MAINTENANCE RESOURCE MANAGEMENT HANDBOOK

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Chapter 1 INTRODUCTION TO MAINTENANCE RESOURCE MANAGEMENT

INTRODUCTION

Though much has been made of crew resource management (CRM) on the flight deck, relatively little attention has been paid to its maintenance-related counterpart, maintenance resource management (MRM). Indeed, this oversight is understandable. Whereas a pilot or pilots' errors can have immediate and highly visible effects, the same can not necessarily be said of a maintenance-based error. Because of this, aviation research into team activities first grew from investigations into aircrew behaviors. This evolution is apparent whenever one encounters references to "cockpit" resource management.

The aviation community has since become much more sophisticated in their approach to reducing human error. Human factors research now encompasses not just the flight crew, but all aspects of aviation in which a human may be involved. This research includes such areas as aircraft design and operation, air traffic control, and, of course, aircraft maintenance.

OBJECTIVES

This handbook was created to help outline and to provide background information on Maintenance Resource Management. Maintenance Resource Management (MRM) is a "general process for improving communication, effectiveness and safety in aircraft maintenance operations."[1] Attention will be given specifically to the implementation and evaluation of MRM training. Much as crew resource management (CRM) was created to address safety and teamwork issues in the cockpit, Federal Aviation Administration (FAA) researchers, in conjunction with industry partners, developed MRM to address teamwork deficiencies within the aviation maintenance environment. By doing so, it is hoped that MRM will foster a culture of safety in all maintenance operations.

MRM HISTORY AND BACKGROUND

From CRM to MRM: A Historical Perspective

Maintenance Resource Management is the result of a series of events that drove its development. First, MRM's development is directly linked to the creation of Cockpit Resource Management (CRM). The catalyst for the development of CRM, the United Airlines (UAL) Flight 173 DC-8 accident, is described below:[2]

As the DC-8 was approaching Portland, Oregon, the flight crew noticed a problem with the landing gear. The pilots kept flying while trying to resolve the problem, thus diverting their attention from the task of monitoring other critical systems. Eventually, they ran out of fuel and crashed short of the runway, killing 10 people. This accident, a classic controlled flight into terrain (CFIT) event, resulted in United

Airlines initiating Cockpit Resource Management (CRM) training.

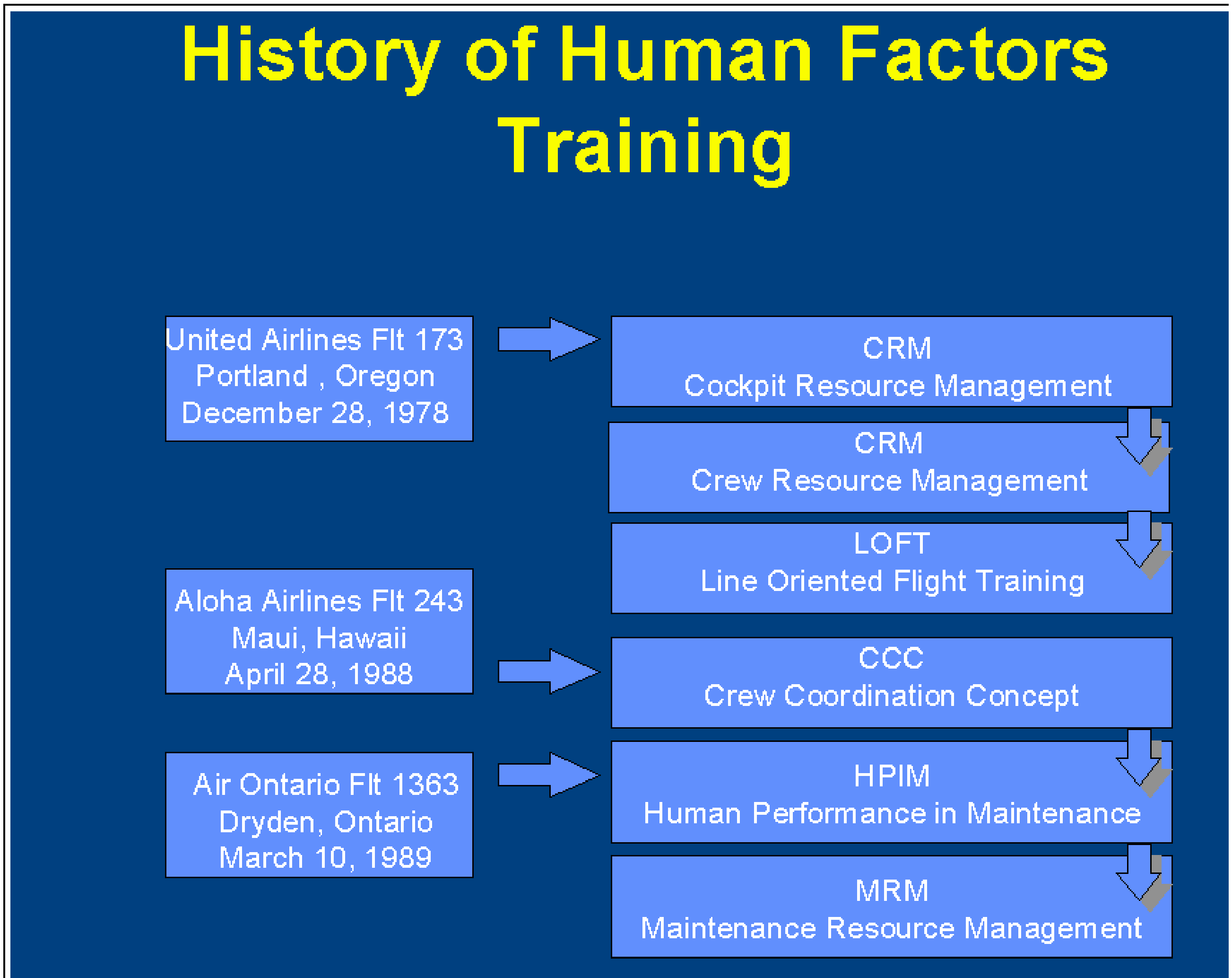

Figure 1.1 The Evolution of Maintenance Human Factors Training

The **UAL CRM** workshop concentrated on improving communication among pilots and other crew members on the flight deck. This program eventually evolved into Crew Resource Management, which pertains to utilizing resources outside the cockpit. This training is now sometimes called Command/Leadership/Resource Management (CLR).

In addition to **CRM** and **CLR**, airlines also created Line Oriented Flight Training (LOFT). LOFT incorporates flight simulators to create better working relationships by devising realistic scenarios that require the use of CRM skills. The feedback that can be given to teams after this type of training reinforces the development of communication and coordination.[3]

Just as **CRM** grew from a reaction to a tragic event, another key mishap led to the development of **MRM** and maintenance-based human factors training. In 1988, Aloha Airlines Flight 243 suffered a near-catastrophic failure.[4] Eighteen feet of fuselage skin separated from the aircraft at an altitude of

24,000 feet, forcing an emergency landing. After this accident, the **FAA** issued an Airworthiness Directive (AD) requiring a close visual inspection of 1300 rivets on B-737 aircraft.[5]

The Aloha B-737 involved in this accident had been examined as required by AD 87-21-08 by two Aloha Airlines inspectors. One inspector had 22 years experience and the other, the chief inspector, had 33 years experience. Neither found any cracks in their inspection. Post-accident analysis determined there were over 240 cracks in the skin of this aircraft.[4] The ensuing investigation identified many human-factors-related problems leading to the failed inspections. Findings showed that although Aloha's maintenance management group were technically knowledgeable and possessed the requisite expertise, organizational factors reduced the effectiveness of their maintenance programs. These findings focused attention onto maintenance and aviation maintenance technicians (AMTs) as potential accident causal factors and led to the development of **MRM** and human factors training.

Due in part to this new focus, in 1991 Continental Airlines expanded and modified its Crew Resource Management training to become Crew Coordination Concept (CCC) training -- designed specifically for its Maintenance Technical Operations. CCC is the precursor of what has become known as **MRM**. MRM shares certain basic features with **CRM**, including addressing the issues of communication and team coordination. The target audience for MRM includes aviation maintenance technicians (AMTs), staff support personnel, inspectors, engineers, and managers--a much more diverse group than cockpit crews.

Since 1991, over 2,000 technical operations personnel and managers have attended the 16-hour **CCC** course.[6] The objective was "to equip all technical operations personnel with the skill to use all resources to improve safety and efficiency." Subsequent evaluation of CCC, over the course of three years, showed positive and significant effects on safety, assertive communication, team coordination, stress management, and dependability.[7]

CCC was shown to reduce maintenance error rates and to improve human reliability in measurable terms, based on a wide variety of objective performance data. Thus, Continental Airlines was able to demonstrate successfully the positive effects of its first "**MRM**" training course. This course provided, in part, the inspiration to develop other MRM training courses.[6,7]

Similarly, in response to the 1989 crash of Air Ontario Flight # 26, Transport Canada developed the Human Performance in Maintenance workshop. These efforts were conducted in parallel with **CCC**. Crew coordination was identified as a contributing factor to this accident. The first workshop, held in January 1994, was successful in providing a heightened awareness of human factors problems and solutions in the maintenance environment. One outcome was the identification of the "Dirty Dozen"--12 human factors elements that degrade people's ability to perform effectively and safely.[8] These dirty dozen are listed below:

1. Lack of Communication
2. Complacency
3. Lack of Knowledge
4. Distraction
5. Lack of Teamwork
6. Fatigue
7. Lack of Resources
8. Pressure
9. Lack of Assertiveness
10. Stress
11. Lack of Awareness
12. "Destructive" Workplace Norms

In response to these initial successes, industry began to develop their own organization-specific **MRM** programs. US Airways (formerly US Air) developed an MRM program that continues to evolve.[9,10,11] This program is the product of a partnership consisting of the following:

- maintenance management
- labor, i.e., the International Association of Machinist & Aerospace Workers (IAM&AW)
- the **FAA** Flight Standards District Offices (FSDO)
- FAA researchers

US Airways' **MRM** activities include:

- participatory methods to reduce paperwork errors
- a paperwork training course and pre-shift meetings
- problem solving meetings (called round tables) that involve management, **IAM&AW** representatives, **AMT**s, and the **FAA**

US Airways designed and developed an **MRM** training course using a participatory design process. The development group was an interdisciplinary team of subject matter experts (SMEs) including **AMT**s, inspectors, managers, human factors and training experts, academic researchers, and representatives from the **FAA**.

The US Airways' **MRM** course provides all maintenance and technical operations personnel with human factors knowledge, an understanding of how maintenance errors occur, safety and situation awareness, communication, assertiveness training, and other team-related skills. After the first course is delivered, a follow-up MRM course is given in 90-120 days for further skill development and practice in MRM principles.

Several other airlines (e.g., United, Northwest, Southwest, American Eagle) have designed human factors training courses for maintenance operations. These courses are typically based on what is known as human performance improvement methods, or HPIM. (This is to be differentiated from Human Performance in Maintenance, also shortened to HPIM.) Common HPIM elements include basic human factors courses, other human factors training materials developed by the **FAA**, and the airline's own human-factors-related experiences and case studies.

Other companies are currently undertaking the design and development of additional **MRM** training that incorporates team situation awareness training.[12] Many repair stations are purchasing MRM training courses from contractors, and some **AMT** schools have incorporated an advanced technology team training program into their curriculum.[13]

Delta Air Lines has designed and developed a Team Resource Management (TRM) course for their ramp workers. They have begun to implement this training course and are concurrently establishing practices that will reinforce TRM skills in the working environment.[14] A comprehensive study of European ground service and ramp personnel has also been completed.[15]

From CRM to MRM: Theoretical Perspective

One of the most intensely studied teams is air and cockpit crews.[16] Previous research demonstrated that aircraft accidents could be traced to human error on the part of the flight crew.[17] It was determined that although each crew member possessed the necessary knowledge and skills for completing his or her job individually, the members of the crew lacked the coordination that characterizes team interdependence. These results became the basis for a systematic training program that identifies behaviors and teaches coordination among flight crew members. This intervention is commonly known as Crew Resource Management (CRM).

CRM researchers identified basic skills necessary for coordination among flight crew members to occur. Among these behaviors are communication, situation awareness, decision-making, leadership, adaptability (also called "flexibility"), and assertiveness.[18] Overall, studies of CRM-type programs demonstrate that training these specific behaviors has a positive effect on performance and performance-related attitudes.[19]

Because **CRM** has been identified as a skill set necessary for the safe operation of aircraft, the **FAA** has outlined CRM training for all multi-crew pilots.[20] This training, as defined by the FAA, encompasses awareness training, practice, and continuous reinforcement. This is also the structure around which **MRM** was designed and implemented.

A review of the literature shows a great deal of transfer of **CRM**-related behaviors and skills to **MRM**. For example, Cannon-Bowers, et al., conducted an extensive review of literature of both theoretical and applied team research in other domains that included CRM, and summarized the behavioral skill dimensions that they found were common to most teams.[21] Though the identified skills vary in labels used in each study, Cannon-Bowers, et al., generated eight core skills common to almost all studies.[21] These are listed below:

1. adaptability
2. shared situation awareness
3. performance monitoring and feedback
4. leadership/team management
5. interpersonal skills
6. coordination skills
7. communication skills
8. decision making skills

Both **CRM** and **MRM** are no exception to the list presented above. The following table is the result of additional reviews by these authors. **Table 1.1** presents a series of behavioral skills common to both CRM and MRM training. Initial research into CRM first identified these specific skills.[16,18,19,20,21,23] Follow-up research in the maintenance environment tested the validity, in terms of acceptance and effectiveness, of those skills for MRM.[6,24,25,26,27,28]

Table 1.1 Behavioral Team Skills Identified in CRM and MRM
Behavioral Team Skills
Communication & Decision Making · briefings · assertiveness · conflict resolution · communication
Team Building & Maintenance · leadership · team climate (norms) · interpersonal climate
Workload Management & (Team) Situation Awareness · preparation · planning · vigilance · decision making · workload management

It must be noted that although team-related behavior and coordination remain the focus of both **CRM** and **MRM**, both philosophies encompass much more. Also included, though dependent on the syllabi of each specific program, are an introduction to basic human factors concepts, training in human error recognition, and worker stress recognition and reduction among other things.

Similarities between **CRM** and **MRM** notwithstanding, they are and should be perceived as two distinct programs; certain CRM principles can not be generalized to **AMT**s. Differences in the training population, knowledge and skill sets, and even the basic tasks make MRM a wholly unique initiative. The remainder of this section details many of these differences.

Though **CRM** and **MRM** are similar in both goals and scope, differences lie in both their target audiences and the job tasks they address. In terms of audience, flight crews are relatively homogeneous in terms of education and experience when compared to **AMT**s. AMTs, on the other hand, vary widely in their education and experience.[8]

The very nature of maintenance tasks dictates important differences between **CRM** and **MRM** training. For example, maintenance crews often are separated from one another by time and space (e.g., separate shifts, hanger versus shop, etc.) Therefore, added effort is invested into teaching maintenance personnel a systemic perspective so that they can better learn how their individual actions fit into maintenance operations as a whole. As one thinks more carefully on the subject, more differences become apparent. The following (**Tables 1.2**-**1.9**) is a sampling of how CRM and MRM differ in terms of the basic skills taught in each. Though not an exhaustive list (others exist that discuss differences between MRM and CRM[8]), the tables presented here were deemed by the authors to be the most immediately relevant.

Discussion of human error and its causes remains an essential component of any safety-oriented program.

Teaching the basic concepts of human error provides trainees the tools to reduce or prevent future mistakes.

Table 1.2 Differences in CRM and MRM (Human Error)

Human Error	
CRM	***MRM***
Flight crew errors are often classified as active failures due to the immediacy of their consequences. This affects the focus of subsequent training in error avoidance and prevention.	**AMT** errors are mostly classified as latent failures, when thought of in terms of public safety. The "latency" of an AMT's actions, in turn, affect how AMTs should be trained to avoid errors in the future.

Many years can be spent studying human factors; however, **MRM** includes only a short primer that discusses its most relevant points. Because the consequences of an **AMT**'s actions differ so much from that of a pilot, the differences in human error frame the course of subsequent human factors training.

Table 1.3 Differences in CRM and MRM (Human Factors Training)

Human Factors Training	
CRM	***MRM***
CRM training emphasizes the psychomotor aspects of human factors training. This makes sense when one considers the immediate effects (active failures) of such things as mental workload and reaction time in piloting aircraft.	Because of the potential for latent failures, MRM training places greater emphasis on a systemic perspective of aviation maintenance operations. Therefore, MRM stresses social and organizational factors in resource management to a greater degree than human engineering concerns.

Communication is also an important issue in all team-training programs. Despite this, each team training situation possesses characteristics unique to each context.

Table 1.4 Differences in CRM and MRM (Communication)

Communication

CRM	*MRM*
Much of flight operations are characterized by synchronous, “face-to-face” communications. Although communication with Air Traffic Control (ATC) is via radio, even these communications benefit from immediate interaction.	Maintenance operations are frequently characterized by asynchronous communications such as technical manuals, memos, Advisory Circulars, Airworthiness Directives, workcards, and other non-immediate formats. In this way, the **AMT** is deprived of certain non-verbal communication cues that are present for flight crews. Therefore, training in the unique characteristics of asynchronous communication is required in MRM.

The composition of the training participants guides not only how a training program is presented but its content as well.

Table 1.5 Differences in CRM and MRM (Team Composition)

“Team” Composition	
CRM	*MRM*
Flight crews are mostly homogenous by nature. Most crew members are similar in education and experience, relative to their maintenance counterparts.	**AMT**s are diverse in their range of experiences and education. This creates new challenges to those who instill teamwork skills into maintenance personnel. A good MRM program should address this and adapt accordingly.

As can be expected, the task that each team performs also determines the content and focus of what is trained. The knowledge, skills, and abilities trained should match the trainee’s environment.

Table 1.6 Differences in CRM and MRM (Teamwork)

Teamwork

CRM	*MRM*
Because flight crews are generally small (2-3 people) and all located in the same cockpit, much of the team behavior training in CRM emphasizes intra-team (within crew) team skills.	Maintenance operations are characterized by large teams working on disjointed tasks, spread out over a hanger. In addition, a maintenance task may require multiple teams (hanger, shop, management) each with their own responsibilities. Therefore, MRM places equal emphasis on inter-team (between crews) teamwork skills.

As is the case with human error, worker safety is also an integral part of any safety-oriented program. However, it is not the purpose of **MRM** to provide general "health tips," though they may be included. The systemic view of operations that MRM endorses also recognizes the importance of a healthy employee in achieving a quality process and structures personal safety discussions in that manner.

