Development and Pilot Testing of Crew Resource Management Training Program for Railroad Industry

Curtis A. Morgan, Leslie E. Olson, and Tobin B. Kyte

Between 2001 and 2005, a research team at the Texas Transportation Institute worked with FRA and the BNSF Railway (formerly the Burlington Northern Santa Fe Railway) to develop a training course in improved crew resource management (CRM) for use in the U.S. rail 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 included the design and pilot implementation of a CRM training course at various locations on the BNSF Railway. The course was designed to be used for training a variety of railroad crafts in technical proficiency, situational awareness, communications, teamwork, and assertiveness. There were 186 railroad workers trained during the pilot testing program, with positive employee response to the course materials and content.

During the 1980s and 1990s, human factors training courses such as crew resource management (CRM) training were adopted by many U.S. industries. CRM first became widely used in the commercial airline industry but military aviation, shipboard crews, medical and 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 and CRM's successful application within the marine industry prompted the National Transportation Safety Board (NTSB) to recommend that a "train CRM" program be developed for the U.S. railroad industry (*1*). The need for such a program is evident when one considers that during the 12-year period of 1992 and 2003, human factor accidents (where human factors has been determined to be the primary cause) have accounted for 42% of all railroad accidents (*2*). A breakdown of these accidents is shown in Figure 1. Over the past 5 years, the percentage of accidents with primary human factors causes has been 37% (*3*).

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

Multimodal Freight Transportation Programs, Texas Transportation Institute, 3135 TAMU, College Station, TX 77843-3135. Corresponding author: C. A. Morgan, c-morgan@ttimail.tamu.edu.

Transportation Research Record: Journal of the Transportation Research Board, No. 1995, Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 62–68.
DOI: 10.3141/1995-08

RAIL INDUSTRY CHARACTERISTICS

Several distinctive characteristics of the railroad industry were important to understand before development of any CRM training or any other human factors training program. Inherent challenges to adapting CRM for use in the rail industry included the rail industry's history of adversarial management–labor relations, similar adversarial stances between railroads and regulatory agencies at state and federal levels, the many labor unions representing the variety of railroad crafts, non-checklist operations, varying company or local standardization of operational practices within federal safety guidelines, and lack of a formal close-call reporting system for accidents. The legal framework under which railroads operate, for example, being subject to Federal Employees Labor Act (FELA) claims, also adds special considerations for adapting programs from other industries for use in the rail industry.

Such factors differentiate the railroad operating environment from that found in either commercial or military aviation safety training programs where CRM training is most established. To develop a rail-based CRM curriculum, TTI formed a multidisciplinary team with experience in the design of technical training specifically for railroad personnel, the makeup and delivery of military aviation CRM training programs, and the industrial and organizational psychology aspects of training development. This diverse background helped the team determine practical approaches to address challenges of adapting aviation-based and other CRM models for use in the rail industry.

TEAMS AND TRAINING IN RAILROAD INDUSTRY

At the time the project began, there had been little or no research completed to document team types and makeup within the railroad industry. TTI began a research project in late 2000 for FRA's Office of Research and Development to identify, document, and classify the existing teams within the railroad industry. For this project, the research team conducted site visits at a cross section of railroads that represented different geographic areas, organizational size, and purpose. Table 1 shows the railroad types and locations visited during this phase of the project.

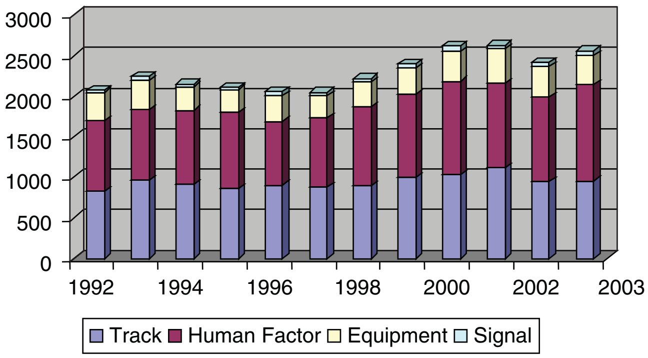

FIGURE 1 Number of train accidents 1992 to 2003, with primary cause shown.

