)

7. **Environmental Costs** -- re-vegetation and other mitigation costs, habitat loss, or other environmental costs.
8. **Aesthetic Costs** -- cost of landscaping replacement (as opposed to re-vegetation to preserve or replace natural areas), changes in property values, or other aesthetic costs.
9. **Social Costs** -- cost of accidents (property damage, injury or fatality), or other social costs.

**Success Factors**

There are any number of factors that may affect the outcome of an action. They are called “success factors”, and will be the basis for some fairly subjective determinations of probability. In each case, you must determine a best estimate of how successful a particular factor will be in the positive outcome of your choice of action or inaction.
Again, there may well be factors not listed here, so you may add or delete from this list as appropriate.

1. **Community Support** -- estimate of percentage of the community that supports the project; be sure to include those who may not be directly impacted but have an interest in the project.

2. **Weather** -- if weather is a factor, using weather records, estimate the probability that it will cooperate.

3. **Terrain** -- if terrain is a factor, estimate how much will the terrain favor the successful outcome of the activity.

4. **Environmental Issues** -- estimate the probability that environmental perspectives will consider the activity positive. Clearly this can be affected by how the activity is designed and carried out.

5. **Data Adequacy** -- level of confidence you have in the available data you are basing the activity on.

6. **Resources Available** -- level of resources available, from funds to labor pool, to carry out the activity in the planned time frame.

The following example is modified from a US Forest Service paper\(^1\) on wildland fire probabilities as it is one of the simplest I was able to find.

- **Calculating Probability**

Statistics and probabilities is a mathematical area that is beyond the scope of this model, but some very basic guidelines are in order. Calculating the probability that a given alternative will be successful requires logic and experience. The more accurately we can determine probability, the more intelligently we select among alternatives.

Use the probability of success in a proposal to apply dust abatement materials to a gravel road. Begin with the weather. If your alternative is based on no rainfall for a period of 48 hours, providing time to apply the material, then determine, through experience or consultation, the likelihood that rain will fall. Let’s say that figure is 10% -- once in every ten similar circumstances, it will rain.

Since this is a rural road, lets also consider the traffic patterns. Low traffic times, say less than 100 ADT, will be the best, while we assume that over 500 ADT will almost certainly result in a failure. Based on your observations, and a quick review of traffic counts, you calculate that the chance of ADT less than 100 is near 0 under current conditions, but that counts over 500 will occur one time in 5, or 20%.

\(^1\) [http://www.fs.fed.us/fire/wfsa/probability.htm](http://www.fs.fed.us/fire/wfsa/probability.htm)
What is the probability of failure in this instance? To put it another way, what is the probability that the no rain will occur and that traffic will remain low? To calculate the probability of both events occurring, we multiply, so our calculation becomes:

\[ 10\% \times 20\% = 2\% \ (0.10 \times 0.20 = 0.02) \]

Or, a probability of success of 80\%\(^2\). Pretty good odds, in fact. If we have multiple events which must all occur in order to bring about failure, we continue to multiply:

\[ P_a \times P_b \times P_c \ldots P_n \]

Where \( P_a \) is the probability that event \( A \) will occur, \( P_b \) is the probability that event \( B \) will occur, and so on through \( N \), which is the last event in our chain.

If we have two independent factors which lead to failure, we need to handle them somewhat differently. Calculating the probabilities of combinations of events more complex than this gets rather involved, and is beyond the scope of this model. Suffice it to say that our approach here is fairly simplistic. If you need more sophisticated projects, you will need to consider a more stringent approach.

These examples are fabrications, but you get the idea. Try to predict the different ways in which your alternative strategy may fail, estimate the probability of each, and calculate as appropriate. There is still an element of subjectivity in your calculations, but at least you will be able to explain them to others.

**Cost of Failure**

The model is set up to use the same cost elements in the cost of failure as in the cost of the action. Almost without exception the elements will be priced differently and for different reasons; however the base assumptions remain.

Review the section on the Cost of Action for the elements to consider, but keep in mind that these are costs that would occur in the event of one of two things. Either you have taken an action, and that action has resulted in a failure in either

\(^2\) The spreadsheet uses a sum of squares deviation test (readily available in Excel) for the probability of failure (1 minus the probability of success) rather than the very simple method noted. Other statistical formulas may be used but only if the effect is understood.
the action or through the Law of Unintended Consequences\(^3\), or inaction has resulted in some other undesirable result.

A good example is a choice to not repair a flood levee along a river, thinking that the odds seem to be good that it will hold. The levee washes out; causing both road damage as well as damage to private homes and businesses that had been protected. Inaction in this scenario will result in the costs of rebuilding the road, repairing or replacing homes, and lost business opportunity costs.

**Risk & Benefit**

The cost of failure can now be directly measured in real dollar terms, and the relative value of various actions can be determined with some degree of certainty.

To obtain the risk cost, simply multiply the probability times the cost of failure to get a risk cost.

Then, to obtain the balance of cost to risk, use the basic benefit to cost ratio by dividing the cost of the action by the risk cost.

Obviously as the assumptions are just that, it cannot be said that the results from this calculation are a perfect projection of what will happen. They do however provide a more sound basis for decisions than experience and judgment alone offer. More important, they provide a basis for quantifying and explaining the decision.

\(^3\) The Law of Unintended Consequences holds that almost all human actions have at least one unintended consequence. Unintended consequences, or situations where the final outcome is unexpected, can be classed into roughly three groups:

- positive, usually referred to as serendipity or a windfall
- a source of problems, according to Murphy's law
- definitively negative or a perverse effect, which is the opposite result to the one intended

(http://en.wikipedia.org/wiki/Unintended_consequence)