U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: MAINTENANCE RESOURCE MANAGEMENT TRAINING	**Date: 9/28/00** **Initiated By: AFS-300**	**AC No: 120-72** **Change:**

1. PURPOSE.

a. This advisory circular (AC) presents guidelines for developing, implementing, reinforcing, and assessing Maintenance Resource Management (MRM) training programs for improving communication, effectiveness, and safety in maintenance operations. These programs are designed to become an integral part of training and maintenance operations.

b. This AC presents one method, but not necessarily the only method, to address MRM training. MRM training focuses on situational awareness, communication skills, teamwork, task allocation, and decision making.

2. RELATED REGULATIONS. Title 14, Code of Federal Regulations; Sections 121.375 and 135.433.

3. DEFINITIONS. For the purposes of this AC the terms listed below have the following meanings:

a. Active Failure: A type of human error whose effects are felt immediately in a system.

b. Assertiveness: The ability to verbalize 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.

c. 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 a shop and the hanger.

d. Authoritarian Leader: A person who dictates the action and the course of a team with little input from team members.

e. Communication: The process of exchanging information from one party to another.

f. Complacency: Satisfaction with a situation to the extent that a degradation of vigilance occurs.

g. Crew Resource Management: Team-based human factors training for flight crews.

h. Dirty Dozen: The twelve most common maintenance-related causes of errors. These twelve causes are:

(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) Norms

i. Egalitarian: Relating to the doctrine of equal political, economic, and legal rights for all human beings.

j. Ergonomics: The applied science having the objective of adapting work or working conditions to enhance performance of the worker.

k. Human Factors: The scientific study of the interaction between people and machines.

l. Inter-team: Occurring between separate teams.

m. Intra-team: Occurring within a team.

n. Instructional Systems Design: A generic term for the methodology of creating and implementing a training program.

o. Latent Failure: A type of human error whose effects may lie dormant until triggered later, usually by other factors.

p. Leadership: The ability to direct and coordinate the activities of group members and stimulate them to work together as a team.

q. Maintenance Resource Management: A general process for maintaining an effective level of communication and safety in maintenance operations.

r. Mental Model: A depiction of a system in a person's mind, i.e. how a person thinks a system is put together and how it works.

s. Norms: Expected, yet implicit rules of behavior that dictate a person's dress, speech, and basic interaction.

t. Participatory Leader: A person who encourages member participation and input to help lead the team's course of action.

u. Safety Culture: A pervasive, organization-wide attitude placing safety as the primary priority driving the way employees perform their work.

v. Situational Awareness: Maintaining a complete mental picture of surrounding objects and events as well as the ability to interpret those events for future use. Situational awareness encompasses such concepts as attention, and vigilance.

w. Stressor: An event or object that causes stress in an individual.

x. Synchronous Communication: 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.

y. Team: A group of interdependent individuals working together to complete a specific task..

z. Team Situational Awareness: Maintaining a collective awareness across the entire team of important job-related conditions.

aa. Teamwork: Joint action by a group of people, in which each person subordinates his individual interests and opinions to the unity and efficiency of the group.

4. ACRONYMS.

a. CRM: Crew Resource Management

b. HF: Human Factors

c. ICAO: International Civil Aviation Organization

d. ISD: Instructional Systems Design.

e. MRM: Maintenance Resource Management

f. SOP: Standard Operating Procedure(s).

5. RELATED MATERIAL.

a. Crew Resource Management.

(1) AC 120-51, Crew Resource Management Training.

(2) Driskell, J. E., & Adams, R. J. (1992). Crew Resource Management: An Introductory Handbook (DOT/FAA/RD-92-26). Washington, DC: Federal Aviation Administration.

(3) Wiener, E. L., Kanki, B. G., & Helmreich, R. L. (1985). Cockpit Resource Management. Orlando, FL: Academic Press.

b. Human Factors.

(1) Bailey, R. W. (1989). Human Performance Engineering: Using Human Factors/Ergonomics to Achieve Computer System Usability (2nd edition). Englewood Cliffs, NJ: Prentice Hall.

(2) Brown, O., & Hendrick, H.W. (Eds.) (1986). Human Factors in Organizational Design and Management II. Amsterdam, Holland: North Holland.

(3) Federal Aviation Administration (1991). National Plan for Aviation Human Factors. Springfield, VA: National Technical Information Service.

(4) Federal Aviation Administration. The Human Factors Guide for Aviation Maintenance and Inspection (Version 3), [CD ROM] (1998) and FAA Human Factors in Aviation Maintenance and Inspection Internet web site http://hfskyway.faa.gov. 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), you may do so on-line via the Internet web site location.

(5) Federal Aviation Administration. Aviation Maintenance and Inspection Phase 9 report via FAA Human Factors in Aviation Maintenance and Inspection Internet web site http://hfskyway.faa.gov.

(6) Reason, J. T. (1990). Human Error. Cambridge, UK: Cambridge Press.

(7) Salvendy, G. (Ed.) (1997). Handbook of Human Factors. New York, NY: John Wiley & Sons.

c. Training.

(1) Goldstein, I. L. (1986). Training in Organizations: Needs Assessment, Development, and Evaluation (2nd Ed). Monterey, CA: Brooks/Cole.

(2) Knirk, F. G., & Gustafson, K. L. (1986). Instructional Technology: A Systematic Approach to Education. New York, NY: Holt Rinehart and Winston.

(3) Reigeluth, C. M. (1983). Instructional-Design Theories and Models: An Overview of Courseware. In D. H. Jonassen (Ed.), Instructional Designs for Microcomputer Courseware. Hillsdale, NJ: Lawrence Erlbaum Associates.

(4) Wexley, K. N., & Latham, G. P. (1991). Developing and Training Human Resources in Organizations (2nd Ed). Glenview, IL: Scott Foresman.

d. ICAO Documents. The following 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
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(1) Human Factors in Aircraft Maintenance & Inspection (Digest No. 12). This document 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.

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

(3) Circular 217 Line-Oriented Flight Training (LOFT).

(4) Circular 247 Human factors, Management and Organization.

6. BACKGROUND.

a. Though crew resource management (CRM) on the flight deck is a topic of regular discussion, relatively little attention has been paid to its maintenance-related counterpart, maintenance resource management (MRM). Indeed, this inattentiveness 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 encountering references to crew resource management.

b. The aviation community has expanded its approach to reducing human error. Human factors programs now encompass not just the flight crew, but all aspects of aviation in which a human may be involved. This activity includes such areas as aircraft design and operation, air traffic control, and, of course, aircraft maintenance.

7. OBJECTIVES.

a. This AC provides background information on Maintenance Resource Management. Maintenance Resource Management (MRM) is a general process for improving communication, effectiveness and safety in aircraft maintenance operations. 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, the Federal Aviation Administration (FAA), in conjunction with industry partners, developed MRM to address teamwork deficiencies within the aviation maintenance environment.

b. MRM is a team-based safety behavior. It teaches managers and maintenance personnel 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:

(1) How the effects of individual actions ripple throughout organizations,

(2) How to utilize available resources safely and effectively, and

(3) How to propagate a positive culture of safety in the organizations through specific, individual actions.

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

8. PHILOSOPHY OF MRM.

a. The philosophy of MRM is based on the philosophy of CRM with emphasis on how maintenance operations differ from flight operations. The work environment of maintenance personnel encompasses a great variety of tasks in varied settings with a great number of people. Because the tasks and work differ from one domain to the other, the basic plan for addressing concepts like human error, teamwork, and safety also differ.

b. This section outlines similarities and differences between MRM and CRM, in order to characterize the philosophy of MRM. First, human error in both the 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.

c. Human error.

(1) The way to understand MRM is to explore the nature of errors in maintenance operations. A widely accepted model of human error is the classification of unsafe acts developed by J.T. Reason. This classification distinguishes between two types of errors:

(a) Active failures, whose effects are felt immediately in a system, and

(b) Latent failures, whose effects may lie dormant until triggered later, usually by other mitigating factors.

(2) 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, consider the case of a mechanic who assembled a component incorrectly which eventually led to a plane crash days or even weeks later. The defenses that should have normally caught this mistake were not in place. These defenses include proper training (the mechanic was taught to fix this particular component very informally and on-the-job), good situational awareness (the mechanic was tired from a double shift the night before), and independent inspection (the job was "pencil-whipped" to save time.)

(3) Active failures are usually the result of actions taken (or not taken) by 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 their actions in the dynamics of the system. Personnel working in vocations such as architectural design, hardware design and equipment maintenance are more prone to cause latent failures than active failures.

(4) Both active and latent failures may 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 to an accident (training, good management, teamwork, etc.) and each hole is a failure in that defense. The last slice is the final action which could serve as a defense before the accident event. The failure in that defense would constitute the active failure precipitating the accident. If the defenses to a situation contain a sufficient number of failures, which allow the holes to "line up," an accident will occur.

(5) 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 of maintenance personnel on the job also requires emphasis on workplace ergonomics. For example, maintenance personnel 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 specific to what is actually performed on the job.

d. Safety Culture.

(1) 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 also it must adopt attitudes that promote safety above all else. Various researchers call these attitudes an organization's safety culture and identify top-level organizational support as the main predictor of a positive safety culture. Put briefly, in order for an organization to create and perpetuate a positive safety culture, senior management must take certain actions, such as:

(a) Setting standards and expectations and providing resources to meet them.

(b) Developing and enforcing standards that emphasize safe work practice.

(c) Setting 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.

(2) An MRM training program provides personnel with the tools to assess and change their own behaviors to work safer and reduce human error. Unlike other safety

programs, MRM is most effective when ALL employees are oriented toward a positive safety culture. Therefore, employees of all levels (upper-level managers included) are encouraged to participate and are trained alongside maintenance personnel.