Site visits to the different railroads allowed the research team to develop a list of the common teams that exist at both freight and passenger railroads in the United States. A report outlining the teams, their makeup, and classification was presented to FRA in late 2003 and published as *Rail Crew Resource Management (CRM): Survey of Teams in the Railroad Operating Environment and Identification of Available CRM Training Methods,* FRA/ORD-06/10 (*4*).

Included in that report was an assessment of the extent to which each of the Class I railroads in North America had implemented CRM training. TTI found that while all of the railroad companies had had some exposure to the AAR and NS–developed program, few of them had established an ongoing CRM program. Instead, CRM had largely been used as a one-time training topic for annual training or as a remedial or corrective measure for specific employees rather than as an overall, companywide program. A notable exception to limited application was at Canadian Pacific Railway (CP), where extensive training of train operating crews was 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 flight deck crews in aviation. To expand this application to other railroad crews, TTI's team classification process needed to address issues related to the organizational types of teams found in the rail industry as well as recommending ways to incorporate more of the existing teams into CRM training.

TWO TYPES OF TEAMS

TTI identified two major types of teams during this phase of the research: elemental teams and interactive teams (*5*). 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 is 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 and decoupling of trains and manual operation of track switches. Another example of an elemental team is a maintenance-of-way (MOW) crew, which typically consists of a foreman, assistant foreman, vehicle driver, and several laborers (trackmen, machine operators, or welders) depending on work tasks planned for that day. In both cases, teams are formed at the beginning of the work shift and operate as a team in carrying out the day's assigned work.

TABLE 1 Site Visit Locations by Railroad Type

Railroad Type	Railroad	Location Visited
Eastern Class I	CSX Transportation	Jacksonville, FL
Western Class I	BNSF	Kansas City, KS
Shortline/regional	Montana Rail Link	Missoula, MT
Commuter	Chicago Metra	Chicago, IL
Intercity passenger	Amtrak	Wilmington, DE/ Washington, DC

The second type of team, the interactive team, is formed when an elemental team must interact with either an outside individual or another elemental team to perform a task that occurs during the workday. This team is formed on site, during the work process, and exists in effect only for the duration of the interaction. An example of such an interactive team is one that is formed when a train dispatcher, MOW crew, and 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 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.

GROUPING TEAMS FOR CRM TRAINING

Once the two types of teams were identified, a second decision was made about the grouping of teams by similar work tasks, 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 on common work functions. Each training track used content and scenarios relevant to that particular group. This decision was based largely on the research team's review of existing CRM training programs in the aviation, marine, and military domains. These industries were most comparable to the rail industry in being transportation oriented and organizationally similar. Each had adopted instructor-led, scenario-driven, classroom-based training during their initial CRM implementation. The identified training tracks for rail (with example crafts in each) were as follows:

- Transportation—locomotive engineers, conductors, dispatchers, switchmen, brakemen, and hostlers;
- Engineering—section gangs (MOW), signal maintainers, and electrical catenary crews; and
- Mechanical—machinists, electricians, pipe fitters, and car men.

CRM training programs in other industries draw on real accident events for illustration of course objectives. With recent, relatable (i.e., closely associated to job tasks of the student) accident scenarios, CRM principles can be reinforced immediately in a manner that exhibits practical application of the concepts into daily work. For this reason, scenarios are most effective when they are specific and relate directly to the daily work of class members being trained. For example, using a scenario related to an engineer–conductor communications failure that 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 CRM basics with interchangeable scenarios related directly to class makeup quickly became the focus of CRM training program development. Six common modules were developed, but the scenarios were changed for each training track (i.e., transportation, engineering, and mechanical) as described in the course content section that follows.

