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Rail Crew Resource Management (CRM): Survey of Teams in the Railroad Operating Environment and Identification of Available CRM Training Methods

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This report summarizes the work undertaken by the Texas Transportation Institute to document the common teams or crews that are present within the rail industry and to evaluate the existing crew resource management (CRM) training methods used in other industries for their applicability to those railroad teams. Several railroads were visited in order to identify railroad crews, and an extensive literature search was performed to classify the broad variety of CRM training methods available. Facilities of five different railroad types were visited to gain a cross-sectional picture of the teams in the rail industry. These railroads included an eastern Class I railroad, a western Class I railroad, a shortline railroad, an urban commuter railroad, and an inter-city passenger railroad. Methods of CRM training from the commercial airline industry, the military, the medical field, the offshore oil production industry, and the nuclear power industry as well as existing railroad CRM training courses were examined concerning their application to the existing teams found during the site visits. Recommendations regarding the appropriate training methods for each railroad team are then made. This report also presents several requirements to develop a fully implemented CRM program in the rail industry.

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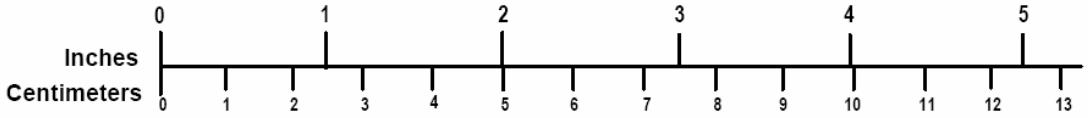

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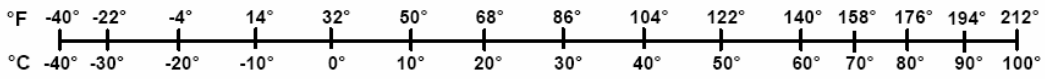

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Executive Summary

Purpose of this Report

This report summarizes the work undertaken by the Texas Transportation Institute (TTI) to document the common teams or crews that are present within the rail industry and to evaluate the existing crew resource management (CRM) training methods used in other industries for their applicability to those railroad teams. TTI visited several railroads during 2002 and early 2003 in order to identify existing railroad teams, and an extensive literature search was performed to classify the broad variety of training methods available.

Background of CRM

The National Aeronautics and Space Administration (NASA) and commercial airlines first developed CRM as cockpit resource management almost a quarter century ago in order to combat the increasing numbers of aircraft accidents that were attributed to pilot error. Research into the causal factors of these accidents found that, in many cases, rather than a lack of skill on the part of the pilots, the actual performance failure that led to the crash was related to improper crew coordination or improper communication of critical information within the crew. CRM was created to help crewmembers use all the resources that are available to them (Salas, Rhodenizer, and Bowers, 2000).

Since that early work, CRM training and its concepts have evolved within commercial aviation to include not only pilots but the entire flight crew, air traffic controllers, and aircraft maintenance personnel. Military aviation, tank, and shipboard crews have all adopted CRM training programs as have the commercial shipping, medical, nuclear power, and other industries. In all cases, positive safety benefits have accrued from instituting formal training in core CRM skills, such as crewmember proficiency, improved communication and teamwork among crewmembers, conflict resolution, and maintaining situational awareness. The rail industry has taken some initial steps into develop CRM training, but those efforts have largely been limited to the operating crafts (i.e., engineer and conductor) and have not included the many other job areas that are present.

Survey of Teams in the Rail Environment

In this study, one railroad each from five different segments of the U.S. rail industry was selected in order to gain a representative cross-section of railroad sizes and types. TTI documented existing teams during site visits to these railroads that have a potential for the application of CRM principles. The research team visited an eastern Class I railroad (CSX Transportation), a western Class I railroad (Burlington Northern Santa Fe), a shortline/regional railroad (Montana Rail Link), a commuter railroad (Chicago Metra), and the national intercity passenger railroad (Amtrak). At each of these rail companies, TTI conducted observations and interviews to determine the size and makeup of work teams in all crafts. The information gathered was then used to classify the teams into those that commonly exist or that have common characteristics across the industry.

Available CRM Training Methods

A second major focus of this study was to research the literature regarding current CRM training in other fields to determine if available training methods could be adapted or applied within the rail industry. This research indicated that a large number of methods exist. Two types of instruction must be included in CRM training, cognitive and behavioral. Cognitive training methods include lecture, film/video instruction, readings and programmed texts, computer-based training (CBT), case studies and incident training, and written exercises. Behavioral methods include role-play, group exercises, and simulation. Rarely does any CRM course of training consist of only one of these methods. Instead they are constructed from the combination of several of them. For example, classroom instruction often includes both cognitive and behavioral methods, such as lecture, film or video, readings, and role-play exercises.

This study found that sufficient available training methods exist that more fully implement CRM training within the rail industry. Several very real financial and organizational impediments, however, exist to rapidly doing so. While the Class I railroads generally have the training facilities and resources to conduct CRM training, it would be much more difficult for shortline and regional railroads or commuter railroads to do so quickly. In spite of this fact, the value of improved safety through reduction of human factors error throughout the various segments studied point to the need for continued development and expansion of CRM training within the rail industry.

Current Project Steps

An extension to the original project was begun in early 2003 that will include development of an initial pilot CRM training program for the rail industry. This training program will build upon the training methods discovered during the process of the research described in this report. The pilot training program should provide introductory awareness of CRM principles. The material will be presented in a manner that can be more fully implemented across all crafts within the rail industry, not just those involved in actual train operation.

1.0 Literature Review

1.1 Origins of CRM Training

1.1.1 Early Development

NASA and commercial airlines originally developed CRM training for use in the aerospace industry as a means to decrease the number of airline crashes that were occurring as a result of breakdowns in crew performance. Accident investigation often found aircrews made up of individuals with excellent individual aviation skills to have made critical errors in teamwork that led to crashes. Investigations conducted into these crashes often included pilot error when listing out causal factors—both mechanical failures and human factors—that had lead up to the accident.

Repeatedly, such pilot errors were found to be a result of the failure of the flight crew to work properly as a team in taking corrective actions or in making flight decisions rather than deficiencies in the technical skills of the pilots involved. Critical information known by one member of the crew was not passed to others, often due to social or positional barriers related to the culture of the airline organization or lack of assertiveness. Research into this problem showed that training for pilots and aircrew traditionally focused on technical aspects related to flying the aircraft (Prince, Chidester, Bowers, and Cannon-Bowers, 1992), but little or no training occurred on how to interact as a crew. Later studies found that, in order for flight crews to exhibit exemplary performance, three elements were needed—technical competency, CRM/interpersonal skills, and an organizational context or culture that supports crew-based rather than individual decisionmaking and that encourages dialogue and feedback among crew members regarding safety issues (Bailey and Shaw, 1996).

1.1.2 Cockpit Resource Management

CRM began as cockpit resource management rather than crew resource management because initially its application was limited only to those members of the aviation industry that were present in the cockpit and that made safety of flight decisions regarding the plane and its in-flight operations. This flightdeck crew that was the focus of early CRM training was usually limited to the positions of pilot, co-pilot, and when applicable, flight engineer.

At most major airlines, individuals in each of these positions hold pilot's licenses with either commercial or airline transport pilot ratings and have hundreds of hours of flight time experience. Each member of this crew has extensive knowledge of the aircraft's flight characteristics, its performance capabilities, and the approved rules and procedures for dealing with a given problem (standardized by the use of checklists), but, in a critical or emergency situation, conflicting opinions among these highly skilled and trained pilots, miscommunication, or failure to pass on vital information within the crew could still lead to selection of improper actions, resulting in a crash.

Decisions based solely upon the seniority and experience of the plane's captain (the pilot-in-command) and his/her perception of the problem often resulted in the failure of the flight crew as a whole to select the safest course of action to mitigate the problem. At times, this occurred despite the initial objection of other crewmembers or the lack of assertiveness of junior crewmembers in making their objections known. When such input was given, senior pilots often disregarded it, instead counting upon their own perception, experience, and skills. Unfortunately, these are not always the most reliable sources of information in making flight decisions.

The traditional airline culture supported the captain in this authoritarian position until several costly crashes in which this was a factor took place. Junior crewmembers' lack of assertiveness, failure of the crew to recognize and correct a problem before it became too late, and last words such as "I knew you were going to do that" on cockpit voice recorders indicated that something had to change. Pilots and the airline industry needed a new way to approach their jobs that allowed for more team decisionmaking and encouraged communication between all members of the crew so that no essential information would be omitted that could be used to prevent a crash.

1.1.3 Identified Need for CRM Training

The initial need for CRM in the aviation industry was, and continues to be, supported by findings by the Federal Aviation Administration (FAA) and others that approximately 30-80 percent of all aviation accidents result from human error (Lauber, 1987). For example, after studying 169 accidents that the National Transportation and Safety Board (NTSB) had investigated, the U.S. General Accounting Office (GAO) found that 30 percent were caused in part by pilot error (USGAO, 1997). In one-third of these accidents, GAO determined that the pilots did not correctly utilize CRM principles. Finally, the GAO report concluded that CRM deficiencies contributed to 50 percent of the serious accidents where at least one fatality had occurred.

Since the realization that such a significant percentage of aircraft accidents resulted from human error, CRM training has continued to be widely adopted by the commercial aviation industry, the military, and other industries, such as medicine, offshore oil production, nuclear power, and commercial shipping. Recent FRA statistics attribute human error as a causal factor in 37 percent of all train accidents not related to highway-rail grade crossings (FRA, 1999). These numbers point to the need in the rail industry to examine all possible methods to increase safety by predicting and preventing human error accidents.

1.2 CRM and its Development

1.2.1 Defining CRM

CRM training was initially created to improve aviation safety by helping crewmembers to use all the resources available to them (Salas et al., 2000). Crew resources can include the training and experience of other members of the crew and all information related to the crew's ability to function. Such information can be internal to the crew itself or available from someone outside the crew with which they can communicate, such as air traffic controllers or aircraft maintenance

specialists at their home base. Failing to consult or take advantage of these resources has been found to be a causal factor in too many accidents.
Likewise, the performance capability of each flight crew member must also be evaluated based upon his/her physical, mental, or emotional condition at the time of the flight. This facet of crew resources can take into account stress, fatigue, illness, or lack of training in a specific area when evaluating the ability of an individual to perform certain tasks. Knowledge of these factors and learning to identify cues related to them can allow for better allocation of tasks within each crew. Keeping them in mind can prevent many errors before they happen.

FAA defined CRM in 1989 as "the utilization of all available human, informational, and equipment resources toward the goal of safe and efficient flight" (FAA 1989, p. 2). The same document further defines CRM:

> CRM is an active process by crewmembers to identify significant threats, to communicate, and to carry out a plan and actions to avoid or mitigate each threat. CRM also deals directly with the avoidance of human errors and the management and mitigation of those errors that occur. CRM reflects the application of human factor knowledge to the special case of flight crews and their interactions with each other, with other groups and with the technology in the system (FAA, 1989, p. 2).

This definition asserts that CRM is a process that crew members should use during flight operations. The authors define this process based on the mitigation and avoidance of threats and human error. Alternatively CRM can be defined as a training method. Salas and his colleagues define CRM as a "family of instructional strategies that seek to improve teamwork in the cockpit by applying well-tested training tools (e.g., simulators, lectures, videos) targeted at specific content (i.e., teamwork knowledge, skills and attitudes)" (Salas, Prince, Bowers, Stout, Oser, and Cannon-Bowers, 1999). Besides coming from a training perspective (compared to a process perspective), Salas et al. (1999) write about CRM as being really about teamwork. The differences in CRM definitions become apparent when one looks at the diverse skills taught in various CRM training programs as shown in Table 1.

1.2.2 Development of Commercial Aviation CRM Programs

United Airlines was the first commercial airline to adopt CRM training for its cockpit crews, and other companies soon followed suit as positive safety benefits became apparent. NTSB and FAA took notice of the reduction of crashes and incidents as more and more airline companies implemented voluntary CRM training programs. Eventually, on March 19, 1998, FAA officially changed its regulations to require CRM training of all airline personnel (Helmreich, Merritt, and Wilhelm, 1999).

Encouraged by the success of CRM training for cockpit crews, commercial airlines began to apply it to other disciplines within the aviation industry. It is no longer just the members of the cockpit who are undergoing CRM training. Maintenance workers, flight attendants, and aircraft

dispatchers must now undergo CRM training. While specific statistics on airline implementation of CRM in other skill areas are scarce, those that can be found paint a favorable picture.

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.

For example, the U.S. Naval Safety Center cites that, after training two-thirds of its maintenance personnel (approximately 1200 employees) in CRM principles, Continental Airlines saw maintenance ground damage costs drop by 66 percent and occupational injuries decrease by 27 percent (Naval Safety Center, n.d.). This type of improvement points to the dramatic potential for improvements in safety that can accrue from the development of a CRM training program within an organization.

Generational Changes in Focus of CRM Training

Since CRM training first began in the late 1970s (see Cooper, White, and Lauber, 1980), CRM within the commercial aviation industry has gone through several stages. Dr. Robert Helmreich and his colleagues, in their 1999 paper *The Evolution of Crew Resource Management Training in Commercial Aviation*, described these stages in the following manner:

- *1st Generation:* Mainly a program for correcting for lack of junior officer assertiveness and pilot authoritarianism.
- *2nd Generation:* A more team-oriented program including decisionmaking training.
- *3rd Generation:* Recognition of human factors issues, such as stress and situational awareness; extension of training to other teams in the airlines, such as flight attendants, air traffic controllers, and maintenance personnel.
- *4th Generation:* CRM program customization by individual airlines to comply with FAA mandates regarding CRM training.

- *5th Generation:* Restored emphasis upon error management and safety.
- *6th Generation:* Identifying/preventing threats to safety at the earliest possible time and managing error.

Specialized Training Areas within CRM Training Programs

In addition to this generational change, several specialized topic areas within CRM training have also emerged. These include traditional crew coordination training as described in Wiener, Kanki, and Helmreich (1993), attitude training (Gregorich, Helmreich, and Wilhelm, 1990), the proper use of assertiveness (Jentsch and Smith-Jentsch, 2001), the role of leadership within CRM (Helmreich et al., 1999), and team building (Helmreich et al., 1999). Within each of these areas, different methods for presenting and reinforcing CRM training have been developed. This chapter will discuss these various training methods later.

Differentiation of CRM Skills/Learning Objectives in Different Applications

The desired CRM skills or learning objectives may be expressed in a variety of ways for varying groups within a single industry, for CRM application in additional industries, and for specific training programs. When CRM competencies are compared across several training programs and several industries; however, a similar set of key subject areas begins to emerge. This set includes subjects such as decision-making, assertiveness, crew coordination, leadership, teamwork, situational awareness, and active practice and feedback. While the main CRM concepts remain largely the same, these essential elements may be organized and presented in a manner that meets the interest of that particular industry. For example, the Naval Safety Center's School of Aviation Safety organizes its CRM training program around seven skills: decisionmaking, assertiveness, mission analysis, communication, leadership, adaptability/flexibility, and situational awareness.

For rail CRM training programs, NTSB has recommended that training include crewmember proficiency, communication, situational awareness, and conflict resolution (NTSB, 1999c). As shown in Table 1, CRM programs in the medical arena include skills such as priority assessment, assertiveness, use of information, communication, leadership, avoidance of preoccupation, and situational awareness. The flexibility to present core CRM concepts in different manners allows for a more direct training focus within each industry and the ability to relate CRM to associated pre-existing training programs.

1.3 Adoption of CRM Training into Military Aviation

The aviation branches of the U.S. military also took notice of the success that CRM training was having within civil aviation. The U.S. Air Force and the U.S. Navy began to develop and implement CRM training programs based upon those found at the airlines during the early 1990s. As in the airlines, the military's motive for doing so was to reduce the number of accidents attributable to pilot error that were costing them millions of dollars in lost aircraft each year. The military's initial CRM training programs began by training only the pilots of multi-piloted aircraft and have since expanded to include other fields in military aviation, such as other aircrew members, maintenance personnel, and air traffic controllers.

While early training materials were adopted, almost wholesale, from the commercial aviation industry, in 1993 the Navy developed its own CRM training program for pilots called Naval Aircrew Coordination Training (ACT). ACT goals were to increase mission effectiveness, minimize preventable error, maximize aircrew coordination, and optimize risk management while ultimately reducing the mishap rate caused by human factors (Naval Aviation Schools Command, 2003a). The ACT program was ultimately based on a set of seven common behavioral skills that a 1991 Navy research and development effort had identified as central to aviation mishaps. In 1993, the Navy implemented an interim ACT program designed to address these seven skills to some degree while at the same time improving standardization among flight training. This interim program developed into the Integrated ACT program in 1995 when a more detailed program was developed. In 1998, the Navy upgraded its ACT program once again to include annual ground training and annual flight evaluation requirements regarding CRM (Naval Aviation Schools Command, 2003b).

In its current format, outlined in official Navy documents as OPNAVINST 1542.7C, the Navy's CRM initiative includes additional training components, such as:

- standardized data collection
- crew feedback
- performance measurement
- an integrated CRM event-based curriculum (with an emphasis on situational awareness and decision making)
- advanced flight instructor skills (with performance assessment and coaching)
- decision skills training (with an emphasis on critical thinking)
- Computer Aided Performance Assessment System (computer analysis of each crewmember's performance in aircraft simulators)
- Tactical Integration/Instructional Systems Design (all designed to teach and reinforce CRM concepts and measure resulting behavioral changes)

Instructors in the program focus upon operational risk assessment and management, aircraft flight control, communication skills, decision processes and skills, situational awareness, and tactical and standard operating procedures. The Navy has seen positive effects from the implementation of its integrated CRM training programs. For example, U.S. Naval helicopter personnel trained in CRM were found to score 20 percent higher on behavioral evaluations and perform better on a written knowledge test and a scenario-based test than did another group who had not received CRM training (Salas, Fowlkes, Stout, Milanovich, and Prince, 1999).