(3) MRM trains personnel to use the resources of their positions to encourage safe operations. For example, managers learn that a positive safety culture can only be fostered if line employees are provided the necessary resources to do their jobs correctly. Line employees must be given the tools that teach them how to do their jobs without error. As an example, upper-level managers provide and control resources such as the number of aircraft 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 of maintenance personnel in the hanger (or on the line). MRM training teaches employees what behaviors are best to use. MRM training also helps managers understand how their own choices affect which behaviors are ultimately used . In this way, the entire organization becomes oriented towards safe, error-free performance.

9. MRM CONCEPTS.

a. Though MRM includes more than training, training is the foundation upon which the program is built. MRM training teaches maintenance personnel specific concepts, both theoretical and applied. Management commitment to a positive safety culture allows maintenance personnel to put into practice the concepts they learn. This section presents and defines MRM concepts in terms of the maintenance environment. In addition, supplemental information on each implementation of a skill is also provided as a sample of the content of an MRM training program.

b. This section and Appendix 1, the sample training course, were written with relatively large maintenance and repair stations in mind; some of the large working group practices may not apply in small stations.

c. Those people familiar with CRM training will see similarities with the skills taught in MRM training. These similarities lie mostly in the broad areas of resource management such as communication, team building, workload management, and situational 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 the components of MRM.

d. Human Factors knowledge.

(1) 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.

(2) Identifying and understanding basic 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 the concepts taught should be tailored to meet the needs of each particular audience.

(3) Recognizing contributing causes to human errors. A basic primer on human error is a key component to MRM training. By understanding the interaction between organizational, work group, and individual factors that may lead to errors and accidents, maintenance personnel 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 the "Dirty Dozen" scenarios. These can also be adapted for use in MRM training.

e. Communication Skills.

(1) 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:

(a) The quality of work and performance may be reduced.

(b) Time and money may be lost as errors occur because important information is not communicated or messages are misinterpreted.

(c) Improper communication may cause frustration and high levels of stress.

(2) People communicate in many different ways, however this AC, will consider three broad forms of communication:

(a) Verbal communication, which relates to the spoken word, whether face to face or through some electronic medium such as a phone, radio, loud speaker, etc.

(b) Non-verbal communication, commonly referred to as "body language." Whether you wave, smile, or wink, you are communicating a message to other individuals.

(c) Written or asynchronous communciation which includes everything that is memorialized in writing or in electronic form, such as publications, letters, forms, signs, e-mail, etc.

(3) 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 documents, 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.

(4) 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 a shop and the hanger.

(5) 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.

(6) Similarities also exist between CRM and MRM, particularly in the form of assertiveness. MRM researchers have identified assertiveness as a positive behavioral skill. Not to be confused with aggressive behavior, assertive behavior in the context of MRM and CRM is defined as verbalizing a series of *rights* to which a team member is entitled. 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. This action is critical for making cooperative situations productive. Thus, assertiveness is a necessary skill for effective team behavior and is addressed specifically in MRM training.

(7) To promote constructive, synchronous communication, peer-to-peer performance feedback techniques are also typically addressed in MRM training, normally in training on interpersonal relations. Teaching-specific, constructive behaviors that may be useful in common situations can still be beneficial. MRM can also address this specific training with examples such as how to handle a troublesome employee and/or supervisor and conflict management or resolution. The specific content of each MRM training module can be tailored to fit a particular organization; however, MRM would be incomplete if the training of "people skills" were omitted.

f. Team Skills.

(1) Team skills and coordination are a vital part of the MRM concept. Competence in team skills tends to be independent of competence in technical skills, yet both skills are equally important in accomplishing the final goal. Unfortunately,

organizations rarely devote time and resources to teach these team skills formally. MRM training provides maintenance organizations the vehicle to accomplish this. The discussion of *teams* has been inferential up to this point. This section will discuss teams specifically. In this way, concepts like inter- and intra-team behavior can be understood with more precision.

(2) Certain qualities differentiate a *team* of people from a *group* of people. Among these are size, a common goal, and interdependence.

(3) 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 an increase in team performance. Additional team members increase the need for all team members to expend time and resources in order to coordinate the team's activities toward accomplishing its goals. A team with many members may fracture and create sub-groups or cliques that 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. For any one particular task, there are an optimum number of people who can do the job; more or fewer people will result in a performance loss. Though the optimum number depends on the team task, process loss becomes significant with more than 10 members.

(4) Secondly, a team works together to accomplish a unified goal or goals. That goal could be an engine change or performing a heavy maintenance check. It must be understood that, just as repairing an airplane consists of numerous steps, a team's ultimate goal is also composed of sub-goals. Each sub-goal must be accomplished in order to reach the team's ultimate goal.

(5) A final quality that is needed to define a team is 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 maintenance personnel can fuel a plane more quickly than one individual alone, if each individual should drop out over time, the person left could still finish the task.

(6) 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 or her final goal (finishing the wash). This is known as *additive* labor, i.e., each team member adds his or 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. The essential characteristics of a team are:

(a) A team is a group of interdependent individuals working together to complete a specific task.

(b) 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.

(7) This analysis 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 that performs a heavy maintenance check in a hanger. Because each team member is working on separate parts of the aircraft, they are separated both in location and sometimes in time. However, when analyzed in terms of the ultimate goal (finishing the check) and being interdependent (each member may have unique maintenance skills, such as airframe, powerplant, or avionics skills etc. that are necessary to perform the heavy check), the definition of a team applies. Also note that the other MRM skills, such as constant communication and people skills, are also at work in this example.

(8) Teams have certain characteristics that make them effective. The following table lists ten important characteristics of an effective team.

Effective Teamwork
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 role of each of 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.

Table 1. Effective Teamwork

(9) Maintenance operations are frequently characterized by large teams, working on disjointed tasks, spread out over a hanger. As a result, maintenance operations rely heavily on asynchronous communication. Because the team members are spread out, there is a lag between queries and responses among team members. As a result of this dependence on asynchronous communication, the team 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. 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) skills as well as intra-team (within crew) skills.

g. Norms.

(1) A side effect of working in teams is 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 meeting is not required by the organization, but expected by the team members, then it is a norm.

(2) Norms are omnipresent in society. Norms are expected, yet implicit rules for behavior. That is, norms dictate fundamental rules of dress, speech, and basic interaction. Because they are rules for behavior that define others' expectations, norms facilitate social interaction by reducing the number of surprises one may encounter in a given social context.

(3) Violation of a norm 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. In this case, others in the surrounding group may sanction the norm breaker.

(4) Norms are usually developed to solve to problems that have ambiguous solutions. When faced with an ambiguous situation, an individual may use another's 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 to the situation are then accepted into the group based on adherence to norms. Very rarely do newcomers initiate change in a group with established norms.

(5) Some norms are unsafe in that they are non-productive or detract from the productivity of the group. Taking shortcuts in aircraft maintenance, working from memory, or not following procedures are examples of unsafe norms. Newcomers are better able to identify these unsafe norms than long-standing members of the group. On the other hand, the newcomer's credibility depends on his or her assimilation into the group. The newcomer's assimilation, however, depends on adherence to the group norms. Everyone should be aware of the perceptiveness of newcomers in identifying unhealthy norms and develop a positive attitude toward the possibility that norms may need to be changed. 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.

(6) Norms have been identified as one of the dirty dozen in aviation maintenance and a great deal of anecdotal evidence points to the use of unsafe norms on the line. The effect of unsafe norms may range from the relatively benign, such as determining accepted meeting times , to the inherently unsafe, such as pencil-whipping certain tasks. Any behavior commonly accepted by the group, whether as a standard operating procedure (SOP) or not, can be a norm. MRM courses should attempt to help individuals identify group norms, ferret out unsafe norms and take appropriate action.

h. Health and Safety/Situational Awareness/Leadership.

(1) MRM training should contain modules that address worker health and safety, situational awareness, and leadership. Each of these concepts has been identified as important to maintaining an effective safety culture.

(2) Worker Health and Safety.

(a) Healthy employees are more productive and effective than non-healthy employees. The focus of MRM training is on public safety (the effect of human error on the flying public, for example). MRM also should encourage employee safety training. Employee safety is an integral part of an overall safety culture in an organization.

(b) Working safely depends on eliminating human error and stressors in the work environment. 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 an aircraft accident 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 analysis, trainees could learn to work more safely in an otherwise hazardous environment.

(c) Second, MRM should emphasize the recognition and reduction of stressors. Maintenance personnel perform a wide range of physical activities. Certain ailments become stressors because they are aggravated by these physical activities. Stressor ailments that maintenance personnel 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 other environmental conditions. 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 maintenance personnel how to assess these problems, judge their susceptibility to them and identify how these problems ultimately impact well-being and performance.

(d) Cognitive and emotional stressors also exist for all people, regardless of their job. The consequences of these stressors should be evaluated in terms of human error in the maintenance environment and should be taught in the MRM course. The two predominant, cognitive and emotional stressors are complacency and fatigue.

(e) Complacency.

1 Complacency is defined as satisfaction with a situation to the extent that the degradation of vigilance occurs. Put simply, a *complacent* person fails to pay attention when performing a task. This, in turn, normally leads to error or deviations from SOPs. Complacency is abetted by a number of factors but three primary ones are:

a Fatigue.

b Too many things happening simultaneously.

c Too few things happening.

2 The effect of fatigue is discussed in more detail in the next section.

3 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.

4 At the same time, a person may have too little to do. A situation may seem boring, with little activity occurring. Or a task may seem routine, having been done by a person a hundred times before. These situations commonly lead to complacency. MRM training is structured so that complacency in maintenance and its effect on human error can be addressed directly.

(f) Fatigue.

