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Special Management

RISK MANAGEMENT (RM) GUIDELINES AND TOOLS

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This Department of the Air Force Pamphlet (DAFPAM) is the process guide for the Department of the Air Force Risk Management (DAF RM) process. This publication implements Air Force Policy Directive (AFPD) 90-8, *Environmental, Safety & Occupational Health Management and Risk Management,* and supports the DAF RM requirements and processes outlined under Air Force Instruction (AFI) 90-802, *Risk Management*. This pamphlet provides the definitions, guidelines, procedures and tools for integration and execution of RM as a risk reduction process to assist leaders in identifying and controlling safety and health hazards in making informed decisions. This pamphlet applies to individuals at all levels who are uniformed military members or civilian employees of the Regular Air Force, Air Force Reserve, the Air National Guard, the US Space Force (USSF), and those who are contractually obligated to comply with Department of the Air Force (DAF) publications. Ensure all records generated as a result of processes prescribed in this publication adhere to AFI 33-322, *Records Management and Information Governance Program*, and disposed of in accordance with the Air Force Records Disposition Schedule, which is located in the Air Force Records Information Management System. Refer recommended changes and questions about this publication to the Office of Primary Responsibility using the AF Form 847, *Recommendation for Change of Publication*; route AF Forms 847 from the field through the Major Command (MAJCOM)/Field Command (FLDCOM) publications/forms managers. This DAFPAM may be supplemented at any level, but all supplements must be routed to AFSEC/SEG for coordination prior to certification and approval. The use of the name or mark of any specific manufacturer, commercial product, commodity or service in this publication does not imply endorsement by the DAF.

SUMMARY OF CHANGES

This document has been substantially revised and needs to be completely reviewed. Major changes include aligning DAFPAM 90-803 with the recently revised AFI 90-802. The pamphlet has been reformatted in its entirety and reflects the addition of the USSF as well as publication designation changes. The old Section H has been replaced by the new **Chapter 8**, and the change recognizes that Real-Time Risk Management (RTRM) still utilizes the basic 5-Step risk management model. The steps are accomplished in a quicker fashion, often an "on the fly" mental assessment, with limited resources. References to the Assess, Balance, Communicate, Decide, Debrief model have been deleted. Other revisions were made to continue the effort to standardize the DAF RM process with sister service RM processes, terms and applications.

Chapter 1

INTRODUCTION

1.1. Scope. Department of the Air Force (DAF) operational missions, work activities and day-to-day routines (on and off-duty) involve levels of risk, which require smart decision-making and effective risk assessment and management for success. Commanders, supervisors and personnel at all levels are responsible for identifying potential risks and adjusting or compensating appropriately. Risk decisions should be made at a level of responsibility that corresponds to the degree of risk and personnel involved, taking into consideration the significance of the mission or activity and the timeliness of the required decision. Risk should be identified using the same disciplined, organized and logical thought processes that govern other aspects of military endeavors. The goal of this pamphlet is to increase mission or activity success while reducing the risk to personnel and resources to the lowest achievable level in both on and off-duty environments.

1.1.1. Other Guidance. DAF RM concerns related to Integrated Life Cycle Management guidelines, policies and procedures for the development, review, approval or management of systems, subsystems, end-items and services are addressed in AFI 63-101/20-101, *Integrated Life Cycle Management,* and related publications. All DAF RM issues related to acquisition and test efforts are addressed in AFI 63-101/20-101 and will be coordinated with the Assistant Secretary of the Air Force for Acquisition (SAF/AQ). DAF RM concerns related to anti-terrorism reside in Department of Defense Instruction (DoDI) O-2000.16 V1_AFI 10-245-O, *Antiterrorism (AT) Program Implementation.* IDRMP is addressed in DAFI 31-101, *Integrated Defense (ID).* DAF RM concerns related to the installation/garrison emergency management program reside in DoDI 6055.17, *Emergency Management Program,* and DAFI 10-2501, *Emergency Management Program.*

1.1.2. Exclusions. This pamphlet excludes explosive safety covered under Defense Explosives Safety Regulation (DESR) 6055.09_Air Force Manual (AFMAN) 91-201, *Explosives Safety Standards,* and also excludes fire prevention and protection covered under DoDI 6055.06, *DoD Fire and Emergency Services (F&ES) Program,* and AFI 32-2001, *Fire Emergency Services Program.* Specific questions on any of the above topic areas should be directed to the appropriate subject matter expert and agency.

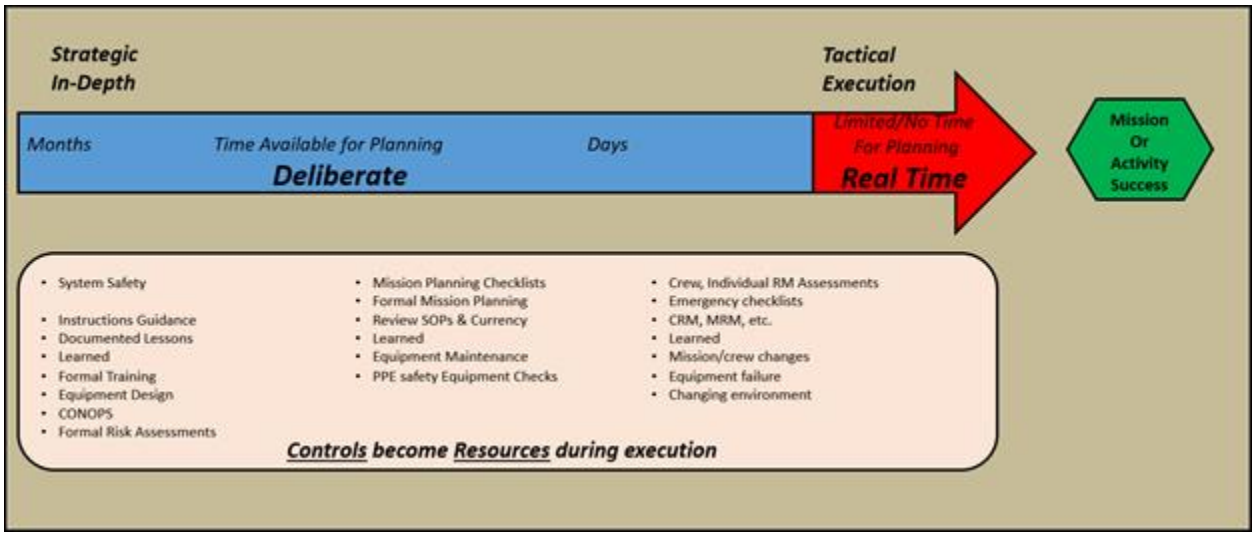
1.1.3. This pamphlet is for reference and is not directive in nature. Although interrelated, it does not address DAF RM guidelines, policies and procedures specifically tied to acquisition and sustainment life cycle management, anti-terrorism, integrated defense RM process (IDRMP), and installation/garrison emergency management (EM) RM. Additionally, this pamphlet does not address the risk assessment applied to the annual planning and programming guidance, the Air Force Requirements Oversight Council, and similar strategic-level applications developed by Air Force/A9 (AF/A9), with the process stakeholders, which link to the Chairman of the Joint Chief of Staff (CJCS) integrated risk matrix and the Air Force's related risk criteria.

1.2. Levels of RM. There are two primary levels of RM (deliberate and real-time) that dictate the level of effort and scope that should normally be undertaken when evaluating risk(s). **Figure 1.1** depicts the basic relationship of the two levels and how they interact across the strategic (long-term) to tactical (short-term) planning spectrums. The controls, resources and issues shown below the RM levels are examples of resources and impacts that might apply across the planning and

execution timelines. As the diagram shows, Deliberate and Real-Time RM are interrelated when making RM decisions. They are separated only at the point where the planning phase transitions to the execution phase of the mission or activity. A strong, effective RM process involves careful and deliberative planning, coupled with effective Real-Time RM. This full spectrum approach ensures comprehensive risk mitigation and the likelihood of mission or activity success.

1.2.1. Deliberate RM. Deliberate RM planning refers to pre-mission/activity planning and involves the full formal application of the complete 5-Step RM process outlined in **paragraph 2.8** This process can range from an in-depth planning process involving thorough hazard identification (ID), detailed data research, diagram and analysis tools, formal testing, and long-term tracking of the risks associated with an operation, activity or system. These risks also include normal day-to-day operations or activity planning that utilizes the same 5-Step RM process, but requires less time and resources to complete. Generally associated with deliberate-level planning, Deliberate RM planning is reserved for complex operations and systems, high priority/high visibility situations, or in situations where hazards are not well understood. Deliberate RM is normally implemented well in advance of the planned system, mission, event, or activity and is normally reserved for more complex and riskier efforts e.g., large troop/unit movements, airshow planning, system development, tactics and training curricula development, road trips, organized camping or hiking activities. As the situation, operation or activity becomes less complex, familiar and/or closer to execution, Deliberate RM planning becomes simplified and the focus shifts to ensuring near-term hazards and mitigation strategies are considered. Across the spectrum of Deliberate RM, always include the experience, expertise and knowledge of unit personnel to identify known hazards/risks and strategies to effectively mitigate risks for the specific mission, activity or task in both on and off-duty situations. Although pre-planning is always desired for any situation, also consider how to deal with RM once the execution phase of an activity begins.

Figure 1.1. Relationship of RM Levels.



1.2.2. Real-Time RM. This level of RM is always associated with RM decisions made in real-time during the execution or tactical phase of training, operations, emergency and/or crisis response situations, or off-duty activities where there is normally little or no time to conduct formal RM planning. It is usually an informal, mental risk assessment that is done "on the fly."

Examples include short-notice taskings, weather or natural phenomena-driven activities, emergency responses, spontaneous off-duty activities, etc. Apply basic RM process steps to identify and mitigate hazards in the new or changing situation. As time is normally constrained or limited in these situations, Deliberate RM planning (**paragraph 1.2.1**) is impractical. In real-time situations, it is imperative that individuals are able to efficiently and effectively apply RM concepts to mitigate risks. Refer to **paragraph 2.4.3** for additional information on general RM principles.

Chapter 2

THE RM PROCESS

2.1. Scope. RM is a continuous process designed to detect, assess and control risk while enhancing performance, maximizing combat capabilities and preserving life in both on and off-duty situations. Individuals at all levels identify and control hazards through the RM process.

2.2. RM Integration. A key objective of RM is to accomplish the RM process as an integrated aspect of mainstream on-duty mission and/or off-duty activity processes. When RM is effectively integrated, it quickly ceases to be consciously identifiable as a separate process. To effectively apply RM, commanders, supervisors and individuals should dedicate time and resources to incorporate RM principles into the planning processes. Risks are more easily assessed and managed in the planning stages of an operation or activity. Integrating RM into planning as early as possible provides the decision maker the greatest opportunity to control risk.

2.3. Benefits. RM is a logical process of weighing potential costs of risks versus anticipated benefits. Benefits are not limited to reduced mishap rates or decreased injuries, but may be seen as actual increases in efficiency or mission effectiveness. Examples of potential benefits include:

2.3.1. A greater level of confidence through prudent risk-taking. Even risky actions may be undertaken when the benefits have been carefully weighed against the probability and severity of loss.

2.3.2. Improved ability to protect the force with minimal losses. Analysis of current practices may reduce risks that are currently accepted.

2.3.3. Enhanced decision-making skills. Decisions are based on a reasoned and repeatable process instead of relying on intuition.

2.3.4. Improved confidence in unit capabilities. Adequate risk analysis provides a clearer picture of unit strengths and weaknesses.

2.4. Acceptability of Risk.

2.4.1. Applying RM requires a clear understanding of what constitutes “unnecessary risk,” when costs outweigh the benefits. Accepting risk is a function of both risk assessment and RM. Risk acceptance is not as elementary a matter as it may first appear. Several points should be kept in mind:

2.4.1.1. Some degree of risk is a fundamental reality.

2.4.1.2. RM is a process of tradeoffs.

2.4.1.3. Quantifying risk alone does not ensure safety.

2.4.1.4. Risk is a matter of perspective.

2.4.1.5. Risk is measured by experience level of the task being performed.

2.4.2. Realistically, some risk should be accepted. How much is accepted, or not accepted, is the prerogative of the defined decision authority. That decision is affected by many inputs. As options are considered and mission or activity planning progresses, it may become evident that some of the mission parameters or circumstances are forcing higher risk levels to ensure successful mission or activity completion. From the commander’s/leader’s perspective,

modifying planned parameters, or courses of action may appear to be advantageous when considering the broader perspective of overall mission success. When a commander or leader decides to accept risk, the decision should be coordinated whenever practical with the affected personnel and organizations, and documented so that in the future everyone will know and understand the elements of the decision and why it was made. In off-duty applications, this same decision process can be applied through effective communication with others. This communication may lead to discussion of alternatives or at a minimum awareness of planned activities and associated risks with others that can assist if problems arise.

2.4.3. General RM guidelines are:

2.4.3.1. All human activity involving a technical device or complex process entails some element of risk.

2.4.3.2. Do not panic because hazards are present; there are often ways of mitigating them.

2.4.3.3. Keep problems in proper perspective.

2.4.3.4. Weigh risks and make judgments based on knowledge, experience, and mission/activity requirements.

2.4.3.5. Encourage others to adopt similar RM principles.

2.4.3.6. Operations or activities always represent a gamble to some degree; good analysis tilts the odds favorably.

2.4.3.7. Hazard analysis and risk assessment do not free us from reliance on good judgment. They improve it.

2.4.3.8. It is more important to establish clear objectives and parameters for risk assessment than to find a "one size fits all" approach and procedure.

2.4.3.9. There is no "best solution;" there are normally a variety of COAs. Each of these COAs may produce some degree of risk reduction.

2.4.3.10. Point out the benefits of RM to mission/activity planners; it is more effective than correcting specific proposals.

2.4.3.11. Zero risk is a condition that seldom can be achieved in a practical manner.

2.4.3.12. There are no "safety problems" in mission/activity planning or design. There are only management problems that, if left unresolved, may cause mishaps.

2.4.3.13. Leaders should utilize safety career field professionals in their risk management decision-making, when practical.

2.4.3.14. Not making a decision is a decision in RM.

2.5. Systematic RM. RM is the systematic application of management, engineering principles, criteria and tools. RM is intended to optimize all aspects of risk within the constraints of mission and activity effectiveness, time, and cost throughout all mission/activity phases. To apply the systematic RM process, the composition of hardware, procedures, and people that accomplish the mission or produce mishaps, should be viewed as a system. To support this concept, there are a couple of models that can assist individuals when analyzing hazards within the scope of an operation or activity. Within the joint service community, the Mission, Enemy, Terrain and

Weather, Troops and support available, Time available, and Civil considerations (METT-TC) Model provides a sound basis for evaluating hazards and risks normally associated with military ground operations and the environment associated with those operations. This model is taught across most of the service-related leadership schools as a standard when preparing for military operations and is one that AF personnel should be familiar with. The METT-TC Model provides a systematic basis for situation analysis, primarily for ground-centric military operations and should be considered when addressing RM concerns in deployed locations. The Man, Machine, Media (environment), Management, and Mission (5-M) Model provides a similar approach as the METT-TC Model, but is less specific with regard to military application; it is an excellent model for both on and off-duty RM considerations. Both models will be described in the following sections; each provides a systematic view of analyzing risk and excellent starting points for conducting risk assessments for on and off-duty operations and activities.

2.5.1. The METT-TC Model. The METT-TC model is comprised of six general areas: mission, enemy, terrain and weather, troops and support available, time available and civil considerations.

2.5.1.1. Mission: Leaders first analyze the assigned mission. They look at the type of mission to be accomplished and consider possible subsequent missions. Certain kinds of operations are inherently more dangerous than others. For example, a deliberate frontal attack is more likely to expose a unit to losses than a defense from prepared positions. Identifying missions that routinely present greater risk is imperative. Leaders also look for hazards associated with complexity of the plan or the impact of operating under a fragmentary order.

2.5.1.2. Enemy: Commanders look for enemy capabilities that pose significant risk to the operation. For example, “What can the enemy do to defeat my operation?”

2.5.1.2.1. Common shortfalls that can create risk during operations include failure to:

2.5.1.2.1.1. Assess potential advantages to the enemy provided by the battlefield environment.

2.5.1.2.1.2. Fully assess the enemy’s capabilities.

2.5.1.2.1.3. Understand enemy capabilities and friendly vulnerabilities to those capabilities.

2.5.1.2.1.4. Accurately determine the enemy’s probable COA.

2.5.1.2.1.5. Plan and coordinate active ground and aerial reconnaissance activities.

2.5.1.2.1.6. Disseminate intelligence about the enemy to all echelons.

2.5.1.2.1.7. Identify terrorist threat and capabilities.

2.5.1.2.2. Intelligence plays a critical part in identifying hazards associated with the presence of an enemy or an adversary. Intelligence Preparation of the Operational Environment is a dynamic staff process that continually integrates new information and intelligence that ultimately impacts the commander’s risk assessment process. Intelligence assists in identifying hazards during operations by:

2.5.1.2.2.1. Identifying opportunities and constraints offered by the battlefield environment to enemy and friendly forces.

2.5.1.2.2.2. Thoroughly portraying enemy capabilities and vulnerabilities.

2.5.1.2.2.3. Collecting information on populations, governments, and infrastructures.

2.5.1.3. Terrain, Weather and Environment. Terrain, weather and the environment pose great potential hazards to military operations. The unit should be familiar with both the terrain and its associated environment for a mission to succeed. Considerations include reliable weather forecast availability, the duration of unit operations in the environment and climate, and previous terrain navigation.

2.5.1.3.1. Terrain. The predominant military considerations of terrain include observation and fields of fire, cover and concealment, obstacles, key terrain, and avenues of approach; these may be used to identify and assess hazards impacting friendly forces. Terrain analysis includes both map and visual reconnaissance to identify how well the terrain can accommodate unit capabilities and mission demands.

2.5.1.3.1.1. Observation and fields of fire. Hazards associated with observation and fields of fire usually involve when the enemy will be able to engage a friendly unit and when the friendly unit's weapon capabilities allow it to engage the enemy effectively.

2.5.1.3.1.2. Cover and concealment. Hazards associated with cover and concealment are created either by failure to use cover and concealment or by the enemy's use of cover and concealment to protect their assets from observation and fire.

2.5.1.3.1.3. Obstacles. Hazards associated with obstacles may be caused by natural conditions (such as rivers or swamps) or man-made conditions (such as minefields or built-up areas).

2.5.1.3.1.4. Key terrain. Hazards associated with key terrain result when the enemy controls that terrain or denies its use to the friendly forces.

2.5.1.3.1.5. Avenues of approach. Hazards associated with avenues of approach include conditions in which an avenue of approach impedes deployment of friendly combat power or conditions that support deployment of enemy combat power.

2.5.1.3.2. Weather. To identify weather-related hazards, leaders and unit personnel should assess the impact on operating systems. Hazards may arise from:

2.5.1.3.2.1. Lack of understanding of reliability and accuracy of weather forecasting due to the inherent spatial and temporal limitations of weather forecasts.

2.5.1.3.2.2. Effects of climate and weather on personnel and equipment operation and maintenance.

2.5.1.3.2.3. Effects of weather on mobility.

2.5.1.3.3. Environment. Give consideration to hazards associated with an adverse change to the environment wholly or partially caused by the mission.

2.5.1.4. Troops and Support Available. Leaders analyze the capabilities of available friendly troops. Associated hazards impact both individual personnel and the unit. Key

considerations are level of training, manning levels, the condition and maintenance of equipment, morale, availability of supplies and services, and the physical and emotional health of personnel. All personnel should be vigilant to the fact that hazards in these areas can adversely affect a mission. Even when all tactical considerations point to success, mission failure can be caused by:

2.5.1.4.1. Hazards Associated with Physical and Emotional Health. The health hazards depend on a complex set of environmental and operational factors that combine to produce disease and non-battle injuries as well as combat injuries. Care of troops requires long-range projection of logistical and medical needs with close monitoring of mission changes that could impact troop support.

2.5.1.4.2. Hazards to Task Organization or Units Participating in an Operation. Hazards include poor communication, unfamiliarity with higher headquarters standard operating procedures (SOPs), and insufficient combat power to accomplish the mission. How long units have worked together under a particular command relationship should be considered when identifying hazards.

2.5.1.4.3. Hazards Associated with Long-term Missions. Long-term missions include peacekeeping, or insurgency/counterinsurgency operations. Hazards associated with these missions include the turmoil of personnel turnover, lack of continuity of leadership, inexperience, and lack of knowledge of the situation and the unit's operating procedures. Long-term missions can also lead to complacency; units conditioned to routine ways of accomplishing the mission fail to see warnings evident in the operational environment and short-term risk aversion, which could result in long-term risk to mission. An especially insidious hazard is the atrophy of critical-skills that results from not performing mission-essential task list related missions.

2.5.1.5. Time Available. The hazard may be insufficient time to plan, prepare, and execute operations. Planning time is always at a premium. Leaders routinely apply the one-third/two-thirds rule (providing two thirds of time available to subordinates for planning) to ensure their subordinate units are given maximum time to plan. Failure to accomplish a mission on time can result in shortages of time for subordinate and adjacent units to accomplish their missions.

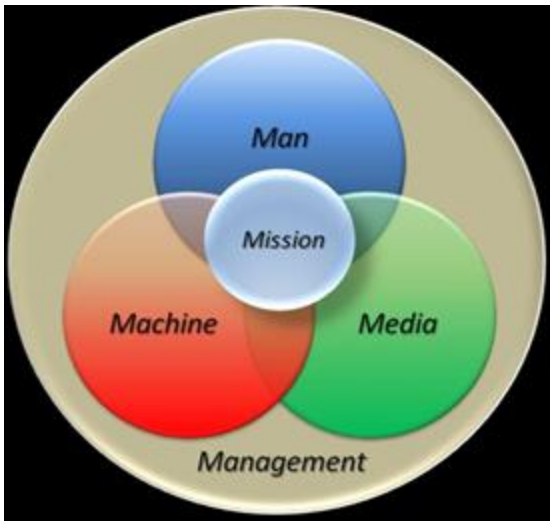
2.5.1.6. Civil Considerations. Consideration should be given to the influence of man-made infrastructure, civilian institutions, and attitudes and activities of the civilian leaders, populations and organizations within an area impacted by military operations. Rarely are military operations conducted in uninhabited areas. Most of the time, units are surrounded by noncombatants. These noncombatants include residents of the area of operations, local officials, and governmental and nongovernmental organizations. Based on information available and their own knowledge and judgment, leaders identify civil considerations that affect their mission. Civil considerations are analyzed in terms of six factors known by the memory aid "ASCOPE": areas, structures, capabilities, organizations, people and events. ASCOPE is a memory aid to organize civil considerations in planning. ASCOPE helps to categorize the man-made infrastructure, civilian institutions, attitudes, and activities of the civilian population and their leaders.

2.5.2. Man, Machine, Media, Management and Mission (5-M) Model. The 5-M Model provides a similar approach as the METT-TC, but is less specific regarding its overt military

application. It is an excellent model for both on and off-duty RM considerations. The 5-M Model (**Figure 2.1**) provides a basic framework for analyzing systems and determining the relationships between component elements that work together to perform the mission. The 5-M Model interacts to produce a successful mission or, sometimes, an unsuccessful one. The amount of overlap or interaction between the individual components is a characteristic of each system and evolves as the system develops. Management provides the procedures and rules governing the interactions between the various elements.

2.5.2.1. **Figure 2.1** is a generalized model of a mission system. There is significant overlap between Man, Media, and Machine, because these elements interrelate directly, but the critical element is Management because it defines how the other elements interact. When a mission and/or activity is unsuccessful or a mishap occurs, the system should be analyzed as well as reassessing the inputs and interaction between the 5-Ms. Management is often the controlling factor in mission success or failure. Military safety centers and the National Safety Council cite management processes in as many as 80 percent of reported mishaps.

Figure 2.1. 5-M Model.



2.5.2.2. Successful and unsuccessful missions (mishaps) do not occur by chance but rather are indicators of how well a system is functioning. The basic causation factors for mishaps fall into the same categories as the contributors to successful missions: man, media (environment), machine, management, and mission.

2.5.2.2.1. Man. Area of greatest variability and thus the source of the majority of risks.

2.5.2.2.1.1. Selection. Right person psychologically and physically, proficient in the task and mission, knowledgeable of procedural guidance, with established habit patterns (good/bad).

2.5.2.2.1.2. Performance. Awareness, perceptions, task saturation, distraction, channelized attention, stress, peer pressure, confidence, insight, adaptive skills, pressure or workload, fatigue (physical, motivational, sleep deprivation, circadian rhythm).

2.5.2.2.1.3. Personal Factors. Expectations, job satisfaction, values, families and/or friends, command and control, discipline (internal and external), perceived pressure (over-tasking) and communication skills.

2.5.2.2.2. Media. External, largely environmental forces.

2.5.2.2.2.1. Climatic. Ceiling (cloud cover), visibility, temperature, humidity, wind and precipitation.

2.5.2.2.2.2. Operational. Terrain, wildlife, vegetation, man-made obstructions, daylight and darkness.

2.5.2.2.2.3. Hygienic. Ventilation/air quality, noise/vibration, dust and contaminants.

2.5.2.2.2.4. Vehicular/Pedestrian. Pavement, gravel, dirt, ice, mud, dust, snow, sand, hills and curves.

2.5.2.2.2.5. Environment. Impact to the environment wholly or partially caused by the mission, e.g., pollution in the air, water and soil that may cause undue exposure to hazardous chemical, physical and biological agents.

2.5.2.2.3. Machine. Used as intended, limitations, interface with man.

2.5.2.2.3.1. Design. Engineering reliability and performance, and ergonomics.

2.5.2.2.3.2. Maintenance. Availability of time, tools and parts, and ease of access.

2.5.2.2.3.3. Logistics. Supply, upkeep and repair.

2.5.2.2.3.4. Tech data. Clear, accurate, useable and available.

2.5.2.2.4. Management. Directs the process by defining standards, procedures and controls. Be aware that while management provides procedures and rules to govern interactions, it cannot completely control the system elements, e.g., weather is not under management control and individual decisions affect off-duty personnel much more than management policies.

2.5.2.2.4.1. Standards. Doctrine statements, policy and directives.

2.5.2.2.4.2. Procedures. Checklists, work cards, technical orders (TOs), multi-command manuals, AFIs, etc.

2.5.2.2.4.3. Controls. Crew rest, altitude/airspeed/speed limits, restrictions, training rules and/or limitations, rules of engagement and lawful orders.

2.5.2.2.5. Mission and/or Activity. The desired outcome.

2.5.2.2.5.1. Objectives. Complexity understood, well-defined, obtainable.

2.5.2.2.5.2. Results of the interactions of man, media (environment), machine, management, and mission.

2.6. Applying Opportunity-Risk and Training Realism Procedures. Just as every organization should be targeting its more important risk issues, it should also be systematically targeting risk barriers to expanded operational capabilities and increased training realism. All-important organizational missions should be analyzed to determine the risk barriers to expanded

capabilities. Procedures should be in place to use the tools of RM to break through these barriers. As a general rule, about half the effort expended on RM should be directed toward using RM to expand operational capabilities and effectiveness. The other half is directed at reducing various types of risk.

2.7. The 5-Step RM Process. RM is a continuous, systematic decision-making tool consisting of five primary steps that define the formal RM process associated with Deliberative RM considerations. The following is a description of the 5-step RM process. **Figure 2.2** shows the standardized DAF RM process "wheel" and associated steps.

2.7.1. Step 1. Identify the Hazards. This step is used to identify hazards within an operation or activity. A hazard can be defined as any real or potential condition that can cause mission degradation, injury, illness, death to personnel, or damage to or loss of equipment, property or the environment. Experience, common sense and specific RM tools help identify real or potential hazards.

Figure 2.2. DAF Standardized 5-Step RM Process.

2.7.2. Step 2. Assess the Hazards. Risk is the probability and severity of loss from exposure to the hazard. The assessment step is the application of quantitative or qualitative measures to determine the level of risk associated with a specific hazard. This process defines the probability and severity of a mishap that could result from the hazard based upon the exposure of personnel or assets to that hazard. Rank the risks in terms of overall impact, addressing the highest risks with the most impact to the operation or activity first.

2.7.3. Step 3. Develop Controls and Make Decisions. Investigate specific strategies and tools that reduce, mitigate or eliminate the risk. Effective control measures reduce or eliminate one of the three components (probability, severity, or exposure) of risk. Decision makers at the

appropriate level choose the best control or combination of controls based on the analysis of overall costs and benefits.

2.7.4. Step 4. Implement Controls. Once risk control strategies have been selected, an implementation strategy needs to be developed and then applied by management and the work force. Implementation requires commitment of time and resources.

2.7.5. Step 5. Supervise and Evaluate. RM is a process that continues throughout the lifecycle of the system, mission or activity. Leaders, supervisors and personnel at every level should fulfill their respective roles in assuring controls are sustained over time. Once controls are in place, the processes should be periodically reevaluated to ensure their effectiveness. If they are found to be inadequate or circumstances have changed that alter the effectiveness of the control measure(s), then the process is repeated to find a more effective RM strategy.

2.8. How to use the 5-Step RM Process Model. To get maximum benefit from this powerful tool, there are several factors to keep in mind:

2.8.1. Apply the Steps in Sequence. Each of the steps is a building block for the next step. It is important to complete each step, however briefly, before proceeding to the next step. **Example:** If the hazard ID step is interrupted to focus on control of a particular hazard before the ID step is complete, other more important hazards may be overlooked and the RM process may be distorted. Until the hazard ID step is complete, it is not possible to properly prioritize risk control efforts.

2.8.2. Maintain Balance in the Process. All five steps are important. If an hour is available to apply the RM process, it is important not to lose sight of the total process. Spending 50 minutes of the hour on hazard ID may not leave enough time to effectively apply the other four steps of the process. The result is sub-optimal RM. Of course, it would be simplistic to rigidly insist that each of the 5 steps gets 12 minutes. The idea is to assess the time and resources available for RM activities and allocate them to the five steps in a manner most likely to produce the best overall result.

2.8.3. Apply the Process as a Cycle. Notice that the Supervise and Evaluate step feeds back into the first step. It is this cyclic characteristic that generates the continuous improvement characteristics of the RM process. When the Supervise and Evaluate step establishes that some risks have been significantly reduced, the hazard ID step is reapplied to find new hazard targets. In this way, the RM process is continually reevaluating the risks.

2.8.4. Fully Involve Affected Personnel. The only way to ensure the RM process is supportive is to provide for the full involvement of the personnel actually exposed to the risks. Take the time to periodically revalidate RM procedures and assure that they are mission supportive and viewed positively by the personnel involved in the mission or activity.