1.4 Beyond Aircrews: The Proliferation of CRM Training

Throughout the last decade other industries, such as medicine, military tank and shipboard operations, offshore oil exploration, commercial shipping, and nuclear power, have applied CRM to crew training for their teams. First the work in these industries is such that, in order for key components of the job to be performed, individuals must work together in teams to perform those functions. Second, these industries involve high risk and high stress activities, just as the airline industry does. Similarly, the rail industry is made up of teams that must work together in a high risk, high stress environment.

Examples of teams that also perform critical operations are hospital surgical teams, tank crews, petroleum and oil platforms crews, crews on a ship's bridge, nuclear power plant control operators, and railroad operating crews. Because many of the incidents that occur to these teams are caused by human error just like in the airline industry, CRM training has quickly moved outside the cockpit in an attempt to increase safety in these industries. The following discusses several of these programs.

1.4.1 Bridge Resource Management (Military and Commercial Shipping)

In their 1993 book on cockpit resource management, Wiener, Kanki, and Helmreich note that, due to the number of merchant vessels lost at sea each year (an average of over one per day), commercial shipping is a prime area for human factors intervention through CRM training. The U.S. Coast Guard, in conjunction with the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW), has recommended the use of bridge resource management (BRM) training as part of a category of safety training for all commercial seagoing vessels (United States Coast Guard Website, n.d.). Multiple-day BRM courses are now being offered by the Maersk Training Center, the U.S. Merchant Marine Academy's Global Maritime and Transportation School, the Maritime Institute of Technology and Graduate Studies, Marine Safety International, Transport Canada, and other instructional facilities, such as universities and maritime institutes. Such courses typically consist of classroom instruction and bridge simulator training.

The Navy has also recognized that human factors errors are a large contributor to the number of naval afloat mishaps (Naval Safety Center, 2002). Based upon work done by James Reason in 1997, the Navy classified four different types of human factors error that contribute to accidents, such as:

- Unsafe acts (including errors and violations)
- Unsafe supervision (including inadequate supervision and supervisor violations)
- Unsafe crew coordination (e.g., crew resource management problems)
- Poor organizational influences (both external and internal)

The Naval Safety Center concluded that 91%, 84%, 56%, and 38% of afloat mishaps could be related to each of these factors respectively. BRM training for shipboard crews, analogous to that used in naval aviation, has been one way to reduce these percentages and improve the safety of naval operations.

One example of a successful commercial CRM training program in the marine industry is at the Maersk Training Centre in Svendbord, Denmark. Maersk's 5-day training program has different tracks which teach navigators and engineers. Skills, such as communication, teamwork, leadership, and situational awareness, are covered. Maersk's use of carefully selected case studies and simulator environments make each course relevant to its target audience. For example, engineers practice CRM principles and behaviors in an engine room simulator. In addition, engine-room case studies, taken from real-life situations, are used to make the concepts relevant to the shipboard engineer students. Maersk's CRM courses are designed to help

navigators and engineers better coordinate their tasks in emergency and routine situations (Maersk Training Center Website, n.d.).

1.4.2 Medical Sciences

Human error is a primary cause of many adverse medical mistakes. For example, between 65-70 percent of anesthesiology accidents or incidents are caused partly by human error (Howard, Gaba, Fish, Yang, Sarnquist, 1992; Pizzi, Goldfarb, and Nash, n.d.). Hospital surgical and emergency rooms and other medical settings mirror the conditions found on the flightdeck of an airliner in that a group of people has responsibility for human lives, must work with a complicated suite of technologically advanced instruments, and must make quick decisions—all with a very narrow margin of error. Years of research have shown that many of the same CRM training principles that have worked well in aviation CRM will transfer to medical situations. Understanding these principles could potentially help surgeons, anesthesiologists, and nurses to function in a team environment and to better identify, understand, learn from, and prevent medical errors.

Although no specific program in the medical field is directly analogous to aviation CRM (Davies, 2001), training programs based on CRM type skills have recently appeared in the medical sciences at a slow but steady rate. One of the first applications of CRM principles in the medical arena was at the Palo Alto Veterans Affairs Medical Center in the Department of Anesthesiology Services. Howard et al. (1992), working at Stanford University, designed an Anesthesia Crisis Resource Management (ACRM) program that was rated highly by participants and increased resident anesthesiologist knowledge of ACRM principles (Howard et al., 1992). Other ACRM programs have since been developed and are currently taught at Harvard University, as well as the Universities of Copenhagen and Toronto (Davies, 2001). These programs are different than traditional CRM programs because they are based around patient simulations and crisis situations, and the individuals trained in groups are specialists within one field (Davies, 2001). In addition to anesthesiology, researchers have also theorized how CRM principles could be used to train teams in operating, labor and delivery, emergency, and cardiac arrest response situations (Gaba, Howard, Fish, Smith, and Sowb, 2001; Halamek, Kaegi, Gaba, Sowb, Smith, Smith, and Howard, 2000; Risser, Rice, Salisbury, Simon, Jay, and Berns, 1999). Learning content related to traditional CRM (for example, fatigue), are also being assessed in the medical fields in terms of how it affects human error and decisionmaking (Jha, Duncan, and Bates, n.d.).

Despite the need for CRM type skills in medicine, the medical sciences have been slow to embrace CRM training, and the dispersion of general CRM principles in medicine has not progressed as fast as it did within the aviation industry. Davies (2001) suggests one of the reasons for this reduced integration has been that a medical equivalent to a plane crash does not exist. That is, a mistake made by a single surgical team does not usually receive national media attention or calls for retraining and regulation like a single commercial airline crash may. Another reason for the slower acceptance of CRM training in medicine has been that the culture of health care professionals is such that medical errors are sometimes ignored (with the hope that they will not later be discovered), covered up, or blamed upon others (Davies, 2001). Despite the open learning environment that many teaching hospitals foster, doctors are seldom taught to

learn from their mistakes, are taught to ignore the performance effects of stress and lack of sleep, and are not supported by their colleagues when admitting that they have erred (Davies, 2001).

1.4.3 Offshore Oil and Gas Industries

Many of the teams that work in the offshore oil and gas industries, such as emergency response teams, crane operation teams, service vessel teams, well control teams, and control room teams, have characteristics that are similar to teams in the aviation industry. Flin and O'Connor (2001) state that offshore workforces perform "complex and potentially hazardous operations in a constrained, isolated, and remote environment" (2001). Similar to other industries using team work structures in a similar environment, human error accounts for between 60 to 80 percent of failures in offshore systems (Moore and Bea, 1993; Cohea, 1997). Similarly, Mearns, Flin, Fleming, and Gordon (1997) reviewed 1268 offshore incidents between 1994 and 1996 and discovered that 46 percent of the human factor causes of these incidents were related to CRM principles. Although not titled CRM training, training programs utilizing CRM principles and targeting areas, such as decisionmaking, communication, stress, and assertiveness, have been in place on oilrigs for a number of years (Flin, O'Connor, Mearns, Gordon, and Whitaker, 2000). Control room operators, offshore installation managers, and regular offshore rig crews that are responsible for a considerable portion of accidents and fatalities in these dangerous operations have been trained using these programs which target potential human factors-related failure.

A number of different offshore companies and training organizations offer CRM training courses for offshore drilling teams. For example, Norwegian offshore oil crews have been successfully trained in CRM for several years (Flin et al., 2000). These 3-day courses are augmented by a 2-day refresher course that is required every 2 years. Shell Expro has used CRM training as a part of its control room operators' emergency response training (Flin, 1995). The Scandinavian oil company Elf Petroleum Norge has a CRM program titled, "Emergency Resource Management" (Grinde, 1994). Additionally, Flin et al. (2000) designed a 2-day course for oil and gas platforms that included lectures, group exercises, group discussions, questionnaires, and videos. Participants' reactions to the course have generally been positive; most participants believed they would be able to make use of the information they learned in the course in their daily work.

1.4.4 Nuclear Power Plants

Because of the catastrophic loss of life that can result from poor decisions in the control rooms of these high-risk facilities, CRM's overall goal of utilizing all available personnel, technical, and informational resources seems particularly relevant in this setting. Operators in the control room of nuclear power plants face stressors, which could lead to potential disasters on a daily basis. These stressors may emanate from environmental, organizational, or operational sources as varied as time pressure, accuracy of information, interagency liaisons, and equipment malfunctions (Paton and Flin, 1999). Fortunately, teams in nuclear power plants have utilized CRM training for over a decade (Harrington and Kello, 1991). For example, British Energy has designed a CRM course for its nuclear control room operators (Flin et al., 2000).

1.4.5 CRM in the Rail Industry

CRM training has also recently been applied within the rail transportation industry to reduce the number of accidents attributed to human factors. Because of the many parallel functions to those in the aviation industry, it would seem that CRM would be readily accepted within the rail industry. Little action, however, was taken to do so until the recommendations of an NTSB accident report regarding a rail accident in Butler, IN, in 1998. This report resulted in an NTSB recommendation that the Federal Railroad Administration (FRA), the Association of American Railroads (AAR), the American Short Line and Regional Railroad Association (ASLRRA), Norfolk Southern Railway (NS), and other railroads develop a Train CRM program. This recommendation was based largely upon the positive benefits that the NTSB had seen from CRM programs in other transportation industries.

In response, AAR and NS jointly developed a CRM training program that consisted mainly of video-based instruction that could be tailored and marketed to other AAR member railroads. Independent of this effort, the Southern Pacific Transportation Company (SP) had developed a rail CRM program based upon the one in use at US Air. Rail companies in Great Britain and other foreign rail companies have also explored the use of CRM as a means to prevent passenger rail disasters. Chapter 3 describes the current state of CRM training at each Class I railroad in the United States in greater detail.

1.5 Learning Domains and Training Methodologies

The overall goal of training is to increase employees' knowledge, skills, and/or attitudes toward specific job dimensions (Blanchard and Thacker, 1999). Literally hundreds of different training methods exist, each one differing in the degree to which they influence knowledge, skills, and/or attitudes. Based upon their influence on specific learning objectives, training methods can be grouped into two different categories or domains: cognitive methods and behavioral methods (Blanchard and Thacker, 1999). These training domains categorize training methods in terms of whether they are mainly used to increase a trainee's knowledge or skills.

As later sections will discuss in more detail, rarely does a training program involve only one training method. In fact, research suggests that a training program should incorporate a variety of methods, including information presentation methods and behavioral practice methods (Burke and Day, 1986). Many of the traditional and popular training methods, such as classroom instruction, are, in fact, not a single method but a collection of methods, systematically arranged to facilitate the learning process. Nearly all training programs use a combination of information presentation techniques and behavioral practice techniques to aid learning. This report will discuss classroom instruction, on-the-job training (OJT), and CBT, separately because of their widespread use in organizations today or because of their unique multi-method nature.

1.5.1 Cognitive Methods

Blanchard and Thacker (1999), state that cognitive methods "provide verbal or written information, demonstrate relationships among concepts, or provide the rules for how to do something" (1999). A cognitive training methods' strength is its effect on knowledge and

attitude. Cognitive training methods include (but are not limited to) lectures, video, film, readings, and computer-assisted instruction.

Lectures

Lectures are the most traditional and widely used method of training delivery. The lecture style format has typically been given in a classroom-type setting (Gray, Hall, Miller, and Shasky, 1997). The benefits of using a lecture format include its ease in imparting declarative knowledge to employees and increasing trainee motivation based on an understanding of the perceived importance of the training content. Other benefits include the potential to be low- tech (and thus low cost), and its flexibility in terms of format and location.

The disadvantages of lectures include the lack of realism that results from trainees learning information in a setting that is not similar to their work environment. In addition, it has been suggested that lectures are not always the most efficient format to increase trainee self-efficacy or procedural learning (Haccoun and Saks, 1998). Group lectures are also insensitive to differences in individuals (ability, attitude, interest) and rarely provide feedback to the trainees (Goldstein and Ford, 2002). The communication of information in lectures is generally unidirectional (i.e., from trainer to trainees), and proficiency is typically assessed through pencil-and-paper knowledge tests rather than through behavioral checklists or OJT tests of procedural learning. Feedback in the lecture setting, however, can vary depending on the degree of interaction between the lecturer and the trainees. This often depends greatly upon the class size and the individual characteristics of both the trainer and those receiving instruction.

Trainees' ability to ask questions and clarify the content of the lecture can prevent misunderstandings, and a group type discussion can aid in the understanding of higher level knowledge objectives (Blanchard and Thacker, 1999). Many times what makes or breaks the lecture technique are the trainer's competence, personality, and skill. Lecturers must keep the material meaningful and interesting, promote discussion, clarify material, and be aware of trainee's reaction to material (Goldstein and Ford, 2002).

Film or Video Instruction

Many times trainees may watch a film or video, which, akin to the lecture method, incorporates audio and visual dimensions. The film/video can offer conceptual and factual information to trainees by its incorporation of audio narration with written information, illustrations, graphics, or animation. The film/video training method allows trainees to observe others in their own working environment to learn how they should perform or behave in similar circumstances. A film or video is sometimes used along with the lecture method in classroom instruction; however, many training programs present a film or video in place of the lecture. Some organizations film a live lecture and play it later for other groups of trainees.

Use of film or video has many advantages including is portability, as well as its capacity to be used and reused at a later time for self-paced makeup programs. Taped lectures may also be used in the development of refresher training courses or to review specific segments of a training course. Although the initial cost of making a video is high, it can be an extremely cost-effective

training method in the long run for companies with large numbers of trainees. According to one study, approximately 96 percent of organizations with 50+ employees use videotapes in their training programs (Training and Development, 1996). The substantial initial production costs of video courses can be recouped over an extended period of time if a large enough number of students can be trained during the useful life of the video materials. The expected time at which the materials in the video production will become outdated due to content or regulatory changes should be taken into account when making a decision to invest in video production for training programs.

Readings and Programmed Texts

Readings and programmed texts are other methods for presenting training content and information to trainees. Assigned readings can be from one or more sources, and they can be changed quickly to adapt the content or length of a training course or to tailor the course to a specific geographic location. For example, a reading segment on railroad operations in sub-zero temperatures might not be needed in a course that is being developed for a shortline railroad that only operates in the desert southwest. This reading could be deleted from the course syllabus, allowing time to expand other readings or replacing it with a reading on desert rail operations. A primary advantage of readings is they are self-paced, meaning that the trainee can take his/her time in absorbing the material and learn at his/her own pace. Usually a test is given at the end of each reading that provides a measure of the subject knowledge that is transferred. A minimum passing grade is required before the trainee is given credit for completion of the training.

A disadvantage of training by assigned readings is that the variance in reading comprehension levels across an employee pool may be great, meaning that readings for more than one comprehension level may be required in order to reach the entire population. Student employees who are not native-English speakers may be especially hard to train in technical matters using this training method. Another difficulty is that employees may not understand the material included in the readings, and limited opportunities to interact with an instructor to ask questions about the material or to clarify misunderstandings exist.

One variant of the readings method that can be used to overcome some of these disadvantages is to organize the material in a programmed text format. In a programmed text, information about a topic is given progressively. A small quantity of instructional material, typically one-two paragraphs, is presented before quizzing the student on the content. The answer(s) to the question(s) is then presented at the beginning of the next section of instructional material. This presentation format gives instantaneous feedback to the student. If an incorrect answer is given, the student can immediately review the previous section to determine the cause of his/her mistake. This method aids comprehension of materials by breaking up the topic and is especially helpful to those employees with lower reading skill levels due to limited educational opportunities or having a non-English native language. A disadvantage of programmed text is that the development of the training materials is work intensive, as extended readings from outside sources cannot be used directly. Much effort must be put into converting the materials to the programmed text format.

CBT

CBT, also called computer-assisted instruction or computer-assisted learning, can also 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, CBT is similar to an automated version of the programmed text discussed earlier. 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. Like the disadvantage of lectures listed earlier, 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 not be a good match for CBT training. For example, the interpersonal communications aspects of CRM do not seem to be supported fully by training them in the CBT method alone. Use of CBT for strictly cognitive knowledge training in concert with other training methods that allow the student to interact with others may be acceptable.

Case Studies and Incident Training

Case studies and incident training consists of the use of real life situations presented through lecture, film/video, or written format that have or could occur in which learning objectives of the training are reinforced. This method can be used to augment lecture training to add realism by requiring students to evaluate the course materials in light of an actual OJT situation. Case studies can be used simply to make a connection between the concepts to the student's daily job activities. An example of training in this manner would be to use the findings of an NTSB accident report to point out deficiencies in CRM that led to a fatal rail accident. This methodology shows how the relevant skill was used or not used, making it more understandable to the trainee. Similarly, progressively working through a case study while quizzing the class can allow the instructor to measure the level of knowledge that is being transferred to individuals in the class. Trainees can thus practice developing verbal or written solutions to problem behaviors related to the training concept.