Table 1.7 Differences in CRM and MRM (Worker Safety)

Worker Safety	
CRM	*MRM*
Alongside cognitive and emotional indicators, the recognition of stressors in CRM includes psychomotor skills such as reaction time and perceptual abilities.	In addition to the effects one's emotional state has on human performance, MRM also places emphasis on gross physical skills due mainly to the intense physical demands of the maintenance job in terms of location and range of activities. This encompasses concepts such as employee health and workplace ergonomics.

Discussion of situation awareness (SA) has long been a component in error reduction strategies. As these strategies are modified, so too should the definitions of situation awareness.

Table 1.8 Differences in CRM and MRM (Situation Awareness)

Situation Awareness

CRM	*MRM*
The flight environment is quickly changing, setting the stage for the creation of active failures. Situation awareness in CRM is tailored to avoid these errors; **LOFT** simulations provide flight crews with real-time, simulated cues to improve future situation awareness.	The maintenance environment, though hectic, changes slowly relative to flight operations (see discussion of **human error**). In terms of **SA**, **AMT**s must have the ability to extrapolate the consequences of one's errors over hours, days, and even weeks. To do this, the situation awareness cues that are taught must be tailored to fit the AMT environment using MRM-specific simulations.

Finally, team dynamics differ dramatically between **CRM** and **MRM**. Because of this, leadership duties and responsibilities likewise change.

Table 1.9 Differences in CRM and MRM (Leadership)

Leadership	
CRM	*MRM*
Similar to teamwork issues, leadership skills in CRM often focus mainly on intra-team behaviors or "how to lead the team" as well as followership skills. Inter-team interaction is somewhat limited during flight.	Because supervisors or team leaders routinely serve as intermediaries among many points of the organization, **AMT** leaders must be skilled not only in intra-team behaviors, but in handling team "outsiders" (personnel from other shifts, managers outside of the immediate workgroup, etc.) during any phase of the maintenance problem. These outsiders also vary widely in experience, mannerisms, etc. A good MRM program should take these issues into account.

MRM Principles

Aviation maintenance is a complex and demanding endeavor. Its success, which is ultimately measured by the safety of the flying public, depends on communication and teamwork. As has been demonstrated by **CRM**, aviation maintenance operations are most successful when crews function as integrated, communicating teams, rather than a collection of individuals engaged in independent actions.

Over the past decade, the importance of teamwork in the maintenance setting has been widely recognized.[1,9,27,29,30,31,32,33,34,35,36] The result has been the emergence of human factors training, Maintenance Resource Management (MRM) programs, and other team-centered activities within the aviation maintenance community. The following principles are fundamental to MRM:

- Maintenance Resource Management is a general process for improving communication, effectiveness, and safety in aviation maintenance operations. Effectiveness is measured through the reduction of maintenance errors, and improved individual and unit coordination and performance.
- **MRM** is also used to change the "safety culture" of an organization by establishing a pervasive, positive attitude toward safety. Such attitudes, if positively reinforced, can lead to changed behaviors and better performance.
- Safety is typically measured by occupational injuries, ground damage incidents, reliability, and airworthiness. **MRM** improves safety by increasing the coordination and exchange of information between team members (intra-team), and between teams of aircraft maintenance crews (inter-team).
- The details of **MRM** programs vary from organization to organization. All MRM programs link and integrate traditional human factors topics, such as equipment design, human physiology, workload, and workplace safety. Likewise, the goal of any MRM program is to improve work performance and safety. MRM programs do this by reducing maintenance errors through improved coordination, communication, and increased awareness.
- A prerequisite for implementing successful **MRM** is management's will to do so. As with any program intended to be diffused throughout an organization, MRM must have the positive, explicit, and demonstrated support of senior management.

Summary

Maintenance resource management represents the next logical step in the evolution of team-based safety behaviors. Just as technical skills alone were not enough for flight crews to manage complex systems, **AMT**s are being taught skills that enable them to work safely in a complex system. **MRM** teaches more than just team skills; it teaches and reinforces an organizational philosophy in which all members of the organization are oriented toward error-free performance. This is accomplished by teaching managers and AMTs:

1. how the effects of their actions ripple throughout their organizations,
2. how to utilize all of their available resources safely and effective, and
3. how to propagate a culture of safety in their respective organizations through specific, individual actions.

The overall goal of **MRM** is to integrate maintenance personnel's technical skills with interpersonal skills and basic human factors knowledge in order to improve communication, effectiveness and safety in aircraft maintenance operations.

Overview of the Handbook

Chapter One introduced **MRM** in the context of previous work both in flight and maintenance operations. The following three chapters provide specific examples of what makes up MRM and systems for delivering MRM training.

Chapter Two describes and explains what exactly constitutes **MRM**. Specific MRM concepts and the rationale behind MRM training will be presented and discussed.

Chapter Three outlines a generic plan with examples of activities for developing, implementing and evaluating a basic **MRM** training program.

Chapter Four summarizes the handbook.

A **glossary of MRM terms** immediately follows the text. The handbook also includes a bibliography of reference materials and provides material for ***Further Reading*** in Appendix B. Finally, a **generic course outline** is provided in Appendix C that provides the foundation material to develop an **MRM** course for your specific organization.

Chapter 2 WHAT IS MAINTENANCE RESOURCE MANAGMENT?

THE PHILOSOPHY OF MRM

The philosophy of **MRM** is based heavily on how maintenance operations differ from flight operations. The aviation maintenance technicians' work environment is viewed as encompassing a great variety of tasks in varied settings with a great number of people. Because the tasks and work differ vastly from one domain to the other, the basic plan for "attacking" concepts like human error, teamwork, and safety also differ.

This section outlines similarities and differences between **MRM** and **CRM**, in order to characterize the philosophy of MRM. First, human error in both flight and maintenance environment is explored in more detail as a foundation upon which to build the discussion of an organization's "safety culture." The section that follows investigates the concept of a safety culture more thoroughly. The promulgation of a good, pervasive safety culture is at the core of MRM's basic philosophy.

Human Error

The way to understand **MRM** is to explore the nature of errors in maintenance operations. A widely accepted model of human error is Reason's classification of unsafe acts.[37] Reason distinguishes between two types of errors: 1) active failures, whose effects are felt immediately in a system, and 2) latent failures, whose effects may lie dormant until triggered later, usually by other mitigating factors.[37]

The presence of defenses or safeguards in a system can usually prevent the effects of latent failures from being felt by closing the "window of opportunity" during which an active failure may be committed. For example, a hypothetical mechanic assembled a component wrong which eventually led to plane crash days or even weeks later. The defenses that should or would have normally caught this mistake were not in place at the time. These defenses included proper training (the mechanic was taught to fix this particular component very informally and on-the-job), good situation awareness (the mechanic was tired from a double shift the night before), and independent inspection (the job was "pencil-whipped" to save time.)

Active failures are usually the result of "front-line" operators such as pilots, air traffic controllers, or anyone else with direct access to the dynamics of a system. Latent failures, on the other hand, are caused by those separated by time and space from the consequences of the system. Examples include architects, hardware designers, and maintenance personnel.

Both active and latent failures interact to create a window for accidents to occur. Latent failures "set the stage" for the accident while active failures tend to be the catalyst for the accident to finally occur. A good way to think of this model of accident creation is as slices of Swiss cheese. Each slice can be thought of as a defense (training, good management, teamwork, etc.) and each "hole" is a failure. The last slice is the final action before the accident event. If a situation contains a sufficient number of failures allowing the holes to "line up," then an accident will occur. **Figure 2.1** demonstrates this model graphically.

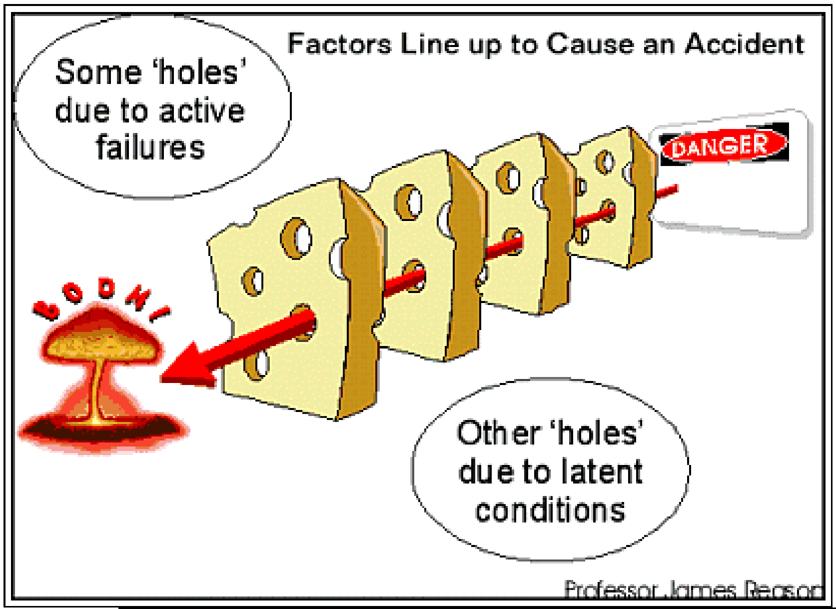

Figure 2.1 "Swiss Cheese" Model of Accident Causation

Differences between active and latent failures cannot be over emphasized; each type of error helps to shape the type of training required to correct them. For example, because of the immediate demands and consequences of their actions, flight personnel require training that includes the psychomotor aspects of physical skills such as improving reaction time in emergency training. The strict physical requirements for employment as a flight officer demonstrate this emphasis clearly. On the other hand, maintenance personnel may require human factors and operations training to account for their susceptibility to latent failures. In addition, the range of physical activities **AMT**s employ on the job also require emphasis on workplace ergonomics, among other things. For example, AMTs may be asked to lift heavy objects, work in awkward positions, or perform tasks in extreme weather conditions. These difficult work conditions all require knowledge of ergonomics to ensure safe, error-free performance. Though **CRM** and **MRM** share the basic concepts of error prevention, the content of what is taught is content-specific to what is actually performed on the job.

Safety Culture

Knowledge about complex systems alone only goes so far in mitigating human error. To combat error, an organization must teach not just how error may be avoided, but enculturate attitudes that promote safety above all else. Various researchers call these attitudes an organization's "safety culture."[38,39,40,41,42,43] Pidgeon and O'Leary identify top-level organizational support as the main predictor of safety culture.[38] Put briefly, in order for an organization to create and perpetuate a safety culture, senior management needs to do a series of things, among which include:

1) Set standards/expectations and provide resources to meet them.

2) Develop and enforce a standard protocol that emphasizes safe work practices.

3) Set up meaningful incentive programs that reward safe and reliable behavior either monetarily or through other means such as days off, or awards of recognition for a job well done.

An **MRM** training program provides personnel the tools to assess and change their own behaviors to work safer and reduce human error. Instituting an MRM program represents a level of managerial commitment toward safety. Unlike other safety programs, MRM is most effective when ALL employees are oriented toward the safety culture endorsed. Therefore, employees of all levels (upper-level managers included) are encouraged to participate and are trained alongside maintenance personnel. However, a mere symbolic commitment by management is not enough to affect a significant cultural change. In truth, implementing an MRM program without true managerial support may undermine any such future efforts.

MRM trains personnel to use the resources of their positions to encourage safe operations. For example, managers learn that a safety culture can only be fostered if line employees are provided necessary resources to do their jobs correctly. Line employees, on the other hand, must be given the tools that teach how to do their jobs without error. As an example, upper-level managers provide and control resources such as the number of planes serviced at one time, the selection of employees to do the work, and the tools with which to perform the necessary tasks. Safety itself, however, is rooted in the actual behaviors **AMT**s perform in the hanger (or the line). MRM teaches employees what behaviors are best to use. MRM also helps managers understand how their own choices affect which of these behaviors are ultimately used on the line. In this way, the entire organization becomes oriented towards safe, error-free performance.

MRM CONCEPTS

Though **MRM** represents more than a single training program, the training is the foundation upon which the program is built. MRM training teaches trainees specific concepts, both theoretical and applied, and allows them to put into practice the things they learn. This section presents and defines these concepts in terms of the maintenance environment. In addition, supplemental information on each implementation of skill is also provided as a sample of the content of MRM.

A typical **MRM** training program addresses each of the following components:

Human Factors Knowledge

- understanding the maintenance operations as a system
- identifying and understanding basic human factors issues
- recognizing contributing causes to human errors

Communication Skills

- basic communication skills
- inter- and intra-team communication
- assertiveness
- peer-to-peer work performance feedback techniques

Teamwork Skills

- basic team concepts
- coordination
- decision making
- norms

Performance Management (leadership)/Situation Awareness

- stress management
    - fatigue
    - complacency
- team situation awareness and error chain recognition
- leadership

Those familiar with **CRM** training will see similarities with the skills that compose **MRM**. These similarities lie mostly in the broad areas of resource management such as communication, team building, workload management, and situation awareness. However, MRM is tailored to fit the unique demands of the maintenance community; its content specifically addresses their problems. The following sections discuss briefly each of these components of MRM, providing more detail to the Tables 1.2-1.9.

Human Factors Knowledge

Understanding the maintenance operation as a system

An understanding of the systemic nature of the maintenance operation is vital to understanding how one's individual actions affect the whole organization. A person who understands the "big picture" is more apt to think things through before acting.

Identifying and understanding basics human factors issues

Basic human factors concepts are also taught in the course of **MRM** training. These concepts typically include human perception and cognition, workplace and task design, group behavior (norms), and ergonomics. However, this list is far from exhaustive and can be tailored to meet the needs of each particular audience.

Recognizing contributing causes to human errors

A basic primer to human error is also a key component to **MRM** training. By understanding the interaction between organizational, work group and individual factors that may lead to errors and accidents, trainees can learn to prevent or manage them proactively in the future. Reason's model provides a good foundation for human error theory; however, many other models of human error exist, such as Dupont's Dirty Dozen, and can also be adapted for use in MRM.

Communication Skills

Communication remains the backbone of both **CRM** and **MRM**, but specific aspects of communication are different in each work environment. Mechanics, crew leads, supervisors, and inspectors all must have the knowledge and skills to communicate effectively. A lack of proper communication can have any or all of the following undesired consequences:

- The quality of work and performance may be reduced.
- Time and money may be lost as errors occur because important information is not communicated or messages are misinterpreted.
- Improper communication may cause frustration and high levels of stress.

We can communicate in many different ways, but for our purposes we will consider three broad forms of communication.

1. Verbal communication is the spoken word, whether face to face or through some electronic medium such as a phone, radio, loud speaker, etc.
2. Non-verbal communication is commonly referred to as "body language." Whether you wave, smile, or wink, you are communicating a message to other individuals.
3. Written or asynchronous, communciation includes everything that is written down, such as publications, letters, forms, signs, e-mail, etc.

Most people associate *communication* with *verbal communication*. For maintenance personnel, communication encompasses much more than inter-team verbal interaction. Communication not only includes face-to-face interaction, but also paperwork such as maintenance cards, procedures, work orders, and logs. In addition, because maintenance is an ongoing process independent of specific teams, inter-team communication, especially between shifts, is extremely important. In this way, *asynchronous* communication (communication in which there exists a time delay between responses) is used to a greater extent than real time, *synchronous* communication. Asynchronous communication is typified by a unique set of characteristics, such as the lack of non-verbal communication cues (e.g., body language, verbal inflection, etc.) An example of asynchronous communication at work in the hanger would be an e-mail message sent from the day supervisor to the night supervisor. Other examples include memos left between shifts or passed between the shop and the hanger.

As one might expect, relying on asynchronous communication affects an organization's ability to adapt quickly to changing situations. The very definition of asynchronous communication implies that a time lag is present between parties. In this way, communication also affects other factors such as decision making, teamwork (and interdependence), and the ability to lead. **MRM** recognizes these differences in communication from **CRM** and accounts for them in training.

Similarities also exist between **CRM** and **MRM**, particularly in the form of assertiveness. Assertiveness was identified by MRM researchers as a positive behavioral skill. Not to be confused with aggressive behavior, Stelly and Taylor define assertive behavior by using a series of *rights* to which a team member is entitled.[24] Some of these rights include the right to say "no," the right to express feelings and ideas, and the right to ask for information. Examples of these rights in action may include refusing to sign off on an inspection that was not performed properly, questioning the appropriateness of certain actions, or demanding the correct number of people to do a job. It has been shown that teams in cooperation openly discuss opposing views, critical for making cooperative situations productive.[43] Thus, assertiveness is a necessary skill for effective team behavior and is addressed specifically in MRM training.

To promote constructive, synchronous communication, peer-to-peer performance feedback techniques are also typically addressed in **MRM** training. This also falls under the general category of interpersonal relations. These concepts are typically labeled “touchy-feely.” However, teaching-specific, constructive behaviors that may be useful in common situations can still be beneficial. MRM allows for this training with examples including “handling a troublesome employee/supervisor” and “conflict management.” The specific content of each module can be tailored to fit a particular organization; however, MRM would be incomplete if the training of people skills were omitted.

Teamwork Skills

Team skills and coordination are a vital link in the **MRM** concept. In fact, researchers have documented that competence in team skills tend to be independent from technical skills, yet are equally important in accomplishing the final goal.[44] Unfortunately, organizations rarely devote time and resources to teach these team skills formally. MRM provides maintenance organizations the vehicle to accomplish this. The discussion of *teams* has been inferential up to this point. This section will define teams specifically. In this way, concepts like inter- and intra-team behavior can be understood with more precision.

The definition of a team can be somewhat tenuous at times. Certain qualities differentiate a *team* of people from a *group* of people. Among these are size, a common goal, and interdependence. First, team size is an important issue in what constitutes a team. Obviously, teams consist of more than one person. The addition of more people does not necessarily mean a similar addition in team performance. Additional team members require additional time, resources, and coordination to accomplish goals. A team with many members may fracture and create sub-groups or cliques that may possess goals different from or even in opposition to the team’s primary goal. In this sense, the return on performance decreases dramatically as more people are added. Taken together, for any one particular task, there exists an optimum number of people that should do the job; more or fewer people will result in a performance loss. Though the optimum number is contingent on the team task, process loss becomes significant with more than 10 members.

Secondly, a team works together to accomplish a unified goal or goals. That goal could be an engine change or rebuilding a 747. It must be understood that, just as rebuilding an airplane consists of numerous steps, a team’s overarching goal is also composed of sub-goals. Each sub-goal exists to reach the team’s ultimate goal. It is this mutual goal that is the purpose for the team’s existence. This goal must also be communicated to all team members.

If the accomplishment of a single goal were the sole defining indicator of teamwork, then many large organizations could be categorized as teams. Therefore, a final quality helps define a team—interdependence. Interdependence is defined as a team situation in which members depend on one another to finish the final job. An activity that can be completed by a single person without having to rely on others is not highly interdependent. For example, even though a group of **AMT**s can fuel a plane more quickly than one AMT alone, if each AMT should drop out over time, the person left could still finish the task.

