Risk-based Decision-making Guidelines

Volume 2
Introduction to Risk-based Decision Making

Basic Principles

Chapter 1 — Principles of Risk-based Decision Making

Chapter Contents

This chapter provides a basic introduction to risk-based decision making. Following are the major topics addressed in this chapter:

Risk-based Decision Making

A process that organizes information about the possibility for one or more unwanted outcomes into a broad, orderly structure that helps decision makers make more informed management choices

1.0 Definition of Risk-based Decision Making

The best place to begin this *Introduction to Risk-based Decision Making* is with the definition of risk-based decision making.

A process ...

Risk-based decision making involves a series of basic steps. It can add value to almost any situation, especially when the possibility exists for serious or catastrophic outcomes. The steps can be used at different levels of detail and with varying degrees of formality, depending on the situation. The *key* to using the process is in completing each step in the most *simple, practical way* to provide the information the decision maker needs. Some situations are so complex that detailed risk assessments are needed, but most can be addressed with more simple risk assessments.

... that organizes information about the possibility for one or more unwanted outcomes ...

This information about the possibility for one or more unwanted outcomes separates risk-based decision making from more traditional decision making. The consideration of possible losses for any set of stakeholders is unique to risk-based decision making. These losses can include such things as harmful effects on safety and health, the environment, property loss, or mission success. The risks for an engineered system or activity are determined by the types of possible losses, the frequency at which they are expected to occur, and the effects they might have. Although not certain, these possible losses present real risks that must be considered in most decision-making processes.

... into a broad, orderly structure ...

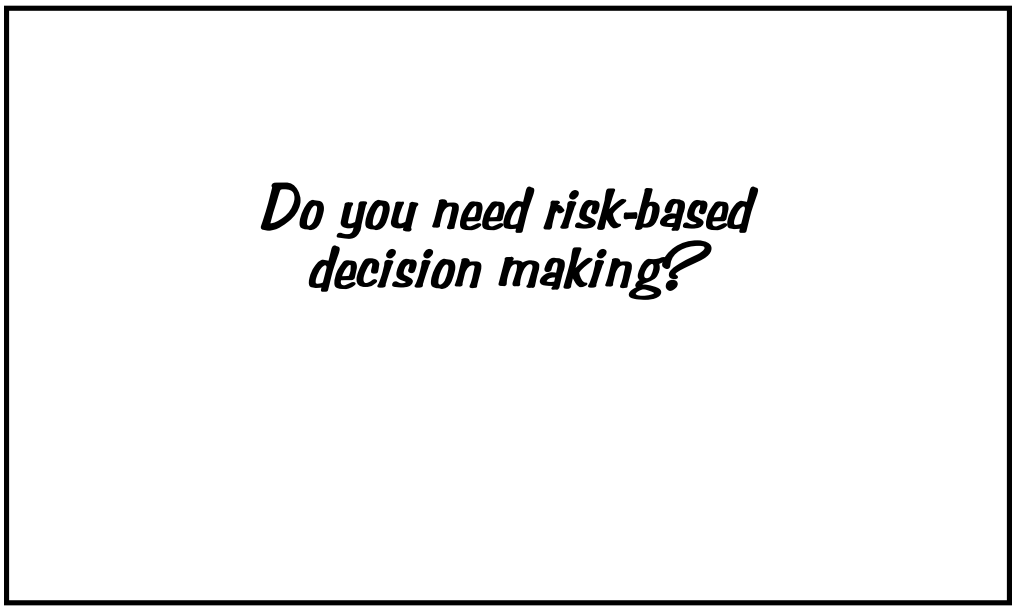
Most decisions require information not only about risk, but about other things as well. This additional information can include such things as cost, schedule requirements, and public perception. In risk-based decision making, all of the identifiable factors that affect a decision must be considered. The factors may have different levels of importance in the final decision. Therefore, an orderly decision analysis structure that considers more than just risk is necessary to give decision makers the information needed to make smart choices.