1 Fatigue degrades a person's ability to work effectively. One cause of fatigue is sleep deprivation. 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 number of errors made, among others. Failure to act on stimuli, even dangerous ones, is also a common result of fatigue.

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

3 A great deal of anecdotal evidence points to fatigue in maintenance personnel 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, studies are currently underway evaluating the factors associated with fatigue and its effect on maintenance personnel.

(3) Situational Awareness.

(a) Situational awareness is one of the foundational concepts of MRM. Typically, situational awareness is thought of in terms of individual maintenance personnel. In addition, situational awareness also encompasses other related concepts such as mental arousal and vigilance. Many of the most common maintenance errors involve the loss of situational awareness among different individuals, often across different teams or shifts. The concept of team situational awareness relates to maintaining a collective awareness of important job-related conditions and events.

(b) Five elements and activities are necessary to improve Team Situational Awareness in the maintenance environment. These are:

1 Shared mental models.

2 Verbalization of decisions.

3 Better team meetings.

4 Teamwork and feedback.

5 Individual situational awareness training.

(c) Shared mental models. A mental model is simply how to depict a system mentally--how the subsystems are put together and how the system works. Good situational awareness at the team level depends on all team members having a clear understanding of what information means when it is conveyed to 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.

(d) Verbalization of decisions. At times team members may find it necessary to take actions that deviate from the norm or are otherwise unexpected. These unexpected actions may cause confusion or other adverse reactions by other team members. It is very difficult to know why a team member has taken a course of action unless he or she tells us. Individual team members need to do a better job of communicating information regarding *why* they decide to (or not to) take a particular course of action.

(e) Team meetings. Team meetings are critical to sharing valuable and necessary information. Team meetings may be used to share information among team members on the same shift and for passing information across shifts. To increase the effectiveness of team meetings in attaining team situational awareness, Team Leads need to receive training in the following:

1 Running a shift meeting and stating common goals for the team.

2 Providing a common understanding of who is doing what.

3 Setting up an understanding of the inter-relationship between tasks and personnel activities.

4 Providing expectations regarding teamwork.

5 Maintaining good communication practices.

(f) Teamwork and feedback. It is important that maintenance personnel receive feedback on the outcome of their work. Such feedback is crucial to the development of better mental models. Without such feedback, it is difficult to improve a person's diagnostic skills. For example, a complex diagnosis and repair may have been totally successful, but the unit may have failed again a few days later at another station; a person would be unable to correct the diagnosis without feedback on the subsequent failure.

(g) Individual situational awareness training.

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

a Forgetting information or steps--frequently associated with task interruptions.

b Not passing information between shifts or team members.

c Missing critical information due to task-related distractions.

d Misinterpreting information due to false expectations.

2 Training maintenance personnel to recognize threats to situational awareness and to cope with their effects can minimize these problems.

(4) Leadership.

(a) In the past, most people thought that the ability to lead was an inherent trait 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. Today leadership is defined less in terms of a trait and more as a function of the group being led. Leadership is seen to include managing individual organizational components as well as their interaction with other groups in the organization.

(b) Leadership has many facets. 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. It includes being in a position to control 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.

(c) Two Specific Types of Leadership.

1 There are many different definitions of leadership. We will discuss two of the more broadly accepted types of leadership. They 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.

2 A participatory leader allows each team member to have a say and to participate in team processes. The team leader is more *egalitarian*, or equal, under participatory leadership than with an authoritative leader. The participatory leader may, however, ultimately decide the team's actions, but takes into consideration the team members' experience, knowledge, and preferences.

a An *authoritarian* leader dictates action and the course of the team with little input from team members.

b A *participatory* leader encourages member participation and input to help lead the team's course of action.

3 One may ask if one form of leadership is better than another form. The answer to that question usually depends on the organization of the team and 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 workday would be unable to perform their duties in a timely manner. However, an overly authoritative supervisor or manager who fails to request input from anyone may suppress the free flow of ideas and dictate team activities that negatively impact safety. Good leadership is a balancing act between the two. The following table presents some guidelines for when to choose which style, but keep in mind that this list is far from complete.

Guidelines for Choosing a Leadership Style	
When to use an authoritative 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.	When to use a participatory leadership style: • 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.

Table 2. Guidelines for Choosing a Leadership Style.

4 In addition to his or her own team members, a frontline maintenance supervisor on the job must interact with a variety of upper-level managers, shop

personnel, shift/crew supervisors and their teams, union representatives, catering/other ground support personnel. As a result, supervisors must be trained not only in the skills to handle those in their assigned teams, but also in interacting effectively with others outside the assigned team.

(d) Responsibilities of Leaders.

1 Leaders have a variety of responsibilities they must meet to ensure a smoothly running team. The following table presents twelve important leadership responsibilities.

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.

Table 3. Leader Responsibilities.

2 Certain behaviors make a leader more effective. Conversely, some behavior detracts from effective leadership. Some of the behavior characteristics that affect leadership effectiveness are listed below.

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

Table 4. Leadership Guidelines

3 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, leadership skills are not innate. Instead, individuals can be trained to be good and effective leaders.

10. SAMPLE MRM TRAINING COURSE. The behaviors and skills described in section 9 are what comprise a typical MRM course. Appendix 1 is a typical MRM training course reflecting many of the concepts discussed in that section. Some of the concepts discussed in Appendix 1 may not apply equally to all organizations. The organization developing the MRM course should tailor the course to fit the particular organization.

11. IMPLEMENTING MRM TRAINING.

a. This section describes a number of the techniques to analyze the necessity and identify the benefits of implementing MRM in an aviation maintenance organization. The emphasis of this section, therefore, is on the introduction of MRM-related knowledge and skills into the workplace, i.e., conducting MRM training.

b. Do not anticipate or assume that most aviation maintenance managers 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. Managers should understand the most important aspects of the framework within which MRM training programs should be developed and evaluated.

c. MRM training should be implemented through 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. This section describes this tailored ISD approach.

d. 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 training design team is essential when using the systems design approach. Each of the major activities in the ISD framework is described in the following sections.

e. Analysis.

(1) 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.

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

(3) Organizational analysis.

(a) Organizational analysis consists of an evaluation of the maintenance organization in which the trainee performs the job, and an evaluation of the training resources that could be applied. The training may be provided by the maintenance organization or by a training organization separate from the maintenance 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.

(b) In determining the reasons why an MRM training program is being undertaken, it is important to analyze:

1 The current performance of the organization and workers.

2 The desired performance of the organization and workers.

(c) If a difference between current and desired performance exists, then 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.

(d) For example, issues that should be addressed by developing a company policy might consist of re-designing of workcards or re-formatting an engineering authorization (EA) form. Training could address the problems of engineers and technical writers in writing a workcard or an EA that is clearly understood by others. MRM training could teach maintenance personnel the skills that allow them to recognize how the environment, such as the readability of a workcard, impacts human performance.

(e) 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.

(f) As part of organizational analysis, 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, in-flight shutdowns, return-overnights, no fault found removals and replacements), safety (ground damage, occupational injuries), and efficiency and quality (component shop statistics).

(4) Task analysis. Conducting a task analysis is the second step in a needs assessment. The task analysis is 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. The task analysis is a critical step in the design process. If the necessary knowledge and skills 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 he or she can create an effective training program. This need not be a resource intensive endeavor; it may entail observing employees over the course of a few days, or 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 providing the wrong or irrelevant knowledge, skills and abilities, resulting in an ineffective training program.

(5) Trainee analysis. One of the major goals of MRM training is to provide maintenance personnel 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.

f. Design.

(1) In the design phase, goals and objectives, content, instructional strategies, and testing procedures are developed for each training topic identified in the front-end analysis. The design process consists of four hierarchical levels are program, curriculum, course, and lesson.

(2) The program and curriculum levels are associated with a high level, or *macro,* type of design. At this point, training is linked with the strategic plans of the organization. A series of course needs is also identified for different groups of trainees.

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

(4) It is important to note that a successful design for MRM training 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 observation of instructional events. This type of learning promotes effectively acquiring and processing information. Participation in specific activities is highly motivating and tends to promote better retention.

(5) 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.

(6) Macro design.

(a) 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 training 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.

(b) 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. Do not decide on a particular delivery system or medium until your analyses are complete.

(c) Do not 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.

(7) Micro design.

(a) Micro design moves from the broad categorization of curricula into courses or modules to the detailed design of the individual course or module and the lessons within each course or module. 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.

(b) Learning objectives are used to develop a content outline for individual lessons and to 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 for the course. 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 training objective.

(c) Media selection.

1 Training designers 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.

2 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.

3 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.

(d) 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 met 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 opinions on how 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.

g. Development.

(1) 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.

(2) Developing training materials.

(a) 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.

(b) 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.

(3) Walkthrough.

(a) It is necessary to identify problems or shortcomings early in the design cycle. The prototype test, or walkthrough, is designed to identify and correct problems before the materials are produced for company-wide use. 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.

(b) 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 re-tested.

(4) Final development.

(a) Final user testing and full-scale development occur after the materials have been modified and re-tested, 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.

(b) 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.

g. Implementation.

(1) In this phase of the ISD process, the fully pre-tested MRM training is moved to the production environment. Implementation typically consists of two parts: scheduling and facilitator training.

(2) Scheduling.

(a) 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.

(b) 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.

(3) Facilitator training.

(a) 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.

(b) 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.

(c) Early experience from MRM courses has shown that MRM training is highly effective when maintenance personnel 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.

i. Evaluation.

(1) 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.

(2) Evaluation types.

(a) There are two types of evaluations: formative and summative. Formative evaluation occurs as the instructional program is being developed and will not be discussed in this Advisory Circular. 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.

