Enclosure (1): Principles of Risk-Based Decision Making

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Most participants in the maritime industry (and all other industries) are continually faced with difficult decisions. It is a simple fact that the hazards of greatest concern today are more difficult to observe and evaluate than the major hazards of the past. Five factors, and likely more, contribute to the growing difficulty in making "good" decisions. These factors include: complexity (of the choices and environment in which made), multiple (and often conflicting) objectives, different perspectives of those involved, sensitivity of decisions to changes (in information, conditions, etc.), and finally the uncertainty of key variables in the decision process. The latter is an important but often neglected point, and is worthy of additional discussion.

Uncertainties (or variabilities) pervade every aspect of the maritime industry from design, through construction and operation, until the final scrapping of a ship, platform, or facility. Variabilities in material properties, construction techniques, and operations are an everyday fact of life in any technical field. Table 1-1 lists and describes the three categories of uncertainties that are encountered. These uncertainties are the primary cause of the risks associated with the maritime industry. The effects of these uncertainties are felt by all involved in the marine system. The field of risk-based decision-making (sometimes called risk analysis or risk management) was developed in order to deal with these uncertainties. Risk-based decision making allows the uncertainties to be characterized, and integrated into such activities as planning, crisis prevention and management. The risk-based decision making methods form a process by which decisions can be made regarding safety, durability, serviceability, and compatibility.

Table 1-1: Types of Uncertainties

Category	Description	Examples
I- Inherent	Natural randomness of a quantity	Structural strength and loading
II- Model	Randomness due to imperfections in imitations of the real world by mathematical models	Assumptions such as holding gravitational acceleration constant
III- Human and organizational error	Variability due to effect of human involvement	Differences in skill and performance levels between individuals and organizations

Risk-based decision making processes have been the subject of a great deal of interest in industry recently, with their ability to encode and incorporate the uncertainties inherent in today's highly complex and variable times. Risk-based decision making provides a process to ensure that optimal decisions, consistent with the goals and perceptions of those involved are reached. This process ensures that all available information is considered and used as appropriate to the decision at hand. This process should not only include information held by the Coast Guard, but

also that information which can be obtained from other stakeholders. “Optimal” decisions are not necessarily those which achieve the best outcome, which is a result of chance as much as decision making skill, but rather those which are most appropriate for the information, values and goals for the particular situation. On average, and over time, these decisions should provide the best outcomes. The use of a risk-based system allows for consistent decisions to be made that will also be consistent with the stated values of the organization. Finally, use of the formal assessment processes minimizes the number and degree of surprises encountered, due to the thorough study of the problem.

There are many benefits from using risk-based methods. First and foremost among these is the ability to optimize a system (including hardware, procedures, regulations, personnel, etc.) for a given application and set of conditions. “Traditional” management techniques will tend to over-strengthen some aspects of the system and insufficiently address others. Risk-based decision making, on the other hand, allows the manager to address the uncertainties associated with the process and identify those areas that may be over- or under-designed. Furthermore, analysis of safety levels of new and unique situations can be made and compared with those deemed as “safe”, which cannot be done using other methods. With these increased insights into the strengths and weaknesses of a given structure or system comes the ability to prioritize attention on those areas that have the lowest safety levels.

The risk-based decision making process outlined later in these Guidelines does not replace a decision maker. Its sole purpose is to support the decision maker as a source of information, supplying not only the optimal solution, but also insight regarding the situation, including uncertainties involved, objectives, tradeoffs, and the various value judgments and assessments of the stakeholders involved.

To use risk-based decision making methods, you must start with a review of the fundamentals of probability and statistics. Following this, the basic principles of risk-based decision making will be discussed. These precepts will be expanded upon in the following enclosures.

1.1 Basic Probability Concepts

The concept of probability (and therefore, risk) is interpreted from three very different viewpoints. These three interpretations are shown in Table 1-2 below. While all three of these methods can and should be used to support decision making, the third interpretation (subjective) is perhaps the most valuable to the maritime manager. Rarely does he/she have the luxury of obtaining a large number of tests (as required for the frequency method), nor are exact probabilities known for most events (as required for the classical method). All three interpretations follow the same rules and axioms, and can therefore be used together to allow the strengths of each to be used.