... that helps decision makers ...

The only purpose of risk-based decision making is to provide enough information to help someone make a more informed decision. The process focuses on organizing information for logical understanding. It does not replace the decision maker. Neither should it force the decision maker into burdensome risk assessments to gather information that is either irrelevant to the decision or too late to affect it.

... make more informed management choices

The goal of risk-based decision making is to help people make better, more logical choices without complicating their work or taking away their authority. A *good* decision made quickly is much better than a *perfect* decision made too late. Also, a *good* decision does not always result in a *good* outcome. The best we can hope for is to equip intelligent decision makers with good information based on a number of decision factors and the interests of stakeholders. On average, and over time, *good* decisions made through this process should provide the best outcomes. They will also provide logical explanations for decisions when the outcomes are not favorable.



2.0 Do You Need Risk-based Decision Making?

We make hundreds of risk-based decisions every day:

- Should I change lanes on the interstate?
- How often should I change the oil in my car?
- What can I do to lower my risk of cancer?
- Can I put off this task until later without affecting my project?

For almost every decision, there is a chance for some unwanted outcome. We include this possibility in our decisions, along with the consequences of the unwanted outcomes and the effort that would be needed to make the unwanted outcomes less likely or less severe.

2.1 Informal risk-based decision making

For most of our decisions, we do not formally assess the likelihood and consequences of possible unfortunate outcomes. For example, we do not study traffic statistics before changing lanes. Instead, we rely on our *feel* for the situation to create a level of comfort. If we are uncomfortable, we look for ways to change the situation to make ourselves more comfortable with the risks. For these types of decisions, the risk-based decision-making process takes place within seconds and becomes second nature.

2.2 Formal risk-based decision making

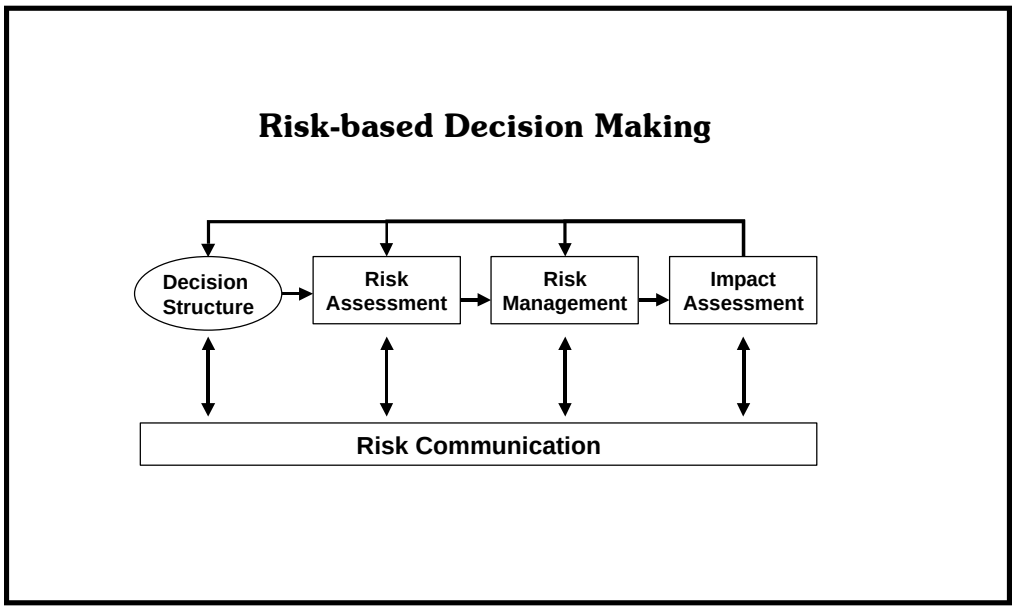
For some decisions, we are more formal about assessing the frequencies and consequences of possible unwanted outcomes. For example, when we decide how to provide for our families in case we are injured or killed, we rate a number of factors, including the following:

- The possible losses we face (from short-term disabilities to death)
- The chances of those losses
- The economic consequences of those losses
- The ways in which we can protect against the effects of the losses; for example, we can buy insurance
- The acceptability of the risks and impacts of the protections; for example, can we afford the insurance or are we willing to give up certain extras?