Taken together, a team is defined as a group of interdependent individuals working together to complete a specific task. The amount of interdependence demonstrated by team members may vary when completing their own individual tasks. For example, a maintenance team washing a plane depends only on each team member to contribute to his or her individual task. However, each member relies on one another to achieve his final goal (finishing the wash). This is known as *additive* labor, i.e., each team member adds her work to the task at hand. A maintenance team changing out a main gear, on the other hand, has a greater amount of interdependence among the team members to finish the task (i.e., imagine trying to change the gear by yourself). A highly interdependent task *requires* the work of others operating together in order to get done.

1. A team is a group of interdependent individuals working together to complete a specific task.
2. All team members depend on one another's knowledge, skills, and abilities to finish the final job. The amount of interdependence among team members may vary from one team to another.

This definition of teams and teamwork provides a clearer picture of the composition of a maintenance team. Though teams are usually composed of members in the same location at the same time, this may not always be the case. For example, consider a team performing a heavy check in a hanger. Because each team member is working on separate parts of the plane, they are separated both in location and sometimes time. However, when defined in terms of possessing an overarching goal (finishing the check) and being interdependent (each member has unique skills, such as airframe, powerplant, avionics, etc. that are necessary to perform the heavy check), the definition of being a team applies. Also note that the other **MRM** skills, such as constant communication and other people skills, are also at work in this example.

Teams have certain characteristics that make them effective. The following is a list of ten of those characteristics.

Table 2.1 Effective Teamwork[45]
Ten Characteristics of an Effective Team
A Clear Purpose: The team has a clear purpose or mission that is accepted by all members.
Relaxed Interaction: The team is relaxed and informal, with no obvious tensions among members.
Participation: There is a lot of discussion between members and everyone participates in decisions and/or activities.
Listening: Each team member actively listens to one another.
Disagreement: Team members are comfortable enough to disagree with one another if the situation calls for it.
Openness: There is full and open communication with no hidden agendas.
Clear Expectations: There are clear expectations about the roles each member plays in the team, and work assignments are fairly distributed among team members.
Shared Leadership: Although there may be a formal team leader, each team member may share leadership responsibilities from time to time as the situation arises.
Relations with Others: The team maintains credibility and good relations with others who may be outside the formal team but who can still affect its functioning.
Team Maintenance: Team members not only focus on their primary goal but spend time recognizing and maintaining the functions of the team itself.

Maintenance operations are characterized by large teams, spread out working on disjointed tasks spread out over a hanger. As a result, maintenance operations rely heavily on asynchronous communication. Relying on asynchronous communication also affects the extent to which team members exhibit interdependence. Because of the lag between query and response, a highly interdependent team that relies on asynchronous communication adapts to changes in its environment very slowly. Consequently, as teams become increasingly interdependent, more media for communications and more standardized procedures should be in place to overcome this organizational *inertia*. In addition, a maintenance task may require multiple teams (hanger, shop, management) each with their own responsibilities. Therefore, **MRM** places emphasis on inter-team (between crews) teamwork skills as well as intra-team (within crew) skills.

Norms

A side effect of working in teams and a group setting are the use of *norms* to guide a person's behavior. For example, a maintenance team may meet regularly before and after a shift is over or even socially, during days off. If this is not required by the organization, but expected by the team members, then it is a norm.

Norms are omnipresent in society. Norms dictate fundamental rules of dress, speech, and basic interaction. In this way, norms can be defined as expected, yet implicit rules for behavior.[46] Because these rules for behavior define others' expectations, norms facilitate interaction by reducing the number of surprises one may encounter in a social context. On the other hand, a violation of norms can prove distressing. For example, a group of maintenance technicians may vigorously enforce the wearing of proper personal protective equipment (PPE) when at work. Not wearing PPE may be not only a source of concern for the norm "breaker," but may also elicit negative reactions from those who conform.[47] In this case, the norm breaker may be sanctioned by others in the surrounding group.

Norms usually develop as a answers to problems that have ambiguous solutions.[48] When faced with an ambiguous situation, an individual may use others' behavior as a frame of reference around which to form his or her own reactions. As this process continues, group norms develop and stabilize. Newcomers into the situation are then socialized into the group norms. Very rarely do newcomers initiate change into a group with established norms. Unfortunately, it is easy for a newcomer to acquire nonproductive or "unhealthy" norms from the group. Finally, as newcomers become assimilated into the group structure, they build credibility with others. Once this has been done, a relative newcomer may begin to institute change within the group. Unfortunately, such actions are often difficult to do and rely heavily on the group's perception of the newcomer's credibility.

Norms have been identified as one of the dirty dozen in aviation maintenance and a great deal of anecdotal evidence points to their use on the line. These norms may range from the relatively benign, such as when accepted meeting times take place, to the inherently unsafe, such as "pencil-whipping" certain tasks. Any behavior commonly accepted by the group, whether standard operating procedure (SOP) or not, can be a norm. Many **MRM** courses attempt to help individuals identify these group norms and handle them appropriately.

Performance Management/Situation Awareness

MRM also contains modules that address worker health and safety, situation awareness, and leadership. Each of these concepts has also been identified as important to maintaining an effective safety culture. The remainder of the chapter details each of the concepts more fully.

Worker Health and Safety

Employee health issues are important to all organizations. Healthy employees are more productive and effective than non-healthy employees. Discussions of safety in **MRM** have, to this point, focused primarily on public safety (the effect of human error on the flying public, for example). MRM also encourages discussion of employee safety as well. Employee safety is an integral part to fostering an overall safety culture in an organization.

Working safely is trained on two fronts. First, human error models are reviewed and placed in the context of one's personal well-being. For example, a human error model used previously to analyze what led to a plane crash could also be used by trainees to analyze an accident that occurred within the hanger. By applying many of the same principles of human factors, trainees could learn to work more safely in an otherwise hazardous environment.

Second, though both **MRM** and **CRM** emphasize the recognition of stressors, these stressors differ from flight to maintenance crews. For example, physical stressors of flight personnel focus on psychomotor and perceptual skills such as reaction time, vision, etc. Maintenance personnel, on the other hand, perform a wide range of physical activities, requiring more gross physical movements. Specifically, the ailments which **AMT**s are most vulnerable to include Lower Back Pain (LBP), cardiovascular (heart) disease, fractures and/or chronic pain, hypertension, hearing damage, and exposure to dangerous chemicals and ever-changing environmental conditions.[49] Therefore an effective MRM program should provide training in basic ergonomics (what and how to lift, workspace requirements, effects of temperature, noise, etc.). In addition, an effective MRM training program should teach the AMT how to assess these problems, judge their susceptibility to them and judge how these problems ultimately impact performance.

Finally, cognitive and emotional stressors exist for all people, regardless of their job. The consequences of these stressors have differing effects based on what each person may do. **MRM** acknowledges these stressors and frames them to be relevant to maintenance. Consequently, discussions of these stressors are in terms of human error in the maintenance environment. A discussion of two such stressors follows.

Complacency.

Complacency is defined as "the degradation of vigilance in a situation."[50] Put simply, a *complacent* person fails to pay attention when performing a task. This, in turn, normally leads to error or deviations from **SOP**. Complacency is generated from a number of factors but three primary ones are:

1. Fatigue.
2. Too many things happening simultaneously.
3. Too few things happening.

The effect of fatigue on attention is discussed in more detail in the next section. However, someone's mental workload also affects one's ability to pay attention. First, a person possesses limited mental resources. If too many things are happening at the same time, that person has to divert his or her attention from one task to another. He or she can be spread thin. This situation leads to reduced attention and/or selective focus

At the same time, a person may have too little to do. A situation may seem boring, with nothing much occurring. Or a task may seem routine, having been done by a person a hundred times before. This situation also commonly leads to complacency. **MRM** is structured so that complacency in maintenance and its effect on human error can be addressed directly.

Fatigue.

Fatigue's effects on flight personnel are well documented.[51] In short, fatigue degrades a person's ability to work effectively. Some of the effects of sleep deprivation are reduced reaction time, impaired short-term memory, decreased vigilance, reduced motivation, increased irritability, and an increase in the numbers of errors made, among others. Failure to act on stimuli, even dangerous ones, is also common in fatigued individuals.

Sleep deprivation is not the only cause of fatigue. *Time on duty* and *time since awake* are common criteria researchers use to measure if fatigue is a factor on the job. Environmental factors, such as extreme temperatures, noise, and vibration, can also induce fatigue.

A great deal of anecdotal evidence exists that point to **AMT** fatigue as a factor leading to human error. **MRM** attempts to increase awareness of fatigue and its causes. MRM also teaches individuals about the consequences of fatigue, especially in terms of human error in maintenance. Though presently no significant quantitative research has been conducted on fatigue in aviation maintenance, work is currently underway examining duty time and its effect on maintainer fatigue.

Team Situation Awareness

Situation awareness is one of the foundation concepts of **MRM**. Typically, situation awareness is thought of in terms of the individual **AMT**. In addition, situation awareness also encompasses other related concepts such as mental arousal and vigilance. MRM does not ignore these components. Many of the most common maintenance errors involve the loss of situation awareness among different individuals, often across different teams or shifts. The concept of team situation awareness relates to maintaining a collective awareness of important job-related conditions and events.

Researchers have identified five elements and activities that are necessary to improve Team Situation Awareness in the maintenance environment.[12,52] These are:

- Shared mental models
- Verbalization of decisions
- Better team meetings
- Teamwork and feedback
- Individual situation awareness training

Shared mental models.

A mental model is simply how we depict a subsystem in our minds--how we think it is put together and how it works. Good situation awareness at the team level depends on having a clear understanding of what information means when it is conveyed across team members. Such shared mental models are provided by developing a good understanding of what other team members know, don't know, or need to know. Team members need to share not only data, but also the significance of data relative to their jobs and the team's goals.

Verbalization of decisions.

Despite some claims to the contrary, most **AMT**s cannot read their co-workers' minds. It is very difficult to know why a team member has taken a course of action unless they tell us. Teams need to do a better job of communicating information regarding why they decide to (or not to) take a particular course of action.

Team meetings.

Having team meetings is critical to pass on valuable and necessary information. This applies to teams on the same shift and to teams passing information across shifts. To increase team situation awareness, Team Leads need to receive explicit coaching in the following:

- Running a shift meeting and stating common goals for the team.
- Providing a common group understanding of who is doing what.
- Setting up an understanding of the inter-relationship between tasks and personnel activities.
- Providing expectations regarding teamwork.
- Maintaining good communication practices.

Teamwork and feedback.

It is important that **AMT**s know the outcome of their work. Such feedback is crucial to the development of better mental models. Without such feedback, it is difficult to improve one's diagnostic skills. For example, a tricky diagnosis and repair may have been totally successful, or may have failed again a few days later at another station; one would be unable to know what ultimately happened without feedback.

Individual situation awareness training.

Many common problems can be linked to situation awareness failures, including the following:

- forgetting information or steps--frequently associated with task interruptions
- not passing information between shifts or team members
- missing critical information due to task-related distractions, and
- misinterpreting information due to false expectations.

These problems can be minimized by training **AMT**s to recognize threats to situation awareness and cope with their effects.

Leadership

In the past, most people thought that the ability to lead was part of a person. Leadership was seen as a logical outgrowth of a person's personality. To add to the confusion, the types of groups that can be led vary as much as the leaders who lead them. Because of this confusion, scientists began to redefine leadership less in terms of a trait and more as a function of the group being led. Scientists now view the concept of leadership from the perspective of a system. In other words, they include more organizational components, as well as studying their interaction, in order to get a more complete definition of what leadership is.

Scientists have now redefined leadership to encompass all facets of leadership. In its simplest form, leadership is the ability to direct and coordinate the activities of group members and stimulate them to work together as a team. In this definition, ability extends beyond a leader's personal ability. Ability to lead also includes being in a position to control and manipulate the resources of a group. Imagine how difficult it would be for a maintenance shift supervisor to lead if he or she did not have a say in assigning people's tasks, determining department budgets, or even determining which planes will be serviced. The definition of leadership is now much more complex than it was 30 years ago.

Two Specific Types of Leadership.

There are as many different definitions of leadership as there are researchers who study it; each person has put his or her own unique spin on it. Because of this variation, we will discuss two of the more broadly accepted types. These two leadership types are *authoritative* and *participatory*. Authoritative is derived from the word "authority." An authoritative leader tends to make all team decisions and controls all resources because the team is structured as a *hierarchy*. A hierarchical structure is one in which many levels of management exist and there is a clearly-defined boss.

On the other hand, a leader can possess a participatory style. In this style, even though a leader may ultimately decide the team's course of action, each team member has a say and participates in team processes. The team leader is more *egalitarian*, or equal, under participatory leadership than with an authoritative leader.

1. An *authoritarian* leader dictates action and the course of the team with little input from team members.
2. A *participatory* leader encourages member participation and input to help lead the team's course of action.

One may ask if one form of leadership is better than another. The answer to that question usually depends on the task being performed. For example, a fully participative team where a vote is taken and every team member surveyed on every little detail of the work day would be unable to perform their duties in a timely manner. However, an overly authoritative boss who fails to request input from anyone may suppress the free flow of ideas and negatively impact safety. Good leadership is a balancing act between the two. **Table 2.2** presents some guidelines for when to choose which style, but keep in mind that this list is far from complete.

Table 2.2 Guidelines for Choosing a Leadership Style

When do you use an authoritative leadership style?	When do you use a participatory leadership style?
· If a task needs to be done quickly. · If a task is structured and a clear cut answer exists. · If conflict and a lack of communication exists between team members. · If you are certain all team members will accept the final decision if made by a single person.	· If there is time to get input from all members. · If a task is unstructured and may require extensive group decision making. · If team members get along and communicate well. · If you are certain team members will not accept the final decision if made by a single person.

As stated previously, leadership demands are usually more a function of the team than of the leader him- or herself. Thus, leadership responsibilities in the maintenance environment are more varied and can be more demanding than in the cockpit due simply to the wide variety of tasks performed by the **AMT**. Furthermore, the cockpit is a restricted environment whose outside contacts are limited to the flight crew, air traffic control, and passengers (if any). In addition to his or her own team members, a frontline maintenance supervisor on the job must interact with a variety of other "non-team" members. These may include upper-level managers, shop personnel, other shift/crew supervisors and their teams, union representatives, catering/other ground support, etc. requiring not just internal but external coordination as well. As a result, supervisors must be trained not only in the skills to handle their subordinates, but also in interacting effectively with others.

Responsibilities of Leaders.

Leaders have a variety of responsibilities they must meet to ensure a smoothly running team. **Table 2.3** presents a list of twelve of those responsibilities. This is not, however, an exclusive or exhaustive list.

Table 2.3 Leader Responsibilities

Responsibilities of leaders
1. Supervise and coordinate crew activity.
2. Delegate tasks to appropriate crew members.
3. Define crew responsibilites and expectations.
4. Focus attention on critical aspects of the situation.
5. Adapt to internal and external environment changes.
6. Keep crew informed of work-relevant information.
7. Ask crew for work-relevant information and respond accordingly.
8. Provide feedback to crew on performance.
9. Create and maintain a professional atmosphere.
10. Promote teamwork.
11. Effectively manage workload issues/stress.
12. Train and mentor subordinates to be proficient at their tasks.

There are certain behaviors a leader can employ to make him or her effective. **Table 2.4** lists some of the guidelines for promoting good and avoiding bad leadership; however, other more team- and task-specific skills may be added to the list.

Table 2.4 Leadership Guidelines

Effective and Ineffective Leadership	
Effective Leadership Skills	Barriers to Good Leadership
· Make suggestions · Make the crew want to perform activities · Lead by inspiration/example · Provide feedback to the crew	· Micromanagement (trying to do everything oneself) · Poor interpersonal skills · Inexperience · Pressure · New situations · (Personal) rigidity/stubbornness

To conclude, leadership is the application of a cluster of teamwork skills on an individual level. These skills include communication, coordination, and decision making as well as technical knowledge. However, though some appear to be "born leaders," it is the contention of **MRM** that leadership skills are not innate; instead, individuals can be trained to be good and effective leaders.

FINAL NOTE

The behaviors and skills described in this chapter are what comprise a typical **MRM** course. **Appendix C** reflects many of the concepts discussed in this section. However, it is understood that some of the concepts discussed in **Appendix C** may not apply equally to all organizations. It is the responsibility of the one instituting MRM to tailor its contents specifically to fit his or her particular organization. For example, this chapter was written with relatively large maintenance and repair stations in mind; discussions of large working groups may not apply in small stations. **Chapter 3** will detail how to develop an MRM training program and how to tailor it to your own organization.

Chapter 3
IMPLEMENTING MAINTENANCE RESOURCE MANAGEMENT TRAINING

INTRODUCTION TO TRAINING

In **Chapters 1** and **2**, we described the definition, evolution, and status of **MRM**. In this section, we describe a number of techniques to analyze the necessity and identify the benefits of implementing MRM in an aviation maintenance organization. The emphasis of this section, therefore, is the introduction of MRM-related knowledge and skills into the workplace, i.e., MRM training.

We do not anticipate that most aviation maintenance managers, the primary readers of this Handbook, will have the training, skills, time, or inclination to develop an **MRM** training program. However, there are many tasks associated with such a program that are within the responsibility of managers. Since we propose a specific framework within which MRM training programs should be developed and evaluated, it will be useful for managers to understand the most important aspects of this framework.

For **MRM**, we advocate the use of the Instructional Systems Design (ISD) method, modified to be applicable directly to MRM and the aviation maintenance workplace. ISD is a generic term for the methodology of creating and implementing a training program. In this section, we describe this tailored ISD approach.

Figure 3.1 depicts the **ISD** model. The ISD approach places a heavy emphasis on user needs. It incorporates extensive user testing during the design and development phases. Involving maintenance workers and managers on an **MRM** design team is essential when using the systems design approach. We describe each of the major activities in the ISD framework in the following sections.

