UNITED STATES ENVIRONMENTAL
PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HI 96801-3378

FEB 11 2016

James A. K. Miyamoto, P.E.
Deputy Operations Officer
Naval Facilities Engineering Command, Hawaii
400 Marshall Road
Joint Base Pearl Harbor Hickam, HI 96860

Dear Mr. Miyamoto,

The United States Environmental Protection Agency (USEPA), its contractors, and the State of Hawaii Department of Health (DOH) have reviewed the Contract Task Order (CTO) for the Risk/Vulnerability Assessment (RVA) at the Red Hill Fuel Storage Facility (RHFSF). While we feel that the 2-phase approach of developing the methodology then performing the RVA is a good one, we have a few concerns with the current iteration of the CTO.

The main concerns are as follows:

1. **The CTO is not adequately specific in scope and is open to interpretation.** We suggest expanding the CTO to provide more information on the same or similar methodologies to those expected to be utilized. To this end, PEMY Consulting and Atlas Geotechnical have put together the attached "Annex" as a starting point for expanding. The "Annex" contains concepts which have already been generally shared by the Navy, but are not included in the current CTO. We believe the annex document may help the Navy identify the appropriate contractor and scope for the RVA.

2. **Impacts to other Sections in the Administrative Order on Consent Statement of Work (SOW) should be evaluated.** The impact of other Sections in the SOW on the RVA is accounted for in 4.3.e., but the reverse has not been identified as a task in the CTO. Decisions made during work for the RVA or outputs for potential management strategies from the RVA (see 3. Below) could affect some of the decisions made in other Sections of the SOW and should be identified. For example, the size of a catastrophic release as decided upon in Section 8 should be one of the inputs for the groundwater model as developed by Section 7 to determine if contamination from a release of such a magnitude would reach any drinking water well. Subsequently, the conclusion of the modeling would feed back into Section 8 to determine overall risk.

3. **The CTO lacks a phase for utilization of the information derived from the RVA, as defined in the SOW, "to inform the Parties in subsequent development of BAPT decisions".** Section 8 fulfills two purposes: 1. Determine the risk of release, considering probability and impact, from the RHFSF, and 2. Determine potential management strategies to improve the infrastructure of the RHFSF if the risk is determined to be unacceptable. Currently, the CTO concentrates on the first purpose, while not addressing the second.

4. **The criteria for selecting a contractor is not specified.** Because of the complexity of the work, specifying certifications may not encompass all of the work required and we agree with requiring the summary of experience in performing RVAs and related references, as mentioned in *Section 1.0 Intent*. However, this, along with other selection criteria, should be clearly stated in its own section as a measure to determine the suitability of potential contractors.

5. **A complete project schedule is not included.** *Section 5.0 Deliverables* has a rough schedule with due dates for deliverables based on certain triggers. It does not include a time period for selection of a contractor, nor the overarching timeline requirement of the Administrative Order on Consent (Scope of Work within 90 days of the last scoping meeting and the final RVA Report 18 months from Scope of Work approval).

In addition to the "Annex", we have also included comments provided by PEMY Consulting and Atlas Geotechnical to USEPA which provide further details on the concerns expressed here, among other concerns.

We look forward to discussing the CTO and our comments at the tentatively scheduled conference call on Friday, February 19, 2016. Please contact us with any questions or concerns.

Sincerely,

Bob Pallarino, EPA Region 9
EPA Red Hill Project Coordinator

Steven Chang, DOH
DOH Red Hill Project Coordinator

Enclosures

cc: John Sato, NAVFAC Pacific

PEMY Comments on Risk/Vulnerability Assessment (RVA) Statement of Work

Principal Concern:

PEMY's principal concern with the draft Statement of Work (SOW) arises from the risk assessment industry's lack of consensus on the methodologies that comprise a quantitative risk assessment. The term QRA, or quantitative RVA in the SOW, has widely different meanings to different practitioners. Bidder's expectations for the outcome of Tasks 1, 2, 3, and 4 could range from a 5x5 risk matrix to a thoroughly rigorous quantitative study. The draft SOW's 2-phase approach, develop the methodology then perform the RVA, ameliorates most of this problem. The expectation that the Phase 1 contractor will continue with Phase 2 execution, though, increases the importance of the initial selection.

Overall, the draft Statement of Work provides a good description of the expected work provided that all bidders interpret the term "quantitative RVA" similarly. In our opinion, Section 4.3 c lacks substantial confining or restrictive guidance for the potential bidders regarding acceptable methodologies for conducting the risk assessment. Expanding the SOW to provide more information about the Navy's and Stakeholder's expectations for the quantitative RVA will, in our opinion, improve proposal responsiveness and improve the selection process.

Statement of Work Supplement:

PEMY has drafted an annex that we believe should accompany the RFP. The purpose of this annex is to describe the preferred risk assessment approach and to illustrate the types of activities that are needed for a successful, defensible risk assessment.

As indicated in the Annex, we believe that multi-attribute utility model is a necessity for successful development and communication of the RVA. Therefore, our first recommendation is to add this Annex to the RFP so that the bidder contractors understand the Navy's expectations about the expertise required for a successful proposal. For example, some of the activities mentioned in the Annex include:

- Multiattribute modeling experience
- Value functions
- Weighting and scoring of value functions
- Ability to construct concise, meaningful event trees, fault trees and other modeling methods such as failure modes and effects
- Scenario generation and lists
- Development of candidate risk reduction projects
- Scoring and grading of risk reduction projects
- Risk communication on a quantitative as well as qualitative but effective manner
- Understanding of limitations of traditional approaches such as the risk matrix, AHP, balanced score cards and Kepner Tregoe methods

Using Bayesian methods of analysis will provide the appropriate maximization of information related to these systems. In addition to specific review of data, human factors considerations are important to assess the likelihood of initiators for undesired outcomes. Deviations of human and organization factors must be included in the risk assessment process.

Suggested SOW Additions:

Supplemental Text

The wide range of risk assessment methods requires that the SOW be more explicit in what methods are expected to be included in the RVA. We suggest that the following paragraphs be considered for inclusion in Item 4.3.

4.3 c. The contractor shall develop a rigorous, auditable methodology and approach for the quantitative RVA. The selected methodology will enable a systematic interdisciplinary study that includes probabilistic risk assessment, decision analysis, and expert judgment. Scenarios will be constructed to show how the initiating events evolve into undesirable consequences.

A value tree, based on multi-attribute utility theory, will be used to capture the decision maker's and Stakeholder's preferences about the impacts on the infrastructures and other assets. The risks from postulated failure scenarios will be ranked according to their Expected Performance Index, which is the product of frequency, probability, and consequence of a scenario. Risks from malicious acts can be ranked according to a performance index that derives from a deliberative process to capture the factors that cannot be addressed in the analysis.

Once organized into a Work Plan, this methodology would provide a framework for the development of a risk-informed decision strategy. The strategy should be multi-attribute in nature since there are competing objectives at the Facility and tradeoffs in the value preserved through risk management will be required.

4.3 d. The Contractor shall determine the data needed for the methodology and identify data gaps. Since the data will be sparse, advanced methods that combine data with expert opinion (Bayesian analysis) will help to make the assessment as good as humanly possible.

Process Diagram

We suggest that a diagram such as Figure 1 (below, from IEC 31010) be used to illustrate the various aspects of the risk assessment process that the Stakeholders are asking the Contractor to perform.