2.8.5. Document the Process. In all Deliberative RM planning, the process should be documented to ensure there is a record of the considered hazards and mitigation strategies applied against the hazards. This documentation provides a basis for future reviews of the operation or activity to ensure the risk mitigation strategies remain effective and as a reference for others who plan to conduct similar activities. AF Form 4437, *Deliberate Risk Assessment Worksheet,* may be used to document the process.

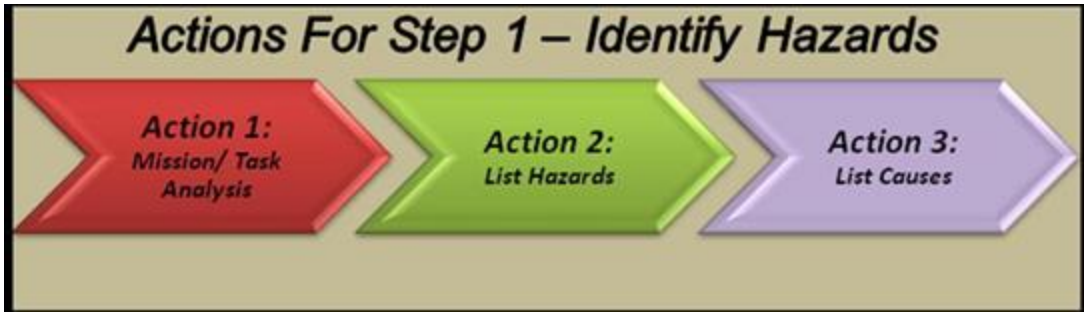
2.8.6. **Chapter 3** and **Chapter 4** provide a more comprehensive explanation of the steps associated with the formal 5-Step RM Process. **Attachment 9** and **Attachment 10** provide practical application of the risk assessment process and an example of the AF Form 4437 to assist in applying the Deliberative steps of the RM process.

Chapter 3

IDENTIFY HAZARDS

3.1. Scope. Hazard identification is the foundation of the entire RM process. Obviously, if a hazard is not identified it cannot be mitigated. The effort expended in accurately identifying hazards has a significant impact on the total RM process. **Figure 3.1** depicts the actions necessary to complete the step. The categories associated with identifying hazards are mission degradation, personal injury or death, property damage and environmental damage.

Figure 3.1. Actions for Step 1—Identify Hazards.



3.2. Action Steps for Hazard Identification.

3.2.1. Action 1—Mission/Task Analysis. The 5-Ms are examined. This is accomplished first by reviewing current planning documents and other available resources associated with the operational or activity mission. The commander or decision maker defines requirements and conditions to accomplish the tasks. Construct a list or chart depicting the major phases of the operation or steps in the job process, normally in time sequence. Break the operation down into bite size chunks. Hazard ID Tools, Details and Examples can be found in **Attachment 4.** The following tools are commonly used to perform mission/task analysis:

3.2.1.1. Operations Analysis (OA)/Flow Diagram (simple).

3.2.1.2. Preliminary Hazard Analysis (PHA) (simple).

3.2.1.3. Multilinear Events Sequence (MES) (complex).

3.2.2. Action 2—List Hazards. Hazards and the factors that could generate hazards are identified based on the deficiency to be corrected and the definition of the mission and system requirements. The output of the ID phase is a listing of inherent hazards or adverse conditions and the mishaps which could result. Examples of inherent hazards in any of the elements include fire, explosion, collision with ground, wind or electrocution, etc. The analysis should also search for factors that can lead to hazards such as alertness, ambiguity or escape route. In addition to a hazard list for the elements above, interfaces between or among these elements should be investigated for hazards. An individual required to make critical and delicate adjustment to an aircraft on a cold, dark night, handling of an air-to-air missile with missile-handling equipment, or frostbite would be examples of interface hazards. Make a list of the hazards associated with each phase of the operation or step in the job process. Stay focused on the specific steps in the operation being analyzed. Hazards should be tracked on paper or in a

computer spreadsheet or database system to organize ideas and serve as a record of the analysis for future use. Tools that help listed hazards are:

3.2.2.1. PHA.

3.2.2.2. "What-if" Tool.

3.2.2.3. Scenario Process Tool.

3.2.2.4. Logic Diagram.

3.2.2.5. Change Analysis Tool.

3.2.2.6. Opportunity Assessment.

3.2.2.7. Training Realism Assessment.

3.2.3. Action 3—List Causes. Make a list of the causes associated with each hazard identified in the hazard list. A hazard may have multiple causes related to areas highlighted within the METT-TC or 5-M Models. In each case, try to identify the root cause, e.g., the first link in the chain of events leading to mission degradation, personnel injury, death, or property damage. Risk controls can be effectively applied to root causes. Causes should be annotated with the associated hazards in the same paper or computer record mentioned in the previous action. The same tools for Action 2 can be used here.

3.3. Deliberate Tools. If time and resources permit and additional hazard information is required, use deliberate hazard analysis tools. These are normally used for medium and long term planning, complex operations or activities, or operations or activities in which the hazards are not well understood.

3.3.1. The first step of in-depth analysis should be to examine available historical and hazard information regarding the operation and any associated mishap information associated with similar operations or activities, if available. Suggested tools are:

3.3.1.1. The mission mishap analysis.

3.3.1.2. Cause and effect diagrams.

3.3.2. The following tools are particularly useful for complex, coordinated operations or activities in which multiple units, participants, system components and simultaneous events are involved:

3.3.2.1. MES.

3.3.2.2. Interface analysis.

3.3.2.3. Failure mode and effect analysis.

3.3.3. The following tools are particularly useful for analyzing the hazards associated with physical position and movement of assets:

3.3.3.1. Mapping tool.

3.3.3.2. Energy trace and barrier analysis.

3.3.3.3. Interface analysis.

3.4. Tool Selection and Other Resources. It is impractical for the DAF to create detailed procedures to ensure the *right* tools are utilized for every activity and every contingency. On the other hand, choosing the best tools is important when planning to undertake a potentially hazardous operation. Most of the tools mentioned can be used in a variety of creative ways.

3.4.1. **Attachment 4** lists and describes a variety of Hazard ID tools that may be useful in various situations. The most frequently used of these tools are depicted in **Figure 3.2** These tools are normally used in the sequence indicated, however it is important for the user to become familiar with them and choose the best combination for a particular situation.

3.4.2. There are many additional tools that can help identify hazards. One of the best is through a group process involving representatives directly from the workplace. Most people want to talk about their jobs; therefore, a simple brainstorming process with a facilitator is often very productive. The following is a partial list of other sources of hazard ID information:

Figure 3.2. Seven Primary Hazard Identification Tools.

Seven Primary Hazard Identification Tools
1. Operations Analysis
2. Preliminary Hazard Analysis
3. "What If" Tool (WIT)
4. Scenario Process Tool
5. Logic Diagram
6. Change Analysis
7. Cause and Effect Tool

3.4.2.1. Mishap Reports. These can come from within the organization, from tenant units, within the chain of command, from outside the chain (other bases, wings, deltas, MAJCOMs, FLDCOMs, etc.), other services, (Department of Defense) DoD agencies, etc. Obviously, a missionized ID is the best, for it represents corporate memory applicable to the local workplace, flight deck, mission, etc. Other sources might be medical reports, maintenance records, and fire and police reports.

3.4.2.2. Unit Personnel. Relevant experience is arguably the best source of hazard ID. Reinventing the wheel each time an operation or activity is proposed is neither desired nor efficient. Seek out personnel that have participated in similar operations or activities and solicit their input. There is no substitute for experience and no better way to ensure the operation or activity has the best chance for success.

3.4.2.3. Outside Experts. Look to those outside the organization for expert opinions or advice. Possible sources of help include safety, quality assurance, manufacturers, depots, other bases, activity experts/instructors, etc.

3.4.2.4. Current Guidance. A wealth of relevant direction can always be found in the guidance that governs operations and activities. Consider regulations, operating instructions, checklists, briefing guides, syllabi, Flight Crew Information Files, SOPs, Notice to Airmen, policy letters, etc.

3.4.2.5. Evaluation and inspection reports. Functional and inspector general (IG) visits provide important feedback and written documentation on local process management. In non-military or off-duty settings, seek out this information where able and appropriate to ensure equipment and facilities are properly maintained and safe for use.

3.4.2.6. Surveys. These can be unit generated. Target an audience and ask some very simple questions such as: *What will be the next mishap? Who will have it? What task will cause it?* and *When will it happen?* The survey can be a powerful tool because it pinpoints people in the workplace with firsthand knowledge of the job. Often, first line supervisors in the same workplace do not have as good an understanding of risk associated with a particular procedure/operation as those who confront it every day.

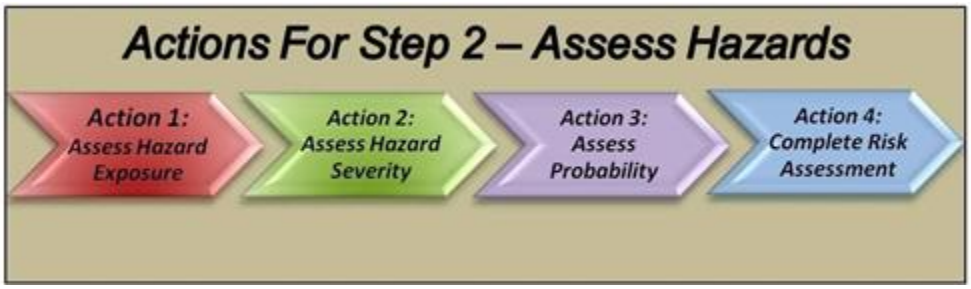
3.4.2.7. Inspections. Inspections can consist of spot checks, walkthroughs, checklist inspections, site surveys, and mandatory inspections. Utilize people in the workplace to provide input beyond the standard third-party inspection. When conducting activities off-duty or outside a normal work environment, take the time to inspect the area, familiarize with the surroundings; try to identify potential hazards and risks.

Chapter 4

ASSESS HAZARDS

4.1. Scope. Hazard assessment is the process, which associates hazards with risks. When various hazards are identified that may impact a mission or activity and an estimate of how likely the hazards are to occur is made, then the hazard is formally defined as a risk. The second aspect of risk assessment is the ranking of risks into a priority order. **Figure 4.1** depicts the actions necessary to complete this step. The number one risk is the one with the greatest combined probability and impact on the mission activity, while the lowest risk has the least greatest combined probability and impact. Keep in mind that this priority listing is intended to be used as a guide to the relative priority of the risks involved and not necessarily an absolute order to be followed.

Figure 4.1. Actions for Step 2—Assess Hazards.



4.2. The Components of Risk. There are three key aspects of risk: probability, severity and exposure.

4.2.1. Probability is the estimate of the likelihood that a hazard will cause a loss. Some hazards produce losses frequently, others almost never do.

4.2.2. Severity is the estimate of the extent of loss that is likely.

4.2.3. Exposure is the number of personnel or resources affected by a given event, or by repeated events over time. Though most Risk Matrix tables only offer the inputs of probability and severity, it is impossible to accurately assess those areas without a robust look at exposure.

4.2.4. To place hazards in rank order, a best possible estimate of the probability, severity and exposure of a risk compared to the other risks that have been detected should be made. A complete description of this concept, including an application of the risk assessment matrix and an example of a risk priority list, are available in **Attachment 5.**

4.3. Action 1—Assess Hazard Exposure. Surveys, inspections, observations and the mapping tool can help determine the level of exposure to a hazard and allow personnel to record it. This record can be expressed in terms of time, proximity, volume or repetition. Does it happen often, or near personnel or equipment? Does the event involve a lot of people or equipment? Repeated exposure to a hazard increases the probability of a mishap occurring. Understanding the exposure level can aid in determining the severity and/or the probability of the event. Additionally, it may serve as a guide for devising control measures to limit exposure.

4.4. Action 2—Assess Hazard Severity. Determine the severity of the hazard in terms of its potential impact on the people, equipment or mission/activity. Cause and effect diagrams, scenarios and "What-If" analysis are some of the best tools for assessing the hazard severity.

Severity assessment should be based upon the worst possible outcome that can reasonably be expected. Severity categories are defined to provide a qualitative measure of the worst credible mishap resulting from personnel error, environmental conditions, design inadequacies, procedural deficiencies, or system, subsystem or component failure or malfunction. The following severity categories provide guidance to a wide variety of missions and systems.

4.4.1. Catastrophic. Complete mission failure, death or loss of system.

4.4.2. Critical. Major mission degradation, severe injury, occupational illness or major system damage.

4.4.3. Moderate. Minor mission degradation, injury, minor occupational illness or minor system damage.

4.4.4. Negligible. Less than minor mission degradation, injury, occupational illness or minor system damage.

4.5. Action 3—Assess Probability. Determine the probability that the hazard will cause a negative event of the severity assessed in Action 2 above.

4.5.1. Probability is proportional to the cumulative probability of the identified causes for the hazard. Probability may be determined through estimates or actual numbers, if they are available. Assigning a quantitative mishap probability to a new mission or system may not be possible early in the planning process. A qualitative probability may be derived from research, analysis and evaluation of historical mishaps from similar missions and systems. The typical mishap sequence is much more complicated than a single line of erect dominos where tipping the first domino (hazard) triggers a clearly predictable reaction.

4.5.2. Supporting rationale for assigning a probability should be documented for future reference. The following are the Joint RM Working Group accepted terms and definitions for the varying levels of probability associated with a standard risk assessment matrix:

4.5.2.1. Probability.

4.5.2.1.1. Frequent (A):

4.5.2.1.1.1. Individual item—Occurs often in the life of the system, with a probability occurrence greater than 10 % (10^{-1}) in that life.

4.5.2.1.1.2. Fleet or inventory—Continuously experienced.

4.5.2.1.1.3. Individual Airman or Guardian—Occurs often in career.

4.5.2.1.1.4. All Airmen or Guardians exposed—Continuously experienced.

4.5.2.1.2. Likely/Probable (B):

4.5.2.1.2.1. Individual item—Occurs several times in the life of the system, with a probability of occurrence less than 10% (10^{-1}) but greater than 1% (10^{-2}) in that life.

4.5.2.1.2.2. Fleet or Inventory—Occurs frequently.

4.5.2.1.2.3. Individual Airman or Guardian—Occurs several times in a career.

4.5.2.1.2.4. All Airmen or Guardians exposed—Occurs regularly.

4.5.2.1.3. Occasional (C):

4.5.2.1.3.1. Individual item—Will occur in the life of the system, with a probability of occurrence less than 1% (10^{-2}) but greater than 0.1% (10^{-3}) in that life.

4.5.2.1.3.2. Fleet or Inventory—Occurs several times in the life of the system.

4.5.2.1.3.3. Individual Airman or Guardian—Will occur in a career.

4.5.2.1.3.4. All Airmen or Guardians exposed—Occurs sporadically.

4.5.2.1.4. Seldom/Remote (D):

4.5.2.1.4.1. Individual item—Possible to occur in the life of the system, with a probability of occurrence less than 0.1% (10^{-3}) but greater than .0001% (10^{-6}) in that life.

4.5.2.1.4.2. Fleet or Inventory—Reasonably expected to occur in the life of the system.

4.5.2.1.4.3. Individual Airman or Guardian—May occur in a career.

4.5.2.1.4.4. All Airmen or Guardians exposed—Occurs seldom.

4.5.2.1.5. Unlikely/Improbable (E):

4.5.2.1.5.1. Individual item—So unlikely you can assume it will not occur in the life of the system, with a probability of occurrence less than 10^{-6} in that life.

4.5.2.1.5.2. Fleet or Inventory—Unlikely to occur, but possible in the life of the system.

4.5.2.1.5.3. Individual Airman or Guardian—So unlikely; assumed it will not occur in a career.

4.5.2.1.5.4. All Airmen or Guardians exposed—Occurs very rarely.

4.6. Action 4—Complete Risk Assessment. Combine severity and probability estimates to form a risk assessment for each hazard. By combining the probability of occurrence with severity, a matrix is created where intersecting rows and columns define a risk assessment matrix. The risk assessment matrix forms the basis for judging both the acceptability of a risk and the management level at which the decision on acceptability will be made. The matrix may also be used to prioritize resources to resolve risks due to hazards or to standardize hazard notification or response actions. Severity, probability and risk assessment should be recorded to serve as a record of the analysis for future use. Existing databases, risk assessment matrices or a panel of personnel experienced with the mission and hazards can be used to help complete the risk assessment. **Figure 4.2** is an example of a matrix. **Note:** Risk assessment matrices can take different forms and should be designed to fit the organization and/or situation as warranted.

4.7. Assessment Pitfalls. The following are some analytical pitfalls that should be avoided in the assessment:

4.7.1. Over Optimism. “It can’t happen to us.” “We’re already doing it.” This pitfall results from not looking for root causes of risk.

4.7.2. Misrepresentation. Individual perspectives may distort data. This can be deliberate or unconscious.

4.7.3. Alarmism. “The sky is falling” approach, or “worst case” estimates are used regardless of their remote possibility.

4.7.4. Indiscrimination. All data is given equal weight.

4.7.5. Prejudice. Subjectivity and/or hidden agendas are used, rather than facts.

4.7.6. Inaccuracy. Bad or misunderstood data nullifies accurate risk assessment.

4.7.6.1. It is difficult to assign a numerical value to human behavior.

4.7.6.2. Numbers may oversimplify real life situations.

4.7.6.3. It may be difficult to get enough applicable data, which could force inaccurate estimates.

4.7.6.4. Oftentimes, numbers take the place of reasoned judgment.

4.7.6.5. Risk can be unrealistically traded off against benefit by relying solely on numbers.

4.8. The Output of the Hazard Assessment Step. The outcome of the risk assessment process is a list of prioritized risks, which are developed from the output of the hazard ID process. The first risk is the most serious threat to the mission; the last is the least serious risk of any consequence (see **Figure 4.3**). Each risk is labeled as high, medium, etc., or the section in which it’s placed is labeled. This allows us to see both the relative priority of the risks and their individual significance.

Figure 4.2. Sample Risk Assessment Matrix.

Risk Assessment Matrix				PROBABILITY Frequency of Occurrence Over Time				
				A Frequent (Continuously experienced)	B Likely (Will occur frequently)	C Occasional (Will occur several times)	D Seldom (Unlikely; can be expected to occur)	E Rarely (Improbable; but possible to occur)
SEVERITY	Effect of Hazard	Catastrophic (Death, Loss of Asset, Mission Capability or Unit Readiness)	I	EH	EH	H	H	M
		Critical (Severe Injury or Damage, Significantly Degraded Mission Capability or Unit Readiness)	II	EH	H	H	M	L
		Moderate (Minor Injury or Damage, Degraded Mission Capability or Unit Readiness)	III	H	M	M	L	L
		Negligible (Minimal Injury or Damage, Little or No Mission Capability or Unit Readiness)	IV	M	L	L	L	L
				Risk Assessment Levels EH=Extremely High H=High M=Medium L=Low				

Figure 4.3. The Risk Ranking Concept.

Chapter 5

DEVELOP CONTROLS AND MAKE DECISIONS

5.1. Scope. Developing controls and making decisions involve several interrelated steps focused at targeting prioritized hazards and risks for elimination or mitigation. Those steps are discussed below. Identifying, developing and making control decisions are accomplished in several ways. **Attachment 5** defines each of these options in detail. **Figure 5.1** depicts the actions necessary to complete this step.

5.1.1. Identify control measures available to mitigate the identified hazard(s).

5.1.2. Determine the effects of each control on the targeted hazard(s).

5.1.3. Prioritize the best controls and/or strategies to mitigate the hazard(s).

5.1.4. Select the risk control measure(s) that will reduce the risks to an acceptable level.

5.1.5. Decide whether or not to accept the residual risk present in a mission, activity or project after applying all practical risk controls. The classic "risk versus reward" decision.

Figure 5.1. Actions for Develop Controls and Make Decisions.

5.2. Action 1—Identify Control Options. Starting with the highest-risk hazards as assessed in Step 2, identify as many risk control options as possible for all hazards. Each hazard should have one or more controls that can effectively eliminate, avoid, or reduce the risk to an acceptable level. Refer to the list of possible causes from Step 1 for control ideas. Whenever possible, involve personnel impacted by risk controls in the development and implementation of the risk controls to ensure that the controls are appropriate for the action, operation or activity and that it is realistic and effective for those most closely involved in its implementation. The Control Options Matrix, Mission mishap analysis, and "What-If" analysis are excellent tools to identify control options. Examples of criteria for establishing effective controls are listed in **Table 5.1**.

5.2.1. There are many types of controls that can be applied to hazards. The following controls are the most common:

5.2.1.1. Engineering Controls. These are controls that use engineering methods to reduce risks by design, material selection or substitution when technically or economically feasible. Design solutions are generally considered the best risk control option when dealing with systems or acquisition development issues.

Table 5.1. Effective Control Criteria.

Control Criteria	Remarks
Suitability	Control removes the threat or mitigates (reduces the risk to an acceptable level).
Feasibility	Has the capability to implement the control.
Acceptability	Benefit or value gained by implementing the control justifies the cost in resources and time.
Explicitness	Clearly specifies who, what, where, when, why and how each control is to be used.
Support	Adequate personnel, equipment, supplies and facilities necessary to implement a suitable control are available.
Standards	Guidance and procedures for implementing a control are clear, practical and specific.
Training	Knowledge and skills are adequate to implement a control.
Leadership	Leaders are ready, willing and able to enforce standards required to implement a control.
Individual	Individual personnel are sufficiently self-disciplined to implement a control.

5.2.1.2. Physical Controls. These controls take the form of barriers to and guards against a hazard, such as fences, equipment guards, personal protective equipment (PPE), etc. **Note:** PPE is also associated with Administrative Controls when its use is directed.

5.2.1.3. Administrative Controls. These are controls that reduce risks through specific administrative actions, such as providing suitable warnings, markings, placards, signs and notices; establishing written policies, programs, instructions and standard operating procedures; conducting job and RM training; donning appropriate PPE, if needed; or limiting the exposure to a hazard, either by reducing the number of assets or personnel, or the length of time personnel are exposed.

5.2.1.4. Educational Controls. These controls are based on the knowledge and skills of the units and individuals. Effective control is implemented through individual and collective training that ensures performance to standard.

5.2.1.5. Operational Controls. These controls involve operational actions such as pace of operations, battlefield controls (areas of operations and boundaries, direct fire control measures, fire support coordinating measures), rules of engagement, airspace control measures, map exercises and rehearsals.

5.2.2. Each control should eliminate or mitigate the risk of a hazard via one or more of the following methods:

5.2.2.1. Rejection. Refuse to take a risk if the overall costs of the risk exceed its mission benefits. For example, operational planners may review the risks associated with a specific ground attack profile for a particular aircraft type. After assessing all the advantages of this profile, evaluating the increased risk associated with it and the application of all available risk controls, it is determined the benefits do not outweigh the expected costs and that the unit is better off not using that profile. This is a valid option when there are insufficient resources to overcome the risks and the appropriate decision-making authority (normally a high-level decision maker) determines that the hazards of the operation or activity do not warrant further consideration.

5.2.2.2. Avoidance. It may be possible to avoid specific risks by "going around" them or by accomplishing the mission or task in a different way. Avoiding risk altogether requires canceling or delaying the job, mission or operation. It is an option that is rarely exercised due to mission importance. However, it is possible to avoid specific risks. Risks associated with a night operation may be avoided by conducting the operation during daylight hours. Likewise, if a known nightclub is a problem area, it may be best to avoid the establishment altogether. Keep in mind that avoiding a risk can present other hazards that will need to be identified and assessed as a result of the avoidance strategy.

5.2.2.3. Delay. If there is no time deadline or other operational benefit to expedite accomplishment of a task with identified hazards, then it may be beneficial to delay task execution. During the delay, the situation and required level of risk acceptance may evolve. During the delay, additional risk control options may become available (resources, new technology, etc.), thereby reducing the overall risk. For example, a commander may be faced with conducting risky training for a special mission that has yet to be given the "go" for actual execution. By delaying the risky training until later in the mission preparation cycle, the commander could effectively prevent unnecessary injuries or damage to equipment if the mission were to be cancelled or change in such a way that ultimately the training was no longer necessary.

5.2.2.4. Transference. Risk may be reduced by transferring all or some portion of that mission or task, to another individual, unit or platform that is better positioned, more survivable or more expendable. Risk transference does not change probability or severity of the hazard, but it may decrease the probability or severity of the risk actually experienced by the individual or organization accomplishing the mission/activity. For example, the decision to fly a remotely operated vehicle into a high-risk environment instead of risking a manned vehicle is risk transference.

5.2.2.5. Spreading. Similar to transference, spreading refers to the movement of forces, equipment or tasks to other areas in order to avoid risk to the entire mission. Risk can also be spread out by either increasing the exposure distance or by lengthening the time between exposure events. For example, placing aircraft or vehicles in a single area can lead to catastrophic losses if an explosion or fire breaks out. Spreading resources can mitigate this potential risk by reducing the exposure of these resources in a single, combined area.

5.2.2.6. Compensation. To ensure the success of critical missions or tasks and compensate for potential losses, assign redundant capabilities. For example, tasking a unit to deploy two aircraft to attack a single high value target increases the probability of mission success, or ensuring there are spare parts in case of an equipment malfunction. Flight control redundancy is an example of an engineering or design redundancy that compensates for primary system malfunctions. Another example is to plan for a back-up designated driver or other means of procuring a ride home after a night out.

5.2.2.7. Reduction. Reducing the number of individuals, equipment or resources exposed to a particular risk is a very simple way of mitigating overall risk. Although this strategy may reduce risk, it should be weighed carefully against potential rewards. Just as compensation allows for probability of success, reduction can sometimes have the negative consequence of not having back-up options available. The overall goal of RM is to plan missions or design systems that do not contain hazards. However, the nature of most

complex missions and systems makes it impossible or impractical to design them completely hazard-free. As hazard analyses are performed, hazards will be identified that will require resolution. To be effective, RM strategies should address the components of risk: probability, severity or exposure. A proven order of precedence for dealing with hazards and reducing the resulting risks flows as follows:

5.2.2.7.1. Plan or design for minimum risk. From the beginning, plan the mission or design the system to eliminate hazards. Without a hazard, there is no probability, severity or exposure. If an identified hazard cannot be eliminated, reduce the associated risk to an acceptable level. For example, flight control components can be designed so they cannot be incorrectly connected during maintenance operations.

5.2.2.7.2. Incorporate safety devices. If identified hazards cannot be eliminated or their associated risk adequately reduced by modifying the mission or system elements or their inputs, that risk should be reduced to an acceptable level through the use of safety design features or devices. Safety devices usually do not affect probability but reduce severity, such as an automobile seat belt does not prevent a collision but reduces the severity of injuries. Nomex® gloves and steel-toed boots will not prevent a hazardous event, or even change the probability of one occurring, but they prevent or decrease the severity of injury. Physical barriers fall into this category.

5.2.2.7.3. Provide warning devices. When mission planning, system design and safety devices cannot effectively eliminate identified hazards or adequately reduce associated risk, warning devices should be used to detect the condition and alert personnel of the hazard. As an example, aircraft could be retrofitted with a low altitude ground collision warning system to reduce controlled flight into the ground mishaps. Warning signals and their application should be designed to minimize the probability of the incorrect personnel reaction to the signals and should be standardized. Flashing red lights or sirens are a common warning device that most people understand.

5.2.2.7.4. Develop procedures and training. Where it is impractical to eliminate hazards through design selection or adequately reduce the associated risk with safety and warning devices, procedures and training should be used. A warning system by itself may not be effective without training or procedures required to respond to the hazardous condition. The greater the human contribution to the functioning of the system or involvement in the mission process, the greater the chance for variability. However, if the system is well-designed and the mission well-planned, the only remaining risk reduction strategies may be procedures and training. Emergency procedure training and disaster preparedness exercises improve human response to hazardous situations.

5.3. Action 2—Determine Control Effects. Determine how each control affects the risk associated with the hazard. A computer spreadsheet or data form may be used to list control ideas and indicate control effects. With controls identified, the hazard should be reassessed, taking into consideration the effect the control will have on the severity and/or probability. The new estimated value(s) for severity and/or probability and the change in overall risk assessed from the risk assessment matrix should be recorded. This refined risk assessment determines the residual risk for the hazard, assuming the implementation of selected controls. At this point, it is also

appropriate to consider the cost (personnel, equipment, money, time, etc.) of the control and the possible interaction between controls.

5.4. Action 3—Prioritize Risk Controls. For each hazard, prioritize those risk controls that will reduce the risk to an acceptable level. The best controls will be consistent with mission objectives and optimize use of available resources (manpower, material, equipment, funding and time). Priorities should be recorded in some standardized format for future reference. Opportunity assessment, cost versus benefit analysis and computer modeling provide excellent aids to prioritize risk controls. If the control is already implemented in an established instruction, document, or procedure, that too should be documented. **Note:** Refer to **Attachment 4** for additional guidance on risk control option analysis tools, details and examples.

5.4.1. As previously discussed in **Attachment 4,** the ideal action is to "plan or design for minimum risk" with less desirable options being, in order, to add safety devices, add warning devices or change training and procedures. This order of preference makes perfect sense while the system is still being designed, but once the system is fielded, this approach is frequently not cost-effective. Redesigning to eliminate a hazard or add safety or warning devices is both expensive, time consuming and, until the retrofit is complete, the hazard remains unabated.

5.4.2. Normally, revising operational or support procedures may be the lowest cost alternative. While this action does not eliminate the hazard, it may significantly reduce the likelihood of a mishap or the severity of the outcome (risk) and the change can usually be implemented quickly. Even when a redesign is planned, interim changes in procedures or maintenance requirements are usually required. In general, these changes may be as simple as improving training, posting warnings or improving operator or technician qualifications. Other options include preferred parts substitutes, instituting or changing time change requirements, or increased inspections.

5.4.3. The feasible alternatives should be evaluated, balancing their costs and expected benefits in terms of mission performance, dollars and continued risk exposure during implementation. A completed risk assessment should clearly define these tradeoffs for the decision maker.

5.5. Action 4—Select Risk Controls. For each identified hazard, select those risk controls that will reduce the risk to an acceptable level. The best controls will be consistent with mission or activity objectives and optimum use of available resources such as manpower, material, equipment, funding and time. **Paragraph 5.2** discussed types of controls and their hierarchy in implementing them (e.g., physical controls are preferable to administrative controls in effectiveness), but the decision maker should determine the appropriate controls for the situation.

