Quick-reference Guide to Risk-based Decision Making (RBDM): A Step-by-step Example of the RBDM Process in the Field

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ABSTRACT

Everyone is talking about RBDM. But what about you? Have you applied RBDM to your job? Do you know how? This paper provides a quick review of RBDM. Our goal is to introduce you to RBDM using a practical example from the field to illustrate the RBDM process. We also provide you with a step-by-step guide to the RBDM process for future reference. We stay away from most theory and background, but all of the details are in G-M's second edition of the RBDM at www.uscg.mil/hq/g-m/risk.html.

OK, SO WHAT IS RBDM?

"Risk-based decision making is a process that organizes information about the possibility for one or more unwanted outcomes to occur into a broad, orderly structure that helps decision makers make more informed management choices." More simply stated, RBDM asks the following questions and uses the answers in the decision-making process:

- What can go wrong?
- How likely are the potential problems to occur?
- How severe might the potential problems be?
- Is the risk of potential problems tolerable?
- What can/should be done to lessen the risk?

BUT WE ALREADY CONSIDER THIS, DON'T WE?

Of course! We make hundreds of decisions every day. For almost every decision, there is some chance of an unwanted outcome. We include this possibility in our decisions; sometimes informally (when we change lanes on the interstate) and sometimes formally (when we perform calculations to decide how much insurance to buy). Increasingly, the world is demanding more structured and more defensible decisions (especially where risk is involved). At the same time, systems and operations are becoming more complex, making intuitive risk management decisions more difficult and less reliable.

RBDM adds to your decision-making process a systematic consideration of diverse risks that may be important to various stakeholders. A wide range of risk analysis tools (from very simple to very sophisticated) is available to help you develop just the right information about risks to support your decision making. The question is not, "Should I use risk-based decision making?" The question is, "How should I use risk-based decision making?" The key is to focus on using the most suitable tool(s) for your situation.

WHAT TOOLS?

Many unique approaches exist for studying how operations are performed and how equipment is configured to find weaknesses that could lead to accidents. Most of these tools also help measure the risk of potential problems so that you can focus appropriate attention/resources on the issues of greatest concern. Some of the tools also help investigate accidents that have already occurred. The second edition of the *RBDM Guidelines* describes in detail (with worked examples) how and when to apply many risk analysis tools.

But RBDM is really not about the tools; it is about supplying the right information for your decision-making process. We do not want to be led by our tools; the tools (if used at all) must serve us by providing (in a timely manner) the types of information that will influence the decision.

SO HOW DOES RBDM WORK?

Regardless of how formally you address risk-based decision making or the specific tools you use, risk-based decision making is made up of the five major components shown in Figure 1.

The second edition of the *RBDM Guidelines* provides a good description of each of these elements of risk-based decision making.

I HAVE SEEN THIS BEFORE, BUT HOW DOES IT REALLY WORK?

We promised a step-by-step example of the RBDM process from the field to help you understand how RBDM really works. This example is based on a real RBDM application at a field unit.

Imagine that you work in the marine inspection department at a Marine Safety Office. Among other duties, your unit is responsible for deciding whether to require a simplified stability test for small passenger vessels (vessels carrying fewer than 49 passengers) in your district. A number of existing vessels that carry a significant number of passengers (up to 49) and operate on an ocean route (100 miles from shore) have never had a stability evaluation done (either a simplified stability test or formal evaluation for sister-ship status). These vessels are not required to have a stability evaluation by either regulation or local policy. For these vessels, your unit is posing the following fundamental question:

> *"For which vessels is a stability evaluation warranted because the potential benefit of detecting an unknown stability deficiency would outweigh the vessel owner's cost of conducting the evaluation?"*

What might the RBDM process for this decision look like? Figure 2 summarizes the key RBDM steps in this application. The tables following the figure illustrate the steps applied by the unit for this decision-making process.