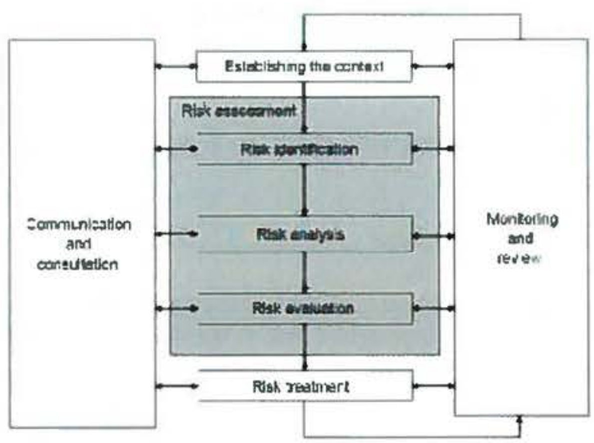


Figure 1 – Contribution of risk assessment to the risk management process

Minor Modifications to SOW:

Minimum RVA Objectives: For Section 4.0 - Scope of Work, in addition to the 7 bullets, we suggest the following bullets be added:

- Internal systems risk based on equipment failures, fires, human factors
- Quantification of reliability of leak detection in terms of ROC Curve characteristics
- Use of FMEA, fault trees, event trees, and expert opinion as needed for all of the specified failure modes
- Analyses for failures of welds, corrosion based degradation, fatigue, pipe joining components (i.e. bolting, gasketing, flanges), materials, pumps, fire, and intentional damage
- Specification of the idealized emergency response systems versus what currently exists
- Disclosure and specifications of what data were used and what not used in the development of the project

Terminology:

- We suggest that the term risk/vulnerability assessment (RVA) be changed to risk assessment and management (RAM).
- Section 4.0 – The term "geologic hazards" is more commonly used than "geotechnical hazards," though the RFP's intent is probably clear to informed readers.

Project Schedule: Section 5.0 - Deliverables does not include enough time for bidder evaluation and meetings on this subject. The difference between a truly qualified and ordinary contractor who thinks they are qualified can be the difference between complete success and failure. Time must be allocated to the stakeholder assessment and evaluation of bidders and their qualification and selection process.

A Methodologically-Based Process for Risk Management

This document provides an overview of a process that can be implemented as a basis for a formal, rigorous and auditable risk assessment and risk management process at a level that engages all stakeholders and at all levels within any of the stakeholders' organizations.

An outline of the contents is shown below.

Introduction

Enterprise-level[1] risk management entails activity in all the following areas:

1. Defining risk for a specific organization or application
2. Identifying where risk exists
3. Measuring risk in quantitative terms
4. Monetizing risk (although proxies may be used)
5. Identifying activities that mitigate risk (reductions in probability or consequence or both)
6. Evaluating (monetizing) the value of risk-mitigating activities
7. Allocating resources to implement risk-mitigating activities
8. Executing risk-mitigating activities once the resources are made available
9. Reassessing risk after the risk-mitigating activities have been conducted

This document specifies a methodologically-based way in which risk can be defined, identified, quantified and mitigated in resource-efficient ways.

The importance of being methodologically based has several components:

- The assumptions necessary for the process to work properly and give accurate assessments are explicit and can be tested before the process is applied

- The logic used in the assessment process is coherent: there are no internal contradictions or disconnects

- The results of the assessment can be "audited" to make sure they are consistent with the inputs: there is no "black box" aspect to the assessment where the logical connections between inputs and outputs cannot be understood and tested for consistency

- The results of the assessment can be defended as being logically derived from the underlying assumptions and applied logic of the process

- As the application domain of the process changes in structure over time, the methodology provides ways to adjust the assessment process so that it remains appropriate for the application.

- The methodological base provides a foundation for more clearly communicating the insights derived from the assessments as well as training others to apply the process for future assessments

[1] By Enterprise we mean a large organization characterized by many stakeholder; an enterprise can be a corporation, a governing or regulatory body; a group of entities tied together by a common risk problem.

Perhaps the most important benefit of a methodological basis for risk management is a clear, formal and rigorous linkage between risk assessment and resource allocation to mitigate risk.

It is common for risk *assessment* processes to be formal and rigorous with explicit assumptions and testable results. It is also common, unfortunately, for the *resource allocation decisions* to mitigate risks to be informal, ad hoc, and the results not made subject to any formal review or evaluation other than a statement of what was done ("roof replaced") rather than what was estimated to have accomplished in risk reduction for the resources invested.

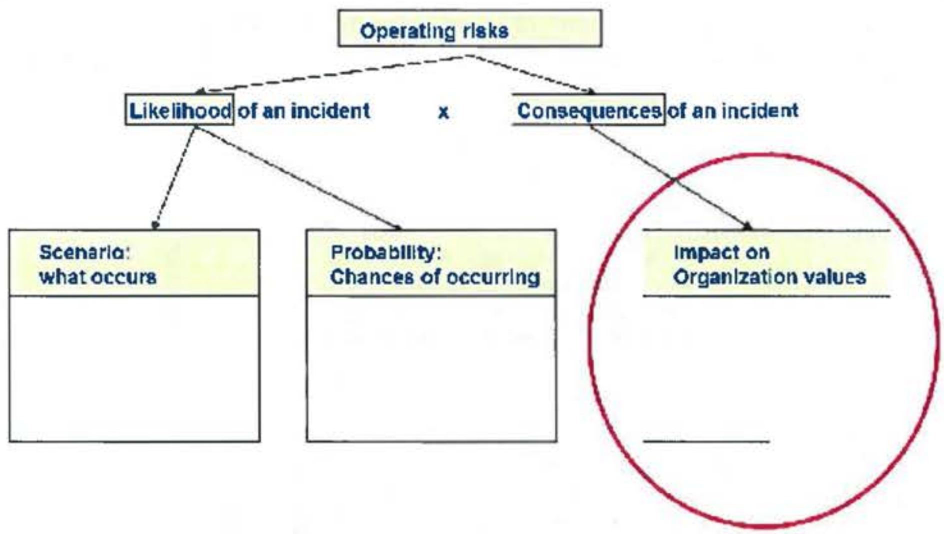
As a result, the reliability of past forecasts of risk reduction, past estimates of costs of risk mitigation, or the reliability and repeatability of risk-reducing activities are often not effectively captured as a way of improving future risk mitigation investments.

The lack of formality and rigor in allocating risk-reducing resources contributes to even greater informality in managing *portfolios* of risk reducing activities or multi-year risk-mitigating activities through changes in managers, budgets, regulations and operating environments. The inter-dependencies, the key role of initiating projects and the need for updating as new technologies, markets and regulations are revealed are often lost, impacting the accuracy of both risk assessments as well as forecasted risk mitigations.

Informality in risk-mitigating resource allocation decision-making makes this process more vulnerable to emotion and reactionary thinking. The most influential items in this aspect of an organization's overall protection of value are very often (1) regulations (do what is required and show compliance as the "accomplishment") and (2) the most recent high-level risky event (e.g., a major valve failure triggers an inspection of all valves everywhere). Allocating resources based on regulations and the latest adverse event is managing risk "looking backwards:" the organization is reacting to what has already occurred and allocating most of its risk-reducing resources based on the most recent changes in regulations and events rather than proactively allocating resources to address potential threats to future operations.

Step 1: Defining risk

Risk has two components: the chance that an adverse impact occurs to things an organization values and the degree of impact, as shown in the diagram below. That is, risk entails both chances of occurrence and the degree of consequence of the occurrence.



A. Defining value

Defining risk has to begin by defining value; without clarity on what is valued it is not possible to identify events that can have adverse impacts because "adverse" is a value judgment.