5.5.1. At this point, it is important to consider the measurements necessary to ensure accurate evaluations of the effectiveness of selected risk controls before they are implemented. These measurements are essential to support the feedback aspect of the RM process as outlined in the final step of the RM process. Establishing evaluation tools such as after action reports, surveys and in-progress reviews provide real-world measurements of the selected control measures and ensure leadership can accurately determine if the controls are working. These measurements should quantitatively or qualitatively identify reductions of risk, improvements in mission success or enhancement of capabilities to be effective. Refer to **Chapter 7** for additional guidance on supervising and evaluating risk management.

5.5.2. In addition, control selection and implementation decisions should be recorded in some standardized format for future reference. As a technique, determine the hazards and associated risk level on the risk assessment matrix (**Figure 4.2**) before implementation of the control(s) and compare this initial risk to the anticipated remaining or residual risk after application of each control. The residual risk may be notional or known depending upon the situation, but it provides the necessary starting point for leaders to make a formal risk decision on which controls to implement. **Note:** Once the operation/activity is conducted and real-world data and measurements are available, then a more accurate determination can be made on the effectiveness of the control and appropriate feedback can be made as described in **Chapter 7.**

5.6. Action 5—Make Risk Decision. Analyze the level of risk for the operation or activity with the proposed controls in place. Determine if the benefits of the operation or activity now exceed the level of risk the operation or activity presents. Be sure to consider the cumulative risk of all the identified hazards and the long-term consequences of the decision. When a decision is made to assume risk, the factors (cost versus benefit information) involved in this decision should be recorded. Documentation is important to provide leaders and managers the steps necessary to mitigate or accept the hazard associated with the risk. This is critical to the success of the supervise and evaluate step in the overall RM process. Refer to **Chapter 7** for additional guidance on the supervise and evaluate step.

5.6.1. If the cost of the risk(s) outweighs the benefits, reexamine the control options to see if any new or modified controls are available. If no additional controls are identified, inform the next level in the chain of command that, based on the evaluation, the risk of the mission exceeds the benefits and should be modified.

5.6.2. If the benefits of the mission or activity outweigh the risk, with controls in place, determine if the controls can all be implemented at the current level in the chain of command or if the decision should be elevated to a higher authority, as applicable. Keep in mind that the decision to elevate a risk control decision may be dictated by unit policy rather than by personal choice. Ensure personnel are aware of the policies and rules under which they are working. If the decision cannot be implemented at the current level due to circumstances or policy, notify the next appropriate decision authority in the chain of command, or others that can assist in the decision as appropriate for the situation.

5.6.3. When notified of a situation in which risk outweighs benefit, the next level in the chain of command should assist with implementing required controls, modify or cancel the mission, or accept the identified risks based on a higher level of the risk-benefit equation. When practical, a higher-level decision maker should explain to lower-level personnel the basis on which the risk decision is reached. This allows the lower-level personnel to understand the reasons for proceeding and helps expand their decision-making experience base. When this situation arises in an off-duty or non-mission related situation, the decision maker should take extra time and care to ensure that they are making a sound and informed decision on accepting a particular risk. Every effort should be made to utilize all available resources to form this decision. If no additional resources or options are available to modify or reduce the risks associated with an activity, the decision maker should lean toward the most conservative decision or option available.

5.6.4. For activities and processes that are routinely repeated and are likely to encounter varying hazards or risk levels, consider documenting the process and establishing formal risk

acceptance levels for these activities and processes, e.g., flying units that require flight personnel to fill out RM worksheets prior to mission execution. These worksheets formally define risk acceptance levels that range from the aircraft commander or flight lead for low risk missions to higher leadership levels (squadron director of operations, squadron top-three, squadron commander, wing commander, delta commander, etc.) as the mission risk increases.

5.7. Special Considerations in Risk Control.

5.7.1. The following factors should be considered when applying the third step of RM.

5.7.1.1. Apply risk controls only in those activities and to those personnel who are actually at risk. Too often risk controls are applied indiscriminately across an organization leading to wasted resources and unnecessary irritation of busy operational personnel.

5.7.1.2. Apply redundant risk controls when practical and cost effective. If the first line of defense fails, the back-up risk control(s) may prevent loss.

5.7.1.3. Involve personnel directly impacted by a risk control in the selection and development of risk controls whenever possible. This involvement will result in better risk controls and in general a more positive risk control process.

5.7.1.4. Benchmark (find best practices in other organizations) as extensively as possible to reduce the cost associated with the development of risk controls. Why expend the time and resources necessary to develop a risk control and then have to test it in application when you may be able to find an already complete, validated approach in another organization?

5.7.1.5. Establish a timeline to guide the integration of the risk control into operational processes.

5.7.2. The decision maker selects the control options after considering all the possible controls. This decision is not ad hoc, but rather a logical, sequenced part of the RM process. Decisions are made with awareness of hazards and how important hazard control is to mission success or failure, e.g., cost versus benefit. Control decisions should be made at the appropriate level. The decision maker should be in a position to obtain the resources needed to implement the risk controls that are approved. Usually, the earlier in the life of the process that a control is implemented, the less costly it becomes. When making control decisions, it is important to keep in mind the law of diminishing returns. There is a point at which it is no longer cost effective to continue applying control measures for the small amount of additional return in terms of reduced risk.

5.8. Decisions Regarding Risk Controls. The primary objective of effective RM decision-making is to select the best possible combination of risk controls from among the options provided via the risk control methods described in the develop controls and make decisions phase of RM. There are several important points to keep in mind when making a risk control decision.

5.8.1. Carefully evaluate the mission impact of the various risk control options. The most effective risk control may also be the one that has the most negative impact on other aspects of the mission or activity. The objective is to choose the option(s) that has the best overall favorable impact on the mission or activity.

5.8.2. Be sure to consider all the positive (benefit) and negative (cost) factors associated with a risk decision. A common mistake is to consider only the safety or other loss control aspects

of risk decisions. Often more important issues are the quality, productivity or morale implications of the decision.

5.8.3. Try to focus risk controls only on those parts of the operation actually impacted by the risk. This may be a specific group of personnel, a particular phase of the operation or activity, or a particular piece of equipment. By tightening the focus, resource requirements are minimized and any negative mission impact is reduced.

5.8.4. Make risk decisions at the right time. It is important to review an activity or mission and identify the points in time at which risk decisions can best be made. On one hand, making risk decisions at the latest possible time provides more time for collecting and considering hazards and associated risks. On the other hand, decisions should be made in time to be effectively integrated in the overall mission or activity process.

5.8.5. Make risk decisions at the right level. The right level is the level that can best judge the full range of issues involved. It is also relevant to ask who will be held accountable if the risk produces a loss. That person should either have a voice in the risk decision or actually be the appropriate decision maker for the operation or activity.

5.9. Making the Overall Risk Decision. Once the best possible set of risk control options has been selected, the individual in charge (decision maker) should make a final decision whether to proceed, thereby accepting the residual risk of the operation. This decision is based on the best possible estimate whether the overall potential benefit to the organization or individuals of a particular mission or activity exceeds the best estimate of the overall potential cost. The first principle of RM tells us to "Accept no unnecessary risk," but to normally accept the risk when the benefits outweigh the costs. This is an especially critical concept of RM. The risk decisions should be based on the question, "Which risk is greater, the risk of doing this or the risk of not doing it?" This view of risk decisions recognizes that organizations are placed at risk when they do not take the risks they need to take to remain superior to or at least competitive with their potential adversaries. It is important to note that the RM process may occasionally reveal areas where regulatory guidance is overly restrictive or otherwise in need of evaluation, however, RM is not authorization to violate policy. Properly performed RM assessments serve as a tool to seek necessary changes through established channels. Remember, the goal is not the least level of risk, it is the best level of risk for the total mission of the organization or individuals.

Chapter 6

IMPLEMENT CONTROLS

6.1. Scope. Once the risk control decision is made and an implementation plan is developed for initiating the controls, assets should be made available to implement the specific controls. Part of implementing control measures includes informing appropriate personnel of the RM process results and subsequent decisions to implement planned measures. Careful documentation of each step in the RM process facilitates risk communication and the rational processes behind RM decision. **Figure 6.1** depicts the actions necessary to complete this step.

Figure 6.1. Actions for Implement Controls.

6.2. Action 1—Make Implementation Clear. To make the implementation directive clear, consider using examples, providing pictures or charts, including job aids, etc. Provide a roadmap for implementation, a vision of the end state and describe successful implementation. The control measure should be deployed in a method that ensures it will be received positively by the intended audience. This can best be achieved by designing in user ownership.

6.3. Action 2—Establish Accountability. Accountability is a critically important area of RM. The accountable person is the one who makes the decision, e.g., approves the control measures, and hence, the right person (appropriate level) should make the decision. The foundation of establishing effective accountability is the principle that behavior and actions equal consequences, and that those delegated to make RM decisions are able to accept the consequences (good or bad) of their approval for specific mission task and or activities. In general, this translates to the premise that as risk increases, so does the level of authority to approve the action, operation or activity. Also, be clear on who is responsible at the unit level for actual implementation of the risk control(s) and ensure they are equally aware of the cost and benefits associated with the action. This accountability should be known and adhered to by all individuals involved in the RM process to ensure that proper decisions are made by the appropriate authorities as the risk equation changes.

6.4. Action 3—Provide Support. To be successful, command/leadership should be behind the control measures put in place. Prior to implementing a control measure, get approval at the appropriate level. Then, explore appropriate ways to demonstrate command/leadership commitment along with accountability (see paragraphs **6.5** – **6.7**). Provide the personnel and resources necessary to implement the control measures. Design in sustainability from the beginning and be sure to deploy the control measure along with a feedback mechanism that will provide information on whether the control measure is achieving the intended purpose.

6.5. Common Problems in Implementing Risk Controls. A review of the historical record of risk controls indicates that many never achieve their full potential. The primary reason for

shortfalls is failure to effectively involve the personnel who are actually impacted by a risk control. **Note:** Virtually all the listed factors are driven by the failure to properly involve personnel impacted by risk controls in the development and implementation of the risk controls:

6.5.1. The control is inappropriate for the problem.

6.5.2. Operators/personnel dislike it.

6.5.3. Leaders dislike it.

6.5.4. It turns out to be too costly (unsustainable).

6.5.5. It is overmatched by other priorities.

6.5.6. It is misunderstood.

6.5.7. Nobody measures progress until it is too late.

6.6. Procedures for Implementing Risk Controls within an Organizational Culture. The following procedures provide useful guidance for shaping risk control within an organizational culture. Followed carefully they will significantly improve the impact and duration of the effectiveness of risk controls.

6.6.1. Develop the risk control within the organization's culture. Every organization has a style or a culture. While the culture changes over time due to the impact of commanders and other modifications, the personnel in the organization know the culture at any given time. It is important to develop risk controls which are consistent with this culture. For example, a rigid, centrally directed risk control would be incompatible with an organizational culture that emphasizes decentralized flexibility. Conversely, a decentralized risk control may not be effective in an organization accustomed to top down direction and control. If there are any doubts about the compatibility of a risk control within the organization, ask some personnel in the organization what they think. People are the culture and their reactions will tell leaders what they need to know.

6.6.2. Generate maximum possible involvement of personnel impacted by a risk control in the implementation of the risk control. **Figure 6.2** provides a tool to assist in assessing this "involvement factor." The key to making RM a fully integrated part of the organization culture, is to achieve user ownership in a significant percentage of all risk controls that are developed and implemented by the personnel directly impacted by the risk. This is essential for both on and off-duty RM control considerations.

6.7. Procedures for Generating Command Involvement in Implementing Risk Controls. As stated in **paragraph 6.4,** a commander's and supervisor's influence behind a risk control can greatly increase its chances of success. It is usually a good idea to signal clearly to an organization that there is leader interest in a risk control if the commander in fact has some interest. **Figure 6.3** illustrates actions in order of priority that can be taken to signal leader support. Most commanders are interested in risk control and are willing to do anything reasonable to support the process. When developing a risk control, take the time to visualize a role for organization leaders.

Figure 6.2. Levels of User Involvement in Risk Controls.

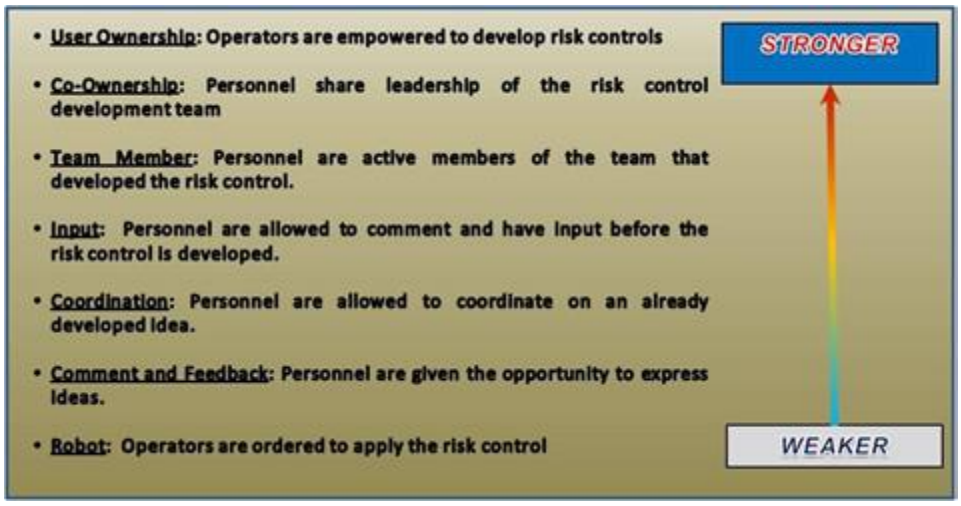
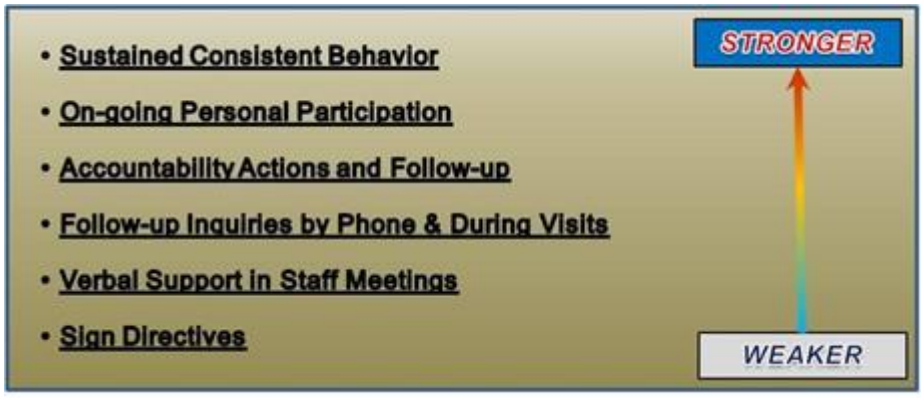


Figure 6.3. Actions by Leaders to Show RM Support.



6.8. Procedures for Sustaining Risk Control Effectiveness. To be fully effective, risk controls should be sustained by maintaining the responsibility and accountability is perpetuity. If the risk control is well-designed for compatibility with the organization's mission and culture, then sustainability should not be difficult. Leaders should maintain accountability and provide a reasonable level of positive reinforcement, as appropriate.

Chapter 7

SUPERVISE AND EVALUATE

7.1. Scope. The fifth step of risk management, Supervise and Evaluate, involves the determination of the effectiveness of risk controls throughout the operation. This step involves three actions. The first action is monitoring the effectiveness of risk controls through proper supervision. The second action involves evaluating and determining the need for further assessment of either all or a portion of the operation due to an unanticipated change as an example. The last action is to capture and provide feedback to ensure that the corrective or preventative action taken was effective. **Figure 7.1** depicts the actions necessary to complete this step.

Figure 7.1. Actions for Supervise and Evaluate.

7.2. Action 1—Supervise. Monitor the operation to ensure:

7.2.1. The controls are effective and remain in place.

7.2.2. Changes that require further RM are identified.

7.2.3. Action is taken when necessary to correct ineffective risk controls and reinitiate the RM steps in response to new hazards.

7.2.4. The risks and controls should be reevaluated any time the personnel, equipment, or mission or activity change, or new actions are anticipated in an environment not covered in the initial RM analysis.

7.2.5. Successful mission performance is achieved by shifting the cost versus benefit balance more in favor of benefit through managing risks. By applying RM principles when changes occur, risk (those known before an operation and those that develop during an operation) can be consistently mitigated. Being proactive and addressing the risks before they get in the way of mission accomplishment saves resources, enhances mission performance and prevents the mishap chain from forming.

7.3. Action 2—Evaluate. Process evaluations should be systematic. After resources are expended to control risks, then a cost-benefit evaluation/review should be accomplished to see if cost and benefit are in balance. Any changes in the system are recognized and appropriate RM controls are applied. **Note:** The METT-TC, 5-M model, and the flow charts from the earlier steps provide convenient benchmarks to compare the present system to the original system.

7.3.1. To accomplish an effective review, supervisors need to identify whether the actual cost is in line with expectations. Also, the supervisor will need to see what effect the control measure has had on mission or activity performance. It will be difficult to evaluate the control

measure by itself so focus on the aspect of mission performance the control measure was designed to improve.

7.3.2. When a decision is made to assume risk, the factors (cost versus benefit information) involved in this decision should be recorded as described in **paragraph 5.6** When mishaps or negative consequences occur, proper documentation allows for the review of the risk decision process to see where errors might have occurred or if changes in the procedures and tools led to the consequences. It is unlikely that every risk analysis will be perfect the first time. When risk analyses contain errors of omission or commission, it is important that those errors be identified and corrected.

7.3.3. Measurements and associated tools (as described in **paragraph 5.5**) are necessary to ensure the accurate evaluation of the effectiveness of selected controls. At this point in the process, the measurements and data tied to the control measure(s) should be reviewed and analyzed to determine if they are effective or ineffective in eliminating or mitigating the risks they were intended for. Once this is determined, effective feedback can be made to leadership and personnel.

7.4. Action 3—Feedback. An evaluation or review by itself is not enough. Mission feedback systems should be utilized and/or established to ensure that the corrective or preventative action taken was effective. That includes any newly discovered hazards identified during the mission or activity. Such hazards need to be analyzed, so that corrective action can be taken. Feedback informs all involved as to how the implementation process is working, and whether or not the controls were effective. Whenever a control process is changed without providing the reasons, co-ownership at the lower levels is lost. The overall effectiveness of the implemented controls should be shared with other organizations with similar risks to ensure the greatest possible benefit. Feedback can be in the form of briefings, lessons learned, cross-tell reports, benchmarking, database reports, etc. Without this feedback loop, there is no way to know if the previous forecasts were accurate, contained minor errors or were completely incorrect.

7.5. Monitoring the Effectiveness of Implementation. This aspect of the Supervise and Evaluate step should be routine. Periodically monitor the progress of implementation against the planned implementation schedule that should have been developed during the third and fourth RM steps. Take action, as necessary, to maintain the planned implementation schedule or make adjustments.

7.6. Monitoring the Effectiveness of Risk Controls. If the risk control has been well designed and documented, it will favorably change either physical conditions or personnel behavior during the conduct of an operation or activity. The challenge is to determine the extent to which this change is taking place. If there has been no change or only minor change, the risk control is likely not worth the resources expended on it. It is extremely important to properly document details of both successful risk controls and controls that do not provide the desired result as lessons learned. It may be necessary to modify it or even rescind it. At first thought, it may seem obvious to only determine if the number of mishaps or other losses has decreased. This is only practical at higher levels of command, typically wing/delta level or higher, because accurate measurement of changes in actual losses almost always requires large amounts of exposure (man-hours, flight hours, miles driven, etc.) only found at those levels of command. Even at those levels, where there is sufficient exposure to validly assess actual losses, it may be a year or more before significant changes actually occur; this is simply too long to wait to assess the effectiveness of risk controls. The

answer is to directly measure the degree of risk present in the system versus relying on mishap data.

7.6.1. Direct Measures of Behavior. When the target of a risk control is behavior, it is possible to actually sample behavior changes in the target group. The results of an effort to get personnel to wear seat belts, for example, can be assessed by making a number of observations of the use of restraints before initiating the seat belt program and a similar sample after. The change, if any, is a direct measure of the effectiveness of the risk control. The sample would establish the percentage of personnel using belts as a percentage of total observations. Subsequent samples would indicate the success in sustaining the impact of the risk control.

7.6.2. Direct Measures of Conditions. In the exact same manner as described in the previous paragraph, it is possible to assess the changes in physical conditions in the workplace. For example, the amount of foreign objects found on the flightline can be assessed before and after a risk control initiative aimed at reducing foreign object damage.

7.6.3. Measures of Attitudes. Surveys can also assess the attitudes of personnel toward risk-related issues. While constructing survey questions is technical and should be done right, the DAF often conducts surveys and it may be possible to integrate questions in these surveys, taking advantage of the experts who manage these survey processes. Nevertheless, even informal surveys taken verbally in very small organizations will quickly indicate the views of personnel.

7.6.4. Measures of Knowledge. Some risk controls are designed to increase knowledge of some hazard or of hazard control procedures. For example, a short quiz administered during a safety meeting or stand-down day can effectively assess the levels of knowledge before and after a risk control is initiated.

7.6.5. Safety and Other Loss Control Audit Procedures. Programmatic and procedural risk control initiatives, such as revisions to standard operating procedures, can be assessed through various kinds of audits. A typical audit involves a standard set of questions or statements reflecting desirable standards of performance against which actual operating situations are compared.

7.7. Evaluating Overall Organization Performance. If the organization is large enough to accumulate enough exposure (e.g., 100,000 flight hours, 200,000 personnel hours, 1,000,000 miles driven) to have statistically valid rates, then rates are an excellent results measure of organization performance. Most organizations do not have this much exposure and consequently valid rates cannot be calculated on an annual basis. Even in organizations that accumulate the exposure necessary to calculate valid rates, it is important to use them properly. Because of their statistical nature, there is a considerable amount of variation in normal rates. They go up and down for no other reason than the normal variation in the occurrence of events. It is important not to let this normal variation be interpreted as meaningful. As an example, when mishap numbers or rates increase or decrease, it is important to have an individual with statistical expertise assess the significance of the changes. In smaller organizations, in which rates are not a useful tool, it is possible to assess overall organization RM success using a cross section of indicators like those described in **paragraph 7.3** Refer to **Attachment 9** for a more detailed explanation. Even larger organizations need such measures of process effectiveness to augment the use of mishap rates or numbers as performance result measures.

Chapter 8

REAL-TIME RISK MANAGEMENT (RTRM)

8.1. Scope. This level of managing risk is normally associated with RM decisions made in Real-Time. These decisions are made most often during the execution phase of training, operations, emergency or crisis response situations, or off-duty activities where there is little or no time to conduct formal RM planning. This is where all personnel operate on a daily basis and is usually an informal, mental risk assessment that is done "on the fly" using basic RM process steps to identify and mitigate hazards in a new or changing situation. As time is normally constrained in these situations, Deliberate application of the 5-Step RM Process is impractical.

8.2. The RTRM Process. RTRM is a less formal risk assessment using basic RM process steps to identify and mitigate hazards in a new or changing situation. Although RTRM is founded on the 5-Step RM Process, streamlining the steps is essential in situations where risk decisions need to be made quickly and in real time.

8.2.1. Identifying and Assessing Hazards. Identifying and assessing hazards in a time-critical environment typically occurs when a planned activity is already underway or when the complexity or perception of overall risk is low. Effective identification and assessment requires the key elements of hazard and risk identification and understanding the negative effects associated with those hazards and risks. It is essential for individuals to seriously consider the activity or action in which they are about to engage and choose appropriate mitigation strategies to address the hazards they identify. In RTRM, a complete assessment of the situation requires three stages of situational awareness in a relatively short time: perception of what is happening, integration of information and goals, and projection into the future. Unlike Deliberate Risk Management, where there is ample time to assess potential situations, it is an individual's ability to discern the situation and apply available resources quickly and effectively that can mean the difference between success or failure.

8.2.2. Developing Controls. After assessing the situation, personnel should consider all available controls (resources) to facilitate mission or activity success and how to manage them effectively. Controls/resources can vary in scope and availability from situation to situation. The better prepared individuals are prior to an activity, the more likely they will have more controls/resources available to create multiple redundancies or "blocks" to effectively eliminate or mitigate potential risks in real-time. As an example, this equates to having a good understanding of the situation, being properly trained, wearing correct PPE, knowing personal limitations, and having a "Wingman" to support their effort(s). Each of these controls/resources serves as a layer of protection and enhances a decision maker's ability to effectively balance risk versus reward through proper preparation and understanding of the situation and options. When making these considerations, it is also essential that Airmen and Guardians communicate with their team and leadership to ensure all options and resources are effectively utilized in making a sound yet timely risk decision.

8.2.3. Communicating. Communication can take various forms such as real-time communication with leadership to discuss problems and/or intentions, internal team/crew communication to discuss real-time hazards and mitigation options, or an individual internalizing their current situation and taking time to evaluate if they are heading down the right path. This action assumes individuals and/or teams carefully consider options and

controls available to them in real-time situations, and that they are aware of how perception and communication skills change in unanticipated and changing environments. Perception and communication skills are adversely affected as individuals become increasingly stressed and lose situational awareness. Feeling undue pressure to succeed or to continue with a plan when anticipated conditions require "mid-stream" changes can have similar effects on individuals and/or team members as they try to compensate. In these high-stress situations, communication skills diminish as individuals channelize attention and lose awareness of the overall situation. They can experience tunnel vision and be unable to multitask effectively to deal with the changing circumstances. Understanding this, individuals and teams who are thrust into these situations can better prepare, anticipate and identify if they or others are losing situational awareness and make corrections. This awareness enables individuals to more effectively communicate with teammates and leadership in real-time situations, and allows them to take a step back and reevaluate options. Asking questions such as, *Who needs to know about the situation? Who can help or assist? Who can provide back-up?* or *Can this be done differently?* are just a few examples of the considerations that should be made prior to implementing a mitigation strategy in real-time.

8.2.4. Making Decisions. Unlike the deliberative RM level, where an implementation strategy is carefully developed and carried out through identification of the who, what, when, where and cost associated with the control prior to an activity, RTRM relies on the individual or small group taking immediate or near immediate action to mitigate risk(s) in real-time. This aspect alone can make RTRM decisions riskier than deliberate RM decisions. Individuals should realize this and make every effort to deliberately weigh risk decisions before taking action to ensure they are selecting the best course of action.

8.2.5. Implementing Controls. Sometimes the original plan should be modified or changed to account for unforeseen issues in order to assure success. Although minor changes or modifications to a plan or strategy may be easily implemented, others may require higher authority, if available, to properly weigh the risk and determine the best course of action. Accountability under these circumstances rests solely with the individual(s) involved in the activity. It is their responsibility to fully understand the scope and limits of their go/no-go decision and act accordingly. As such, the acceptance of risk and associated consequences needs to be taken seriously with the understanding that any adverse outcome from a selected course of action may not only affect the individual, but greatly impact loved ones, coworkers and ultimately their valuable contribution to the DAF mission. Although the goal for any mission or activity is to operate safely and achieve success, all Airmen and Guardians should consider the possibility of abandoning the mission or activity if the situation appears too risky or too costly to continue.

8.2.6. Supervising and Evaluating. It is essential that both leadership and personnel involved in a mission or activity ensure that the feedback loop or "Evaluate" aspect of the RM process is performed. This vital process step prompts individuals to complete the 5-Step process by identifying what worked, and what did not work, and documenting and disseminating lessons learned. Debriefs will improve performance, mitigate risks in future activities and are essential in completing the RM 5-Step process. To ensure future activities are improved and risks are reduced, leaders, crews, teams and individuals should ask the following questions, as a minimum, *Was our assessment accurate or were we lucky? How well did we use the controls/resources? Was the communication effective?* and *What can we do to improve the*

events in the future? are a few examples of questions that leaders, crews, teams and individuals can ask in debriefs to ensure future activities are improved and risks are reduced.

8.2.7. Knock-it-off and Timeout Concepts. Integral to RTRM are the concepts of "Knock-it-off" and "Timeout" during an ongoing operation/activity. These concepts are essential to ensuring that all personnel have a voice in any situation to identify concerns or to inform others of a developing hazardous situation. Verbalizing either of these calls send a message to those involved in a specific action to stop, take a moment to reset and reevaluate the current situation. The concepts should be adopted as an essential part of all on and off-duty activities. Key aspects of these two terms include:

8.2.7.1. Empower all DAF personnel, regardless of rank or position, to use these terms without any fear of repercussion.

8.2.7.2. When either term is used, immediately halt all current actions in order to stabilize the situation, so specific concerns can be properly evaluated. This invocation is nonnegotiable and cannot be overridden by command authority.

8.2.7.3. After the knock-it-off or timeout call, make one of the following determinations:

8.2.7.3.1. The current activity may be continued safely.

8.2.7.3.2. It requires change(s).

8.2.7.3.3. It must be terminated based upon the perceived concern(s).

8.2.7.4. The alerts provided by these terms do not prevent actions from continuing, once safety and risk concerns are addressed, but provide all personnel with an avenue to effectively mitigate risk through immediate intervention in any evolving operation/activity.

JEANNIE M. LEAVITT
Major General, USAF
Chief of Safety

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

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Prescribed Forms

None

Adopted Forms

AF Form 847, *Recommendation for Change of Publication*

AF Form 4437, *Deliberate Risk Assessment Worksheet*

Abbreviations and Acronyms

5-M—Man, Machine, Media (environment), Management, and Mission

AF—Air Force

AFI—Air Force Instruction

AFMAN—Air Force Manual

AFPD—Air Force Policy Directive

AFR—Air Force Reserve

AFSEC—Air Force Safety Center

ASCOPE—Areas, Structures, Capabilities, Organizations, People and Events

AT—Antiterrorism

BOT—Behavior Observation Tool

COA—Course of Action

DAF—Department of the Air Force

DAFPAM—Department of the Air Force Pamphlet

DAF RM—Department of the Air Force Risk Management

DESR—Defense Explosives Safety Regulation

DoD—Department of Defense

E—Exposure

EH—Extremely high

ETBA—Energy Trace and Barrier Analysis

F&ES—Fire and Emergency Services

FLDCOM—Field Command

FMEA—Failure Modes and Effects Analysis

FTA—Fault Tree Analysis

H—High

HAZOP—Hazard Operability

ID—Identification

ID—Integrated Defense

IDRMP—Integrated Defense RM Process

IG—Inspector General

L—Low

JHA—Job Hazard Analysis

M—Medium

MAJCOM—Major Command

MES—Multilinear Events Sequence

METT—TC—Mission, Enemy, Terrain & Weather, Troops & support available, Time available and Civil considerations

MORT—Management Oversight and Risk Tree

OA—Operations Analysis

OSHA—Occupational Safety and Health Administration

P—Probability

PHA—Preliminary Hazard Analysis

PPE—Personal Protective Equipment

QA—Quality Assurance

RM—Risk Management

RTRM—Real-Time Risk Management

S—Severity

SAF/AQ—Assistant Secretary of the Air Force for Acquisition

STEP—Sequential Time Event Plot

TO—Technical Order

TRA—Training Realism Assessment

US—United States

USSF—United States Space Force

WIT—What-if Tool

Terms

Airman/Airmen—Any officer, enlisted or civilian personnel who actively supports US Air Force operations and activities.