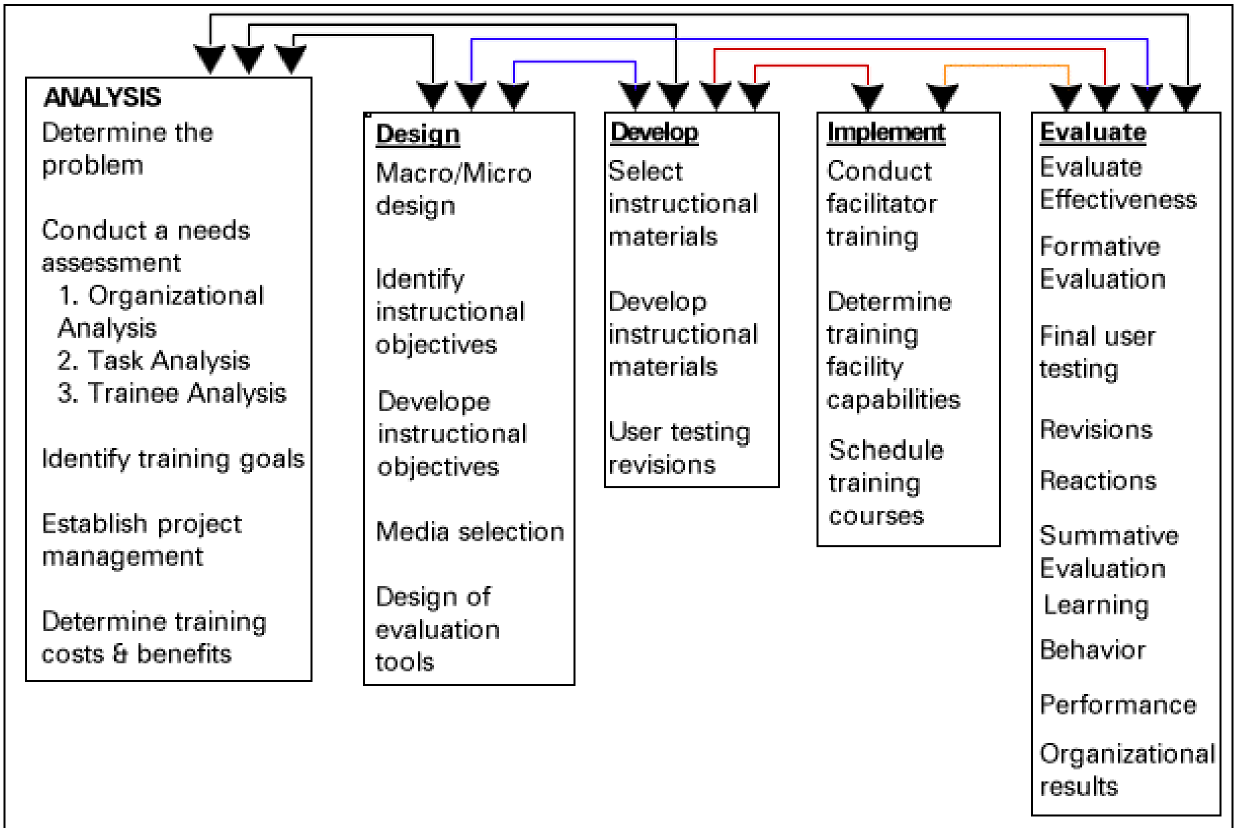

Figure 3.1 The Instruction Systems Design (ISD) Model

Analysis

The first phase of the **ISD** process consists of analysis, usually called "front-end" analysis. Activities in this phase consist of gathering and analyzing information, followed by writing the objectives, goals and functional specifications for the training program. The idea is for the **MRM** design team to identify the organizational and trainee needs and constraints before it begins designing the training program.

Needs Assessment

The analysis phase begins by assessing the requirements, or needs, that the **MRM** training program must satisfy. There are three levels of needs assessment: 1) organizational analysis, 2) task analysis, and 3) trainee analysis.

Organizational analysis.

Organizational analysis consists of an evaluation of the organization and/or industry in which the trainee performs the job, and an evaluation of the organization expected to provide the training. These may or may not be the same organization.

The **MRM** training design and development team is selected during this phase of the process. It is critical to the success of the training program to include representatives from all of the essential areas of the maintenance organization. Likewise, senior management must allow team members to devote the necessary time to the project.

In determining the reasons why an **MRM** training program is being undertaken, it is important to answer two basic questions:

1) What is the current performance of the organization and workers?

2) What is the desired performance of the organization and workers?

If a difference between current and desired performance exists, then we say there is a "performance gap." Organizational analysis determines the probable cause(s) of performance gaps and includes a distinction between needs that can be solved by training and other needs that must be addressed by a change in organizational procedures or policies.

For example, issues that should be addressed by developing a company policy might be re-designing of workcards or re-formatting an Engineering Authorization (EA) form. Examples of a training need could include the inability of engineers and technical writers to write a workcard or **EA** that is clearly understood by others. An **MRM** training need would be to teach **AMT**s the skills that allow them to recognize how the environment, such as the readability of a workcard, impacts human performance.

The second part of organizational analyses is evaluating the resources available for the development and delivery of the **MRM** training program. This consists of identifying various constraints, such as the availability of equipment, time, money, and instructors. This information is transformed into a set of functional design specifications, a specific list of training goals, and system requirements that will provide the boundaries of the training program. The initial specifications document helps the training designer(s) generate appropriate design solutions. Later in the design phase, these functional specifications may be expanded to include detailed specifications for training program development.

As part of organizational analysis, we identify training costs and the outcomes or benefits from implementing **MRM** training. Benefits can be measured by the company's typical performance measures related to maintenance tasks, such as dependability (departures, "return-overnights"), safety (ground damage, occupational injuries), and efficiency and quality (component shop statistics).

Task analysis.

Conducting a task analysis is the second step in a needs assessment. Task analyses are performed to determine the tasks required in a job, the subtasks performed for each task, and the knowledge and skills required to successfully perform the subtasks. Task analysis is a critical step in the design process. If the knowledge and skill requirements are not adequately identified, then the designers will have difficulty determining the required content for the training program. In other words, a trainer must know *what* skills to train and *which* of them are important to completing a task before they can create an effective training program. This need not be an expensive endeavor; it may entail observing employees over the course of a few days, or you may accomplish this by interviewing experts or highly experienced individuals. It is vital, however, that these data are obtained systematically and as completely as possible. If not, a trainer may end up training the wrong or irrelevant knowledge, skills and abilities, resulting in an ineffective training program.

Trainee analysis.

One of the major goals of **MRM** training is to provide **AMT**s with the knowledge and skills that will allow them to function well as part of a maintenance team. Trainee analysis is performed to identify the relevant characteristics of the people who will be participants in the program. Information obtained in this analysis includes demographic data (such as age and gender), occupational experience, existing knowledge and skills relevant to the training program, and a list of elements the trainees regard as important. Trainee analysis should identify the trainees' perceptions of the job-related skills and knowledge they need to effectively perform their jobs.

Design

In the design phase, goals and objectives are developed to select content, instructional strategies, and testing procedures for each training topic identified in the front-end analysis. The design process consists of four hierarchical levels: 1) program, 2) curriculum, 3) course, and 4) lesson. The "program" and "curriculum" levels are associated with a *macro* type of design. At this point, training is linked with the strategic plans of the organization, and a series of course needs are identified for different groups of trainees.

The "course" and "lesson" levels comprise a more in-depth, or *micro,* type of design. At this point, decisions are based on instructional theory and research. Thus the designers are concerned with the learners' ability to understand, remember, and transfer the training concepts to the work site.

It is important to note that a successful training design for **MRM** courses includes a high level of interaction, i.e., group exercises, case studies, and practice sessions. This type of design is known as "adult inquiry learning," in that learners manipulate materials and equipment, participate in problem solving discussion groups, respond to open-ended questions, and collect data from direct observations of instructional events. This type of learning promotes effectively acquiring and processing information. Concrete experiential activities (actually doing something) are highly motivating and tend to promote better retention.

Macro design

During the macro design step, goals are developed that position the **MRM** training program to achieve the company's goals and mission. General training areas are specified and organized into curricula. Curricula may be organized by subject matter, such as MRM awareness or MRM skills development. Once training needs are placed into curricula categories, they are further organized into individual courses or modules, that are then prioritized and scheduled for development and implementation. An additional component of macro design is the initial selection of methods and media that can be used to deliver the training.

Instructional design vs. media technology.

It is important to note that it is *not* the choice of a particular technology that ultimately determines the effectiveness of a training program. Rather, the soundness of the instructional design will set the stage for the efficiency and effectiveness of the training. The design process should not be media technology driven. We should not decide on a particular delivery system or medium until our analyses are complete.

Sometimes we want to deliver a training lesson via videotape or lecture without considering the underlying instructional objectives. A medium inherently is neither "good" nor "bad", but it can be either appropriate or inappropriate. If sound instructional design principles are used, the designer will choose instructional materials and technologies that meet identified learning objectives and functional requirements.

Micro design

Micro design moves from the broad categorization of curricula into courses or modules to the detailed design of the individual courses and the lessons within each course. Micro design is based on the educational goals for each training topic. Learning objectives--what the trainees are expected to know and be able to do after training--guide the selection of "enabling objectives." Course prerequisite knowledge and skills are established. The differences between pre-training and post-training knowledge and skills are transformed into learning objectives for individual lessons.

Learning objectives are used to develop a content outline for individual lessons and finalize the selection of instructional methods and media. A curriculum hierarchy is developed. The terminal objectives are at the top of the hierarchy, followed by enabling objectives. At the bottom of the curriculum hierarchy are the trainees' prerequisites and prior knowledge analysis. This learning task hierarchy flows from the bottom to the top. A trainee must successfully meet one training objective before moving to the next higher level. Training designers next determine if it is possible to purchase existing courses, lessons, and audio-visual materials from vendors that will meet their requirements, or if training materials need to be developed.

Media selection.

During the micro design phase, media and instructional methods are selected for each lesson. For example, a videotape clip may be selected to present the lesson objective, followed by a group exercise. Media selection is dependent on the learning objectives that are to be achieved. There are media selection models that suggest what media (technology) is optimal for specific types of learning objectives.

Often, the design of a lesson will include several complementary media. A module related to shift turnover might include a one- to two-hour videotape describing and demonstrating an effective shift turnover meeting followed by role-playing at a mock shift turnover meeting with feedback from the training facilitators.

The design concept includes a description of one or more delivery methods, as well as the form and content of the actual lesson material. In some cases, several alternative design concepts might be generated for preliminary testing and evaluation.

Design of evaluation tools.

The tools for evaluating the training program should be identified and developed during the design phase.

A number of evaluation tools are commonly used for **MRM** training. Typically, questionnaires are used to measure how well the trainees have learned the course objective(s) immediately after completing the training course. Included in the post-training and follow-up (2-12 months after training) questionnaires are questions concerning how useful the course was to the learner, and his opinions on how he felt the course accomplished the stated training goals. All of these questionnaires need to be designed, validated, and developed in order to be included in the evaluation phase of the **ISD** model.

Development

Following the design phase, the actual **MRM** courseware must be developed. This includes developing all training material, in whichever media are selected during the design process. Since various media interact with certain instructional methods, the development phase includes walkthroughs of all modules that include some type of live instructor/trainee interaction.

Developing training materials

The design team develops drafts of the materials required and seeks the artistic and production expertise of audiovisual specialists. Specifications developed in the design phase are completed for each lesson. Tasks include writing a detailed outline and developing conceptual sketches for audiovisual aids. The outline and sketches are generally reviewed by the entire design team before they are fully developed into instructor scripts, handouts, and participant exercises. Generally, drafts are reviewed and revised before a formal walkthrough takes place.

Prior to conducting a walkthrough, or other type of formative testing, the training materials should be considered to be prototypes. They should have the look and feel of the final product to the extent possible. Prototyping provides the basis for a formative evaluation in which feedback is solicited from the trainee population, managers, peer professionals, and subject matter experts. The prototype test, or walkthrough, is designed to identify and correct problems before the materials are produced for company-wide use.

Walkthrough

It is necessary to identify problems or shortcomings early in the design cycle. Therefore, a walkthrough evaluation is conducted. In a walkthrough, the design team meets with members of a review team and walks them through the prototype course materials. The two groups identify potential problems and discuss any suggestions for improving the materials.

It is possible at this time to have the design team test various instructional options with the actual learners to determine whether less resource-intensive alternatives will result in satisfactory learning. This prototyping phase determines whether certain instructional strategies are necessary and sufficient to accomplish the training goals. User testing should be carried out to ensure that the training program fulfills the needs identified in the instructional functional specifications and learning task hierarchy. Based on the data obtained through user testing, the prototype can be modified and retested.

Final development

Final user testing and full-scale development occur after the materials have been modified and retested, based on information obtained during the walkthrough and other user testing. After the training program is fully developed, it should be subjected to final user testing before being implemented.

Final development of the training program includes all training material and media development. This is usually the most time-consuming step of the entire design process. Final pre-implementation user testing consists of actually conducting the training in a typical training environment. This "test training" uses all the training materials and the trainees perform all of the course exercises. The follow-up questionnaires should be administered after the test training is complete.

Implementation

In this phase of the **ISD** process, the fully pretested **MRM** training is moved to the production environment. Implementation typically consists of two parts: scheduling and facilitator training.

Scheduling

A schedule delineates how and when **MRM** training is to be delivered. For most large-scale programs, it is beneficial to implement the training in stages. A staged approach is useful because it allows trainers, trainees, and management to evaluate the program as it is being rolled out. It also promotes a readiness for change by demonstrating results.

Often, a tentative implementation plan is developed at the end of the front-end analysis phase, once curriculum requirements are identified and a schedule for course development can be determined. As part of this plan, program evaluation criteria should be specified.

Facilitator training

In many instances, the facilitators or instructors are not part of the design team. Even when they are involved in the design process, they may have to learn certain facilitator skills, as well as learning the course materials and the intent of the training. Such training is usually designed and written during the development phase and presented as required throughout the prototyping and implementation stages of the **ISD** process.

For **MRM** training programs, co-facilitation is essential as it provides the opportunity for two representative workers to actively present and facilitate the instructional process. Having co-facilitators allows for a high level of interaction among the course participants as well as providing subject matter expertise in the field of aviation maintenance.

Early experience from **MRM** courses has shown that MRM training is highly effective when **AMT**s co-facilitate with human factors experts. Together, they can be a dynamic team representing a valid combination of knowledge and work experience. Additionally, they can respond to course participants with examples and scenarios that demonstrate the training concepts being presented.

Evaluation

It is very important to evaluate the effects of the **MRM** training program. This step is often overlooked in industrial settings. However, a reasonable evaluation effort can determine whether the overall program was successful and met the training program goals. The output of the evaluation can be used to determine whether and what type of revisions or modifications needs to take place.

Evaluation types

There are two types of evaluation: formative and summative. Formative evaluation occurs as the instructional program is being developed. Summative evaluation occurs after the training is implemented. Summative evaluation takes place during the implementation stage of the **ISD** process. It is typically conducted at the end of each training presentation. It acts as a summation of that course session.

Summative data collection includes the assessment of the trainees' mastery of the course material, as well as the appropriateness of the training design. Summative evaluation can also be conducted some time after the instruction has been taught. In these instances, it is often called follow-up evaluation. Its purpose is to determine if the training is being used by the participants. It is most often used to determine the success and effectiveness of the training program.

Summative evaluation

The summative evaluation process can be viewed as a four-step process:

1. **Baseline Assessment**: In order to establish if your training has had any effect on the organization, a baseline assessment must be made. A baseline assessment is merely a measure of the current environment before testing. It is important to use consistent measures for future post-training assessment; baseline and post-training measures will be compared to evaluate the effect of training.
2. **Reaction:** Post-training questionnaires are administered immediately after the training to evaluate and measure the program success. The facilitators are also evaluated. The main thrust of this evaluation should occur during final user testing as well as upon completion of the course.
3. **Learning:** Subject mastery is measured before and after training. Criteria used to measure the level of learning is identified in the design phase. Typically a pre/post training questionnaire is used to evaluate the learning that takes place as a result of the training. Learning includes gaining principles, facts, techniques and attitudes.
4. **Behavior:** The effect of training on the learners' work performance is evaluated at this step. Has the trainee transferred the concepts from the training program to the work site and applied them so that there is an observable difference? Self-reported comments on follow-up questionnaires as well as interviews and observations of the trainees in the field are most valuable.
5. **Organizational results:** At this step, organizational performance measures identified in the analysis phase are tracked over time to determine if a difference (attributable to the training program) has occurred. Any evaluation at this point can be viewed as a secondary result of the training program. That is, changes in attitudes and behavior affect job performance, which, in turn, affects organizational factors such as safety, dependability, quality, and efficiency.

Table 3.1 summarizes and gives examples of each of these evaluation types.

Table 3.1 Five-Step Evaluation Process	
Examples of Evaluation Measures	
1. Pre-Training Baseline Assessment	Questions asked of trainees concerning the training objectives, e.g., *"What are four human factors elements that impact performance?"*
2. Trainee Reaction	Questions asked of trainees concerning usefulness, value and relevancy of the training, e.g., "*How useful was the lessons on norms?*"
3. Learning	Content-related questions asked of trainees that are the same as pre-training questions, e.g., "*What are three types of human error?*"
4. Performance (Behaviors on the Job)	Observations, interviews, and behaviors; questions can be asked of the trainee of their behavioral intentions, e.g., "*How will you use this training on the job?*"; "*What changes have you made on the job?*;" Observations: Supervisor and Leads observe crews and rate them on a scale assessing the use of a new behavior.
5. Organizational Results	These are performance measures gathered at the unit and organizational level, e.g., aircraft ground damage indices, number of on-the-job injuries, percentage of on-time departures, etc.

It is important to measure the effectiveness of the training program using all four evaluation criteria levels. Commonly, organizations apply only Levels 1 and 2, reaction and learning, evaluation criteria, and do not conduct an evaluation at Levels 3 and 4. This is because it typically takes additional resources to conduct these evaluations. However, it is critical to evaluate the training program in a comprehensive manner to fully understand its effects.

FINAL NOTE

Implementing a training program seems at once simple and complicated. On one hand, training programs are implemented everyday; on the other hand, the guidelines outlined above show that proper implementation is made up of a variety of tasks and subtasks, each one building upon another. However, when broken down into its basic parts, development, implementation, and evaluation, training is not complicated. It requires only the ability to manage a variety of tasks, combined with the skill to perceive these tasks as a whole. Keeping in mind how training will be evaluated months in the future will help in the initial design of the program.

The "big picture" does not just stop there, however. It must also be remembered that **MRM** is more than just a training program or its parts. That is easy to forget when one is bogged down in the details of creating a human factors course, for example. MRM represents a shift in thinking about how one does his or her job. It encourages individuals to feel personally responsible for safety and provides the tools for them to begin down that path. To that effect, a holistic approach must be taken when developing and implementing an MRM training program. It should not be done half-heartedly with shoddy materials and insufficient resources, for example. This does not demonstrate full commitment, and will not inspire trainees to embrace a safety culture. After all, if management does not care enough, why should I? Therefore, MRM's effectiveness does not necessarily lie in a training program; the training program only provides MRM's tools. For MRM to be fully effective, employees should be encouraged to use those tools, believe that they can use those tools, and be shown that those tools make a difference. This remains the basic philosophy of MRM.