Since organizations have more than one thing that is valued in their operations, there are typically multiple sources of value in the definition of risk.

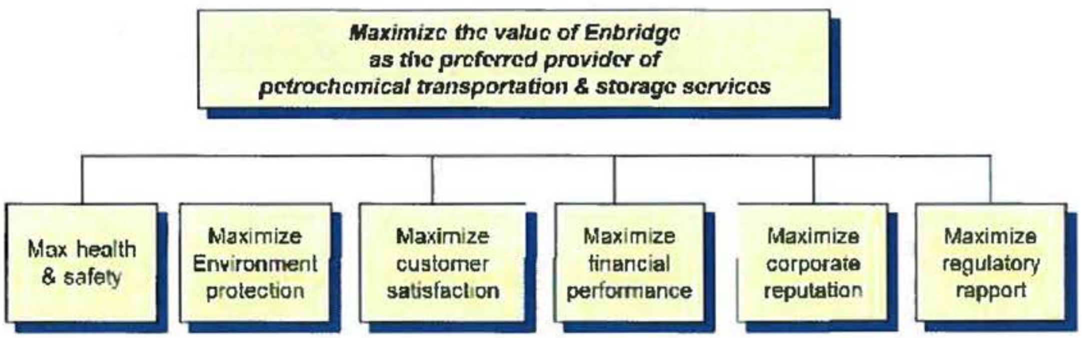
Utility theory provides a methodological basis for both defining value and measuring it quantitatively. Multiattribute utility theory provides a basis for defining and measuring value from multiple sources. The process of multi-attribute utility assessment (MUA) model development provides explicit assumptions necessary for the proper application of value assessment and is flexible enough to address the following aspects of value assessment:

- Multiple and conflicting attributes
- Value dependencies between attributes
- Hierarchical dependencies between attributes
- Changing risk tolerances as the degree of impact on attributes change
- A single overall quantitative measure of risk is desired

- The ways in which attribute values combine vary (additive, multiplicative, interaction effects, etc.) and a structured method for determining the correct way is needed.
- There is uncertainty about value impacts

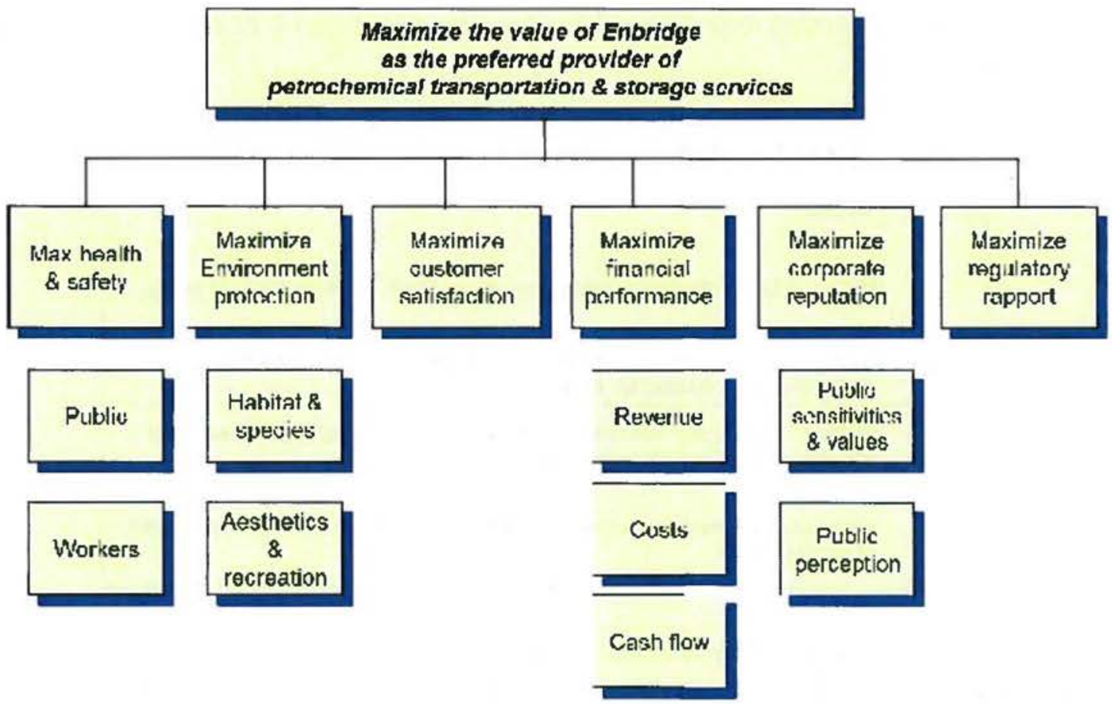
Multiattribute utility models provide a structured and rigorous methodology for eliciting values from an organization's decision makers, determining how to measure impact on these attributes (metrics), assigning quantitative measures of value to the metrics and determining tradeoff coefficients showing relative importance of the attributes, determining how the attributes should be combined to give an overall quantitative value.

An example set of attributes is shown below.



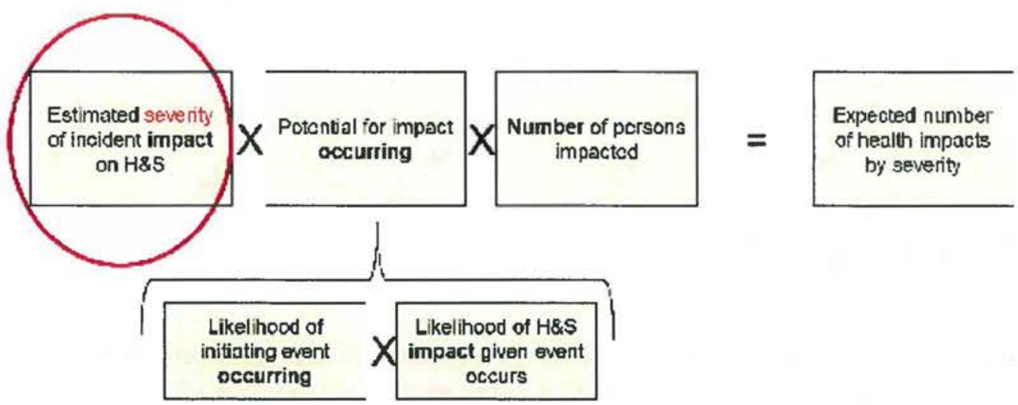
These attributes defining value for the organization are ultimately determined by senior management.
They are fundamental to the organization's identity & business model.

More specificity can be added to the model to facility more accurate measurement of value as shown in the diagram below.



In the attribute model shown in the diagram above, metrics would be developed for each of the lowest-level operating objectives or attributes. For example, metrics would be developed for measuring impacts to the health and safety of workers, the health and safety of the public, environmental impacts to general and protected habitat and specifies, and so on.