Cross-tell—The sharing and transfer of information between MAJCOMs, FLDCOMs, units, working groups, DAF personnel and military services.

Deliberate Risk Management—The pre-mission or activity planning, which involves the complete formal application of the 5-Step RM process, including an in-depth planning process (hazard identification, detailed data research, diagram and analysis tools, formal testing and long-term tracking of the risks associated with an operation, activity or system.

Exposure (E)—The number of personnel or resources affected by a given event or, over time, by repeated events. This can be expressed in terms of time, proximity, volume, or repetition. This parameter may be included in the estimation of severity or probability, or considered separately.

Guardian(s)—Any officer, enlisted or civilian personnel, who actively supports US Space Force operations and activities.

Hazard—A condition with the potential to cause injury, illness or death of personnel, damage to or loss of equipment or property, or mission degradation.

Infrastructure—The basic, underlying framework or features of the RM system.

Knock-it-off/Timeout Concepts—A safety call, using sound risk management, made by any participant during an activity or operation, immediately halting all actions until the situation is stabilized to a safe position.

Lessons Learned—An observation that, when validated and resolved, results in an improvement in military operations or activities at the strategic, operational, or tactical level and results in long-term, internalized change to an individual or an organization.

Mishap—An unplanned event or series of events resulting in death, injury, occupational illness, or damage to or loss of equipment or property.

Probability (P)—The likelihood that an individual event will occur.

Real-Time Risk Management—This level of risk management includes risk management decisions made in real-time, such as short notice taskings, responding to emergency situations or making spur of the moment decisions during tactical or training operations.

Risk—The probability and severity of lost or adverse impact from exposure to various hazards..

Risk Assessment—The process of detecting hazards and their causes, and systematically assessing the associated risks.

Risk Control—An action designed to reduce risk by lowering the probability of occurrence and/or decreasing the severity of an identified hazard.

Risk Management (RM)—The systematic process of identifying hazards, assessing risk, making control decisions, implementing control decisions and supervising/reviewing the activity for effectiveness.

Risk Management Instructors/Advisors—MAJCOM, FLDCOM, wing, delta or unit-assigned personnel who act as primary RM instructors/advisors for their functional area(s) of responsibility. They are responsible for providing RM expertise and functional-level RM training as necessary for their organization.

Safety—The programs, RM activities, and organizational and cultural values dedicated to preventing injuries and accidental loss of human and material resources, and to protecting the environment from the damaging effects of DoD mishaps.

Severity (S)—The expected consequences of an event in terms of mission impact, injury, or damage.

Space Delta (or Delta)—A component of the USSF that is organized around a specific function, such as operations, installation/garrison support, and training. Deltas are commanded by an officer in the rank of colonel.

Space Force Garrison—A command within the USSF, responsible for providing installation support functions for the resident air operations, space-based missile warning capabilities, space surveillance operations, and space communications.

System—A composite, at any level of complexity, of personnel, procedures, materials, tools, equipment, facilities, and software. The elements of this composite entity are used together in the intended operational or support environment to perform a given task or achieve a specific mission requirement.

System Safety—The application of engineering and management principles, criteria, and techniques to achieve acceptable mishap risk, within the constraints of operational effectiveness and suitability, time, and cost, throughout all phases of the system life cycle. (MIL-STD-882E, *Standard Practice: System Safety*).

Attachment 2

PRIMARY HAZARD ID TOOLS

A2.1. Primary Hazard ID Tools. The seven tools described in this attachment are considered the primary or basic set of hazard ID tools to be applied on a day-to-day basis in organizations at levels down to and including non-supervisory personnel. There are several reasons that these tools have been chosen as primary, which are listed in **Figure A2.1** In organizations with a mature RM culture, the use of these tools by personnel should be regarded as a natural course of events. The cultural norm should be, *Why would I even consider exposing myself and others to the risks of this activity before I have identified the hazards involved using the best procedures available?*

Figure A2.1. Reasons for Choosing Primary Hazard ID Tools.

- Simple to use
- Effective
- Complement one another
- Supported w/job aids
- Support Strategic & Deliberate RM

A2.2. The Operations Analysis (OA) and Flow Diagram. This tool is also known as the Flow Diagram, Flow Chart or Operation Timeline.

A2.2.1. Purpose. The OA provides an itemized sequence of events or a diagram (in the case of the Flow Diagram) depicting the major events of an operation. The purpose of this flow of events is to assure that all elements of an operation are evaluated for potential sources of risk. This overcomes a major weakness of traditional RM which tends to immediately focus effort on one or two aspects of an operation that intuitively are identified as risky to the exclusion of other aspects that may actually prove to be higher risk. The OA also guides the allocation of RM resources over time as an operation unfolds, event by event, in a systematic manner.

A2.2.2. Application. The OA or Flow Diagram is used in virtually all RM applications to include the most time critical. It responds to the key RM question, *What am I facing here and from where can risk arise?*

A2.2.3. Method. Whenever possible the OA is taken directly from the products of the personnel planning an operation. It is difficult to imagine planning an operation without identifying the key events in a time sequence. If for some reason such a list is not available, then the analyst creates a list using the best available understanding of the operation. A key issue is level of detail. The best practice is to break the operation down into time sequenced segments that have strongly related tasks and activities. This is normally well above the detail of individual tasks. The examples provided in **paragraph A2.2.6** are good guides for appropriate detail levels. It may be appropriate to break down aspects of an operation that are obviously higher risk down into more detail than is necessary for lower-risk areas. The output product of an OA is the major events of an operation in sequence with or without time checks. An alternative to the OA is the Flow Diagram. The Flow Diagram converts the list of events of the OA into a diagram using the well established procedures of the Flow Diagram. Commonly used symbols are provided in **Table A2.1** Consider putting the steps of the process

on index cards or Post-its. This allows for rearranging the diagram without erasing and redrawing, making it easy to reconfigure the diagram and encouraging contributions.

Table A2.1. Examples of Flow Chart Symbols.

SYMBOL	MEANING	EXAMPLES
	START or STOP	•Receive Tasking •Begin Trip •Open Checklist or Tech Order
	ACTIVITY	•Mission / Activity Planning •Start Car •Step #1 in Checklist or Tech Order
	DECISION POINT	•Yes / No •Approve / Disapprove •Pass /Fail
	FORK / SPLIT (Other Considerations for Activity)	•Preposition Vehicles and Supplies •Release Cutch and Press Accelerator •Observe Flight Controls While Moving Stick

A2.2.4. Resources. The key resource for the OA is the mission planners. Using the mission layout, from a mission planner, will facilitate the integration of risk controls in the main operational plan and will virtually eliminate the expenditure of duplicative resources on this key aspect of hazard ID.

A2.2.5. Comments. It is imperative to look back on personal experience. Everyone can recall a time that they have been surprised or seen others surprised because they overlooked possible sources of problems. The OA is the key to minimizing this source of failure.

A2.2.6. Examples. Following are examples of operations analyses and flow diagrams illustrating variations of this tool.

A2.2.6.1. The first example (**Figure A2.2**) is of a major operational activity-deployment of a large element to a foreign airbase. The initial analysis may be at a relatively macro level, listing the major events in the deployment scenario.

Figure A2.2. Example Operations Analysis.

Deployment to a Friendly Airbase (Key Timeline Events)
• Contingency Concept Development • Planning initiated • Deployment initiated • Operations initiated • Operations Are Extended • Contingency: Additional Unit Deployed to Base • Contingency: A Security Threat • Operations Cease • Redeployment • Arrive at Home Base – Normal Ops

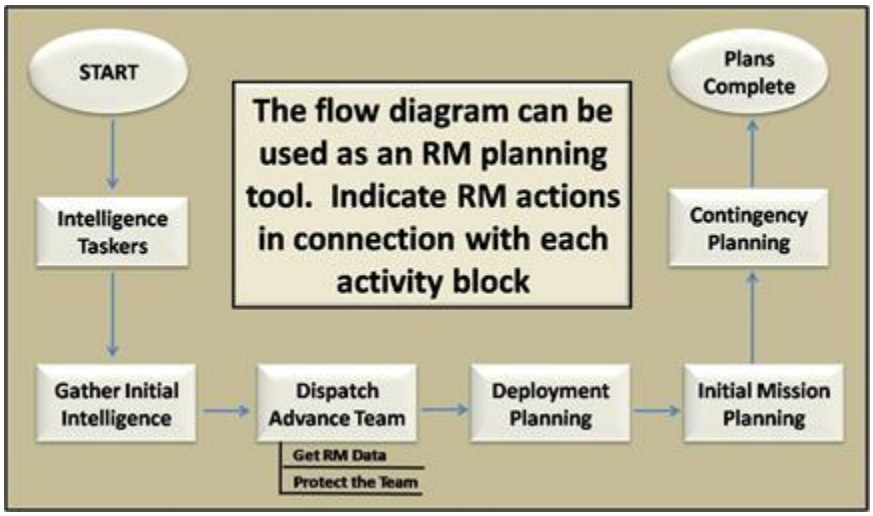
A2.2.6.2. Any one event of the above sequence may be examined in more detail, if developing an OA of events for any one is deemed useful. For example, the planning phase can be selected for more detailed examination as illustrated in **Figure A2.3**.

A2.2.6.3. If more detail and more structured examination of the operation is desired, the flow diagram can be used. The flow diagram will add information through the use of graphic symbols and will add rigor to the process. A flow diagram of the planning phase above might be developed as illustrated in **Figure A2.4**.

Figure A2.3. Example Planning Phase Events.

The Planning Phase (Key Timeline Events)
• Initial Intelligence Received (Maps, Facility Lists, etc.) • Advance Party Dispatched • Advance Party Data Received • Deployment Planning Underway • Deployment Preparations Initiated • Initial Mission Planning Underway • Contingency Planning Underway

Figure A2.4. Example Flow Diagram.



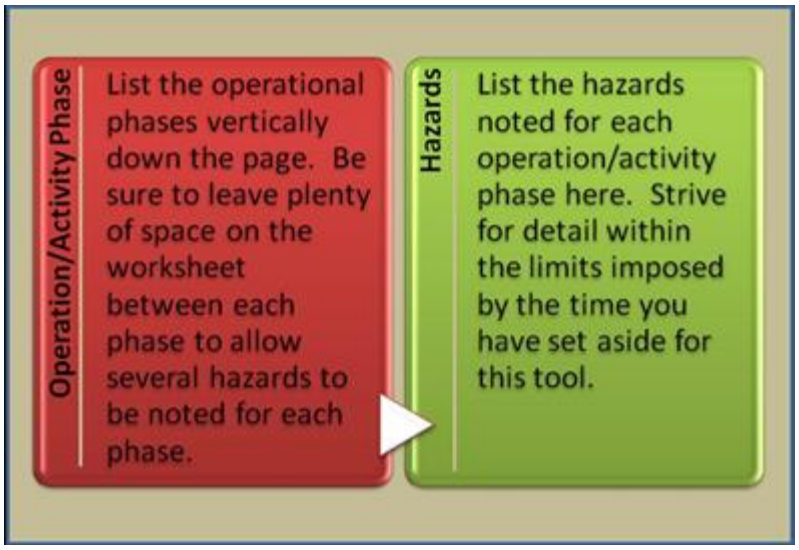
A2.3. The Preliminary Hazard Analysis (PHA).

A2.3.1. Purpose. The PHA provides an initial overview of the hazards present in the overall flow of an operation. It provides a hazard assessment that is broad, but usually not deep. The key idea of the PHA is to, at least briefly, consider risk in every aspect of an operation. The PHA helps overcome the strong tendency in traditional, intuitive RM to focus immediately on risk in one aspect of an operation. This often leads to overlooking more serious issues hidden in other aspects of the operation. The PHA will often serve as the total hazard ID process when risk is low or routine. In higher risk operations or activities, it serves to focus and prioritize follow-on hazard analyses by displaying the full range of risk issues.

A2.3.2. Application. The PHA is used in virtually all RM applications except the most time critical. Its broad scope is an excellent guide to the ID of issues that may require more detailed hazard ID tools.

A2.3.3. Method. The PHA is usually based on the OA or flow diagram. Take each event in turn from the OA, apply experience and intuition, use reference publications/standards, and consult with personnel who have experience or knowledge useful to the analysis. The extent of the effort is dictated by available resources, time limitations and by the estimated degree of overall hazards inherent in the operation/activity. Identified hazards are often listed directly on a copy of the OA as illustrated in **Figure A2.5** The output of the PHA is either hazards noted on the OA or the more formal completed PHA worksheet listing all of the hazards of each phase of the operation. The completed PHA is used to identify hazards requiring more in-depth hazard ID. A key to an effective PHA is to assure that all events of the operation are covered.

Figure A2.5. Building the PHA from the OA Flow Diagram.



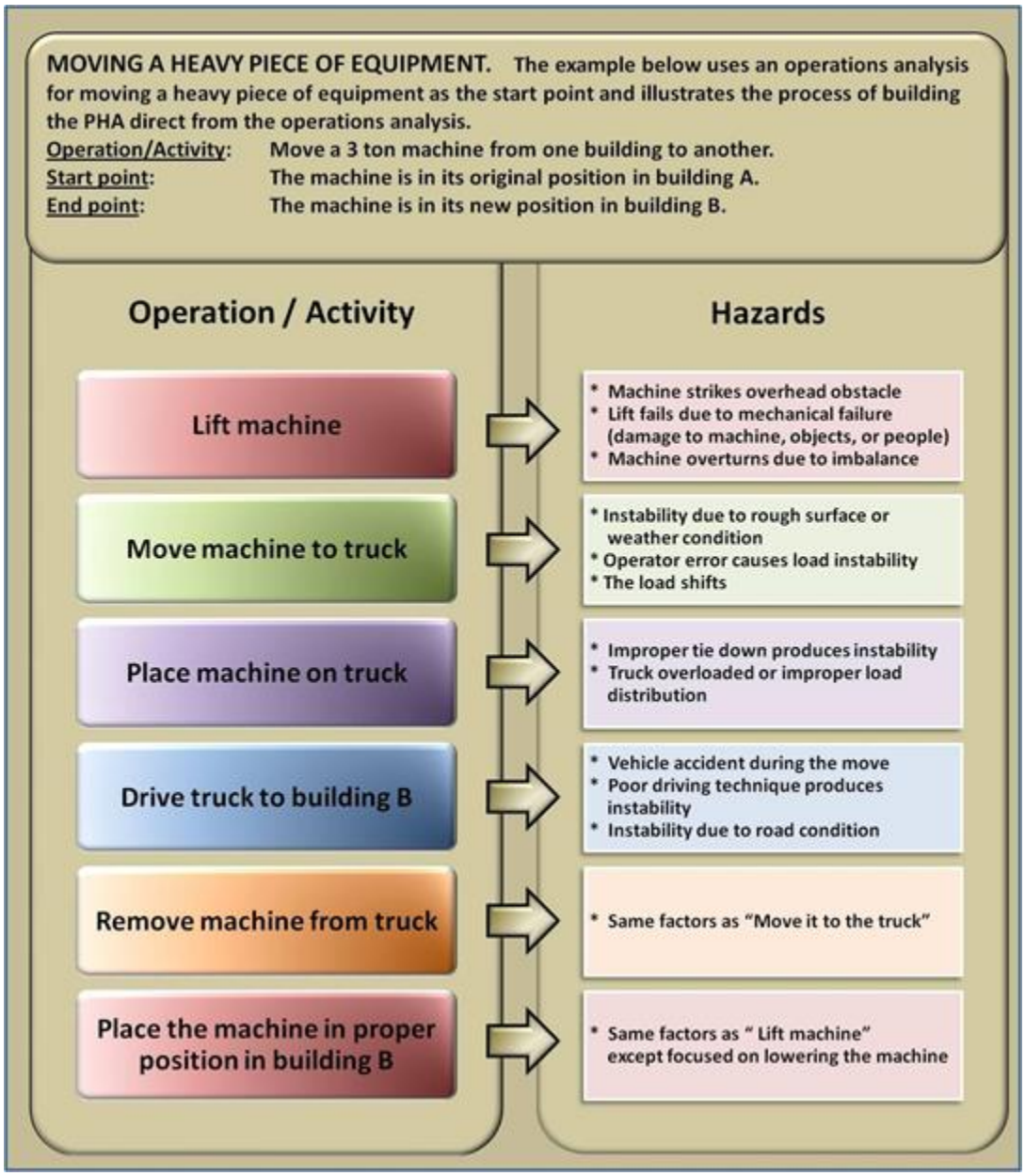
A2.3.4. Resources. The two key resources for the PHA are the expertise of personnel participating in the operation and the body of regulations, standards, TOs and operations instructions (OIs) that may be applicable. The PHA can be accomplished in small groups to broaden the base of experience and expertise. A copy of a quality PHA accomplished for an earlier, similar operation will expedite the process.

A2.3.5. Comments. The PHA is relatively easy to use and takes very little time. Its significant power to impact risk arises from the forced consideration of risk in all phases of an operation. The key to success is to link the PHA closely to the OA. **Figure A2.6** is an example of a PHA.

A2.4. The What-If Tool (WIT).

A2.4.1. Purpose. The WIT is one of the most powerful hazard ID tools. It is designed to add structure to the intuitive and experiential expertise of operational personnel. The WIT is especially effective in capturing hazard data about failure modes. It is somewhat more structured and rigorous than the PHA. Because of its ease of use, it is probably the single most practical and effective tool for use by operational personnel.

Figure A2.6. Example PHA.



A2.4.2. Application. Because of its ease of use and effectiveness in identifying hazards, the WIT should be used in most hazard ID applications to include many time critical applications. The WIT is generally the first tool used after the OA and the PHA. For example, if the PHA reveals an area of hazard that needs additional investigation, the best single tool to further investigate the identified area will be the WIT. This tool will allow the user to hone-in on a particular area of concern, add detail to the OA in the identified area, and then use the WIT procedure to dig out the hazards.

A2.4.3. Method. It is imperative to ensure participants have a thorough knowledge of the anticipated flow of the operation. The WIT is initiated by visualizing the expected flow of events in their given sequence, from beginning to end. The user then identifies a segment of

the operation on which to focus. This identified area is scrutinized for possible failures with the use of Murphy's Law (anything that can go wrong, will go wrong). The key is to ask *what-if* various failures occur or problems arise. Potentially hazardous failures are then identified and added to a hazard list, where they will be assessed on probability and severity. Scenario style thinking will assist in expanding the hazard list. Follow the guidelines in **Figure A2.7** to develop short scenarios, reflecting the worst credible outcome possible for given hazards.

Figure A2.7. Guidelines for Written Scenario Thinking.

1	• Target Length is 5-6 sentences
2	• Ignore Grammar
3	• Include: METT-TC or 5-M Considerations
4	• Begin with History
5	• Develop to Worst Possible Outcome
6	• Edit

A2.4.4. Resources. A key resource for the WIT is the OA. It may be desirable to add detail to the OA in the area to be targeted by the WIT analysis. However, in most cases the OA can be used as is. The WIT is specifically designed to be used by personnel actually involved in an operation. Therefore, the most critical WIT resource is the involvement of operators and their first line supervisors. Because of its effectiveness, dynamic character and ease of application, these personnel are generally quite willing to support the WIT process.

A2.4.5. Comments. The WIT is so effective that the Occupational Safety and Health Administration (OSHA) designated it one of six tools from which activities facing catastrophic risk situations should choose under the mandatory hazard analysis provisions of the process safety standard. **Figure A2.8** illustrates an extract from the typical output of the WIT.

Figure A2.8. Example WIT Output.

SCENARIO: A group of three employees informally applies the round-robin procedure for the *what if* tool to a mission. The mission is to move a multi-ton machine from one location to another. A part of the discussion might go as follows:	
Joe	*What if* the machine tips over and falls breaking the electrical wires that run within the walls behind it?
Bill	*What if* it strikes the welding manifolds located on the wall on the west side? *(This illustrates "piggy-backing" as Bill produces a variation of the hazard initially presented by Joe.)*
Mary	*What if* the floor fails due to the concentration of weight on the base of the lifting device?
Joe	*What if* the point on the machine used to lift it, is damaged by the lift?
Bill	*What if* there are electrical, air pressure hoses or other attachments to the machine that are not properly neutralized?
Mary	*What if* lockout/tagout is not properly applied to energy sources servicing the machine?
Note: It is important to capture each what if on a worksheet. When the ideas are exhausted or time runs out, the hazards are grouped into similar categories. For example, the above list can be broken out as follows: Group 1 – Machine falling hazards; Group 2 – Weight induced failures; Group 3 – Machine disconnect and preparation hazards. These related hazard groups are then subjected to the remaining five steps of the RM process.	

A2.5. The Scenario Process Tool. This tool is alternatively known as the mental movie tool.

A2.5.1. Purpose. The scenario process tool is a time-tested procedure to identify hazards by visualization. It is designed as a systematic and structured means of capturing the intuitive and experiential expertise of personnel involved in planning or executing an operation. In other words, it adds increased rigor to the intuitive and experiential processes of traditional RM. It is especially useful in connecting various individual hazards into scenarios that might actually occur. It is also used to visualize the worst credible outcome of one or more related hazards and is therefore an important contributor to the risk assessment process.

A2.5.2. Application. Because of its simplicity and powerful ability to identify hazards, the scenario process tool should be used in most hazard ID applications to include some time critical applications. In the time critical mode, one of the few practical tools is the scenario process tool in which the user quickly forms a "mental movie" of the flow of events immediately ahead and the associated potential hazards.

A2.5.3. Method. The user of the scenario process tool attempts to literally visualize the flow of events in an operation. It is often effective to literally close the eyes, relax and let the images flow. Usually the best procedure is to use the flow of events established in the OA. An effective tool is to actually visualize the flow of events twice. The first time, view the events as they are intended to flow. The next time, inject Murphy's Law at every possible event. As hazards are visualized, they are recorded for further action. Follow the guidelines in **Figure A2.9** to develop effective scenarios.

Figure A2.9. Scenario Process Tool Event Building Guideline.

1	Target Length 60 Words or less
2	Ignore Grammar
3	Rely on Historical Events
4	Encourage Imagination
5	Develop to Worst Possible outcome

A2.5.4. Resources. The key resource for the scenario process tool is the OA. It provides the script for the flow of events that will be visualized. Because of its simplicity, key resources often available for the scenario process tool are the operational personnel leading or actually performing the mission. This tool is often entertaining, dynamic and motivating for even the most junior personnel in the organization.

A2.5.5. Comments. A special value of the scenario process tool is its ability to link two or more individual hazards, developed using other tools into a mission relevant scenario. **Figure A2.10** and **Figure A2.11** are examples of how the scenario process tool might be used in an operational situation.

Figure A2.10. Example Deployment Scenario.

From the Deployment Example (Visualized Event)
During a security drill, a vehicle carrying 10 personnel from the rapid reaction force turns a corner at high speed.
On the other side of the corner is a troop formation in the middle of the road.
The vehicle runs into the troop formation.
1 person killed, 15 wounded.

Figure A2.11. Example Machine Movement Scenario.

From the Machine Movement Example (Visualized Event)
As the machine to be moved was being jacked up (for proper placement of the forklift), the lift point fitting broke.
The machine tilted and fell in the direction of the jack, striking the wall.
When the machine hit the wall, it broke a fuel line in the wall.
The gas was already turned off as a precaution, but the machine struck the shutoff valve and gas vapors were released into the shop.
There was an explosion when the vapors came in contact with a fan motor.
Several personnel were badly burned.
The entire shop was badly damaged.
The shop was out of commission for three weeks.

A2.6. The Logic Diagram. This tool is also referred to as the logic tree.

A2.6.1. Purpose. The logic diagram is intended to provide the maximum structure and detail among the primary hazard ID procedures. Its graphic structure is an excellent means of capturing and correlating the hazard data produced by the other primary tools. Because of its graphic display, it can also be an effective hazard briefing tool. The structured and logical nature of the logic diagram adds substantial depth to the hazard ID process and it complements the other more intuitive and experiential tools. Finally, an important purpose of the logic diagram is to establish the connectivity and linkages that often exist between hazards. It does this very effectively through its tree-like structure.

A2.6.2. Application. Because it is more structured, the logic diagram requires more time and effort than other tools. Following the principles of RM, its use will be more limited than the other primary tools. This means limiting its use to higher risk issues. By nature, it is also most effective with more complicated operations or activities in which several hazards may be interlinked. Because it is more complicated than the other primary tools, it requires more practice and may not appeal to all operational personnel. However, in an organizational climate committed to RM excellence, the logic diagram will be a welcomed and often used addition to the hazard ID armory.

A2.6.3. Method. There are three major types of logic diagrams. Each diagram style is explained in **Figure A2.12** All variants of the logic diagram can be applied to an actual or planned operating system. The best time for application is in the planning stages of the operational lifecycle. All of the logic diagram options begin with a top block. In the case of the positive diagram, this is a desired outcome; in the case of the event diagram, this is an operations or activities event or contingency possibility; in the case of the negative diagram, it is a loss event. When working with a positive or negative diagram, the user reasons out the factors that could produce the top event. These are developed into the subsequent line of blocks. With the event diagram, the user lists the possible results of the event being analyzed. The conditions that could produce the factors on the second line are then considered and they are entered on the third line. This process can go to several levels, but the utility of going beyond 3 or 4 levels is usually very limited. The goal is to be as logical as possible when constructing logic diagrams, but it is more important to keep the hazard ID goal in mind than to construct a masterpiece of logical thinking. Therefore, a logic diagram should be a worksheet with lots of changes and variations marked on it. Logic diagrams can be completed by a single individual, but with the addition of a chalkboard or flip chart, it also becomes an excellent group tool. **Figure A2.13** is a generic diagram followed by a simplified example of each of the types of logic diagrams (**Figure A2.14** and **Figure A2.15**).

Figure A2.12. Types of Logic Diagrams.

Positive Diagram	- Highlights factors that should be in place if risk is to be effectively controlled in an operation - Works from a safe outcome back to the factors should be in place to produce it
Event Diagram	- Focuses on an individual event and possible consequences

	- Works from a specific event that may produce risk and shows the loss outcome possibilities of each event
Negative Diagram	- Selects a loss event and analyzes hazards that could produce the event - Works from a loss event and IDs factors that could produce it

Figure A2.13. Generic Logic Diagram.

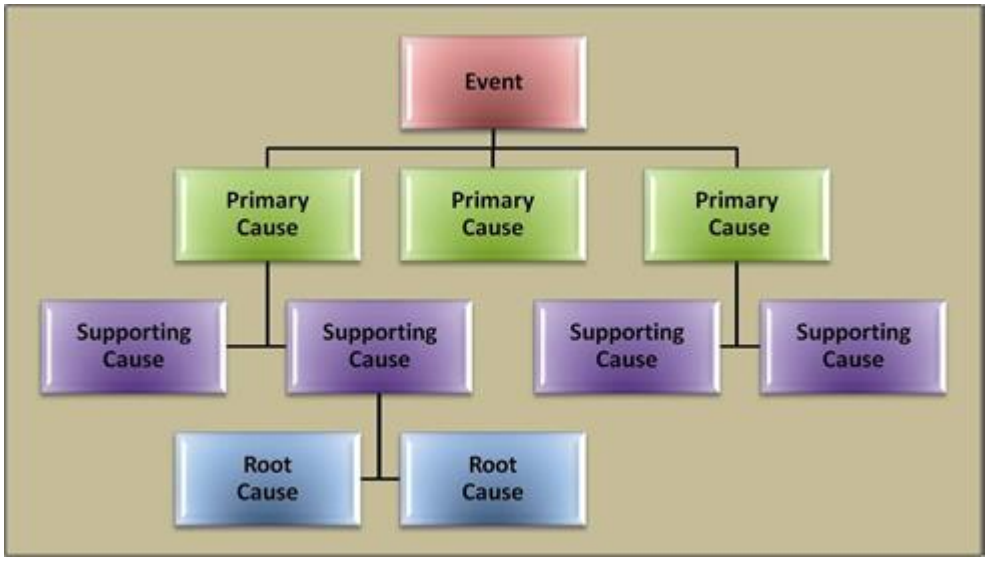


Figure A2.14. Positive Event Logic Diagram.

