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Rail Crew Resource Management (CRM): Pilot Rail CRM Training Development and Implementation

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13. ABSTRACT

This report summarizes the work undertaken by the Texas Transportation Institute (TTI) to develop and implement a pilot program of Rail-Based Crew Resource Management (CRM) training that can be used for a variety of crafts throughout the railroad industry. Pilot program development was a follow-on to the previous tasks to document the types of teams that exist in the railroad industry and the state of rail CRM training at U.S. Class I railroads, which TTI completed and documented in a separate report to the Federal Railroad Administration in September 2003. The pilot program builds upon the training methods and procedures identified in the earlier work.

This report documents the development of the program and the experiences encountered in implementing it at the railroad division level. The report presents data from pre-training and post-training surveys of participants that were administered during the pilot course as measures of the effectiveness and acceptance of the training program materials. The study also includes recommendations on further steps to broader CRM implementation within the railroad industry.

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LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

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1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

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1 ounce (oz)	=	28 grams (gm)
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1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

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1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
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1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

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METRIC TO ENGLISH

LENGTH (APPROXIMATE)

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1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

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1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
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1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

VOLUME (APPROXIMATE)

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1 liter (l)	=	1.06 quarts (qt)
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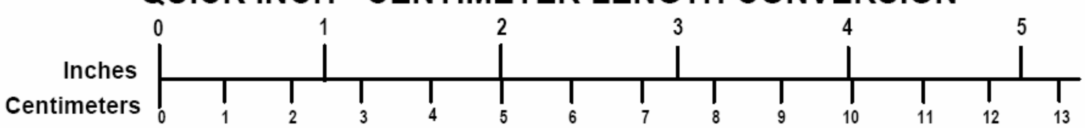
QUICK INCH - CENTIMETER LENGTH CONVERSION



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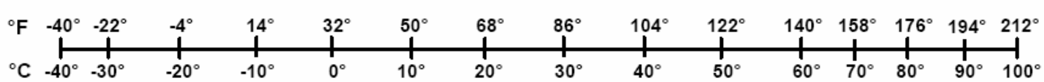

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Executive Summary

Purpose of this Report

This report summarizes the work undertaken by the Texas Transportation Institute (TTI) to develop and implement a pilot program of Rail-Based Crew Resource Management (CRM) training that can be used for a variety of crafts throughout the railroad industry. Pilot program development was a follow-on to the previous tasks, documenting the types of teams that exist in the railroad industry and the state of rail CRM training at U.S. Class I railroads, which TTI completed and documented in a separate report to the Federal Railroad Administration (FRA) in September 2003. The pilot program builds upon the training methods and procedures identified in the earlier work.

This report documents the program's development and the experiences encountered in implementing it at the railroad division level. This report presents data from pre-training and post-training surveys of participants that were administered during the pilot course as measures of the effectiveness and acceptance of the training program materials. The study also includes recommendations on further steps to broader CRM implementation within the railroad industry.

Project Background

During the past 4 years, a research team at TTI worked with FRA and the BNSF Railway (formerly the Burlington Northern Santa Fe Railway) to develop an improved CRM training course for use in the U.S. railroad industry. Initial tasks included site visits to a cross-section of railroad types in various U.S. locations, identification of railroad team makeup and tasks, and classification of railroad teams. Subsequent tasks have included design and pilot implementation of a CRM training course at various locations on the BNSF, which this report describes. The course was designed for training a variety of railroad crafts in technical proficiency, situational awareness, communications, teamwork, and assertiveness.

During the 1980s and 1990s many U.S. industries adopted human factors training courses, such as CRM. CRM first became widely used in the commercial airline industry, but military aviation, shipboard crews, medical/surgical teams, offshore oil crews, nuclear power plant operating crews, and other high-consequence, high-risk, time-critical industry teams soon followed. The success of CRM programs in reducing the number of airline accidents attributed to human error prompted the National Transportation Safety Board (NTSB) to recommend that a "Train CRM" program be developed for the U.S. railroad industry (NTSB, 1999). The need for such a program becomes evident considering that over the 12-year period between 1992 and 2003, human factor accidents (where human factors were determined to be the primary cause) have accounted for 42 percent of all railroad accidents (FRA, 2005).

In response to the NTSB's recommendation, the Association of American Railroads (AAR) and Norfolk Southern Railway (NS) jointly developed a video-based CRM training course, which was oriented largely to train operating crews (engineers and conductors). Several FRA Office of Safety personnel and the safety managers of several railroads were interested in seeing CRM training applied more broadly across the many varied crafts and skills within the railroad industry. This led them to approach TTI, seeking the development of a pilot rail CRM course that could be used to meet this need.

Development of Pilot Rail CRM Training Course

TTI based its pilot rail CRM training program upon the team classification models that it developed for FRA during earlier phases of this project. Researchers determined that a facilitator-led, scenario-based training program was the most effective method of initial CRM awareness training. In order to meet the need to reach a broader base of railroad crafts, researchers developed a core curriculum of CRM topics with the flexibility to select scenarios based upon the makeup of class participants. To achieve this, researchers developed three basic training tracks for rail CRM. The identified training tracks (with example crafts in each) were:

- *Transportation:* Locomotive engineers, conductors, dispatchers, switchmen, brakemen
- *Engineering:* Section gangs (maintenance-of-way (MOW)), signal maintainers, electrical catenary crews
- *Mechanical:* Machinists, electricians, pipe fitters, carmen

Each training track is supported by several scenarios from its own craft area in order to ensure that the training is job relevant for the class participants. Chapter 1.0 includes further information on course development.

Implementation and Testing of Pilot Course Materials

Once the course curriculum was nearing completion and the supporting scenarios developed, researchers scheduled several training classes with the host railroad to pilot test the materials. A total of 9 transportation classes and 6 engineering classes have been held, resulting in the training of 86 transportation personnel and 100 engineering personnel. Due to several events described in this report, the mechanical track materials have not been pilot tested. Chapter 2.0 describes information on the implementation and pilot testing of this program.

Analysis of Pilot Rail CRM Program

During the administration of the pilot rail CRM classes, a pre- and post-training survey was given to each class so that a variety of analyses could be performed to assess the effectiveness of the training materials. The evaluation consisted of several measures of participant characteristics, such as attitude changes, knowledge gain, and perceptions about the content of the course materials. The analysis shows that the class was well received in the locations where the pilot training took place. Chapter 3.0 provides detailed analysis and graphs showing participant characteristics.

Recommendations

The final chapter of the report contains several recommendations regarding the further implementation of CRM within the railroad industry. Several of these recommendations are related to the need for recurrent training to follow up on the initial training conducted during this pilot testing program. The research team recommends wider implementation of CRM training programs for all railroad crafts throughout the railroad industry. Both management and labor should be involved in this process, along with input from FRA on course content. The proven CRM principles from other industries can be implemented to address the human factors-related errors and accidents occurring in the railroad industry. The research team also recommends that FRA and railroad company safety training experts be identified and trained to facilitate CRM training classes throughout the railroad industry. The experience and expertise of these highly trained individuals will give them added credibility in presenting CRM concepts to railroad personnel that could not be immediately achieved by a group of outside subject matter experts in CRM or human factors training.

1.0 Pilot Rail CRM Training Program Development

1.1 Project Background

During the past 4 years, a research team at TTI has been working with FRA and BNSF Railway to develop an improved CRM training course for use in the U.S. railroad industry. Initial tasks included site visits to a cross-section of railroad types in various U.S. locations, identification of railroad team makeup and tasks, and classification of railroad teams. Subsequent tasks have included design and pilot implementation of a CRM training course at various locations on the BNSF, which are described in this report. The course is designed to be used for training a variety of railroad crafts in technical proficiency, situational awareness, communications, teamwork, and assertiveness.

During the 1980s and 1990s, many U.S. industries adopted human factors training courses, such as CRM. CRM first became widely used in the commercial airline industry, but military aviation, shipboard crews, medical/surgical teams, offshore oil crews, nuclear power plant operating crews, and other high-consequence, high-risk, time-critical industry teams soon followed. The success of CRM programs in reducing the number of airline accidents attributed to human error prompted NTSB to recommend that a Train CRM program be developed for the U.S. railroad industry (NTSB, 1999). The need for such a program becomes evident when considering that over the 12-year period between 1992 and 2003, human factor accidents (where human factors were determined to be the primary cause) have accounted for 42 percent of all railroad accidents (FRA, 2005). Figure 1 shows a breakdown of these accidents.

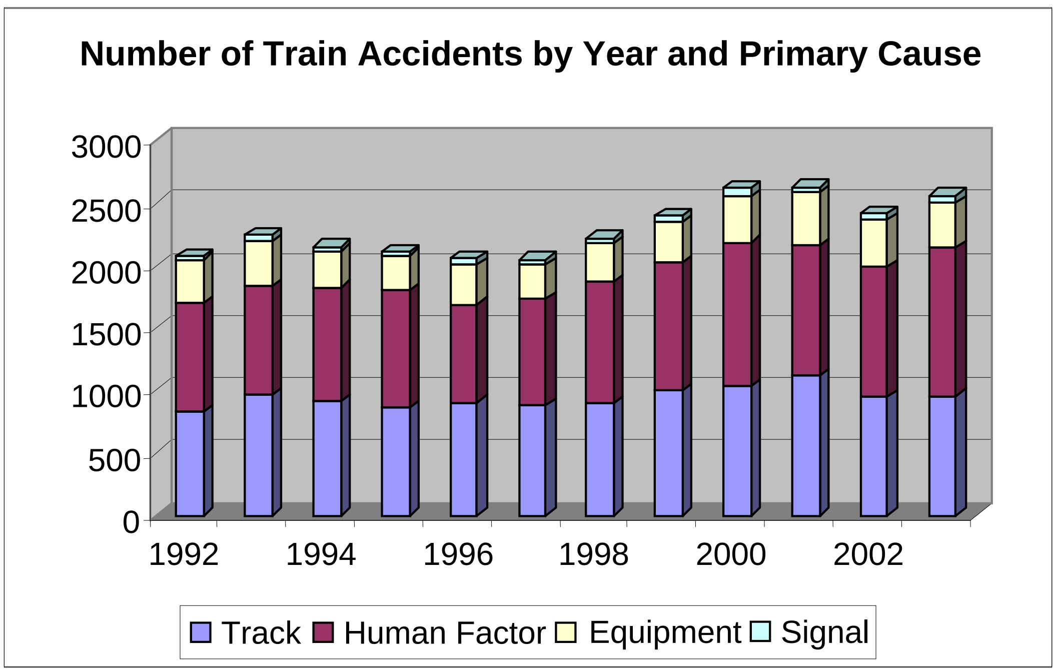

Figure 1. Number of Train Accidents by Year and Primary Cause

In response to the NTSB's recommendation, AAR and NS jointly developed a video-based CRM training course, which was oriented largely to train operating crews (engineers and conductors). Several FRA Office of Safety personnel and the safety managers of several railroads were interested in seeing CRM training applied more broadly across the many varied crafts and skills within the railroad industry. This led them to approach TTI seeking the development of a pilot rail CRM course that could be used to meet this need.