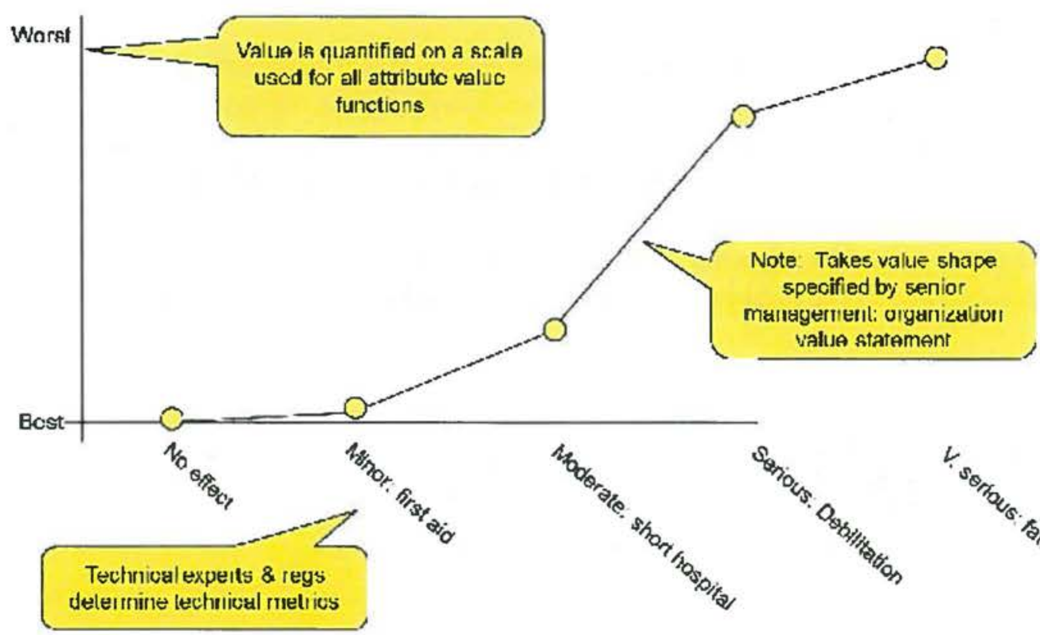
Metrics are developed based on the applicable science, existing regulatory requirements and available data that can be obtained. An example metric for health and safety is shown below.



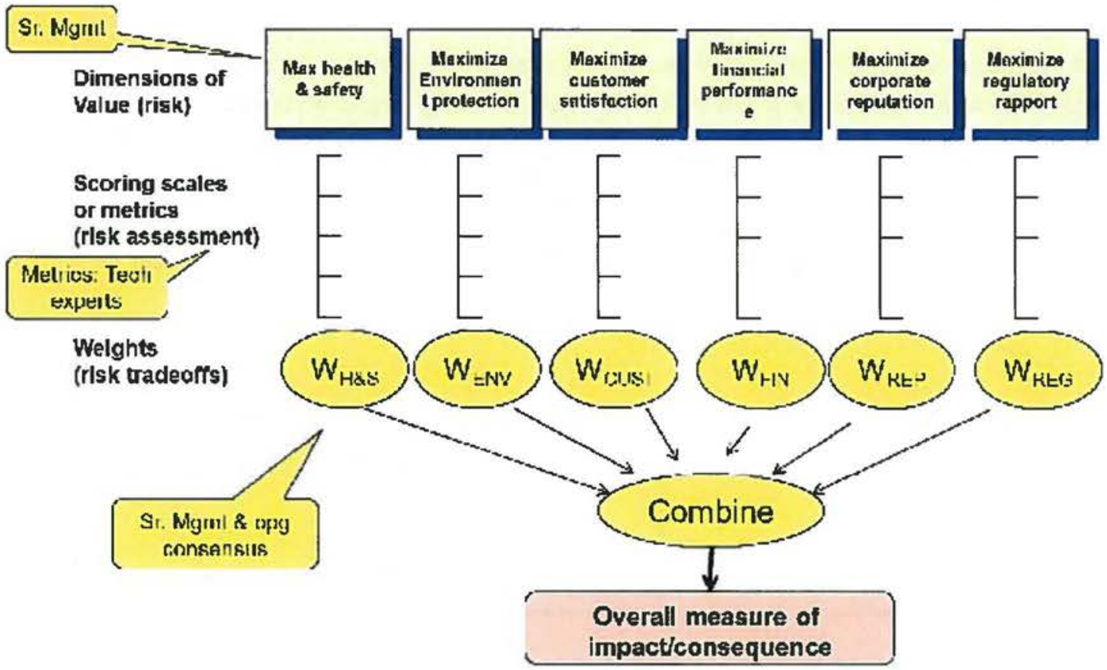
The severity of an impact has to be further defined and the table below is an example of how that might be done.

Score	Severity of Impact
0	No effect
1	**Minor: Minor irritation or temporary discomfort; modest first aid needs**
2	Moderate: Painful but not long-term or life-threatening; may require short-term hospitalization care
3	**Serious: Permanent debilitating injury or serious long-term illness that results in some reduction in quality of life**
4	**Very serious: Death or permanent debilitation resulting in near total loss of quality of life**

Finally, a value function (or utility function) quantifies the actual "value" associated with protecting each level of the severity metric. An example value function is shown below.



A value function is determined by the decision makers and resource managers for the organization. Finally, the relative importance of the attributes is shown through the trade-off coefficients or "weights" that are determined for them by the organization's senior management. An example structure for the overall value model with the weights is shown below.



The "weights" for the attributes can be monetized using "willingness to pay" measures for full achievement of each attribute. These monetized weights can be checked against regulatory guidelines, as well, to make sure that the organization's values are aligned with societal and agency value structures when making decisions on risk management investments later in the process.

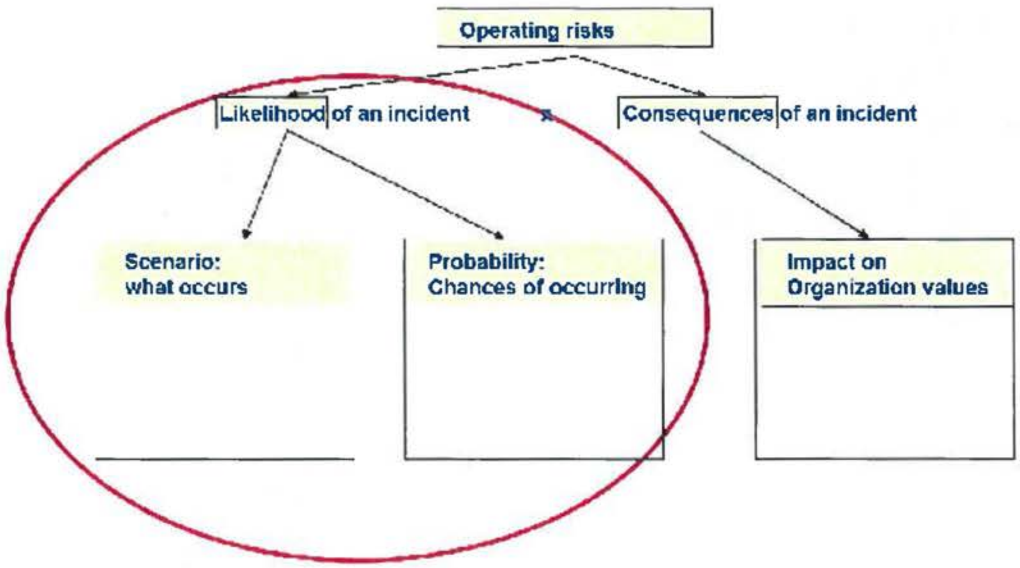
• Objective Willingness to pay

Cost:	$1.4 million
– Quality:	$2.3 million
– Schedule reliability:	$2.0 million
– Reputation:	$6.5 million (10% of Mission budget)
– Customer satisfaction:	$800,000
Mission focus & support:	$500,000

These values represent the willingness to pay to reduce each adverse impact from its worst level of impact to its best level of impact. Regulatory guidelines address these in some areas of operations.