DEVELOPING COURSE CONTENT AND SCENARIOS

Previous research has suggested that participants complete three critical phases of CRM training for it to be effective (*6, 7*). Similarly, FAA's regulatory policies on CRM reflect the importance of each of these three phases (*8*). These phases are as follows:

- 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, awareness, is generally accomplished through formal classroom instruction, while the second phase of practice and feedback is accomplished through use of a simulation or practice. The third phase is not one specific to the training program itself but is relevant because, for training to work, the culture of the organization must support or reinforce the training. More macrotype issues within an organization, such as organizational commitment to training objectives, are thought to be some of the most important aspects of long-term training effectiveness (*9*).

IDENTIFYING AND DEVELOPING RAIL CRM CONTENT

The needed content of the rail CRM training course was first outlined by NTSB. In its recommendation to develop rail-based CRM training, NTSB suggested that the program address four main topics: crewmember proficiency, situational awareness, effective communication and teamwork, and strategies for appropriately challenging and questioning authority (*1*). Working with the BNSF Railway (BNSF) and FRA, the research team developed a core outline for an introductory rail CRM course with six training modules to meet NTSB's recommendation. Those six modules are as follows:

- Introduction and background of CRM,
- Technical proficiency,
- Situational awareness,
- Communications,
- Teamwork, and
- Assertiveness.

Once this framework was in place, scenarios for each topic and each training track were developed; however, sources of detailed information on rail accidents are limited, and resistance to using current, actual accident scenarios in training was encountered.

The lack of a formal close-call reporting system within the rail industry limits the documentation of underlying human factors causes and calculation of the number of accidents that were prevented at the last moment. Consequently, few positive examples of CRM "saves" were available to be developed into scenarios for the training program. This resulted in most of the training scenarios in the pilot program centering on fatal accidents that had been documented either in NTSB reports or in the limited number of detailed FRA fatality reports from 1997, 1998, and 2002 that were available to the developers. While these sources provide accident analysis at the level of detail required to develop rail CRM scenarios, typical FRA accident reports do not. Standard FRA accident reports include physical and numerical data that describe injuries and account for the value of the damage to rolling stock and track infrastructure, but little in-depth information on underlying human factors causes associated with accidents. The exception is the in-depth analysis in FRA studies of employee fatalities and NTSB reports. FRA is currently working with the railroads to develop a close-call reporting system that could fully address many of these issues and greatly expand the available information for development of CRM scenarios.

Railroad companies are interested in preventing accidents for two main reasons: to protect the safety of their employees and to reduce their own liability and costs. Railroads are almost universally self-insured and want to limit their exposure to liability for any latent factors that may have contributed to an accident. Because railroad companies are subject to the provisions of the FELA, some of them may be reluctant for a CRM training program to include recent accidents as scenarios. This characteristic differs greatly from the environment of aviation CRM where companies are eager to expose inherent problems. so that procedures can be corrected to prevent future similar accidents. 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 representatives also had to be convinced that maintaining the ability to identify accident scenarios to specific railroads was important to maintain the necessary realism in program scenarios.

PILOT RAIL CRM TRAINING DELIVERY

Once each training track curriculum was completed, TTI worked with FRA and BNSF to arrange classes to pilot test the course. This process consisted of a beta test of the transportation track in September 2004 and actual training classes for both transportation and engineering tracks in the spring and summer of 2005. Classes typically took between 6 and 8 h depending on the number of attendees and amount of discussion that occurs among participants. Maintenance track training materials were completed, although pilot testing was not conducted before the project's conclusion. A total of 186 individuals were trained during the pilot testing—86 engineers and conductors and 100 MOW workers.

Each of the training tracks experienced challenges associated with scheduling classes for presentation of the pilot course. In the transportation training track, the greatest difficulty was encountered in scheduling engineers and conductors, due to the crew-scheduling process by which students were assigned to attend. Trainees were often given little or no notice of the class and were called to report for training when they were expecting assignment to an operational job that day. This lack of communication and change in expected job duties presented an obstacle for some trainees, which added to the students' initial resistance to the class. This barrier often took the first few hours of the class to overcome. The problem was not as acute in the scheduling of engineering classes, since group training and a scheduled monthly training day was already a part of those participants' regularly planned activity. Additionally, the interest of the division engineer in seeing the program implemented enabled courses to be scheduled more readily.