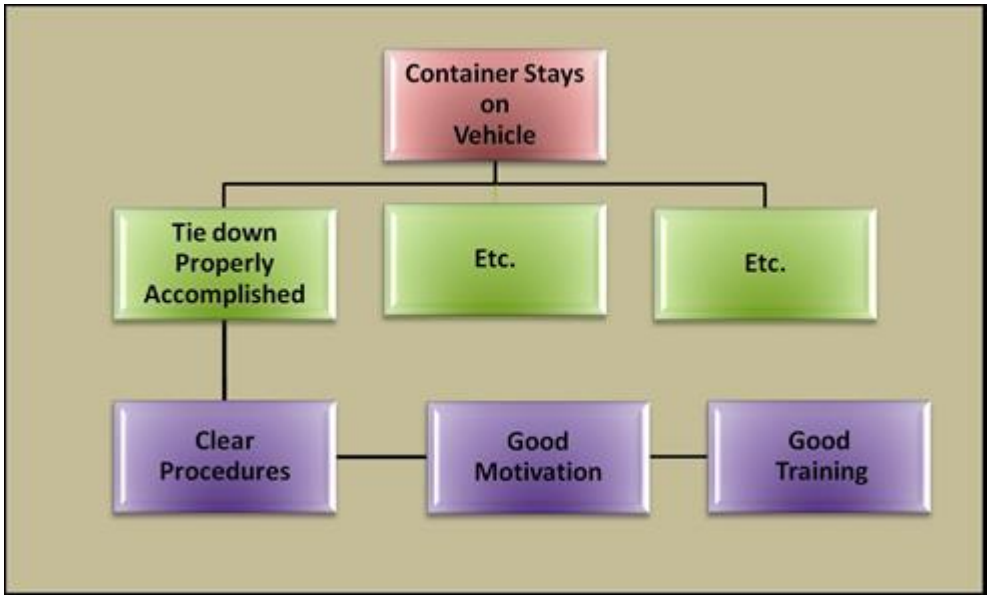
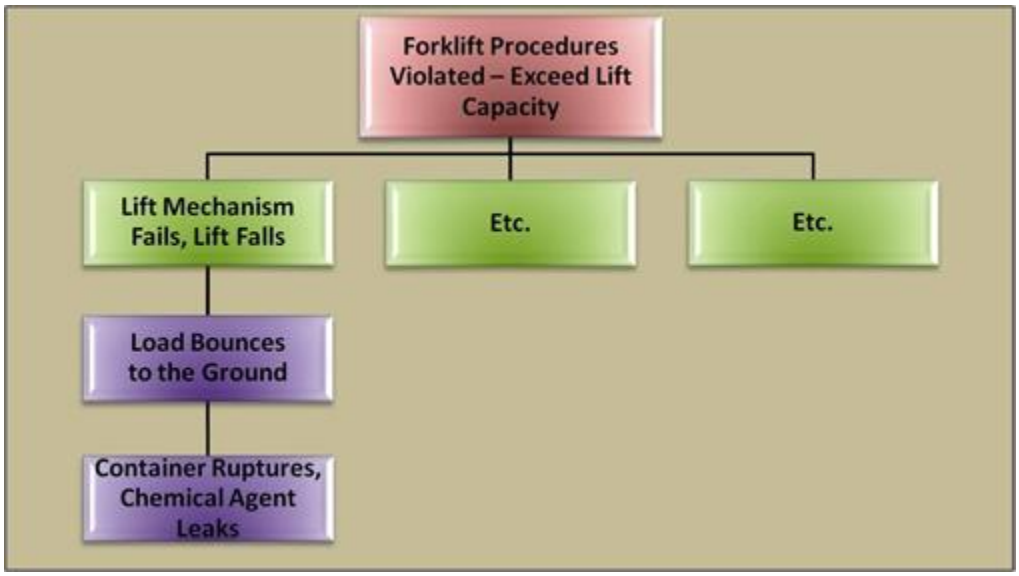


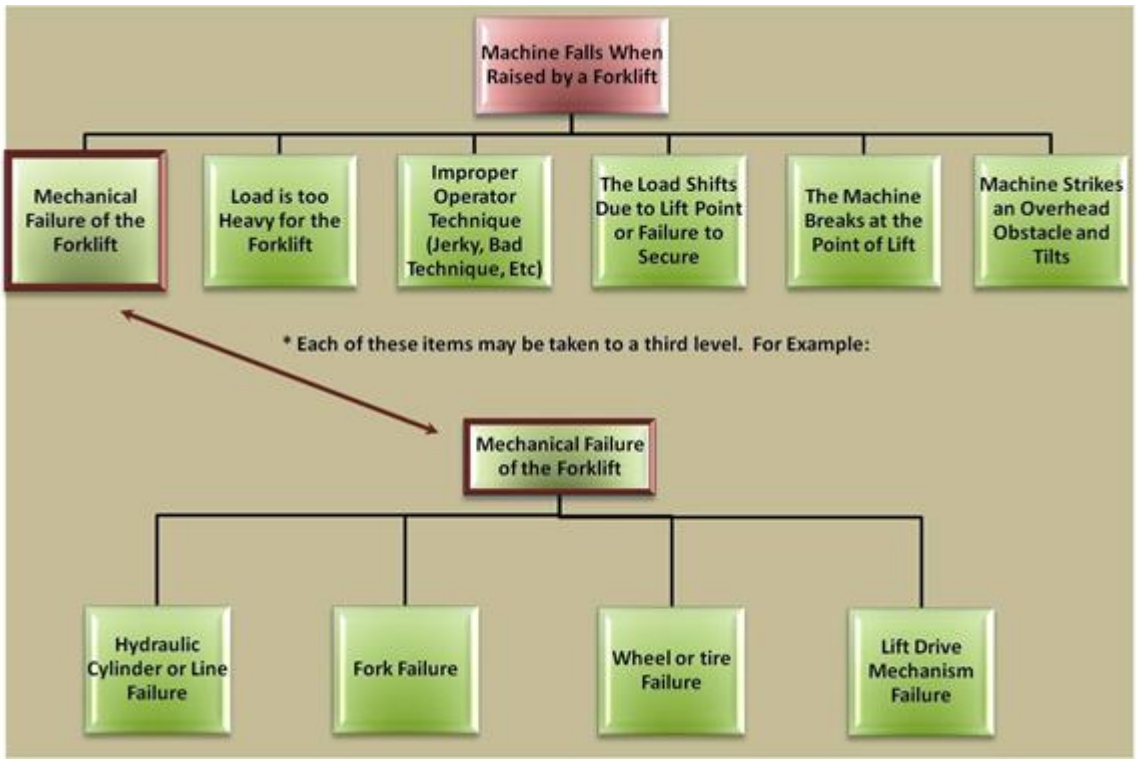
Figure A2.15. Risk Event Diagram.



A2.6.4. Resources. All other primary tools are key resources for the logic diagram. The logic diagram can correlate hazards generated by the other tools. If available, a safety professional may be an effective facilitator for the logic diagram process.

A2.6.5. Comments. The logic diagram is the most comprehensive tool available among the primary procedures. Compared to traditional hazard ID approaches, the logic diagram will substantially increase the quantity and quality of hazards identified. Its versatility, arising from its many variations, also makes it an essential weapon in the operational leader's RM toolbox. **Figure A2.16** illustrates how a negative diagram could be constructed when moving a heavy piece of equipment.

Figure A2.16. Example Negative Diagram.



A2.7. The Change Analysis.

A2.7.1. Purpose. Historically, change has been an important source of risk in operational processes. **Figure A2.17** illustrates this causal relationship. Some changes are planned, but many occur incrementally over time without any intentional or conscious direction. The change analysis is intended to analyze the hazard implications of either planned or unplanned changes. Properly used, the change analysis allows the RM process to focus on only the changed aspects of the operation. This eliminates the need to reanalyze the total operation simply because a change has occurred in one area. The change analysis is also used to detect the occurrence of change. By periodically and systematically comparing current procedures with previous procedures, unplanned changes are identified and clearly defined. Finally, change analysis is an important mishap investigation tool. Because many mishaps are caused by the injection of change into systems, an important investigative objective is to identify these changes using the change analysis procedure**.**

Figure A2.17. Change Causation.

A2.7.2. Application. Change analysis should be routinely used to periodically detect the occurrence of unplanned changes in important mission operations. It is also useful whenever significant changes are planned in an operation involving significant risk. A typical example of this type is when attempting to conduct an operation at night when it has only previously been accomplished during daylight hours. The change analysis tool is also a useful mishap

investigation tool. It can be implemented retrospectively to better understand the change causation relationship. Finally, when an operation has been subjected to in-depth hazard analysis, this tool can be used to reveal if any elements exist in the current operation that were not considered in the previous in-depth analysis.

A2.7.3. Method. The change analysis is best accomplished using a worksheet style format. The factors in the left column of **Figure A2.18** are intended as a comprehensive change checklist.

A2.7.4. Resources. A key resource for the change analysis tool is experienced operational personnel who have long-term involvement in an operational process. These personnel should help define the comparable situation. Another important resource is the documentation of process flows and task analyses. Analysis materials, in connection with quality improvement and reengineering projects, are excellent definitions of the baseline against which change can be evaluated.

A2.7.5. Comments. The change analysis is one of the most important hazard analysis tools. In organizations with mature RM processes, most, if not all, higher risk activities will have been subjected to thorough RM applications and the resulting risk controls will have been incorporated into operational guidance. Only if specific changes are detected will it be necessary to apply any RM procedures. If there is no change, optimum procedures will already have been fully integrated in the established operational guidance. **Figure A2.18** illustrates the comprehensive change checklist required for an adequate change analysis worksheet and represents a change analysis scenario.

A2.8. The Cause and Effect Tool. This tool is sometimes known as the Cause and Effect diagram, fishbone tool and the Ishikawa diagram.

A2.8.1. Purpose. The Cause and Effect tool is a variation of the logic tree tool and is used in the same hazard ID role as the general logic diagram, e.g., a more rigorous and detailed tool.

A2.8.2. Application. The tool is among the most commonly applied quality procedures and significant numbers of personnel are comfortable using it. It should be used in the same manner as the logic diagram previously covered and can be applied in both a positive and negative variation.

A2.8.3. Method. The Cause and Effect diagram is essentially a logic diagram but with a significant variation. The Cause and Effect diagram provides more structure than the ordinary logic diagram through the branches that give it one of its alternate names, the fishbone diagram. **Figure A2.19** illustrates this structure. (**Note**: There are two basic variations, one for tactical type operations (the 4 "M") and another for administrative processes (the 4 "P").) Of course, the user can tailor the basic "bones" based on special characteristics of the operation or mission that is being analyzed. As in the case of the logic diagram, either a positive or negative outcome block is designated at the right side of the diagram. Then, using the structure of the diagram, the user or team of users completes the diagram by adding causal factors in either the M or P structure. By using branches off the basic entries, additional hazards can be added to the diagram. The examples provided illustrate this process. The Cause and Effect diagram is a very effective team hazard ID tool and should be used in a team setting whenever possible.

A2.8.4. Resources. Personnel should consult online resources and associated publications for more specific information and examples on the Cause and Effect tool and related diagrams.

A2.8.5. Comments. This procedure has proven very effective and has established the Cause and Effect diagram as a powerful hazard ID tool. An example of the Cause and Effect tool and diagram is illustrated at **Figure A2.19**.

Figure A2.18. Example Change Analysis.

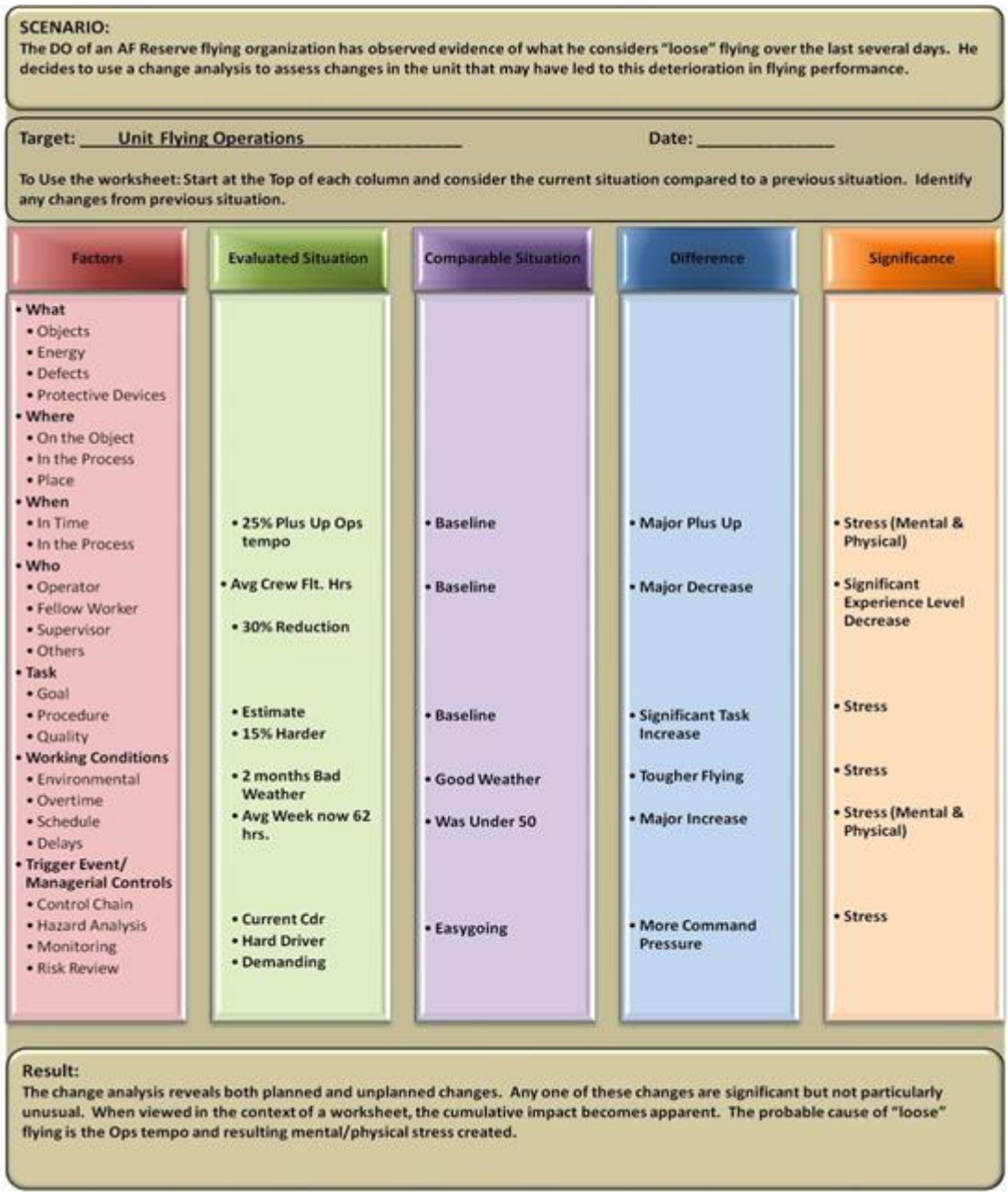
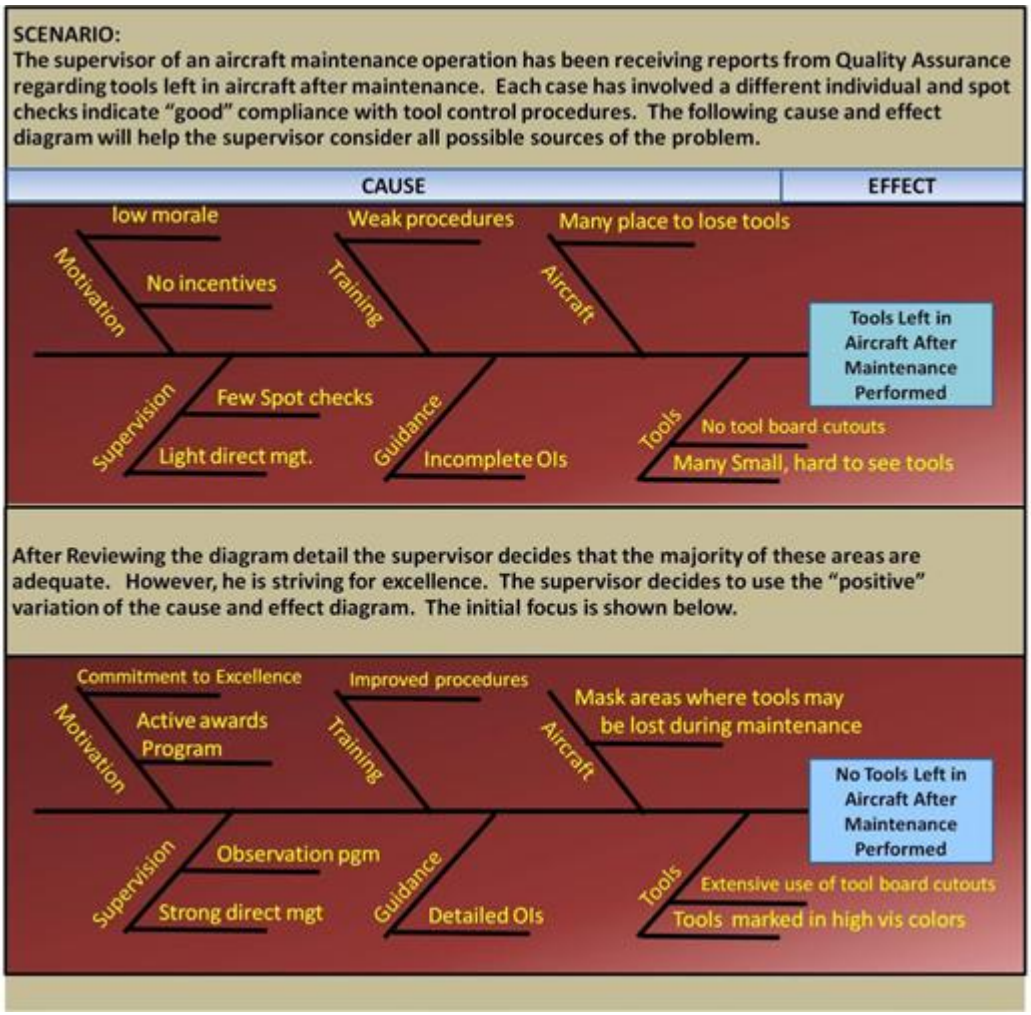


Figure A2.19. Example of Cause and Effect – Fishbone Diagram.



Attachment 3

SPECIALTY HAZARD ID TOOLS

A3.1. Scope. The 14 tools that follow are specialty hazard ID tools designed to augment the primary tools outlined in **Attachment 2,** as needed**.** These specialty tools, illustrated in **Figure A3.1,** fulfill several purposes as described in the figure. An organization with a mature RM culture should be aware of the existence of these specialty tools and will be capable of recognizing the need for their application in support of the primary tools. While not all personnel will be comfortable using some of these procedures, a number of personnel within the organization should have experience applying them. MAJCOM, FLDCOM, wing/delta and unit RM process managers, instructors and advisors, etc., should be able to assist in facilitating their application. The following pages describe each tool using a standard format, with models and examples.

Figure A3.1. Purposes Fulfilled by Specialty Hazard ID Tools.

1	Can Be Used By all Personnel of an Organization (may require some training/facilitation)
2	Provide a Special Capability not Fully Realized in Primary Tools
3	Use Traditional Safety Program Tools to Support the RM Process
4	Generally Well Supported with Forms, Job Aids and Models
5	Effectiveness Has Been Proven in Field Application

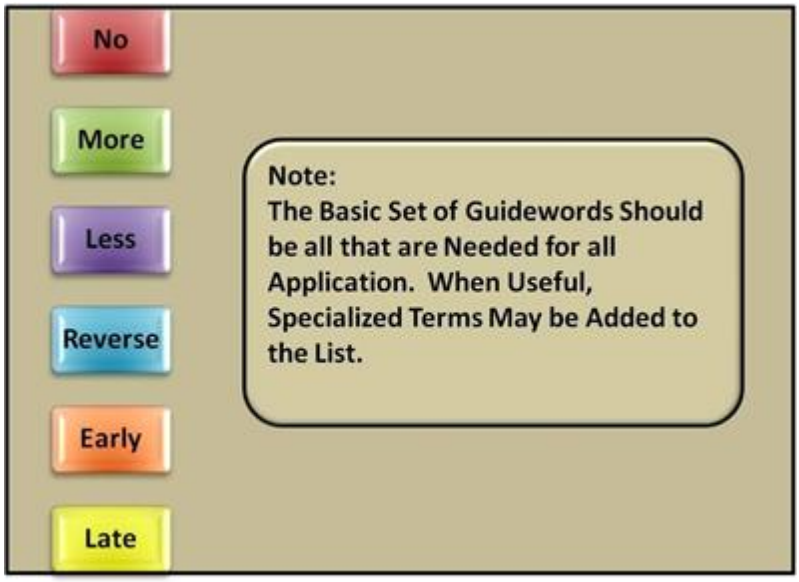
A3.2. The Hazard and Operability (HAZOP) Tool.

A3.2.1. Purpose. The special role of the HAZOP is hazard analysis of completely new operations or activities. In these situations, traditional intuitive and experiential hazard ID procedures are especially weak. Because they are totally new, no one has any experience and there is little basis for intuition. This lack of experience hobbles tools such as the WIT and Scenario Process Tools, which rely heavily on experienced operational personnel. The HAZOP deliberately maximizes structure and minimizes the need for experience to increase its usefulness in these novel situations.

A3.2.2. Application. As indicated above, the HAZOP should be considered when a completely new process or procedure is undertaken. The issue should be one where there is significant risk because the HAZOP demands significant expenditure of effort and may not be cost effective if used against low risk issues. The HAZOP is also useful when an operator or leader senses that something is wrong, but can't identify it. The process of the HAZOP will dig very deep into the operation and is very likely to identify what the *something* is.

A3.2.3. Method. The HAZOP is certainly the most highly structured of the hazard ID procedures. It uses a standard set of guidewords (**Figure A3.2**) which are then linked in every possible way with a tailored set of process terms (for example "flow"). The process terms are developed directly from the actual process or from the OA. The two words together, for example "no" (a guide word) and "flow" (a process term) will describe a deviation. These are then evaluated to see if a meaningful hazard is indicated. If so, the hazard is entered in the hazard inventory for further evaluation. Because of its rigid process, the HAZOP is especially suitable for one person hazard ID efforts.

Figure A3.2. Standard HAZOP Guidewords.



A3.2.4. Resources. Because of its rigid characteristics, there are few base-level resources available to assist with HAZOP; however, numerous HAZOP references can be found via internet search.

A3.2.5. Comments. The HAZOP is highly structured, one could say rigid, and often quite time-consuming. Nevertheless, in its special role, this tool works very effectively. It was selected by OSHA for inclusion in the set of six mandated procedures of the OSHA process safety standard. Extracts from a HAZOP application are illustrated in **Figure A3.3**.

A3.3. The Mapping Tool. This tool is also known as map analysis.

A3.3.1. Purpose. The map analysis is designed to use terrain maps and other system models and schematics to identify resources at risk and sources of hazards. It is a powerful and convenient tool that can be easily linked to the military's heavy dependence on maps. Properly applied the tool will provide the benefits listed in **Figure A3.4**.

A3.3.2. Application. The mapping tool is an extremely versatile tool that can be used in a wide variety of situations. The explosive quantity-distance criteria is a classic example of map analysis. The location of the explosives is plotted and then the distance to various targets (inhabited buildings, highways, etc.) is determined. The same principles can be extended to almost any facility. We can use a diagram of a maintenance shop to note the location of hazards such as gases, pressure vessels, flammables, etc. Key assets can also be plotted. Then potentially hazardous interactions are noted and the layout of the facility can be optimized in terms of risk reduction. Another obvious use is in the layout of billeting and bivouac areas from the point of view of both safety and force protection.

A3.3.3. Method. The mapping tool requires some creativity to realize its full potential. The starting point is a map, facility layout or equipment schematic. The locations of potential hazard sources are noted. Locating energy sources is the easiest way to detect potential hazards. All hazards involve the unwanted release of energy. **Figure A3.5** lists the basic kinds of energy in question. Mark the locations of these sources on the map or diagram. Then, keeping the

mission in mind, locate the personnel, equipment and facilities that the various potentially hazardous energy sources could impact. Note these potentially hazardous links and enter them in the hazard inventory for RM.

A3.3.4. Resources. When working with terrain maps, someone who has actually seen the terrain in question is an invaluable asset. Maps can convey a great deal of information, but they cannot replace the value of an on-site assessment. Similarly, when working with an equipment schematic or a facility layout, there is no substitute for an on-site inspection of the equipment or survey of the facility. GeoBase capabilities may be available on base through the CE office or other agency.

A3.3.5. Comments. The map analysis is valuable in itself, but it is also excellent input for many other tools such as the interface analysis, energy trace and barrier analysis, and change analysis. **Figure A3.6** illustrates the use of a facility schematic that focuses on the energy sources there as might be accomplished in support of an energy trace and barrier analysis.

Figure A3.3. HAZOP Application.

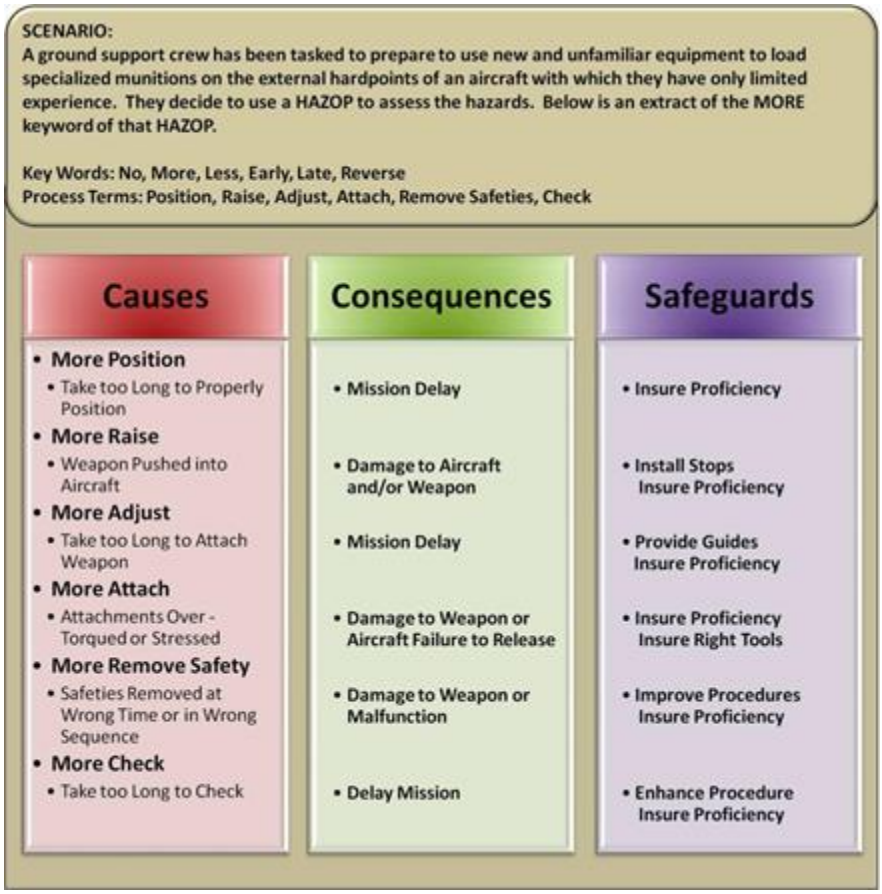


Figure A3.4. Benefits of the Mapping Tools.

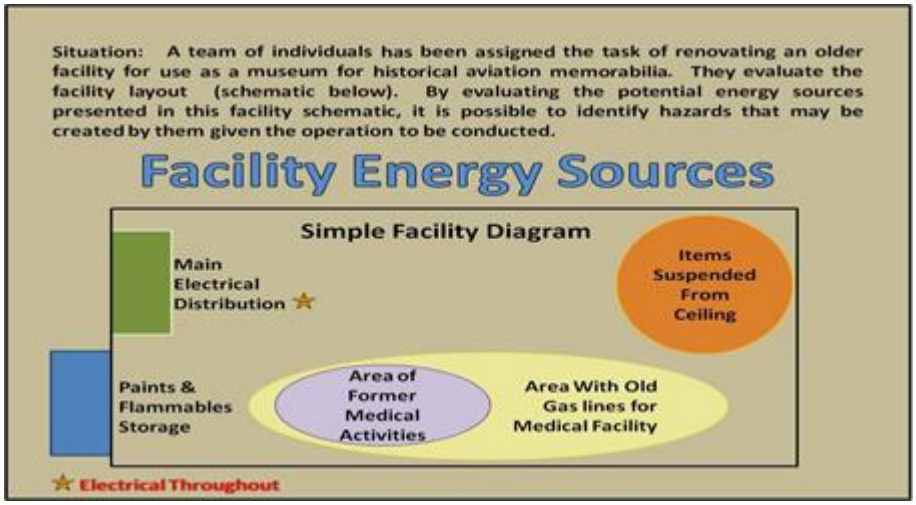
1	Reveal Mission Elements at Risk
2	Reveal the Sources of Risk
3	Reveal the Extent of a Given Risk (Proximity)

4	Reveal Potential Barriers Between Hazards Sources and Mission Assets

Figure A3.5. Major Types of Energy.

1	Electrical
2	Kinetic (Moving Mass – Vehicle, Machine Parts, Bullet)
3	Potential (Non-Moving Mass – Heavy Suspended Object)
4	Chemical (Explosives, Corrosive Materials)
5	Thermal (Heat)
6	Radiation (Non-Ionizing – Microwave) (Ionizing – X-rays, Radiation)
7	Pressure (Air, Water)

Figure A3.6. Example Map Analysis.



A3.4. The Interface Analysis.

A3.4.1. Purpose. The interface analysis is intended to uncover the potentially hazardous linkages or interfaces between otherwise unrelated activities. For example, if a new facility is planned for a base, this tool will help identify what hazards may be created for other operations on the base during construction and after the facility is opened. The interface analysis focuses on energy exchanges to reveal these potential hazards. A hazard necessarily involves the transfer of energy from one point to another. By looking at these potential energy transfers between two different activities, it is possible to detect important hazards that are difficult to detect any other way.

A3.4.2. Application. Generally speaking, an interface analysis should be conducted any time a new activity is being introduced and there is any chance of an unfavorable interaction. A good cue to the need for an interface analysis is the use of either the change analysis (indicating the injection of something new) or the map analysis (with the possibility of interactions).

A3.4.3. Method. The interface analysis is normally based on an outline such as the one illustrated at **Figure A3.7** Interfaces take the form of energy exchanges, so the outline provides a list of potential energy types and guides consideration of the potential interactions. A

determination is made whether a particular type of energy is present and then whether there is potential for that form of energy to adversely impact on other activities. As in virtually all aspects of hazard ID, the creation of a good OA assures that interactions in all phases of the lifecycle are considered.

Figure A3.7. The Interface Analysis Worksheet.

Energy Element	• Kinetic (objects in motion) • Electromagnetic (microwave, radio, laser) • Radiation (radioactive, x-ray) • Chemical
Personnel Element	• Personnel moving from one area to another
Equipment Element	• Machines and material moving from one area to another
Supply / Materiel Element	• Intentional movement from one area to another • Accidental movement from one area to another
Product Element	• Movement of product from one area to another
Information Element	• Flow of information from one area to another or interference (e.g., jamming)
Bio-material Element	• Infectious materials (virus, bacteria, etc.) • Wildlife • Odors

A3.4.4. Resources. Interface analyses are best accomplished when personnel from all of the involved activities participate in the process. In this way, hazards and interfaces in *both* directions can be effectively and knowledgeably addressed. A safety office representative can also be useful in advising on possible types and characteristics of energy transfers.

A3.4.5. Comments. The lessons of the past indicate that the interface analysis is an invaluable tool. Serious adverse mission consequences have proven an issue for many past military operations because of overlooked interfaces. An interface analysis using the general outline is shown in **Figure A3.8**.

Figure A3.8. Example Interface Analysis.

SCENARIO:
Construction of a major heavy equipment maintenance facility is planned for the periphery of the main base complex at a major air base. This is a major complex that costs over $20,000,000 and requires approximately eight months to complete. The objective is to detect interface issues in both directions. Notice that the analysis reveals a variety of interface issues that need to be thought through carefully.