B. Estimating probability of impact

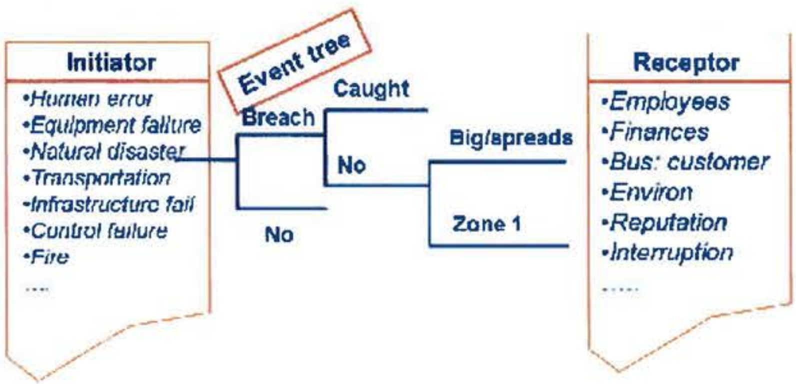
The diagram below highlights the second component of risk assessment, which is the identification and quantification of events that can adversely impact an organization's values.



As illustrated in the diagram, identifying and evaluating events has two logical steps: identifying a scenario or event that can adversely impact value and then estimating the probability of that scenario or event occurring.

Step 2. Risk scenarios using event trees

1. Event trees are a useful tool for both defining events and quantifying their chances of occurrence. The development of event trees is a structured process that uses existing data on past events, near-misses, possible initiating events, propagation pathways and impacts. The logic of the structure is illustrated in the structure outlined below.



2. Compile data
   a. Use checklists, coordinate assignments
   b. Identify subject matter experts for development meeting

3. Develop base maps
   a. Review base map information with the team and have knowledgeable persons fill in details
   b. Identify key resources, hazards, pipeline and tank and manifold conditions, population centers, environmental resources and activity levels

4. Record recent events
   a. Review complied incident lists and events which have occurred on this or other similar facilities. Use spill and accident records where available.

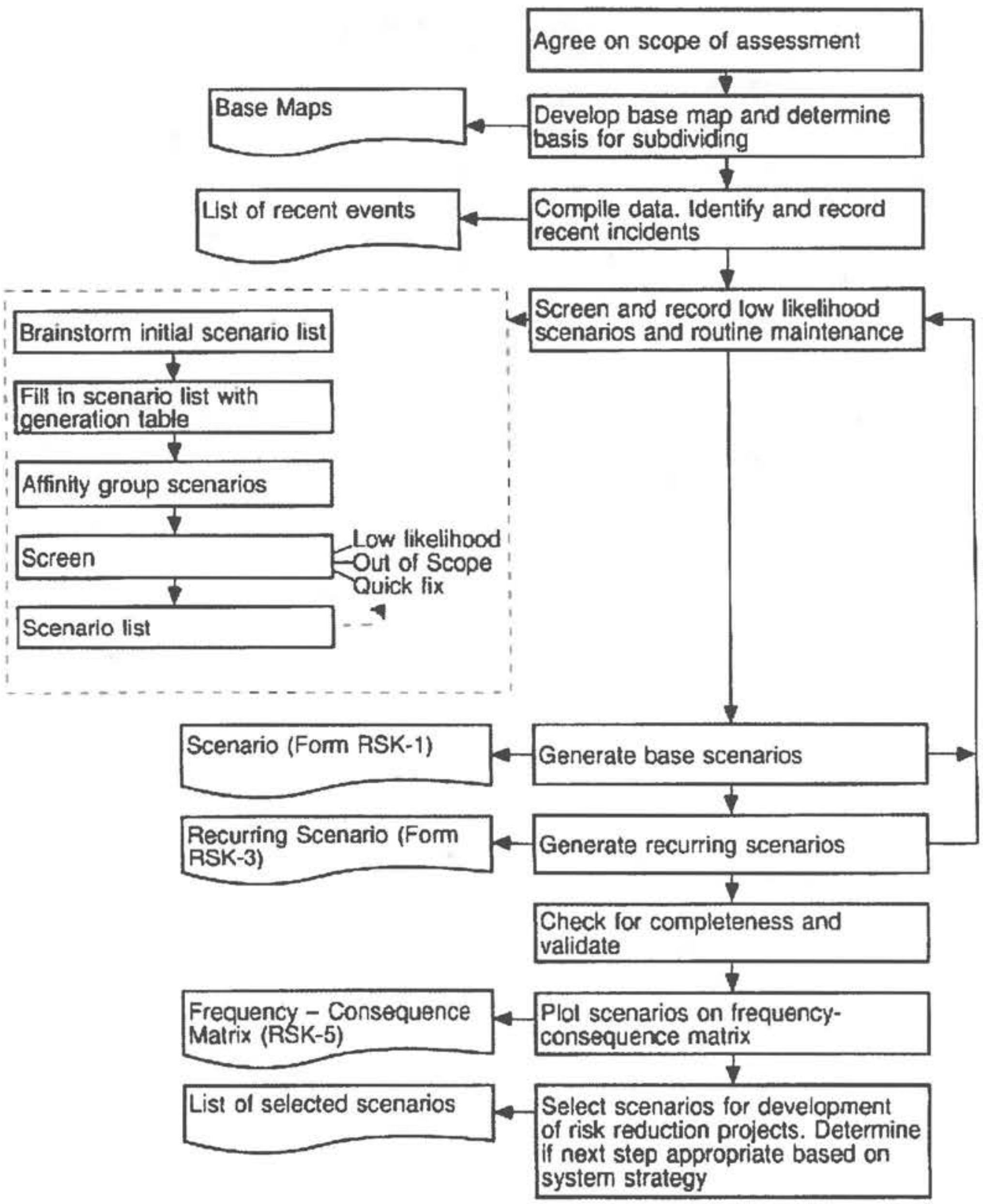
A scenario generation table can help:

General Cause	*Impact / Result*	*Receptor*
○ Failure of:	○ Release / spill	○ Human / density
Pipe -- coating	Draindown volume	Rural
Pipe -- Corrosion	Pump volume	Tribal
Pipe -- ERM		Urban
Pipe -- welds	○ Explosion / Fire potential	Other
Critical equipment		
Electric / power		○ Environmental resource
Pump station	○ Material	
Tank containment	Heavy crude	River / creek
	Light crude	Wetland
○ Third party	Sour crude	Refuge
	Product	T&E species
○ Natural	Poisonous gas	Farmland
Fault Storm		Unused land
Landslide		Marine
○ Operator error		○ Customer service
○ Transport problem		Corporate
Train Car		External
Truck Barge		Internal
○ Vandalism / sabatoge		