COURSE CONTENT DESCRIPTION

The CRM presentation developed for this course was made up of the six modules, to be discussed. At the end of each module, a scenario based on an actual accident or incident that supports the learning objectives of the module is presented. Each scenario is based on reports published by NTSB or FRA. Scenarios are reviewed in small groups of class participants, and each group is asked a number of questions related to CRM principles discussed during the lecture portion of each module.

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

Following the safety briefing, all facilitators and class participants were offered an opportunity to introduce themselves and give some information on their background as it related to the class (e.g., name, years of railroad experience, job assignment). Once introductions were completed, a pretraining survey was administered to class participants to gain baseline information for evaluating effectiveness of the course.

Introduction

Module 1 of the course provides basic definitions for CRM and provides 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 covered in the class and crew management, as the term used by several Class I railroads to describe their system of notifying train crews when they are required to report for duty. It is made clear that CRM, as discussed in class, is not directly related to this crew-calling function. History of the project is included as well as a discussion 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 Norfolk Southern–CSX train accident at Butler, Indiana, in 1998, which led NTSB to recommend that the railroad industry institute "train CRM" for the first time. NTSB investigation concluded that a major contributing factor of the accident was that each member of the train crew was acting as an individual with little or no communication as a team. Discussion of this accident and the breakdown in crew coordination that led to it forms the basis for the day's discussion of CRM principles.

An outline of the planned training schedule, as well as an overview of the topics to be studied throughout the day, is also presented. At the end of this module, time for two to three additional accident scenarios is allotted to begin to acquaint and involve the participants, acting in small groups, with the group review and evaluation technique that will be used throughout the day. Discussion of the introductory scenarios also allows the small groups to begin to coalesce and form internal roles that can be built on as the class progresses.

Technical Proficiency

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

A second facet of technical proficiency related to CRM is assessing and taking into account the technical proficiency of other team members. Key to this facet is not assuming that a co-worker has a specific skill, but the need to ask someone directly if there is any question about his or 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 also discussed.

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

Situational Awareness

Module 3 introduces 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 on what they perceive as reality is discussed—as is the importance of becoming more aware of the actual situation both as individuals and as a team. Recognition of situational cues and the role that fatigue can play in loss of situational awareness are also discussed. Tools are reviewed in regard to recognizing a loss of situational awareness, regaining situational awareness, and maintaining situational awareness.

This module typically uses one scenario exhibiting a loss of situational awareness and one video clip showing fatigue cues, to aid participants in relating to the subject material. Discussion of the scenario, in small groups and subsequent discussion by the whole class, normally allows time for the participants to examine and consider how crews in the scenario could lose situational awareness, as well as identify some points in the scenario where a different action should have been taken. By this point in training, the facilitator must see that members of the class identify and point out such events.

Communications

Module 4 covers communication skills and ways to improve communication between crewmembers of both elemental and interactive teams. It includes three video clips from the AAR-NS CRM program of the same two individuals discussing a job assignment in a rail yard, each time using improved communication skills to increase safety through information exchange. For the transportation track, an audio recording of the dispatcher to train crew communications from the head-on collision of trains in Clarendon, Texas, which took place on May 28, 2002, 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.) As the recording advances, class members are asked to identify problems in communication either internal to the operating crews or between the train crews and the dispatcher. After the audio track is completed, participants are asked to read a short description of the head-on collision to provide further information on how it occurred. Small groups then can 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 nonverbal, two-way versus one-way communication, and active listening. Other communications methods used by the railroad industry are reviewed, for example, radio, hand signals, and written orders, as well as the strengths and weaknesses of each communication method. The module continues with a discussion of new communications technologies (e.g., 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 importance of active participation in job briefings are reviewed and discussed. Participants are reminded that both overt and subtle cues may be displayed during the briefing, which can greatly affect the crew's later performance.

Teamwork

Module 5 has the goal of relaying to participants that safety hinges on both individual and team actions. Principal issues discussed are the difference between the lines of authority or leadership as opposed to safety leadership, which should be exercised by all team members; developing conflict resolution skills; making sure that the work load is equally distributed throughout the working crew; and keeping all members of the crew actively involved and situational aware by recognizing co-worker cues and their environment. The module normally uses one scenario related to teamwork or job assignment roles and two video clips related to conflict management to illustrate the principles covered.