Chapter 4 SUMMARY

Aviation has made great strides in safety over the past 50 years. Presently, aviation enjoys an enviable rate of reliability, safely transporting millions of passengers each day. However, as the sheer number of passengers and departures increase, accidents will likely experience a similar increase. Though the mishap rate remains exceedingly low, extrapolating upon the current rate of growth in air travel, a major accident will occur once a week, on average, by the year 2010.[53] The Federal Aviation Administration has deemed this unacceptable and has instituted a range of programs to combat the expected rise in aviation mishaps.

Crew Resource Management, among other initiatives, represents one of the first *people-oriented* programs specifically designed to reduce the human error that leads to accidents. Its success is well-documented. But just as the flight crew is a piece of the aviation puzzle, so are maintenance personnel another piece. Maintenance Resource Management represents a modern, holistic approach to aviation safety. It encompasses all employees who have contact with aircraft and who have a direct or indirect impact on the safety of the flying public by establishing an overall *safety culture*. Currently, **MRM** is targeted specifically towards maintenance personnel, but its philosophy may be extended to include other employees, such as those on the ramp. By including all members of an organization, safety can be inculcated and become second nature to everyone. When everyone feels *personally* responsible for the safety of the flying public, the public *will* be that much safer.

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Appendix A: GLOSSARY

active failure: a type of human error whose effects are felt immediately in a system

AMT: aviation maintenance technician

assertiveness: verbalizing a series of "rights" that belong to every employee. Some of these rights include the right to say "no," the right to express feelings and ideas, and the right to ask for information

asynchronous communication: communication in which there exists a time delay between responses) Asynchronous communication is typified by a unique set of characteristics, such as the lack of non-verbal communication cues (e.g., body language, verbal inflection, etc.) Examples of asynchronous communication include an e-mail message sent from the day supervisor to the night supervisor or memos left between shifts or passed between the shop and the hanger.

authoritarian leader: dictates action and the course of the team with little input from team members.

communication: the process of exchanging information from one party to another

complacency: the degradation of vigilance in a situation

Crew Resource Management: team-based human factors training for flight crews

"Dirty Dozen"*:* Twelve common maintenance-related errors

Human Factors: the scientific study of the interaction between people, machines, and each other

inter-team: occurring between separate teams

intra-team: occurring within a team

ISD: Instructional Systems Development

instructional systems design: a generic term for the methodology of creating and implementing a training program

latent failure: a type of human error whose effects may lie dormant until triggered later, usually by other mitigating factors

leadership: the ability to direct and coordinate the activities of group members and stimulate them to work together as a team

Maintenance Resource Management: a general process for improving communication, effectiveness, and safety in airline maintenance operations

mental model: how a subsystem is depicted in a person's mind, i.e., how we think a system is put together and how it works

participatory leader: encourages member participation and input to help lead the team's course of action

norms: expected, yet implicit rules of behavior that dictate fundamental rules of dress, speech, and basic interaction

"***safety culture***": a pervasive, organization-wide orientation placing safety as the primary priority driving the way employees perform their work

situation awareness: maintaining a complete mental picture of surrounding objects and events as well as the ability to interpret those events for future use. Situation awareness encompasses such concepts as arousal, attention, and vigilance

SOP: standard operating procedures

stressor: an event or object that causes stress in an individual

synchronous communication: real-time communication in which a minimal delay exists between the message being sent and the message being received. Examples include face-to-face conversation and communication via radio.

team: a group of interdependent individuals working together to complete a specific task

Team Situation Awareness: maintaining a collective awareness across the entire team of important job-related conditions

Appendix B:
FURTHER READING

The documents listed here provide detailed information related to the topics discussed in this report.

Cockpit/Crew Resource Management

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You may order the electronic version of The Human Factors Guide for Aviation Maintenance and Inspection (Vol. 3) from Galaxy Scientific Corporation. The "Human Factors Guide" reviews and summarizes a variety of human factors issues, from workplace design to human error to training, as they apply specifically to aviation maintenance. To request a CD ROM free of charge (to those within the United States), please write:

ATTN: FAA CD98 Distribution
Galaxy Scientific Corporation
2130 LaVista Executive Park Dr.
Tucker, GA 30084
or call **(770) 491-1100**.

ICAO Documents

Human Factors Digest No. 12: Human Factors in Aircraft Maintenance & Inspection

Human Factors Digest No. 2 - Flight Crew   Training: Cockpit Resource Management

Circular 217 Line-Oriented Flight Training   (LOFT)

Circular 247 Human factors, Management and Organization

Human Factors in Aircraft Maintenance & Inspection (Digest No. 12) provides a very good overview of the problems in aviation maintenance. It uses a few high profile accidents to illustrate its points and discusses the importance of looking past the obvious micro issues to organizational culture factors, which contribute to latent failures and overall systems problems. All of these ICAO documents are available from:

ICAO
Document Sales Unit
1000 Sherbrooke Street West, Suite 400
Montreal, Quebec
Canada H3A 2R2
Phone: (514) 285-8022
Fax: (514) 285-6769
E-mail: sales unit@icao.org

Training

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Appendix C: Maintenance Resource Management Sample Curriculum

Facilitator Handbook: Maintenance Resource Management Training

Module 1 **<u>MRM Human Factors Training: Introduction</u>**

Maintenance Resource Management

Day 1: Training Goals:

1. To understand what human factors and maintenance resource management principles are.

2. To increase the awareness of how human factors and MRM principles impact human performance.

3. To understand how MRM and Human Factors principles can promote a safe and error free workplace.

4. To examine the human role in the maintenance operations in relation to chain of events.

5. To provide human factors and MRM techniques and skills that will help you interact with others.

6. To develop an understanding of available Human Factors and MRM resources, internally and externally to your company.

Day 1: Training Objectives:

1. To recognize and identify the Human Factors elements

2. To understand human error and recognize contributing causes

3. To identify the chain of event in an accident

4. To develop safety nets or "link busters"

5. To identify and recognize norms

6. To be aware of individuals differences and behavioral styles

7. To be aware of how written communication can reduce human error

8. To develop effective communication skills

Activity/Overhead	Facilitator Notes

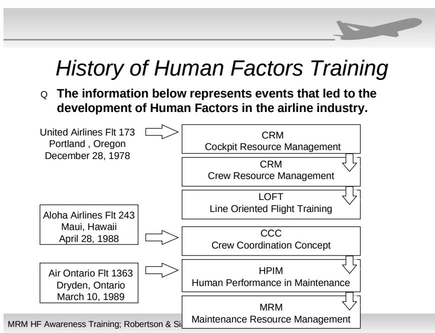
Handout

Pre-training questionnaire

Explain: This course is being evaluated. We need a before and after picture. Here is a survey we want you to complete. Your answers, combined with all other people in Maintenance who take this course, will help us better understand our Human Factors training program. Of course, the survey is completely confidential. Please do not put you name on it anywhere.

Assign group names: types of aircraft

Overhead: History

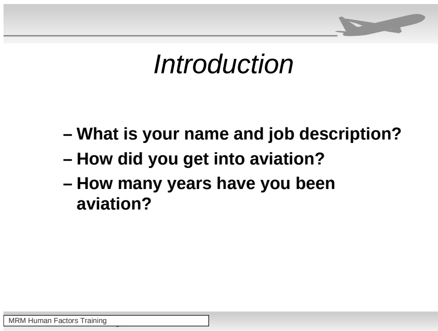


Explain: This overhead illustrates the events that led to the development of Human Factors training. We are here today in our MRM course to learn about error management, by using human factors skills and understand what error-prone tasks are.

The importance of human factors and maintenance resource management can be traced back to the Aloha Airlines accident in 1988 followed by the Dryden Air Ontario accident in 1989. Maintenance Resource Management built on Crew Resource Management programs that had been developed for pilots.

In today's course we will be introducing MRM principles and concepts to you as they related to aircraft maintenance. This course was developed for maintenance personnel from the start based on a review of how you do your jobs and where the problems occur.

Overhead: Class Introduction



Introduce facilitators and participants (Allow 30 seconds for each participant).

Name/Title

Years of service

How did you get into aviation?

After introduction, explain: As you can see there is a considerable amount of experience within this room. We have different backgrounds and cultures, but we all are part of aircraft maintenance.

Overhead: Workshop Agenda

We understand that some of these terms may be new to you, but as the day goes on, you will understand what these terms mean. Please be prompt on returning from your breaks. Lunch and breaks are at... Feel free to use the restroom.

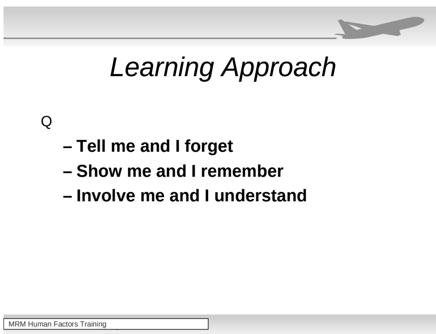
First we’ll begin by presenting and discussing what is human factors and MRM. This includes identifying important human factors elements, understanding human error and causes, recognizing the dirty dozen or human factors elements in aircraft maintenance and identifying chains of events and breaking the chain of events by implementing safety nets or “link busters.”

Next, we will recognize norms and understand their impact on human performance. Then we will cover the idea of individual differences and how they can influence our behavior on the job. Understanding the importance of effective communication that is written and verbal will be our last MRM training area, and we will have some great group exercises in this section. That will wrap up Day 1.

Day 2 will build on these MRM concepts and you will be begin to become more aware of the importance of human factors and MRM. Our first activity will be to discuss teamwork and have a group exercise. Next we will talk about stress management, how to recognize stress, and how to manage it. We will also talk about fatigue and shiftwork and how it effects our performance. Recognizing how task interruptions impact our performance and can cause us to make errors is our next area of discussion. We will also talk about complacency and how we can develop safety nets or link busters to avoid errors.

We’ll also learn to recognize and avoid situation awareness problems, and understand the factors that can impact situation awareness within a maintenance team. To better understand what MRM and human factors programs our company has developed and what departments exist we are going to present you what our MRM and human factors activities are. This will also include what MRM and human factors resources we have in our company and who we should contact. We want to you to understand who and what department you can contact to present and discuss MRM and human factors issues and ideas.

Overhead: Learning



This is a workshop, not a lecture. You will get out of it what you are willing to put into it. If I lecture, you will not remember, but if you are involved, you will get more from this course. Involvement is an important way of doing business at XYZ airline. This class includes case studies, reviewing videos, and doing group activities. It is highly interactive.

Overhead: We agree/you agree

We have a lot of material to cover, and we need to remain focused on the topic.

We are going to do a lot of table or group exercises in this class. We may mix up the participants in each group as the workshop evolves over the next two days. This will give everyone an opportunity to work with different individuals from different department within maintenance operations. We have found that this experience of working with others from other areas within the company is beneficial to understanding what each other’s job just are, and especially in how our job may affect their job.

We would like each person to have the opportunity to either write down the group’s ideas when we go through our group exercises and/or present the groups ideas to the whole class. At the end of the workshop you will see all of our hard work posted around the room. As you can see now, we have posters up containing MRM and human factors materials.

Let's have fun in this workshop; we are here to learn, expand our thinking, and listen to others.

IF there are issues that are not relevant to this MRM workshop, we are going to write them on this flipchart and they will serve as a list of issues that need to be addressed at another time. This will keep us focus on the workshop topics presented, not a "whining" session about the problems of work.

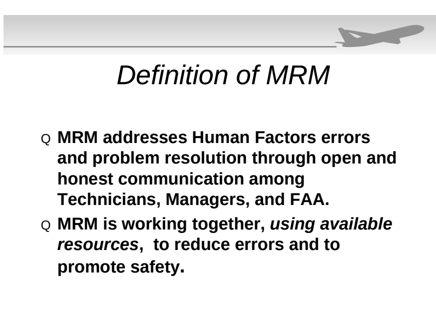
We will have lots of activities during the course of this workshop and we look forward to working with you on sharing and developing our knowledge about MRM and human factors.

Video or "visible" support from top management regarding MRM/HF course. Plans and actions for implementing MRM in the maintenance operations.

Examples: Senior manager(s) comes to the beginning of course; "talking head" video; letter; newsletters

Explain: MRM is Maintenance Resource Management. As you can see, we are dedicated to enhancing safety through implementing these MRM principles, together... all maintenance operations personnel.

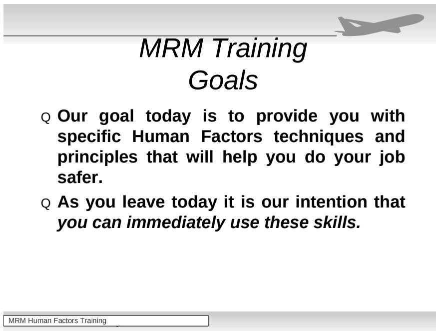
Overhead: MRM definition



Refer to current MRM and human factors articles in the appendix section of your handbook.

MRM Human Factors Training

Overhead: Goals

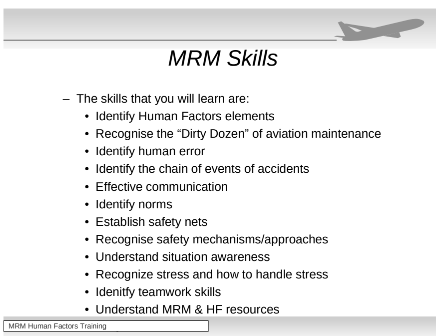


Emphasize: you can immediately use these skills!

MRM Goals:

1. Increase safety
2. Reduce human error
3. Reduce the effects of human error
4. Enhance teamwork
5. Increase situation awareness
6. Increase effective communication

Overhead: MRM Skills



We are going to learn these skills today in class.

BREAK

10 minute break

Module 2 **<u>Human Error</u>**

Training Objectives:

1. To understand human error and recognize contributing causes

2. To be aware of how errors can impact human performance

3. To identify human error types

Activity/Overhead Facilitator Notes

Video: Show Dryden video or Show Nation Air video

Note: Depending on time, MRM facilitators will need to decide whether to show two videos or one. The Nation Air video is produced by MARS. Contact them to acquire the video. Dryden video can be purchased from Qantas airlines (CRM training). Both videos clearly demonstrate crew management problems as well as several other Human Factors problems. Design this specific module carefully to use these videos to accomplish specific training objectives and skills. You may want to break the presentation into two parts. Have a discussion or group exercise to begin to de-brief the video.

Let’s watch a short video.

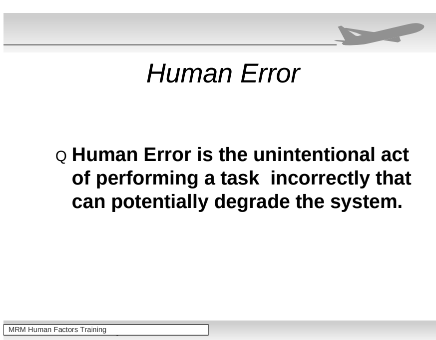
Question: Why did this accident happen?

Discuss the role human error played in the accident. Defrief class as to why this accident happened. Make the class aware that an accident was caused by human error.

Question: What is human error?

Human error can also be defined as:

Overhead: Human Error is..

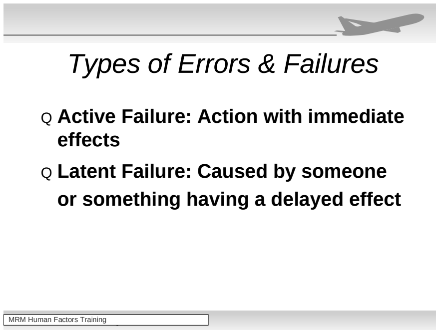


Slip: a good plan, bad execution

Mistake: bad plan

A violation can be seen as an intentional deviation from safe operating practices, procedures, standards or rules.

Overhead: Two types of errors or failures



These errors are very important to recognize in our maintenance operations. Latent failures are ones that we really need to pay attention to. These types of failures sneak up on us and we sometimes do not know why they happened. There are so many causes and the errors all have to line up in order for an accident to happen.

Reference (Reason, 1997)

Overhead: Factors Line up to Cause an Accident

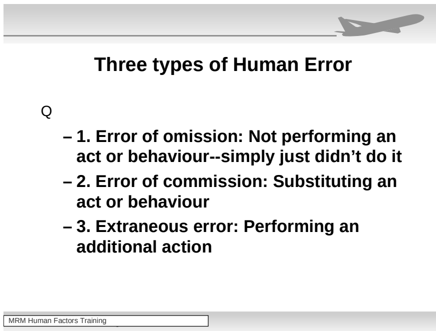
Active and latent failures and conditions are present and can become "holes" in several layers of defenses. If these holes line up, then when a series of human errors occur and accident can occur.

Overhead: A Human Factors Accident

This slide shows how an accident can occur when all the holes are lined up and active and latent conditions or failures exist.

Let us walk through an accident scenario where all of the defenses did not work.

Overhead: Types of Human Errors



Explain error of omission.

Example of error of omission:

Elevator scenario: get in elevator, door closes, forget to push button--, error of omission. Get in elevator, want to go to ninth floor and push the fourth floor button instead--, error of commission. Get in elevator, wants to go to ninth floor and pushes fourth button instead--, gets off on fourth floor---, extraneous error.

Question: Ask class what type of errors did the crew do in the Dryden accident.

Overhead: Nuts & Bolt

There is only one way to disassemble

40,000 ways to error in reassemble

Class demonstration

Group Exercise

(Reference: Reason, 1997)

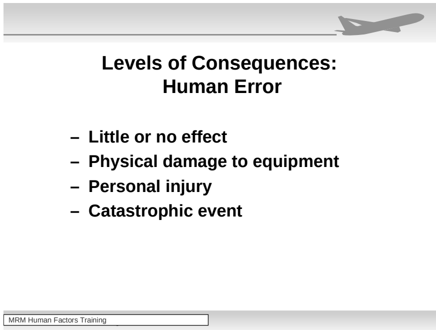
Questions:

Have either facilitator or groups study a bolt with a series of nuts on it. Discuss the implications of removing the nuts. What are the human factors implications? What type of errors could occur?

What type of human factors design principles could be used to prevent errors?

These are called safety nets or link busters (Porter, 1997).

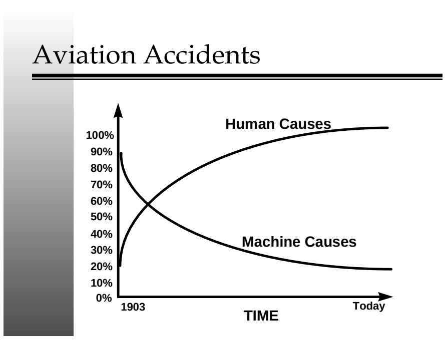
Overhead: What are the level of consequences of human error?



Ask: What the level of consequence was on the Dryden incident?