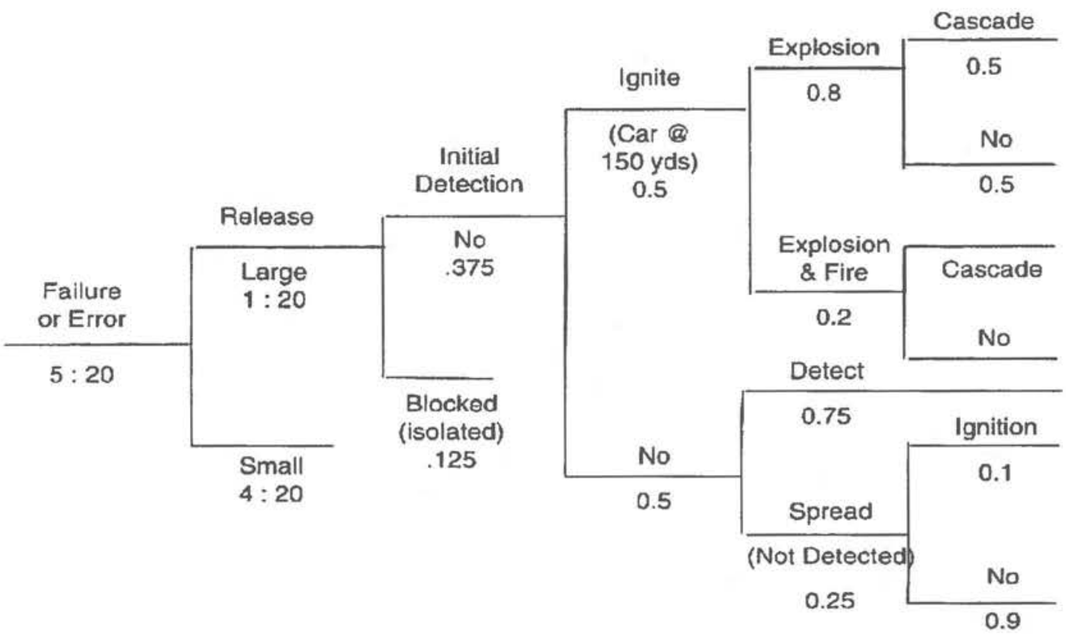
5. Develop scenario list
    a. Lead team through a limited brainstorming session to identify possible risk scenarios to be evaluated.
    b. Review the scenario generation list with the team and identify additional risk scenarios. Low likelihood events are recorded on a running list.
    c. Review potential risk scenarios for dependencies on others and for combinations into more comprehensive scenarios
    d. Create a running list of scenarios that have low likelihood or low consequence such as natural hazards not present in the area or other improbable events
    e. Create and record a running list of routine maintenance items such as pump seal leaks, etc. Identify those that can be quickly repaired (running list of "quick fixes" is kept).
    f. Record justification for eliminating any scenario categories
    g. Determine the basis for subdividing the system or facility into segments for analysis
        i. For pipelines, the recommended practice is to divide the system on an operational basis, i.e., pump station to pump station
        ii. For facilities, the recommended practice is to divide the facility into components, i.e., tanks, piping, infrastructure, docks, or other like features
        iii. Other methods for subdividing include
            1. Geography (urban, rural, features, etc.)

2. Environmental (sensitive water crossings, habitat, etc.)
3. Regulatory (DOT classifications, etc.)

An example flow chart of this process is shown below.



An example scenario or event tree is shown below.



Step 3. Development of risk reduction projects

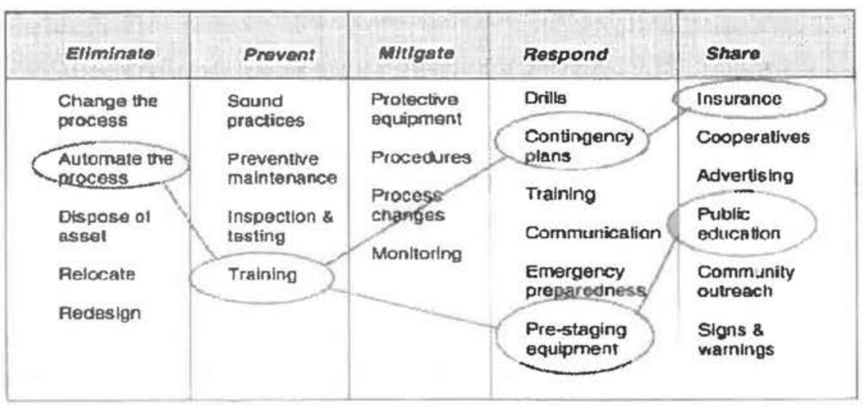
This part of the risk management process includes the systematic development of a range of projects to reduce risks identified in the scenario generation procedure.

This process is a tool for general use in the development of alternatives for proposed projects and activities and for describing the primary tasks and costs of the projects along with estimates of the effectiveness in reducing risks.

A general approach includes the following steps:

1. Describe feasible projects using summary forms that can be developed. An example is shown below.

For each problem, consider possible mitigating activities

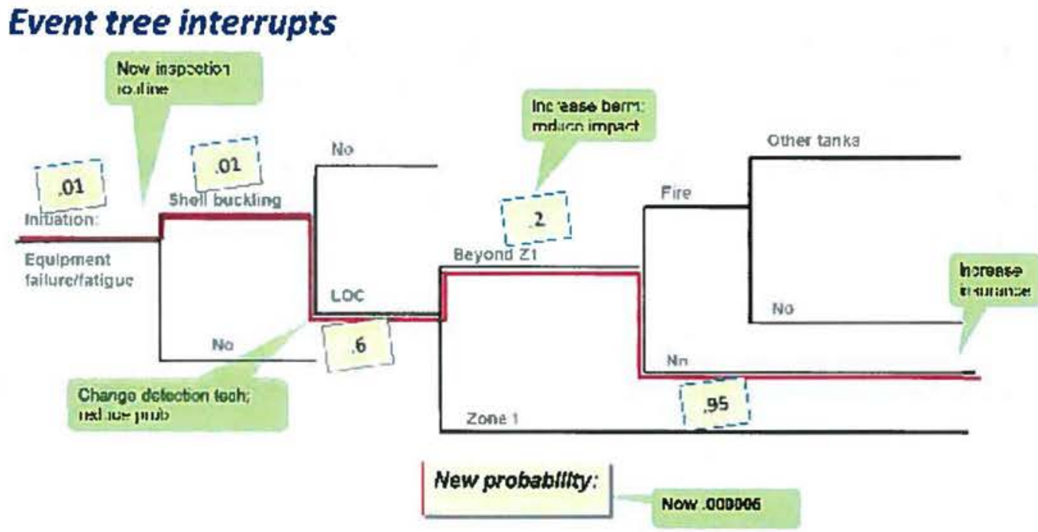


Some benefits:

- ✓ Aids "structured creativity"
- ✓ Supports collaboration of different disciplines
- ✓ Documents project thinking
- ✓ A learning aid for new participants

2. Once a set of mitigating projects have been identified, validate the information in the proposed activity and make a preliminary evaluation of the project effectiveness, including impact on frequencies of initiating events and changes in consequence levels to the various attributes (health, environment, finance, etc.) from the multiattribute value model.

3. Record the impacts on the event tree, as appropriate, and consider any added risks resulting from the project (e.g., added construction risk is a new containment wall is to be built). An example of projects associated with an event tree is shown below.