Written Exercises

Many times written exercises are included in a training program. For example, a self-administered personality test could be used as an exercise. This would give an individual a better understanding of the way he/she behaves on the job or at home, as well as his/her attitude toward the training topic. Answers to such exercises can often give students self-insight, enable them to evaluate where they stand in terms of the ability to learn and apply a particular skill, or

make the content more understandable as it is presented to them. Written exercises can also be used to point out an employee's own knowledge deficiencies or problem areas that may need to be focused upon as the training takes place.

1.5.2 Behavioral Methods

Behavioral training methods use a simulation of some aspect of the trainees' normal working environment to allow the student to practice specific behaviors. Behavioral methods are mostly used to encourage skill development by actual performance of the task, but these methods can also be used to modify one's attitudes regarding a subject (Blachard and Thacker, 1999). Most often behavioral training methods and simulation techniques are designed to make individuals keenly aware of the connection between the concepts and information learned in prior cognitive training and how they can apply it to their OJT duties and activities. Some examples of behavioral training methods include role-playing, interactive group exercises, and the use of low and high fidelity simulators.

Role-Play

Role-play is a training method in which trainees are assigned specific roles and required to act out a situation that occurs in the real working environment. The trainee may take on the role he/she plays in his/her normal working situation, a traditionally adversarial role, or one with which he/she is not particularly familiar but may interact with frequently during his/her work. For example, a locomotive engineer could be asked to take on the role of a conductor or dispatcher to better understand the decisionmaking process and required information to perform these jobs. In such a situation, role-play gives trainees an understanding of different viewpoints that they may not have previously considered (Hargreaves and Jarvis, 1998). A role-play exercise should be designed to instill the training objective, as well as provide a forum to practice reacting to situations and cues that are similar to cues they will face on the job.

Group Exercises

Numerous group exercises that can be included as part of a training program, such as group brainstorming, small group exercises, group case study, and experiential exercises (McPherson and Beard, 1999). A group exercise, compared to an individual exercise, must be completed by a group and is designed to have a high degree of group interaction. Many training courses use group exercises for the sole purpose of getting group members to communicate with one another. Other exercises can be used to develop a particular skill relevant to job, as well as foster communication skills.

An example of an exercise that helps trainees develop specific relevant job skills and communication skills is a group decision making/prioritization exercise. Many jobs entail the accomplishment of numerous tasks in a given period; in order to perform the job effectively, those tasks must be prioritized or accomplished in a specific order. Task prioritization exercises are created with this in mind. For example, one exercise that can be used to train task prioritization and communication is the group desert survival exercise. In this exercise a group is

given a scenario in which they are lost in the desert. The trainees are given a list of different items (for example, a mirror, comb, matches) in which they must decide how important each item is in terms of increasing their chances of survival. Specific to the skill set of an office manager, a group in-basket exercise can be used to prioritize office tasks, as well as practice communication skills and get feedback. A similar exercise has been used in railroad CRM programs to teach the skill of task prioritization to individual engineers. Railroad crews could complete this type of exercises together to engender communication skills, such as assertiveness and situational awareness. This group exercise would also be more realistic in terms of how decisions are made in the locomotive cab.

Simulations

Many consider simulation exercises to be the backbone of behavioral training methods. The primary reason for this belief is that they are specifically designed to simulate the real working environment. Because simulations typically use real equipment (or training devices that closely approximate real equipment), they have a high degree of realism. Simulations require trainees "to use the same procedures, movements, and/or decision processes they would use with equipment back on the job" (Blanchard and Thacker, 1999). Among the advantages of using simulators are that they: allow controlled reproducibility, allow safe practice of dangerous behaviors, utilize learning considerations, and typically cost less than training in the real work environment (Goldstein and Ford, 2002). Conceptually, a simulator's learning advantage lies in its fidelity or its ability to replicate the actual job setting. A simulator's physical fidelity is the degree to which it resembles the physical aspects of the equipment and operating environment. For example, in a high fidelity simulator, the switches and monitors used by trainees in the simulator would be exact replicas of the switches and monitors in a real cockpit. The psychological fidelity of a simulation refers to the degree in which the psychological aspects of the situation are the same in the simulator as they are in the real environment. Psychological aspects should be present in the simulation environment that are similar to those that employees experience on the job. For example, adding stress and fatigue factors to the simulation exercise by scheduling it at the end of a shift or making it a pass/fail event can potentially improve the realism of the simulation and therefore the quality of the training transfer. The importance of such psychological fidelity in simulations cannot be understated. For example, Kyte (1998) noted that a lack of psychological fidelity (anxiety, fatigue, stress) is one disadvantage in the New York Police Department's (NYPDs) use of the Fire Arms Training Simulator (FATS) to teach police cadets the proper use of deadly force in police work.

High fidelity simulators are also used to train many groups, including commercial and military aircrews, police officers, military equipment operators, taxi drivers, maintenance workers, telephone operators, ship navigators, train crews, and product development engineers (Blanchard and Thacker, 1999; Kyte, 1998). One advantage of such simulations is their usefulness in training highly important but very infrequent behaviors. For example, flight simulators can be used to simulate emergency situations, such as an engine fire, without destroying a valuable engine and a police firearm simulator can replicate an attack by a man with knife without putting his/her life in danger.

In a perfect world, all simulations would be high fidelity; however, realism comes at a price. Overall, the more realistic the simulation, the more it costs to develop and maintain the equipment (Marquardt and Kearsley, 1999). The most expensive simulators in the world are full motion, multi-axis flight simulators used to train aircrews. The enormous costs involved in constructing and operating such simulators make time in those that exist hard to schedule due to their low availability.

One alternative is to use low fidelity simulations or simulations that do not match as closely the physical environment of the real working space, but that may still have high psychological fidelity for supporting cognitive training without as great an expense. It is suggested that a large number of training programs can use simpler low fidelity simulations and still generate positive results (Marquardt and Kearsley, 1999). Researchers suggest that it is essential that behavioral cues that drive performance be identified in the task environment and that these cues be emphasized when designing simulations (Swezey, Owens, Bergondy, and Salas, 1998). Adding components to the simulation that, while more closely mimicking the job environment, are not essential to effective job performance will not add to a simulation's effectiveness. Transfer of training is based on many factors outside of simulator fidelity, including supervisory support, organizational climate, and individual level factors. Recent technological advances have made simulators an even more useful tool. Teleconferencing, satellite television, high-speed Internet connections, and wireless communication now allow simulation technology to mimic real world interactions much more closely. For this reason, low fidelity simulators have increased in popularity in recent years.

1.6 Currently Accepted CRM Training Systems

Although numerous training methodologies are available to safety managers, only a few are currently being used when providing CRM training in today's high-risk industries. Most training is accomplished through a training system or a combination of training methodologies. Today's accepted CRM training systems include classroom instruction, OJT and assistantships, and fully integrated computer-based training (FICBT) systems. The following discusses each of these.

1.6.1 Classroom Instruction

As stated previously, classroom instruction is not a distinct training method per se but a collection of training methods organized in a systematic way such that in combination they can be used to train individuals in a classroom setting. Classroom instruction uses a combination of information presentation techniques and behavioral practice techniques to aid learning. Most classroom instruction is anchored by the lecture method but also involves other cognitive methods (Gray et al., 1997). These other cognitive methods might include overhead slides, examination of case studies, computer presentations, discussions, questionnaires, and multimedia demonstrations (e.g., videos). Classroom instruction also has the flexibility to incorporate behavioral methods like role-play, group exercises, and computer simulations. Training in a classroom setting is so versatile that the training content may be offered to a wide variety of audiences including intact work groups, groups of individuals holding the same position in varying locations across an organization, general audiences, and instructors of future classes in order to train them to do so. Other advantages include that classroom-style training may be offered onsite, through distance learning, or at centralized training locations.

An important component to consider in selecting the classroom instruction method is the importance of the trainer or training facilitator to instill in the trainee the desire and motivation to learn the topic. Because trainees in any one class will have a wide range of ability, attitude, communication styles, and interests, the multiple training method nature of classroom instruction can often improve the knowledge transfer, skill acquisition, or motivation for a wider variety of individuals. Like the lecture method alone, however, the competence, personality, and skill of the trainer have an enormous effect upon the motivation, and therefore the learning capacity, of the trainees.

1.6.2 OJT and Apprenticeships

OJT and apprenticeships are different than other training methods because they take place in the real working environment, involve the trainee actually working on the task, and entail some degree of one-on-one interaction between a trainee and his/her trainer (Rothwell, 1999). One of the foundations of OJT and apprenticeships is a reliance on behavioral modeling. With a theoretical background in social learning theory (Bandura, 1986), the principle behind behavioral modeling is that trainees can learn appropriate on-the-job behaviors and skills by observing those who have already mastered the job.

The quality and extent of OJT effectiveness can vary greatly for almost all jobs have some sort of training that takes place while on the job. OJT can be informal, where a trainee watches experienced workers perform the job, asks questions, and gradually tries his/her hand at performing. It can also be a more formal program, where a carefully designed on-the-job instructional system outlines training objectives, and the work environment is especially arranged for instruction of employees (Goldstein and Ford, 2002).

In apprenticeships, a master or subject matter expert introduces and models a new skill set for an apprentice or trainee. Gradually the input from the master is reduced, and the student is allowed more and more independence. Apprenticeships are a special type on OJT because they are reserved for different kinds of skilled trades, such as bricklayers, electricians, sheet metal workers, and pipefitters. Federal and State guidelines have specific sets of rules and regulations for apprenticeship programs, and they are an integral part of the licensing of many of the skilled trades (Goldstein and Ford, 2002).

The effectiveness of OJT and apprenticeships is largely dependent on the skills, attitudes, and motivations of the trainers/mentors. These trainers should be selected based on their skills and their ability to be an effective instructor. Employees with the most seniority do not always make the best trainers. Instruction in teaching techniques and philosophies, reinforcement, and distributed practice should be administered to all trainers/mentors. It is important for organizations to select, reward, and reinforce positive behaviors of employees who serve in these roles.

1.6.3 FICBT Systems

CBT can range from a simple CBT method, as discussed in the cognitive methods section of this report, or can be part of a more fully integrated multi-method training approach (Blanchard and

Thacker, 1999). This type of fully integrated approach that includes CBT gives a learner knowledge of the topic material and "allows individualized instruction with the advantages of self-pacing, active practice or rehearsal, immediate feedback, continuous monitoring and assessment of learning, diagnosis of learning problems, and remedial assistance when needed" (Tannebaum and Yukl, 1992). Recent technology is now being used to design more elaborate CBT systems, including interactive features over the Internet, the use of videodiscs and digital video discs (DVDs), touch screen technology, voice recognition capability, optical readers, and video teleconferencing of training material (Tannebaum and Yukl, 1992).

1.7 Phases of CRM Training

Koenig (1997) suggests that training programs in CRM often have three phases: formal classroom instruction, practice and feedback, and organizational reinforcement. Similarly, Prince et al. (1992) notes that in an FAA circular it was recommended that CRM programs in the airlines follow three phases:

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

Prince et al.'s (1992) research, along with the FAA's own efforts to integrate CRM into the Advanced Qualification Programs of airlines beginning in 1996, suggests that FAA suggested training in CRM principles long before they became mandatory in 1998.

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, like organizational commitment to training objectives is thought to be one of the most important aspects of long-term training effectiveness (Salas et al., 2000).

1.7.1 Awareness Phase

CRM Classroom Instruction

Classroom instruction is currently the most widely used CRM training method in the airline, medical, military, oil, marine, nuclear, and rail industries. As stated previously, classroom instruction is a conglomerate of several different training methods, usually including many cognitive training methods and some behavioral methods. Trainees must have the knowledge and understanding of concepts related to CRM before starting to practicing CRM techniques in the field. Because trainees most often are unfamiliar with CRM and the concepts behind CRM, the cognitive training methods through which the knowledge is transferred is of the utmost importance. Historically, the training methodology that is conducive to giving individuals

introductory knowledge of a concept is formal classroom instruction. As stated previously, classroom instruction methods can vary widely, yet usually crewmembers complete seminar instruction or classroom lectures along with group exercises, video presentations, and role-play. More interactive methods of learning (for example, group exercises and role-play) can not only help trainees learn the concepts (awareness phase), but can also be used to practice some of the communication skills required for application of CRM. The instructor can monitor the students' activities and thus get feedback on how well those skills are being transferred (practice and feedback phase). Recently, CBT has been used in conjunction with, or even instead of, classroom instruction as a means to develop initial awareness of many CRM training concepts.

CRM training courses using predominantly a lecture-style format can be customized to last anywhere from several hours to several days. The length of the course should be based upon the current training needs of the individuals, group, and organization as a whole, taking into account concerns for costs (including time off from the job) and resource availability (e.g., number of classrooms or trainers available). Regardless of the length of the initial training session, it is recommended that trainees receive refresher courses in the principles of CRM every 1 or 2 years (Flin, O'Connor, Mearns, Gordon, and Whitaker, 2000). FAA recommends that CRM should be "sustained over the long term, rather than attempting to implement a 'quick fix'" (Koenig, 1997). Helmreich et al. (1999) note that CRM training should be neither integrated completely into other types of technical training nor used as a one-time intervention; rather, CRM should add to the continuing culture of safety within an organization.

Examples of organizations that have used lectures in a classroom instruction format as at least a significant component of a CRM training program include Continental Airlines, Marine Safety International, the U.S. military, and Maersk (a Danish shipping company). A number of university and public and private training centers also offer courses in CRM, including Washington State University, the University of Southern California, Texas A&M University at Galveston, the Naval Postgraduate School's School of Aviation Safety, and Marine Safety International.

During the literature review phase of this project only one commercially available CRM training program, designed specifically for the rail industry, was identified, and it was classroom-based. It was located at the Centre for Rail Training and Technology (CRTT) at the Southern Alberta Institute of Technology (SAIT) in Calgary, Canada. A typical format for a course in rail CRM was used in this program. The course begins with an overview of general CRM definitions and principles and the history of CRM's recent application to the rail industry. A review of human factors issues is provided, which includes a description of three types of human processing systems and four types of human errors, discussion of different performance-reducing states (e.g., stress, fatigue, etc.), and the demonstration of techniques to reduce the negative effects of human factors. Several key competencies of CRM are then explained to trainees, including situational awareness, communication, and teamwork. For each competency, a definition is provided along with an explanation of when and where each skill could help on the job and useful strategies to best utilize each skill. Finally, trainers teach the application of CRM principles by presenting a number of railway operation scenarios ripe for CRM utilization.

Finally, with the more widespread proliferation of CRM courses, it is helpful to know that several resources are becoming available to guide an organization's training department personnel in the creation of CRM training materials for use in the classroom setting. For example, the University of Southern California offers a course called Developing a Crew Resource Management Program as a part of its Aviation Safety Program. Other resources on CRM training design are available through the FAA and the U.S. military branches. Reference materials that describe these courses are often available via the Internet.

1.7.2 Practice and Feedback Phase

CRM Practice in Simulators

In the practice and feedback phase, trainees are typically given the opportunity to perform work activities in a controlled environment while obtaining feedback from the instructor and/or other trainees. Simulations may also be run and videotaped so that trainees can review their own performance directly. This allows for immediate feedback on performance of CRM behaviors and teaches the student to accept feedback from a variety of outside sources, as well as practicing self-evaluation.

This category of training methodologies includes low-fidelity and high-fidelity simulations, group exercises, and role-play exercises. Before any of these methods are used, a complete task analysis should be undertaken of the job that is being simulated (Salas et al., 2000). Job tasks should be mapped to training objectives and then linked to competencies that have been identified as important for successful performance on the job. Training scenarios can then be developed which bolster these competencies (Salas et al., 2000). When simulators are used specifically to train CRM skills, it is necessary to use facts from normal operating procedures, as well as examples of mishaps, to garner information for the simulation's content. Because CRM skills, such as communication, assertiveness, and error management, should be used in everyday situations, participants practicing CRM skills in a simulator should be provided with opportunities to exhibit mastery of these skills.

Simulators have been proven highly effective in reducing human factor errors. In the aviation industry, a meta-analysis of flight data by Jacobs, Prince, Hays, and Salas (1990) found that combining simulator training with training on actual aircraft was more effective than training on the aircraft alone. This is true especially with CRM training in the simulated environment. In fact, Spiker, Nullmeyer, Tourville, and Silverman (1997) found very high correlations (e.g., $\underline{r}$ = .86) between training participants' performance on a simulated tactical mission upon completion of a comprehensive CRM program.

An additional advantage of simulator-based scenarios is their usefulness in training highly important but very infrequent behaviors. For example, most commercial pilots will complete hundreds of hours of actual in-flight training without experiencing an engine fire. Should this situation arise, however, a pilot must have the training necessary to respond appropriately. Simulators allow this situation to occur and closely mimic the conditions a pilot would face inside a real plane, without exposing the pilot to such a potentially dangerous flight condition. Another advantage of simulators is that they eliminate the additional wear and tear that occurs

when an expensive piece of equipment (e.g., an aircraft or tank) is used over and over for training procedures. No fuel, maintenance, or additional support personnel are required for use with a simulator, as is necessary when a plane is used for a training mission. Disadvantages in the use of simulators include time constraints, availability, and expense. In particular, simulators in the railroad industry are not widely available to all crewmembers, so costs are higher and availability is lower than for airlines and other industries.