1.2 Identification of Teams and Training Groups

In late 2000, TTI began the original phases of its CRM research project for FRA's Office of Research and Development to identify, document, and classify the existing teams within the railroad industry. As part of the project, the research team conducted site visits at a cross-section of railroads that represented different geographic areas, organizational size, and purpose. Researchers visited several railroads throughout the United States to identify existing teams in the railroad environment. These early project tasks allowed the research team to develop a list of the common teams which exist at both freight and passenger railroads in the United States. In late 2003, the team presented a report to FRA that outlined the teams, their makeup, and classification (Morgan, Kyte, Olson, & Roop, 2003).

In addition, the report includes an assessment of the extent to which each of the large, Class I railroads in North America had implemented CRM training. TTI found that while all of the railroads had had some exposure to CRM, few of them had established an ongoing, active CRM training program. Instead, CRM was used as an annual training topic or as a remedial or corrective measure. A notable exception to limited application was at the Canadian Pacific Railway (CPR) where extensive training of train operating crews had been completed and operational reinforcement of CRM practices was beginning. Throughout the industry, however, application of CRM was almost exclusively restricted to train operating crews—much as early cockpit resource management had been restricted to flightdeck crews in aviation. In order to expand this application to other railroad crews, TTI's team classification process had to address issues related to the organizational types of teams found in the railroad industry, as well as recommending ways to incorporate more of the existing teams into CRM training.

1.2.1 Classification of Railroad Teams

TTI identified two major types of teams during this phase of the research, which the report terms elemental teams and interactive teams (Morgan, Kyte, Olson, & Roop, 2003). These terms come from the fact that certain teams are elemental—in the sense that they are relatively consistent in their makeup from day-to-day and that they are formed for the entire work period. An example of an elemental team would be a train operating crew for either mainline or yard operations consisting, most often, of an engineer and conductor but occasionally with the addition of a switchman or brakeman to assist in coupling/de-coupling of trains and manual operation of track switches. Another example of an elemental team would be an MOW crew, which typically consists of a foreman, an assistant foreman, a vehicle driver, and several laborers (trackmen, machine operators, or welders) depending upon the work tasks planned for that day. In both cases, the teams form at the beginning of the work shift and operate as a team in carrying out the day's assigned work.

The second type of team, the interactive team, forms when an elemental team must interact with either an outside individual or another elemental team in order to perform a task that occurs during the course of the workday. This type of team is formed onsite during the work process and exists, in effect, only for the duration of the interaction. An example of such an interactive team would be the team which is formed when a train dispatcher, an MOW crew, and a train operating crew must coordinate their efforts to safely move a train through an area of the track where the MOW crew is repairing or maintaining the track.

For this train movement to be safely accomplished, the dispatcher must communicate with both the train crew and the MOW crew to ensure that the track is in place and in a condition that will allow train movement; that the MOW crew, their vehicles, and their tools are not fouling the track; and that the train crew is aware of any speed restrictions while operating through the area. The MOW crew and train crew may also communicate directly by removing trackside maintenance warning signs and by ringing the locomotive's bell while transiting the work area. While conducting these activities, the dispatcher, MOW crew, and train crew form an interactive team process that dissolves once the train has completed its passage through the work area. The individual elemental teams then continue with their work until another interactive team is needed for another train to pass or until the track work is complete.

1.2.2 Grouping Teams for CRM Training

Once researchers identified the two major types of teams, a second decision was made to determine the grouping of the teams by similar work tasks in order to more effectively conduct CRM training. This classification process took the teams identified in the earlier project and grouped them into three separate training tracks based upon common work functions. This decision was based largely upon the research team's review of existing CRM training programs in the aviation, marine, and military domains. These industries were most comparable to the railroad industry in being transportation-oriented and organizationally similar. Each of them had adopted facilitator-led, scenario-driven, classroom-based training during their initial CRM implementation. The identified training tracks for rail (with example crafts in each) were:

- *Transportation:* Locomotive engineers, conductors, dispatchers, switchmen, brakemen
- *Engineering:* Section gangs (MOW), signal maintainers, electrical catenary crews
- *Mechanical:* Machinists, electricians, pipe fitters, carmen

Figures 2, 3, and 4 provide charts that show which teams or individuals would be assigned each of these training tracks.

Certain individuals are assigned to more than one training track. For example, a track inspector might benefit from participation in both the transportation and engineering tracks of the CRM course since that position relates closely to train operations and MOW.

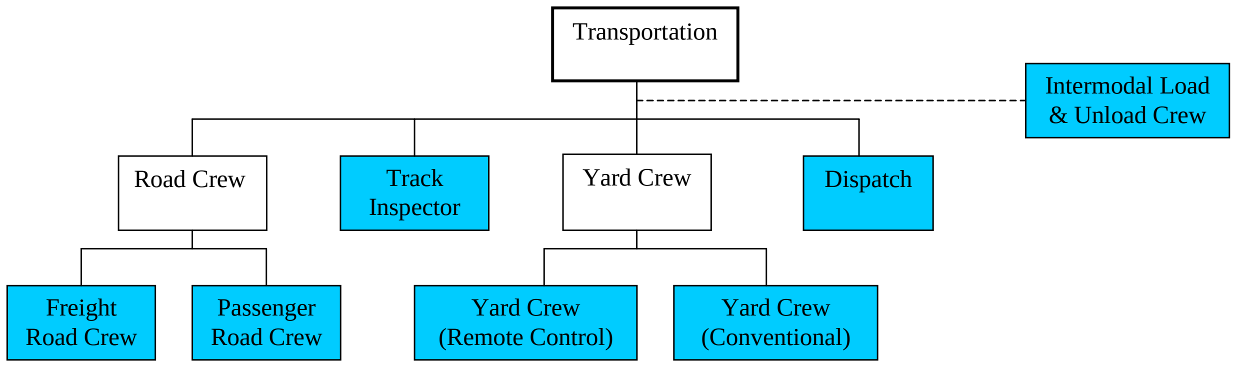

Figure 2. Transportation Crews

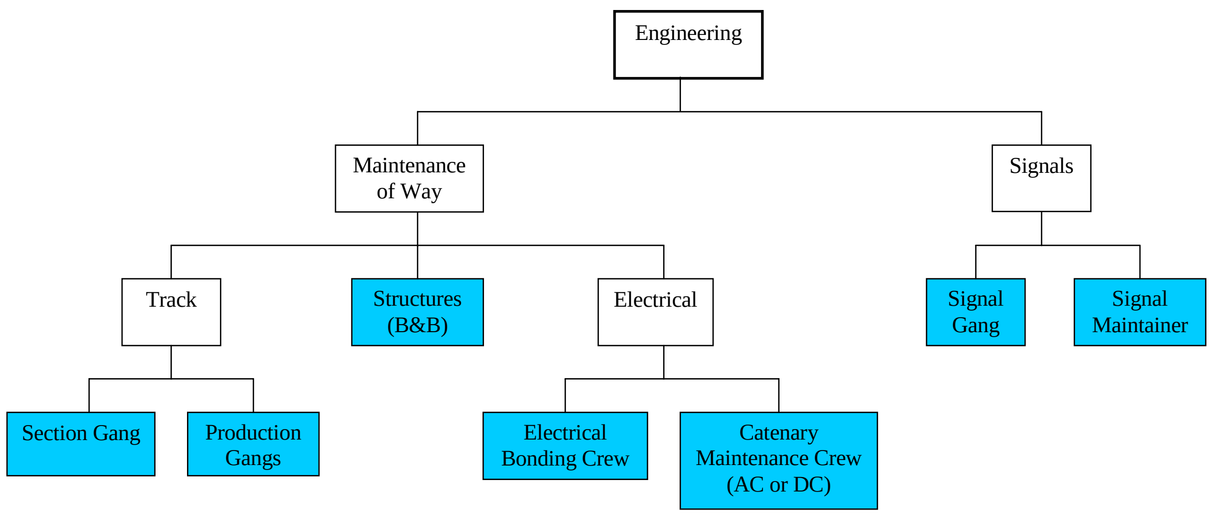

Figure 3. Engineering Crews

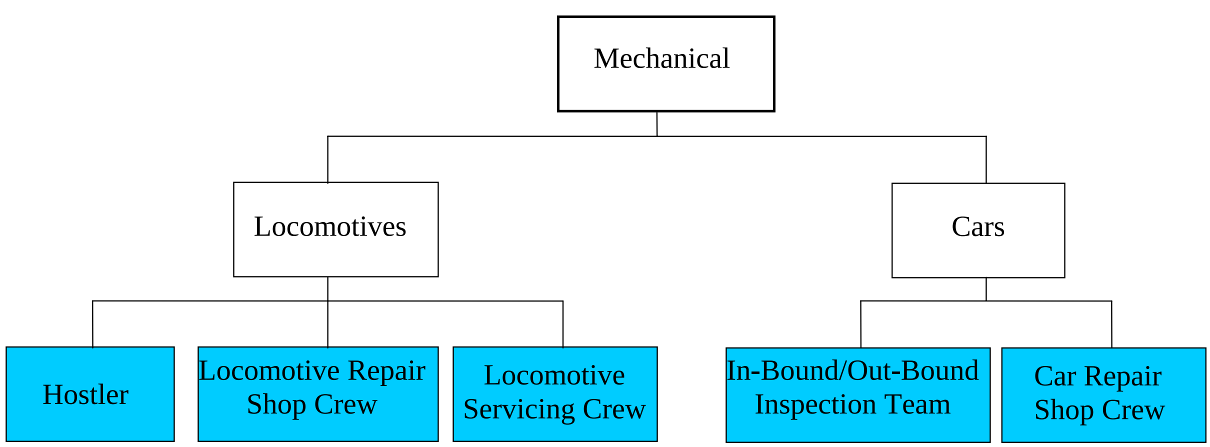

Figure 4. Mechanical Crews

1.2.3 Use of Recent Accidents for Training Scenarios

The importance of using scenarios taken from real accidents is evident from its frequent occurrence in implementation of CRM training in other industries. By using recent, relatable (i.e., closely associated to the job tasks of the student) accident scenarios, CRM principles are immediately reinforced in a manner that exhibits practical applications of the concepts into daily work. For this reason, scenarios are most effective when they relate directly to the daily work of the class members being trained. For example, using a scenario related to an engineer-conductor communications failure which led to a crash would be most useful in a class of engineers and conductors; however, it would not be nearly as effective in a class made up of signal maintainers or locomotive maintenance personnel. Developing a core course on the CRM basics with interchangeable scenarios related directly to the class makeup quickly became the focus of the pilot rail CRM training development.

1.2.4 Phases of CRM Training

Previous research suggests that participants should complete three critical phases of CRM training for it to be effective (Koenig, 1997; Prince, 1992). Similarly, the Federal Aviation Administration's (FAA) regulatory policies regarding CRM reflect the importance of each of these three phases (FAA, 2004). These phases are:

- *Awareness Phase:* Crewmembers complete seminar instruction and group exercises to learn the basic components of CRM.
- *Practice and Feedback Phase:* Crews participate in a realistic scenario in a simulator and receive feedback on their performance.
- *Reinforcement Phase:* The concepts become part of the organization's overall training and operation practices.