For these types of decisions, the risk-based decision-making process is more structured and more defensible, but it takes more time.

2.3 To use or not to use

The question is not, "Should I use risk-based decision making in the marine industry?" The question is, "How can I use risk-based decision making most effectively for my needs?" These *Guidelines* present several tools used in risk-based decision making so that you can choose the most useful approach for you. Your emphasis should always be on using the most suitable tools for the situation, not just on following one approach. It is, however, important to follow some standard procedures and techniques for (1) improving the efficiency of your efforts, (2) ensuring that your approach is technically sound, and (3) gaining acceptance of your work from others.



3.0 The Risk-based Decision-making Process

Regardless of how formally you address risk-based decision making or the specific tools you use, risk-based decision making is made up of five major components, which are shown in the figure above.

Components of risk-based decision making

The following sections introduce the five components of risk-based decision making.

Step 1 — Establish the decision structure

Understanding and defining the decision that must be made is critical. This first component of risk-based decision making is often overlooked and deserves more discussion. The following steps must be performed to accomplish this critical component:

Step 1a — Define the decision. Specifically describe what decision(s) must be made. Major categories of decisions include (1) accepting or rejecting a proposed facility or operation, (2) determining who and what to inspect, and (3) determining how to best improve a facility or operation.

Step 1b — Determine who needs to be involved in the decision. Identify and solicit involvement from key stakeholders who (1) should be involved in making the decision or (2) will be affected by actions resulting from the decision-making process.

Step 1c — Identify the options available to the decision maker. Describe the choices available to the decision maker. This will help focus efforts only on issues likely to influence the choice among credible alternatives.

Step 1d — Identify the factors that will influence the decisions (including risk factors). Few decisions are based on only one factor. Most require consideration of many factors, including costs, schedules, risks, etc., at the same time. The stakeholders must identify the relevant decision factors.

Step 1e — Gather information about the factors that influence stakeholders. Perform specific analyses (e.g., risk assessments and cost studies) to measure against the decision factors.

Chapter 5 of this *Introduction to Risk-based Decision Making* provides an overview of common decision analysis tools to help you structure your overall decision-making process.

Step 2 — Perform the risk assessment

Different types of risk are important factors in many types of decisions. Very simply, risk assessment is the process of understanding the following:

- What bad things can happen
- How likely they are to happen
- How severe the effects may be

The bad things of interest can be safety and health losses, property losses, environmental losses, schedule impacts, political issues, etc.

Risk assessment can range from very simple, personal judgments by individuals to very complex assessments by expert teams using a broad set of tools and information, including historical loss data. The key to risk assessment is choosing the right approach to provide the needed information without overworking the problem. The following steps must be performed to assess risk:

Step 2a — Establish the risk-related questions that need answers. Decide what questions, if answered, would provide the risk insights needed by the decision maker.

Step 2b — Determine the risk-related information needed to answer the questions. Describe the information necessary to answer each question posed in the previous step. For each information item, specify the following:

- Information type needed
- Precision required
- Certainty required
- Analysis resources (staff-hours, costs, etc.) available

Step 2c — Select the risk analysis tool(s). Select the risk analysis tool(s) that will most efficiently develop the required risk-related information.

Step 2d — Establish the scope for the analysis tool(s). Set any appropriate physical or analytical boundaries for the analysis.

Step 2e — Generate risk-based information using the analysis tool(s). Apply the selected risk analysis tool(s). This may require the use of more than one analysis tool and may involve some iterative analysis (i.e., starting with a general, low-detail analysis and progressing toward a more specific, high-detail analysis).

Chapter 2 of this *Introduction to Risk-based Decision Making* explores the topic of risk assessment in more detail.