One possible solution to the availability problem is the use of lower fidelity simulators (Motowidlo, Hanson, and Crafts, 1997). Baker, Prince, Shrestha, Oser, and Salas (1993) were able to demonstrate that a tabletop computer-based simulator used for CRM training was accepted by aircrews as a format and acceptable as a method for training CRM skills. Bowers, Salas, Prince, and Brannick (1992) also found a low-fidelity simulation to be an acceptable, lower cost alternative to high-fidelity simulations for a helicopter flight task. Finally, low-fidelity simulations have been found to be accurate predictors of future job performance (Motowidlo, Dunnette, and Carter, 1990). This trend to lower fidelity simulation has begun even within the rail industry as some large railroads have moved from use of full-sized locomotive cab simulators to less complicated and less expensive console-based simulators using large computer monitors rather than projected images for visual cues. The lower cost of these simulators allows for more to be purchased and distributed throughout the railroads' territory.

Another way to make the use of simulators more effective for teaching and reinforcing CRM skills is to use railroad locomotive simulators to train more members of the crew simultaneously. Currently such simulators are used almost exclusively to train only locomotive engineers rather than train an engineer and conductor as a crew. Other transportation industries (e.g., commercial airlines and shipping companies) and the military tend to train entire crews rather than individual members of the crew in their simulations for activities that require more than one person. Training in this manner adds to the realism of the simulation and makes it a forum where CRM skills can be practiced by both participants and observed by the instructor. Interaction with other associated crafts can also be a part of such crew-based simulator use. For example, the use of CRM principles in the crew's communications with a dispatcher can be evaluated if the instructor takes on the role of the dispatcher in providing input to the crew. Alternatively, an actual dispatcher or dispatcher trainee could be included in a simulator-training scenario that would evaluate the crew (e.g., engineer and conductor) and the dispatcher.

An example of the successful use of a simulator to reinforce CRM concepts is the U.S. Navy's Line-Oriented Flight Training (LOFT) program. LOFT incorporates a broad category of flight simulations that may be used for a number of different purposes (Guzzo and Dickson, 1996). In a typical LOFT simulation, the entire team that is involved in a mission follows procedures as if an actual flight was taking place. These procedures include several phases, such as pre-flight preparation, the use of different communication systems, and all necessary paperwork. Participants are presented with realistic problems, and they must utilize communication and decisionmaking strategies that are essential to CRM (Guzzo and Dickson, 1996). After the exercise is complete, the entire team is debriefed on their performance, including feedback on when they exhibited proper CRM skills or should have exhibited them.

Advanced CBT

Although not currently in use, an excellent example of how CBT could be put to use for CRM training comes specifically from work that has been completed to adapt intelligent tutoring systems (ITSs) to train situational awareness (SA), a key component of CRM. Bass (1998) explains that ITSs can work to combine the roles of instructor, simulator, and traditional CBT formats by "coaching as the student performs, scaffolding the student's performance until he can perform the procedures solo, guiding SA skills by pointing out the relevant cues, and fading away as the student masters the skills." The ITSs help with SA training by providing students with feedback during simulations regarding the deviation from the current state of the system (i.e., how the student is performing) in relation to what the ideal state should be. After the session has been completed, the ITSs can review these discrepancies with the student in a debriefing session (Bass, 1998).

One common misconception regarding CBT is that the introduction of technology to change the modality of training procedures will automatically be an improvement on traditional paper-based training materials (Oser, Gualtieri, Cannon-Bowers, and Salas, 1999). It is important for the training developer to make a clear case for why a training program should be moved on-line or to a video or digital format. Traditionally, a disadvantage of CBT has been the cost and time involved in developing the software (and sometimes hardware) necessary to run the training program. Such cost and time issues have been reduced in recent years thanks to worldwide decreases in technology costs and the development of software and programming products that allow for customizable training programs. When developing a training program without the use of such packaged programs, however, a great deal of expertise is required in a diverse set of areas including software (or courseware) design, educational psychology, human development, training, human-computer interface, cognitive processes, and the specific subject matter (i.e., training objectives) (Bass, 1998; Eberts and Brock, 1987; Muraida and Spector, 1993). One challenge that developers of CBT will always face is keeping up with the technology that supports their programs (Muraida and Spector, 1993). New and more efficient technologies may be developed months or even weeks after a training program has been launched in a particular technological format.

OJT/Hands-On Training

One training methodology that shows a lot of promise in terms of CRM training is OJT or hands-on training. As stated previously, OJT is different than other training methods because it takes place in the real working environment, involves the trainee actually doing his/her job, and entails some degree of one-on-one interaction between a trainee and his/her trainer (Rothwell, 1999). Most OJT is associated with technical skills training; however, recently it has been used to teach or coach CRM skills in the field once a student has undergone initial training in CRM principles.

The Line Operations Safety Audit (LOSA) is a program method of evaluating, among other things, the CRM skills used in cockpits (Helmreich, Klinect, and Wilhelm, in press). More specifically, LOSA involves trained observers riding along in actual aircraft cockpits to observe threatening situations encountered by the crews, errors made by the aircrew, and how crews handle the threatening situations. This observational data, along with pilot/co-pilot interviews, is

put into a LOSA database, which can be used to study the actual degree to which pilots are employing certain CRM skills and their performance. The observers debrief the crew members and give feedback to the pilots in terms of CRM-related skills that they exhibited during the flight and opportunities they had to do so but did not.

Canadian Pacific (CP) railroad plans to implement on-the-job CRM training/assessment in late 2003. Instructors or coaches will be observing road and yard crew's CRM skills while riding along with them during normal operations (P. Wajda, personal communication, April 03, 2003). Following these ride-alongs, the instructors will give feedback to the crew members. Both LOSA and CP's future on-the-job CRM training program's effectiveness is largely dependent on the skills, attitudes, and motivations of the trainers/mentors. As stated previously, these trainers should be selected based on their skills and their ability to be an effective instructor. In addition, they should receive special training as observers so that they can identify more readily all crew actions or inactions related to CRM skills.

1.7.3 Reinforcement Phase

Support of CRM Principles within the Organization

The third phase of CRM training, according to Koenig (1997), involves the supporting of CRM principles by the organization in which it is being implemented. Although this phase of training is separate from the training itself, it is considered an essential component because it is vital in making the awareness and practice/feedback phases of training come to fruition and affect job performance (Salas et al., 2000). This third phase of training comes from a systems perspective, which looks at training in the larger context of the organization and its environment. Research has determined that training effectiveness not only depends on the content that is covered, the training methods used, the degree of practice and feedback, or the instructor's ability, but also by other factors that are beyond the immediate training environment. Taking a systems view of training helps trainers understand how organizational, situational, and trainee characteristics influence training effectiveness by their influence on pre-training and post-training motivation (Salas et al., 2000). The motivation to enter into training and an individual's learning of the material can be effected by pre-training organizational, situational, and trainee characteristics. For example, a trainee who has a choice in terms of the type of training he/she receives has been shown to be more motivated to learn the training material (Baldwin, Magjuka and Loher, 1991).

Similarly, post-training organizational, situational, and trainee characteristics can influence the degree to which trainees are motivated to use what they learned in training, on the job. This is the essence of Koenig's third phase (post-training) support of CRM principles by the organization. A number of organizational factors communicate to a trainee that the organization is behind CRM. These factors relay to the trainee the importance of CRM principles in the organization. Some examples of these factors include supervisor support and participation (Baldwin and Ford, 1988), a reward system that reinforces safety compliance along with on-time performance (Hackman, 1990), an environment conducive to the positive transfer of the training skills to the work space (Tracey, Tannenbaum, and Kavanagh, 1995), and a continued commitment to use CRM to enhance an overall safety culture (Helmreich, in press). Fortunately, several researchers have developed instruments and measurement systems that measure the

organizational transfer climate in relation to CRM (Salas et al., 2000). The results can be used to make changes to certain organizational dimensions that might impede the transfer of learning.

2.0 Survey of Railroad Teams

2.1 Site Visits

2.1.1 Selection of Survey Participants

One of the primary tasks of this project was to visit a cross section of railroad companies to determine the size and makeup of existing teams within the rail industry. While much literature exists which describes the functions of individual crafts within the rail industry, little prior work seems to have been done to identify the teams that exist within it. The fact that railroad teams are often made up of individuals from a variety of crafts, with varied training backgrounds, has made teaming studies especially difficult in the past. Likewise, the distrust between labor and management within the rail industry has caused suspicion of studies of this type. Obviously, not every railroad company could be visited in order to catalog its existing teams, so a representative group of rail companies were selected from each major segment of the industry.

The original FRA proposal outlined the minimum criteria for selecting railroads to visit. These included two Class I railroads (one from the east and one from the west), a shortline or regional railroad, and a passenger or commuter railroad. TTI also proposed and completed a site visit to the National Rail Passenger Corporation (Amtrak) to account for the known and appreciable differences in crews involved in the operation of long-distance, intercity passenger train service, and either freight or commuter train operations. Each of the site locations provided the research team with a good opportunity to observe variety in operating crew forces (e.g., track gangs, locomotive crews, mechanical shop crews, and signal and communications maintenance workers). The project survey requirements were met by the research teams visits to the following railroad companies during the timeframes shown in Table 2.

Table 2. Research Team Visits and Timeframes

Railroad Class	Rail Company Visited	Dates
Eastern Class I	CSX Transportation	February 17-20, 2003
Western Class I	BNSF	May 20-24, 2002
Shortline/Regional	Montana Rail Link	October 26-30, 2002
Passenger/Commuter	Chicago Metra	January 21-24, 2003
Intercity Passenger Rail	Amtrak	March 24-26, 2003

2.1.2 Site Visit Locations

A variety of geographical locations were selected by the research team in conjunction with the cooperating railroads in order to account for as much regional crew diversity as possible. The selected locations in major terminal areas also provided an opportunity to see as many teams as possible during the limited periods available under this study. Table 3 shows the locations that researchers observed at each railroad:

Table 3. Rail Companies and Site Visit Locations

Rail Company	Location
CSX Transportation	Jacksonville Terminal Area, FL
BNSF	Kansas City Terminal Area (Argentine Yard), KS
MRL	Missoula Terminal Area, MT
Chicago Metra	Chicago Terminal Area, IL
Amtrak	Wilmington, DE, and Washington, DC

2.1.3 Site Visit Descriptions

BNSF
May 20-24, 2002

The first site visit to observe, survey, and catalog railroad teams took place the week of May 20-24, 2002, at BNSF's Argentine Yard in Kansas City, KS. It was a very successful trip during which a variety of teams were identified including, yard and road operating crews, yard and road maintenance-of-way (MOW) crews, field and shop car maintenance teams, locomotive shop maintenance teams, dispatching center operations teams, and signal maintenance personnel. At the end of the visit, the team was able to debrief the BNSF Kansas Division General Manager, Manager of Transportation, Director of Administration, and Safety Manager. They showed great interest in the project and the potential of CRM in the rail environment, but they had some concerns about the costs involved in implementing an across-the-board training program. During the visit, the team made observations at the following BNSF sites:

- Division Headquarters
- System Engineering and Maintenance Office
- Dispatch Center–System Support Offices
- Mechanical–Car Running Repair Shop and Repair-in-Place (RIP) track
- Signal/Crew Building
    - Signal and radio repair facility
    - On-duty point for mid-shift yard engine crews
- Terminal Control Tower
- Road Crew; On-Off Duty Yard Office
    - Hot Seat Trainmaster–Yard Receiving and Departure Trains
- Mechanical–Locomotive Diesel Service Facility
- Mechanical–Locomotive Diesel Shop
- Engineering Yard
    - Maitenance-of-way Office

MRL
October 26-30, 2002

The team conducted a site visit to observe teams at the MRL headquarters terminal facility in Missoula, MT, from October 26 to October 30, 2002. The research team gained great insight into how the team structure might be different at shortline and regional railroads based upon this visit. The most notable team difference at MRL was its use of two engineers as an operating crew rather than an engineer and a conductor. Based upon discussions with MRL personnel, this is not common at shortlines and may, in fact, be unique to MRL. In addition to assisting these observational efforts, MRL's Training Rules and Safety Department also provided the team with a copy of the course syllabus and video from a CRM training program that they had used during annual engineer training approximately 2 years prior to this visit. This information proved useful in understanding the state-of-the-art rail CRM training that was used at that time before the distribution of the AAR's program. During the visit, researchers made observations at the following MRL sites:

- Training Center
- Missoula Yard
- Missoula Yard Tower
- Crew Calling Center
- Dispatch Center
- MOW Yard Office
- Missoula Mechanical Shop
- Missoula Tank Car Transfer
- Participated in Ride Along with Local Train Crew

Chicago Metra
January 21-24, 2003

A very productive site visit to Chicago's Metra commuter rail line took place. The team identified several similarities and differences in crew size, makeup, and responsibilities between the passenger/commuter rail and the freight rail companies that we had previously visited. The team conducted observations and discussions that allowed it to take into account the effects on operations, maintenance, and safety that tightly scheduled, highly structured train operations can have upon the interaction between train crews and dispatchers. The team was also able to identify some additional teams, not existing in the freight environment, mostly those related to the operation and maintenance of an overhead, electrically powered rail line. These new functions included both catenary MOW crews and dispatching center crews that also served as power controllers for specific line segments. This was not something that researchers had been able to observe in previous visits to non-electric freight railroads. In addition, the differences in the functions of road crews and dispatchers on a passenger railroad in comparison with freight railroads were noted. During this visit, observations were made at the following Metra sites:

- Randolph Street Station
- Electric Line Dispatch/Electric Control Center

- Union Station
- Electric District
- South Chicago Branch (ride along with local train crew)
- Kensington Yard
- Locomotive Repair Shop
- Car Repair/Maintenance Shop
- Consolidated Control Facility

CSX Transportation (CSXT)
February 17-20, 2003

During this visit to CSXT's Jacksonville, FL, terminal facilities in February 2003, researchers were able to observe a diverse set of railroad teams, including dispatchers, road operating crews, locomotive servicing crews, MOW crews, and yard inspection crews. In addition, researchers met with several members of the railroad management staff involved with operating practices and training. Researchers were able to brief them on the project and some elementary principles of CRM.

This visit afforded members of the team a good deal of time to spend with dispatchers in a central operations center in order to observe the full level of the interactions that dispatchers have with road crews during operations. Researchers also spent several hours with a track gang as they repaired and replaced a switch at the edge of the yard limits. Other carrier's trains were operating on adjacent tracks, and a nearby public rail crossing continued in operation. The team was able to observe the MOW crew and its communications from the time of their safety briefing at the initial morning meeting. The team also attended the on-site job safety briefing and was able to observe the use of track warrants as the crew completed its work. The team also noted the interaction between the foreman of the road gang, the yard dispatcher, and local and road crews. Other teams were similar to those already identified at the other freight railroads the research team had previously visited.

During the visit, the TTI project director was able to attend the *CSXT Safety Leadership Process* class, a training course that has recently been required for all CSXT personnel. This training would not be classified as a CRM course per se; however, it includes many of the CRM elements relating to communication and conflict resolution. During the visit, researchers made observations at the following CSX sites:

- Dispatch Center
- Moncrief Yard
- Locomotive Service Shop
- MOW Office
- Yard Master's Office
- Train Master's Office
- CSXT Intermodal Yard

Amtrak
March 24-26, 2003

On the first day of this visit, researchers conducted an in-depth interview with Amtrak Training Center personnel and discussed the current Amtrak CRM training program for engineers at the Amtrak Training Center in Wilmington, DE. Copies of Amtrak's training syllabus and video were provided to the TTI team. Subsequent days were spent at Union Station in Washington, DC, and at Lorton, VA, observing crew briefings and makeup. The operation of Amtrak trains with the engineer as the only crewmember in the cab, as well as the great variance in numbers of on-board-service (OBS) personnel, were the most distinctive characteristics discovered during this visit. The researchers also noted other differences in communications techniques and operational requirements. During the visit to Amtrak, the following facilities were visited:

- Amtrak Training Center, Wilmington, DE
- Union Station, Washington, DC
  - Train Crew On-Duty Office
  - Engineering Offices
- Auto Train Terminal, Lorton, VA

2.2 Team Member Identification and Classification

Salas, Dickinson, Converse, and Tannenbaum (1992) define a team as a "distinguishable set of two or more people who interact, dynamically, interdependently, and adaptively toward a common and valued goal/objective/mission, who have each been assigned specific roles or functions to perform, and who have a limited life-span of membership."

While Kline (1999) suggests that "there is as yet no common way to talk about different types of teams," others (e.g., Salas et al., 1992) argue that because a lack of consensus over the types of teams exists, a discrete taxonomy for defining and classifying teams should not be used. Despite these objections, it is possible to describe the nature and identify the members of teams in the railroad industry without attempting to place the teams into a specific taxonomy or classification tool that may not be applicable to a railroad operating environment. Kline (1999) states that recent research has suggested that there are perhaps several "common threads in what differentiates team types, including degree of structure of the task, prescriptiveness of the roles of the members, nature of the communications between members, nature of the information exchange between members, and type and degree of sharing of common goals among the members."

Using these dimensions, teams in the railroad industry would most appropriately fit into the definition of a crew (similar to the air crews) because they have highly structured tasks, prescribed roles, well-defined communication links, high but often implicit information exchange routes, and common but short-term goals. The dissimilarities between aircrews and railroad crews, however, may be just as important as the similarities. For example, although the CRM was designed for of aircrews, "decision making in the cockpit is unlike other group-decision situations. One significant difference is that crew decision making is hierarchically

managed decision making; each member of the crew contributes his/her knowledge and opinions, and the captain is the final decision-maker" (Guzzo and Dickson, 1996). These authors also suggest that flight crews may be more heterogeneous than other groups due to the varied levels of experience found in crewmembers. Finally, flight crews work together for only a short duration (a few hours to a few days) before being reassigned. This duration is different than many traditional teams but may be similar to those in the railroads. As a caveat, if teams in the railroad industry are discovered to have a short duration, it would important to understand that the training should be conducted not "with the intention of strengthening [a] *particular* team, but rather with the goal of making the individuals more effective in whatever team/crew they find themselves" (Guzzo and Dickson, 1996).