Table 1-2: Probability Interpretations

Probability Interpretation	Description
Classical	The probability of an event is the ratio of the number of outcomes with the attributes of the event to the total number of equally likely and different ways.
Frequency	The probability of an event is given by the limit of its relative frequency as the number of samples becomes large.
Subjective	The probability of an event is a measure of the degree of belief that one holds for that event.

One of the first concepts that must be understood before undertaking risk-based decision making is that most fundamental notion- "What is risk?". Given the relatively recent development of the field of risk analysis and risk management, there has not been time to reach a consensus on the exact definition of this term. Here, we will define risk as the exposure to the chance of loss, or the combination of the probability of a hazard occurring and the significance of the consequence of the hazard occurring. Mathematically, this is can be interpreted as shown in Equation 1-1.

Risk of a specific Hazard = Probability of that Hazard * Consequence of that Hazard 1-1

Hazards are potential undesirable events in a given system along with their associated consequences and are characterized in terms of their associated consequence (dollars spent, lives lost, etc.). Risks, on the other hand, are a somewhat more nebulous quantity, as they incorporate the likelihood of experiencing that hazard. In attempting to prevent and mitigate hazards within the maritime system, we define and rank their associated risks.

Risks can be characterized in terms of probability (the likelihood of some event occurring), consequence (the monetary and non-monetary "costs" of an event) and sensitivity to countermeasures (susceptibility to risk management measures), as shown in Figure 1-1.

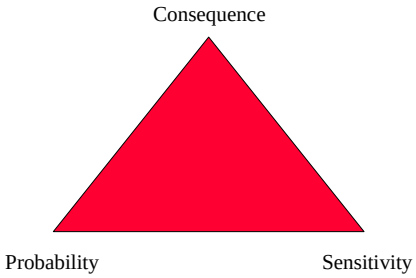

Fig 1-1: Risk Characteristics

Risk characteristics can be rated either qualitatively (e.g., low, medium or high) or quantitatively (e.g., dollar amounts or numerical probabilities). (Descriptions and examples of qualitative ranking systems can be found in MIL-STD-1629A and elsewhere and will therefore be discussed only briefly in these Guidelines.) Quantitative ranking systems are the easier to utilize, if the risk

characteristics can be naturally derived from available data. Qualitative ranking systems are useful in comparing dissimilar risks or risks for which reliable data is not available.

Risk characterization typically takes place in the risk assessment process (as shown and described below), although it can be continued in the risk management phase as well. These processes will now be briefly described.

1.2 Risk-based Decision Making Process

Risk-based Decision Making is composed of five major components, as shown in Figure 1-2. This is an iterative, never ending process. While this may seem to be troublesome given the limited resources available to a manager, it should be noted that, after experience with the process and philosophy of risk-based decision making, this will become almost second nature. It is our goal that the use of risk-based decision making as a formal program be short-lived. Instead, it should be de-formalized and incorporated into everyday management activities.