Chapter 6 provides an overview of many of the most common risk assessment tools for marine applications.

Step 3 — Apply the results to risk management decision making

One goal in most decision-making processes is to lower risk as much as possible. Sometimes the risk will be acceptable; at other times, the risk must change to become acceptable. To reduce risk, action must be taken to manage it. These actions must provide more benefit than they cost. They must also be acceptable to stakeholders and not cause other significant risks. The following steps must be performed to manage risk:

Step 3a — Assess the possible risk management options. Determine how the risks can be managed most effectively. This decision can include (1) accepting/rejecting the risk or (2) finding specific ways to reduce the risk.

Step 3b — Use risk-based information in decision making. Use the risk-related information within the overall decision framework to make an informed, rational decision. This final decision-making step often involves significant communication with a broad set of stakeholders.

Chapter 3 of this *Introduction to Risk-based Decision Making* explores the topic of risk management in more detail.

Step 4 — Monitor effectiveness through impact assessment

Impact assessment is the process of tracking the effectiveness of actions taken to manage risk. The goal is to verify that the organization is getting the expected results from its risk management decisions. If not, a new decision-making process must be considered.

Step 5 — Facilitate risk communication

Risk communication is a two-way process that must take place during risk-based decision making. At every step in the process, encourage stakeholders to do the following:

Provide guidance on key issues to consider. Stakeholders identify the issues of importance to them. They present their views on how each step of the process should be performed, or at least provide comments on plans suggested by others.

Provide relevant information needed for assessments. Some or all of the stakeholders may have key information needed in the decision-making process.

Provide buy-in for the final decisions. Stakeholders should agree on the work to be done in each phase of the risk-based decision-making process. They can then support the ultimate decisions.

Chapter 4 of this *Introduction to Risk-based Decision Making* explores the topic of risk communication in more detail.

Example application of the risk-based decision making process

The following table illustrates how each of the five steps of the decision-making process were addressed for a specific application at an MSO.

Approving Reduced Lifesaving Requirements for Passenger Vessels with an MSO

Step 1: Establish the Decision Structure

Step 1a: Define the decision

Description:	Example Result:
Specifically describe what decision(s) must be made. Major categories of decisions include (1) accepting or rejecting a proposed facility or operation, (2) determining who and what to inspect, and (3) determining how to best improve a facility or operation.	Changes in the Code of Federal Regulations (CFRs) have increased lifesaving capacity requirements for small passenger vessels operating in both cold and warm water. In addition, changes in how the Coast Guard designates cold-water operations will cause a number of small passenger vessels operating in the MSO's AOR to comply with cold-water lifesaving requirements (which are more demanding than requirements for warm-water operations). These upgrades are likely to be expensive for many vessels and may result in reduced passenger capacity (or other operational restrictions), which could have negative economic effects on the industry. For operations in bays, lakes, sounds, and rivers, the CFRs allow the Officer in Charge of Marine Inspections (OCMI) some discretion in the enforcement of the new requirements. The OCMI wanted to determine under what conditions should waivers be considered.

Step 1b: Determine who needs to be involved in the decision

Description:	Example Result:
Identify and solicit involvement from key stakeholders who (1) should be involved in making the decision or (2) will be affected by actions resulting from the decision-making process.	The unit chose to involve only USCG personnel in the demonstration workshop. Ordinarily, the team would have involved the owners/operators in developing the decision framework and any vessel analysis.