(b) 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 participants are using the training. It is most often used to determine the success and effectiveness of the training program.

(3) Summative evaluation.

(a) The summative evaluation process can be viewed as a five-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 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.

(b) It is important to measure the effectiveness of the training program using all four evaluation criteria levels. Commonly, after the Baseline Assessment, organizations apply evaluation criteria to only Reaction and Learning, and do not conduct an evaluation of Behavior and Organizational Results. 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.

12. TRAINING SUMMARY.

a. 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 of 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.

b. 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 to move 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. This does not demonstrate full commitment, and will not inspire trainees to embrace a safety culture. 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.

for L. Nicholas Lacey
Director, Flight Standards Service

APPENDIX 1. MAINTENANCE RESOURCE MANAGEMENT SAMPLE CURRICULUM

(The following sample curriculum is a guideline only and is not meant as the only presentation method. Facilitators should tailor the course material and presentation to meet their specific objectives.)

Module 1 MRM Human Factors Training: Introduction

Maintenance Resource Management
Day 1: Training Goals:

1. To understand what Human Factors and MRM 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 maintenance operations in relation to a 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 Human Factors elements**
2. **To understand human error and recognize contributing causes**
3. **To identify the chain of events 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

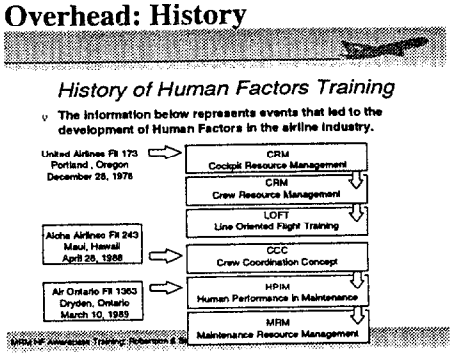
Handout
Pre-training questionnaire

Facilitator Notes

Explain: This course is being evaluated. We need a before and after picture to determine the effectiveness of this training. Here is a survey we want you to complete. Your answers, combined with those of all other people who take this course, will help us better evaluate our MRM 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

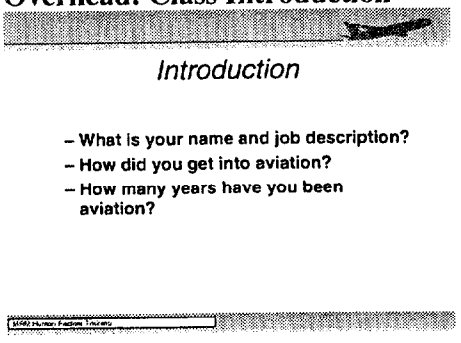


Explain: This overhead illustrates the events that led to the development of Human Factors training. We are here today in our MRM course to learn about error management, by using Human Factors skills and understand what error-prone tasks are.

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 are 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 problems occur.

Overhead: Class Introduction

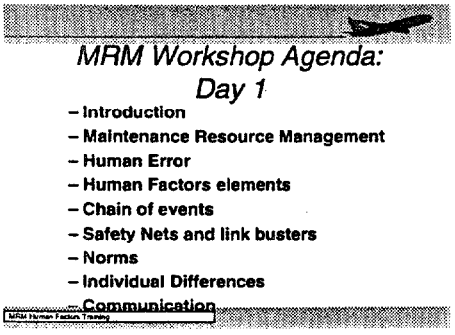


Introduce facilitators and participants (Allow 30 seconds for each participant).

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.

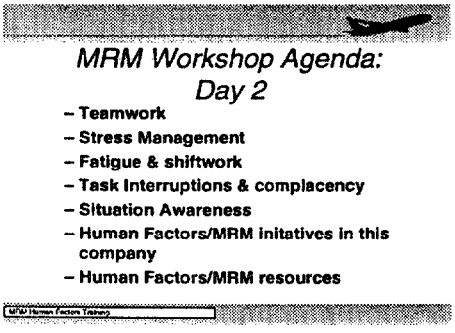
Overhead: Workshop Agenda



We understand that some of the terms we will discuss 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 Human Factors and MRM are. This includes identifying important Human Factors elements, understanding human error and causes, recognizing the "dirty dozen" or Human Factors elements in aircraft maintenance, identifying chains of events and breaking chains 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 the MRM concepts you learned on Day 1 and you will 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 shift work 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.

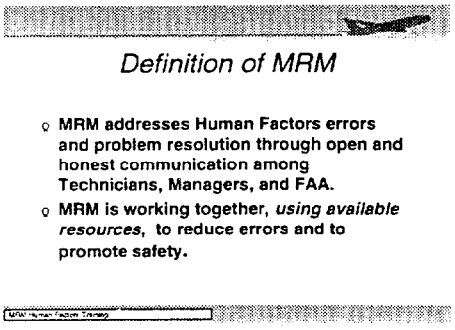
We'll also learn to recognize and avoid situation awareness problems, and understand the factors that can impact situation awareness within a maintenance team. To better understand what MRM and Human Factors programs our company has developed and what departments exist to help you we are going to tell 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 you should contact. We want you to understand who and what departments you can contact to present and discuss MRM and Human Factors issues and ideas.

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

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

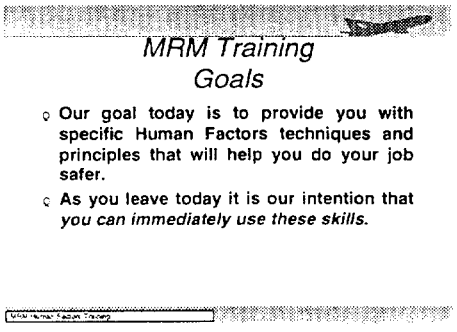
Explain: MRM is Maintenance Resource Management. As you can see, we are dedicated to enhancing safety through implementing MRM principles. Together our efforts can enhance the safety of all actions taken by all maintenance and operations personnel at our company.

Overhead: MRM definition



Refer to current MRM and Human Factors articles in the appendix section of your handbook.

Overhead: Goals



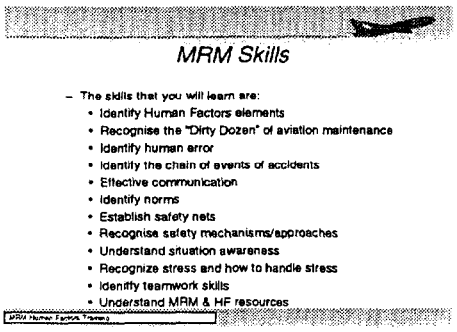
Emphasize: you can immediately use these skills!

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.



Module 2 **Human Error**

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. The 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. Debrief the class as to why this accident happened. Make the class aware that an accident was caused by human error.
Question: What is human error? **Overhead: Human Error is..** *Human Error* o Human Error is the unintentional act of performing a task incorrectly that can potentially degrade the system.	Human error can also be defined as: Slip: a good plan, bad execution Mistake: bad plan Infringement can be seen as an intentional deviation from safe operating practices, procedures, standards or rules.

Overhead: Two types of errors or failures

Types of Errors & Failures

- Active Failure: Action with immediate effects
- Latent Failure: Caused by someone or something having a delayed effect

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," an 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

Three types of Human Error

- 1. Error of omission: Not performing an act or behaviour–simply just didn't do it
- 2. Error of commission: Substituting an act or behaviour
- 3. Extraneous error: Performing an additional action

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, want 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

Class demonstration
Group Exercise

Questions:

There is only one way to disassemble
40,000 ways to error in reassembly
(Reference: Reason, 1997)

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.

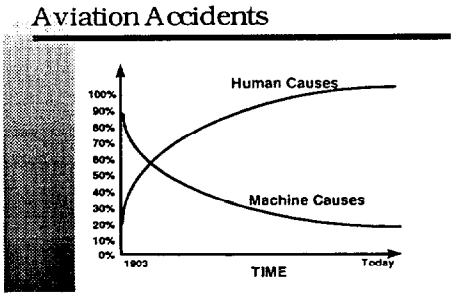
Overhead: What are the levels of consequences of human error?

Levels of Consequences: Human Error

- Little or no effect
- Physical damage to equipment
- Personal injury
- Catastrophic event

Ask: What was the level of the consequences of 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 accidents with an underlying human component have increased. (Mainly because that's what is left to blame when something goes wrong.)

Overhead: Accident causes/percentages

Significant accident causes and percentage present in 93 major accidents: (Graber & Marx, 1992)

- Pilot deviated from basic operational procedures	33%
- Inadequate cross-check by second crew member	26%
- Design faults	13%
- Maintenance and inspection deficiencies	12%
- Absence of approach guidance	10%
- Captain ignored crew inputs	10%
- Air traffic control failures or errors	9%
- Improper crew response during abnormal conditions	9%
- Insufficient or incorrect weather information	8%
- Runways hazards	7%
- Air traffic control/crew communication deficiencies	6%
- Improper decision to land	6%

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

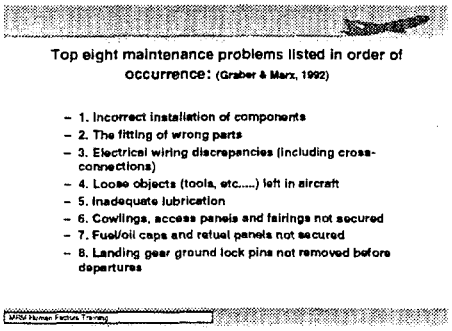
Not only pilot errors are included in human error--12% involved maintenance and inspection errors. Therefore, pilots are not the only ones—maintenance personnel cause errors in aviation also. Show the role that maintenance and inspection play (other crews).