Risk-based Decision Making

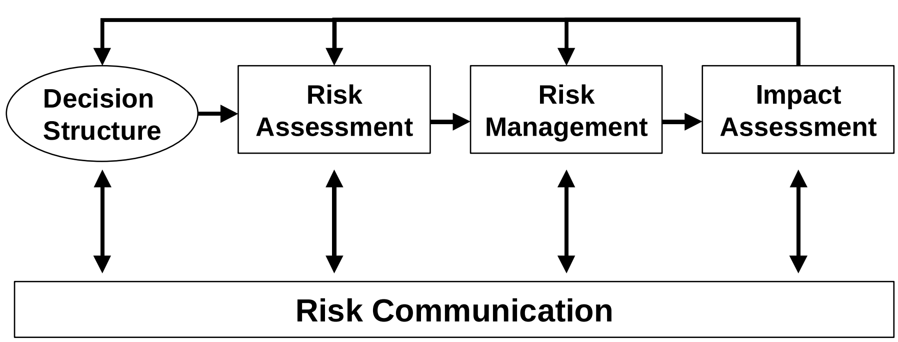

Figure 1 Risk-based Decision-making Process

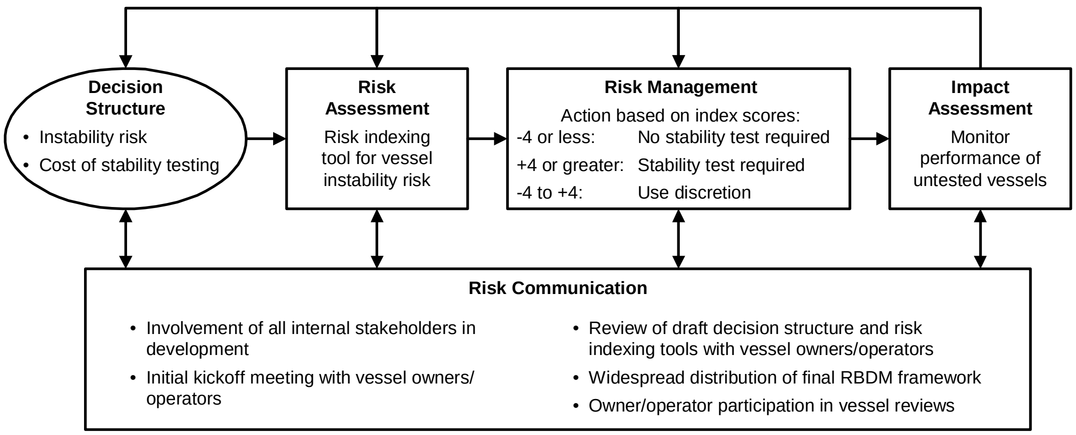

Figure 2 RBDM Process for Stability Testing Application

Step 1: Establish the Decision Structure	
Step 1a: Define the decision	
Description: 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.	**Example Result:** The Officer-in-Charge, Marine Inspections (OCMI) can require stability evaluations of new and existing vessels if stability is in question. The unit defined the decision as follows: "For which vessels is a stability evaluation warranted because the potential benefit of detecting an unknown stability deficiency would outweigh the vessel owner's cost of conducting the evaluation?"
Step 1b: Determine who needs to be involved in the decision	
Description: 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.	**Example Result:** The unit decided that the OCMI, the inspection department, and the U.S. Coast Guard (USCG) Marine Safety Center were the key stakeholders involved in making the decision. They also chose to involve a marine engineering consultant on vessel stability. The RBDM team also knew that the potentially affected vessel owners/operators were stakeholders and should be involved through special outreach efforts (see the description under "*All Steps: Facilitate Risk Communication*").
Step 1c: Identify the options available to the decision maker	
Description: Describe the choices available to the decision maker. This will help focus efforts only on issues likely to influence the choice among credible alternatives.	**Example Result:** The unit decided that the following options were available to the decision maker: ▪ Require simplified stability tests for all vessels ▪ Require simplified stability tests only where indicated by regulations ▪ Require simplified stability tests only for "high risk" vessels or as specifically required by regulations

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 unit identified the following decision factors:
	
	▪ Vessel instability risk, based on:
	
	    ▪ Route
	    ▪ Operations
	    ▪ Design
	    ▪ Modifications
	    ▪ Vessel history
	
	▪ Cost of conducting simplified stability tests (including actual testing and loss of service time)
	
	The unit did note a few special cases that warranted prescriptive decisions:
	
	▪ Never require a stability test for a powered catamaran
	▪ Never require a stability test for a vessel with a true sister ship (whose stability is already established)
	▪ Always require a stability test for a vessel on an exposed route
	▪ Always require a stability test if a vessel has had a >2% aggregate weight change

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 understood the approximate cost of simplified stability tests and the associated loss of service time for vessels. The team chose not to evaluate this factor further. Instead, the unit focused on measuring relative risks of vessel instability among new and existing vessels in the unit's zone. The unit decided to use a risk assessment process (as described in Step 2) to measure the relative risks.