Step 1c: Identify the options available to the decision maker

Description:	Example Result:
Describe the choices available to the decision maker. This will help focus efforts only on issues likely to influence the choice among credible alternatives.	The unit decided that the following options were available to the decision maker for each vessel: • Do not grant a waiver, forcing strict regulatory compliance • Help the vessel find operational changes to achieve compliance without changing lifesaving equipment • Under acceptable conditions, allow a vessel to comply with the warm-water lifesaving requirements instead of the cold-water requirements

Step 1: Establish the Decision Structure (continued)

Step 1d: Identify the factors that will influence the decision (including risk factors)

Description:	Example Result:
Few decisions are based on only one factor. Most require consideration of many factors, including costs, schedules, risks, etc., at the same time. The stakeholders must identify the relevant decision factors.	The management team identified the following decision factors: • Waivers can only be granted if the operator implements the 15-minute communication protocol specified in the CFRs (or if the vessel participates in a vessel traffic service [VTS]) • Factors that (1) minimize the number of people exposed to loss, (2) reduce the likelihood of initiating events that require the use of lifesaving equipment, and/or (3) increase the likelihood of quickly rescuing people from the water (before hypothermia occurs) could justify allowing a vessel to comply with warm-water requirements instead of cold-water requirements. (The team actually used a simple, informal event tree model during the RBDM workshop to explore these factors.) • Certain types of vessels and services should not be eligible for waivers because of the generally recognized risks

Step 1e: Gather information about the factors that influence stakeholders

Description:	Example Result:
Perform specific analyses (e.g., risk assessments and cost studies) to measure against the decision factors.	The unit decided to perform risk analysis for each vessel's unique configuration/operation to evaluate the risks associated with a possible waiver.

Step 2: Perform the Risk Assessment

Step 2a: Establish the risk-related questions that need answers

Description:	**Example Result:**
Decide what questions, if answered, would provide the risk insights needed by the decision maker.	The unit decided that the basic risk-related question was as follows: "What combination of vessel and operational characteristics poses sufficiently low risk to justify allowing compliance with warm-water lifesaving requirements instead of applicable cold-water requirements?"

Step 2b: Determine the risk-related information needed to answer the questions

Description:	**Example Result:**
Describe the information necessary to answer each question posed in the previous step. For each information item, specify the following: • Information type needed • Precision required • Certainty required • Analysis resources (staff-hours, costs, etc.) available	*Information Type Needed* An index value that represents accumulated risk credits for vessel and operational characteristics that lower the risk of losses requiring deployment of lifesaving devices *Precision Required* The index number does not have to be highly precise (e.g., integer values), but the risk factors considered must be defined very specifically *Certainty Required* The RBDM team needs to have high confidence that high index scores reflect a sufficient number of risk credits to warrant consideration of a waiver *Analysis Resources Available* Application of the risk-scoring process to a particular vessel must be very efficient (e.g., requiring only minutes to hours to apply) and must not require a risk analysis expert. However, the unit was willing to spend a couple of days developing a risk analysis job aid.

Step 2c: Select the risk analysis tool(s)

Description:	**Example Result:**
Select the risk analysis tool(s) that will most efficiently develop the required risk-related information.	Based on the decision-making situation and the type of information needed, the unit decided to create a simple relative ranking/risk indexing tool (as described in Volume 3, Chapter 5 of the *Guidelines*). The team also used event tree analysis to help ensure that the right risk factors were built into the index tool. (A copy of the index tool is provided at the end of Volume 3, Chapter 5 of the *Guidelines*.) The team determined that the following actions should be taken for certain risk index values: • Less than 0: Do not consider a waiver • 0 or greater: Consider a waiver

Step 2: Perform the Risk Assessment (continued)	
Step 2d: Establish the scope for the analysis tool(s)	
Description: Set any appropriate physical or analytical boundaries for the analysis.	**Example Result:** The unit focused only on vessels that either (1) have an acceptable 15-minute radio communication plan with an operations base or (2) participate in a VTS. The unit's analysis considered only the risk factors that the team explicitly built into the risk index tool (i.e., no other brainstorming was performed). In addition, the unit did not apply the tool to wood boats, high-speed craft, vessels with no subdivision, or vessels with no stability letter because the decisions for these vessels would not be affected by the risk scores. The unit had already determined that waivers would not be considered for these vessels.
Step 2e: Generate risk-based information using the analysis tool(s)	
Description: Apply the selected risk analysis tool(s). This may require the use of more than one analysis tool and may involve some iterative analysis (i.e., starting with a general, low-detail analysis and progressing toward a more specific, high-detail analysis).	**Example Result:** First, the unit applied the risk index tool to a number of test case vessels to ensure that the tool was "tuned" properly. The unit compared the resulting decisions to its own subjective priorities assigned from experience. Based on these tests, the unit made some revisions to the index tool. This reality check helped validate the tool before it is used in actual RBDM applications for vessels. Then, the unit began applying the risk indexing tool for specific vessels requesting waivers. The unit uses the results to help make risk management decisions for each vessel. Vessel owners/operators (or their representatives) are directly involved with unit personnel in this process.