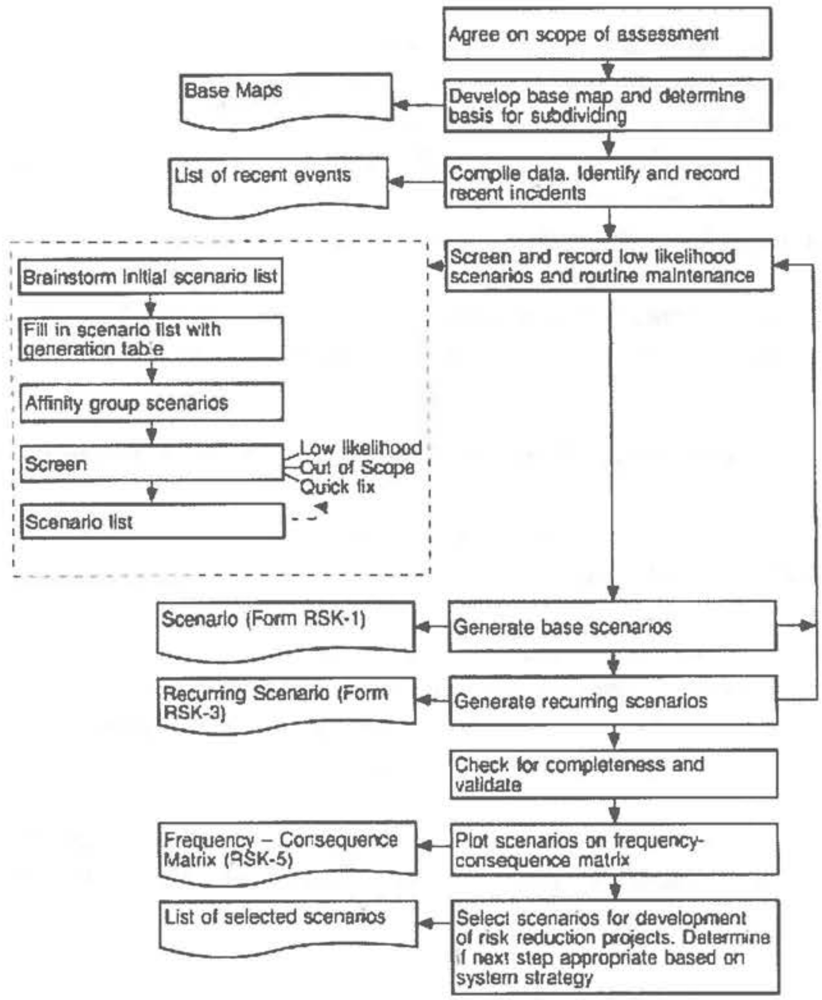


The project generation forms can be an aid in listing what measures are already in place and what additional measures have been proposed for consideration. This helps provide a more comprehensive listing of what is being done and what changes could be made.

The results of this portion of the process is a list of proposed activities to be evaluated by subject matter experts and other knowledgeable people to provide accurate estimates of the resource requirements and the impacts on both frequency and consequence that are forecasted to be the results of implementing the various projects.

It's important to make explicit in this documentation that the changes in operating risks resulting from proposed risk reducing projects are actually forecasts of the future in the form of probabilistic predictions of impacts.

The overall process is shown in the flow diagram below.



Step 4. "Scoring" (evaluating) risk mitigating projects

This step in the process combines the work done in developing the base maps, scenarios and event trees along with the project descriptions that include estimated impacts on frequencies and consequences, total costs, time requirements, cash plow and net present value information.

The objective is to develop a monetized estimate of the benefits resulting from implementation of the proposed risk-reducing projects and a monetized estimate of the costs incurred. The resulting benefit and cost information can be used to estimate the "pay back" value of each of the proposed risk-reducing projects.

The scoring is done using the event tree as the basis for evaluation.

1. Estimate the *frequencies* without a project implemented and
2. the frequencies after a project is implemented.
3. The second part of the scoring is to estimate the *impact on each of the attribute metrics* without the project and
4. the impact on each of the attribute metrics after the project is implemented.

A form can be used to capture these estimates. The estimates are provided by the subject matter experts in each area and reviewed by the team until consensus is agreed to.

Step 5. Prioritization of resource allocation and risk reducing projects

The ultimate objective of a risk management process is the allocation of resources and implementation of risk-reducing projects.

Organizations whose activities pose potential threats to the public and the environment (in addition to their own assets and employees) are required to demonstrate responsible risk management practices. This means that the logic not only of the risk assessment procedures that are employed but also of the allocation of resources to address potential threats.

The responsibility of risk management, then, ultimately requires a logical defense of resource allocation (both the amounts and the activities to which these amounts are allocated) and what the estimated impacts on overall risk are for those allocations.

There are a number of ways that organizations have used to demonstrate effective resource allocation. Some of the most common include the following:

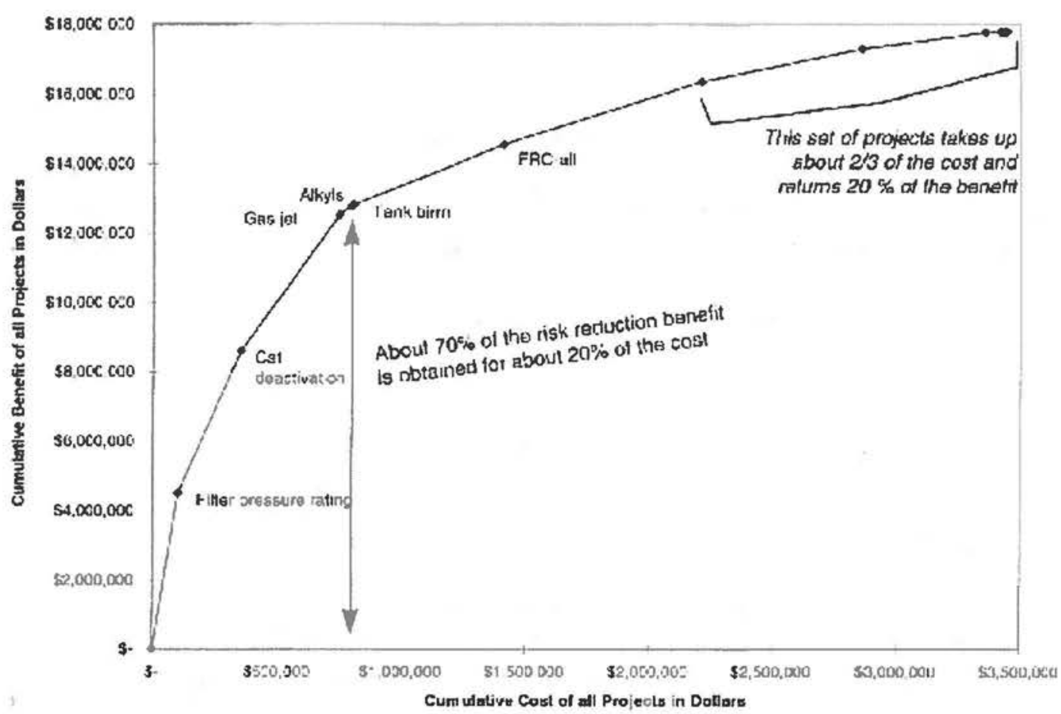
- Show that resources have been allocated to mitigating every identified risk scenario
- Show that resources have been allocated to every identified mitigating strategy
- Show that resources have been allocated to mitigating activities addressing the biggest identified risks
- Show a "risk matrix" that has no identified threats in the "red zone"
- Show that resources have been allocated to mitigating activities in every regulatory category or every area where past adverse events have occurred or to well-recognized areas (health, environment, etc.)

Unfortunately, none of these strategies are effective in serving the organization's and public's best interest, which is the fastest possible reduction in overall risk for the amount of resources and time allocated.

The use of the monetized multi-attribute value model together with the monetized costs of the proposed projects provides a financial estimate of the value of the risk reduction associated with every risk-reducing project or activity that has been evaluated. In addition, there is an "audit trail" that documents the definition, identification and quantification of the risk, the event sequence creating the risk, the mitigating activities proposed for the risk and the evaluation of those proposed mitigations so the most effective can be identified.

The projects can be ranked by benefit to cost ratio, assuring the organization, the public and the regulatory agencies that risk reduction is maximized for every additional resource allocated. The graph below illustrates this prioritization process.