Energy Element
- Movement of heavy construction equipment
- Movement of heavy building supplies
- Movement of heavy equipment for repair
- Possible hazmat storage/use at the facility

Personnel Element
- Movement of construction personnel (vehicle or pedestrian) through base area
- Movement of repair facility personnel through base area
- Possible movement of base personnel (vehicle or pedestrian) near or through the facility

Equipment Element
- Movement of equipment as indicated above

Supply / Materiel Element
- Possible movement of hazmat through base area
- Possible movement of fuels and gases
- Supply flow for maintenance area through base area

Product Element
- Movement of equipment for repair by tow truck or heavy equipment transport through the base area

Information Element
- Damage to buried or overhead wires during construction or movement of equipment
- Possible electro-magnetic interference due to maintenance testing, arcing, etc.

Bio-material Element
- None

A3.5. The Mission Protection Tool.

A3.5.1. Purpose. The mission protection tool is designed to focus explicitly on protection of the mission rather than on protection of personnel or things. The tool recognizes the fact that the mission or activity can be stopped partially or completely by events that may injure no one and cause very little damage. Since there is little injury or damage risk, these hazards could easily be categorized as low risk under traditional criteria. This tool focuses on the key components of mission or activity continuity and success, and what could interrupt them. A special characteristic of the mission protection analysis is its consideration of any source of mission or activity interruption, not just those arising from traditional mishap sources. For example, a mission protection analysis is as concerned about the interruption of mission or activity critical spare parts due to a transportation strike as it would be as a result of an interruption caused by a vehicle mishap.

A3.5.2. Application. As time and resources permit, mission protection analyses should be completed on all the major missions of an organization. The most important missions should be analyzed first with other missions following in the appropriate order.

A3.5.3. Method. The mission protection analysis has no particular method. This tool is characterized by its focus rather than its method. When the decision is made to complete a mission protection application, the responsible person examines the nature of the mission and then chooses the most effective hazard ID tools. The most likely tools to be used are the primary hazard ID tools, but many of the specialty hazard ID tools will also be useful. Mission protection analyses can be extended to any level of detail, but for important missions, the in-depth analysis is appropriate.

A3.5.4. Resources. A clear and detailed statement of the mission/activity is an important resource for the mission protection tool. Also, diagrams of the key processes used to accomplish the mission or activity are important.

A3.5.5. Comments. The idea of mission is at the heart of the RM process. What is RM all about? Optimizing the mission. The mission protection tool is central to fully effective RM. An example of the process that might be used to select a set of tools for the mission protection analysis of a mission critical computer facility is illustrated in **Figure A3.9**.

Figure A3.9. Example Mission Protection Application.

SCENARIO: A major material management center uses a computer to help manage the complex distribution and cost accounting needed to successfully carry out the mission. If this computer were to be seriously impaired in any way, the mission could be down for a time ranging from several hours to several days. The decision is made to complete an in-depth mission protection analysis of the computer operation. The individual responsible for the application uses his hazard ID toolbox to select the following tool for this important mission protection analysis.	
TOOLS TO BE USED	
Operations Analysis	• To establish the full dimension of the operation
What If Analysis	• To establish contingency-type threats to the mission
Interview Analysis	• To get inputs from personnel involved in the operation
Logic Analysis	• Used to explore several of the higher risk issues revealed by the tools above
Interface Tool	• Used to detect any threat from non-related functions
Change Analysis Tool	• To assess any intentional or unintentional change in the last one or two years
Note: The products derived from this analysis are essentially the same as the hazard identification assessments except that the focus is on those things that impact the mission system (whether they cause physical damage/injury or not).	

A3.6. The Safety Quiz. The formal name of this tool is the safety knowledge assessment. It is more commonly referred to as the safety quiz.

A3.6.1. Purpose. Human error is a key causal factor in mishaps and the creation of risk. One key source of human error is lack of knowledge of hazards and risk control procedures. The safety quiz is designed to measure the degree to which critical hazard and risk control knowledge is possessed by a given target group. Another aspect of the safety quiz tool is the attitude survey. The objective is to assess attitudes toward risk control processes and requirements.

A3.6.2. Application. The safety quiz should be used to assess the status of risk-related knowledge and attitudes that are connected to high and extremely high risk issues. It should also be used when other hazard ID tools seem to indicate a skill, knowledge, or attitudinal problem. Alternatively, this tool can be used to assess progress in continuously improving these key areas. In these situations, the quiz is used to assess the degree of the problem and pinpoint the specific areas of weakness.

A3.6.3. Method. The key to the safety quiz is the selection and development of the questions that are placed on the quiz. It is essential that questions be solidly linked to real hazards. The questions should truly determine if the target group has the necessary skills and knowledge or attitudes to perform safely. (**Note:** The group may not be performing safely even though it has the needed knowledge. In these cases, the problem is motivation, not skills or knowledge.) A second important consideration is the administrative process of administering and using the quiz. Quizzes should be timed to minimize the administrative burden on the organization. Safety stand-down days are an excellent opportunity to use quizzes. Also, care should be taken to avoid embarrassing individuals who may score poorly. There may be many reasons for poor performance and it is important not to turn the quiz process into a negative event. The quiz should be only as long as necessary to evaluate key knowledge and attitudes.

A3.6.4. Resources. An experienced trainer can be of real help in insuring questions are well developed. An effective database or risk information management system is also important in selecting the critical skills and knowledge to be evaluated.

A3.6.5. Comments. The safety quiz is an efficient and effective way to ensure that an organization possesses the risk control skills, knowledge and attitudes needed to achieve RM success. Extracts from safety quizzes targeted at skills and knowledge are provided in **Figure A3.10**.

Figure A3.10. Example Safety Quiz Application.

SCENARIO:
The supervisor of a maintenance facility, in which considerable quantities of hazmat are used, is concerned about the extent of knowledge of the personnel. In order to test this knowledge, the supervisor develops an eight-question quiz which samples key required procedure knowledge. Excerpts are shown below:

Note: The information obtained from these quizzes can be vital in understanding exactly how well the risk control program is progressing.

Question 3. List the four required steps in the event of a reading of over 350 lbs. on the primary pressure gauge.

- **A._____**
- **B._____**
- **C._____**
- **D._____**

Question 5. Who should be notified in the event of a Type 3 incident and how is contact established with that individual?

- NAME._____
- Method of Contact:_____

Question 7. The four steps for operating the dry chemical fire extinguishers used in this facility are:

- Step 1._____
- Step 2._____
- Step 3._____
- Step 4._____

A3.7. The Next Mishap Assessment.

A3.7.1. Purpose. Research has established that there are certain indicators that show a statistically significant correlation with high risk of mishap involvement. The Next Mishap Assessment uses this information to assess the likelihood that a given activity or situation will result in a mishap. The ability to pinpoint risks opens the door to resolution with focused effort.

A3.7.2. Application. The Next Mishap Assessment is an excellent safety stand-down day or safety meeting agenda item. Variations of the Next Mishap Assessment tool exist to support individual self-assessment or for leaders to assess inputs from their subordinates. Because an organization's risk changes over time as mission circumstances change, it is useful to repeat the assessment process once every year or two.

A3.7.3. Method. There are a variety of Next Mishap Assessment tools which should be utilized over locally developed assessment tools. Locally developed assessment tools should be avoided because the research necessary to validate the product cannot normally be accomplished by anyone other than specialized professionals. These include:

A3.7.3.1. Self-assessment tools that are used by individuals and only the user knows the outcome.

A3.7.3.2. Tools specialized to the aviation arena.

A3.7.4. Resources. There are a variety of established next mishap assessment tools. Guidance on locating these tools can be obtained from the Air Force Safety Center or a local safety office. Other copyrighted tools may be commercially available.

A3.7.5. Comments. Next mishap assessments are effective tools that allow focus specifically where the problems are, not on everything. That is the essence of the RM process. Examples of these tools can be obtained from the sources outlined above.

A3.8. The Mission Mishap Analysis. This tool is also known as the mission accident analysis.

A3.8.1. Purpose. Most organizations have accumulated extensive, detailed mishap databases that are gold mines of risk data. The purpose of the mission mishap analysis is to assure that this data is being effectively applied to the prevention of mishaps.

A3.8.2. Application. It is recommended that every organization should complete a mission mishap analysis annually. The objective is to update the understanding of current mishap trends and causal factors. Changes that occur in less than a year are not likely to be statistically significant. Waiting more than a year may cause important changes in trends to be missed. The analysis should be completed for each organizational component that is likely to have unique mishap factors.

A3.8.3. Method. The art and science of mishap analysis can be approached in many ways. Essentially, it relies on Pareto's Principle (the fact that in a wide variety of activities, 80% of the problems are found in 20% of the exposure). **Example:** 80% of the unsafe acts in a group of employees may be committed by only 20% of the employees. The process of mission mishap analysis is finding the 20% of personnel, facilities, activities, etc. that are causing the bulk of the risk in an organization. If the mishap database is computerized, the computer can do much of the initial sorting of data. A human analyst will have to do the final interpretation of the data. If the work should be done manually, the process involves determining likely risk factors and then examining the data to determine if those factors in fact exist. Typical factors to examine include those listed in **Figure A3.11**.

Figure A3.11. Typical Examination Factors.

1	Activity at the Time of the Mishap
2	Distribution of Mishaps Among Personnel
3	Mishap Locations
4	Distribution of Mishaps by Sub-Unit
5	Patterns of Unsafe Acts or Conditions

A3.8.4. Resources. The mission mishap analysis relies on a relatively complete and accurate mishap database. The base safety office will normally have the needed data. That office can also provide assistance in the analysis process. Safety personnel may have already completed analyses of similar activities or they may be able to suggest the most productive areas for initial analysis.

A3.8.5. Comments. The data in mishap databases has been acquired the hard way, through the painful and costly mistakes of hundreds of individuals. It is tragic when organizations fail to take full advantage of this information and therefore doom themselves to experience the same failures over and over again. Examples of mishap analyses and mishap data available can be obtained from servicing safety offices.

A3.9. The Interview Tool.

A3.9.1. Purpose. Some of the most knowledgeable personnel in the area of risk are the personnel who are operating the system. They are there every working hour of every working day, seeing the problems and hopefully, occasionally thinking about potential solutions. The purpose of the interview tool is to capture the risk-related experience of these personnel in ways that are efficient and positive for the people involved. Properly implemented, the interview tool can be among the most valuable hazard ID tools.

A3.9.2. Application. Because of its versatility, it is possible for any and every organization to use the interview tool in one form or another.

A3.9.3. Method. The interview tool's greatest strength is versatility. **Figure A3.12** illustrates the many options available to collect interview data. A key to all of these is creating a situation in which personnel feel free to honestly report what they know without fear of any retribution or adverse consequences. This means absolute anonymity. This may be guaranteed by not using names in connection with data.

Figure A3.12. Interview Tool Alternative.

1	Direct Interviews With Operational Personnel
2	Supervisors Interview Subordinates and Report Results
3	Questionnaire Interviews are Completed and Returned
4	Group Interview Sessions
5	Hazards Reported Formally or Informally
6	Coworkers Interview One Another

A3.9.4. Resources. It is possible to operate the interview process on a base-wide basis with the data being supplied to individual units. Interview processes can also be integrated in other interview activities. For example, leader-subordinate counseling sessions can be modified to include a hazard interview segment. In these ways, the expertise and resource demands of the interview tool can be minimized.

A3.9.5. Comments. The heart of the mishap problem and the key source of risk is human error. Of all the hazard ID tools, the interview tool is potentially the most effective at capturing human error data. By choosing from among the many variations of the tool, it can also be among the most effective.

A3.9.6. **Figure A3.12** illustrates several variations of the interview tool. One or more of these can be effective in your organization. For example, the exit interview tool asks individuals leaving the command to report hazards on a short form (**Figure A3.13**), which is completed during the out-processing cycle. Because they are out-processing, there is no loss of productivity and personnel tend to be more open and candid in their comments.

Figure A3.13. Example Exit Interview Format.

Name (Optional): _____ Organization: _____

A major interest of any commander is finding out what is not really going as well as it should in their organization. One important responsibility is seeing that working conditions for personnel are as safe and healthy as possible. Last year over 100 DAF personnel died in mishaps. Your help is need in eliminating the causes of these losses. You can help significantly by answering carefully and thoroughly the questions below. Thank you for your cooperation in making this unit a safer and better place to live and work.

Question 1. Describe at least two mishaps, near misses or close calls that you have experienced or seen since you have been in this organization. State the location and nature (e.g., what happened and why) of the incident. If you cannot think of an incident, then describe two hazards you have observed.

- Incident 1 Location: _____
  What Happened / Why: _____
- Incident 2 Location: _____
  What Happened / Why: _____

Question 2. What do you think other personnel, supervisors and top leadership can do to eliminate these problems?

- Personnel:
  Incident 1: _____
  Incident 2: _____
- Supervisors:
  Incident 1: _____
  Incident 2: _____
- Top Leadership:
  Incident 1: _____
  Incident 2: _____

A3.10. The Inspection Tool. This tool is also known as the assessment tool.

A3.10.1. Purpose. Inspections have two primary purposes. The first is the detection of hazards. Inspections accomplish this through direct observation of operations or activities. The process is aided by the existence of detailed standards against which operations or activities can be compared. Air Force Occupational Safety and Health guidance and OSHA standards, in conjunction with other national standards safety organizations, provide good examples. The other purpose of the inspection tool is to evaluate the degree of compliance with established risk controls. When inspections are targeted at management and safety management processes they are usually called assessments. These assessments gauge the effectiveness of management procedures by evaluating status against survey criteria or standard. In addition to the two major

objectives outlined above, inspections are also important as accountability tools and can even be turned into important training opportunities.

A3.10.2. Application. Inspections and assessments are used in the RM process in much the same manner as in traditional safety programs. However, in the RM concept these tools are much more focused on critical risk factors. Where the traditional approach may require that all facilities be inspected on the same frequency schedule, the RM concept would dictate that high risk activities may be inspected more frequently than lower risk operations or activities, and that some of the lowest risk operations or activities might only be inspected once every few years. The degree of risk drives the frequency and depth of the inspections and surveys.

A3.10.3. Method. There are as many methods of conducting inspections as there are safety offices. From a RM point of view, the key target is focusing on what will be inspected. The RM response is the highest risks. The first and most important step in effective inspections is the selection of inspection criteria and the development of the inspection checklist or protocol. This should be a risk-based process. Commercial protocols are available that contain criteria validated to be connected with safety excellence. Alternatively, excellent criteria can be developed using mishap databases and the results of other hazard ID tools such as the OA and logic diagrams, etc. Many excellent inspection and assessment processes have been developed within the DAF. Some of these have been computerized to facilitate entry and processing of data. Once solid criteria are developed, a schedule is created and inspections may begin. It is important that the conduct of the inspection be as positive an experience as possible. Personnel performing inspections should be carefully trained, not only in the technical processes involved, but also in the human relations aspects. During inspections, the RM concept encourages another departure from traditional inspection practices. Instead of noting deficient performance as in traditional procedures, the RM concept also encourages recording observations that meet or exceed the standard. This practice makes it possible to evaluate the trend in organizational performance by calculating the percentage of unsafe (non-standard) versus safe (meets or exceeds standards) observations. Once the observations are made the data should be carefully entered in the overall hazard inventory database. Once in the database the data can be analyzed as part of the overall body of data or as a mini-database composed of inspection findings only.

A3.10.4. Resources. As noted above there are many inspection criteria, checklists and related job aids available commercially and within the DAF. Many of these have been tailored for specific types of organizations and activities. The local safety office can be a valuable resource in the development of inspection and assessment criteria. It can also provide technical support in the form of interpretations, procedural guidance and correlation of inspection data with other like units.

A3.10.5. Comments.

A3.10.5.1. Inspections and assessments have long track records of success in detecting hazards and reducing risk. They have been criticized as being inconsistent with modern management practices because they are a form of “downstream” quality control. By the time a hazard is detected, it already exists and may have already caused loss. The RM approach to inspections emphasizes focus on the higher risks within the organization and emphasizes the use of management and safety program surveys that detect the underlying

root causes of hazards rather than the hazards themselves. Properly designed and conducted, inspections and assessments retain a vital place in an effective RM process.

A3.10.5.2. Conventional inspections normally involve seeking and recording unsafe acts or conditions. The number of unsafe acts or conditions can be the result of either the number of unsafe acts or conditions in the organization or possibly the extent of effort extended to find hazards. Conventional inspections can never be a reliable indicator of the extent of risk. To change the nature of the process to reliably indicate the extent of risk, it is often only necessary to record the total number of observations made of key behaviors and then determine the number of unsafe behaviors. This yields a rate of unsafe behavior that is independent of the number of observations made.

A3.11. The Mishap/Incident Investigation. This is also known as the incident tool.

A3.11.1. Purpose. The traditional mishap investigation has the objective of determining the causes of a mishap so that these causes can be eliminated or mitigated. The RM approach adds a new dimension to the traditional concept. RM stresses the determination of the inadequacies in the RM process that allowed the mishap cause factors to impact the organization. A mishap investigation therefore becomes primarily an investigation of the RM process itself to determine if it can be strengthened to control the risk factors that led to the mishap. The question now is not only what the cause is, but also how could the cause exist in the context of the RM process.

A3.11.2. Application. Ideally, all mishaps and incidents should be thoroughly investigated. Unfortunately, mishap investigations are expensive. The organization should have a process to select mishaps and incidents against which to allocate limited investigative resources. Severity is a relevant factor in this decision, but it should not be the dominant factor that it is in most investigation systems today. Simply because a mishap was serious does not mean that it is worth in-depth investigation. On the other hand, what appears on the surface to be a minor incident may be a gold mine of data regarding RM processes. An effective risk manager will be able to sort out the opportunities and direct the investigative effort where it will produce the best return on investment.

A3.11.3. Method. Both the technical and management processes involved in a mishap/incident investigation are complex beyond the scope of this publication. Detailed guidance is provided in AF publications. From a RM perspective the key is to investigate the RM issues that are factors in the direct mishap causes. Only by correcting these root RM cause factors will the mishap investigation process be fully effective.

A3.11.4. Resources. Most safety offices have personnel trained in the mishap investigation processes. They can serve as consultants in this critical process. Policy and procedures to follow in the process of investigating and reporting mishaps is contained in DAFI 91-204, *Safety Investigations and Reports*, and applicable supplements.

A3.11.5. Comments. Mishap and incident investigations have a long track record of success in preventing future mishaps. Installation/garrison safety offices can provide guidance on the investigation and reporting process and on the use of the data for hazard ID.

A3.12. Job Hazard Analysis (JHA).

A3.12.1. Purpose. The purpose of the JHA is to examine in detail the safety considerations of a single job. A variation of the JHA called the task analysis focuses on a single task. The idea is to get into the job or task in detail and maximize the effectiveness of the safety procedures.

A3.12.2. Application. There are certain situations that supervisors are required to perform a JHA. Some organizations have established the goal of completing JHAs on every job in the organization. If this can be accomplished cost effectively, it is a worthwhile goal. Certainly, the higher risk jobs in an organization warrant application of the JHA procedure. Within the RM approach, it is important that such a plan be accomplished by beginning with the most significant risk areas first. Refer to AFI 91-202, *The US Air Force Mishap Prevention Program,* for additional guidance.

A3.12.3. Method. The JHA is best accomplished using an outline similar to the one illustrated at **Table A3.1** As shown on the illustration, the job is broken down into the individual task steps. Jobs that involve many quite different tasks should probably be handled by analyzing each major task on a separate form. Notice that the illustration considers both risks to the workers involved and to the system. It also considers risk controls for both risk issues. Tools such as the Scenario and WIT can contribute to the ID of potential worker or system hazards. There are two basic strategies for accomplishing the JHA process. The first involves a safety professional completing the process by asking questions of the workers and supervisors involved. The second involves providing supervisors training in the JHA process and motivating them to analyze the jobs they supervise.

Table A3.1. Sample Job Hazard Analysis Format.

Job Safety Analysis	Job Title or Operation		Page___ of ___JSA Number
	Job Series/AFSC		Supervisor
Organizational Symbol	Location/Building Number	Shop Title	Reviewed By:
Required and/or Recommended Personal Protective Equipment (PPE)			Approved By:

SEQUENCE OF BASIC JOB STEPS	POTENTIAL HAZARDS UNSAFE ACTS OR CONDITIONS	REOMMENDED ACTION OR PROCEDURE
1.		
2.		
3.		
Etc.		

A3.12.4. Resources. Most safety offices have personnel trained in the JHA process. They can serve as consultants to walk personnel through the entire process. Refer to AFI 91-202 for further guidance.

A3.12.5. Comments. The concept of completing in-depth hazard assessments of all jobs involving significant risk with the active participation of the personnel doing the work is an ideal model of RM in action. Examples can be obtained from the installation/garrison safety office on many different types of operations or activities.

A3.13. The Behavior Observation Tool (BOT). This tool is also known as the performance management tool.

A3.13.1. Purpose. The BOT is a specialized inspection tool designed to improve performance in risk critical behavioral areas and create a high degree of positive employee involvement. It uses modern performance management technology to create performance improvements in risk critical areas.

A3.13.2. Application. The BOT is a sophisticated tool that requires the commitment of the total organization. If an adequate foundation is in place, the BOT can vastly improve safety performance. Because of the resource demands of the process, it should only be undertaken in situations in which risk reductions will produce important mission benefits.

A3.13.3. Method. The BOT process consists of several steps. The first is the commitment of management to the process. This commitment is ideally undertaken with full consultation with operating personnel of the organization and with union leaders if civilian employees are involved. The second step is to identify critical behaviors. These are behaviors that have a clear and direct connection to risk and associated losses in the organization. Selection of critical behaviors should involve the full participation of operators. These critical behaviors are carefully analyzed and the criteria for safe versus unsafe performance are clearly stated.

A3.13.3.1. On this foundation, a group of employees from the various organizational elements participating in the application are selected and trained in the BOT inspection process. This training involves clearly understanding the safe behavior criteria and, more importantly, the procedures for making observations of fellow employees. The trained observers make workplace observations of their fellow employees on a regular schedule.

A3.13.3.2. The observations are performed in an open and non-threatening manner with the full knowledge of the employee(s) being observed. The observer provides immediate feedback to the employees stressing things done correctly, but noting unsafe performance as well; the feedback is provided in a confidential and non-attribution manner.

A3.13.3.3. The observer then provides feedback to a program coordinator regarding the percent safe versus unsafe for each of the critical behaviors. This data is not linked to any particular observations to protect the confidentiality of all involved.

A3.13.3.4. The program coordinator then rolls the data up into a total for each critical behavior. This information is provided to the total workforce on a regular schedule, at least monthly. This is often accomplished using a large graph posted right in the workplace. As certain major “safe” behavior milestones are reached, the work group may claim certain rewards.

A3.13.4. Resources. Some DoD locations may have experience in the implementation of the behavior observation tool, but personnel should utilize online resources for finding BOT and performance management tool examples.

A3.13.5. Comments. The BOT is a powerful, high operator involvement tool that can dramatically reduce unsafe behavior and ultimately mishaps. Successful application requires sophisticated understanding of the tool and the willingness to invest considerable resources up-front in the form of training and observation time. Success also depends on the organization

using it possessing certain characteristics that form a foundation for BOT application. A flow diagram illustrating the BOT implementation process is illustrated at **Figure A3.14**.

A3.14. Training Realism Assessment (TRA).

A3.14.1. Purpose. The TRA is a procedure intended to assist in the detection and elimination or modification of safety restrictions that prevent fully effective training of military missions. Using a logic tree, the TRA assists in the detection of training realism shortcomings and then guides the user through the alternatives for overcoming them.

A3.14.2. Application. The TRA is among the most critical RM procedures in military organizations. In cases where there are significant differences between how the organization trains and how it intends to fight, it is recommended that a TRA be applied. It can also be used periodically to detect such differences.

A3.14.3. Method. The TRA uses a job aid such as the one shown at **Figure A3.15** The user identifies either a training application or a combat procedure. The training procedure is then compared step-by-step with the combat procedure (or vice versa). When differences are detected they are evaluated using the procedures in the job aid.

A3.14.4. Resources. Effective use of the TRA depends on the availability of personnel who understand in detail both the training and combat procedures.

A3.14.5. Comments.

A3.14.5.1. In a military organization, the TRA is a primary RM tool that cannot be overlooked. RM seeks to create the optimum level of risk, not the lowest level of risk. The TRA is a key tool in achieving the optimum goal. Omitting use of the TRA creates the real risk that the RM process may result in inappropriately conservative risk decision-making in pursuit of reduced risk as an end in itself. However, do not forget that RM does not authorize violation of policy or standards. If an assessment identifies an area where a policy or standard unnecessarily restricts operations or activities, seek to have the item changed or request a waiver as appropriate through applicable channels.

A3.14.5.2. Training realism assessments almost invariable create controversy. The objective of the tool is to resolve this controversy on the basis of the best possible information and on the foundation of the best possible RM principles. The outcome should be a course of action in the best interests of the overall DAF and national interests.

Figure A3.14. BOT Implementation Process.

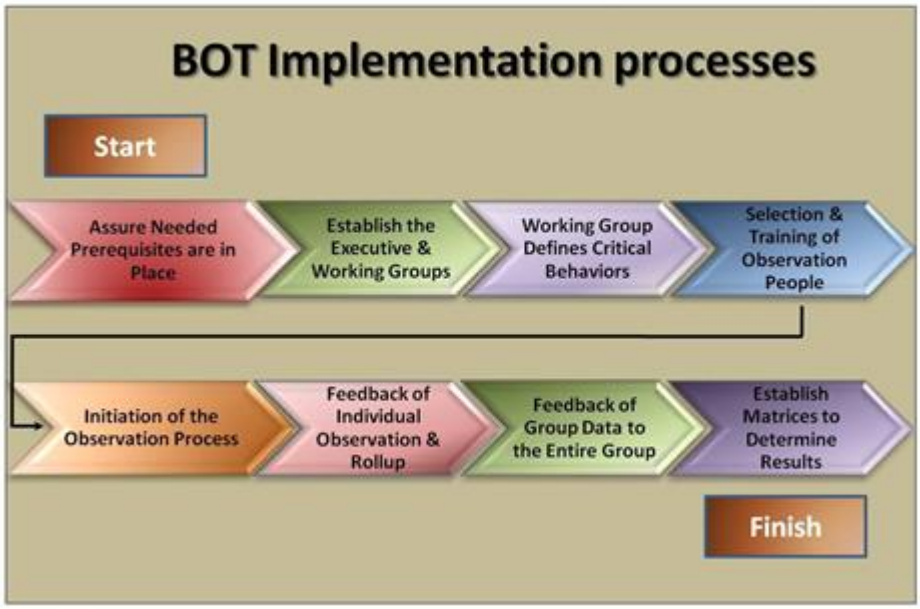
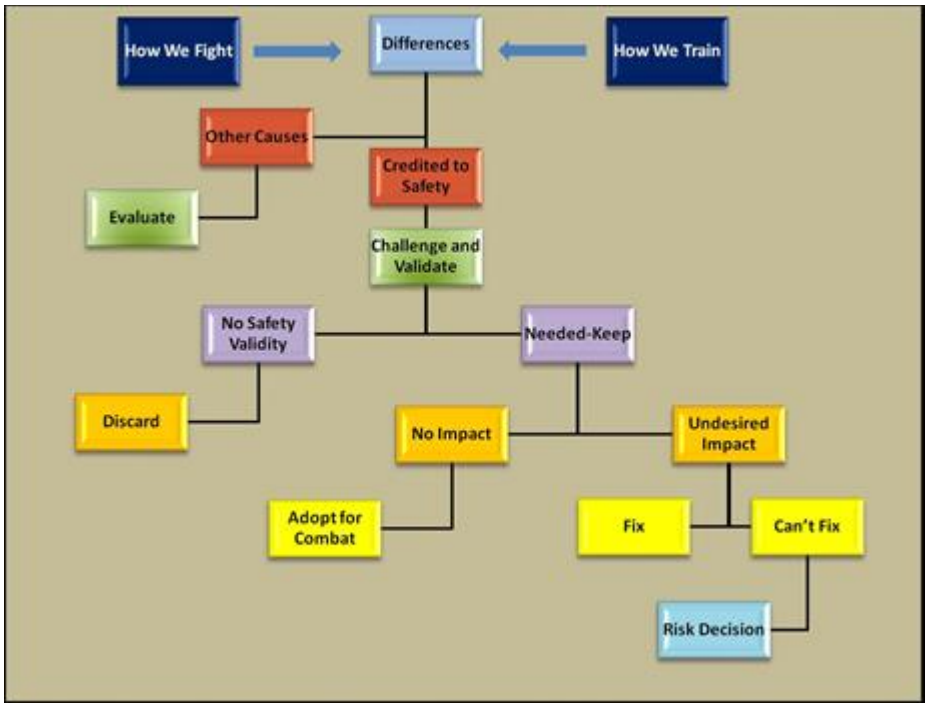


Figure A3.15. Example Job Aid.



A3.15. The Opportunity Assessment. This is also known as the opportunity-risk tool.

A3.15.1. Purpose. The opportunity assessment is intended to identify opportunities to expand the capabilities of the organization and/or to significantly reduce the operational cost of risk control procedures. Either of these possibilities means expanded mission capabilities and superiority over potential future adversaries.

A3.15.2. Application. Organizations should be systematically assessing their capabilities on a regular basis, especially in mission critical areas. The opportunity assessment can be one of the most useful tools in this process and it is recommended to be completed on all significant missions and be periodically updated at least every two years.

A3.15.3. Method. The opportunity assessment involves five key steps as outlined at **Figure A3.16**.

Figure A3.16. Opportunity Analysis Steps.

1	Review key missions to identify opportunities for enhancement. Prioritize.
2	In areas when opportunities exist, analyze for risk barriers
3	When barriers are found, apply the RM process
4	When available RM processes can't breakthrough, innovate!
5	When a barrier is breached, push through until a new barrier is reached

A3.15.3.1. Step 1. Identifies and prioritizes mission areas that would benefit substantially from expanded capabilities. Additionally, areas where risk controls are consuming extensive resources or constraining mission capabilities are listed and prioritized.

A3.15.3.2. Step 2. This critical step involves the analysis of the specific risk-related barriers that are limiting the desired expanded performance or causing the significant expense. Only by identifying the risk issues precisely can focused effort be brought to bear to overcome them.

A3.15.3.3. Step 3. This step attacks the barriers by using the RM process. This normally involves reassessment of the hazards, application of improved risk controls, improved implementation of existing controls or a combination of these options.

A3.15.3.4. Step 4. Used when available RM procedures don't appear to offer any breakthrough possibilities. In these cases, the organization should seek out new RM tools using benchmarking procedures or, if necessary, innovate new procedures.

A3.15.3.5. Step 5. This step involves the exploitation of any breakthroughs achieved by pushing the operational limits or cost saving until a new barrier is reached. The cycle then repeats and a process of continuous improvement begins.