The first phase of CRM training, the awareness phase, is generally accomplished through formal classroom instruction. The second phase, practice and feedback, is accomplished through the use of a simulation or practice. The third phase is not a phase specific to the training program itself but is relevant because in order for training to work, the culture of the organizations must support or reinforce the training. More macro type issues within an organization, such as organizational commitment to training objectives, is considered one of the most important aspects of long-term training effectiveness (Salas, Rhodenizer, & Bowers, 2000). The course designed by TTI during this project is meant to train in the awareness phase with on-the-job practice, feedback, and reinforcement to follow once the workers return to their job sites.

1.3 Identifying and Developing Rail CRM Learning Objectives

Before designing the specific items to be included in the pilot rail CRM training program, it was important for the research team to identify and develop a list of overall learning objectives for the course. To fulfill this need, the research team built upon the examination of CRM training programs in other industries that had been conducted during the earlier phases of this project.

That research found that while many of the core skills contained in CRM training are similar across all industries, each industry has developed its own terminology and divided the course into a number of segments according to its own needs. Table 1 shows the results of this program review.

Researchers found three factors to be determinant in guiding the research team to choose how the pilot rail CRM course should be segmented—information gathered on existing CRM programs in the railroad industry and other closely associated industries, CRM factors listed in the NTSB recommendation, and input from FRA and partner railroads who were participating in the project. While each of these played an important role, the review of other programs was the most important. The TTI research team, with the assistance of an adult education expert from one of TTI's sister agencies, the Texas Engineering Experiment Station (TEEX), set out to develop a number of specific learning objectives for the pilot program.

Table 1. Differing Terminology for Core CRM Skills by Industry

U.S. Navy	Commercial Aviation	Bridge Resource Management	Medical Fields	NTSB
Decisionmaking	Decisionmaking	Decisionmaking	Priority Assessment	Crewmember Proficiency
Assertiveness	Pilot Judgment	Planning	Assertiveness	Assertiveness
Mission Analysis	Crew Coordination	Stress and Fatigue Management	Use of Information	Crew Coordination
Communication	Communication	Communication	Communication	Communication
Leadership	Leadership	Error Management	Leadership	
Adaptability/ Flexibility		Teamwork	Avoidance of Preoccupation	Teamwork
Situational Awareness		Situational Awareness	Situational Awareness	Situational Awareness
Active Practice and Feedback		Relationship Issues		Active Practice and Feedback

Note: Shaded areas denote common skills listed across two or more industries.

TTI and TEEX worked together to develop a set of five overarching goals for the pilot CRM training program. These goals suggested that upon completion of the anticipated instruction, learners should do the following:

- a. *Understand what CRM is and what it is not.*
- b. *Know CRM methods and appreciate their value for improving railroad safety.*
- c. *Understand that safety hinges on both individual and team actions.*
- d. *Know techniques and attitudes that foster effective communication within and between teams.*

e. *Understand situational awareness and how job safety is affected by circumstances both on and off the job.*

TTI and TEEX then worked together for several months to refine these goals and create learning objectives which would meet them. Each of the goals was analyzed and assigned specific learning objectives. The learning objectives desired for each participant, in order to meet the goals, included the following:

a. *Understand what CRM is and what it is not.*
   1. Explain where CRM techniques originated.
   2. Describe the difference between CRM and crew management.
   3. Describe how CRM can be used to reduce accidents related to human error.
   4. Name the principal elements (main areas) of CRM practices (as described in the course).
   5. Identify ways that effective crews may already be practicing some of these principles.

b. *Know CRM methods and appreciate their value for improving railroad safety.*
   1. Describe how CRM techniques can be important to safe railroad operations.
   2. Explain the benefit of CRM to enhancing safe crew functions.
   3. Explain to a coworker how CRM can benefit the quality of one's job-life.
   4. Make appropriate choices from among competing safety considerations.
   5. Name the three elements of technical proficiency as related to CRM practices.
   6. Give an example of maximizing use of available resources to enhance safe operations.

c. *Understand that safety hinges on both individual and team actions.*
   1. Identify and give examples of four types of human error.
   2. Explain why optimizing safety involves team responsibility, as well as individual responsibility.
   3. Describe the role of exercising safety leadership (in achieving safe outcomes).
   4. List the benefits of improved team decisionmaking.

d. *Know techniques and attitudes that foster effective communication within and between teams.*
   1. List the main factors affecting how individuals communicate.
   2. Describe his/her own communication style.
   3. Identify barriers to full communication of safety information among crewmembers.
   4. Explain why one's communication should be tailored to the style of communication common to the listener.
   5. Demonstrate appropriate use of assertiveness in job communications.
   6. Give examples of information that might need to be shared with coworkers to enhance team safety.
   7. Illustrate good and bad techniques for communicating in a job briefing.

e. *Understand situational awareness and how job safety is affected by circumstances both on and off the job.*
   1. Explain some of the ways non-work life can affect on-the-job safety.
   2. Describe personal and team cues that indicate potential safety breakdowns.

3. Give examples of identifying error and potential error at the earliest stage of situation development.
4. Describe the potential impact of stress and fatigue on worker perceptions of developing situations.
5. Explain to a coworker why maintaining situational awareness is so important to job safety.
6. Be able to list four techniques that individuals can use to maintain situational awareness on a team.

The research team traveled to Washington, DC, and reached agreement on these learning objectives with FRA and ENSCO personnel in July 2003. Once these goals and specific learning objectives were in place, the team was able to develop almost all of the lecture materials in the course to directly meet them; however, in addition to objective CRM content, the training course also required that realistic scenarios be developed.

1.4 Identifying and Developing Rail CRM Scenarios

In its recommendation to develop rail-based CRM training, NTSB suggested that the program should address four main topics: crewmember proficiency, situational awareness, effective communication and teamwork, and strategies for appropriately challenging and questioning authority (NTSB, 1999). It was important that these elements be brought into the course design while still meeting the goals and learning objectives described in the previous section. Following discussions with and input from BNSF and FRA, the research team decided to adopt a core outline for the pilot rail CRM training course, which consisted of the following six training modules:

- Introduction/Background of CRM
- Technical Proficiency
- Situational Awareness
- Communications
- Teamwork
- Assertiveness

Once this framework was in place, the researchers developed scenarios to support each topic and training track. Researchers also located audio/video materials to support each module; however, sources of detailed information regarding rail accidents are limited. Initial resistance to using recent, actual accident scenarios was encountered from the railroad companies involved due to legal concerns. After some discussion, FRA and railroad representatives agreed to allow the research team to use NTSB reports and FRA fatality reports in developing scenarios since these reports were already in the public domain. Railroad company representatives also had to be convinced that selecting the most appropriate examples of each of the CRM traits exhibited from the pool of available NTSB and FRA reports was a better choice than trying to ensure that the number of examples selected from each railroad company was the same or that no accidents on the host railroad should be used.

Although a close calls reporting system is now under development by FRA and the railroads, at the time of this project one did not exist. As a result, few examples of positive CRM saves (accidents prevented by practicing CRM skills) reported through an anonymous system were available to be developed into scenarios. This resulted in most of the program scenarios centering on fatal accidents that had been documented in either NTSB reports or the limited number of detailed FRA fatality reports from 1997, 1998, and 2002, which FRA has published. While these sources provide accident analysis in the level of detail required to develop rail CRM scenarios, typical FRA accident reports do not. FRA accident reports have numerical data that describe injuries and account for physical damage to rail rolling stock (i.e., locomotives and cars) and tracks, but little emphasis in accident reporting to date has gone into investigation of human factors unless fatalities have occurred.

Once the course goals and learning objectives were in place and the sources of scenario materials received approval, actual course development could begin. This was an iterative process which took quite some time. The next chapter describes the course content and testing process.

2.0 Testing and Implementation of Pilot Rail CRM Training Program

2.1 Pilot Testing and Presentation of Course Materials

TTI conducted beta testing of transportation and engineering tracks of the program in fall 2004 to determine the effectiveness of the training materials that remained under development. Researchers made changes to the content and organization of the CRM training presentation and scenarios based upon input received at those two beta test classes. The team also decided to provide each attendee with a participant's guide, which contained copies of the presentation slides, room for taking notes, and written versions of each scenario along with questions to be used by the small groups. Regular training sessions in the transportation and engineering tracks followed the beta testing phase in spring and early summer 2005 at various locations as shown in Table 2.

Pilot testing of the maintenance track materials did not take place due to several setbacks. Originally, maintenance track pilot testing was scheduled at the Kansas City Southern (KCS) maintenance facilities in Shreveport, LA; however, after the resignation and departure of the member of the safety management team at KCS who was supporting this project, an agreement to conduct the mechanical classes could not be reached with KCS. Other KCS management officers were asked for permission to conduct the classes, and both TTI and FRA personnel made repeated attempts to schedule the courses at BNSF sites. Ultimately, these efforts proved unsuccessful.

2.2 Pilot Rail CRM Training Delivery

TTI worked with personnel at FRA and BNSF to arrange classes to pilot test the training course once each of the training track curriculums was completed. This process consisted of beta test courses conducted in late 2004 and training classes for transportation and engineering tracks in spring and early summer 2005. Classes typically took between 6 and 8 hours to complete depending upon the number of attendees and the amount of discussion that occurred among the participants.

Each of the training tracks has experienced challenges associated with scheduling and conduct of the pilot courses, which will need to be considered to further implement the program. In the transportation training track, the greatest difficulty encountered when scheduling classes was due to the crew scheduling process by which students are assigned to the pilot classes. Often trainees were given little or no notice of the class being scheduled and had to report for training when they were expecting an operational job on that day. This lack of notice about the class angered and frustrated many of the participants. It often took several hours to overcome this obstacle and win over the participants to the value of the training.

Table 2. Pilot Rail CRM Training Locations, Dates, and Class Size

Location	Date	Training Track	Number of Attendees
Saginaw, TX	September 22, 2004	Transportation (BETA)	17
"	December 2, 2004	Engineering (BETA)	3
"	April 12, 2005	Transportation	14
"	April 20, 2005	"	12
"	April 21, 2005	"	4
"	April 25, 2005	"	12
"	April 26, 2005	"	8
"	April 27, 2005	"	4
"	May 3, 2005	"	8
"	May 4, 2005	"	7
Ft. Worth, TX	May 17, 2005	Engineering	14
"	May 18, 2005	"	22
Childress, TX	June 8, 2005	"	16
Norman, OK	June 14, 2005	"	22
Perry, OK	June 15, 2005	"	23

Researchers did not encounter this problem when scheduling engineering classes since group training and a monthly training day were already a part of their regularly planned activity. Additionally, the interest of the division engineer in seeing the program implemented enabled the courses to be scheduled more readily. Maintenance classes are pending location and participant scheduling by the host railroad and FRA.

2.3 Course Content Description

The following six modules make up the CRM presentation developed for this course. The end of each module presents a scenario based upon an actual accident or incident that supports the learning objectives of the module. Each scenario contains information from reports published by NTSB or FRA. Class participants are put into small groups, where they review the materials and answer a number of questions related to the CRM principles discussed during the lecture portion of each module.