Projects ranked by benefit-to-cost ratio



Since many (perhaps most) risk reducing projects take more than one fiscal year to implement and complete, this economic valuation of risk reduction aids the organization in developing five year plans and overall portfolios of risk mitigation activities.

This structure is important because some basic projects that are the platform for a wide range of subsequent smaller projects can be developed first so that the organization captures the efficiencies of risk reduction investments.

Risk management and some traditional approaches

There are a number of widely used approaches to defining, identifying, measuring and mitigating organizational risks. Some of the benefits and limitation of a few of the more common approaches are listed below.

Traditional "risk matrix" approaches to ranking risks

Most organizations that have taken a systematic approach to monitoring and managing organizational risk have employed, at some point, risk matrices as a tool for plotting and comparing risks.

This approach uses a two-axis graph for plotting the probability and consequences of specified events. The graphical presentation can be very useful for displaying (and communicating) relative risks visually. This approach is typically not very helpful for prioritizing risk mitigation activities and projects because the graphical display has a number of weaknesses:

- The calibration of the axes is arbitrary, so the relative display varies as the units of measure on the axes change

- Dependencies and linkages between risky events are not apparent so unless this is covered in some other part of the risk assessment process, evaluating the impact of risk-mitigation projects is difficult to display

- Most events that entail risk for an organization have a range of potential outcomes both in terms of probability and consequence levels. Since these outcomes can often stem from a single root cause, displaying them is often reduced to displaying only the highest consequence outcome rather than the "distribution" of outcomes

- Allocation of resources for risk mitigation is not easily displayed so the "risk reduction per unit of resource allocated" is difficult to capture.

- The categorization of risk is typically done by blocking the risk matrix off into rectangular or square regions of the matrix. While this is an easy way to identify higher risk categories, there is nothing about relative risk that lends itself to "decision blocking" where one blocked region is more or less concerning than another.

Nevertheless, risk matrices are still useful and remain widely used for displaying, discussing and communicating relative risks and in this way play a key role in the risk management process of many organizations.

Balanced score card methods

The use of balanced score card methods has been popular for decades as an aid to organizational decision making. This structure allows decision makers to be explicit about multiple objectives (or evaluation criteria) and some of the methods allow further categorization by "required" and "helpful" or "desired" categories for the scoring and weighting of proposed projects.

What these approaches lack is a sound methodological base for eliciting the evaluation criteria, developing the metrics and "value functions" for the scoring process, or a methodological basis for establishing the tradeoff coefficients, or weights. In addition, they are not formally linked to the risk assessment process but serve, rather, as an ad hoc add-on at the end for "scoring" projects.

These approaches are useful for smaller projects but are typically not rigorous or integrated enough to evaluate portfolios of resource allocation options to address enterprise-level risks.

Kepner-Tregoe

Kepner-Tregoe decision procedures are a special case of balanced score card type approaches. They are a set of ad hoc commercial products and procedures that can be employed to aid decision makers in keeping track of root cause analyses, multiple objectives, and relative scores of various activities or projects competing for resources. These procedures are variations of the balanced score card approaches. They are useful for straight-forward and less complex projects but are not methodologically based, have difficulty evaluating projects with competing objectives, and cannot be expanded appropriately to portfolios of projects or resource allocations.

Like other balanced score card approaches, the rules for value functions and combination rules are fixed and the determination of tradeoff coefficients (weights) are not methodologically based, so are vulnerable to unintended biases or skewing.

Neither K-T nor balanced score card methods more generally are methodologically linked to incorporating uncertainty as part of the risk assessment or management but include this aspect in a more general ad hoc fashion.

Analytical Hierarchy Process (AHP)

AHP is a formal process for evaluating and prioritizing activities when there are multiple objectives to be used in the evaluation of the competing projects or activities. The development of the objectives and metrics for measuring the degree of achievement for projects is structured and can provide a lot of value to organizations in need of identifying the set of criteria to be achieved in their risk management program.

The actual evaluation and prioritization scoring is based on solving the Eigen-structure of the score matrix for the projects. The eigenvalues from this structure are used to determine the priority of the projects. This makes the AHP approach vulnerable to the "sensitivity to unconsidered alternatives." For example, if scoring and prioritizing of four options shows that alternatives A, B, C, and D are ranked in that order, if project D is dropped from consideration and the same original scoring for the remaining three projects is retained and the AHP matrix run again, the order may no longer be A, B, and C, even though nothing has changed in their scores and the only difference in the analysis is that D, the least-valued alternative, was dropped from the scoring matrix.

This kind of axiomatic flaw makes AHP, while a useful framing process for decision making, unreliable for larger or sequential evaluations.

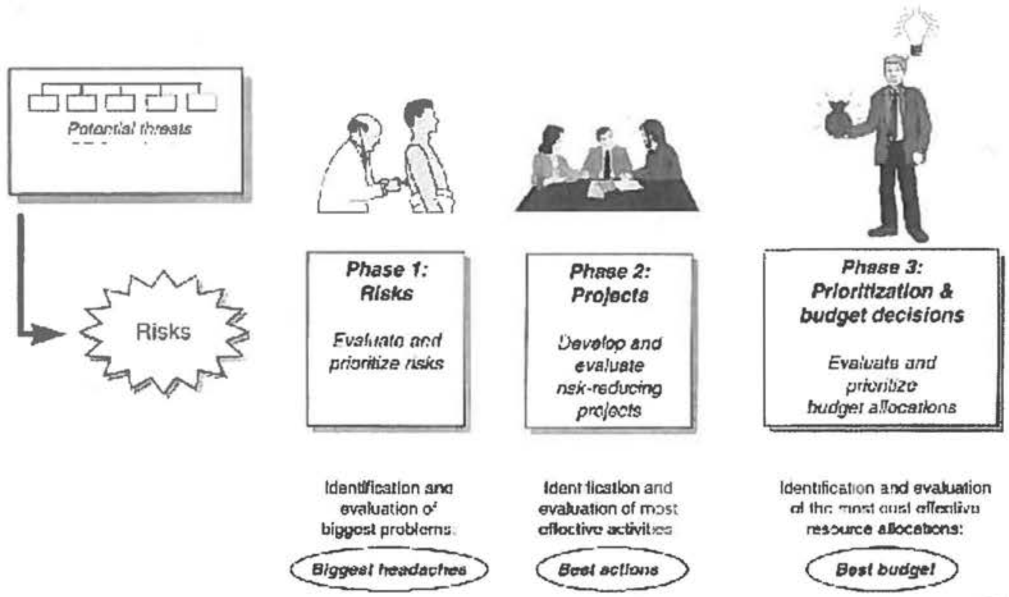
Summary

This outline illustrates some of the key steps in an integrated, enterprise-level, strategic risk management process. Because it is methodologically based from risk definition through the ultimate allocation of resources for risk reduction, it can be communicated effectively to senior stakeholders or management, to the public, to regulatory agencies and within the organization itself in terms of how resource allocations are impacting risk exposures.

In addition, it provides an aid to enterprise budget management decision makers.

Finally, this process recognizes that risk assessment is an expensive information gathering process and risk assessment should be conducted in a way that best serves risk management. An integrated decision structure allows the organization to estimate the "value of information" and allocate scarce resources – often the time of key subject matter experts and access schedules – to the most useful risk assessment activities.

The diagram below summarizes the three key portions of the process.



Effective risk management entails the active updating and use of all three assessments: biggest threats and risk, best and most effective mitigations and best budget allocations. Knowing the most pressing threats, where to develop effective mitigations and how best to allocate resources to both assessment and mitigation activities are the building blocks of an effective, integrated, enterprise-level risk management process.