Step 3: Apply the Results to Risk Management Decision Making

Step 3a: Assess possible risk management options

Description:	Example Result:
Determine how the risks can be managed most effectively. This decision can include (1) accepting/rejecting the risk or (2) finding specific ways to reduce the risk.	For each vessel, the unit looks for simple vessel configuration or operational changes that either (1) make waivers unnecessary or (2) improve the level of risk credits that a vessel receives. Once improvement options have been fully considered, the team uses the final risk index value to help make a decision about waivers.

Step 3b: Use risk-based information in decision making

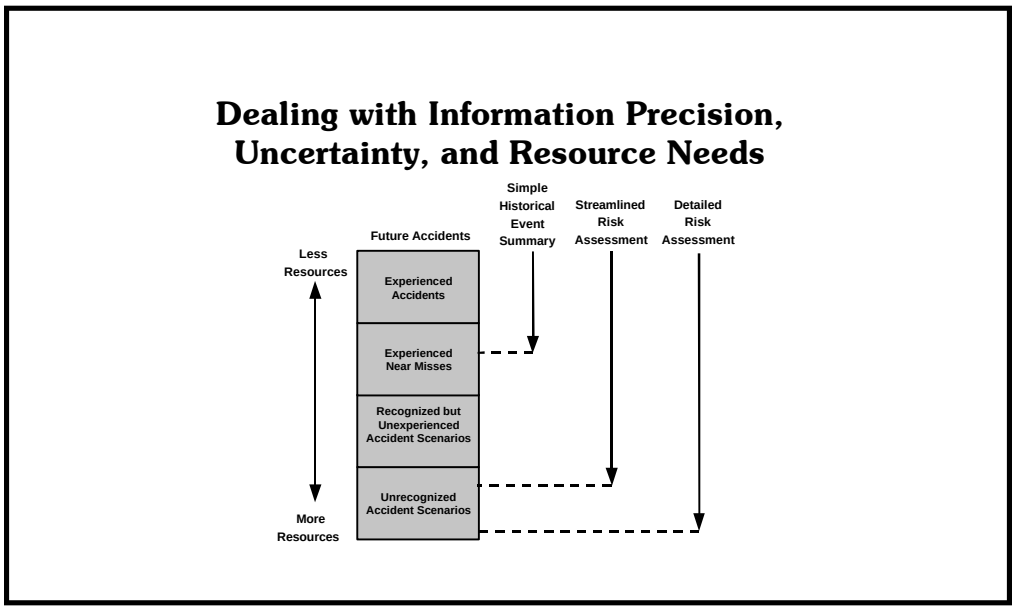
Description:	Example Result:
Use the risk-related information within the overall decision framework to make an informed, rational decision. This final decision-making step often involves significant communication with a broad set of stakeholders.	The index score strongly influences the decision as described previously, but the ultimate decision to issue a waiver rests solely with the OCMI.

Step 4: Monitor Effectiveness Through Impact Assessment

Description:	Example Result:
Track the effectiveness of actions taken to manage risks. The goal is to verify that the organization is getting the expected results from its risk management decisions. If not, a new decision-making process must be considered.	The unit is monitoring the long-term results of decisions made using this RBDM process. If (1) issues arise that were not predicted by the index tool or (2) other exclusions from the use of the tool become evident, the unit will revisit the RBDM process and make appropriate improvements.