Before beginning the first module, each class receives a Safety Briefing regarding the classroom location, a headcount is taken, and emergency plans are made should an unforeseen event occur during the training. This briefing is done in accordance with the host railroad's procedures and policies. Whenever possible, the facilitators allowed a senior member of the class to lead or assist in conducting this briefing.

Following the safety briefing, each facilitator and class participant are given an opportunity to introduce themselves and give some information on their background as it related to the class (i.e., name, years of railroad experience, job assignment, etc.). Once introductions are completed, a pre-training survey is administered to the class participants to gain baseline information for evaluating course effectiveness.

2.3.1 Module 1: Introduction

Module 1 of the course provides basic definitions for CRM and a history of the origins and development of CRM. This module describes what CRM is and what it is not, specifically addressing the difference between the CRM concepts that are covered in the class and crew management, which is the term used by several Class I railroads to describe their system of notifying train crews when they are required to report for duty. The instructor makes it clear that CRM, as discussed in this class, is not directly related to this crew calling function. A discussion of the project's history is included, as well as an overview of elemental and interactive teams, and an explanation of the training tracks that make up this CRM training program.

This module also includes a discussion of NTSB's investigation of the NS–CSX train accident at Butler, IN, in 1998, which led NTSB to recommend that the railroad industry institute train CRM for the first time. The NTSB investigation concluded that a major contributing factor of the accident was that each member of the train crew acted as an individual with little or no communication as a team. The discussion of this accident, and the breakdown in crew coordination which led to it, laid the basis for the day's discussion of CRM principles.

The facilitator presents an outline of the planned training schedule, as well as an overview of the topics to be studied throughout the day. This module allows time for two to three additional accident scenarios at the end to begin to familiarize and involve the participants in analysis of the human factors causes of accidents. The participants, acting in small groups (or as one large group depending on class size), review and evaluate each scenario before the facilitator reviews and discusses its relationship to CRM principles. This acquaints the participants with techniques that are used throughout the day to evaluate scenarios in each subsequent module. Discussion of the introductory scenarios also allows the small groups to begin to coalesce and form internal roles that can be built upon as the class progresses.

2.3.2 Module 2: Technical Proficiency

Module 2 is typically a very short module in comparison with the others in this course. The development of technical (or job) proficiency has often been the focus of the majority of job training that is provided by railroad companies to new hires and long-time employees. In relation to CRM, technical proficiency is foundational because each team member is expected to know his/her procedures, know his/her equipment, and know how to put knowledge of those two items into practice as skilled job performance.

A second facet of technical proficiency related to CRM that is discussed by the instructor is to assess and take into consideration the technical proficiency of other team members both before and during job activities. The key is not to assume that a coworker knows a specific skill, but to ask him/her directly if any question exists regarding his/her ability to complete an assigned task. Other methods of assessing or determining a co-worker's level of technical proficiency, as well as situations where a lack of technical proficiency can lead to an accident, are discussed.

The facilitator stresses to the participants that this module is not a forum to evaluate their individual technical proficiency. Rather, it is a reminder that, along with the individual and railroad responsibilities for ensuring that a person is trained in his/her job functions, the members of each railroad team must work together to identify any areas where technical proficiency may be lacking. At the end of the module, a scenario in which a lack of technical proficiency led to an accident is discussed.

2.3.3 Module 3: Situational Awareness

This module introduces the students to the concept of situational awareness and uses presentation graphics to compare what is actually occurring (reality) versus what is viewed to be happening (perception of reality). The fact that people act upon what they perceive as reality is discussed by the facilitator, as is the importance of becoming more aware of the actual situation as individuals and as a team. This module also allows discussion of recognizing situational cues and the role that fatigue can play in loss of situational awareness. This module also reviews tools for recognizing a loss of situational awareness, regaining situational awareness, and maintaining situational awareness.

Module 3 typically uses one scenario exhibiting a loss of situational awareness and one video clip showing fatigue cues to aid the participants in relating to the subject material. Discussion of the scenario in small groups and subsequent discussion as a whole class normally allows time for the participants to examine and question how the crews in the scenario could lose situational awareness, as well as identify some points in the scenario where a different action should have taken place. The facilitator must work to begin to have class members identify and point out such events by this time in each training session.

2.3.4 Module 4: Communications

This module covers communication skills and ways to improve communication between crewmembers of elemental and interactive teams. It includes three video clips of the same two individuals discussing a job assignment in the yard, each time using improved communication skills to increase safety through information exchange. The video clips illustrate communication skills presented in the module. For the transportation track, a recording of the dispatcher to train crew communications from the head-on collision of trains in Clarendon, TX, is presented to the class. (This audio file was provided to the team by FRA staff who participated in the NTSB investigation of the accident.) The class is asked to identify problems in communication either internal to the operating crews or between the train crews and the dispatcher as the recording advances. After the audio track is completed, the participants read a short description of the head-on collision to provide further information on how it occurred. The small groups can then evaluate what went wrong during the period building up to the time of the accident.

This module stresses the importance of evaluating multiple characteristics of communication, such as non-verbal, two-way versus one-way communication, and active listening. Other communications methods used by the railroad industry are reviewed (for example, radio, hand signals, written orders, and the strengths and weaknesses of each communication method). The module continues with a discussion of new communications technologies (cell phones, electronic authority exchange, automated information exchange, etc.) and how they will potentially change the way in which railroad crews communicate. Finally, the importance of the job briefing process and the importance of active participation in job briefings are reviewed and discussed.

Participants are reminded that overt and subtle cues may be displayed during the briefing that can greatly affect the crew's later performance.

2.3.5 Module 5: Teamwork

The teamwork module's goal is to relate to the participants that safety hinges on individual and team actions. Principal issues discussed are the difference between the lines of authority or leadership as opposed to safety leadership, developing conflict resolution skills, making sure the work load is equally distributed throughout the working crew, and keeping all members of the crew actively involved in safety while recognizing coworker cues. The module normally utilizes one scenario related to teamwork or job assignment roles and two video clips related to conflict management to illustrate the principles covered.

2.3.6 Module 6: Assertiveness

This module discusses the need for assertive communication within railroad teams to help ensure that accidents do not occur due to a failure to communicate information or to point out hazards due to authority roles within the crew. Proper methods of being assertive are reviewed, and one video clip is presented that illustrates how an accident can occur when an individual does not act assertively and submits to the judgment of a more senior coworker, even though he/she is uncomfortable with the situation.

2.3.7 Course Review and Final Scenario

The course review discusses the items covered throughout the day's CRM training. To wrap up the course, a major scenario incorporating all the elements of CRM is presented for small group review and evaluation. This scenario allows the group to utilize the skills learned during the entire class. The facilitator has the participants identify and describe each of the different elements of CRM (i.e., technical proficiency, situational awareness, communication, teamwork, and assertiveness) that play a role in the accident scenario, as well as corrective actions that the crew could have taken before or during the unfolding accident. Once this discussion is complete, a post-training survey is administered to the class in order to assess knowledge transfer, attitude changes, and acceptance of CRM principles by the participants. The next chapter contains a detailed analysis of the results of this measurement of class responses.

3.0 Analysis of Pilot Rail CRM Program

3.1 Characteristics of Training Participants

As part of this pilot rail CRM training program, a total of 186 participants were trained. The average class size was 13; however, class sizes ranged from 3 to 24 participants. In the 9 transportation track CRM classes, a total of 86 engineers, conductors, and/or switchmen were trained. Furthermore, a total of 100 MOW employees attended 1 of the 6 engineering track pilot rail CRM training classes. The MOW employees who attended the training included welders, welder's helpers, equipment and machine operators, track laborers, truck drivers, signal inspectors, MOW foremen, and assistant foremen. A small number of bridge and building supervisors attended the engineering beta course. Furthermore, several road masters, track supervisors, and a safety assistant participated in one or more engineering track training programs.

TTI collected data on age and years of railroad service from 75 percent of the training participants. The average age of the sample group was 45 years old; however, further examination of the data revealed a bi-modal distribution, with two main age groups. Figure 5 shows one mode around 34 years of age, while another is around 52 years of age. The distribution of years of service on the railroad had similar properties. Overall, participants averaged 20 years of service on the railroad; however, inspection of Figure 6 shows a tri-modal distribution including a large group with 1 year or less of experience (new hires), participants with around 8 years of experience, and finally participants with about 30 years of experience.

Before this pilot program, many CRM principles and skills had been taught to the broad employee base throughout the railroad industry but not through any formal training that is called CRM (Morgan, Olson, Kyte, Roop, & Carlisle, 2003). For example, teamwork is often taught as a value, and the associated actions relating to many of the teamwork skills contained in formalized CRM programs are provided through a variety of training courses. The idea of teamwork within a CRM framework, however, is not necessarily taught. Consequently, the extent to which participants had received previous CRM or CRM-type human factors training was also assessed through a post-training survey given to a sample of participants (58 percent). Results showed that 3.8 percent of those participants sampled indicated that they had previously attended CRM training, 11.3 percent indicated that they had previous training on communication, 7.5 percent specified that they attended previous situational awareness training, 11.3 percent had some sort of teamwork training, and finally 7.5 percent indicated that they had previous assertiveness training.

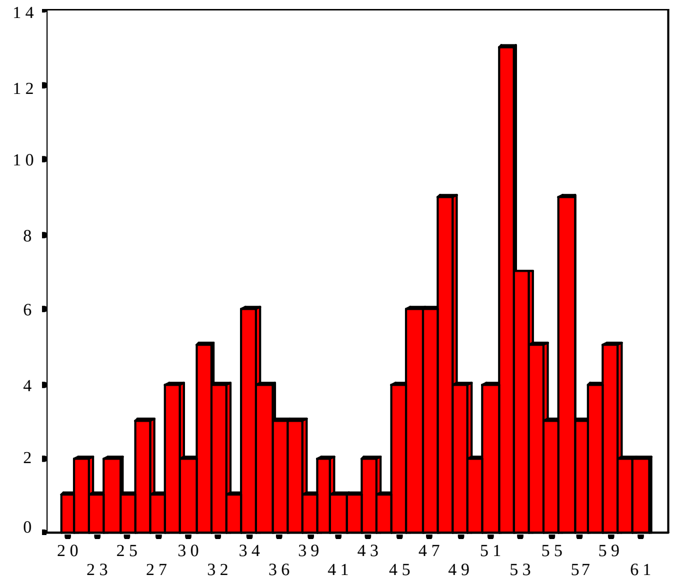

Figure 5. Age of Training Participants (N=139)

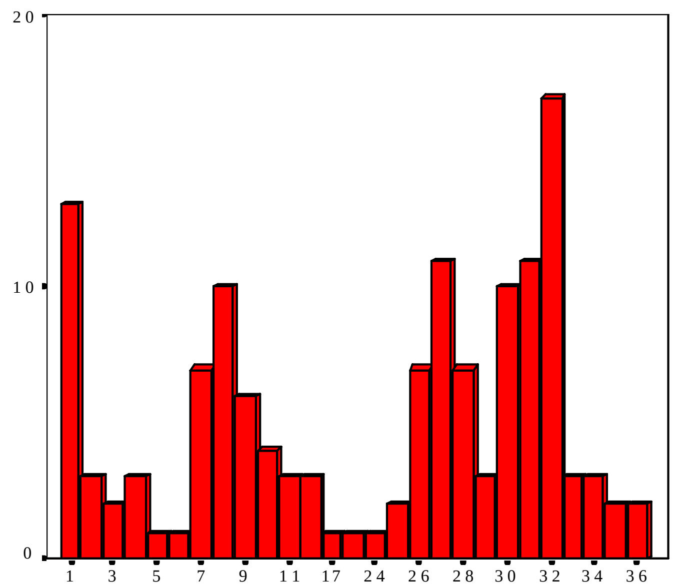

Figure 6. Years of Service of Training Participants (N=137)

3.2 Evaluation of CRM Training

Goldstein (1991) states that the training process is a "systematic acquisition of attitudes, concepts, knowledge, rules, or skills that result in improved performance at work" (p. 508). Training evaluation is "the systematic collection of descriptive and judgmental information necessary to make effective training decisions related to the selection, adoption, value, and modification of various instructional activities" (Goldstein, 1991, p. 557). Thus, the evaluation of training is an essential component of any training program because it tells whether the program is having a positive effect on training outcomes and whether it is an appropriate investment for the organization or funding agency (Salas, Burke, Bowers, & Wilson, 2001).