Step 2: Perform the Risk Assessment	
Step 2a: Establish the risk-related questions that need answers	
Description: Decide what questions, if answered, would provide the risk insights needed by the decision maker.	**Example Result:** The unit decided that the basic risk-related question was as follows: "What combination of vessel and operational characteristics poses significant vessel instability risks that might require a simplified stability test?"
Step 2b: Determine the risk-related information needed to answer the questions	
Description: 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	**Example Result:** *Information Type Needed* A risk index number is needed for measuring the risk of an unknown instability for a given vessel and operational condition. *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 high risk and low index scores reflect low risk, recognizing that some intermediate scores may represent a gray area where the risk is unclear. *Analysis Resources Available* Application of the risk scoring process to a particular vessel must be very efficient (e.g., requiring only a few minutes 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: Select the risk analysis tool(s) that will most efficiently develop the required risk-related information.	**Example Result:** 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 the second edition of the *RBDM Guidelines*). The team also used **event tree analysis** to help ensure that the right risk factors were built into the index tool. The team determined that the following actions should be taken for certain risk index values: ▪ **-4 or less:** No stability test required ▪ **+4 or greater:** Stability test required ▪ **-4 to +4:** Use discretion in deciding

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 for which stability tests were not specifically required by regulations. 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 powered catamarans, vessels with true sister ships, or vessels on exposed routes because the decisions for these vessels would not be affected by the risk scores (as mentioned previously).
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 risk priorities 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 was used in actual RBDM applications for vessels. Then, the unit began applying the risk indexing tool for specific vessels needing stability test determinations. 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.

<table>
<tr><th colspan="2">Step 3: Apply the Results to Risk Management Decision Making</th></tr>
<tr><th colspan="2">Step 3a: Assess possible risk management options</th></tr>
<tr><td>Description:

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.</td><td>Example Result:

For each vessel, the unit looks for simple vessel configuration or operational changes that might make stability testing unnecessary, especially when a preliminary analysis indicates that testing may be required (or if the decision is unclear).

Once improvement options have been fully considered, the team uses the final risk index value to help make a decision about stability testing.</td></tr>
<tr><th colspan="2">Step 3b: Use risk-based information in decision making</th></tr>
<tr><td>Description:

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.</td><td>Example Result:

For vessels with extreme risk index scores (above +4 or below –4), the index score drives the decision as described previously. For intermediate scores, the stakeholders discuss how severely the cost of the stability test and the interruption in service time would affect the owner/operator. The OCMI ultimately determines whether a stability test will be required.</td></tr>
<tr><th colspan="2">Step 4: Monitor Effectiveness Through Impact Assessment</th></tr>
<tr><td>Description:

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.</td><td>Example Result:

The unit is monitoring the long-term results of decisions made using this RBDM process. If (1) stability 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.</td></tr>
<tr><th colspan="2">All Steps: Facilitate Risk Communication</th></tr>
<tr><td>Description:

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</td><td>Example Result:

The unit directly involved the important stakeholders within the USCG in the process. The vessel owners/operators were 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</td></tr>
</table>

SEEMS EASY ENOUGH; IS RBDM HARD TO IMPLEMENT?

Actually, the RBDM process is relatively straightforward and intuitive. Learning how to apply some of the risk analysis tools does take some effort, and some of the more sophisticated tools are actually quite complex. Knowing where to get data to support your analyses can be difficult. However, for most of the situations you are likely to encounter, providing pertinent risk information to decision makers is easily within your grasp.

WILL I REALLY SEE ANY BENEFITS?

You should see three benefits from structured RBDM:

1. A common decision-making process that your peers and superiors will already understand and expect

2. Decisions that you can more easily defend because of the process you followed and the stakeholders you involved

3. Better decisions in cases where systematic consideration of risk reveals information that leads to different decisions

The first two benefits are important but hard to quantify. The third benefit can save lives, protect the environment, and promote commerce, but it will not be realized in all applications. This is because (1) less informed decisions often produce good results (e.g., 50% of the time, the toss of a coin will result in the "right" outcome among two options) and (2) sometimes the additional information gathered simply reinforces the experienced judgment of the decision maker.

Remember, you can (and should) tailor the RBDM process to be as simple as possible (maybe even only a mental checklist) for your application. If you are not using a systematic RBDM process, you should ask yourself one question: "Do I feel lucky?"

ANY LAST ADVICE?

Remember, the ultimate question is not, "Should I use risk-based decision making?" The question is, "How should I use risk-based decision making most effectively to meet my needs?" Your emphasis should be on providing urgently needed information using the most suitable tools for the situation, not just following one approach.

Each application you face will have to be context specific. Our experience shows that the best way to build the right structure for getting the information you need is through a systematic risk-based decision-making process. With such a clear blueprint for building the right risk-related information, you should be able to select the right mix of tools and successfully apply RBDM.

Note: The opinions expressed in this paper are those of the authors and are not representative of the views of the U.S. Coast Guard or Department of Transportation.