A3.15.4. Resources. The opportunity assessment depends on a detailed understanding of mission processes so that barriers can be identified. An effective opportunity assessment will necessarily involve the input of operations experts.

A3.15.5. Comments. Properly implemented, at least half the value of RM should be realized in the form of expanded mission capabilities. The opportunity assessment is a process by which that benefit is achieved. An example of the opportunity assessment is provided in **Figure A3.17**.

Figure A3.17. Example Opportunity Assessment.

TARGET: Crew endurance **OBJECTIVE:** Extend Crew Endurance by 15% as a contingency capability. Current Capabilities are Restricted by Progressively increasing Risk of Human Error When Operations are Extended **POTENTIAL OPERATIONAL BENFIT:** A Surge Capability of 15% Over and Above that Currently Recognized Could Represent a Decisive Capability When Confronted With a Critical Operational Need **Risk Issues to be Targeted:**
Benchmark all available research and operational sources for background on the fatigue issue
Determine the differential endurance capabilities of individual personnel and effective ways to measure this differential in a combat environment
Assess the full potential of medicinal options (particularly recent developments) for performance enhancements
Evaluate the increased use of automated flight to reduce pilot fatigue and evaluate fully the impact of progress made to date
Enhance the quality of rest opportunities for crews through applications of technology
Exploit research on the impact of fatigue and critical risk issues it creates
Establish fatigue-connected risk assessments for major operational activities and use these as guides for use on specific operations. For example, use time multipliers for high task activities or missions
Refine understanding of the types of fatigue (e.g., physical, mental, jet lag, etc.) and the varying risk implications of each
Develop easy-to-use job aids, tools and model programs to guide field personnel in the full scope of fatigue management issues
Develop programmatic matrices that effectively assess, in an ongoing way, the impact of all fatigue management initiatives

Attachment 4

ADVANCED HAZARD IDENTIFICATION (ID) TOOLS

A4.1. Scope. The advanced hazard ID is designed to support strategic hazard analysis of higher risk and mission critical operations or activities. Advanced hazard ID consist of five element/tools. These advanced tools are often essential when in-depth hazard ID is needed and provide the mechanism needed to push the limits of current hazard ID technology. For example, the management oversight and risk tree (MORT) represents the full-time efforts of dozens of experts over decades to fully develop an understanding of all of the sources of hazards. As might be expected, these tools are complex and require significant training. Full proficiency requires experience. As a result, these tools are generally used exclusively by loss control professionals. Of course, personnel with a background in engineering, science or other technical background are certainly capable of using these tools with a little read-in. Although the tools are used by professionals, much of the data that should be fed into the procedures should come from operators. In an organization with a mature RM culture, all personnel in the organization will be aware that higher risk justifies more extensive hazard ID. They will feel comfortable calling for help from various loss control professionals, confident that these individuals have the advanced hazard ID tools needed to cope with the most serious risk situations. These advanced tools will play a key role in the mature RM culture in helping the organization reach its hazard ID goal of no significant hazard undetected.

A4.2. Energy Trace and Barrier Analysis (ETBA).

A4.2.1. Purpose. The ETBA is a professional-level procedure intended to detect hazards by focusing in detail on the presence of energy in a system and the barriers for controlling that energy. It is conceptually similar to the interface analysis in its focus on energy forms, but is considerably more thorough and systematic.

A4.2.2. Application. The ETBA is intended for use by loss control professionals and is targeted against higher risk operations and activities, especially those involving large amounts of energy or a wide variety of energy types. The method is used extensively in the acquisition of new weapons systems and other complex systems.

A4.2.3. Method. The ETBA involves five basic steps as shown at **Figure A4.1**.

Figure A4.1. ETBA Steps.

1	Identify the types of energy present in the system
2	Locate energy origin and trace the flow
3	Identify and evaluate barriers (mechanisms to confine the energy)
4	Determine the risk (the potential for hazardous energy to escape control and damages something significant)
5	Develop improved controls and implement as appropriate

A4.2.3.1. Step 1. The ID of the types of energy found in the system. It often requires considerable expertise to detect the presence of the types of energy listed at **Figure A4.2**.

Figure A4.2. Types of Energy.

1	Electrical
2	Kinetic (Moving Mass – Vehicle, Machine Parts, Bullet)
3	Potential (Non Moving Mass – Heavy Suspended Object)
4	Chemical (Explosives, Corrosive Materials)
5	Thermal (Heat)
6	Radiation (Non-Ionizing – Microwave) (Ionizing – X-rays, Radiation)
7	Pressure (Air, Water)

A4.2.3.2. Step 2. Referred to as the trace step, once identified as present, the point of origin of a particular type of energy should be determined and then the flow of that energy through the system should be traced.

A4.2.3.3. Step 3. Analyzes the barriers to the unwanted release of that energy. For example, electrical energy is usually moved in wires with an insulated covering.

A4.2.3.4. Step 4. Assesses the risk of barrier failure and the unwanted release of the energy.

A4.2.3.5. Step 5. Considers and selects risk control options.

A4.2.4. Resources. This tool requires sophisticated understanding of the technical characteristics of systems and of the various energy types and barriers. Consultation with a safety professional, especially a safety engineer or other professional engineer is recommended when utilizing this tool.

A4.2.5. Comments. All mishaps involve the unwanted release of one kind of energy or another. This fact makes the ETBA a powerful hazard ID tool. When the risk stakes are high and the system is complex, the ETBA is a should have. A simplified (no use of electrical schematics) example of the ETBA procedure is provided at **Figure A4.3**.

Figure A4.3. Example ETBA Procedure.

SCENARIO:
The supervisor of a maintenance facility has just investigated a serious incident involving one of his personnel who received a serious shock while using a portable power drill in the maintenance area. The tool involved used a standard three prong plug. Investigation revealed that the tool and the receptacle were both functioning properly. The individual was shocked when he was holding the tool and made contact with a piece of metal electrical conduit (the same one his drill was plugged into) that had become energized as a result of an internal fault. As a result, the current flowed through the individual to the tool and through the grounded tool to the ground resulting in the severe shock. The supervisor decides to fully assess the control of electrical energy inn this area.

Option 1

- Three Prong Tool: Electrical Energy Flow is from the source through an insulated wire, to the tool, to a single insulate electrical motor. In the event of an internal fault, the flow is from the case of the tool through the ground wire to ground through the grounded third prong through a properly grounded receptacle.
- Threats**:** Receptacle not properly grounded, third prong removed, person provides lower path of resistance, break in any of the ground paths (case, cord, plug, receptacle). These threats are serious in terms of the frequency encountered in the work environment and might be expected to be present in 10% or more cases.

Option 2

- Double Insulated Tool: The tool is not grounded. Protection is provided by double insulating the complete flow of electrical energy at all points in the tool. In this event of an internal fault, there are two layers of insulation protection between the fault and the person preventing shorting through the user.
- Threats**:** If the double layers of insulation are damaged as a result of extended use, rough handling or repair/maintenance activity, the double insulation barrier can be compromised. In the absence of a fully effective tool inspection and replacement program, such damage is not an unusual situation.

Option 3

- Circuit Fault Interrupters: Either of the above types of tools are used (double insulated is preferred). Electrical energy flows as described above in both the normal and fault situations. However, in the event of a fault (or any other cause or a differential between the potential and ground side of a circuit), it is detected almost instantly the circuit is opened preventing the flow of dangerous amount of current. Because no dangerous amount of current can flow, the individual, using the tools, is in danger of shock. Circuit interrupters are reliable at a level of 1 in 10,000 or higher and when they do fail, most failure modes are in the fail-safe mode. Circuit fault interrupters are inexpensive to purchase and relatively easy to install.

Note: In this case, the best option is very likely the use of the circuit interrupter in connection with either Option 1 or Option 2, with 2 the preferred Option. This combination for all practical purposes eliminates the possibility of electrical shock and injury/death as a result of using portable power tools.

A4.3. The Fault Tree Analysis (FTA).

A4.3.1. Purpose. The fault tree analysis (FTA), also called the probabilistic logic tree, is a professional-level hazard ID tool based on the negative type logic diagram. The FTA adds several dimensions to the basic logic tree. The most important of these additions are the use of symbols to add information to the trees and the possibility of adding quantitative risk data to the diagrams. With these additions, the FTA adds substantial hazard ID value to the basic logic diagram previously discussed.

A4.3.2. Application. The method is used extensively in the acquisition of new weapons systems and other complex systems where, due to the complexity and criticality of the system, the tool is a should.

A4.3.3. Method. The FTA is constructed exactly like a negative logic diagram except that the symbols depicted in **Table A4.1** are used.

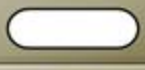
A4.3.4. Resources. Like the other more advanced tools, using the FTA will normally involve the consultation of a safety professional or engineer trained in the use of the tool. If the probabilistic aspects are added, it will also require a relatively sophisticated database capable of supplying the detailed data needed.

A4.3.5. Comments. The FTA is one of the few hazard ID procedures that will support quantification when the necessary data resources are available. A basic example of the FTA is provided at **Figure A4.4** Please note the example is not fully developed as it is intended as a brief example of the tool. It illustrates how an event may be traced to specific causes that can be very precisely identified at the lowest levels.

A4.4. Failure Mode and Effects Analysis (FMEA).

A4.4.1. Purpose. The FMEA is a professional-level hazard ID tool specifically designed to detect and evaluate the impact of the failure of various system components. Most FMEAs have traditionally been directed at the failure of parts in mechanical systems, but the tool is suitable for analyzing the failure of any component of any type of system. A brief example of FMEA illustrating this purpose is the analysis of the impact of the failure of the communications component (e.g., radio, landline, computer) of a system on the overall mission. The focus of the FMEA is on how such a failure could occur (failure mode) and the mission impact of such a failure (effects).

Table A4.1. Key Fault Tree Analysis Symbols.

SYMBOL	NAME	DESCRIPTION
	Output Event (Ellipse)	Identification of a particular event in the sequences of an operation
	Basic Event (Circle)	An event, usually a malfunction, for which further causes are not normally sought
	Normal Event (House)	An event in an operational sequence that is within expected performance standards
	"AND" Gate	Requires all of the below connected events to occur before the above connected event can occur
	"OR" Gate	Any one of the events can independently cause the event placed above the "OR" gate
	Undeveloped Event (Diamond)	An event, usually a malfunction, at the lowest level of examination. Can be expanded into a separate fault tree
	Transfer Symbol (Triangle)	Transfers the user to another part of the diagram. Eliminates the need to repeat identical analyses already completed in another part of the fault tree

A4.4.2. Application. The FMEA is generally regarded as a professional tool, but with the assistance of the FMEA job aid and their wing RM process manager, most operational personnel can use the tool effectively. The FMEA can be thought of as a more formal and detailed *What-if* analysis. It is an especially useful tool in contingency planning where it is used to evaluate the impact of various possible failures (contingencies). The FMEA can be used in place of the what-if analysis when greater detail is needed or it can be used to examine the impact of hazards developed using the what-if tool in much greater detail.

A4.4.3. Method. The FMEA is normally accomplished using a worksheet similar to the one illustrated at **Table A4.2** As noted on the sample worksheet, a specific component of the system to be analyzed is identified. Several components can be analyzed. For example, a rotating part might freeze up, explode, breakup, slow down or even reverse direction. Each of these failure modes may have differing impacts on connected components and the overall system. The worksheet then calls for an assessment of probability.

A4.4.4. Comments. Like the other more advanced tools, using the FMEA will normally involve the consultation of a safety professional or engineer trained in the use of the tool. A basic example of the FMEA is provided at **Table A4.3**.

Figure A4.4. Example Fault Tree Analysis.

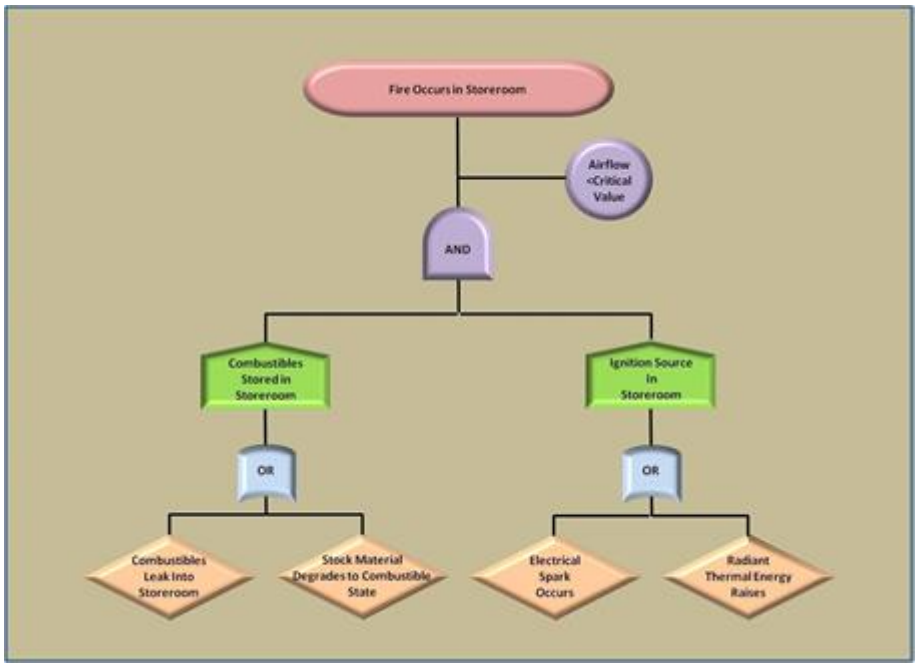


Table A4.2. Sample Failure Mode and Effects Analysis Worksheet.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA)

Page_____of_____Pages

System:_____ Date:_____

Subsystem:_____ Analyst:_____

Function:_____

Component Description	Failure Mode / Cause	Effects on Other Components	Effects On Systems	RAC or Hazard Category	Probability	Remarks / Corrective Action

A4.5. Multi-linear Events Sequencing (MES). This tool is sometimes referred to as the timeline tool or the sequential time event plot tool.

A4.5.1. Purpose. MES is a highly specialized hazard ID procedure designed to detect hazards arising from the time relationship of various operational activities. The MES detects situations in which, either the absolute timing of events or the relational timing of events may create risk. For example, an operational planner may have crammed too many events into a single period of time, creating a task overload problem for the personnel involved. Alternatively, MES may reveal that two or more events in an operational plan conflict because a person or piece of

equipment is required for both but obviously can't be in two places at once. MES can be used as a hazard ID tool or as a mishap investigation tool.

Table A4.3. Example FMEA.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA)

Page 1 of 1 Pages

System: Telephone Landline System Date: 1 June 2011

Subsystem: N/A Analyst: Joe Smith

Function: Sole External Communication Capability at Site #1

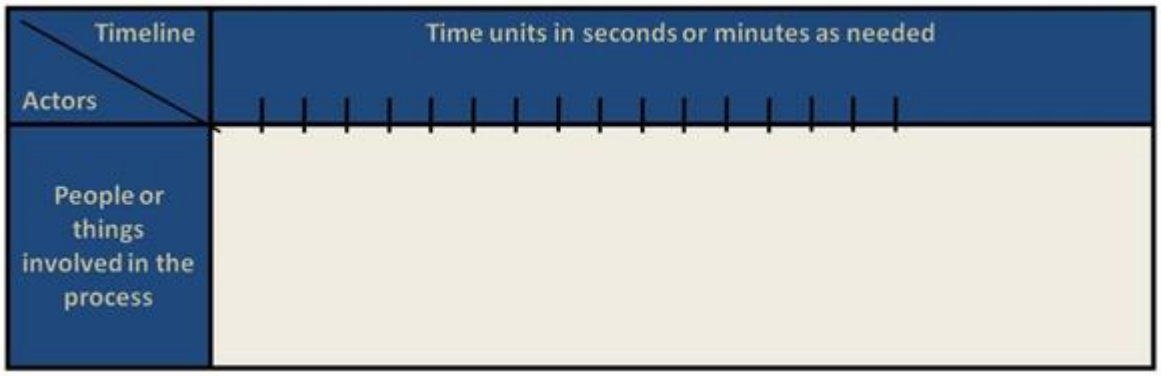
Component Description	Failure Mode / Cause	Effects on Other Components	Effects On Systems	RAC or Hazard Category	Probability	Remarks / Corrective Action
Landline	Cut- Natural cause, falling tree, etc.	None	External Comm system down	High	Probable	Clear natural obstacles from around facility
Wire	Cut- Unrelated operational activities	None	External Comm system down	Moderate	Probable	Warn all operations (placement of wire)
Wire	Line Failure	None	External Comm system down	Low	Probable	Placement of wire (proper grounding)
Wire	Cut-Vandals or theives	None	External Comm system down	Low	Unlikely	Placement of wire (area security)

A4.5.2. Application. MES is usually considered a professional loss prevention level tool, but MES worksheet actually simplifies the process to the point that a motivated individual can effectively use the tool. MES should be used any time that risk levels are significant and when timing and/or time relationships may be a source of risk. It is almost an essential tool when the time relationships are relatively complex.

A4.5.3. Method. MES is accomplished using a worksheet/form similar to the one illustrated at **Figure A4.5** The sample worksheet displays the timeline of the operation across the top and the actors (e.g., people or things) down the left side. Notice that in some operations or activities the timeline may literally be broken down in seconds. The flow of events is then displayed on the worksheet showing the relationship between the actors on a time basis. Once the operation is displayed on the worksheet, the sources of risk will be evident as the flow is examined.

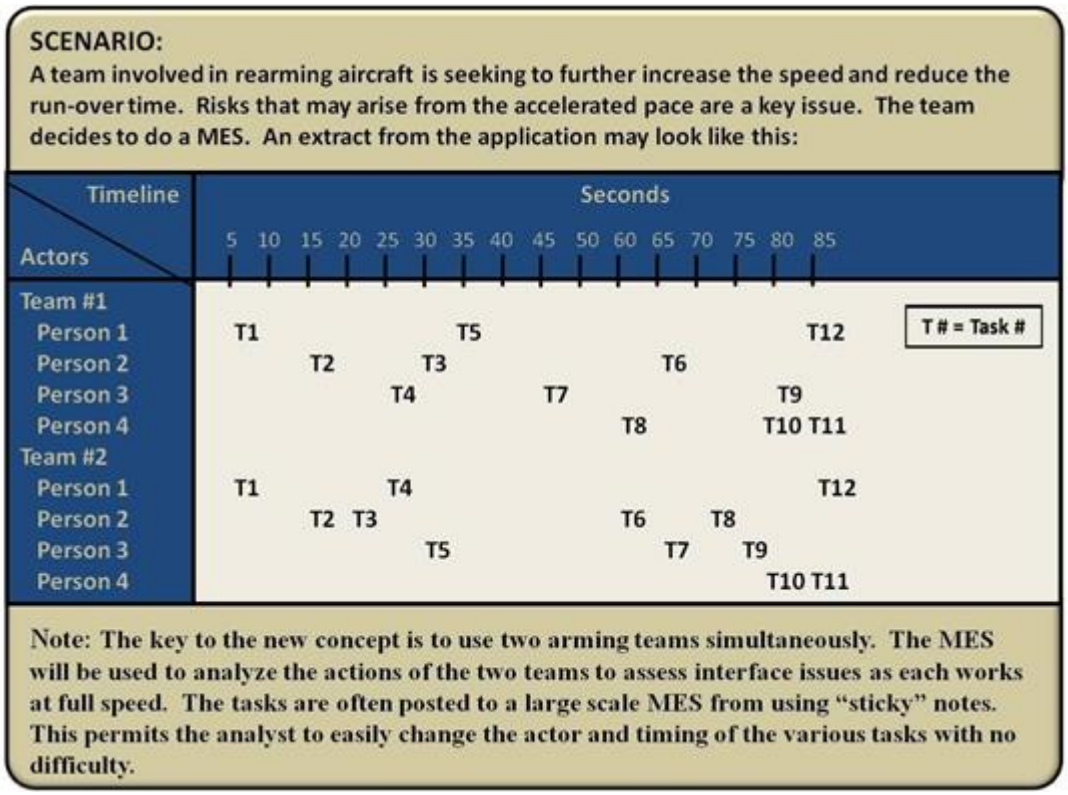
A4.5.4. Resources. As with the other more advanced tools, using the MES will normally involve consultation with a safety or engineering professional familiar with its application.

Figure A4.5. MES Form.



A4.5.5. Comments. MES is unique in its role of examining the time-risk implications of operations or activities. A simplified example of MES is provided at **Figure A4.6**.

Figure A4.6. Example MES.



A4.6. Management Oversight and Risk Tree (MORT).

A4.6.1. Purpose. The MORT is the most comprehensive hazard ID tool. The MORT uses a series of charts developed and perfected over several years by the Department of Energy in connection with their nuclear safety programs. Each MORT chart identifies a potential operating or management level hazard that might be present in an operation. The attention to detail characteristic of MORT is illustrated by the fact that the full MORT diagram or tree contains more than 10,000 blocks. Even the simplest MORT chart contains over 300 blocks. Obviously, full application of MORT is a very time-consuming and costly venture. The basic

MORT chart with about 300 blocks can be routinely used as a check on the other hazard ID tools. By reviewing the major headings of the MORT chart, an analyst will often be reminded of a type of hazard that was overlooked in the initial analysis. The MORT diagram is also very effective in assuring attention to the underlying management root causes of hazards.

A4.6.2. Application. Full application of MORT is reserved for the highest risks and most mission critical activities because of the time and expense required. MORT is also a professional tool requiring a specially-trained loss control professional to assure proper application. The basic MORT diagram can be used to facilitate and check on the overall hazard ID process by those with the interest and motivation to ensure excellence.

A4.6.3. Method. MORT is accomplished using the MORT diagrams. As indicated above there are several levels of the MORT diagram available. The most comprehensive, with about 10,000 blocks, basically, fills a book. There is an intermediate diagram with about 1500 blocks, and a basic diagram with about 300. Of course, it is possible to tailor a MORT diagram by choosing various branches of the MORT tree and using only those segments. The MORT is essentially a negative tree, so the process begins by placing an undesired loss event at the top of the diagram used. The MORT user then systematically responds to the issues posed by the MORT diagram. All aspects of the diagram are considered and the “less than adequate” blocks are highlighted for risk control action.

A4.6.4. Resources. The best sources of information on the MORT are the internet and other professional engineering resources.

A4.6.5. Comments. The MORT is the most comprehensive of the RM hazard ID processes. Unfortunately, in a military context, rarely will the time, resources, expertise, and mission critical issue come together to permit full application of the process. Nevertheless, the wise risk manager will become familiar with the MORT processes and use the basic MORT diagram to reinforce mainstream hazard ID tools. The MORT diagram is essentially an elaborate negative logic diagram. The difference is primarily that the MORT diagram is already completed for the user, allowing a person to identify various contributory cause factors for a given undesirable event. Since the MORT is very detailed, personnel can identify basic causes for essentially any type of event.

Attachment 5

RISK ASSESSMENT TOOLS, DETAILS, AND EXAMPLES

A5.1. Scope. There are many ways to assess risk, but the easiest and most effective for routine RM applications is the risk assessment matrix introduced in **Chapter 4.** The easiest way to understand the application of the matrix is to apply it. Follow the reasoning of the matrix user in the example below while applying the matrix to the assessment of the hazards associated with the movement of a heavy machine from point A to point B.

A5.1.1. Hazard to be Assessed. The hazard associated with this task is the machine falling over and injuring personnel.

A5.1.2. Probability Assessment. **Figure A5.1** illustrates the thought process that might be followed in developing the probability segment of the risk assessment.

A5.1.3. Severity Assessment. **Figure A5.2** illustrates the thinking process that might occur in selecting the severity portion of the risk assessment matrix for the machine falling hazard.

A5.1.4. Make a Risk Assessment (Example). Combine the probability frequency with the severity effect of the hazard in the matrix. The probability category *occasional* is in the middle of the matrix (**Figure A5.3**). Follow this column down until it meets the *critical* category coming from the left side. The result is a High (H) rating. Notice that it is among the lower of the H ratings but it is still considered high for risk considerations.

A5.2. Matrix Limitations. There are a few limitations and concerns with the use of the matrix. These include the following:

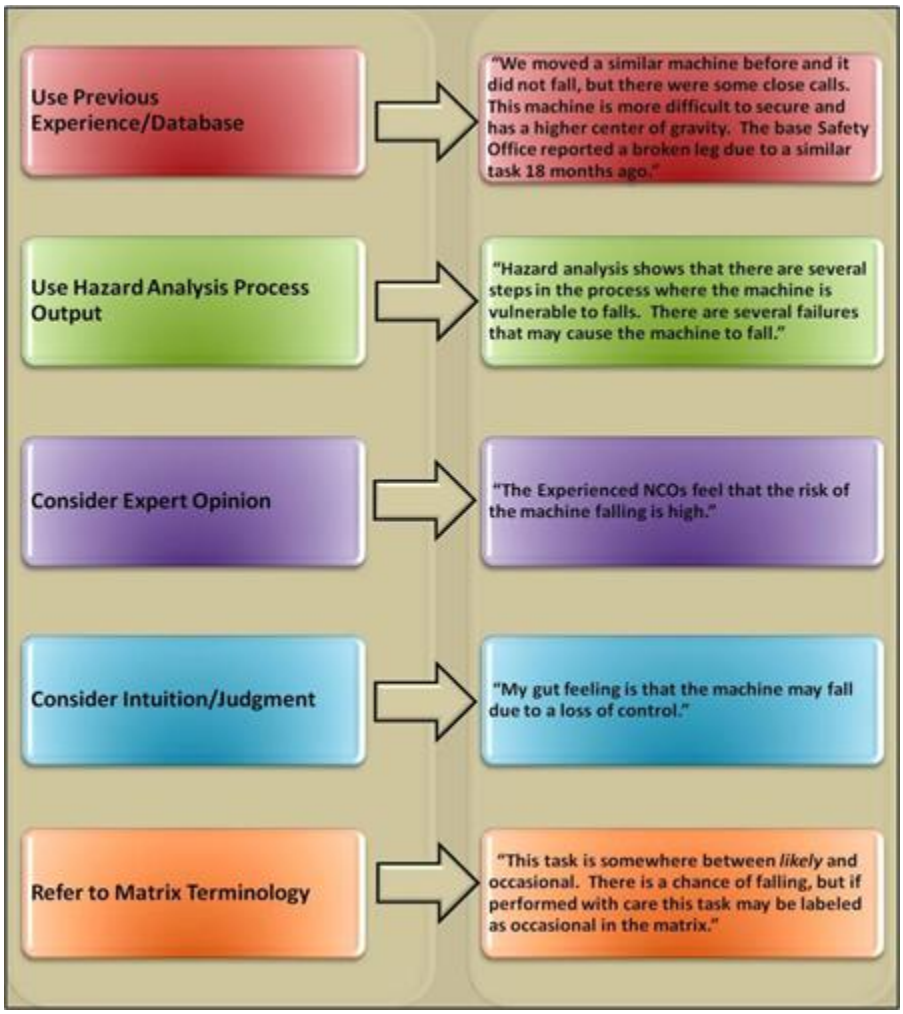
A5.2.1. Subjectivity. There are at least two dimensions of subjectivity involved in the use of the matrix. The first is the interpretation of the matrix categories. One person's interpretation of the term *critical* may be quite different from another's. The second is the interpretation of the hazard. If in recent personal experience a machine, much like the one to be moved, fell over and crushed a person to death, a user might have a greater tendency to rate both the probability and severity higher than someone who did not have such an experience. If time and resources permit, this variation can be reduced by averaging the rating of several personnel.

A5.2.2. Inconsistency. The subjectivity described above naturally leads to some inconsistency. A hazard rated very high in one organization may only have a high rating in another. This becomes a real problem if the two hazards are competing for a limited pot of risk control resources. There is a tendency to inflate risk assessments to enhance competitiveness for limited resources.

A5.2.3. Small Scope in Rankings. The standard matrix produces only four levels of risk: Extremely High (EH), High (H), Medium (M) and Low (L). The highest level, EH, will normally be corrected immediately. The lowest level, L, is often so minor that it does not warrant serious consideration. This means that the vast majority of meaningful hazards are either H or M. Since most meaningful risks are located in only two categories, there is a prioritization dilemma when trying to construct a risk priority. An option to overcome this problem is to assign numbers to each block of the matrix. These numbers can then be used to augment the basic categories. An example is shown below in **Figure A5.4** (**Note:** The modified matrix provides 20 levels of risk. The numbers do not replace the basic EH, H, M

and L categories, they augment them. Although the levels are arranged so that the higher risks have a low number, the matrix can be constructed so high numbers reflect higher risk levels. Use whichever method is most suitable.

Figure A5.1. Probability Assessment Example.



A5.3. Risk Priority List. The risk priority list is designed to display the hazards of an operation in a top down order of priority. The highest risk hazard is placed at the top of the priority list with progressively less risky hazards displayed in order of priority below. All hazards are displayed on the priority list until the risk is determined to be low enough that the hazards are not likely to warrant any expenditure of resources to control them. It is desirable to indicate the risk rating (EH, H, M, L) for hazards by either labeling each hazard or by labeling each group. The priority list is used to assure that risk issues are attacked on the basis of worst first and that the greatest resource expenditures are focused on the worst hazards. **Figure A5.5** is an abbreviated example of a priority list for the machine movement example.

A5.4. Use of the Priority List. Because the priority list displays all hazards in order of importance, it helps to prioritize risk control efforts. However, it can be useful for other functions as well. For example, it is also useful when evaluating different hazards that may be attacked with a single risk control. In the example above, several hazards arise from the potential of the heavy

and unstable machine. One potential risk control: attaching the machine to a wider, more stable base before lifting and moving the machine may reduce the risk from all these related issues. The risk priority list can also be used to break the overall list of hazards out into clusters of related risk issues so that the responsible personnel for trouble areas can address risks in order of priority. This can be a positive step toward integration of RM roles.

Figure A5.2. Severity Assessment Example.