Aside from the indication of whether the goals and objectives of a specific training resulted in the desired outcome, systematic training evaluation can serve other important functions as well (Goldstein, 1993; Salas et al., 2001). For example, it can be used as a way to collect feedback on the training program itself, so that adjustments and revisions can be made to maximize training effectiveness in the future. Likewise, it can be used to assess which aspects of training work and do not work for different training groups and populations.

Different criteria can be used to assess some of the different objectives of training evaluation. The most common framework for categorizing these criteria is Kirkpatrick's (1976) typology. Kirkpatrick outlined four different types of evaluation criteria including reaction, learning, behavioral, and organizational criteria. Reaction criteria include a trainees' feeling toward the training program itself. These can include affective reactions to the course content or instructors, as well as judgments as to the utility of the training program for changing on-the-job behavior (Kraiger, Ford, & Salas, 1993). Learning is the second level of evaluation criteria developed by Kirkpatrick, who describes it as a trainee's learning of principles, facts, and skills. Over the years, the concept of Kirkpatrick's (1976) learning level has expanded to include cognitive learning, skill-based, and affective outcomes (Kraiger et al., 1993). Cognitive criteria include verbal knowledge, knowledge organization, and cognitive strategies. Skill-based outcomes include compilation and automaticity, while affective outcomes included attitudinal and motivational indices. Behavioral indices, Kirkpatrick's third level of training evaluation criteria, include trained behaviors displayed on the job. His fourth level, titled organizational outcomes, might include increases in performance or productivity, or decreases in turnover, downtime, or accidents.

Many researchers suggest using a multifaceted approach to training evaluation, which includes several levels of training criteria (Salas, Prince, Bowers, Stout, Oser, & Cannon-Bowers, 1999). The current pilot rail CRM training program was evaluated using Kirkpatrick's level one criteria (participant reactions), as well as his level two criteria. This includes the extent of cognitive learning (verbal knowledge) and affective outcomes. Although important, the assessment of behavioral and organizational criteria was beyond the scope of the current project.

3.2.1 Participant Reactions to Training

Participants' positive affective reactions to a training program should be an important goal of any of any training initiative (Salas et al., 2001). Trainees who enjoy the training and think it is practical and useful should have a greater willingness to pay attention and motivation to learn. Just as important, a positive reaction to training can influence labor and management support of future training (Alliger, Tannenbaum, Bennett, Traver, & Shotland, 1997; Salas et al., 2001). On the other hand, negative reactions can provide feedback to help training developers revise and improve the program (Orlady & Foushee, 1987).

The training content and the methods used in the current pilot rail CRM program were specifically developed to increase the relevance of the material for the rail environment. As previously outlined, the program consisted of rail-specific, real-life accident scenarios and videos, which is different than other CRM programs seen in the railroad industry (Morgan et al., 2003). The program developers believed that using realistic videos and scenarios from the rail environment would result in training becoming more enjoyable, practical, and useful to railroad participants. Furthermore, the current CRM training gives the trainees several opportunities to discuss the scenarios and other content with groups of their peers in class. As a result of these factors and the documented positive reactions to CRM training in the airline industry (Salas et al., 2001), program developers believed that rail CRM would be considered enjoyable, as well as seen as practical and useful, to railroad employees.

Participants' reactions to the current pilot rail CRM training program were assessed using a post-training survey. Three reaction items asked participants to indicate to what degree they agreed with a series of statements on a seven-point Likert scale (1=strongly disagree, 7=strongly agree). Three of the items were, "I found this training to be enjoyable," "The training was job relevant," and "The training had practical value." A fourth item asked, "To what degree will this training influence your ability later to perform your job?" For this fourth item, participants were asked to indicate their perception of the degree of influence on a seven-point Likert scale (1=no influence, 7=strongly influence).

Results showed that participants found the training to be enjoyable with an average rating of 5.09 (SD=1.42). Figure 7 shows the distribution of these responses. Furthermore, participants indicated that they believed the training was job relevant and had practical value as indicated by mean ratings of 5.57 (SD=1.46) and 5.58 (SD=1.34), respectively. Figures 8 and 9 show the distribution of responses to these items. Lastly, as seen in Figure 10, participants believed that the training would influence their ability to perform their job later with a mean of 5.19 (SD=1.31). A series of statistical tests analyzing the variance in the responses (ANOVAs) were run to determine if reactions to training differed depending on age, years of service position, or training track. None of these variables significantly affected reactions to training, indicating that participants of all ages, years of service, positions, and training tracks had similar positive reactions to the training.

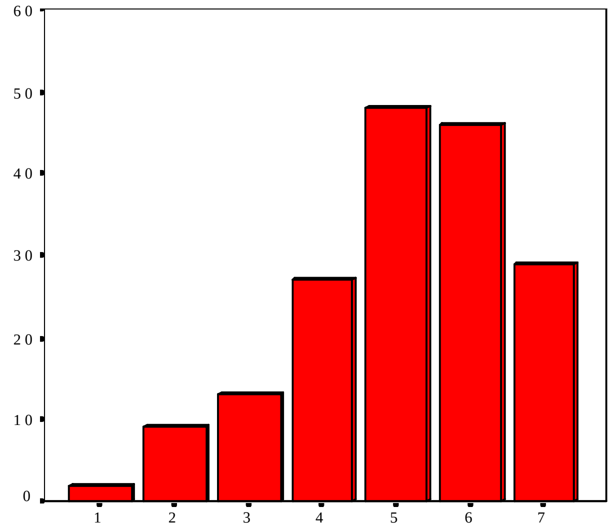

Figure 7. Distribution of Responses to the Item, "I found this training to be enjoyable." (1=strongly disagree, 7=strongly agree) (N=174, Mean=5.09, SD=1.42)

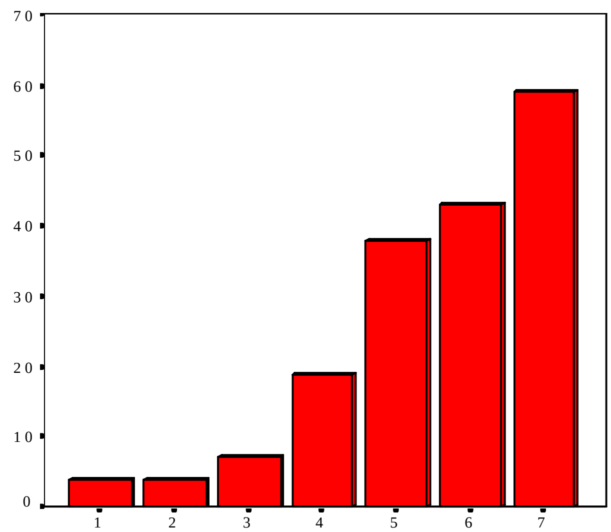

Figure 8. Distribution of Responses to the Item, "The training was job relevant." (1=strongly disagree, 7=strongly agree) (N=174, Mean=5.57, SD=1.46)

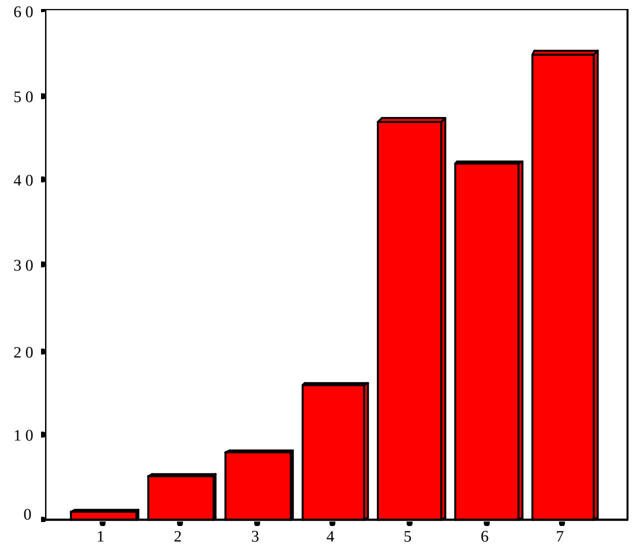

Figure 9. Distribution of the Responses to the Item, "The training had practical value." (1=strongly disagree, 7=strongly agree) (N=174, Mean=5.58, SD=1.34)

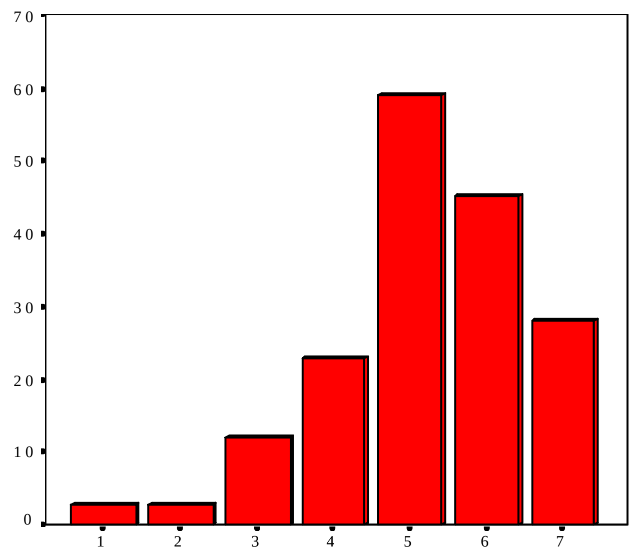

Figure 10. Distribution of Responses to the Item, "To what degree will this training influence your ability later to perform your job?" (1=no influence, 7=strongly influence) (N=173, Mean=5.19, SD=1.31)

3.2.2 Participant Learning

According to Kirkpatrick (1976), learning can be evidenced by detailing, "the principles, facts, and skills which were understood and absorbed by participants" (p. 11). One of the most important cognitive learning outcomes is verbal knowledge because it is a foundation for later cognitive skill development (Anderson, 1982). Consequently, measuring and assessing the amount of verbal knowledge at the completion of training is most appropriate in the initial orientation stages of training (Kraiger et al., 1993). Researchers suggest that multiple choice, true-false, and free recall are the best formats for testing verbal knowledge (Gagne, 1977; Kraiger et al., 1993).