All Steps: Facilitate Risk Communication

Description:	Example Result:
Encourage two-way, open communication among all stakeholders so that they will: • Provide guidance on key issues to consider • Provide relevant information needed for assessments • Provide buy-in for the final decisions	The unit directly involved the important stakeholders within the USCG in the process. Outside of the demonstration project, the vessel owners/operators would have been involved at various stages of the RBDM process through the following: • An initial kickoff meeting to gather ideas, discuss issues, and solicit other input • A review meeting to present a draft of the USCG's RBDM framework and index tools and to solicit comments • Widespread distribution of the final RBDM framework and index tools before actual use • Owner/operator participation in individual vessel reviews



4.0 Dealing with Information Precision, Uncertainty, and Resource Needs

Information needed for decision making is characterized by its precision and certainty. The level of precision and certainty is balanced by our willingness to expend resources to obtain it. Generally, highly precise, highly certain information is very expensive to obtain.

To make risk-based decisions, the decision maker must understand how future accidents can occur. For example, information on historical performance may be available, but the decision maker believes that this information does not adequately predict the existence of other potential accidents. Therefore, the decision maker commissions a risk assessment to provide more certain information about future accidents. As expected, additional resources were expended to obtain this more certain information. As more certain, more precise information is required to predict future performance, more resources are required to obtain it.

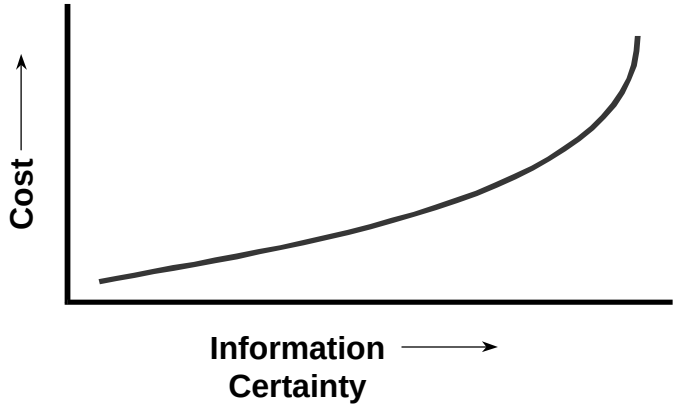
4.1 Dealing with information precision

The precision of information is characterized by its level of detail. For example, a person can be from the United States, Texas, or Dallas. Likewise, a number can be described by the number of places following the decimal point. The more precise the information, the more detail is inherent in it.

The decision maker must understand the precision required to make a decision. If knowing that a person is from Texas is sufficient to make a decision, there is no need to expend resources to determine which city in Texas the person is from. Likewise, if numerical information to one decimal place is precise enough to make a decision, information precise to three decimal places will not affect it.

4.2 Dealing with information uncertainty

In any decision-making process, there is constant struggle between the need for more and better information and the practicality of improving the information. This is illustrated by the simple figure below.



Even when a lot of information is collected, a great deal of uncertainty remains. So the decision makers and information suppliers must work together to make sure that the cost of collecting more accurate data does not outweigh the benefits of having it. This is why analysts should never use very complex risk assessment tools without first trying to meet decision-making needs with simpler tools.

Dealing with uncertainty is part of any decision-making process. Therefore, those taking part in decision making, either directly or indirectly, must be aware of the most likely sources of uncertainty: model uncertainty and data uncertainty.

Model uncertainty

The models used in both the general decision-making structure and in detailed risk assessments will never be perfect. The detail in a model and scope boundaries will determine how well the model reflects reality. Even if the data are perfect, the model usually brings some doubt into the results.

For example, Phil was asked to describe what factors would influence his choice of a new car. If Phil cannot describe all of the factors that influence his choice, then these factors will not appear in his decision model.