Team formation is the first stage in the life of a railroad team (Hackman, 1990). The amount of time involved in and decisions that direct team formation of railroad teams should be assessed to understand the nature of team interactions. Relevant questions regarding team formation might include:

- Who is involved in choosing team members for a team?
- What criteria are used to choose team members?
- Are different criteria used depending on the type of team (e.g., MOW, operating crew, etc.)?

Spiker et al. (1997) recommend collecting a team member background survey to get a descriptive profile of the team before any training be conducted. This survey could assess such variables as team members' age, time in position, previous positions held within the organization and in the industry in general, time with organization, and previous training experience (in particular with CRM).

2.3 Identified Teams

During the site visits to the railroads in this study, the research team was able to identify two different types of teams, called elemental and interactive teams in this report. Elemental teams are the basic teams that carry out functions at the railroads. Interactive teams are those teams that are formed when an elemental team must interact with an outside individual or another elemental team(s) to safely carry out an activity. While undoubtedly some variability exists from the teams listed here at railroads throughout the United States, the teams listed below are indicative of the common types of teams that exist and show the potential for much wider application of CRM training within the rail industry. The following common teams from across the rail industry were evident from the cross-section of railroads that were visited during this study.

2.3.1 Elemental Teams

Elemental teams are divided into three areas according to function: transportation, engineering, and mechanical. The following will discuss each elemental team's function and its relationship to other teams and CRM.

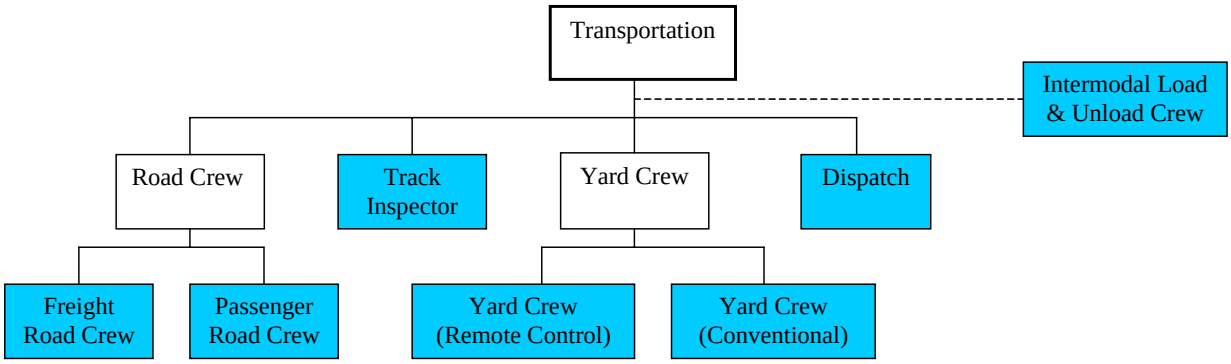

Figure 1. Transportation Crews Chart

2.4 Transportation Crews

2.4.1 Freight Road Crews

Table 4. Freight Road Crew

General job description: To safely move freight train between destinations.
Elemental team: 2-3; Engineer, Conductor, *Brakeman or Switchman.*
Communication within elemental team: Verbal, non-verbal (hand signals), and radio communication.
Team interacts with: Dispatcher, yard crew, MOW crew, Carmen, and/or yardmaster; via verbal and radio communication.
Variability with rail industry and other information: (1) Some railroads (MRL) utilize two engineers and no conductors as road crew elemental teams; (2) at some railroads (MRL), elemental road crew individuals regularly work as an on-duty team; whereas in most railroads, road crews are comprised of different individuals for each on-duty period.
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties
The general job duty of a freight road crew is to safely operate a freight train from point A to point B while complying with all Federal and company rules and regulations. A road crew (also called a train crew) is comprised of at least two persons, the train engineer and train conductor. The locomotive engineer controls the train's movement while observing and complying with all signal indications and speed restrictions. He or she also ensures that trains are loaded in compliance with recognized handling procedures. The engineer also performs all required brake tests. The conductor is responsible for the overall operation of the train, including all train documentation, any restriction existing on the train, speed requirements, track restrictions, classification of the cars in the train, pre-trip planning, and post-trip summaries. Other members

of a road crew might include a brakeman (also called a switchman in some operations). A brakeman operates car brakes, assists in switching operations, and assists the conductor and engineer in the inspection of the train consist.

Some variability exists in the composition of a freight road crew elemental team within the rail industry. As previously stated, the standard freight road crew is comprised of an engineer and a conductor; however, a few railroad companies operate with two engineer-qualified personnel rather than an engineer and conductor. (One of the railroads visited during this study, MRL, operated in this manner.) One engineer is in charge of the movement of the train, while the other carries out those duties generally assigned to a conductor at other railroads. The presence of two engineer-qualified personnel in the cab allows the crew to switch positions at an intermediate stop during a long distance trip or to swap duties for the return trip.

Another relevant difference in road crew makeup at some railroads is the assignment of engineers and conductors by rotation from an assignment board or as semi-permanent crews that are assigned to work together over a period of weeks or months. For example, at most railroad companies, road crews are assigned to a daily schedule from a board that lists the available individuals in each position (e.g., engineer, conductor, brakeman, or extras). The next available crew member in each category is assigned to make up the crew for the upcoming trip. Because the numbers of available personnel in each craft are unequal (due to illness, leave, job vacancies, etc.), the members of an assigned crew are not constant. Over time, all personnel at the terminal will rotate through crew assignments with the assigned personnel in the other positions. At other railroads, usually those with smaller workforces such as shortlines, crew assignment may be much more regular with the same personnel. For example, at MRL particular members of an elemental road crew regularly work together as an on-duty team and bid for jobs as a crew rather than as individuals. At other shortlines, regular assignment may be more of a function of limited personnel in each craft rather than assignment as an on-duty team. The working location of crewmembers may also vary. For example, in a freight road crew, the engineer and conductor generally work together in the locomotive cab of the train, but occasionally the conductor may leave the cab to inspect or adjust train equipment when the train is stopped.

Communication within the Team

Freight road crew personnel communicate with one another in a variety of ways. Because road crew members spend much of their on-duty time in close proximity to one another in the locomotive, verbal face-to-face communication is most frequently used. Hand signals are also used to communicate between crewmembers when they can maintain visual contact yet the work environment is not suitable for verbal communication. For example, when some distance between the members or background noise makes verbal communication dubious. When operating at a distance from one another and outside of visual contact, road crew personnel commonly use handheld radios to communicate with one another.

Interactions with Other Teams

A freight road crew interacts with various other teams and individuals throughout their regular work period, including yardmasters, carmen inspecting the train, dispatchers, yard crews, and MOW crews. Clear and unambiguous communication between the road crew and other functional teams and individuals outside the crew is crucial to the overall safety of the

workplace. Road crews most often communicate with these individuals and groups via verbal face-to-face and/or radio communication. Some railroads may have recently begun using direct connect cell phone-based walkie-talkies, which combine the services of a cell phone with a walkie-talkie. (The research team noted this practice at Chicago Metra, a passenger railroad, but freight crews may also be doing this.) Such phones provide a convenient means of direct communication between two workers, although the direct, one-on-one communication link does not allow others in the environment to hear the decisions or clearances granted as would open radio frequency communication.

The Elemental Team and CRM

Several characteristics of the freight road crew's work environment are relevant to CRM principles and training. On a road trip, the sensory environmental inputs for the road crew change relatively infrequently. When a change does occur, it occurs in a manner that is often predictable. This predictability and similarity of sensory characteristics can lead to habitual behavior and potentially lead to a decrease in situational awareness. Locomotive crews can potentially develop undue dependence upon outside cues, such as signals and dispatching, rather than maintaining situational awareness of their own environment. Similarly, the long work hours of train crews in this environment can cause fatigue, which can also result in loss of situational awareness. These factors should be taken into account in developing a CRM training program for this elemental team. Other potential CRM-related issues include the uncertainty over who has authority over train operations—the conductor who is responsible for movement of the train to its destination or the engineer who operates the locomotive and determines train performance by adjusting power inputs to make possible that movement. Internal crew conflict over suggested actions could occur unless they interact as a crew. For example, the engineer may be offended or not take input on how to operate the train from a non-engineer qualified conductor as a result of the strictly defined roles. In addition, communication between crewmembers may vary due to distractions in the locomotive cab or outside communications, such as calls to the dispatcher or cell phone calls. Personality differences or conflict can also lead to temporary loss of situational awareness. Working with the same person (or persons) over a period of time may improve crew performance because each individual's capabilities and characteristics are known by other crewmembers, but familiarity or assumption that certain actions will be taken by other crewmembers can also lead to loss of situational awareness or lack of attention due to expectation.

2.4.2 Passenger Road Crew

Table 5. Passenger Road Crew

General job description: To safely move passenger train between terminals and to assist passengers.
Elemental team: 2-5; Engineer, Conductor, *Brakeman, Switchman, Assistant Conductor(s) (Metra and Amtrak), Collector (Metra). (Amtrak trains may have as many as 40 additional personnel assigned to OBS crews providing services to passengers. These personnel are generally not considered part of the crew but could be called upon to assist the crew in an emergency situation.)*
Communication within elemental team: Verbal, non-verbal (hand signals) and radio communication.
Team interacts with: Dispatch, Terminal crew, MOW crew, Terminal Masters, and/or Carmen; via verbal, radio and/or *cell-based walkie-talkie radio communication (Metra).*
Variability within rail industry and other information: On passenger trains the conductor is often carrying out his duties in the passenger cars, leaving the engineer as the lone crew member in the train's cab. Amtrak assigns a second engineer if train operations are expected to exceed 6 hours.
Appropriate CRM Training Methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties
The general job duty of a passenger road crew is to safely move passenger trains between terminals and to assist passengers. The passenger road crew is always comprised of at least two persons, the engineer and conductor. The engineer controls the train's forward and reverse movement while observing and complying with all signal indications, speed restrictions, and/or time tables. The conductor is responsible for the overall operation of the train, including all train documentation, any restriction existing on the train, speed requirements, and track restrictions. On passenger trains, the conductor is often carrying out his duties in the passenger cars, leaving the engineer as the lone crewmember in the cab of the train. The conductor's duties in the car include selling and taking passenger tickets, as well as generally assisting passengers on and off of the train. Passenger assistance can also include answering questions or resolving conflicts between passengers.

Other members of a passenger road crew might include a brakeman, switchman, assistant conductor(s), and/or collector. A brakeman or switchman becomes part of the passenger road crews in situations where the train needs to switch tracks. The brakeman operates the manual switches and assists the conductor and engineer in the inspection of the train. The assistant conductor helps collect tickets and assists the conductor with his other job duties. The collector (as seen at Metra) works on large trains (usually at rush hours) to help collect and sell tickets to

passengers. Like the assistant conductor, the collector also assists passengers to board and leave the train and answers questions from passengers regarding train rules, station, and timetable information. Working together, these people make up a passenger road crew elemental team.

Another variability in the composition of a road crew within the rail industry is the assignment of additional personnel. For example, Amtrak assigns a second engineer to a passenger train if train operations are expected to exceed 6 hours. This lets the engineers switch off roles and duties, allowing them to rest, thereby counteracting fatigue factors. Engineers on passenger road crews are much more likely to be alone in the cab since the conductor is busy serving the passengers rather than assisting with train operational needs.

Communication within the Team

Passenger road crew personnel communicate with one another in a variety of ways. Unlike freight road crews, members of a passenger road crew spend much of their on-duty time out of one another's sight. For example, the engineering control booth for Metra's passenger trains is on the second floor on the cars, and the booth is closed for security purposes. The conductor, assistant conductors, and collector, however, are usually on the first floor of the cars (where most passengers ride). Because of the distance between members of the road crew, members of a passenger train use handheld radios, cell-based walkie-talkies, or the train's passenger intercom system. This system is also used to alert team members of emergency situations that might need the attention of the engineer or conductors.

Interactions with Other Teams

A passenger road crew interacts with various other teams and individuals throughout their regular work period. Passenger road crews interact with dispatchers, terminal crews, terminal masters, carmen, and various MOW crews. Passenger road crews on long-distance intercity railroads interact with these same crews, as well as other crews on the train (for example, OBS crews providing food services, cleaning, changes of linens, etc). Clear and unambiguous communication between the passenger road crew and other functional teams and individuals outside the crew is crucial to the overall safety of the workplace. Passenger road crews most often communicate with these individuals and groups via verbal face-to-face and/or radio communication. Some railroads have recently begun using cell-based phone/walkie talkies, which combine the services of a cell phone with a walkie-talkie (Metra). This provides a convenient means of communication between two workers, although the direct, one-on-one communication link does not allow others in the environment to hear the decisions or clearances granted as would open radio frequency communication.

The Elemental Team and CRM

Several characteristics of the passenger road crew's work environment are relevant to CRM principles and training. On a road trip, the sensory environmental inputs for the road crew change relatively infrequently. When a change does occur, it occurs in a manner that is often predictable. This predictability and similarity of sensory characteristics can lead to habitual behavior and a decrease in situational awareness. Similarly, the long work hours of train crews in this environment can cause fatigue, also resulting in loss of situational awareness. In commuter train operations, crews often run the same route day in and day out leading to habitual

behavior and a decrease in situational awareness through expectation. These factors should be taken into account in developing a CRM training program for this elemental team.

2.4.3 Track Inspector

Table 6. Track Inspector

General job description: Examine track and structure in compliance with Federal and company rules, and report condition upon completion. **Elemental Teams**: 1-2; Track Inspector, *Track Inspector, Lookout.* **Communication within elemental team**: Verbal, non-verbal (hand signals) and radio communication. **Interacts with**: Road crew, MOW crew, and dispatch; via verbal, written, and radio communication. **Variability within rail industry and other information**: Two-person inspection crews at Metra report to section gang through engineering rather than being assigned through transportation. **Appropriate CRM training methods**: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training. *Italics–Not relevant to all elemental teams.*

General Duties

The general job duty of a track inspector is to examine track, roadbed, equipment, and structures in compliance with Federal and company rules and to report their condition. He or she will note damage, wear, or defective parts, including switches, tie plates, joint bars, and rails, including identification of loose bolts and ties. Sometimes track inspectors will activate manual switches to determine that they are in good operating condition. The inspector often travels on the track via a hi-rail vehicle. He or she might also walk the track checking the condition of the roadbed and looking for loose ballasts and determining if they require repacking.

A track inspector usually works by himself or herself or with one other inspector. When a pair of track inspectors is working together in a crew, one inspector takes on the traditional role of inspector while the other acts as a lookout. The lookout watches for oncoming trains or other work vehicles on the tracks, adjacent tracks, or access roads, and communicates this information to the track inspector.

Communication within the Team

When two or more track inspectors are working together, they communicate with one another via verbal, non-verbal (hand signals), and radio communication. The team dynamics of a track inspecting team make it essential that the lookout communicate clearly to the track inspector when a train or other vehicle is approaching.

Interactions with Other Teams
Track inspectors interact with various other teams and individuals throughout their regular work period. Track inspectors interact with road crews, section gangs, and dispatchers via verbal and/or radio communication. The track inspector also communicates with many outside groups using written communication. He or she prepares detailed reports that indicate the equipment, track, or section of roadbed that is in need of repair. These notes outline the location, nature of damage, and post-repair conditions once a section gang has made repairs. Track inspectors most often communicate with other individuals and groups (for example, section gangs), via verbal face-to-face when on site or at a specific problem area. The track inspector will often call for a section gang to repair or replace defective equipment or to reballast the roadbed. The track inspector will also inspect completed work to verify that repairs conform to FRA and/or company regulations. All of these duties require clear and concise communication in order to be safe.

The Elemental Team and CRM
Several characteristics of the track inspectors work environment are relevant to CRM principles and training. Even though the track inspector or lookout might have a warrant to occupy a track, he or she can not get lost in the task that he or she is doing and forget that a train might come by on an adjacent track. Communication between the lookout and the inspector must be effective and in line with CRM principles. Proper written communication between inspector and section gang via writing of a clear and concise repair is necessary so that no misunderstanding occurs in terms of the location and nature of the required repair.

2.4.4 Yard Crew (Remote Control (RC))

Table 7. Yard Crew (Remote Control (RC))

General job description: To safely assemble and disassemble trains within yard limits using remotely controlled locomotives *or railcars (MRL)*.
Elemental Team: 2-3; remote control operator(s), switchman.
Communication within elemental team: Verbal, non-verbal (hand signals) & radio communication.
Interacts with: MOW crew, carman, trainmaster, and yardmaster; via verbal, written, and radio communication.
Variability within rail industry and other information: Remote control may be operated via the locomotive or another piece of operating equipment (i.e. modified caboose).
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties
The general job duty of a yard crew (RC) is to safely assemble and disassemble trains within yard limits using remote controlled locomotive systems. A yard crew (RC) is comprised of at least two individuals, a remote control operator and a switchman. The remote control operator

controls a switching locomotive within the railroad yard for the purpose of switching railroad cars for loading, unloading, and makeup or breakup of trains. He or she is on the ground using a handheld remote control device to control the train's movement. A remote control may be operated via the locomotive or another piece of operating equipment (i.e., a modified caboose that slave controls an adjacent locomotive).