In this vein, participant learning was evaluated by assessing participants' verbal knowledge of CRM concepts after the completion of rail CRM training. Test items were constructed by reviewing the content of the course in detail. Specific care was taken to have a broad spectrum of test items from each of the six training modules. For each training track, a slightly different test was created, reflecting some of the differences in content between the two tracks. The final test consisted of 9 multiple choice, 10 true-false, and 5 fill-in-the-blank questions. The five fill-in-the-blank questions asked for 13 total responses from participants, resulting in a final test consisting of 32 questions.

As a result of the knowledge test being given at the end of the training session (and at the end of the day), many participants had to return to work before being able to start the test. Of the 186 participants, 160 attempted the post-CRM knowledge test. Similarly, as a result of being called to work, some participants were unable to complete the test, which resulted in 16.7 percent of the test items being left blank. In light of this and to get a valid indicator of post-CRM training knowledge, each test was reviewed to determine the degree of test completion. For those training participants who were unable to complete the test because of time constraints or other responsibilities (i.e., the blank items are at the end of the test), their test score was determined by dividing the number of correct responses by the number of items attempted. However, items left blank prior to their stopping point were counted as incorrect. Test scores for all other participants were calculated by dividing the number of correct responses by the number of items on the test (32). Similar to the prior group, items that were left blank within the test were scored as incorrect.

Results indicate that participants correctly answered 83 percent of the questions. A one-way ANOVA was run on the data to determine if learning was dependent on the training track, and a significant main effect was found $F(1, 156)=4.85$, $p<.05$. Assessment of the means within training track revealed that participants in the transportation track (engineers and conductors) answered a greater percentage of questions correctly (M=84%) than MOW participants in the engineering track (M=80%). After training, however, all groups showed a high level of knowledge regarding CRM concepts and principles.

3.2.3 Attitudes Regarding CRM Principles

One of the objectives of CRM training is to change participants' attitudes regarding CRM concepts and principles. Reflecting this, the most common type of evidence used to examine how CRM effects participant learning in the aviation environment is attitudes (Salas et al., 2001). An attitude is an internal state that influences the choice of personal action and thus is believed to be an important influence on behavior (Gagne, 1984). Research in the aviation community has shown that certain attitudes are related to ineffective crew performance (Helmreich, Chidester, Foushee, Gregorich, & Wilhelm, 1990). Specifically, Helmreich, Foushee, Benson, &

Russini (1986) showed a link between self-reported attitudes (using the Crew Management Attitude Questionnaire (CMAQ)) and independent evaluations of performance by check airmen. Attitude characteristics of an effective pilot include being able to recognize personal limitations and diminished decisionmaking ability in emergency situations. Furthermore effective pilots tend to encourage other crewmembers to question decision and actions, are sensitive to personal problems of other crewmembers that might affect operations, and feel obligated to discuss personal limitations (Helmreich et al., 1986). Thus, evaluation of attitudes is important because of its link to effective crew performance.

3.3 Development of the Railroad-Crew Management Attitudes Questionnaire (RCMAQ)

To assess the impact of rail CRM training on participants' attitudes, the authors developed a RCMAQ. The RCMAQ is based on the original 25-item CMAQ developed by Helmreich and colleagues (Gregorich, Helmreich, & Wilhelm, 1990; Helmreich, 1984). The CMAQ assesses aircraft cockpit crewmembers attitudes toward (1) communication and coordination, (2) command responsibility, (3) recognition of stressor effects, and (4) avoidance of interpersonal conflict (Gregorich et al., 1990). The research team reviewed the individual items on the CMAQ, as well as the factor structure (Gregorich et al., 1990), and assessed each item's relevance to the railroad team environment. All factors, except Command Responsibility, were considered relevant to crews in the railroad environment and theoretically could be influenced by the current pilot rail CRM program. The original CMAQ's Command Responsibility scale includes items such as, "The captain should take control and fly the aircraft in emergency and nonstandard situations," and "There are no circumstances (except total incapacitation) where the first officer should assume command of the aircraft" (Gregorich et al., 1990). Several factors result in these items not translating well to the railroad environment. First, the command, workload, and leadership structure is different in the railroad environment then in the aviation environment. For example, in the cockpit, the captain is considered in charge of the aircraft, and regulations and task structure allow him/her to control and fly the aircraft. However, in the railroad environment, the command of the train is the conductor's responsibility, even though the engineer is the one physically controlling the train's movement. Only in an emergency situation or other special condition would a conductor (who is an untrained engineer) take control of the locomotive. For this reason, the RCMAQ does not include items relating to the scale Command Responsibility in the original CMAQ.

Minor modifications were made to the wording of the remaining CMAQ items to reflect the specifics of the railroad environment and of the particular railroad crew being assessed. For example, the item in the engineering track questionnaires, "Pilots should be aware of and sensitive to the personal problems of other crew members," was changed to, "Maintenance of way crewmembers should be aware of and sensitive to the personal problems of other crewmembers." For the transportation track, the item, "Even when fatigued, I perform effectively during critical flight maneuvers," was changed to, "Even when fatigued, I perform effectively during critical times on a trip." Additional items were also added to the original CMAQ to assess some of the specifics of the pilot rail CRM program's content.

The final RCMAQ consisted of 28 items. Participants responded to each item of a seven-point Likert scale (1=strongly disagree, 7=strongly agree). Participants completed the RCMAQ both before and after CRM training. The pre-training questionnaire was given after the introduction of facilitators and participants, and the safety briefing. The post-training questionnaire was given immediately after the completion of training content, and the completion of the questionnaire signaled the end of training after which participants were free to leave the training facilities. Full copies of the RCMAQ questionnaire will be included as part of the pre- and post-surveys on the training materials CD-ROM, which is being submitted separately.

3.3.1 The Factor Structure of the RCMAQ and the Creation of Composite Scores

It is a stated goal of CRM researchers within the aviation community to understand what attitudes lead to increases in safety and error management (Gregorich et al., 1990). An import component of this is to develop inventories that tap those attitudes, which can then be used to assess differences in attitudes between organizations, positions, and even industries. These inventories can also be used to look at how certain factors (e.g., organizational support or a training program) might influence individual attitudes.

Gregorich et al. (1990) state that one of the goals of CRM attitude research is to "push the aviation community, both within and across organizations, toward convergence on related attitudinal issues" and that "convergence assumes that individuals' attitudes share desired direction and magnitude (elevation), are homogeneous (scatter), and are interrelated (shape) in a way that is consistent with effective CRM" (p. 683). Factor analysis plays an important role in this because it can determine the factor structure of the CMAQ for a specific population and can be used to determine if it converges with the factor structure from other populations. To the research team's knowledge, this is the first time a study into the factor structure of a CRM type attitudes questionnaire in the railroad environment has been completed.

Separate factor analyses were run on the pre-training RCMAQ and post-training RCMAQ. Scree plots (Cattell, 1966) for both analyses showed that a three- or four-factor solution was appropriate. The factor structures from both orthogonal (Varimax, Quartimax, and Equimax) and oblique (Promax) rotations were assessed. Ultimately, Promax (Hendrickson & White, 1964) achieved the simplest structure. Three- and four-factor solutions were calculated for the pre- and post-training RCMAQs, and it was determined that with both, a four-factor solution had the simplest structure and was interpretable. A four-factor solution was then adopted.

The structure loadings from both data sets yielded somewhat similar factor interpretations. As stated previously, the factors structure on the pre-training RCMAQ revealed four factors. Factor 1 consisted of an orientation toward communication and crew coordination (e.g., "A debriefing and critique of procedures and decision after each job is an important part of developing and maintaining effective crew coordination"). This factor is in line with the factor Communication and Coordination in the original CMAQ (Gregorich et al., 1990). Similarly, Factor 2 is consistent with the CMAQ's Recognition of Stressor Effects (e.g., "I am less effective when stressed or fatigued"). Factor 3, also consistent with the CMAQ, could be titled, Avoidance of Interpersonal Conflict (e.g., "It is important to avoid negative comments about the procedures and techniques of other crewmembers"). Analyses of the structure matrix leads to title Factor 4, Recognizing Personal Life's Effect on Work Performance. This factor was not consistent with the original CMAQ.

The factor structure on the post-training RCMAQ also revealed four factors. Similar to the pre-training RCMAQ, Factor 1 consisted of an orientation toward communication and crew coordination and was consistent with the factor Communication and Coordination in the CMAQ. Factor 2 was consistent with the CMAQ's Recognition of Stressor Effects. Factor 3 was not consistent with the CMAQ and was represented by items that suggested the acknowledgment of team-interdependence and was labeled such. Factor 4 is titled Avoidance of Conflict because of its identification by items suggesting the avoidance of interpersonal conflict. This factor is also consistent with the original CMAQ (Gregorich et al., 1990).

Only the factors that were consistent across both pre- and post-questionnaire administrations were used for the creation of composite scores. Thus, items relating to the factor Recognizing Personal Life's Effect on Work Performance in the pre-questionnaire and Team-Interdependence in the post-questionnaire were dropped. Furthermore, the two items that related to the Avoidance of Conflict factor in each administration were dropped because of the small number of items identifying that factor. The remaining two factors (Communication and Coordination and Recognition of Stressor Effects) did not load consistently on the specific factor across administrations and were dropped from the analysis before composite-score construction. Lastly, and consistent with Gregorich et al. (1990), researchers reflected several of the items from the factor Recognition of Stressor Effects so that the composite scores would theoretically be positively related to CRM. The final Communication and Coordination composite score was made up of a total of 11 items, and the Recognition of Stressor Effects was made up of four items.

The reliability of each subscale was assessed by computing the Cronbach's alpha for each administration of the RCMAQ. The coefficients alphas for the pre-training administration were .82 and .49 for the Communication and Coordination and Recognition of Stressor Effects, respectively. The coefficient alphas for the post-training administration were .89 and .57 for the Communication and Coordination and Recognition of Stressor Effects, respectively. The seemingly low reliabilities of the Recognition of Stressor Effects subscale is the result of that scale's length; however, it is considered adequate and mirrors the reliabilities seen with these subscales on the CMAQ (Gregorich et al., 1990).

3.3.2 The Effect of CRM on Participant's Attitudes

To determine if CRM training positively changed participants' attitudes, the research team performed two separate repeated-measures ANOVAs on the pre- and post-training composite scores for Communication and Coordination and Recognition of Stressor Effects. Administration (pre-training RCMAQ versus post-training RCMAQ) was the within-subjects factor. To assess any differences in scores across training tracks, the team entered training track as an independent variable. Consistent with Gregorich et al. (1990), the F tests used the univariate approach, type III sums of squares.