More detailed levels of risk analysis can reduce model uncertainty by more thoroughly accounting for potentially important loss sequences. However, more thorough analysis also costs more.

The simplest risk assessments are historical event summaries and account only for known accidents, and possibly some near misses, that have occurred during some reporting period. Streamlined risk assessments require more resources, but they also account for more near misses, as well as other recognized accident scenarios that did not occur. More detailed risk assessments require even more resources, but they systematically identify and account for previously unrecognized accident scenarios.

Data uncertainty

Data uncertainty causes much concern during decision making. Data uncertainty arises from any or all of the following:

- The needed data do not exist
- The analysts do not know where to collect the data, or they do not have the staff, funds, or time to collect it
- The quality of the data is questionable, usually because of the methods used to gather it
- The data vary widely, making their use complex

Although steps can be taken to reduce uncertainty in data, all data have some uncertainty. This uncertainty cannot be ignored. Following are methods available for dealing with data uncertainty:

Subjectively characterize uncertainty (for example, as high or low). A simple approach in which doubt in the final answer is estimated based on personal experience or belief.

Perform calculations using best-case and worst-case situations. An approach that uses different calculations for best-case and worst-case conditions to reflect the range of possible outcomes.

Analyze a number of possible situations (i.e., what-if scenarios). An expanded version of the previous approach that involves calculations for many other sets of conditions, usually including an estimate of how likely each set is to occur.

Decrease the precision requirements. Using broader ranges when categorizing the frequency and consequence of accidents increases the certainty in the selection.

Perform calculations using probability distributions in place of discrete estimates. A more complicated approach that uses statistics to describe data used in a model so that statistical descriptions of the expected outcomes can be formed.

Choose a simple method first for dealing with uncertainty. If decision makers need better estimates, the uncertainty can be reduced for the issues that most affect the model.

4.3 Dealing with resource needs

The objective is to use the minimum resources necessary to develop the required information. One effective means of minimizing resources involves starting with the lowest-cost approach that can possibly provide needed information with the required precision and certainty. This strategy most often relies on "streamlined" forms of traditional risk assessment tools. For example, before requesting any detailed modeling, the decision maker might contact one or more system experts and simply ask their perception of the answer to the risk-based question. Based on their experience, the experts may be able to provide the needed results with adequate precision and certainty. The need for more detailed analysis is therefore avoided. Be ready to commission more detailed risk assessments, though, if results from the less detailed approaches are not suitable for making a decision.

**Risk-based Decision vs.
"It's always been done this way"**

5.0 Barriers to Risk-based Decision Making

A common barrier to risk-based decision making is the perception that mounds of highly precise, technical data are required before a decision can be made. Overcome this perceived barrier by trying to develop the data from information that is already at hand. Even though the precision and certainty of this data may not be high, they may be high enough for the decision maker. When more detailed data are required, then you know that you have at least tried to develop the required decision-making information from what was immediately available to you using the minimum resources.

Another common barrier to risk-based decision making is the perception that the risk assessment part of the process takes far too much time. There is no question that more time is required for complicated decisions that use information developed from highly precise and certain data. However, risk-based decisions are often not this complicated. Do existing risk-based decision-making tools like checklists and risk indexes work? These tools take very little time, but they often end up providing the information needed to make the decision.

One impediment to risk-based decision making is found in the culture of "it's always been done this way." Challenge this thinking. Why has it always been done this way? Do regulations REQUIRE this decision to be made this way, or is this simply a convenient interpretation of a flexible rule?

Sometimes the prescriptive requirements that appear to be inflexible can be changed. Use the risk-based decision-making process to help change prescriptive requirements that do not effectively manage important risks.

Risk-based decision making is for everyone. An inexperienced person given basic training in the use of a well-developed risk-based checklist will make good risk-based decisions. Tear down barriers that cause people to believe risk-based decision making is only for the most experienced. Use the experienced people to help develop information for complex decisions and to create new risk-based decision-making tools. No one should perceive experience as a barrier to risk-based decision making.