Video: Show short video clips of AA#1 and Dash 8

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

Group or class exercise

Overhead: Top 8 maintenance problems

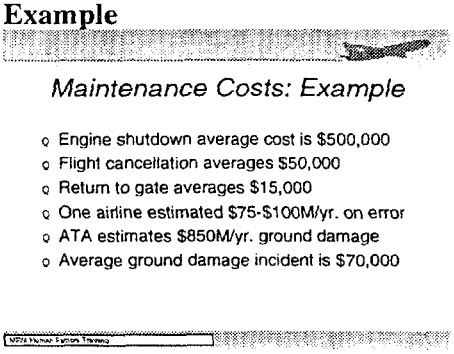


Facilitator's note: class exercise
Before showing slide, ask, "What do you think are some of the maintenance problems that contribute to accidents?" Take the class's reasons. Then show this slide. Compare.

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 or incident 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.

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

Organization Culture

- A pattern of beliefs and expectations shared by an organizaiton's members
- Shaped by rules and procedures stated by upper-levle management

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. The company may not give its employees enough time for a proper aircraft turnaround, and second, may not give them the power to ground a suspect plane. Even though management may not intend to, their practices may encourage unsafe aircraft.

Overhead: List of organizational and local factors

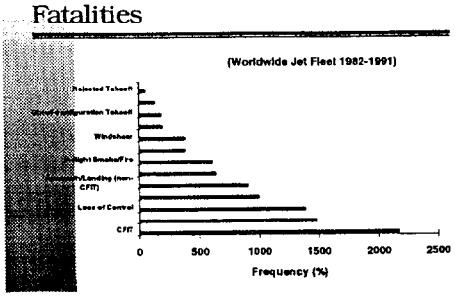
Organizational and Local Factors

- Organizational Factors:
  - structure
  - quality & availability of resources
  - training and selection
  - incentives
  - career paths
- Local Factors
  - knowledge, skills and abilities
  - morale
  - resources
  - environment

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 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, disposition, and mood. Local and organizational factors may interact in such a way to create an extremely error-prone work environment.

Overhead: Safety issues vs. Onboard fatalities

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).

Reference:

Comment

Errors affect profit.

Errors may be frequent but tolerance is high.

A small percentage of errors actually cause accidents or 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. These are 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 that we want to understand these elements so that we can contribute to reducing errors.

Module 3 **Human Factors Elements**

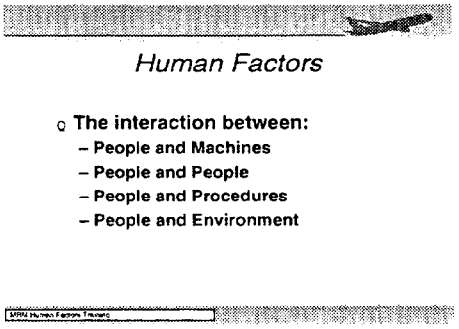
Training Objectives:

1. **To understand what Human Factors is.**
2. **To identify Human Factors elements.**

Activity/Overhead Question:

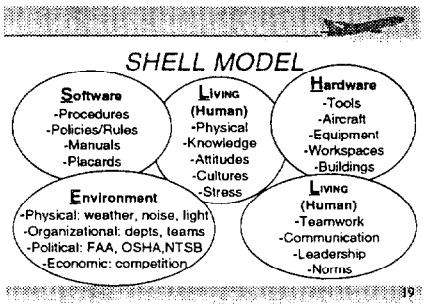
Facilitator Notes
What is Human Factors?

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, and equipment to get our job done. We also interact with the environment—that is, the weather, physical structures, organizational structures (departments), and other companies. They are external environments. 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)

The design of 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 consists of the company culture, departments, team structure, divisions, and other organizational structures. We all work in a department that interacts with other departments in this company and each department has its own policies and procedures. We also have company policies that 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 aircraft, 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 provide 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

Human Factors

Our performance is impacted by:

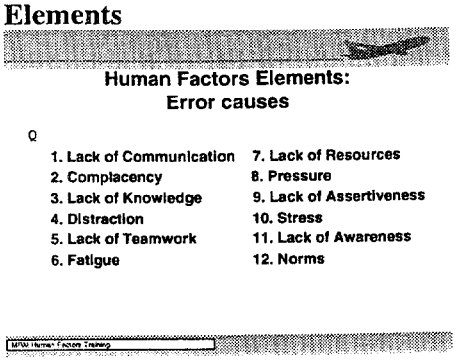
- Design of tools, equipment (manufacturing, computers) and workplaces (hangars, offices, warehouses)
- Design of training programs and personnel selection
- Design of software and procedures/manuals (Citext, DDE, MPP, workcards)
- Job Design (shiftwork, schedules and job tasks)
- Design of the organizational environment (structure, departments, teams , decision making)
- Physical environment factors (weather, noise, light)
- Physical body size and dimensions.

The design of machines, tools, software, and 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 do any of these HF elements affect you? Any examples?

Transition

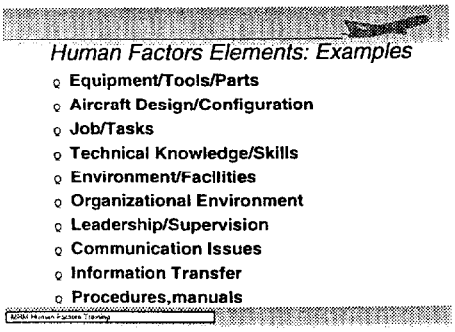
We've been looking at what HF elements are and how they affect our performance. Now, let's look at 12 error causes that have been identified as the most frequent factors that play a role in maintenance related accidents. These errors are caused by Human Factors elements. They have been called the "Dirty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

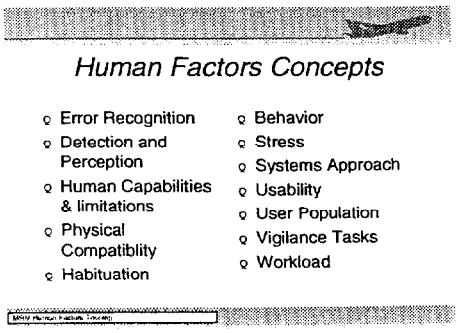
Overhead: Human Factors Elements



Human Factors elements
"Dirty Dozen" (reference Dupont,1997)

**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.

Overhead: Human Factors Elements: Examples

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.

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.

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.

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.

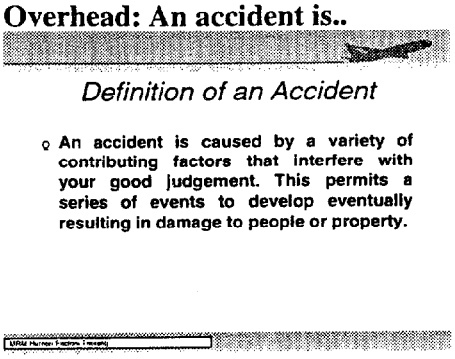
Module 4 **Chain of Events**

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.**

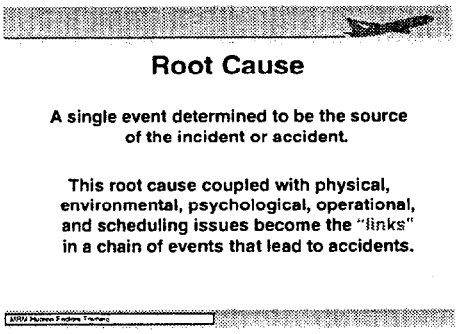
Activity/Overhead

Overhead: An accident is..

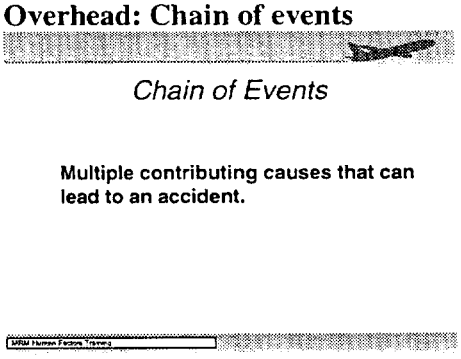


In every accident there are a series of events that link together to form a chain. We call this a *chain of events*. This is the Human Factors definition of an accident. The FAA, NTSB, and the company have different definitions, but this is how we will be defining it for this course.

Overhead: Root cause



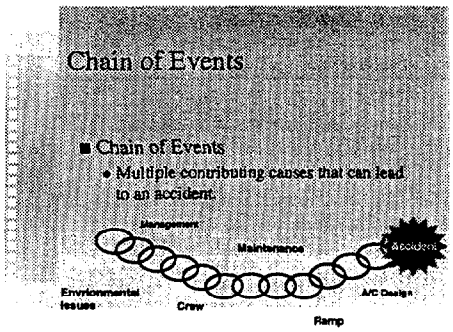
Overhead: Chain of events



Example of chain of events, use examples from the SHELL model
-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.

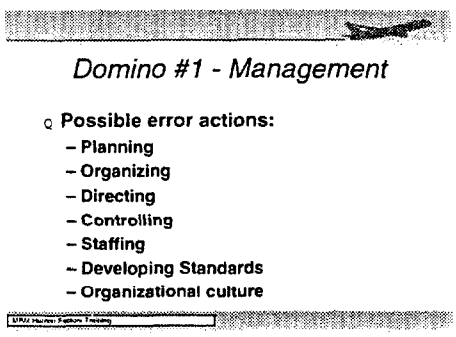
Accident Chain:
1. Contributing factors
2. Serial events
3. Conditional events
4. All factors must be present
5. Break the chain

Domino's Effect
Overheads
"Swiss cheese" Model or Reason, Model
Show line up of causes, failures, filters, defenses—accident scenario

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.