Answer: Catastrophic

Overhead: Aviation accident chart

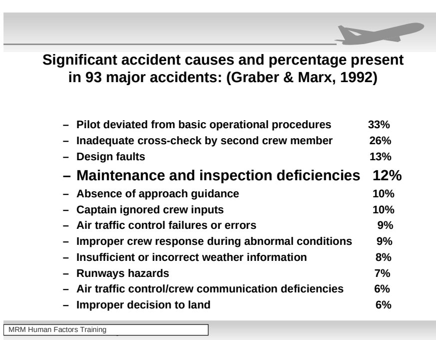


Explain chart: State that 80% of accidents are caused by human error.

If we look at aviation accidents over the course of history, we see that accidents due to mechanical deficiencies have declined. Systems are much safer than they were for Orville & Wilbur Wright.

Correspondingly, however, those with an underlying human component have increased. (Mainly because that's what is left to blame when something goes wrong.)

Overhead: Accident causes/percentages



In general, around 80% of accidents have human error as a major causal factor.

Not only pilot errors are included in human error--

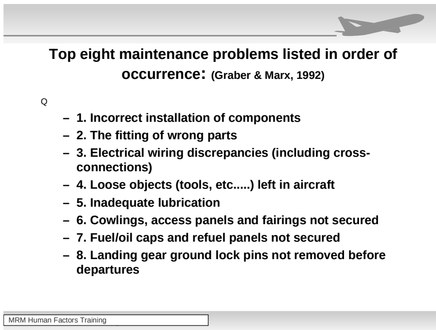
12% involved maintenance and inspection errors.

Therefore, pilots are not the only ones-- maintenance personnel cause errors in aviation also. Show the role that maintenance and inspection play,(other crews).

Video: Show short video clips of AA#1 and Dash 8	Maintenance contributed to both of these accidents. (Incorrect wiring on AA, improper fuel filter installation on Dash 8) (Boeing company manufacturing and safety video).

Group or class exercise

Overhead: Top 8 maintenance problems



Facilitator's note: class exercise

Before showing slide, ask, "What do you think are some of the maintenance problems that contribute to accidents?" Take the class's reasons. Then show this slide. Compare.

Explain overhead:

This is a list of the most frequent maintenance errors. Any of these can lead to a loss of airworthiness, delays, inflight emergencies, or an accident if not corrected.

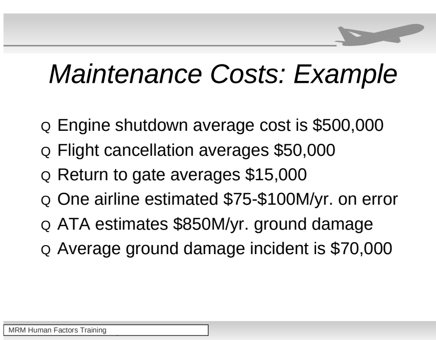
Most of these problems involve human error. Unfortunately, within the term *human error* is an underlying theme of "finding who is to blame?" It is our natural tendency to look for the last person who touched the aircraft or part and blame that person for the error.

However, error can be caused by many contributing factors. Human factors studies those factors that can lead to problems or failures in the human component of a system.

Reference: Three year study by UK CAA; reported in Graeber & Marx, 1992.

Now lets look at how these maintenance problems relate to human lives lost in aircraft accidents.

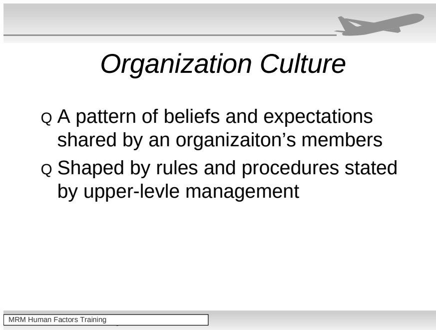
Overhead: Maintenance Costs Example



Maintenance errors can be translated into costs. These are some examples of maintenance costs.

Can you think of any others?

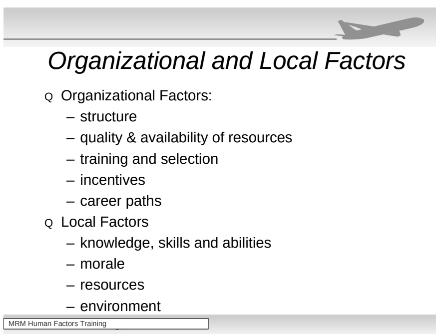
Overhead: Maintenance & Organizational Culture



An organization's culture also can contribute to error.

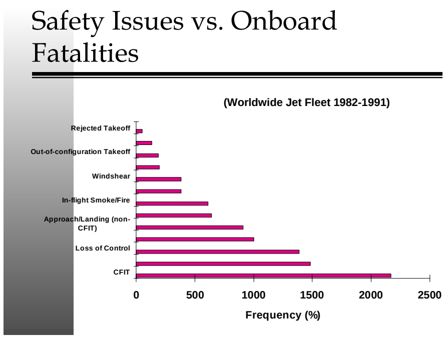
For example, an organization that makes on-time departures its number one priority may, in fact, be neglecting or even eroding safety. This company does not give its employees enough time for a proper aircraft turnaround, and second, does not give them the power to ground a suspect plane. Even though management may not intend to, their practices encourage unsafe aircraft.

Overhead: List of organizational and local factors



In any company, organizational factors interact with local factors. Organizational factors include the organizational structure, the quality and availability of resources and their distribution to employees, the training and selection of personnel, and the awareness of how incentives, career paths, and other people management factors affect employees. Local factors are those factors found on the hanger floor itself. These include the knowledge, skills and abilities of those in the work group, employee morale, the availability and quality of resources in the hanger itself, and the environment. Other local factors include your own personality, dispositions, and the types of moods you feel. Local and organizational factors may interact in such a way to create an extremely error-prone work environment.

Overhead: Safety issues vs. Onboard fatalities



Explain maintenance's involvement toward the loss of life in aircraft accidents.

Worldwide, maintenance problems are the second greatest contributor to onboard fatalities, following controlled flight into terrain (CFIT) problems.

Reference:

Reference: United Kingdom Civil Aviation Administration (1992), maintenance error, Asia Pacific Air Safety, September. Referenced in Marx, D. A., & Graeber, C. R. (1994). Human error in aircraft maintenance. In Johnston, N., Mcdonald, N., Fuller, R. Aviation Psychology in Practice, United Kingdom: Avebury.

Comment

Errors affect profit

Errors are frequent but tolerance is high

Small percentage actually cause incidents

Most of these discrepancies involve human error. Unfortunately, within these definitions of error is an underlying theme of who is to blame. It is our natural tendency not to search for a root cause, but to look for the last person who touched the broken object. However, human error can be caused by one or more contributing factors. This is what we define as human factors elements. Now, lets discuss what human factors is and how to recognize human factors elements and understand how they impact our performance, thus contributing to human error. Remember, we want to understand this so that we can contribute to reducing errors.

Training Objectives:

1. **To understand what Human Factors is.**

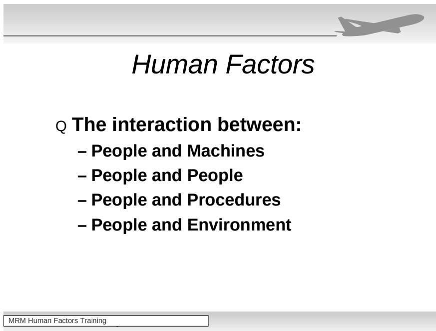
2. **To identify Human Factors elements.**

Activity/Overhead	**Facilitator Notes**

Question:

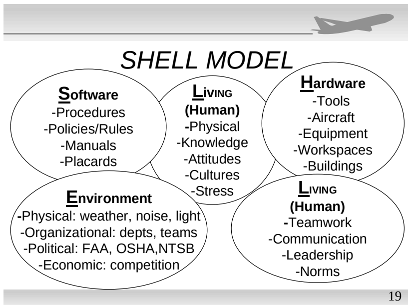
What is Human Factors?

Overhead: Human Factors



Human factors is the interaction between human and machine, human and environment, human and procedures, and human and human. We are the core of this model. We interact with other humans to get our job done. We interact and work with procedures, tools, equipment to get our job done. We also, interact with the environment--that is, the weather, physical structures, organizational structures (departments), and other airline companies—they are external environments to us. We interact and work with them to get our job done; if we need parts, we borrow from them, with paperwork and procedures to follow.

Overhead: SHELL Model



Define the acronym of SHELL.

Software

Hardware

Environment

Liveware (Living)

Liveware (Living)

The design of the hardware and software impacts our performance. The environment also impacts our performance as we interact with these technologies and work in physical environments. We interact as we work with co-workers, and they each have individual differences like us. We have to interact with others in order to get our job done safely and error free. We are affected by other co-workers' attitudes.

The organizational environment is the company culture, departments, team structure, divisions, and other organizational structure. We all work in a department that interacts with other departments in this company and each of us has policies and procedures and so do they. Then we have company policies that might outline our work tasks. These all impact our performance.

Outside external economic factors are political factors, regulations, (FAA, NTSB), the public, and other airlines. They are our competition.

We have many airlines that are responding to the market; they have changed their public image by changing their name, painting the aircrafts, changing logos and themes, etc.

Let's look at how these human factor elements interact with us individually. Any interactions between us and these human factors components provides the opportunity for human error which can potentially result in an accident. We are in the center of the model and play a central role in error management. If we understand how all of the HF elements affect us we can move toward increasing our awareness of ***how*** human errors can occur and begin to manage the process better.

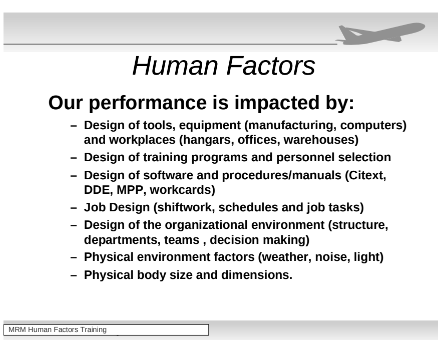
We have to accept that we as humans are fallible, ***however***, we can change the working conditions and awareness in which people work. This type of thinking leads us toward increasing our human reliability and ultimately the systems reliability. (human reliability + equipment reliability = system reliability)

Question:

Are there any questions on this model?

Let me provide some more examples of these human factors elements and how they impact our performance.

Overhead: Human Factors



The design of machines, tools, software, organizations all can impact our performance. Our performance is impacted by the following human factors elements. It is the interaction between these human factors elements that provides the opportunity for human error which can potentially result in an accident.

How does any of these HF elements affect you? Any examples?

Transition

We've been looking at what HF elements are and how our performance is affected by them. Now, let's look at 12 error causes that have been identified as the most frequent factors that play a role in maintenance related accidents. These error factors are caused by human factors elements. They have been the "Dirty Dozen" (Dupont, 1997); or simply human factors elements. They are specifically human factors elements. They are specifically related to maintenance operations and how all of these affect our performance and can lead to human errors. These are not excuses--these are identified reasons that can lead us to make errors.

Overhead: Human Factors Elements

Human Factors elements
“Dirty Dozen” (reference Dupont,1997)

Human Factors Elements:
Error causes

Q

1. Lack of Communication	7. Lack of Resources
2. Complacency	8. Pressure
3. Lack of Knowledge	9. Lack of Assertiveness
4. Distraction	10. Stress
5. Lack of Teamwork	11. Lack of Awareness
6. Fatigue	12. Norms

MRM Human Factors Training

Overheads:

Examples of Human Factors Elements & Concepts

These two overheads provide examples of human factors elements and concepts. More discussion could occur here with the class.

Human Factors Elements: Examples

- **Equipment/Tools/Parts**
- **Aircraft Design/Configuration**
- **Job/Tasks**
- **Technical Knowledge/Skills**
- **Environment/Facilities**
- **Organizational Environment**
- **Leadership/Supervision**
- **Communication Issues**
- **Information Transfer**
- **Procedures,manuals**

MRM Human Factors Training

Human Factors Concepts

- Error Recognition
- Detection and Perception
- Human Capabilities & limitations
- Physical Compatiblity
- Habituation
- Behavior
- Stress
- Systems Approach
- Usability
- User Population
- Vigilance Tasks
- Workload

MRM Human Factors Training

Overhead: Human Factors Elements

Human Factors Elements Examples

- Lack of Communication: A lack of clear direct statements and good, active listening skills.
- Complacency: Self-satisfaction accompanied by a loss of awareness of the dangers.
- Lack of Knowledge: Lack of experience or training in the task at hand.
- Distraction: Draw one's attention away; mental emotional confusion or disturbance.

MRM Human Factors Training

Presented here are the definitions of the human factors elements and human factors causes which consists of the "dirty dozen." (Reference, Dupont)

We will be discussing some of these human factors elements later in more detail. Others will be covered in future MRM courses.

Overhead: Human Factors Elements: Examples

Human Factors Elements: Examples

- Lack of Teamwork: Lack of working together to achieve a common goal.
- Fatigue: Weariness from labor or exertion, nervous exhaustion; temporary loss of power to respond.
- Lack of Resources: Failure to use or acquire the appropriate tools, equipment, information and procedures for the task at hand.
- Pressure: Pushing against opposing forces; Creating a sense of urgency or haste.

MRM Human Factors Training

Human Factors Elements: Examples

- Lack of Assertiveness: A lack of positive communication of one's ideas, wants and needs.
- Stress: Mental, emotional or physical tension, strain, or distress.
- Lack of Awareness: Failure to be alert or vigilant in observing.
- Norms: The commonly accepted practice of working routine jobs without the manual.

MRM Human Factors Training

BREAK 10 minutes

Module 4 **<u>Chain of events</u>**

Training Objectives

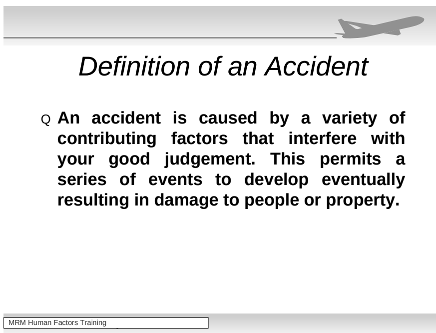
1. To understand an accident chain of events.

2. To be aware of how human factors elements contribute to each link of the chain.

3. To understand what a safety net is and how it can break the chain of events.

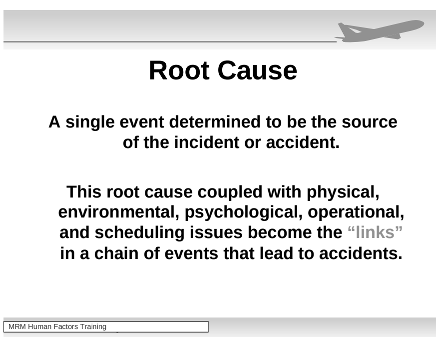
Activity/Overhead

Overhead: An accident is..

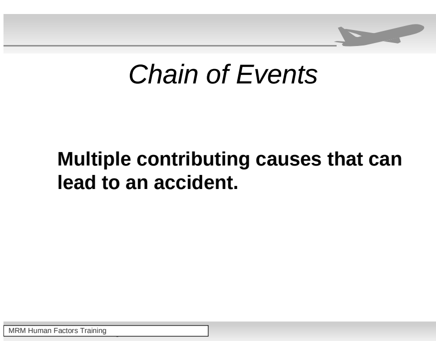


In every accident there are a series of events that link together to form a chain. We call this a *chain of events*. This is our definition of an accident. The FAA, NTSB, and the company have different definitions, but this is how we will be defining it for this course.

Overhead: Root cause



Overhead: Chain of events



Example of chain of events, pull example from the SHELL

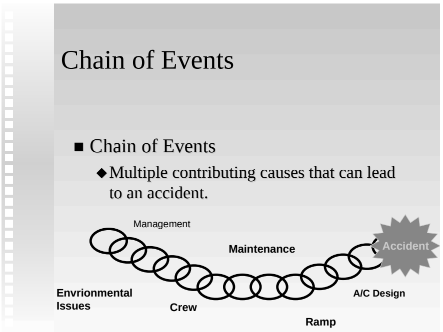
-poorly designed tools

-poorly designed procedures

-weather

These could be possibly be links in a chain of events to an accident.

Overhead: Chain of events



As stated earlier, in every accident there is a series of events that link together to form a chain. We call this a chain of events.

Each one of these links could represent a component of the SHELL model, i.e., procedures, weather, tooling, etc.

Accident Chain:

1. Contributing factors
2. Serial events
3. Conditional events
4. All factors must be present
5. Break the chain

Domino's Effect

Overheads

"Swiss cheese" Model or

Reason, Model

Show line up of causes, failures, filters, defenses—accident scenario

This domino model show how components in a maintenance operations or airline system can interact to create an accident. Think of an accident as the last domino in a line of dominoes. Human factors such as the environment, policies that are in place, equipment, and the people who take part in the system are all represented as the earlier dominoes. Remember how we discussed active and latent failures and how they need to line up in order for an accident to occur. We are using the domino effect as another example of chain of events. Each domino can also be thought of as an accident causal factor.

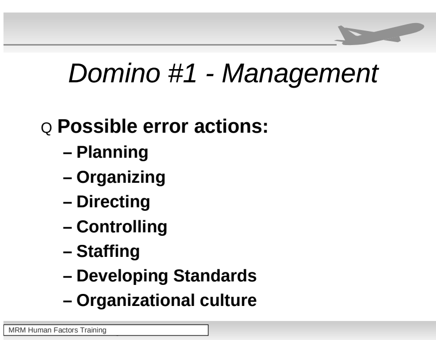
Class Exercise/Demonstration

Set up Domino's in a line and demonstrate how they fall. Take one out and see how that can "break" the chain.

If each domino is faulty and falls, it will cause the next domino to fall, until the last one, the "accident," falls. The purpose of human factors is to identify each of those dominos and try to remove at least one, if not all from the line. If we do this, the last domino won't fall and we prevent an accident.

One way we can do that is by developing a safety net. We'll talk about safety nets soon.