The remote control operator gets his/her orders by first reading switching orders from the yardmaster or listening to switching orders over the in-cab radio from the yardmaster. He or she does so in accordance with railroad rules and regulations. The switchman is responsible for throwing track switches within the railroad yard to switch cars for loading, unloading, making up, and breaking up of trains. The switchman works with the remote control operator to completely follow the switching instructions given by the yardmaster. The switchman also is certified and equipped with a remote control device in case the first remote control fails, or the remote control operator is unable to perform his/her duties due to a fall or other injury. At present, the position of remote control operator can be filled by either a certified locomotive engineer or by another employee who has been specifically trained in the use of the remote control device.

Communication within the Team

Yard crews (RC) communicate with one another in a variety of ways. They use verbal, non-verbal (hand signals), and radio communication. The remote control operator and the switchman will use verbal face-to-face communication when within speaking distance from one another. They will use non-verbal (hand signals) in circumstances where they are in sight of each other, but the distance or environment does not allow verbal communication. Yard crews (RC) will use handheld radios to communicate verbally to one another when hand signals are not possible or in question.

Interactions with Other Teams

A yard crew (RC) interacts with various other teams and individuals throughout their regular work period, including MOW crews, carmen performing railcar inspections, yard clerks, and the yardmaster. They communicate with these individuals or groups via verbal, written, and radio communication. Clear and unambiguous communication between the yard crew (RC), other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace. Yard crews (RC) could also communicate using cell phone-based walkie-talkies, which combine the services of a cell phone with a walkie-talkie. This phone provides a convenient means of communication between two employees through the direct, one-on-one communication link but does not allow others in the environment to hear and be made aware of the other actions taking place on nearby yard tracks as would open radio frequency communication.

The Elemental Team and CRM

Several characteristics of the yard crew's (RC) work environment that are relevant to CRM principles and training. The working environment of a yard crew is very hazardous. Often debris such as removed spikes or trash, the large numbers of tracks, and the presence of many slow moving trains can make working around the yard quite unsafe if constant attention and teamwork are not applied. Yard crews must focus not just upon what they are doing (remotely

moving the locomotive), but where they are moving on the ground and the activities taking place upon adjacent tracks. The remote control operator and the switchman must remain in constant communication to prevent accidents from occurring. Proper job briefing and training for all personnel involved in remote operations is essential. Working as a crew rather than as individuals to verify that all steps are taken is another aspect of CRM that can be applied to this elemental team.

2.4.5 Yard Crew (Conventional)

Table 8. Yard Crew (Conventional)

General job description: To assemble and disassemble trains within yard limits.
Elemental Team: 2-3; yard engineer, conductor, switchman.
Communication within elemental team: Verbal, non-verbal (hand signals), and radio communication.
Interacts with: Carman, trainmaster and yardmaster; via verbal, written, and radio communication.
Variability within rail industry and other information: Specific functions of the yard crew may change depending on the location and railroad company.
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

General Duties
The general job duty of a yard crew (conventional) is to safely assemble and disassemble trains within yard limits. A yard crew is comprised of between two to three individuals, including a yard engineer, a conductor, and a switchman. The yard engineer, also called a switch engineer, controls a switching locomotive within the railroad yard for the purpose of switching railroad cars for loading, unloading, and makeup or breakup of trains. The yard engineer gets his/her orders by first reading switching orders from the yardmaster or listening to switching orders over the in-cab radio from the yardmaster. He or she does so in accordance with railroad rules and regulations. The switchman is responsible for throwing track switches within the railroad yard to switch cars for loading, unloading, making up, and breaking up of trains. The switchman works together with the yard engineer to completely follow the instructions given by the yardmaster. The specific functions of the yard crew may vary depending on the location and the railroad company.

Communication within the Team
Yard crews communicate with one another in a variety of ways, including verbal, non-verbal (hand signals), and radio communication. The yard engineer and the switchman will use verbal face-to-face communication when within speaking distance from one another (for example, when in the locomotive). They will use non-verbal (hand signals) in circumstances where they are in sight of each other, but the distance or environment does not allow verbal face-to-face communication. For example, the switchman on the ground will communicate to a yard engineer in the locomotive that a switch is aligned and it is alright to proceed through the switch. Yard

crews will use handheld radios to communicate verbally to one another when hand signals are dubious.

Interactions with Other Teams
A yard crew (conventional) interacts with various other teams and individuals throughout their regular work period, including carmen, trainmasters, and yardmasters. They communicate with these individuals or groups via verbal, written, and radio communication. Clear and unambiguous communication between the yard crew, other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace. Some railroads have recently begun using cell-based phone/walkie-talkies, which combine the services of a cell phone with a walkie-talkie (Metra). This type of phone provides a convenient means of direct communication between two workers, although the direct, one-on-one communication link does not allow others in the environment to hear the decisions or clearances granted as would open radio frequency communication.

The Elemental Team and CRM
Several characteristics of the yard crew's work environment are relevant to CRM principles and training. The working environment of a yard crew (conventional) is very hazardous. Often debris such as removed spikes or trash, the large numbers of tracks, and the presence of many slow moving trains can make working around the yard quite unsafe if constant attention and teamwork are not applied. Yard crews (conventional) must focus not just upon what they are doing (building and separating trains and moving railcars), but where they are moving on the ground and the activities taking place upon adjacent tracks. The yard crew in the cab and the switchman must remain in constant communication to prevent accidents from occurring. Proper job briefing and training for all personnel involved in switching operations is essential. Working as a crew rather than as individuals to verify that all steps are taken is another aspect of CRM that can be applied to this elemental team. Frequent changes in crew personnel can also be an issue for yard crews.

2.4.6 Dispatch Crew

Table 9. Dispatch Crew

General job description: Authorizes and controls track occupancy for all operations.
Elemental Team: 2-3; dispatchers plus immediate supervisor (chief dispatcher).
Communication within elemental team: Verbal face-to-face, and telephone communication.
Interacts with: Road crew, MOW crew, signal maintainers, B&B department, *block/tower operators (Metra)*; via radio communication.
Variability within rail industry and other information: The job duties of some dispatchers on electrical lines may also include electrical control (Metra's electric line).
Appropriate CRM Training Methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties
The general job duty of a dispatch crew is to authorize and control track occupancy for all operations. A dispatch crew is comprised of at least two persons, the dispatcher plus the immediate supervisor (chief dispatcher). Train dispatchers control and supervise the safe and efficient movement of trains, authorizing the occupancy of main track and sidings for train operations and track inspections, as well as MOW personnel. Most train dispatchers use a Computer Aided Dispatching (CAD) auto-routing system to track trains. They interact with the system as well (for example, recording train delays), ensuring movement of priority trains, as well as aligning switches and adjusting signals that are not produced automatically by the system. The chief dispatcher supervises dispatchers, making sure that train movements are safe and efficient and that trains are moved according to all railroad rules and regulations. Other members of the dispatch team include other dispatchers that control adjacent territories.

Some variability does exist in the composition of a dispatch crew in the railroad industry. For example, the job duties of some dispatchers on electrical lines (for example, Metra's electric line) also include electrical control to the segments over which trains are operating. This can involve interacting with various electricity suppliers, checking the flow of electricity on the control panel, and, if need be, changing the supply of electricity to the system or specific track.

Communication within the Team
Dispatchers and the chief dispatcher communicate with one another in a variety of ways, including verbal face-to-face and telephone communication. A railroad's dispatch center layout can vary; however, most dispatchers sit close to one another, sometimes separated by cubicle walls to keep distractions to a minimum. Dispatchers must communicate to one another when passing trains from one dispatcher's area of responsibility to another. They can communicate with the other dispatcher face-to-face by verbally notifying the other dispatcher that a train is coming into his territory. Alternatively, a dispatcher can utilize the dispatch radio/telephone to speak to him or her and point out the train entering his area of responsibility on the CAD screen display. A chief dispatcher will communicate to the dispatch via verbal face-to-face communication or the telephone. He or she might notify dispatchers of daily changes in the control operations, give them feedback on performance, or answer questions related to the control of trains.

Interactions with Other Teams
A dispatch crew interacts with various other teams and individuals throughout their regular work period, including road crews, MOW crews, signal maintainers, B&B department, and block/tower operators (Metra). Clear and unambiguous communication between the dispatchers, road crews, other functional teams, and individuals outside the crew is crucial to the overall safety of the railroad workplace. Dispatch crews communicate with these individuals and groups via radio communication. Although some railroads have begun using cell phone based walkie-talkies, dispatchers are not allowed to use them for outgoing calls because they are not recorded. Dispatchers must use land line phones that are recorded for outgoing information.

The Elemental Team and CRM
Several characteristics of the dispatchers work environment are relevant to CRM principles and training. Dispatchers must maintain situational awareness at all times while sitting at their desk

observing computer screens for 6-8 hour shifts and must constantly monitor the situation. Dispatchers are constantly communicating and must always be clear, thorough, and concise. Dispatchers must communicate daily with individuals with different personalities, ethnicities, generational attitudes, and cultures. They must know how to handle each of these differences effectively as taught in many CRM training programs. Because they control movement of trains by granting track access, dispatchers must work to prevent accidents where trains encounter the public. Miscommunication or loss of awareness by a dispatcher can thus be a safety concern for the general public as well as the railroad.

2.4.7 Intermodal Load and Unload Crews

Table 10. Intermodal Load and Unload Crews

General job description: Safely loads and unloads shipping containers and/or truck trailers to and from intermodal cars. **Elemental Team**: 2; lift crane operator, groundsman. **Communication within elemental team**: Verbal face-to-face, non-verbal (hand signals), and radio communication. **Interacts with**: Mule operator (yard tractor) and yard dispatch; via radio communication. **Variability within rail industry and other information**: Predominantly carried out by private contractors; however, may be railroad personnel. Special situations require supervision by foreman and may require more than one lift crane operator. **Appropriate CRM training methods**: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

General Duties

The general job duty of an intermodal load and unload crew is to safely load and unload shipping containers and/or trailers to and from intermodal cars. An intermodal load and unload crew is usually comprised of one or two lift crane operators. The lift crane operator sits in an elevated control room and uses hand controls to operate the lift crane. He or she quickly and repeatedly adjusts the controls of the lift to exact positions. During loading and unloading operations, the lift crane operator inspects and compares load weights with lifting capacity to ensure against overload. A high degree of manual dexterity and depth perception are needed in order to operate efficiently. He or she must also inspect and adjust crane mechanisms and accessory equipment to prevent malfunction and wear. The groundsman job is to clear the path for the crane to aid in setting the load where it belongs. Additionally, he or she communicates with the lift crane operator as to the placement of the container and to secure containers on the chassis.

Some variability exists in the set up of intermodal load and unload crew elemental team within the rail industry. Private contractors, not the host railroad, predominantly carry out intermodal yard task functions, including the intermodal loading and unloading of containers onto intermodal cars or truck chassis. Railroad personnel, however, may carry out these operations. In terms of the variability of the make up of an intermodal load and unload crew, special situations require supervision by foreman and may require more than one lift crane operator.

Communication within the Team

Intermodal load and unload crew personnel communicate with one another via verbal, radio, and non-verbal (hand signal) communications. Before the work day or a specific job, the lift crane operator and the groundsman will have an informal verbal face-to-face meeting to discuss specific aspects of the upcoming job and to discuss any special loads. Similarly, they will use radio communication to coordinate their efforts once the lift crane operator is in position in the crane control room.

Most of the actual communication during the actual loading and unloading of containers is done using hand signals. The groundsman will give hand signals (many times subtle) to the lift crane operators, who watches closely. These hand signals include commands, such as stop, left, right, lower, and higher. The groundsman also uses hand signals to confirm that the container is in place before securing it on the chassis.

Interactions with Other Teams

An intermodal load and unload crew also interacts with various other teams and individuals throughout their regular work period, including mule operators, road crews, intermodal yard crews, and yardmasters via radio communication. For example, they communicate with the mule operator when they need a string of chassis moved. They communicate with yard dispatchers when questions regarding car order or container identification are unclear or confusing. Clear and unambiguous communication between the intermodal load and unload crew, other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace.

The Elemental Team and CRM

Several characteristics of the intermodal load and unload crew's work environment are relevant to CRM principles and training. For example, frequent movement of heavy loads by crane requires constant communications and maintenance of situational awareness. The interaction between contractor and railroad personnel calls for improved communication and coordination in carrying out operations. This could also be a potential area where contractor and railroad rules conflict, requiring quick decisionmaking by the team. Adverse winds or weather could affect the crane and intermodal equipment's performance can.

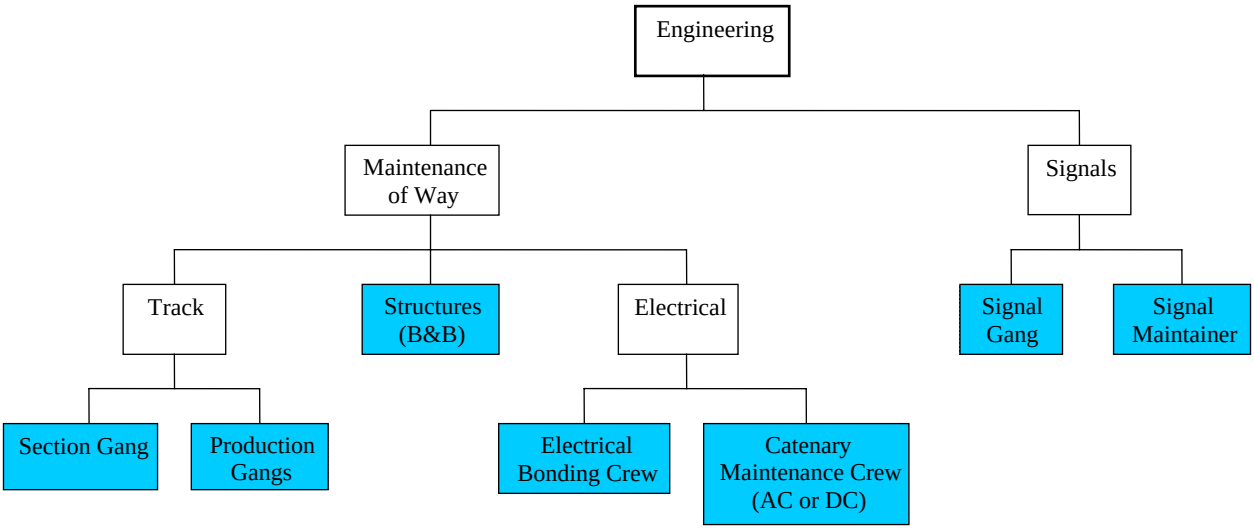

Figure 2. Engineering Crews Chart

2.5 Engineering Crews

2.5.1 Section Gang

Table 11. Section Gang

General job description: Performs daily assigned maintenance and repairs of track and right of way.
Elemental team: 4-10; foreman, assistant foreman, trackman laborer(s), truck driver, Machine Operator(s), *welder and grinder team, speed swing operator, front-end loader, dump truck loader, flagman, lookout.*
Communication within elemental team: Verbal and non-verbal (hand signals) communication.
Interacts with: Track supervisor, dispatch, yardmaster, signal maintainer(s), road crews; via radio and *Nextel® radio communication (Metra).*
Variability within rail industry and other information: Metra section gangs use Nextel® to communicate outside the team almost exclusively. Track inspectors also work more directly with section gangs at Metra than roadmasters do at the freight railroads.
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties

The general job duty of a section gang is to perform daily assignments of maintenance and repairs of track and rights of way. A section gang is generally comprised of at least four persons—a foreman, a trackman laborer, a truck driver, and a machine operator. On a larger job, a section gang can be augmented by the addition of an assistant foreman, track supervisor, a welder and grinder team, a speed swing operator, a front-end loader operator, a dump truck loader, or a flagman or lookout. Furthermore, additional trackman laborers and machine operators can be in a section gang. The foreman supervises the section gang and helps with any of the work. The foreman is in charge of supervising the section gang, including performing the job/safety briefing at the beginning of any job and the beginning of each working day. Track laborers, working as a member of a crew, will do a variety of jobs related to installing and repairing railroad track. These can include pulling spikes, cleaning and placing plates, cutting ties to fit plates, and helping to align rail. A truck driver operates the work truck that carries the crew to the worksite. The machine operator most often maneuvers the machinery that moves and lays track or rails to construct, repair, or maintain railroad tracks. A welder and grinder work together to connect rail. A grinder grinds the end of new rail to achieve a smooth joint; the welder then welds the rail together. A speed swing operator operates a piece of heavy equipment mounted on the ground or track that is used to place new rail on track and/or hold it while being cut. A front-end loader operator uses a front-end loader to pick up and move various objects (such as ties, rocks, rail) from one area of the worksite to another.

Communication within the Team

Section gang personnel communicate with one another in a variety of ways. Because section gang members spend much of their on-duty time in close proximity to one another while on the jobsite, verbal face-to-face communication is frequently used. Hand signals are also used to communicate between crewmembers when they can maintain visual contact, yet the work environment is not suitable for verbal communication (for example, when some distance between the members exists or background noise from equipment such as a hydraulic spike driver, makes verbal communication difficult). When aligning rail for installation, hand signals and instruments may be used to communicate to machine operators and others the alignment of the rail.