BIOGRAPHIES

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Mr. Bert Macesker has worked at the U.S. Coast Guard Research & Development (R&D) Center from 1990 to the present. He has been the project officer and test director for much of the new ship acquisition RDT&E carried out by the R&D Center. For several years, Mr. Macesker was the project manager for the R&D Center's Marine Safety and Naval Architecture program. He currently is the project manager and team leader for a number of Coast Guard initiatives to develop risk-based technologies for the Offices of Marine Safety and Environmental Protection and Safety and Environmental Health. These projects represent research in areas of internal U.S. Coast Guard operational risk and external risk as it relates to U.S. Coast Guard activity impacts on industry and public safety. Mr. Macesker was a research test engineer at Electric Boat Division of General Dynamics from 1985 through 1989, working on the SSN21

SEAWOLF design. He worked as a project engineer for Applied Measurement Systems, Inc. from 1989 through 1990, developing and testing new towed sonar arrays.

Mr. Macesker received his B.S. degree in ocean engineering from Florida Atlantic University and his M.S. degree in engineering from the University of Connecticut.

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Mr. Joseph Myers has over 19 years experience in health and safety. He is a graduate of the Johns Hopkins University's Whiting School of Engineering. He worked for several defense contractors in the areas of occupational and system safety, environmental compliance, and risk assessment. Mr. Myers holds a CSP in system safety aspects. He chaired the Sub-Committee of the GEIA G-48 System Safety Committee, which coordinated industry input to the revision of MIL-STD-882D. Mr. Myers earned his masters in public health from the John's Hopkins School of Hygiene and Public Health with a concentration in injury prevention and risk sciences. He is employed by the U.S. Coast Guard supporting the Prevention Through People Program. His activities concentrate on developing and expanding the use of risk-based decision making in the field of Marine Safety and Environmental Protection. He has presented at three previous International System Safety Conferences.

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Mr. Guthrie, director of operations for the Knoxville Office of EQE, has 24 years of experience in performing and managing reliability and risk assessment tasks involving complex engineered systems. Mr. Guthrie has participated in and managed numerous safety assessments, risk assessment tasks, and criticality risk assessments. He is currently participating in EQE's efforts in support of the U.S. Coast Guard's projects. He also managed several projects for upgrading the safety analysis basis for multiple facilities at an Oak Ridge, Tennessee, site.

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Mr. Walker is a project manager for EQE and an instructor for one of EQE's training divisions, the Process Safety Institute. He has worked in the process safety and risk assessment field for the past 13 years. During this time, he has led or participated in numerous studies, including quantitative risk assessments, process hazard analyses, facility risk reviews, audits of process safety management (PSM) systems, development of PSM programs, and incident investigations. Furthermore, he has developed, or participated in the development of, several software packages for supporting reliability and hazard analysis studies. These projects have served a range of domestic and international clients, including companies in the petroleum, petrochemical, chemical, manufacturing, and other allied industries, as well as government facilities.

Mr. Walker received both his B.S. and M.S. degrees in mechanical engineering from the University of Tennessee. He has written or coauthored several books, guides, and articles, including:

- *Guidelines for Hazard Evaluation Procedures, Second Edition with Worked Examples*, Center for Chemical Process Safety
- "A Step Beyond the Standard Process Hazard Analysis," American Institute of Chemical Engineers Summer Annual Meeting
- "Managing Safety: Do's and Don'ts to 'OSHA-Proof' Your Process Hazard Analyses," *Chemical Engineering*
- *Managing Process Changes: A Manager's Guide to Implementing and*

Improving Management of Change Systems, American Chemistry Council

Mr. Walker teaches several different courses for the Process Safety Institute, including *Hazard Evaluation: Quantitative Frequency Analysis Methods*, *Process Hazard Analysis Leader Training Using the HAZOP and What-if/ Checklist Techniques*, *Incident Investigation Programs and Techniques*, and *Compliance Auditing for Process Safety/Risk Management*.

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Mr. Schoolcraft is a project engineer for EQE. He has over 10 years of experience developing, implementing, and auditing risk management systems, including mishap investigation, system safety, occupational safety, emergency management, and emergency response programs. At EQE, he currently serves as a project manager on various risk management projects for the U.S. Coast Guard, National Aeronautics and Space Administration (NASA), and commercial clients. Before joining EQE, Mr. Schoolcraft was employed as a senior loss control consultant specializing in fire and occupational loss control. From 1991 until 1997, he served as a fire and occupational safety program manager for NASA's Goddard Space Flight Center (GSFC) in Maryland. For nearly 7 years, Mr. Schoolcraft served as a safety engineer with NASA's GSFC. He developed and implemented the chemical safety and safety verification programs for two NASA field centers (GSFC and Wallops Flight Facility [WFF]). He also managed NASA's onsite emergency response team (fire, medical, HAZMAT, and technical rescue) and led mishap investigations for GSFC. His other duties at GSFC included performing annual and semiannual hazardous facility safety and fire protection surveys and construction site safety inspections. As the chemical safety program manager, Mr. Schoolcraft inspected and approved the use of hazardous processes at GSFC and WFF.