Reference: Reason, 1997



Reason Model of: These factors line up, that is

Underlying Cause (Management)

Basic cause (System)

Immediate Cause (Individual)

Safety Defenses: Filters (Countermeasures)

Consequences; Results (Incidents, accidents)

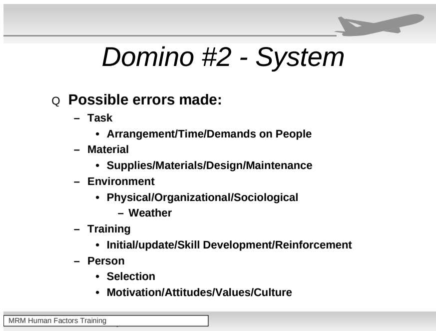
Management; communication, decision making

System: Policies, procedures, structure

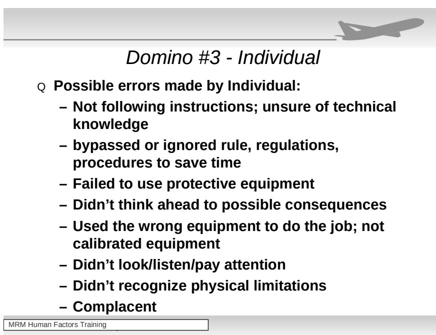
Individual: Physical & Mental limitations

Filters: (Counter Measures—Developing Safety nets

Results: (Accidents, Incidents, Near misses, mishaps, close calls)

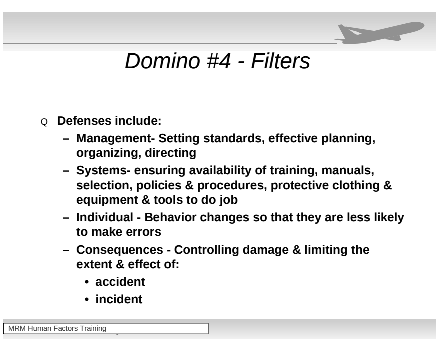


We discussed earlier active and latent (or hidden) errors. The domino theory focuses on what the underlying cause, basic and immediate causes are. There can be several causes and this is why we view an accident chain as a system problem. There can be several safety defenses and filters. These are developing safety nets or link busters. They are the application of human factors and MRM principles. That is, effective communication and teamwork, aware of others in the workplace, stress management, accurate procedures, etc.

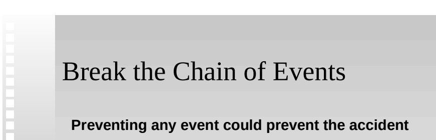


Note: You may want to provide several maintenance examples to illustrate the domino theory and layers.

Explain and demonstrate Domino Collapse.

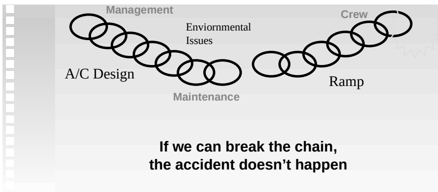


Overhead: Broken Chain



IF we can break the chain at any link, the accident doesn't happen.

Harry Truman had a sign on his desk that said "the



buck stops here." In maintenance we need the same philosophy.

If we can break the chain at the maintenance level, the accident doesn't happen.

"Link Busters"

Any mechanism or filter that is put in place that can help break the chain of events (Porter, 1997).

Allow 12 minutes to read

Read: Dryden: Case Study (Part I)

Two parts of Dryden

Reference: Case study on the crew coordination issues, pilot and cabin crews.   Case study on the maintenance role in the Dryden accident. (Taylor, 1997).

Ask Question:

What was the role of maintenance in Dryden?

Discussion:

It is important to understand the chain of events and that maintenance did have a role in this accident. If the chain of events had been broken, the accident would not have occurred. What we could have done as a Technician is broken that chain by having the APU working.

Video: Dryden (part II): Maintenance

Let's watch the Dryden video to identify other Human Factors contributing causes that we discussed in the SHELL model and the Dirty Dozen. Refer to a worksheet in your participant workbook. Also identify the chain of events. Look around the room for the posters of the Dirty Dozen, the SHELL model, and chain of event.

De-brief exercise

Flip charts are given to each group and then a member is selected as a spokesperson to present the group work. Other class members provide suggestions and comments.

Group Exercise One group identifies the dirty dozen, (break into two groups and one group identify the first six of the dirty dozen and the other group identify the last six dirty dozen), another the Shell, another chain of events.

***Class Exercise** *Note: The Nation Air video could be substituted for the Dryden video. MARS has produced a maintenance video about this accident involving Nation Air. Check references to order the video.

Video: Nation Air We are going to watch another aircraft accident. As you watch the video, see how many HF elements you recognize as well as the Dirty Dozen. This accident cost 264 people their lives.

Read: Nation Air Have the participants read the Nation Air case study.

Group exercise Break into groups and have one group identify the SHELL components, Dirty Dozen (again split the first DD and the second DD), and Chain of events.

Remember: to change the assignments for each group.

Discussion on Nation Air What caused this accident?

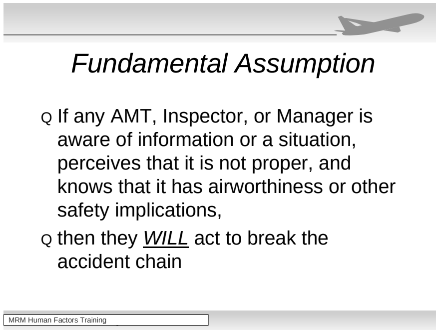
Module 5 **Safety Nets**

Training objectives:

1. **To understand what a safety net is.**

2. **To develop safety nets to break the accident chain.**

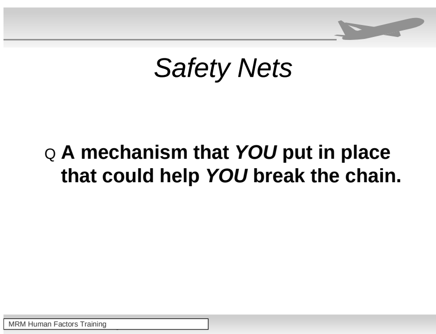
Overhead:
Fundamental Assumption



This is fundamental assumption is important. We will be discussing more about the concept of situation awareness and how we can increase our situation awareness to break the accident chain.

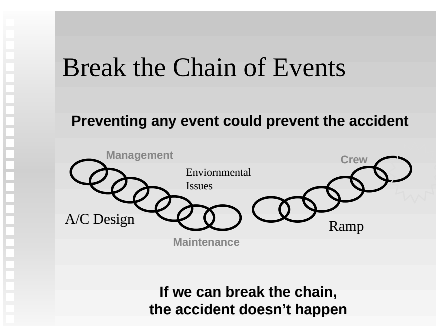
This is just one human factors element we need to be aware of that can help us break the chain of events. We need to be aware of how we can develop safety nets.

Overhead: Safety Nets



Safety nets are mechanisms that you can put into place to help break the chain and insure an error doesn't go on to create an accident. All of the factors in the SHELL model that we talked about can be designed to prevent errors, just as they can help create errors if they aren't supporting human performance and your job.

Overhead:
Break the Chain of Events



We need to learn how to develop safety nets so that we can break the chain of events leading to an accident.

"Link Busters"

Any mechanism or filter that is put in place that can help break the Chain of events (Link Busters, Porter, 1998).

De-brief Nation Air video for developing safety nets

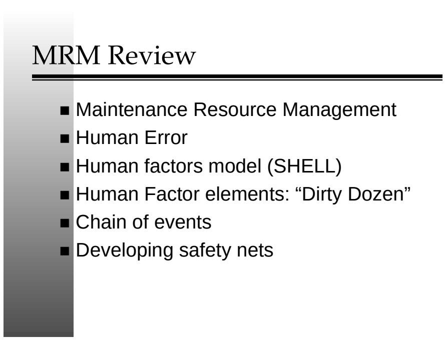
Question:

What are some safety nets that you can put into place to prevent the errors we've talked about in the Nation Air accident?

Group exercise

Group Exercise: break into groups and have a quick brainstorm of ideas in what types of safety nets could have been developed in order to break the chain of events in the Nation Air accident. List them on a flip chart. Have a spokesperson present to class. Tape the list on the wall.

Overhead:
Review of modules 1-5



To summarize key issues from MRM

Definition of Maintenance Resource Management and Human Factors.

The SHELL model describes software, hardware, environmental and liveware factors that can all contribute to what gets labeled as "human error."

We talked about the Dirty Dozen--human factors elements that have been found to be particular problems in aircraft maintenance.

Finally we talked about the idea of a chain of events and how you can put safety nets into place to prevent errors or prevent errors that do happen from going on to become accidents.

Discuss how to recognize and identify the chain of events and how to develop safety nets or "link busters."

Module 6 **Norms**

Training Objectives:

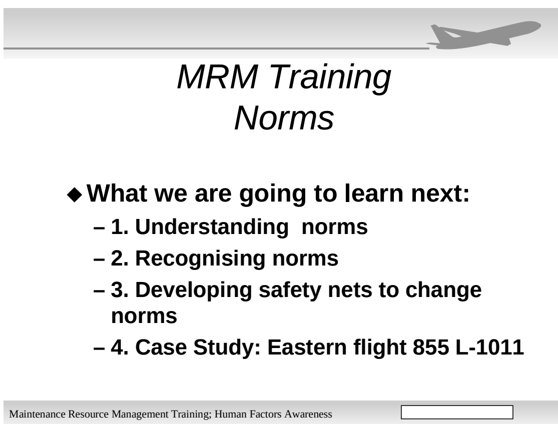
1. To understand norms

2. To recognize norms

3. To develop safety nets to break norms

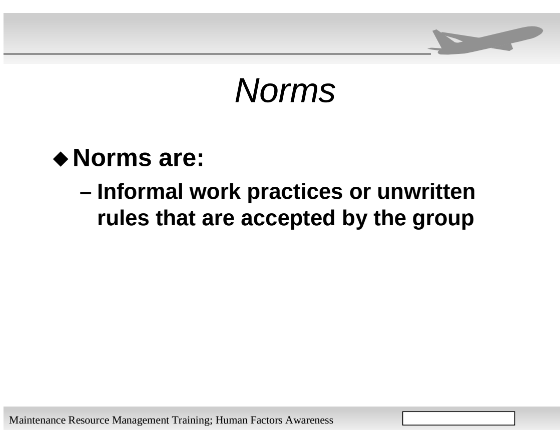
Activity/Overhead **Facilitator Notes**

Overhead: Norms



Training Objectives for this module on norms.

Overhead: Norms



What are norms?

Define norms.

Norms are tolerated and even encouraged by the group.

If one person conducts that behavior then it could be considered a personal preference.

Overhead: Different types of norms

Different types of norms

- Norms can be positive (effective)
- Norms can be negative (ineffective)

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There are different types of norms; positive and negative norms.

Overhead: Positive Norms

Positive Norms

- Positive norms have an overall positive effect on the organization.
  - Example:
    - Double checking your work

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Positive norms are expected behavior condoned for the betterment of the group.

Negative Norms

- Negative norms have a negative effect on the organization and have the potential to cause errors.
  - Example:
    - Completing the job from memory

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These types of norms are unsafe.

OVERHEAD: Negative Norms

Negative Norms

- **Negative norms are short cuts or accepted practices which the group encourages or tolerates.**

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These types of norms are unsafe.

We do them because they generally save us time and steps. We can get the job done faster. Also, an experienced individual shows the novice worker a "short cut."

OVERHEAD: KILLER NORMS

"Killer Norms"

- **"Killer Norms" are those norms that may affect the safe operations.**
- **Negative norms can become "killer" norms when the group fails to see the danger in the short cut or accepted practice.**
  - **Example:**
    - **Deviating from the manufacturers maintenance manuals**

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Negative norms can become killer norms when the group fails to see the danger of the shortcut or accepted practice.

Example: Improvising tools or equipment use.

QUESTION:

Just ask yourself...

Question?

- How can we identify the positive from the negative norms?
- Does it enhance or detract from an established procedure?

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CLASS EXERCISE: QUESTION?

OVERHEAD: EXAMPLES OF NORMS

Ask the class if these are positive or negative norms.

Examples of Norms

– Performing a final walk-around before each flight
– Working without using a maintenance manual
– Asking a fellow AMT if s/he would re-check your work
– Signing for work not done in order to get the aircraft out on time.

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OVERHEAD: EXAMPLES OF NORMS

Examples of Norms

– Pushing the aircraft back without using a wing walker
– Checking all “B” nuts by hand after the job is done.
– Signing off on someone else’s work
– Verbal turnover
– Running with scissors

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OVERHEAD: "BREAKING NORMS"

"Breaking" Norms

- **What can we do about norms?**
  - **Look for the norms we live and we work with**
  - **Identify the positive norms from the negative norms**
  - **Accentuate the positive and eliminate the negative**
  - **Do this by discussing them and using your influence in the group to change the negative norms.**
  - **If you're sure, maintain your standard**

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To know what we can do about norms, we first have to recognize them, like we just did.

This is easier said than done. How do we do this?

It's not easy. It can be uncomfortable if the norm is accepted by the group and they are pushing that it be done that way.

Remember norms will set you up for an accident.

OVERHEAD: ORGANIZATIONAL CULTURE & NORMS

Organizational Culture & Norms

- **Corporate culture breeds norms**
- **Corporate culture either encourages or discourages norms.**

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Just the fact that we are sitting here today is a very good indication of our airline's corporate culture.

This is a commitment to change our airline's culture.

How are we going to do this?

By increasing awareness with every employee in this company. This awareness training includes this human factors-MRM training course.

Human factors training is the key to reducing maintenance errors.

We are going to look at a case study of EAL #855. This case study involves a maintenance error as a primary cause of an near fatal accident.

GROUP EXERCISE: BACKGROUND

OVERHEAD: CASE STUDY

Case Study: Norms

- **Case Study:**
  - **– Eastern Flight 855, L-1011**
    - **Group Exercise**
    - **Identify Norms**
    - **Develop Safety Nets to change norms**
    - **List norms on flipchart**
    - **Select spokesperson**

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Group Exercise: Have participants read case study of EAL #855. Have each group identify the norms, develop safety nets, and list them on a flipchart for presentation to the class.

Background and Discussion:

In your appendix of your handbook you will find this case study.

This maintenance error was not a complicated one.

The O-rings were not installed on the master chip detector.

Norms played a key role in this incident.

The company culture and everyone in maintenance all contributed to allow for these norms to occur.

Case Study: Norms

- **What were some of the norms in this incident?**
- **How could we break these norms?**
- **What were the “killer” norms?**
- **Was this accident preventable?**

For discussion after groups presentations:

What was the level of consequences of this accident?

Case Study: Norms

- **What were some of the norms in this incident?**
- **How could we break these norms?**
- **What were the "killer" norms?**
- **Was this accident preventable?**

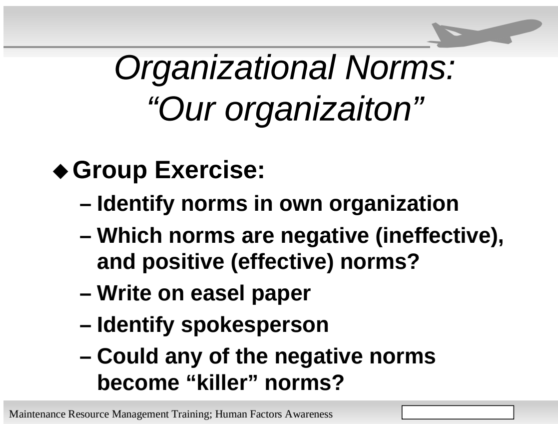
Further discussion and questions:

What were some of the human Factors elements that you saw in this case study?

Example of safety nets: Special training procedures are safety nets. They are here for our protection—read them.

GROUP EXERCISE: IDENTIFYING ORGANIZATIONAL NORMS

OVERHEAD: ORGANIZATIONAL NORMS



Break participants into DIFFERENT groups now.

Have them identify norms in their own workplace, listing them on the flipchart, and select a spokesperson to present to the class.

Directions:

What are some examples of norms you have observed in your work place?

Place a + sign by the positive norms

Place a - sign by the negative norms

DISCUSSION:

Our company culture will allow positive norms to become policy.

How do we go about making a positive norm the proper procedural way?

Facilitator Note: At this time, it is important to show "within the company" examples of how individuals can use the right resources and processes to have a positive norm recognized. Show examples of previous positive changes in procedures. Relate to emphasize MRM and human factors principles used. Company Maintenance Operations newsletter also are great written and documented examples of how positive norms--that is, safe actions and processes--were adopted.

The next overhead emphasizes developing safety nets. This is where the facilitator can point out in the participant handbook the appendix section that has Who's Who (MRM and human factors resources and references, internally and externally to the company).

Norms: Safety Net

- **A safety net is a mechanism *YOU* put in place that could help *YOU* break the chain of events.**

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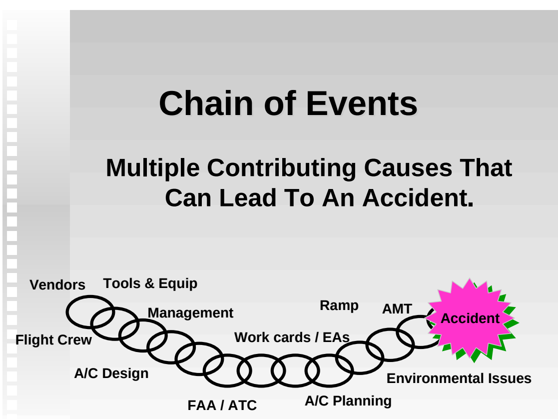
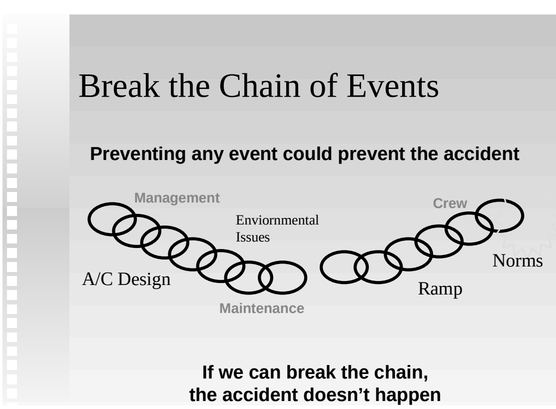
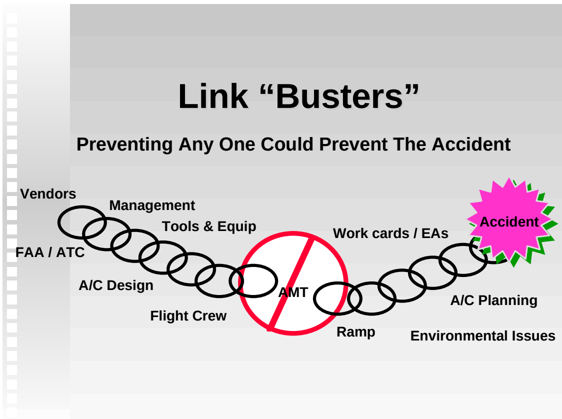
Let's look again at what a safety net is.

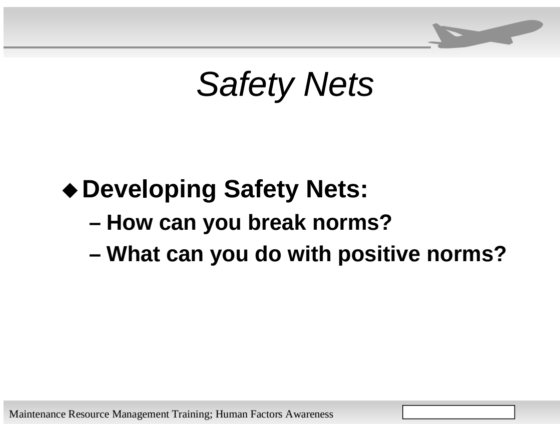
Reminder of breaking the chain of events.