Assertiveness

Module 6 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. One video clip is presented that illustrates how an accident can occur when an individual does not act assertively but submits to the judgment of a more senior co-worker even though he is uncomfortable with the situation.

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 use the skills learned during the entire course. 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 and corrective actions that could have been taken by the crew before or during the unfolding accident. Afterward, a post-training survey is administered to assess knowledge transfer, attitude changes, and acceptance of CRM principles.

PRELIMINARY FEEDBACK AND COURSE EVALUATION

There were positive reactions to the training program itself from most participants according to the preclass and postclass surveys administered to the 186 participants during the pilot program. The average class size was 13, although class sizes ranged from 3 to 24 participants. In the nine transportation track CRM pilot classes, a total of 86 engineers, conductors, and switchmen were trained. A total of 100 MOW employees attended one of the six engineering track pilot rail CRM training classes. 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.

As seen in the post-training survey, overwhelmingly, participants enjoyed the training and found it both job relevant and practical. Participants were asked to indicate to what degree they agreed with a series of statements, through use of a 7-point Likert scale (1 = strongly disagree to 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 7-point Likert scale (1 = no influence to 7 = strongly influence).

Results showed that participants found the training to be enjoyable, with an average rating of 5.09 ($N = 174$, SD = 1.42). The distribution of these responses can be seen in Figure 2. Furthermore, participants indicated that they believed the training was job relevant and had practical value as indicated by mean ratings of 5.57 ($N = 174$, SD = 1.46) and 5.58 ($N = 174$, SD = 1.34), respectively. Figures 3 and 4 show the distribution of responses to these items. Last, as seen in Figure 5, participants believed that the training would positively influence their ability to perform their job later, with a mean of 5.19 ($N = 173$, SD = 1.31). A series of analysis of variance (ANOVA) was 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.

Surveys also revealed that after CRM training, participants exhibited high levels of knowledge about CRM principles and training

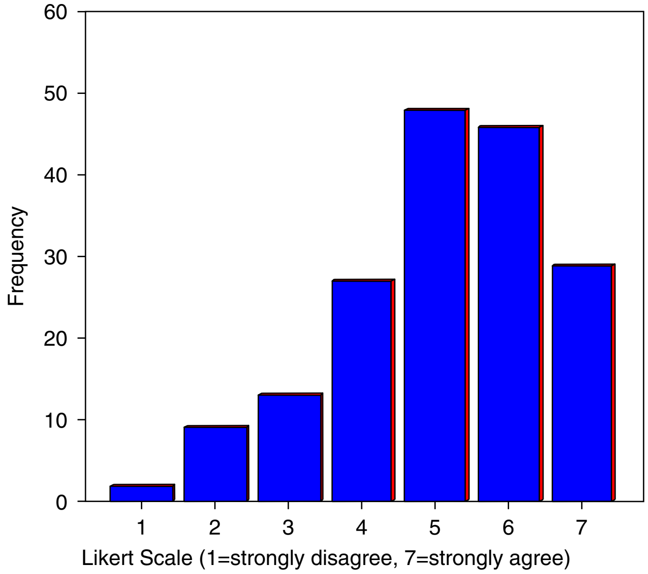

FIGURE 2 Distribution of responses to "I found this training to be enjoyable."

content. Participants' learning was evaluated by assessing their knowledge of CRM concepts after completion of rail CRM training. Test items were constructed by reviewing 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 tracks. The final test consisted of 9 multiple-choice, 10 true-or-false, and 5 fill-in-the-blank questions asking for 13 total responses from participants, resulting in a final test consisting of 32 questions.