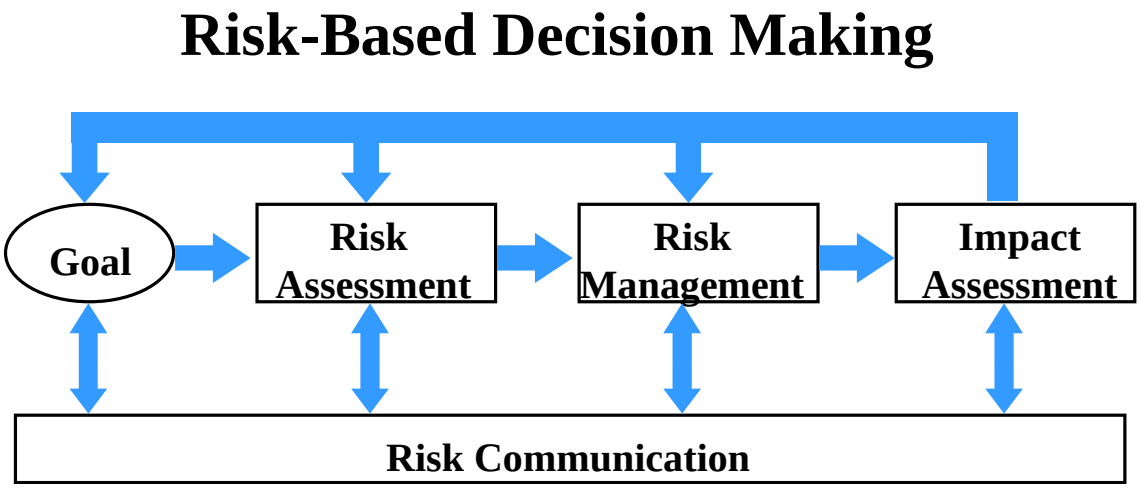

Fig 1-2: Risk-based Decision Making Process

The first step in this decision making process is the identification and delineation of a set of goals for the group. This step, as with every step, should be a group effort, ratified by group consensus. Not shown here, but a critical step in the process is the involvement of stakeholders in identifying and resolving problem areas. With increased group involvement come many benefits, such as greater acceptance of the goals (with the resultant increase in motivation) and better understanding of the goals (with the increased ability to effectively support goal-related activities). Goal selection, while a very important step, is covered in other Guidelines and directives, and will not be covered here. In this Guideline, geared toward helping Marine Safety Units in supporting and achieving local Business Plan goals, the assumption is that the group goals have already been established and validated. What remains is the development of the rest of the process, whereby assessments and plans are made for the achievement of those goals, as well as the development of a feedback loop, which provides for the continual improvement of the goals. These stages are briefly described here in order to provide a basic understanding of the

overall process. They will be described individually in greater detail in later enclosures, to provide you with adequate information and guidance for utilizing the process.

1.2.1 Risk Assessment

Risk Assessment is the process of identifying potential hazards in the system, and ranking them (and/or their components) in terms of risk characteristics, as defined previously. As such, it attempts to provide answers to the following questions.

- What can go wrong?
- What is the likelihood that it will go wrong?
- What are the consequences?

1.2.2 Risk Management

Once a screened and prioritized list of risks has been developed, a risk management action plan can be developed. As the risk countermeasures will vary widely for different situations, no comprehensive list of potential management actions is possible. Generally, risk management attempts to provide answers to the following questions.

- What can be done?
- What options are available and what are their associated tradeoffs?
- What are the effects of current decisions on future options?

1.2.3 Impact Assessment

In order to provide input for future Risk Assessments and goal setting and selection, an assessment of the effect of the countermeasures used must be conducted. As with all the data collection and analysis in this process, both subjective and objective means should be used to identify and rank the changes in risk resulting from Risk Management activities. For objective data, sources such as governmental and industry databases should be investigated for relevant and accurate data.

1.2.4 Risk Communication

As shown in Figure 1-2, effective Risk Communication is a two-way process that must take place throughout the Risk-based Decision Making process. It starts in the assessment process with the incorporation of subjective and objective stakeholder input. This not only provides a more complete set of information for the analysis, but also heightens awareness and goes a long way towards ensuring their “buy in” to the assessment results and subsequent management activities. After the screened and prioritized list of risks has been developed, it must then be communicated to the stakeholders. Urgent items should be forwarded up the chain of command for informational and action/decision purposes. Once the stakeholders have had time to review and discuss the assessment results, the communication would continue by way of them providing input for determining appropriate management actions. Finally, reports on the results shall be made to stakeholders and up the chain of command. Senior commands would review these in order to obtain the information needed for their own risk assessment and management activities.

1.3 Conclusion

What has been presented here is but a brief summary of Risk-based Decision Making. A great deal more information is available in the literature of the field. This Guideline is not intended to replace or repeat the numerous references available. Instead, the goal here was to present a decision making methodology and the major principles contained and used therein.

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