Norms are part of the chain of events.









Question: Class exercise or group exercise

What type of safety nets, link busters or filters could be developed or introduced that would break ***our*** negative norms?

What can you do with your own positive norms?

What experiences have you had in identifying positive norms, and changing procedures?

MODULE 8 **<u>Effective communication (shift turnover & feedback)</u>**

Training Objectives:

1. **To understand how written communication can lead to the reduction of human errors.**

2. **To understand the importance of written communication.**

3. **To recognize examples of poor written communication.**

4. **To understand how we communicate.**

5. **How to write effectively.**

6. To understand the importance of a written turnover.

7. To recognize the value of feedback.

OVERHEAD: TRAINING OBJECTIVES

Here is what we are going to do next.

MRM Training
Effective Communication

- What we are going to learn next is:
  - What is effective communication?
  - Written communication
  - Listening skills
  - Speaking skills
  - Shift turnover
  - Feedback

CLASS or GROUP EXERCISE

Communicating Decisions

- Say What to Do
  - 3 a.m.: Engine is disassembled and in trouble-shooting. Diagnosis is made.
  - Maintenance Control says send plane to CLE for scheduled maintenance
  - Result: AMTs can't finish job even though they know the problem and can fix it.
    - Issue MEL.
    - Lost 3 hours of work.

Typically communications between groups or individuals simply involves passing a statement of what needs to be done. For example, an actual problem situation was as follows.

Very often what doesn't get passed in communications is saying WHY. It is very important to say not just what to do but also your reasons behind that decision. For example, what if we take the same problem situation but in this case maintenance control says <u>why</u> the plane needs to be sent to Cleveland. The scheduled maintenance is for a carpet change out. The result may have been quite different.

Communicating Decisions

- Say Why to Do it
  - 3 a.m.: Engine is disassembled and in trouble-shooting. Diagnosis is made.
  - Maintenance Control says send plane to CLE for scheduled maintenance
  - Scheduled maintenance is for carpet change-out
  - Result: Why don't we do carpet change-out here so that we can finish the job?
    - No MEL is needed
    - Work is completed without lost time

The extra piece of information about the reason for the decision allowed the line station to instead suggest that they could do the carpet change out themselves and finish the repair thereby avoiding the MEL and completing the repair without losing the work they already had done. With this piece of information, they completed the job on time and got the aircraft on the gate on time.

Let's look at another example of communicating decisions and the importance of communication.

Communicating Decisions

- Say What to Do
  - Problem diagnosis entered into maintenance computer for next shift or station
  - Next shift replaces part indicated, but that

IF in the same situation, the AMT also entered why he had arrived at that diagnosis and the options that had been tried and the information regarding the diagnosis activities, the next shift would

Next shift replaces part indicated, but that doesn’t fix problem
- Result: AMT must trouble-shoot again, repeating many steps taken on first shift
  - Aircraft delay

have been much better able to deal with this problem and arrive at a new diagnosis. Effective communication is critical for many types of job functions in order to have safe operations.

When you communicate decisions between groups or shifts, it is important to not only communicate the decision but also why you made that decision. This provides a better understanding of the situation and allows people to better interpret the information relevant to the situation. It also allows the knowledge and ideas of a wider group of people to come into play. Other people may have information that you don’t have.

By drawing on the information of the wider group, you may be able to get better solutions than any one person acting alone. Use our valuable and experienced resources within our company.

We are going to do a teamwork exercise where this idea will really become valuable.

Communicating Decisions

- Say Why to Do it
  - Problem diagnosis entered into maintenance computer for next shift or station
  - Also enter options already tried and information that was used to arrive at that diagnosis
  - Next shift replaces part indicated, but that doesn’t fix problem
  - Result: AMT can quickly determine

We all need to communicate.

Importance of Communicating Reasons for Decisions

- Communicate decision
  - Do this action
- Communicate Why you made that decision
  - Provides better understanding & interpretation of information
  - Allows knowledge & ideas of everyone to come into play
  - Leads to better solutions than one person acting alone

Who Needs to Communicate Decisions?

- Supervisors
- Leads
- AMT
- All Tech Ops Organizations

OVERHEAD: DEFINITION

A definition of communication.

Communication

Process Whereby Information is Exchanged Between Individuals Through a Common System of Symbols, Signs or Behavior

Effective Communication

What is communication?

The exchange of information that conveys

– The exchange of information that conveys *meaning* between two or more people

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Ask the class what effective communication is.

OVERHEAD: COMPONENTS

Effective Communication

- Communication:
  - – Has both a sender and receiver
  - – Verbal or written

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These are the basic components of communication.

OVERHEAD: METHODS OF COMMUNICATION

Methods of Communication

- **Verbal**
- **Non-verbal**
- **Written**

There are several methods of communication; verbal, non-verbal and written. We will discuss each of these and provides examples in our maintenance operations.

NOTE: Facilitator it is important to have several examples of written, and verbal communication. Have these as handouts, overheads, or a video vignette that demonstrate the methods of communicating.

Effective Communication

- How do we communicate?
  - Verbal:
    - Two way (face to face): body language, tonality, eye contact, facial expressions, immediate feedback
    - Two way (not face to face): e.g., on telephone, only tonality, immediate feedback

Requirements of Good Verbal Communication

- We Must Think Before We Speak
- Think About How the Message will be Accepted
- Be Non-Accusatory (Watch Our Tone of Voice)
- Communicate Why We Made the Decision
- Give Positive Feed Back
- Establish Eye Contact
- Allow for the Other to Respond
- Do not Interrupt the Other Person
- Be an Active Listener

Here are some important requirements of good verbal communication that we should consider very careful. You may want to refer to these later when you go back to your work area. We need to remind ourselves of these important ideas constantly. Be assertive in helping others and yourself in using these skills. Provide feedback to others.

Learn to Listen

- **Don't:**
  - Debate what is being said in your mind
  - Detour (i.e., look for a key word to change the subject)
  - Finish the other persons sentences
  - Pre-Plan (figure out what you're going to say next)
  - Tune-out
- **Do:**
  - Ask questions
  - Paraphrase
  - Make eye contact
  - Use positive body language

Active listening is a very important skill. It takes time to become an active listener. We will always be practicing. Use the assertive model to practice your listening skills.

Note: facilitator provides some listening examples. For example, reading off a list of bedroom items (10-15), but never stating the word bedroom. This shows individual have we have the tendency to not active listen and we fill in the gaps of information with our own perceptions and thoughts.

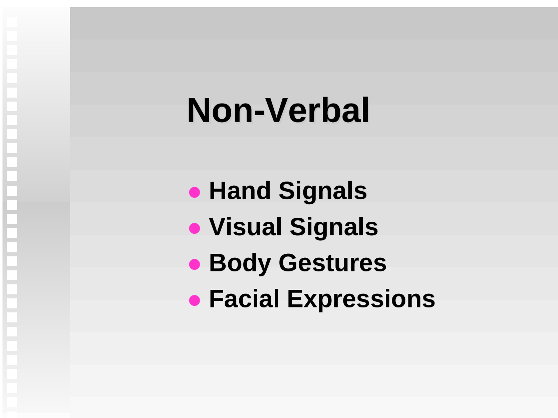
Note: Provide examples of these, if possible, by pictures or video.

OVERHEAD: NON-VERBAL

Note: Show examples of written communication and how we can mis-interpret. These leads to errors.

Group Exercise: Follow directions exercise:

Pass out directions for a task. Interrupt them at the beginning while they are reading the instructions. Devise the instructions that tell me to stop early in the process. Those who do not read the instructions carefully and thoroughly will complete all of the Unnecessary tasks.



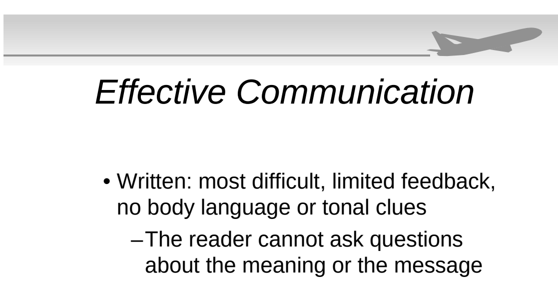
De-brief: Why did you not read the instructions clearly?

Why is written communication difficult?

Is this important in shift turnovers?

GROUP EXERCISE

Why do we need to be so concerned about effective communication?



Ask class....

When do we need to communicate the most?

How important is it that we communicate?

What are the consequences and what types of human errors could be committed? Error of omission, commission?

We are going to talk more about written communication, then we will talk about the importance of shift turnovers and communication.

Effective Communication

- Why are we concerned about effective written communication?
  - Logbook write-ups and/or signoff can result in an incident
  - Vague/unclear/incomplete EA/CD resulting in an incident
  - Shift Turnover

OVERHEAD: WRITTEN COMMUNICATION

These are some very important rules about good written communication.

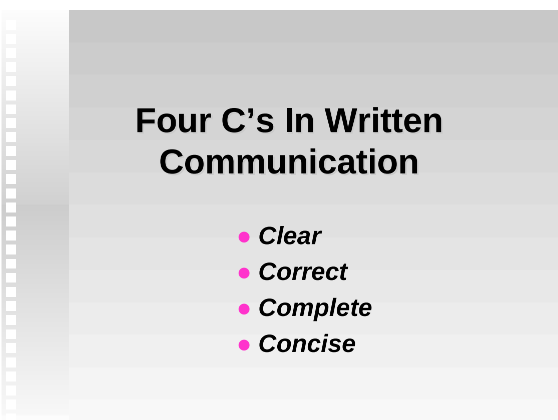
Written communication tends to be the most difficult kind of communication. Immediate feedback is limited. There is no body language or tonal clues. The reader cannot ask questions about the meaning or the message. It has one major advantage: there is a permanent record of message.

Written communication therefore is the most difficult means of effectively completing the communication process.

NOTE:

Let's look at some examples.

OVERHEAD: FOUR C'S



For a message to be understood and not misinterpreted it must be clear, correct, complete and concise.

OVERHEAD: CLARITY

Effective Communication

- For the message to be **clear:**
  - Say what you mean
  - State the point
  - Short sentences
  - Be careful of acronyms and abbrevations

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Note: show an example of a written message that is NOT clear--but very confusing. Show an example of a well-written, clear message.

OVERHEAD: CORRECTNESS

Effective Communication

- For the message to be **correct:**
  - Technically accurate
  - Proper reference to the maintenance manual

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Remember use your technical and company resources.

OVERHEAD: COMPLETENESS

Effective Communication

- For the message to be **complete:**
  - Provide enough information
  - One action per step
  - Proper sequence
  - Be careful of errors of omission

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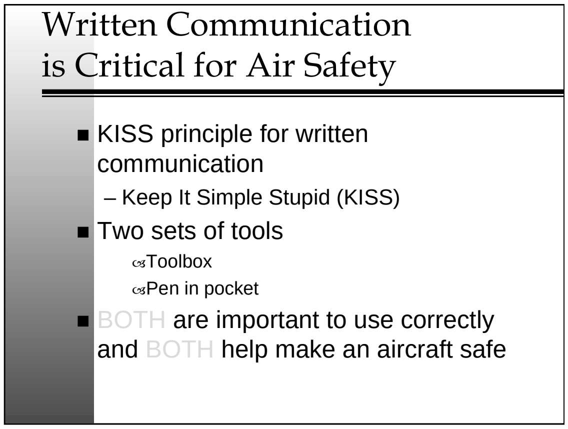
For the message to be complete, remember to state first safety issues and warnings and ALWAYS try out your message on someone else. They should provide you with some valuable feedback.

OVERHEAD: EXAMPLES

Effective Communication

- Written communication
  - "The less I write, the less trouble I can get into in the future"
  - "Just scribble anything because no one reads all that stuff anyway"
  - "Paperwork never made any airplane fly better"
  - "I don't have time for all that paperwork

Watch out for these statements!

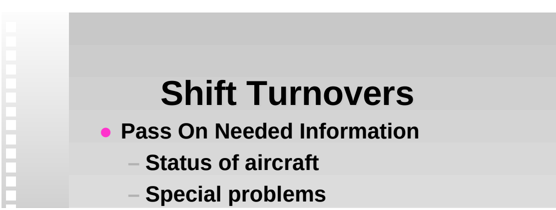


Practice, Practice, Practice your writing skills and try it out on someone else who needs to understand what you want someone to do--make the correct action.

OVERHEAD:

Good communication is always important. But there are certain times when we have found that you need to be especially careful that you communicate fully. (1) Communicating the status of on-going work at the shift change is of course extremely important. Many accidents have been linked to information not being passed to the next shift. (2) The same is true as a plane transitions to the next maintenance station. We frequently do a poor job of communicating the results of all the work and troubleshooting we have done when a plane needs to go on to the next station. (3) These problem-solving insights need to be shared within the maintenance team and to others that become involved. (4) Written logs are a major way of communicating in the maintenance domain: both through the maintenance computer and the maintenance log book. (5) Whenever you work with others.

OVERHEAD: SHIFT TURNOVERS



There are two important functions of shift meetings. 1) To make sure that needed information is passed to the incoming maintenance crew. This includes information on the status of the aircraft that they are going to be working on and any special problems that may be present. 2)

- Serve to Establish Expectations
  - What is my job?
  - What will others be doing?
  - How will the jobs relate to each other?
  - What is my role in working with others?

Shift meeting also serve to establish your expectations for the maintenance team and to create the big picture. This involves not only what each person has to do but also provides an understanding of what others are going to be doing and how their jobs interrelate. This creates the big picture that is needed.

You also create expectations regarding teamwork. Teamwork has to do with the degree to which people work together to accomplish the maintenance goal as opposed to the degree to which they only do their specific task assignments. Creating a sense of teamwork is important for insuring that maintenance goals are met most effectively. Teamwork is our next training module and we will be involved in a group exercise.

Solutions For Shift Turnovers & Meetings

- Give complete explanations of status of work
- Ensure that all parties understand the message being conveyed
- Provide a written turnover to serve as a reference later

Here are some suggestions on how we can improve shift turnovers and meetings.

Are we conducting our shift turnovers this way now?

GROUP EXERCISE:

MAINTENANCE LOGBOOK

CAMPAIGN DIRECTIVE

SQUAWKS

ENGINEERING AUTHORIZATION

NOTE: Facilitator needs to provide examples of poor, unclear, written communications that are internal examples from the company.

Have groups identify why these examples are confusing and unclear. Have the groups list how they could improve these written communications.

GROUP EXERCISE: SHIFT TURNOVER

Remember: The lack of effective communication is a factor that can have serious consequences relative to flight safety and maintenance error.

NOTE:

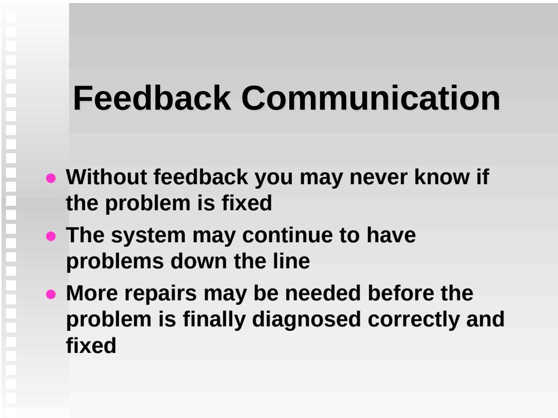
Facilitators could design a shift turnover exercise where something as simple as re-creating a pattern using dominos can be done. For example, one shift could write a series of written instructions about this pattern and leave them for the next crew. The next crew will have to follow the instructions and create the exact pattern. Of course, physically moving the two shifts needs to be done. De-briefing the exercise demonstrates how difficult it is to write clear instructions so that the next crew or individual clearly understands exactly what to do.

Discussion: As AMTs, we sometimes have a distrust of the written word. Thus we sometimes do not even write a turnover to provide the next crew with essential information about what we have completed and what the status of the repair is.

For written communication we do not want the reader to misinterpret and fill in the gaps. Many of you probably filled in the gaps when you were completing the pattern for the dominoes exercise. You may have been correct or incorrect. The consequences of your actions here are minimal. However, as we have pointed out before, the consequences of your actions can lead to catastrophic errors or physical damage.

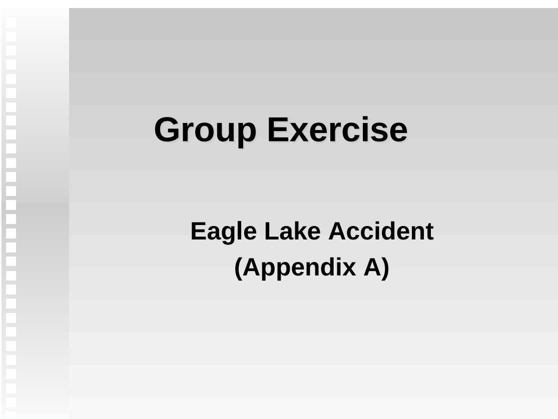
Reference: (Robertson, Driscoll, Kleiser, Spinks, 1997)

OVERHEAD: FEEDBACK



Feedback is critical in creating good mental models. You may make a repair, but unless you have feedback you may never know if you have correctly diagnosed the problem and fixed it. The system may continue to have problems and may have had several repairs down the line before it is fixed correctly. Without feedback you will never develop an understanding of the problem and what works to fix it.

GROUP EXERCISE:



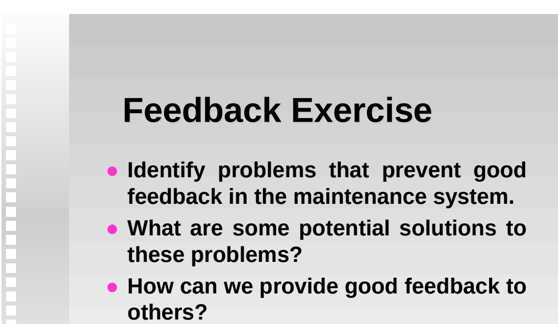
Let’s review a case study for communication problems and shift turnover.

Let’s get our groups and have each group identify communication problems and other human factors and MRM issues.

List these issues and identify a spokesperson.

NOTE: Facilitator, you may want to have one group list communication problems, the other groups to look at human factors elements, chain of events or developing safety nets.

CLASS ROOM OR GROUP EXERCISE:



NOTE: This could be another communication and feedback exercise. Take a communication problem that has occurred in the company and use it to demonstrate problems of communication and feedback. Have the groups develop filters, safety nets, projected changes

- **Where do we go at our company to give feedback?**

regarding human factors elements, organizational resources, policies, etc.

This is a good opportunity to view objectively issues in the company.