Because the knowledge test was given at the end of the training session (and end of the day), several participants who were called out of training to return to work did not complete the knowledge test. Of the 186 participants, 160 attempted the post-CRM knowledge test. Similarly, as a result of being called to work during the test, some participants started but were unable to finish the test, which resulted in 16.7% of test items left blank. Given that situation, and to get a valid indicator of post-CRM training knowledge, each test was reviewed to determine the degree of 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 before their stopping point were counted

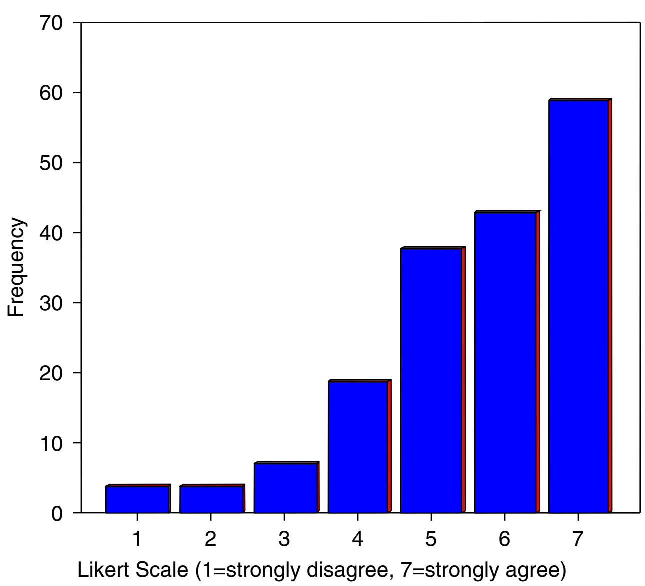

FIGURE 3 Distribution of responses to "The training was job relevant."

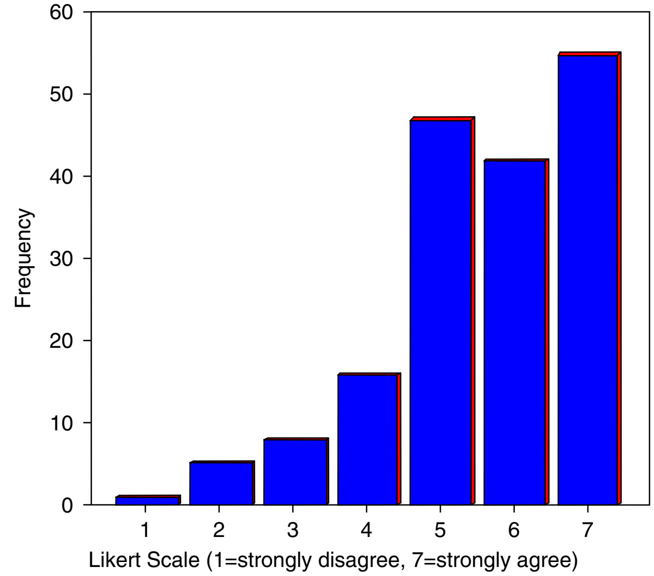

FIGURE 4 Distribution of responses to "The training had practical value."

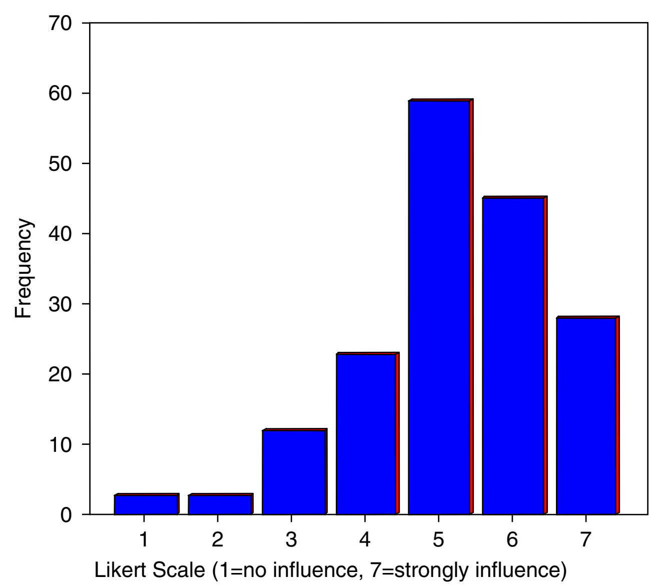

FIGURE 5 Distribution of responses to "To what degree will this training influence your ability later to perform your job?"