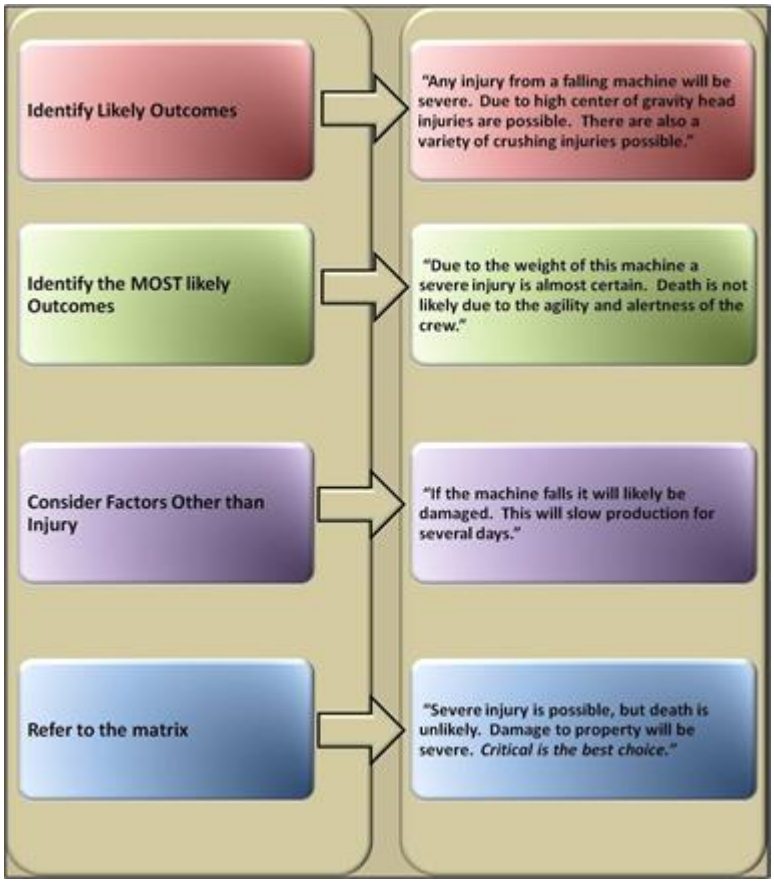


Figure A5.3. Risk Assessment Matrix.

Risk Assessment Matrix				PROBABILITY: Frequency of Occurrence Over Time				
				A Frequent (Continuously experienced)	B Likely (Will occur frequently)	C Occasional (Will occur several times)	D Seldom (Unlikely; can be expected to occur)	E Rarely (Improbable; but possible to occur)
SEVERITY	Effect of Hazard	Catastrophic (Death, Loss of Asset, Mission Capability or Unit Readiness)	I	EH	EH	H	H	M
		Critical (Severe Injury or Damage, Significantly Degraded Mission Capability or Unit Readiness)	II	EH	H	H	M	L
		Moderate (Minor Injury or Damage, Degraded Mission Capability or Unit Readiness)	III	H	M	M	L	L
		Negligible (Minimal Injury or Damage, Little or No Mission Capability or Unit Readiness)	IV	M	L	L	L	L
				Risk Assessment Levels: EH=Extremely High H=High M=Medium L=Low				

Figure A5.4. Modified Risk Matrix.

Modified Risk Assessment Matrix				PROBABILITY: Frequency of Occurrence Over Time				
				A Frequent	B Likely	C Occasional	D Seldom	E Unlikely
SEVERITY	Effect of Hazard	Catastrophic: Loss of Mission Capability, Unit readiness or asset; death.	I	1	2	6	8	12
		Critical: Significantly degraded mission capability or unit readiness; severe injury or damage.	II	3	4	7	11	15
		Moderate: Degraded mission capability or readiness; minor injury or damage.	III	5	9	10	14	16
		Negligible: Little or no impact to mission capability or unit readiness; minimal injury or damage.	IV	13	17	18	19	20
				20 Risk Levels: 1-20 (high risk = low numbers) (low risk = high numbers)				

Figure A5.5. Example Risk Priority List.

Extremely High Risks	• None
High Risks	• Personnel Injured During Forklift Operations • Personnel Injured by Falling Machine During Initial Lift • Personnel injured During Final Placement • Damage to Critical Facilities (Welding Station, etc.)
Medium Risks	• Machine Damage Due to a Fall • Damage and./or Injury During Truck Movement • Machine Damage During Handling Operations

Extremely High Risks	• None
	• Strain and/or Sprain Injuries to Personnel During Life Phase
Low Risks	• Minor Personnel Injuries Due to Cuts, Abrasions, etc. • Minor Machine or Facility Damage Due to Machine Handling

Attachment 6

RISK CONTROL OPTION ANALYSIS TOOLS, DETAILS AND EXAMPLES

A6.1. Scope . The major risk control options were outlined in **Chapter 5** and the following expands on this discussion.

A6.2. Risk Control Options Matrix. A comprehensive list of risk control options is illustrated in the sample risk control options matrix (**Figure A6.1**). These options are listed in priority order of preference. Add those controls that appear suitable and practical to a list of potential options. Many of the options may be applied at more than one level (the training option may be applied to operators, supervisors, more senior leaders, or staff personnel).

Figure A6.1. Sample Risk Control Options Matrix.

Engineer (Energy Mgt)	• Limit Energy • Substitute Safer Form • Prevent / Restrict Buildup / Release • Re-channel / Separate in Time / Space • Provide Special Maintenance of Controls
Guard	• On Source • Barrier Between • On Human or Object • Raise Threshold (Hardened Surface)
Warn	• Signs / Color Coding • Audio / Visual Alarms • Briefings
Limit Exposure	• Number of People or Items • Time • Iterations
Selection of Personnel	• Mental Criteria • Emotional Criteria • Physical Criteria • Experience
Train and Educate	• Core Tasks (Especially Critical Tasks) • Leader Tasks • Emergency / Contingency Tasks • Safety Tasks • Rehearsals
Improves Task Design	• Sequence of Events (Flow) • Timing (Within Tasks, Between Tasks) • Man-Machine Interface / Ergonomics • Simplify Tasks • Reduce Task Loads (Physical, Mental, Emotional)
Motivate	• Measurable Standards • Essential Accountability • Positive / Negative Incentives

	• Competition • Demonstrations of Effects
Reduce Effects	• Emergency Equipment / Procedures • Rescue Capabilities • Emergency Medical Care • Damage Control Procedures / Plans • Backups / Redundant Capabilities
Rehabilitate	• Personnel • Facilities / Equipment • Mission / Capabilities

Attachment 7

MAKE CONTROL DECISIONS TOOLS, DETAILS, AND EXAMPLES

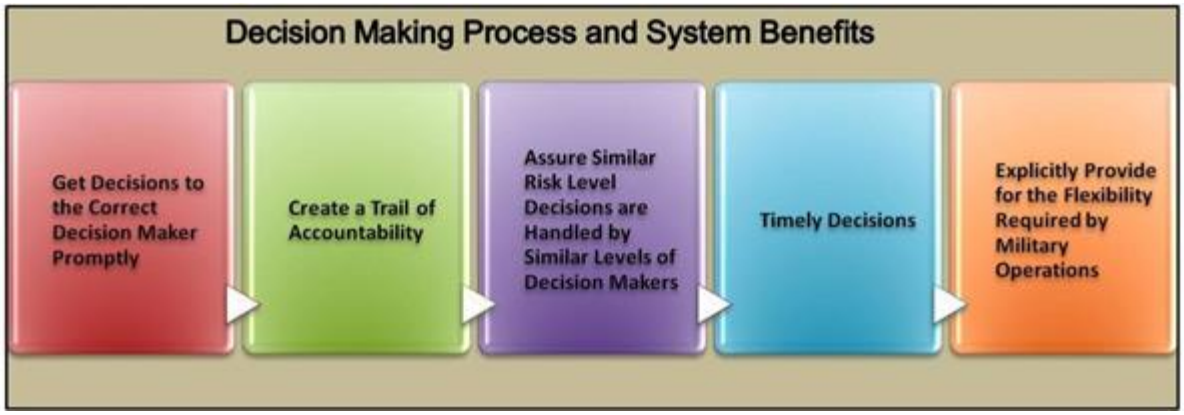
A7.1. Scope. The fourth step of the RM process involves making control decisions regarding the best risk control options to apply toward a given situation. If Step 3 (develop risk control options) has been effectively accomplished there should be a number of practical control options to consider. These will include the basic options (reject, transfer, spread, etc.) as well as a comprehensive list of risk reduction options generated through use of the risk control options matrix. Of course, a decision requires a decision maker. The organization will require a procedure to establish who should, as a matter of routine, make various levels of risk decisions. Finally, after the best available set of risk controls is selected, the decision maker will make a final go/no-go decision.

A7.2. Development. Risk decision-making should be routinized in developed risk decision systems and processes.

A7.2.1. This system will produce several benefits, listed in **Figure A7.1**.

A7.2.2. A decision matrix is an important part of a good decision-making system. These are normally tied directly to the risk assessment process. An example of risk decision-making guidance is shown at **Figure A7.2**.

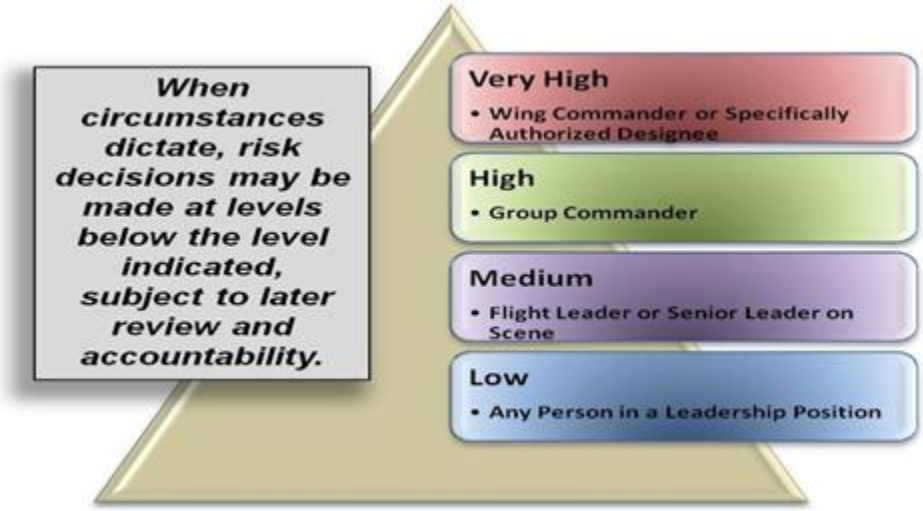
Figure A7.1. Decision-Making Process and System Benefits.



A7.3. Selection. Selecting the best combination of risk controls can be made as simple as intuitively choosing what appears to be the best control or group of controls, or so complex they justify the use of the most sophisticated decision-making tools available. For most risks involving moderate levels of risk and relatively small investments in risk controls, the intuitive method is fully satisfactory. Here are a few guidelines to keep in mind as these intuitive decisions are made:

A7.3.1. Don't select control options to produce the lowest level of risk; select the combination yielding the most mission supportive level of risk. This means keep in mind the need to take risks when those risks are necessary for improved mission performance. Remember there is a mission risk associated with *not* taking risks that advance mission performance.

Figure A7.2. Example Risk Decision-Making Guidance.



A7.3.2. Be aware that some risk controls are incompatible. In some cases, using Risk Control Option A will cancel the effect of Risk Control Option B. Obviously, using both A and B is wasting resources. For example, a fully effective machine guard may make it completely unnecessary to use personal protective equipment such as goggles and face shields. Using both will waste resources and impose a burden on operators.

A7.3.3. Be aware that some risk controls reinforce each other. For example, a strong enforcement program to discipline violators of safety rules will be complemented by a positive incentive program to reward safe performance. The impact of these complimenting programs will usually lead to a stronger overall safety program.

A7.3.4. Evaluate full costs versus full benefits. Try to evaluate all the benefits of a risk and evaluate them against all of the costs of the risk control package. Traditionally, this comparison has been limited to comparisons of the mishap costs versus the safety function costs.

A7.3.5. When it is mission supportive, choose redundant risk controls to protect against risk in-depth. Keep in mind, the objective is not only to mitigate risk to a minimally acceptable level, it is to optimize risk management.

A7.4. Cost/Benefit Assessment. In cases where risk level is high and risk control costs are important, the stakes are high enough to justify application of more formal decision-making processes. All of the tools existing in the management science of decision-making apply to the process of risk decision-making. Two of these tools should be used routinely. The first is cost-benefit assessment, a simplified variation of cost-benefit analysis. Cost-benefit analysis is a science in itself; however, it can be simplified sufficiently for routine use in RM decision-making even at the lowest organizational levels. Some fiscal accuracy will be lost in this process of simplification, but the result of the application will be a much better selection of risk controls than if the procedures were not used. Budget personnel are usually trained in these procedures and can add value to the application. The process involves the steps listed in **Figure A7.3**.

Figure A7.3. Cost-Benefit Analysis Steps.

1	Measure the full, lifecycle costs of the risk controls, to include all costs to all involved parties. For example, a motorcycle helmet standard should account for the fact that each operator will need to pay for a helmet even though the DAF does not have to pay for any
2	Develop the best possible estimate of the likely lifecycle benefits of the risk control package, to include any non-safety benefits expressed as a dollar estimate. For example, an ergonomics program can be expected to produce significant productivity benefits, in addition to a reduction in cumulative trauma injuries
3	Let your budget experts fine tune your efforts
4	Develop the cost-benefit ratio. You are seeking the best possible benefit-to-cost ratio but at least 2 to 1
5	Fine tune the risk control package to achieve an improved "bang for the buck." The example in **Figure A7.4** illustrates this process of fine tuning applied to an ergonomics training course (risk control)

Figure A7.4. Example 5-Step Risk Controls Selection.

SCENARIO:
An ergonomics training program is required to train 400 supervisors in a 4 hours (3 hours training, 1 hour admin) ergonomics training course. Cost is $30,500. Ergonomics losses average $300,000 annually. It is estimated that risk control measures will reduce this by 10% ($30,000) giving a $500 loss when compared to the cost of training.

However, if viewed in the light of injuries/illnesses from loss control office data, risk management concepts and "Pareto's Law," this program becomes beneficial.

Pareto's Law: 80% of most problems can be found in 20% of the exposure.

Step 1	Assume that Pareto's Law applies to the distribution of ergonomics problems within this organization. If so, then 80% of the ergonomics problem can be found in 20% of our exposures. The data can tell us which 20%. It is then possible to target this 20% (80 students) of the 400 students that account for 80% of the ergonomics cost ($240,000)
Step 2	Assume Pareto's Law applies to the tasks taught in this training course. There are 10 tasks performed during the three hours of training. Assume 20% (2 tasks) account for 80% of the benefit of the course. Assume all tasks take an equal amount of time to teach. It might be deemed beneficial to teach only these two tasks (36 min). 80% of the $240,000 target value will be maintained ($192,000)
Step 3	Since training now requires 36 minutes, procedures may be modified to conduct the training in the workshops rather than a classroom. This reduces

	admin time from 1 hour (clean up, travel to/from, etc.) to 4 minutes. Total training time is now 40 min.
Summary: Total cost is now $2500. This is figured by 80 employees participating in a 40-minute local course, earning $15/hour as opposed to 400 students participating in a 1 hour out of office course. This cuts teaching expenses by 1.5" of the $6,000 previously expected. The program is now targeting $192,000 of the original $300,000 annual loss. A 10% reduction will now save $19,200 and total cost-benefit is 7.68 to 1.	

A7.5. Decision Matrices. When risks are high and risk control costs are important, an excellent tool for evaluating various risk control options is the decision matrix. On the vertical dimension of the matrix, mission supportive characteristics for risk controls are listed. Across the top of the matrix various risk control options (individual options or packages of options) are listed. Control options are ranked on a scale of 1 (very low) to 10 (very high) in each of the desirable characteristics. Each desirable characteristic can then be weighted (if desired) based on its mission significance to come up with a calculated/weighted score (illustrated below). All things being the same, the options with the higher scores are the stronger options. A generic illustration is provided at **Table A7.1**.

Table A7.1. Sample Decision Matrix.

Rating Factor	Weight*	Risk Control Options / Package					
		# 1	#2	#3	#4	#5	#6
Low Cost	5	9/45	6/30	4/20	5/25	8/40	8/40
Easy to Implement	4	10/40	7/28	5/20	6/24	8/32	8/32
Positive Operator Involvement	5	8/40	2/10	1/5	6/30	3/15	7/35
Consistent with Culture	3	10/30	2/6	9/27	6/18	6/18	6/18
Easy to Integrate	3	9/27	5/15	6/18	7/21	6/18	5/15
Easy to Measure	2	10/20	10/20	10/20	8/16	8/16	5/10
Low Risk (Sure to Succeed)	3	9/27	9/27	10/30	2/6	4/12	5/15
TOTALS :		229	136	140	140	151	165
* Weighting is optional and is designed to reflect the relative importance of the various factors.							

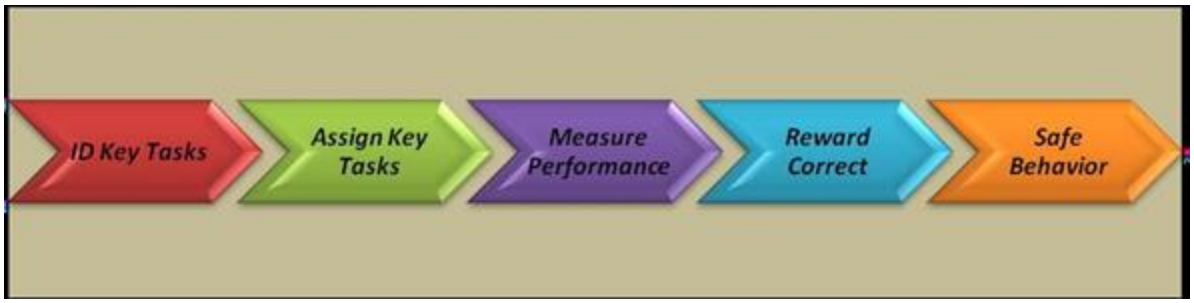
A7.6. Summary. It is not unusual for a risk control package to cost hundreds of thousands of dollars and even millions over time. Millions of dollars and critical missions may be at risk. The expenditure of several tens of thousands of dollars to get the decision right is sound management practice and good RM.

Attachment 8

RISK CONTROL IMPLEMENTATION TOOLS AND DETAILS

A8.1. Scope. Accountability is an essential element of RM success. Organizations and individuals should be held accountable for the risk decisions and actions that they take. If there is no accountability, there will be little motivation to achieve the degree of excellence in management of risk that the DAF seeks. Strong accountability and the resulting motivation it can create is not a matter of luck. Strong accountability is created through the development of effective accountability systems and the delivery of focused rewards and corrective actions. The model depicted at **Figure A8.1** is the basis of positive accountability and strong risk control behavior.

Figure A8.1. Implementation Mode.



A8.2. Model Application. The example below illustrates each step in the risk control implementation model applied to the sometimes difficult task of assuring that personnel consistently wear and use their protective clothing and equipment. The steps of the model should be applied as follows.

A8.2.1. Identify Key Tasks. This step may seem obvious. The task needs to be defined with sufficient precision so that personnel know what is expected of them and expectations produce the risk control desired. It is also important that the task be made as simple, pleasant and trouble free as possible. In this way, we significantly increase the ease with which the rest of the process proceeds. It is critical to actually define the key tasks with enough accuracy that effective accountability may be justified. The following questions will help define key tasks in the example regarding use of protective clothing and equipment.

A8.2.1.1. When is the use of such items required?

A8.2.1.2. Is it when personnel enter the door of a work area?

A8.2.1.3. Is it when personnel approach a machine?

A8.2.1.4. If so, how close?

A8.2.1.5. What about on the loading dock?

A8.2.1.6. Exactly what items are to be worn?

A8.2.1.7. Is there any specific way that protective clothing should be worn?

A8.2.1.8. What-if a person is wearing ear plugs incorrectly and has them stuck in the outer ear, producing little or no noise reduction benefit?

A8.2.1.9. Does this meet the requirement?

A8.2.2. Assign Key Tasks. Personnel need to clearly understand what is expected of them, especially if they are going to be held accountable for the task. This is normally not difficult. The task can be included in job descriptions, operating instructions, or in the task procedures contained in manuals. It can very effectively be embedded in training. In less structured situations, tasks can be assigned through a clear verbal order or directive.

A8.2.3. Measure Performance. Task needs to include at least a basic level of measurement. It is important to note that measurement does not need to include every time the behavior is displayed. It is often practical to sample performance only once in large numbers of actions, perhaps as few as one in several hundred actions as long as the sample is an example of routine behavior. Often the only person who needs to perform measurements is the individual responsible for the behavior. In other situations, the supervisor or an outside auditor may need to perform the observations. Performance should be compared to the standard, which should have been communicated to the individual responsible for the task. This step of the process is the rigorous application of the old adage, *What is monitored (or measured) and checked gets done.*

A8.2.4. Reward/Correct. Reward correct behavior and correct inadequate behavior. The emphasis should be on reinforcing correct behavior. Reinforcement is any action that increases the likelihood that a person will display the desired behavior again. It can be as informal as a pat on the back or as formal as a major award or cash incentive. Correction of inadequate behavior should be accomplished whenever inadequate behavior is observed. The special case of punishment should only be used when all other means of producing the desired behavior have failed.

A8.2.5. Risk Control Performance. If the steps outlined above have been accomplished correctly, the result will be consistent success in mitigating risk. (**Note:** The extent of the rewards and corrective actions required will be dictated in part by the degree of difficulty and unpleasantness of the task.) The harder the task for whatever reason, the more powerful the rewards and corrective actions needed will be. It is important to make risk control tasks as uncomplicated, and pleasant as possible.

Attachment 9

SUPERVISE AND EVALUATE DETAILS AND EXAMPLES

A9.1. Scope. Management is moving a task or an organization toward a goal. To move toward a goal three things are essential: there should be an identified goal, a known current position of the unit or organization in relation to the goal and an organized plan to reach the goal. An effective set of risk matrices provides two of these elements.

A9.2. Develop Indicators. In regard to RM, indicators should provide information concerning the success or lack of success of controls intended to mitigate a risk. These indicators could focus on those key areas identified during the assessment as being critical to minimizing a serious risk area. Additionally, matrices may be developed to generically identify operations/areas where RM efforts are needed. Below is a representative set of risk measures that a maintenance shop leader could use to assess the progress of their shop toward the goal of improving safety performance. Similar indicators could be developed in the areas of environment, fire prevention, security and other loss control areas.

A9.2.1. Tool Control Effectiveness Index. Establish key indicators of tool control program effectiveness (percentage of tool checks completed, items found by quality assurance (QA), score on knowledge quiz regarding control procedures, etc.). All that is needed is a sampling of data in one or more of these areas. If more than one area is sampled, the scores can be weighted if desired and rolled up into a single tool control index by averaging them. See **Figure A9.1** for the example.

Figure A9.1. Example Tool Control Effectiveness Measurement.

Percent of Tool Checks Completed	**94%**
Items Found by QA. (Items were found in 2% of QA inspections)	**98%**
Tool Control Quiz Score	**88%**
Quarterly Tool Control Safety Index: 93.3%	
Note: All items are weighted equally (94 + 98 + 88 / 3 = 93.3)	

A9.2.2. Protective Clothing and Equipment Risk Index. This index measures the effectiveness with which required protective clothing and equipment are being used by shop personnel. Data is collected by making spot observations periodically during the work day. Data is recorded on a check sheet and rolled-up monthly. The index is the percentage of safe observations as illustrated at **Figure A9.2**.

A9.2.3. Emergency Procedures Index. This index measures the readiness of the shop to respond to various emergencies such as fires, injuries, and hazmat releases. It is made up of a compilation of indicators as shown at **Figure A9.3** A high score is desirable.

A9.2.4. Quality Assurance Score. This score measures a defined set of maintenance indicators tailored to the particular type of aircraft serviced. QA personnel record deviations in these target areas as a percentage of total observations made. The specific types of deviations are noted. The score is the percentage of positive observations with a high score being desirable. Secondary scores could be developed for each type of deviation if desired.

Figure A9.2. Example Safety Observation Measurement.

Protective Clothing and Equipment	
Total Observations	27
Safe Observations	21
Safety Index	78%
Note: In this index, high scores are desirable (21/27=78%)	

Figure A9.3. Example Procedures Measurement.

Emergency Procedure Quiz Score	**90.5**
Percentage of Emergency Equipment (available/operational)	**82.0**
Emergency Response Drill Scores (indicates speed, accuracy, effectiveness)	**96.4**
TOTAL:	**268.9**
Average:	**89.6**

A9.2.5. Overall Index. Any combination of the indicators previously mentioned, along with others as desired, can be rolled up into an overall index for the maintenance facility as illustrated at **Figure A9.4**.

Figure A9.4. Example Overall Measurement.

Tool Control Safety Index
93.3
Protective Clothing and Equipment Safety Index
78.0
Emergency Procedures Index
88.4
Quality Assurance Score
97.9

TOTAL: 357.6

Average: 89.4

Note: This index is the overall safety index for the maintenance facility. The goal is to push toward 100% or a maximum score of 400. This index would be used in our accountability procedures to measure performance and establish the basis for rewards or corrective action.

A9.3. Summary. It is not difficult to set up useful and effective measures of risk, particularly once the key risks have been identified during a risk assessment. Additionally, the workload associated with such indicators can be minimized by using data already collected and by collecting the data as an integrated routine aspect of operational processes. Once the data has been collected and analyzed, the results need to be provided to the unit. With this information, the unit will be able to concentrate their efforts on those areas where improvement would produce the greatest gain.

Attachment 10

PREPARATION OF FORMAL RISK ASSESSMENTS

A10.1. Scope. A formal risk assessment succinctly documents the results of the Deliberate 5-Step RM process and supports follow-on decision-making processes. Decision options typically involve determining whether one or more particular COAs should be pursued (e.g., implementing equipment improvements, safety or warning device improvements, operational improvements, technical improvements, policy/procedure improvements) and whether a risk should be accepted, mitigated or rejected. A risk assessment supports decision-making processes by objectively identifying a hazard, assessing its risk, thoroughly analyzing potential options for mitigation and making a recommendation. **Note:** The term losses include fatalities and system losses. **Figure A10.1** provides a sample risk assessment layout in document form to include descriptions of each section.

Figure A10.1. Sample Risk Assessment Layout and Guidance.

Risk Assessment Title

- **Background**: Broadly describe the situation being evaluated. Provide sufficient detail so the remainder of the risk assessment may be easily understood.
- **Hazard Identification:** Accurately and succinctly describe the hazard (e.g., deficiency with engineering design, material, quality, software, operations, maintenance) being analyzed.
- **Initial Risk:** Using quantitative (preferred) and qualitative (alternate) means, identify the probability and severity of a mishap that could result from the hazard, based upon the exposure of personnel or assets to the identified hazard. Use the baseline or "as designed" state as the basis for determining the initial risk. Fully explain the methodology used, data considered (e.g., reported mishaps/events, deficiency reports, test results) and rationale for determining initial risk.
- **Interim Risk:** Many times initial mitigation steps have already been taken prior to the completion of a written risk assessment. These steps may include permanent risk mitigation measures or temporary stop-gap risk mitigation measures. Describe these measures and explain how the initial risk is being mitigated, their effectiveness and the resulting interim risk until final risk mitigating options can be implemented.
- **Risk Mitigation Options:** It is likely several options still exist to mitigate the risk of the identified hazard. Effective control measures reduce or eliminate one of the three components (e.g., probability, severity or exposure) of risk. Investigate specific strategies and tools that reduce, mitigate or eliminate risk. Address each risk mitigation option separately. One option to always consider is "taking no further action" which is the equivalent of accepting the initial risk and acknowledging and accepting projected future losses.
- For each option, including accepting the initial risk, address:
    - **Description:** Describe the option being evaluated.

- **Impact:** Describe the impact of this option. What are its benefits; limitations? Address its effectiveness and explain how it will eliminate or control future losses. Does it address other hazards/problems or introduce new ones?
- **Cost:** Estimate the costs (e.g., financial, operational, maintenance) to implement this option.
- **Schedule:** Estimated timeline needed to implement this option.
- **Target Risk:** Great risk mitigation options eliminate hazards and their risk entirely; others only reduce the risk. Assuming this risk mitigation option is implemented; identify the probability and severity of a mishap that could result from the hazard based upon the exposure of personnel or assets to the identified hazard. Fully explain the methodology used (including analytical assumptions and limitations), data considered, and rationale for determining the target risk.
- **Projected Losses:** Estimate the projected losses with implementation of this option. Express losses over a period of time, a number of events or for a given population as appropriate. Fully explain the methodology used, data considered and rationale for determining these projected losses.

- **Summary of Options:** If the number of risk mitigation options is lengthy, a tabular summary may be appropriate. Include, as necessary.
- **Recommendation:** State the recommended courses of action, including rationale.
- **Endorsements:** Document the program office's preparation and review of the risk assessment by providing dates, signature blocks and signatures for the risk assessment's author, the System Safety Manager, the Chief Engineer, and the Program Manager.

A10.2. Questions that should be considered when conducting a formal risk assessment. Note: Not all of the following questions will apply to every risk.

A10.2.1. What were the preliminary mishap risk index results when the safety deficiency was initially identified? **– Initial Risk**

A10.2.2. What are the identified deficiencies (design, maintenance, material, quality, software, etc.)? **– Hazard ID**

A10.2.3. What are the hazards caused by the deficiencies in light of known requirements and interrelationships with man, machine and media (environmental) system elements? **– Background and Hazard ID**

A10.2.4. What, if any, supporting historical data substantiate the need for controls or changes (list Class A, B, C mishaps, Hazard Abatement Programs, etc.)? **– Initial Risk**

A10.2.5. What, if any, interim corrective action has already been taken to reduce risk (change in mission, operational restrictions, grounding, increased inspections, time compliance technical order actions, etc.)? **– Interim Risk**

A10.2.6. What, if any, additional action has been recommended by operators, planners, system safety groups or other groups? **– Risk Mitigation Options**

A10.2.7. What are the expected total future direct losses (and indirect losses) if the controls are not implemented? If sufficient data exists to make these predictions, what is the current mishap severity, probability and frequency, and resulting mishap risk index values? **– Risk Mitigation Options**

A10.2.8. How will the proposed mitigations eliminate or control these losses? **– Risk Mitigation Options**

A10.2.9. How effective will the control of losses be? **– Risk Mitigation Options**

A10.2.10. If the control is approved, what are the expected losses to be avoided, and any other quantitative or qualitative benefits? **– Risk Mitigation Options**

A10.2.11. Does the proposed control create any new hazards for the mission/activity (consider mission and people, machine and environmental system elements)? **– Risk Mitigation Options**

A10.2.12. Why are other alternatives to risk reduction unacceptable (accept losses, preferred parts substitution, time change, training, procedural changes, increased inspections, etc.)? **– Risk Mitigation Options**

A10.2.13. If the control is approved, what will be done to reduce risk until the control is fully implemented? **– Risk Mitigation Options**

A10.3. Deliberate Risk Assessment Worksheet. See AF Form 4437, *Deliberate Risk Assessment Worksheet*, for a formal risk assessment worksheet example.