Interactions with Other Teams

A section gang interacts with various other teams and individuals throughout their regular work period, including dispatchers, track inspectors, signal maintainers, trainmasters, road crews, and track supervisors. A track supervisor communicates with the section gang during the work session. He or she ensures that the section gang's work assignment is productive by evaluating work progress and reassigning personnel and equipment as necessary.

They communicate with these teams or individuals via radio and cell phone-based walkie-talkie radio communication (Metra). Metra section gangs use cell-based walkie-talkies to communicate outside the team almost exclusively. Clear and unambiguous communication between the section gang and other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace. Track inspectors seem to work more directly with section gangs at Metra than roadmasters do at the freight railroads due to their differing organizational structure.

The Elemental Team and CRM
Several characteristics of the section gang's work environment are relevant to CRM principles and training. Working in and around tracks, moving trains, industrial equipment and machinery, and loose ballast can all be very hazardous if not properly briefed and coordinated. The environment is often noisy and has extreme temperatures, leading to increased fatigue. Work must be coordinated with other crewmembers to avoid injury or damage to equipment. Track authority to do work must be coordinated with dispatchers, and train crews must be made aware of their presence in order to prevent accidents.

2.5.2 Production Gang

Table 12. Production Gang

General job description: Installs, rehabilitates, and repairs track in large sections.
Elemental Team: 10-60; foreman, trackman laborers, truck drivers, machine operators, assistant foremen, track supervisor(s), *welder and grinder team(s), speed swing operator(s), front-end loader(s), dump truck loader(s), flagman, lookout(s).*
Communication within elemental team: Verbal face-to-face, hand signals, and radio communication.
Interacts with: Dispatch, road crews and signal maintainers; via radio communication.
Variability within rail industry and other information: Production gangs are often subdivided into specialized surfacing, tie, and rail production gangs that must be coordinated within the elemental team. Production gangs are often organized at the system level and work seasonally from late spring through mid-autumn to take advantage of better weather conditions.
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties
The general job duty of a production gang is to install, rehabilitate, and repair track in large sections. A production gang is similar to a section gang only their operations take place on a larger scale. A railroad will usually take a large section of track out of service for an extended period of time to do the work. Production gangs are often organized at the system level and work seasonally from late spring through mid-autumn to take advantage of better weather conditions. Production gangs are often subdivided into specialized surfacing, tie, and rail production gangs that must be coordinated within the elemental team.

Many of the workers on production gangs are seasonal workers, meaning that they only work during specific months of the year. These months are usually in the slower freight or passenger season or when weather conditions are most conducive. A production gang is usually comprised of between 10 and 60 workers. A typical production gang is comprised of a foreman, trackman laborers, truck drivers, and machine operators augmented by the appropriate number of assistant foremen, track supervisors, welder and grinder teams, speed swing operators, front-end loader

operators, dump truck loaders, and/or flagman lookouts. The foreman supervises the production gang and helps direct work activities as necessary. The foreman is in charge of the job briefing at the beginning of any job and the beginning of each working day. Track laborers will do a variety of jobs, including pulling spikes, cleaning and placing tie plates, and helping to align rail. Other members of the production gang operate equipment as described in the previous description of section gangs.

Communication within the Team

Production gang personnel communicate with one another in a variety of ways. Because production gang members spend much of their on-duty time in close proximity to one another, verbal face-to-face communication is frequently used. Hand signals are also used to communicate between crewmembers when they can maintain visual contact or the work environment is not suitable for verbal communication. When some distance between the members exists or background noise from equipment, such as a hydraulic spike driver, makes verbal communication difficult or impossible, foremen, laborers, and machine operators may communicate to one another using hand signals. Unlike the smaller section gangs, production gangs cover a large distance of track, and communication between different work groups is imperative. The production gang may operate with specialized subgroups, such as surfacing, tie, and rail production gangs at some distance from one another. Thus production gangs also depend upon radio communication to communicate between workers.

Interactions with Other Teams

A production gang interacts with various other teams and individuals throughout their regular work period, including dispatch and perhaps passing road crews on adjacent tracks, via radio communication. Clear and unambiguous communication between the production gang, other functional teams, individuals outside the crew is crucial to the overall safety of the workplace. As stated above, many production gangs are fortunate to have all rail traffic halted or re-routed around their work area for a period of hours or days while their work is completed. In such cases, work progress must be periodically reported to management and dispatching so that future operational plans may be adjusted accordingly. Additionally, signal gangs may be working nearby to install new or improved signal system infrastructure as the production gang completes its work.

The Elemental Team and CRM

Several characteristics of the production gang's work environment are relevant to CRM principles and training. Working in and around tracks, moving trains, industrial equipment and machinery, and loose ballast can all be very hazardous if not properly briefed and coordinated before each job. The working environment is often noisy and subject to extreme temperatures leading to increased fatigue. Work must be coordinated with other crewmembers to avoid injury or damage to equipment. Track authority to do work must be coordinated with dispatchers, and passing train crews must be made aware of their presence in order to prevent accidents. The seasonal nature of most production gang jobs also tends to be filled by less experienced or skilled workers, thus requiring even more attention to be paid to situational awareness and communications training.

2.5.3 Structures (B&B)

Table 13. Structures (B&B)

General job description: Builds, maintains, and repairs structures limited to bridges and buildings (B&B).
Elemental Team: 5-12; foreman (leadman), carpenter(s), electrician(s), truck driver, crane operator, *station attendant(s)/janitor(s).*
Communication within elemental team: Verbal face-to-face, hand signals, and radio communication.
Interacts with: Dispatch, road crew(s) and roadmaster via radio communication.
Variability within rail industry and other information: Janitorial and station attendant services in some passenger railroads perform vital tasks, such as snow removal from passenger platforms. Team size is dependent upon specific task assigned.
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties
The general job duty of a structures crew is to build, maintain, and repair major railroad structures, such as bridges or buildings. A structures crew is typically comprised of between 5 to 12 workers including a foreman (leadman), carpenter, electrician, truck driver, and crane operator. Passenger railroads may also consider station attendants/janitors who care for their stations or remove snow from platforms as part of the structures crew. The size of these teams depends upon the specific task assigned. The foreman (leadman) receives work assignments and supervises work completion. The carpenter builds and repairs hardware involved in a structures job. He or she uses a variety of tools, including saws and hammers to work with wood, metal, and sheetrock. The carpenter must also verify the soundness of the structure. The electrician's duties are principally to maintain and protect electrical equipment used by the other crew members and to install and ensure proper rail joint bonding and rail isolation joints on bridge structures. Additionally, electricians may install and repair electrical wiring, equipment, and fixtures in buildings. Structures crewmembers also receive additional training in working from bridges and the specialized safety equipment and techniques that must be used when working at elevation.

Communication within the Team
Structures crew personnel communicate with one another in a variety of ways, including verbal face-to-face, hand signals, and radio communication. They communicate verbally when they are a distance from one another to get verbal feedback. Hand signals are also used to communicate between crewmembers when they can maintain visual contact, yet the work environment is not suitable for verbal communication (for example, when some distance between the members exists or background noise makes verbal communication unreliable). When operating at a

distance from one another and outside of visual contact, structures personnel commonly use handheld radios to communicate with one another. Hand signals also play an important part in directing the placement of structural members (e.g., piles, bents, stringers, etc.).

Interactions with Other Teams
A structures crew interacts with various other teams and individuals throughout their regular work period, including dispatchers, road crews, and yard crews via radio communication. Clear and unambiguous communication between the structures crew, other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace. Structures crews most often communicate with these individuals and groups via verbal face-to-face and/or radio communication. Structures workers communicate with dispatchers when working on or near active tracks or when exercising/vacating their track warrant authority. They might talk to other crews when they need access on or through their work area.

The Elemental Team and CRM
There are several characteristics of the structure crew's work environment are relevant to CRM principles and training. These include communication between workers, assertiveness in correcting observed unsafe conditions while working above the ground on a structure, or pointing out faulty job practices. Station attendants may be working in close proximity to live tracks. Situational awareness regarding equipment usage or passing trains is important in both of these situations.

2.5.4 Electrical Bonding Crew

Table 14. Electrical Bonding Crew

General job description: Performs electrical bonding of track to carry electricity to power locomotive on electrically powered rail lines. **Elemental team**: 2-3; inspector, bonder(s). **Communication within elemental team**: Verbal face-to-face and radio communication. **Team interacts with**: Dispatcher via radio communication. **Variability within rail industry and other information**: Certain bond repairs may be done without contacting dispatcher. **Appropriate CRM training methods**: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

General Duties
The primary job duty of a electrical bonding crew is to perform electrical bonding of track in order to carry electricity to power locomotive on electrically powered rail lines. An electrical bonding crew is comprised of at least two persons; an inspector and a bonder. An inspector examines track wiring to determine continuity of electrical connections. A bonder uses a variety of welding equipment including gas or electric welders to weld bonding wires across rail joints. A larger bonding job can mean an electrical bonding crew may add more bonders to complete the work.

Communication within the Team
Electrical bonding crew personnel communicate with one another in a variety of ways. Because electrical bonding crewmembers spend much of their on-duty time in close proximity to one another, verbal face-to-face communication is frequently used. When operating at a distance from one another and outside of visual contact, electrical bonding crew personnel commonly use handheld radios to communicate with one another.

Interactions with Other Teams
An electrical bonding crew interacts with the dispatcher via radio communication in order to ensure authority to work on the tracks. Clear and unambiguous communication between the electrical bonding crew, other nearby functional teams, and individuals outside the crew is crucial to the overall safety of the workplace. Electrical bonding crews most often communicate with these individuals and groups via verbal face-to-face and/or radio communication. Some electrical bonds, however, may be done without notification to the dispatcher during times when operations are not taking place. In these circumstances however, a lookout must be present.

The Elemental Team and CRM
Several characteristics of the electrical bonding crew's work environment are relevant to CRM principles and training. Because of the very high risk involved in working in and around high voltage electric lines, teamwork within a bonding crew and with the dispatcher controlling power to the line must be highly coordinated. Crewmembers must provide lookout protection while others in the crew are working in order to protect one another. Each worker must exercise situational awareness in the busy track environment.

2.5.5 Catenary Maintenance Crew (AC or DC)

Table 15. Catenary Maintenance Crew (AC or DC)

General job description: Maintains overhead catenary wires.
Elemental Team: 2-6; supervisor, electrician(s).
Communication within elemental team: Verbal, radio, and *Nextel® radio communication (Metra).*
Interacts with: Dispatch/electric control; via radio communication.
Variability within rail industry and other information: AC/DC catenary gangs exist only on railroads with electrically powered rail lines. Larger six-person gangs are used when working on hot lines. Smaller two- or three-person gangs exist when there is track and electric protection.
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties
The general job duty of a catenary maintenance crew is to maintain overhead catenary wires; thus these gangs only exist on railroads with electrically powered rail lines. A catenary maintenance crew is comprised of at least two persons, including one supervisor and an electrician. The larger the maintenance job, or jobs in which they are working on hot (electrically charges lines), a larger crew works together. A smaller two- or three-person gang can work a job if there is track protection (no-trains) and electrical protection (lines are not charged). Electricians install new catenary wires, as well as maintaining and repairing old catenary wires.

Communication within the Team
Catenary maintenance crew personnel communicate with one another in a variety of ways. Because catenary maintenance crewmembers spend much of their on-duty time in close proximity to one another, verbal face-to-face communication is frequently used. Hand signals are also used to communicate between crewmembers when they can maintain visual contact, yet the work environment is not suitable for verbal communication (for example, when some distance exists between the members or background noise makes verbal communication questionable). When operating at a distance from one another and outside of visual contact, catenary maintenance crew personnel commonly use handheld radios or cell-based phone/ walkie-talkies to communicate.

Interactions with Other Teams
A catenary maintenance crew interacts with dispatch throughout their normal working period. Smaller catenary gangs communicate with dispatch/electrical control over the radio when they require the AC or DC wire to be de-electrified or re-electrified. Larger catenary gangs working on electrically charged hot lines will communicate with dispatch when a train or other vehicle is occupying the tracks or using the wires in which they are working. Clearly, unambiguous communication between the catenary maintenance crew and the dispatcher who is controlling both power and train movement is critical to the overall safety of the workplace.

The Elemental Team and CRM
Several characteristics of the catenary maintenance crew's work environment are relevant to CRM principles and training. Internal communication and teamwork within the catenary maintenance team, proper use of tools, and proper protective equipment usage are all important on this team. Because of their work with high voltage electric lines, constant awareness of the team's immediate environment is essential and characteristics of the situation must not be assumed. Similarly, the environment is one in which a lack of assertiveness in terms of assuring safe operations can be extremely unfavorable.

2.5.6 Signal Gang

Table 16. Signal Gang

General job description: Install and repair signal infrastructure on specific sections of track in the context of large projects. **Elemental team**: 10-15; signal supervisor, installers, laborers. **Communication within elemental team**: Verbal face-to-face, hand signals, and radio communication. **Interacts with**: Dispatch, road crew(s), production gang and MOW crews via verbal face-to-face and radio communication. **Variability within rail industry and other information**: Size and makeup can vary depending on the size of project. **Appropriate CRM training methods**: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

General Duties

The general job duty of a signal gang is to install and repair signals on specific sections of track in the context of large projects. Many times a signal gang works alongside a production gang when a railroad has taken a large section of track out of service for major repair or rehabilitation. Large signal gangs, however, can also work on signal on track that is not out of service, putting in new equipment while existing signals remain in place. Like production gangs, signal gangs are often organized at the system level and work seasonally from late spring through mid-autumn to take advantage of better weather conditions.

A signal gang is usually comprised of between 10 to 15 individuals, including a signal foreman, electricians, and signal maintainers. The signal supervisor assigns tasks and personnel to the jobs required. Furthermore, the signal supervisor performs tests on installed equipment and circuits for verification of correct system operation. The signal supervisor in the signal gang typically does troubleshooting to correct the installed equipment. The installers carry out the task of physically installing wire, cabling, cabinets, pole lines, and fiber optic systems. Laborers perform assistance as directed in accordance with instructions for installers or supervisors.

Communication within the Team

Signal gang personnel communicate with one another in a variety of ways. Because signal gang members spend much of their on-duty time in close proximity to one another in the field, verbal face-to-face communication is frequently used. Hand signals are also used to communicate between crewmembers when they can maintain visual contact, yet the work environment is not suitable for verbal communication (for example, when some distance exists between the members or background noise makes verbal communication uncertain). When operating at a distance from one another and outside of visual contact, signal gang personnel commonly use handheld radios to communicate with one another.

Interactions with Other Teams
A signal gang interacts with various other teams and individuals throughout their regular work period, including dispatchers, road crews, production gangs, and MOW crews. They communicate with these other groups and individuals via verbal face-to-face and radio communication. Clear and unambiguous communication between the signal gang, other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace. Signal gangs most often communicate with these individuals and groups via verbal face-to-face and/or radio communication.

The Elemental Team and CRM
Several characteristics of the signal gang's work environment are relevant to CRM principles and training. Because they work in close proximity to the tracks and with other crews so often, they must constantly be in communication, both internally and externally to the signal gang itself. The intricate tasks involved in building and installing new signal infrastructure, as well as the presence of electricity, leads to a hazardous environment in which awareness and teamwork are highly necessary.

2.5.7 Signal Maintenance Crew

Table 17. Signal Maintenance Crew

General job description: Maintains the signals on an assigned section of track, applies electrical bonding wires to rail, and installs insulated joints for signal system continuity.
Elemental Team: 1-2; signal maintainer(s).
Communication within elemental team: Verbal face-to-face, hand signals, and radio communication.
Interacts with: Dispatch and road crew, via verbal, written, radio, and *Nextel® radio (Metra*) communication.
Variability within rail industry and other information: Usually works as an individual on assigned territory but can work with another maintainer on specific projects, or when required to perform repairs at night.
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties
The general job duty of a signal maintainer is to perform periodic maintenance and repairs on the signals on an assigned section of track. He or she also applies electrical bonding wires to rail and installs insulated joints for signal system continuity. A signal maintainer usually works as an individual on an assigned territory but can work with another maintainer on a specific project or when repairs are required at night. The signal maintainer will perform minimal troubleshooting but carries out comprehensive tests on the signal systems in the field.

Communication within the Team
Signal maintainers communicate with one another in a variety of ways. Because signal maintainers often work independently, they are more likely to use radios or other electronic means to communicate with other maintainers or other crews. When working with other maintainers, they will use verbal face-to-face communication or hand signals.

Interactions with Other Teams
Signal maintainers interact with various other teams and individuals throughout their regular work period including dispatch and road crews. They interact with these groups via verbal, written, and radio communication. Clear and unambiguous communication between the signal maintainers, other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace. Signal maintainers most often communicate with these individuals and groups via verbal face-to-face and/or radio communication.

The Elemental Team and CRM
Several characteristics of the signal maintainer's work environment are relevant to CRM principles and training. Although they often work independently, they can be called to join and assist a MOW crew that is repairing rail (for example, to ensure signal continuity or track isolation). When performing this activity they must be able to communicate with the others on scene to quickly determine the situation. The independent nature of their normal day-to-day activity also makes them depend on their own proficiency and that of the dispatchers and other teams nearby to keep them informed of changes in their environment.