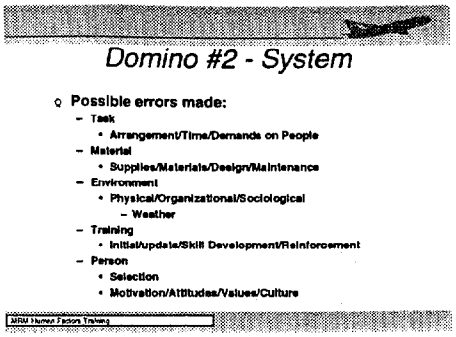
This domino model shows how components in a maintenance operation or airline system can interact to create an accident. Think of an accident as the last domino in a line of dominoes. Human Factors such as the environment, policies that are in place, equipment, and the people who take part in the system 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 a chain of events. Each domino can also be thought of as an accident causal factor.

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

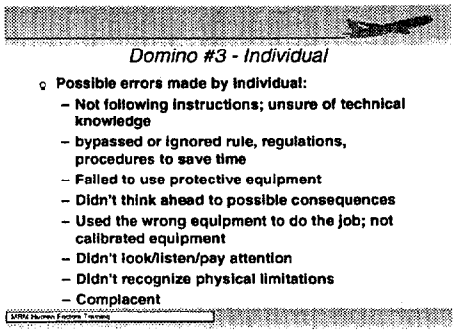


Reference: Reason, 1997

Reason Model : 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)

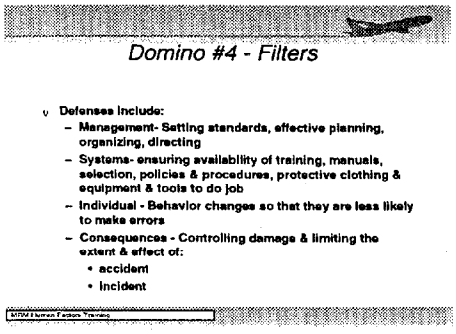


We discussed earlier active and latent (or hidden) errors. The domino theory focuses on what the underlying , basic, and immediate causes are. There can be several causes and this is why we view an accident chain as a system problem. There can be several safety defenses and filters. These are safety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

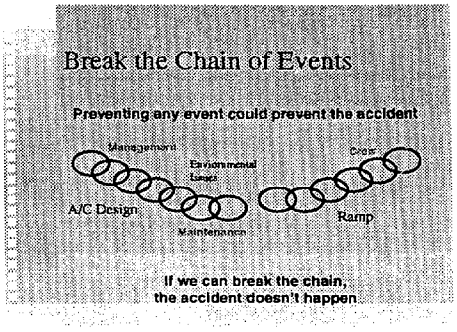


Note: You may want to provide several maintenance examples to illustrate the domino theory and layers.

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

Read: Dryden: Case Study (Part I)
Two parts of Dryden

Allow 12 minutes to read the case study on pilot and cabin crew coordination issues and the case study on maintenance issues in the Dryden accident. Why are we

	using a crew resource management case in MRM training.
Ask Question:	What was the role of maintenance in the Dryden case?
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 to have broken that chain by ensuring that the APU was 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 events.
De-brief exercise	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 identifies the first six of the dirty dozen and the other group identifies the last six "Dirty Dozen"), another the SHELL components, another the 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", and chain of events.
	Remember: to change the assignments for each group.
Discussion on Nation Air	What caused this accident?

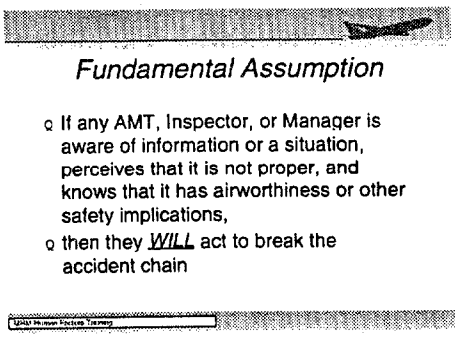
Module 5

Safety Nets

Training objectives:

1. **To understand what a safety net is.**
2. **To develop safety nets to break the accident chain.**

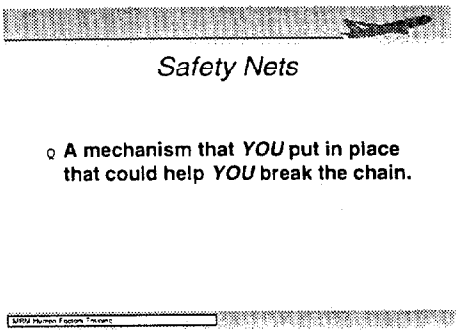
Overhead:
Fundamental Assumption



The fundamental assumption stated on the overhead 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.

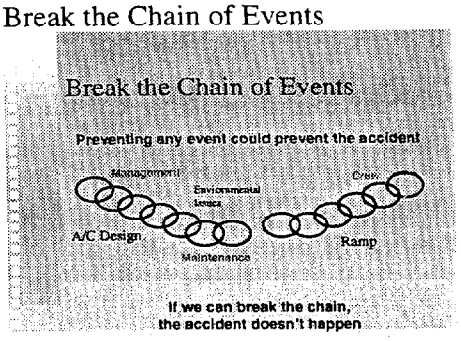
This situational awareness is just one Human Factors element we need to be aware of that can help us break the chain of events.

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.

Discuss "Link Busters"

A 'link buster" is any mechanism or filter that is put in place that can help break the chain of events.

De-brief Nation Air video for developing safety nets

Group exercise

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: break into groups and discuss 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 chart. Have a spokesperson present to class. Tape the list on the wall.

Overhead:
Review of modules 1-5

MRM Review

- Maintenance Resource Management
- Human Error
- Human factors model (SHELL)
- Human Factor elements: "Dirty Dozen"
- Chain of events
- Developing safety nets

Summarize the key issues from MRM.

Review the definitions of Maintenance Resource Management and Human Factors.

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

Review the 'Dirty Dozen"--Human Factors elements that have been found to be particular problems in aircraft maintenance.

Talk 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."

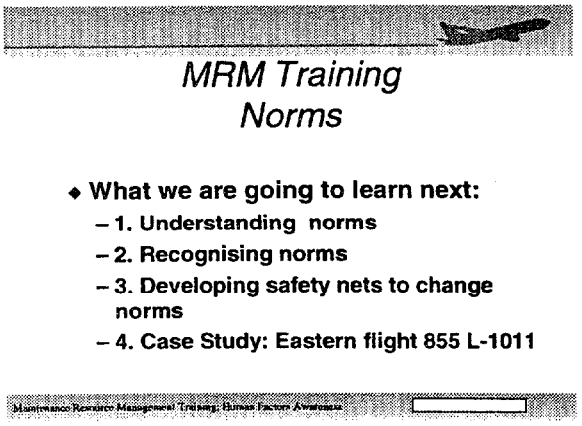
Module 6 **Norms**

Training Objectives:

1. **To understand norms**
2. **To recognize norms**
3. **To develop safety nets to break norms**

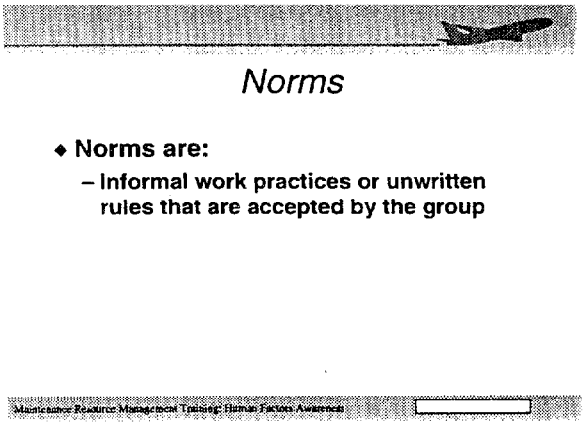
Activity/Overhead **Facilitator Notes**

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 demonstrates a certain behavior 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)**

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**

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**

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.**

These types of norms are unsafe.
We act in accordance with them because they generally save us time and steps. We can get the job done faster. An example of a negative norm would be when 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**

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:

Question?

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

Just ask yourself...

CLASS EXERCISE: QUESTION?

OVERHEAD: EXAMPLES OF 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.

Ask the class if these are positive or negative norms.

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

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

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

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 the group is pushing that something be done according to the norm.

OVERHEAD: ORGANIZATIONAL CULTURE & NORMS

Organizational Culture & Norms

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

Remember negative norms may set you up for an accident.

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

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

How are we going to do this?

By increasing awareness of Human Factors and MRM in every employee of this company. This Human Factors-MRM training course is a part of increasing this awareness.

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 a 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**

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

Background and Discussion:

In the 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 exist.

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 group 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?

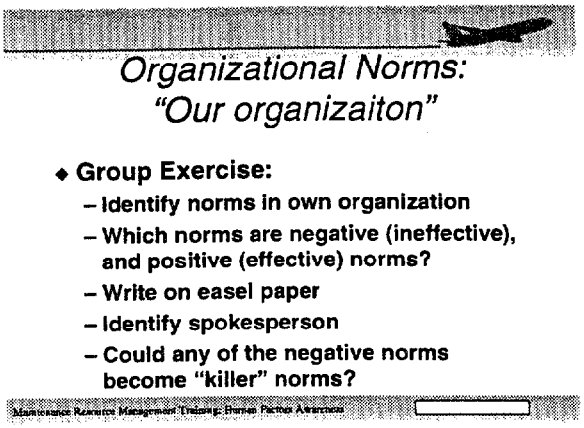
Example of safety nets: Special training procedures are safety nets. They are here for our protection—read them.

GROUP EXERCISE: IDENTIFYING ORGANIZATIONAL NORMS

Break participants into DIFFERENT groups now.

OVERHEAD: ORGANIZATIONAL NORMS

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



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

Discuss the positive and negative norms identified by the class.

Our company culture will allow positive norms to become policy.