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 (i.e., 32). As with the previous group, items that were left blank within the test were scored as incorrect.

Results indicate that participants correctly answered 83% 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 the training track revealed that participants in the transportation track (engineers and conductors) answered a greater percentage of questions correctly ($M = 84\%$) than did MOW participants in the engineering track ($M = 80\%$). However, after training, all groups showed a high level of knowledge about CRM concepts and principles.

FINAL PRODUCTS

Presentation materials from each of the three training tracks along with student and facilitator guides for each were placed on a CD-ROM for potential future distribution by FRA. A bank of CRM scenarios was also included so that instructor–facilitators will be able to select the scenarios most appropriate to the attendee makeup of any given class. These training materials should be available for use as a basis for CRM training programs at railroad companies throughout the United States, on FRA approval of the materials.

The open format of the training curriculum allows new scenarios to be developed that could replace those used in the pilot program. These scenarios could be based on more recent accidents that reinforce the need for CRM skills covered in each module. New scenarios could be developed by end users (railroad companies), FRA human factors personnel, or outside contractors. Sources could continue to be NTSB and FRA reports, but as FRA's new close-call reporting system comes on line, this too could be a source for potential new scenarios. Through the use of different scenarios, both the realism and relevance of the course and core material can be preserved over time.

The FRA Office of Safety has sponsored additional work with TTI to document the business case for broader implementation of CRM within the rail industry. Further programs need to be developed that move beyond the CRM awareness phase that was covered by this project. They would include recommended practices for implementing CRM at the practice and feedback and reinforcement phases following initial awareness training, and recommended intervals and methods for recurrent training. Additional programs would include methods of incorporating CRM principles and crew-based training into other railroad training programs, and methods of developing management support for implementing CRM training across a broader spectrum of crafts within the rail industry.

REFERENCES

1. *Safety Recommendation (NTSB/R/99/26)*. National Transportation Safety Board, U.S. Government Printing Office, 1999.
2. Office of Safety Analysis's On-Line Railroad Accident Database. FRA, 2005. safetydata.fra.dot.gov/officeofsafety. Accessed July 25, 2005.
3. *National Rail Safety Action Plan: One Year Progress Report*. FRA, U.S. Department of Transportation, 2006. www.fra.dot.gov/downloads/safety/Action_Plan/final_action_plan_oneyear_report.pdf Accessed Aug. 1, 2006.
4. *Rail Crew Resource Management (CRM): Survey of Teams in the Railroad Operating Environment and Identification of Available CRM Training Methods,* FRA/ORD-06/10, 2006. www.fra.dot.gov/downloads/Research/ord0610.pdf. Accessed July 31, 2006.
5. Morgan, C. A., T. B. Kyte, L. E. Olson, and S. S. Roop. Assessment of Existing Teams and Crew Resource Management Training Within the Rail Industry. Presented at the 83rd Annual Meeting of the Transportation Research Board, Washington, D.C., 2004.
6. Koenig, R. L. FAA Identifies CRM-Related Issues and Training Needs in Flight-Inspection Missions. *Human Factors and Aviation Medicine,* Vol. 44, No. 1, 1997, pp. 1–7.
7. Prince, C., T. R. Chidester, C. Bowers, and J. Cannon-Bowers. Aircrew Coordination: Achieving Teamwork in the Cockpit. In *Teams: Their Training and Performance* (R. W. Swezey and E. Salas, eds.), Ablex Publishing, Norwood, N.J., 1992, pp. 329–353.
8. *Advisory Circular: Crew Resource Management Training*. 120-51E. FRA, U.S. Government Printing Office, 2004.
9. Salas, E., L. Rhodenizer, and C. A. Bowers. The Design and Delivery of Crew Resource Management Training: Exploiting Available Resources. *Human Factors,* Vol. 42, 2000, pp. 490–511.

The Railroad Operational Safety Task force sponsored publication of this paper.