A marginally significant main effect for administration was found for Communication and Coordination $F(1, 143)=3.02$, $p<.10$. Composite means show that attitudes toward Communication and Coordination increased in a positive direction from 63.93 (pre-test) to 65.18 (post-test). Interestingly, a significant main effect for training track was also found for Communication and Coordination $F(1, 143)=11.75$, $p<.01$. Inspection of means show that engineering track participants endorsed the items on this dimension (M=66.7) more than transportation track participants (M=62.4). No significant interactions were found. Figure 11 shows the training track by Administration cell means. Mean Communication and Coordination scores for engineering track participants increased from 66.5 to 67, while mean scores for transportation track participants increased from 61.4 to 63.4 from pre- to post-administration of the RCMAQ.

The second ANOVA found a significant main effect for administration for the Recognition of Stressor Effects scale $F(1,143)=12.57$, $p<.01$. Composite means show that attitudes toward Recognition of Stressor Effects increased in a positive direction from 15.3 (pre-test) to 16.4 (post-test). No other main effects or interactions were found. Figure 12 shows the training track by Administration cell means. Mean Recognition of Stressor Effects scores for engineering track participants increased from 15 to 15.9, while mean scores for transportation track participants increased from 15.7 to 16.9 from pre- to post-administration of the RCMAQ.

In summary, the results suggest that the pilot rail CRM training positively changes participants' attitudes toward CRM principles. Specifically it increases their orientation toward communication and coordination and their recognition of stressor effects. One interesting finding is that, in general, MOW employees have a greater orientation toward communication and crew coordination than conductors and engineers. Perhaps MOW employees, typically working within a larger crew (5-12) compared to a train crew (2-3), experience a greater need for communication and coordination, and they develop an appreciation for such factors. This in turn might increase their attitudes toward this dimension.

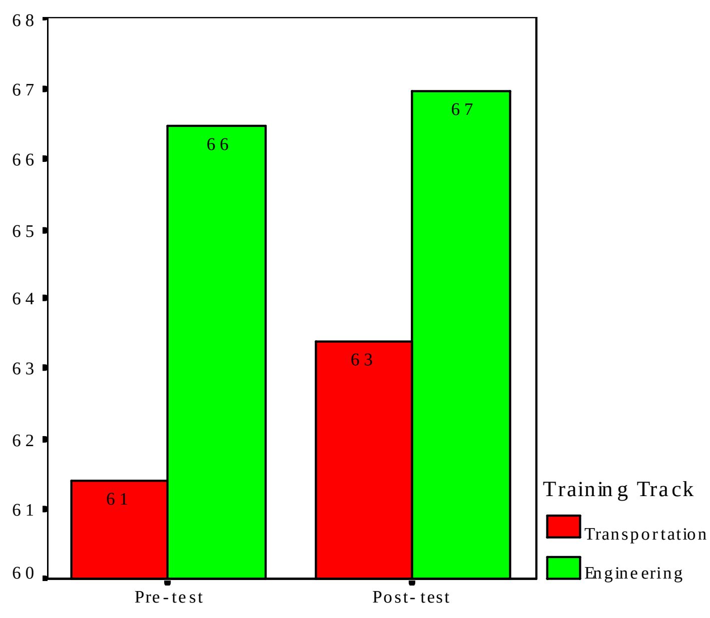

Figure 11. Mean Scores on the RCMAQ Communications and Coordination Scale (Administration and Training Track)

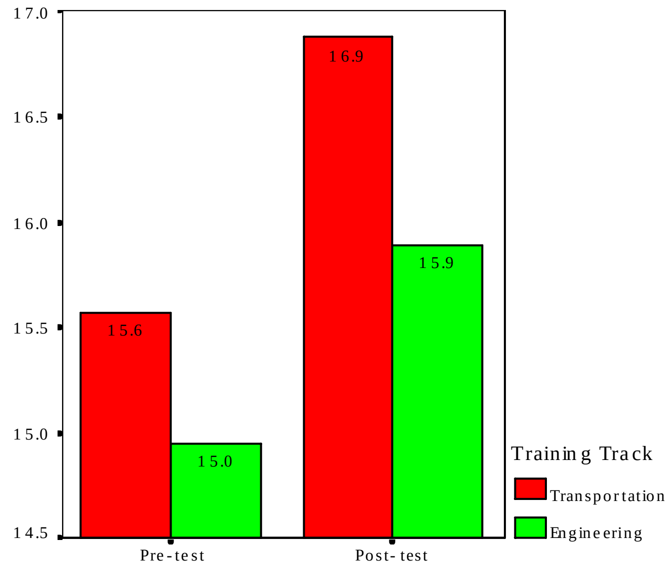

Figure 12. Mean Scores on the RCMAQ Recognition of Stressor Effects Scale (Administration and Training Track)

Increasing railroad employees' recognition of stressor effects is particularly important given the amount of stress and fatigue placed on employees working in the railroad environment, and the effects of that stress and fatigue (FRA, 1992; 1997). In fact, the scale, Recognition of Stressor Effects, could be titled Recognition of Stressor and Fatigue Effects because half of the items in the subscale specifically mention fatigue (e.g., "Even when fatigued, I perform effectively during critical times on a job," and "I am less effective when stressed or fatigued"). This suggests that CRM training, in conjunction with other initiatives, could be used as a fatigue counter-measure in the railroad environment.

4.0 Issues Related to Broader Rail CRM Training Implementation

4.1 Additional Tasks Related to CRM Training Implementation

This chapter will outline other issues related to rail CRM training implementation that were listed as tasks in the project work plan that have not yet been discussed. As this report has already alluded to, many of the specific timelines and training plans for certain training tracks changed during the course of its development due to a variety of factors. For example, the pilot testing of the course was to take place over a period of several months at two different railroads; ultimately, most of the training classes took place in a relatively short period of time at only one railroad, largely due to personnel changes at the railroad companies involved along with contracting and scheduling problems that were encountered. In spite of these challenges, most of the project's originally envisioned goals have been met. Among the remaining factors to be discussed in this report are the issues of recurrent CRM training needs following initial CRM awareness training conducted by this pilot course and the training of FRA and/or railroad personnel as CRM training facilitators.

4.2 Recurrent Training Recommendations

Interviews with aviation CRM experts suggest that the most important characteristic of CRM training within the aviation community is that CRM skills and attitudes learned in initial, awareness phase training are reinforced through recurrent training. Without recurrent training, it is unlikely that CRM in either the airline or the railroad environment will have any lasting impact on participant behavior or ultimately safety.

4.2.1 Importance of Recurrent Training

One objective of recurrent training is to oppose skill decay. Skill decay refers to "the loss or decay of trained or acquired skills (or knowledge) after periods of nonuse" (Arthur, Bennett, Stanush, and McNelly, 1998). Skill decay results from a situation in which participants receive some sort of initial training, but they do not use what they learned for an extended period of time. One example is reserve personnel in the military, given by Arthur et al. (1998). Skill decay also exists in jobs where employees perform their job duties on a daily basis. This occurs when the behavior or action that requires the trained skill rarely occurs during the course of an employee's workday. Because these particular behaviors are not displayed and the skills not utilized, they might be more susceptible to decay than skills and behaviors that were essential for the completion of a frequently performed work task.

Several reasons exist for behavior that might not be displayed on a regular basis in a job. First, few opportunities to display a particular behavior might exist. For example, in the railroad environment, intentionally assertive behavior (and its use of assertive communication skills) might only become necessary in certain low frequency situations when crewmembers may be unfamiliar with one another or when an incorrect decision could lead to a catastrophic outcome that a coworker does not recognize. Many environmental factors can influence which behaviors are displayed and what skills an employee uses on the job. One of the most important environmental influencers is organizational, supervisory, and peer support for a particular behavior.

Attitude decay or decay in attitudes toward CRM concepts also must be taken into account within any long-term CRM training initiative. In their most current CRM circular, the FAA states that when recurrent training is not in place and no effective reinforcement of CRM concepts exists, improvements in attitudes after initial CRM training have a tendency to disappear and participants' attitudes return to pre-CRM training levels (FAA, 2004). The effect of this cannot be underestimated. As stated previously, one of the objectives of CRM training is to change participants' attitudes toward CRM concepts and principles. This is important because research in the aviation community has shown that certain attitudes are related to ineffective crew performance (Helmreich et al., 1990). Attitudes are extremely important because of their link to effective crew performance. Recurrent training is thus essential for CRM to have an enduring impact on the skills, attitudes, and behavior of participants. Increased safety, the ultimate goal of CRM, is dependent on long-term behavior and attitude change, hence making recurrent training essential for these safety gains to materialize.

4.2.2 Benefits of Recurrent Training

Recurrent training can have several benefits. First, gives participants an opportunity to refresh their knowledge of CRM concepts. Second, because it occurs after trainees have had an opportunity to practice the behaviors in the work environment, it gives trainees an opportunity to get feedback on these behaviors and discuss issues related to the transfer of training from the participants' perspective. Lastly, a recurrent training initiative shows employees that there is organizational support for the specific training program and the goals it is attempting to achieve. Participating in recurrent training reminds workers that safety and CRM skills must be practiced every day, at all levels of an organization, in order to be ultimately effective.

4.2.3 Suggested Training Methods for CRM Refresher Training

Recurrent CRM training, as suggested by FAA (2004), is included as part of the CRM training initiative in the airline industry. The current circular advises that, "recurrent CRM training should include classroom or briefing room refresher training to review and amplify CRM components, followed by practice and feedback exercises, preferably with taped feedback; or a suitable substitute, such as role-playing in a flight training device and taped feedback" (p. 9). Due to the differences in the two industries and the current stage of CRM in the railroad industry, such a recurrent training initiative in the railroad industry would be infeasible. At this stage, however, the research team feels that recurrent training could include classroom training, with expanded practice and feedback exercises. Furthermore, as stated earlier, one benefit of recurrent training is the opportunity it gives participants to get feedback on CRM behaviors and discuss issues with transfer of training from the participants' perspective.

Other benefits of recurrent training in the classroom exist. As outlined in this paper, one key aspect of the pilot rail CRM program was its use of rail accident scenarios. These scenarios show real life examples of accidents that were caused in part by a failure of CRM between members of the accident crews. As stated earlier in this report, because of a lack of published accounts, few examples exist of positive CRM saves or the prevention of a would be accident as a result of the effective use of CRM. During the course of pilot training, several participants volunteered examples of situations where they believed effective use of CRM prevented an accident. It is likely that, over time, participants working in the railroad environment with knowledge of CRM principles (through initial training) will recognize situations where effective CRM helped prevent a possible accident. Recurrent training in the classroom environment would give participants an opportunity to share these experiences with others, which would strengthen other participants' acceptance of CRM.

Many industries, including the railroad industry, are increasingly using computers to present much of their initial and refresher training. Computer-based training (CBT), also called computer-assisted instruction or computer-assisted learning, can be used to present training content and informational material. Trainees typically complete a computer software program on a computer using a keyboard and mouse to input information and set the pace of the program while reading the relevant information from a computer screen. An example of CBT would be to have a trainee go through a self-paced computer slide presentation on the relevant material.

CBT has many of the same advantages as readings because it is self-paced and learners can complete one or more courses over an extended time period. Unlike readings however, CBT can be interactive or can have dialogue with the learner (Wilson, 1999). An interactive CBT course can periodically ask the learner questions about the material, and the learner will respond to the questions. In this sense, the CBT is similar to an automated version of the programmed text discussed in the previous report. The computer creates a flexible learning process by interpreting the response and adjusting the content and direction of the program based on that response.