How do we go about making a positive norm ?

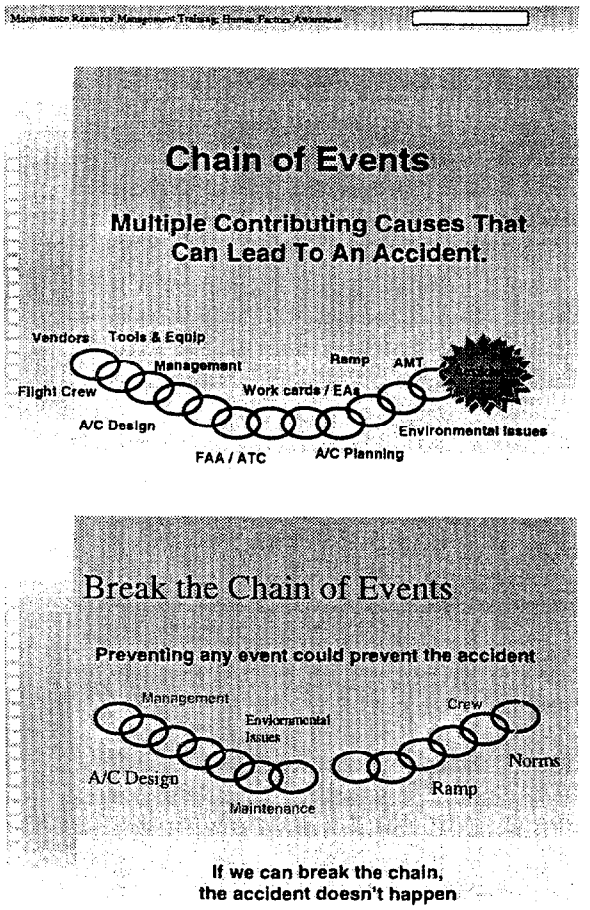
At this time, it is important to show "within the company" examples of how individuals can use the right resources and processes to have a positive norm recognized. Show examples of previous positive changes in procedures. Emphasize MRM and Human Factors principles in any discussion of the examples. Company newsletters 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 a Who's Who of MRM and Human Factors resources and references, internally and externally to the company.

Norms: Safety Net

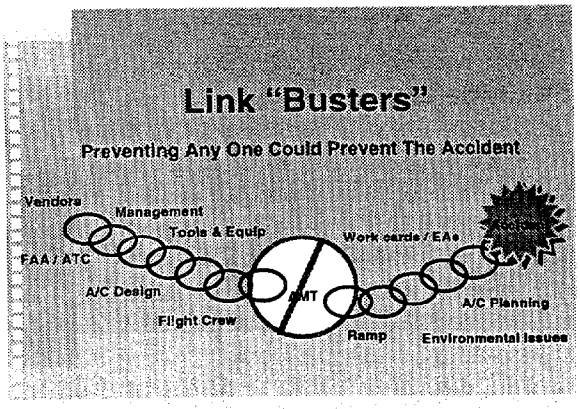
- **A safety net is a mechanism *YOU* put in place that could help *YOU* break the chain of events.**

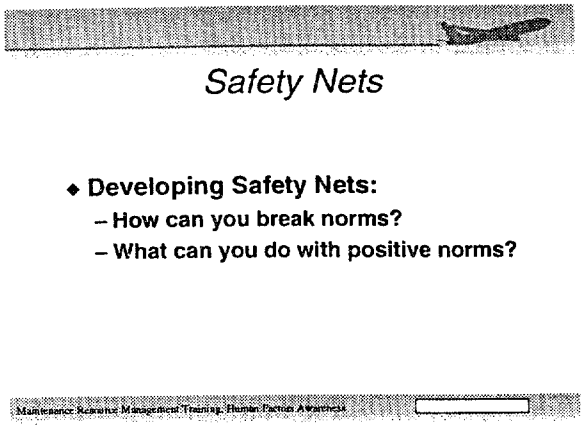
Let's look again at what a safety net is.



Reminder of breaking the chain of events.

Norms are part of the chain of events.





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?

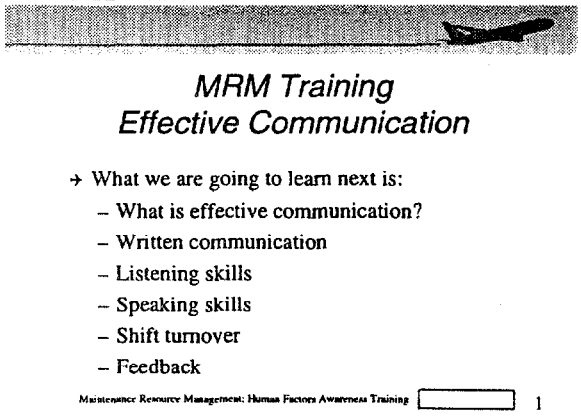
What experiences have you had in identifying positive norms, and changing procedures?

MODULE 8 Effective Communication (Shift Turnover & Feedback)

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 shift turnover document.**
7. **To recognize the value of feedback.**

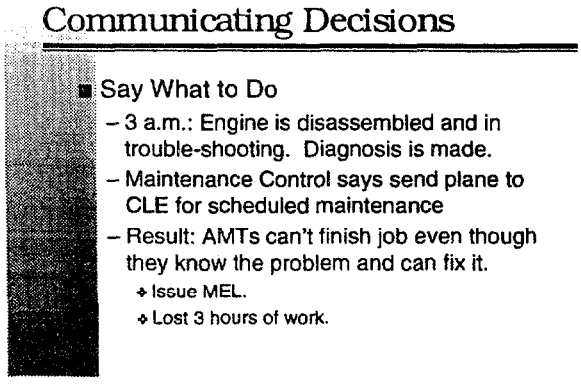
OVERHEAD:



TRAINING OBJECTIVES

Here is what we are going to do next.

CLASS or GROUP EXERCISE



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 something must be (or was) done. 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 entry and completing the repair without losing additional time. 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 doesn't fix problem
  - Result: AMT must trouble-shoot again, repeating many steps taken on first shift
    - Aircraft delay

IF in the same situation, the person performing the maintenance 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 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.

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

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.

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
- Maintenance Personnel
- 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

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

What is communication?

Ask the class what effective communication is.

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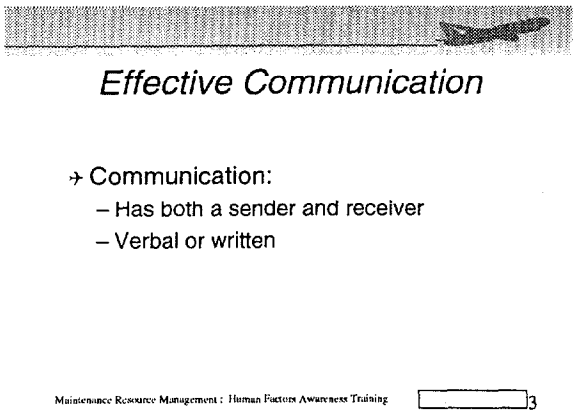
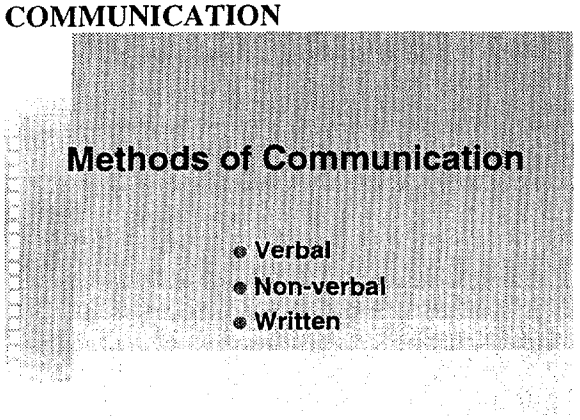
OVERHEAD: COMPONENTS



These are the basic components of communication.

OVERHEAD: METHODS OF COMMUNICATION



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

NOTE: 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

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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 carefully. 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

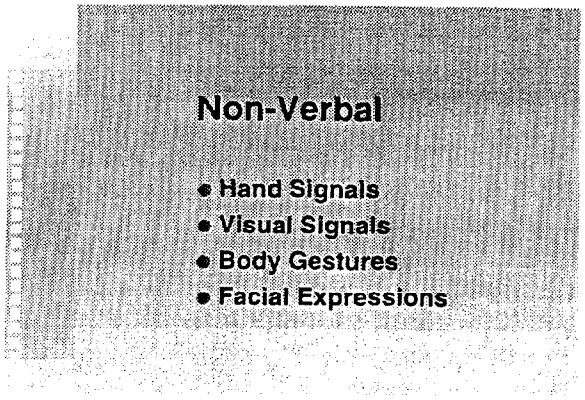
- Don't:
  - Debate what is being said in your mind
  - Detour (i.e., look for a key word to change the subject)
  - Finish the other persons sentences
  - Pre-Plan (figure out what you're going to say next)
  - Tune-out
- Do:
  - Ask questions
  - Paraphrase
  - Make eye contact
  - Use positive body 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 we have the tendency to not actively listen and we fill in the gaps of information with our own perceptions and thoughts.

Note. Provide examples of non-verbal methods of communication , if possible, by pictures or video.

OVERHEAD: NON-VERBAL



Note: Show examples of written communication and how we can misinterpret them. These misinterpretations lead to errors.

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

GROUP EXERCISE

Debrief: Why did you not read the instructions clearly?

Effective Communication

- Written: most difficult, limited feedback, no body language or tonal clues
  - –The reader cannot ask questions about the meaning or the message

Why is written communication difficult?

Is this important in shift turnovers?

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

{Eliminate or ensure proper sequence numbers on overheads.}

When do we need to communicate the most?

How important is it that we communicate?

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

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.

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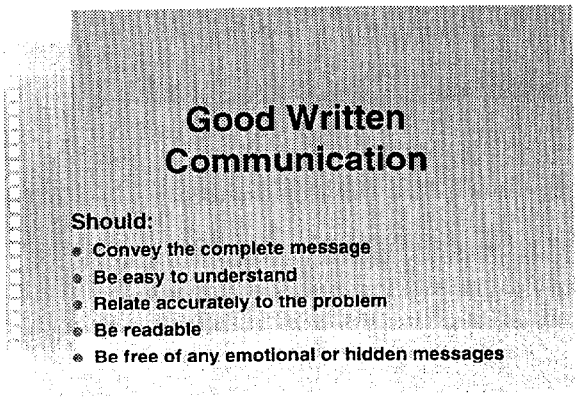
OVERHEAD: WRITTEN COMMUNICATION

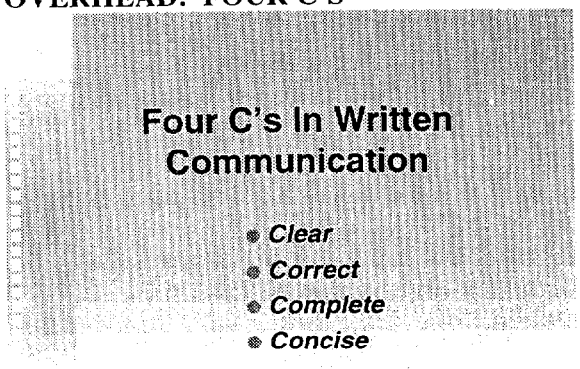


These are some very important rules about good written communication.

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

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
- Use Short sentences
- Be careful of acronyms and abbreviations

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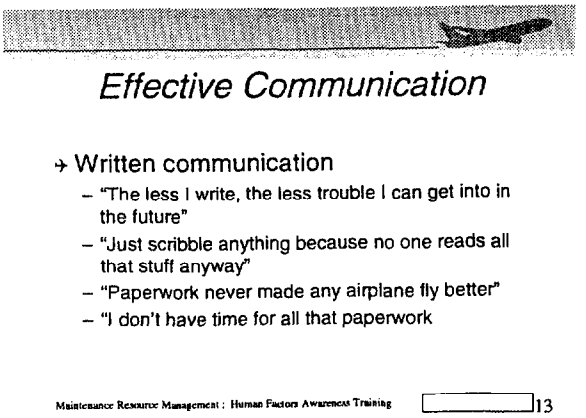
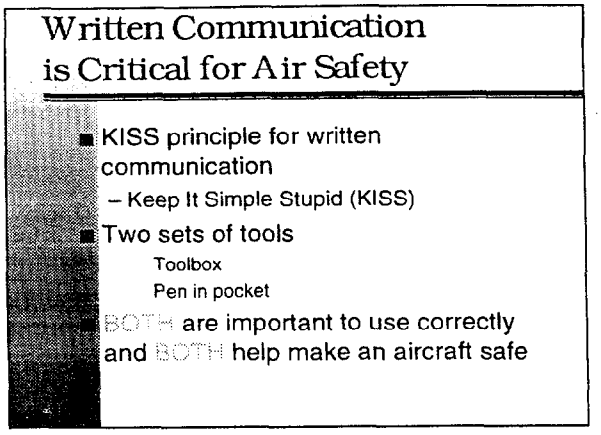
For the message to be complete, remember to state first safety issues and warnings and ALWAYS try out your message on someone else. They should provide you with some valuable feedback.

OVERHEAD: EXAMPLES

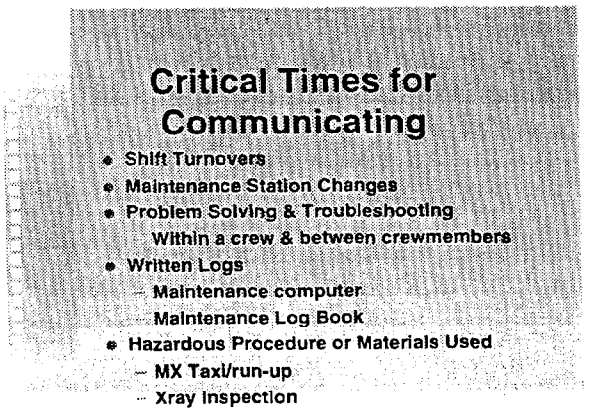


Watch out for these statements!



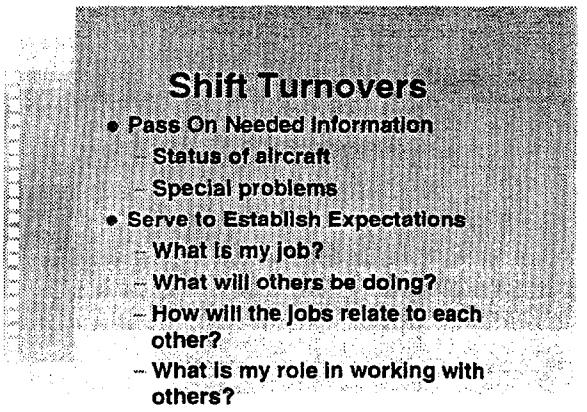
Practice your writing skills and try them out on someone who needs to understand what you want someone else to do—.

OVERHEAD:



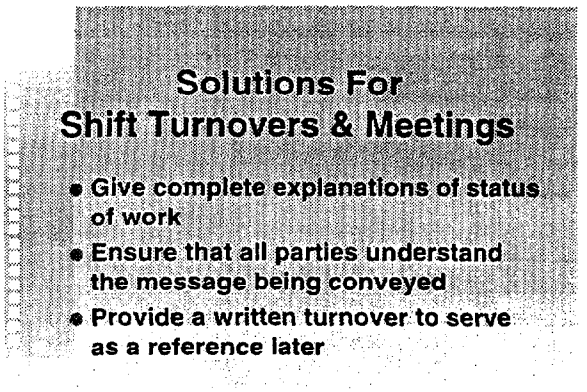
Good communication is always important. But there are certain times when we have found that you need to be especially careful that you communicate fully. (1) Communicating the status of on-going work at the shift change is of course extremely important. Many accidents have been linked to information 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) The problem-solving insights we have gained 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 turnover meetings. 1) They make sure 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) Shift turnover meetings also serve to establish your expectations for the maintenance team and to create the big picture. This involves describing not only what each person has to do but also providing 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.



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.

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

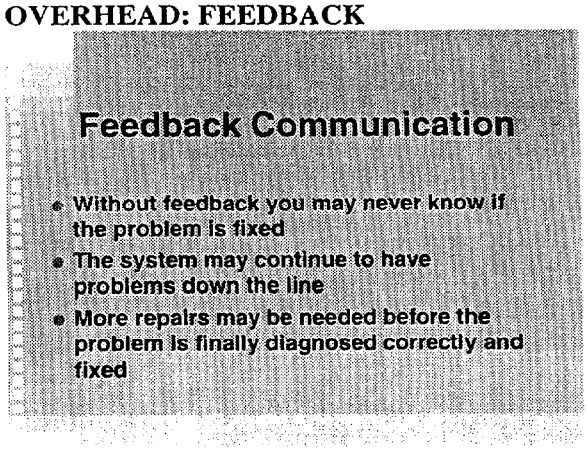
GROUP EXERCISE: SHIFT TURNOVER

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 maintenance personnel, we sometimes have a distrust of the written word. Thus we sometimes do not even write a shift turnover memo to provide the next crew with essential information about what we have completed and what the status of the repair is.

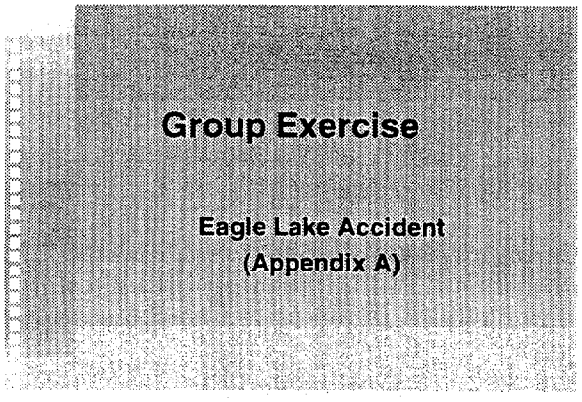
For written communication we do not want the reader to misinterpret and fill in the gaps. Many of you probably filled in the gaps when you were completing the pattern for the domino exercise. You may have been correct or incorrect. The consequences of your actions here are minimal. However, as we have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

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:



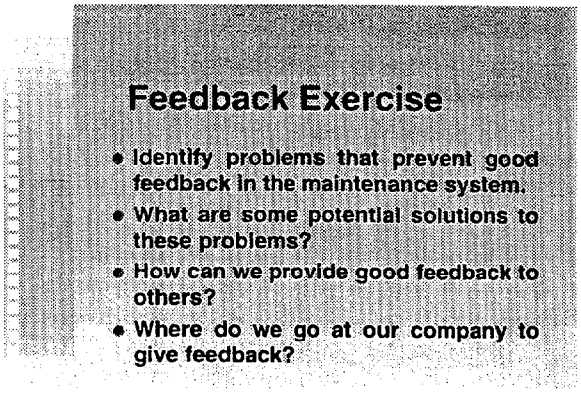
Let's review a case study for communication problems at a shift turnover.

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.

The facilitator may want to have one group list communication problems and the other groups to look at Human Factors elements, chains of events or developing safety nets.

{Where is appendix A? What is this accident about? Can we summarize it somewhere?}
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 regarding Human Factors elements, organizational resources, policies, etc.

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

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