Unfortunately, CBT can also have significant disadvantages depending on the course materials that are to be presented. CBT training often lacks the realism of training in the actual environment in which the behaviors or skills being taught are to be performed. Some specific topics may also not be a good match for CBT training. For example, the interpersonal communications aspects of CRM do not seem to be fully supported by training them in the CBT method alone. Use of the CBT for strictly cognitive knowledge training, in concert with other training methods that allow the student to interact with others, may be more effective.

As shown earlier in the report, participants found the classroom training feature of the pilot rail CRM training program to be rather enjoyable (see Figure 7). Feedback from several of the participants in the pilot training course suggested that one of the reasons for this included the host railroad's decision to use CBT to teach the majority of training in recent years. Participants took advantage of the opportunity the CRM classroom training gave them, to interact with the facilitators and their peers and actually discuss issues and experiences with CRM topics. The match between the content (e.g., communication) and the delivery method (e.g., interactive) seems to make classroom training more appropriate for CRM training. It was also most likely this match between the content and method in the pilot CRM program that resulted in participants viewing CRM training as practical and job relevant (see Figures 8 and 9).

In summary, although CBT training could be used to conduct refresher CRM training, the research team, like FAA (2004), recommends that recurrent CRM training take place in a classroom setting similar to the initial pilot CRM training conducted during this project. One benefit of recurrent training in the classroom is it allows participants to practice CRM behaviors and receive feedback on their effectiveness. Aviation CRM guidelines suggest that, "feedback has its greatest impact when it comes from self-critique and from peers, together with guidance from a facilitator with special training in assessment and debriefing techniques" (FAA, 2004, p. 9).

4.2.4 Suggested Content of CRM Refresher Training

With these factors in mind, the research team suggests that the content of recurrent training remain similar to the current pilot railroad CRM program and consist of the same basic modules. One of the key features of the program design is its flexibility. This will allow different accident scenarios to be developed and substituted for the ones used in initial training. This feature should be used to keep the training fresh and interesting. New accident scenarios, in combination with examples of good CRM gathered as both crew interaction in classes and the development of a close-calls reporting system, will help to ensure that the CRM training program remains relevant. Responsibility for making this take place will rest with FRA and railroad company safety staff as they take on the responsibilities of facilitating and reinforcing CRM principles in the railroad environment.

4.3 CRM Facilitator Training

4.3.1 FRA Training as Part of This Project

One of the sub-tasks enumerated in the work plan for this project was for the research team to conduct orientation training regarding the pilot rail CRM program for FRA Region 5 personnel. Training was to take place once the materials had been tested in all three training tracks. This sub-task was at one time removed from the work plan by FRA and then reinstated. FRA project sponsors also requested that rather than Region 5 personnel, the training might be performed for FRA personnel in the Washington, DC, area. One reason for this change was the transfer of the project's FRA contact from his position as Deputy Regional Administrator at Region 5 to a position in the Washington, DC, area in the Office of Safety. The protracted efforts to schedule railroad training and the inability to conduct testing for the mechanical track resulted in this training of FRA personnel not taking place to date. TTI offered to complete this training in the final month of the project once it became clear that mechanical track courses would not be held. No date for this training, however, has been scheduled.

4.3.2 Future Training of FRA and Railroad Personnel as Facilitators

Whether or not FRA personnel are trained as part of this project, the research team recommends that both FRA and railroad personnel should be trained to conduct future CRM training sessions if CRM is to be implemented on an industry-wide basis. Most FRA and railroad personnel have a ready knowledge base and experience in day-to-day rail operations and operational rules that could prove invaluable in the facilitation of human factors training courses, such as CRM. This would give them immediate credibility with class participants that could not be immediately developed by the members of the research team while conducting the pilot program.

That being said, it is important that the facilitators for CRM classes be trained properly as facilitators, be carefully selected from among their peers, be motivated about CRM and safety topics, and exhibit a thorough understanding of CRM. Knowledge of general human factors principles should also be considered a prerequisite. Not all railroad safety representatives or FRA instructors may be appropriate choices to facilitate this material. CRM facilitators must be able to connect with the class participants and be able to present the scenarios in a manner that will allow the students to learn each CRM concept. The complexity and detailed nature of the CRM material requires that specific training and preparation take place in CRM facilitation before teaching any class. While the facilitator's guides that were developed for each track under this program have suggested dialogue for each point of the presentation and suggested points for each scenario, each instructor will need to spend several hours with the course materials in order to develop the familiarity necessary to lead the class.

4.4 The Future of CRM in the Railroad Industry

The decision on what will be done with CRM at U.S. railroads rests with FRA and management and labor leaders at the individual railroad companies. The FRA Office of Safety representatives working on this project understand the benefits of CRM training in reducing human factors accidents and fatigue, but, thus far, FRA has not taken steps to make CRM mandatory. In many ways, this is similar to the FAA's stance on CRM that existed in the early- to mid-1990s. TTI's research of aviation CRM suggested that, along with the FAA's own efforts to integrate CRM into the Advanced Qualification Programs of airlines beginning in 1996, FAA suggested CRM principles long before they became mandatory in 1998 (Prince et al., 1992).

For CRM principles to take hold within the railroad industry, it will take much more than a minor pilot testing program. Wider implementation that focuses not only upon employee training programs but also upon management involvement in the process is required. Recent high-profile accidents, such as the toxic release of tank car contents following human factors and CRM-related failures, point to implementation of CRM training to address the problem. CRM training also supports the goals of FRA's recently announced National Rail Safety Action Plan to address accidents caused by human error.

References

Alliger, G.M., Tannenbaum, S.I., Bennett, W., Jr., Traver, H., & Shotland, A. (1997). A meta-analysis of relations among training criteria. *Personnel Psychology, 50*, 341-358.

Arthur, W. Jr., Bennett, W. Jr., Stanush, P.L., & McNelly, T.L. (1998). Factors that influence skill decay and retention: A quantitative review and analysis. *Human Performance, 11,* 57-101.

Cattell, R.B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research, 1(2)*, 245-276.

Federal Aviation Administration [FAA] (2004). *Advisory Circular: Crew Resource Management Training (120-51E).* Washington, DC: U.S. Government Printing Office.

Federal Railroad Administration (1992). *Engineman Stress and Fatigue: Pilot Tests (FRA/ORD-92/17).* Washington, DC: U.S. Government Printing Office.

Federal Railroad Administration (1997). *The effects of work schedule on train handling performance and sleep of locomotive engineers: A simulator study* (*FRA/ORD-97/09*). Washington, DC: U.S. Government Printing Office.

Federal Railroad Administration (2005). FRA/Office of Safety Analysis's On-Line Railroad Accident Database. Retrieved July 25, 2005 from the World Wide Web: http://safetydata.fra.dot.gov/officeofsafety/

Gagne, R.M. (1977). *The conditions of learning*. New York: Holt, Rinehart & Winston.

Gagne, R.M. (1984). Learning outcomes and their effects: Useful categories of human performance. *American Psychologist*, *39*, 277-85.

Goldstein, I.L. (1991). Training in work organizations. In M.D. Dunnette & L.M. Hough (Eds.) *Handbook of industrial and organizational psychology, Vol. 2* (2nd ed.), p. 507-619. Palo Alto, CA: Consulting Psychologists Press, Inc.

Gregorich, S.E., Helmreich, R.L., & Wilhelm, J.A. (1990). Structure of cockpit management attitudes. *Journal of Applied Psychology, 75*, 682-690.

Helmreich, R.L. (1984). Cockpit management attitudes. *Human Factors, 26*, 583-589.

Helmreich, R.L., Foushee, H.C., Benson, R., & Russini, R. (1986). Cockpit management attitudes: Exploring the attitude-performance linkage. *Aviation, Space and Environmental Medicine, 57,* 1198-1200.

Helmreich, R.L., Chidester, T.R., Fousheee, H.C., Gregorich, S., & Wilhelm, J.A. (1990). How effective is cockpit resource management training. Exploring issues in evaluating the impact of programs to enhance crew coordination. *Flight Safety Digest*, pp. 1-17.

Hendrickson, A.E., & White, R.O. (1964). Promax: A quick method for rotation to oblique simple structure. *British Journal of Statistical Psychology, 17*, 65-70.

Kirkpatrick, D.L. (1976). Evaluation of training. In R.L. Craig (Ed.), *Training and development handbook: A guide to human resources development* (pp. 18.1-18.27). New York: McGraw-Hill.

Kraiger, K., Ford, J.K., & Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. *Journal of Applied Psychology, 78(2)*, 311-328.

Morgan, C.A, Olson, L.E., Kyte, T.B, Roop, S.S., & Carlisle, T.D. (2003). *Rail crew resource management (CRM): Survey of teams in the railroad operating environment and identification of available CRM training methods* (Tech. Report TR-474450-0001). Texas Transportation Institute, College Station, TX.

National Transportation Safety Board. (1999). *Safety Recommendation (NTSB/R/99/26).* Washington, DC: U.S. Government Printing Office.

Orlady, H.W., & Foushee, H.C. (1987). *Cockpit Resource Management Training* (NASA CP-2455). Moffett Field, CA: NASA-Ames Research Center.

Prince, C., Chidester, T.R., Bowers, C., & Cannon-Bowers, J. (1992). Aircrew coordination: Achieving teamwork in the cockpit. In R.W. Swezey & E. Salas (Eds.), *Teams: Their training and performance*. Norwood, NJ: Ablex Publishing.

Salas, E., Prince, C., Bowers, C., Stout, R.J., Oser, R.L, & Cannon-Bowers, J.A. (1999). A methodology for enhancing crew resource management training. *Human Factors, 41*, 326-343.

Salas, E., Rhodenizer, L., & Bowers, C.A. (2000). The design and delivery of crew resource management training: Exploiting available resources. *Human Factors, 42*, 490-511.

Salas, E., Burke, C.S, Bowers, C.A., & Wilson, K.A. (2001). Team training in the skies: Does crew resource management (CRM) training work? *Human Factors, 43(4)*, 641-674.

Wilson, J.P. (1999). *Human Resource Development: Learning & training for individuals and organizations.* London, UK: Kogan Page Limited.

Acronyms

AAR	Association of American Railroads
ANOVA	Analysis of Variance statistical method
BNSF	Burlington Northern Santa Fe Railway
CBT	computer-based training
CMAQ	Crew Management Attitude Questionnaire
CPR	Canadian Pacific Railway
CRM	Crew Resource Management
CSX	CSX Transportation, Inc.
FAA	Federal Aviation Administration
FELA	Federal Employees Labor Act
FRA	Federal Railroad Administration
KCS	Kansas City Southern Railway
MOW	maintenance of way
MRL	Montana Rail Link
NS	Norfolk Southern Railway
NTSB	National Transportation Safety Board
RCMAQ	Railroad Crew Management Attitude Questionnaire
SACP	Safety Assurance and Compliance Program
TAMRF	Texas A&M Research Foundation
TEEX	Texas Engineering Experiment Station
TTC	Technical Training Center
TTI	Texas Transportation Institute