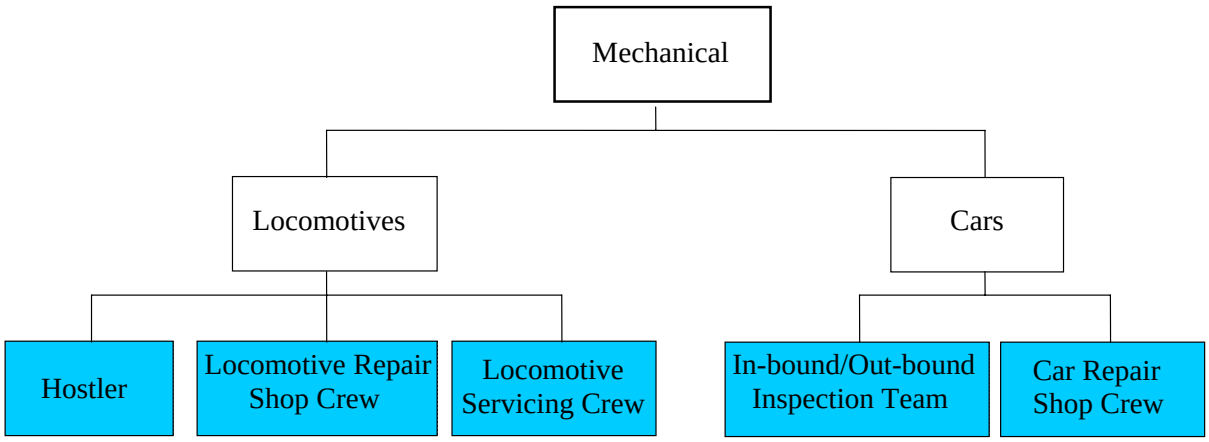

Figure 3. Mechanical Crews Chart

2.6 Mechanical Crews

2.6.1 Hostler Crew

Table 18. Hostler Crew

General job description: Moves locomotives in and out of locomotive repair shop to various locations in yard.
Elemental team: 2; hostler, brakeman (switchman).
Communication within elemental team: Verbal face-to-face, hand signals, and radio communication.
Team interacts with: road crew, dispatch, yardmaster, locomotive repair shop crew, yard foreman, via radio and verbal face-to-face communication.
Variability within rail industry and other information: Although most hostlers work inside designated yard limits, some hostlers can, with special qualifications, work outside those yard limits to transfer power to other yards.
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties
The general job duty of a hostler crew is to move locomotives in and out of locomotive repair shop to various locations in yard. Although most hostler crews work inside designated yard limits, some hostlers can, with special qualifications, work outside those yard limits to transfer power to other nearby yards. A hostler crew is comprised of two persons, the hostler and a brakeman (switchman). The hostler gets his/her instructions from a trainmaster and drives the locomotive to designated locations in the rail yard to be cleaned, serviced, repaired, and supplied with fuel oil, water, lubricating oil, and/or sand. After the locomotive is serviced, the hostler delivers the locomotive to a location for pick up by a yard crew. The brakeman (switchman) throws track switches within the railroad yard.

Communication within the Team
A hostler crew communicates with one another in a variety of ways. Because much of the work done by the hostler crew involves the brakeman on the ground, much of the communication between the hostler and the brakeman is done with hand signals or radio communication. Hand signals are used to communicate between crewmembers when they can maintain visual contact yet the work environment is not suitable for verbal communication (for example, when some distance exists between the members or background noise makes verbal communication questionable). When operating at a distance from one another and outside of visual contact, hostler crew members commonly use handheld radios to communicate with one another. For example a hostler may call the switchman via radio when verifying that a switch has been thrown.

Interactions with Other Teams
A hostler crew interacts with various other teams and individuals throughout their regular work period, including road crews, dispatch, yardmasters, locomotive repair shop crews, and yard foreman. Hostler crews communicate with these groups or individuals via radio and verbal face-to-face communication. Clear and unambiguous communication between the hostler crew, other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace.

The Elemental Team and CRM
Several characteristics of the hostler's work environment are relevant to CRM principles and training. The hostler and switchman must work together as a team to safely move the locomotive in the yard environment. They must work with the yardmaster and yard dispatch to ensure that they remain clear of other yard traffic while doing so. The hostler crew must coordinate his efforts to ensure that he/she moves the locomotives in a sequence that does not conflict with the maintenance efforts in the locomotive repair shop. Safety in and around the shop when taking out a locomotive that has recently been serviced requires attention to detail and situational awareness of other ongoing activities.

2.6.2 Locomotive Repair Shop Crew

Table 19. Locomotive Repair Shop Crew

General job description: Inspects, maintains, and repairs locomotive air brakes, diesel engines, air compressors, wheels, and trucks. **Elemental team**: 3-6; foreman, sheet metal worker(s)/boilermaker(s), machinist(s), boilermaker(s), electrician(s), laborer(s), pipe fitter(s), *and cab carpenter(s) (Metra).* **Communication within elemental team**: Verbal face-to-face and non-verbal (hand signals) communication. **Team interacts with**: Carmen, Hostlers, Shop Foreman; via verbal and/or radio communication. **Variability within rail industry and other information**: The number and combination of crew members depends on the size of the job (daily inspection versus major overhaul). **Appropriate CRM training methods**: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

General Duties
The general job duty of a locomotive repair shop crew is to inspect, maintain, and repair locomotive air brakes, diesel engines, air compressors, wheels, and trucks. A locomotive repair shop crew is comprised of between three to six individuals. A team always includes a foreman; however, the range of jobs a locomotive repair shop crew can vary from a daily inspection to a major overhaul. Depending of the size and content of the job, the locomotive repair shop crew can include two or more of the following: sheet metal workers, machinists, boilermakers, cab carpenters, electricians, laborers, and/or pipefitters.

The foreman supervises employees in the maintenance and repair of locomotives and equipment, troubleshooting of mechanical and electrical systems, and assists in the training of employees. The sheet metal worker/boilermaker cuts, bends, blocks, and forms material to repair damaged locomotives. He or she uses tools, such as shears, brakes, presses, and welders, to work with the material. A machinist works on the locomotive diesel engine carrying out tests and replacing parts and components. A machinist might use hand tools, hydraulic pressure gauges and pumps, pneumatic impact wrenches, and other power tools in this effort. The cab carpenter maintains the interior components in the cab including overhead panels and seats, using a variety of manual and power-operated hand tools. Electricians perform troubleshooting tasks to determine what locomotive systems require repair or replacement. They install replacement components and work with machinists to test the overall locomotive function. (Radiomen (electricians) install and maintain locomotive radios in compliance with regulation). Pipefitters maintain air piping and fuel lines in the locomotive system using hand wrenches, saws, cutting torches, pipe threaders, and benders. Laborers do any variety of manual tasks related to repairing the locomotive including working with other individuals on their tasks. While each of these crafts has specific assigned tasks, together they act as a team, responsible to the foreman, for completely performing the required repairs to the locomotive and returning it to service.

Communication within the Team

Locomotive repair shop crew personnel communicate with one another in a variety of ways. They communicate their presence to one another on the locomotive through the Federal blue flag requirement by attaching their personal blue flag to the blue flag post attached to the locomotive cab. Because locomotive repair shop crew members spend much of their on-duty time in close proximity to one another in or around the locomotive, verbal face-to-face communication is frequently used. Hand signals are also used to communicate between crewmembers when they can maintain visual contact, yet the work environment is not suitable for verbal communication (for example, when some distance exists between the members or background noise makes verbal communication dubious). When working on and around a locomotive, it can be very loud, making internal crew communication difficult.

Interactions with Other Teams

A locomotive repair shop crew interacts with various other teams and individuals throughout their regular work period, including carmen, hostlers, and shop foreman via verbal and/or radio communication. Clear and unambiguous communication between the locomotive repair shop crew, other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace.

The Elemental Team and CRM

Several characteristics of the locomotive repair shop crew's work environment are relevant to CRM principles and training. Although the members of this crew are carrying out different functions, they must coordinate their work with that of the other crewmembers and the foreman. The noisy and hazardous environment means that they must be constantly aware of their surroundings. Each member of the crew is expected to carry out his or her work in a technically proficient manner to prevent injury and error to others in this crew or the operating crew who will receive the locomotive once it leaves the shop. Engine function tests must be coordinated to make sure that other members of the crew are still inside performing maintenance.

2.6.3 Locomotive Service Crew

Table 20. Locomotive Service Crew

General job description: Fuels and services locomotive prior to departure of train.
Elemental team: 2-3; foreman, laborer(s).
Communication within elemental team: Verbal face-to-face, radio, and hand signal communication.
Team interacts with: Hostler, road crew via verbal face-to-face and radio communication.
Variability within rail industry and other information: May be carried out by senior mechanical forces qualified to perform locomotive inspections.
Appropriate CRM Training Methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

General Duties
The general job duty of a locomotive service crew is to fuel and service locomotives prior to departure of train. A locomotive service crew is comprised of at least two persons, a foreman and a laborer. More laborers will be in a crew depending on the size of the job. The foreman supervises the personnel carrying out the fueling and servicing of the locomotive. Laborers do a variety of tasks related to the fueling and servicing on the locomotive. These include refueling, refilling sand reservoirs, and inspecting the locomotive for damage and defects to body, mechanical, or electrical components. Laborers may also perform such duties as cleaning the locomotive cab and bathroom, as well as refilling train crew amenities (water bottles). The locomotive service area may have one or more senior mechanical crew members assigned to the area in order to perform locomotive inspections.

Communication within the Team
Locomotive service crew personnel communicate with one another in a variety of ways including verbal face-to-face, radio, and hand signal communication. Many times the locomotive service personal work alone and do not have a great deal of interaction among laborers. This is because usually each laborer has a specific job duty to perform, which requires little interaction or coordination in order to accomplish a specific task. Circumstances exist, however, where locomotive servicing crew members do work together to perform a specific task related to the servicing of the locomotive.

Interactions with Other Teams
A locomotive service crew interacts with various other teams and individuals throughout their regular work period, including carmen and hostlers, via verbal and/or radio communication. They interact with hostlers when the locomotive must be moved in or out of the servicing facility to other areas of the yard (for example, to the locomotive repair shop). Clear and unambiguous communication between the locomotive service crew, other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace.

The Elemental Team and CRM
Several characteristics of the locomotive service crew's work environment are relevant to CRM principles and training. Coordination of activities, communication, and technical proficiency are the primary areas for this team. Situational awareness can be an important factor in this job as well. For example, a crewmember could fall from the locomotive, or a fuel leak or other unsafe condition could occur.

2.6.4 Inbound-Outbound Train Inspection Team

Table 21. Inbound-Outbound Train Inspection Team

General job description: Repairing and inspecting railway cars, including identification of bad order cars.
Elemental team: 1-2; carmen.
Communication within elemental team: Verbal face-to-face, non-verbal (hand signals), and radio communication.
Interacts with: Train crews, yard crews and yardmaster via verbal face-to-face, non-verbal (hand signals), and radio communication.
Variability within rail industry and other information: Crews are commonly two carmen each inspecting one side of train; they may walk or use mechanized transport (e.g., ATV or motorized cart) to travel alongside train while inspecting; outbound inspectors may also be responsible for applying air to train's air brake system once inspected and assisting with brake checks.
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

General Duties
The general job duty of an inbound-outbound train inspection team is to repair and inspect railway cars, including identification of bad order cars. An inspection team can consist of one or more carmen. A carman's duty is to inspect railroad cars for structural defects and test mechanical equipment, such as brakes, air hoses, and couplings to ensure that they are in operating condition. They may also inspect cars for electrical circuitry problems. They observe cars from the ground as they roll by. They may also climb aboard cars to test equipment and to locate defects.

Although an inspection team can consist of only one carman, inbound-outbound inspection crews are commonly made up of two carmen, each inspecting one side of train. They may walk or use mechanized transport (e.g., ATV or motorized cart) to travel alongside the train while inspecting. Outbound inspectors may also be responsible for applying air to trains air brake system once it has been inspected and assisting with brake checks.

Communication within the Team
Inbound-outbound train inspection team personnel communicate with one another in a variety of ways, including verbal face-to-face, non-verbal (hand signals), and radio communication.

Carmen, when they are having a job briefing or when they must work together in a specific situation, generally use verbal communication. Hand signals are also used to communicate between crewmembers when they can maintain visual contact yet the work environment is not suitable for verbal communication (for example, when some distance exists between the members or background noise makes verbal communication unsure). When operating at a distance from one another and outside of visual contact, inbound-outbound train inspection team personnel commonly use handheld radios to communicate with one another. Carmen also use written communication to pass information on bad order cars to car repair shop crews and other yard personnel.

Interactions with Other Teams

An inbound-outbound train inspection team interacts with various other teams and individuals throughout their regular work period, including road crews, yard crews, and yardmasters. They communicate with these other crews and individuals via written, verbal face-to-face, non-verbal (signs and hand signals), and radio communication. Carmen communicate to other teams in writing by preparing reports on their findings, indicating number of car and type of repair required. They may also tag cars in need of immediate repairs. They use non-verbal communication for safety purposes (for example, placing flags in front and rear of train to warn other workers that inspection is being performed). Clear and unambiguous communication between the inbound-outbound train inspection team, other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace.

The Elemental Team and CRM

Several characteristics of the inbound-outbound train inspection team's work environment are relevant to CRM principles and training. Carmen in the inbound-outbound inspection crews are working in and around tracks and moving railcars while performing an inspection. They must be constantly aware of their environment and communicating with one another and other crews working in the yard. They must be technically proficient, or a defective car could leave the yard and cause an accident.

2.6.5 Car Repair Shop Crew

Table 22. Car Repair Shop Crew

General job description: Rebuilding, repairing, and inspecting rail cars.
Elemental Team: 2-6; carmen/sheetmetal worker(s), pipe fitter(s), *and electrician(s) (Metra)*
Communication within elemental team: Verbal communication.
Interacts with: Hostlers via verbal face-to-face and radio communication.
Variability within rail industry and other information: Carmen and electricians usually work together, while many times the pipe fitters and sheetmetal workers work independently (Metra). The supervision of car repair shop crews is variable. Most crews have an immediate supervisor directing their work; however, some railroads employ independent work teams (MRL).
Appropriate CRM training methods: Classroom instruction (lecture, visual aids, role-playing), CBT, simulator training.

Italics–Not relevant to all elemental teams.

General Duties
The general job duty of a car repair shop crew is to rebuild, repair, and inspect rail cars. A car repair shop crew is comprised of at least two persons, including a carman, pipefitter, sheetmetal worker, or electrician(s) (Metra). Car repair shop crews can be as large as six, taking on extra electricians, pipe fitters, or carman/sheetmetal workers depending on the characteristics and size of the job. The carmen/sheetmetal worker replaces or repairs Federal appliances on cars to prevent personnel injuries from occurring. He or she also cuts, bends, blocks, and forms material for train cars. He or she uses machines such as shears, brakes, and presses for work with the material. Electricians install electrical wiring, equipment, fixtures, and other related devices related to rail cars. Pipefitters install and repair the pipes in the car airbrake system using saws, cutting torches, pipe threaders and benders. Usually the carmen and electricians work together, while many times the pipe fitters and sheetmetal workers work independently (for example, at Metra).

Some variability in the supervision of a car repair shop crew elemental team does exist within the rail industry. Most car repair shop crews have an immediate supervisor directing their work; however, some railroads, for example MRL, employ independent work teams.

Communication within the Team
Because car repair shop crewmembers spend much of their on-duty time in close proximity to one another around a single rail car, verbal face-to-face communication is almost always used. Unlike locomotive repair shop crews, where the noise of the engine can make verbal face-to-face communication difficult, the noise level in a car repair shop is much lower except when mechanized tools are in use.

Interactions with Other Teams
A car repair shop crew interacts with various other teams and individuals throughout their regular work period. They communicate with yard personnel via face-to-face communication and hand signals when they are using a locomotive or a mule (car moving equipment) to move damaged or repaired cars in or out of the car repair shop. Clear and unambiguous communication between the car repair shop crew, other functional teams, and individuals outside the crew is crucial to the overall safety of the workplace.

The Elemental Team and CRM
Several characteristics of the car repair shop crew's work environment are relevant to CRM principles and training. Carmen working together must coordinate their efforts. Other crafts must determine that the car is stable before attempting to carry out work. The car is often placed upon jacks to change out wheel sets, resulting in dangerous situations that must be handled through situational awareness and technical proficiency.

2.7.1 Interactive Teams

As stated above, a large number of interactive teams are also formed throughout the rail industry when an individual interacts with an elemental team, or two or more elemental teams work together to perform a task. While elemental teams are effectively defined and constant, interactive teams are not. In interactive teaming, the team makeup can vary greatly, and the teams may only be formed for a short time period and then dispersed.

Often these teams can exist across organizational divisions within the railroad industry or at great geographic distances. Nonetheless, the individuals or elemental teams that come together to form the interactive team must communicate and cooperate in much the same way as the members of an elemental team must in order to safely complete a task. Table 23 shows examples of interactive teams. Although this table is not an exhaustive list, it gives models of how CRM principles—such as crewmember proficiency, situational awareness, communications and teamwork, and conflict resolution—can be applied at a higher level and not only at the easily-identifiable, elemental team or basic crew level.

It is important to realize that these crews have already received some training or on-the-job experience in how to work together. The addition of formalized CRM training has the potential to improve this capacity to cooperate by teaching specific skills and cues that indicate a lack of understanding or decreased ability to perform. Using CRM skills and recognizing these cues, team members can change the way in which they present information or give additional information that will aid in safely completing an assigned work task. Chapter 4 will discuss the training of interactive teams in CRM principles in more detail; however, one of the better ways to accomplish this is to conduct CRM training in groups that include a mix of personnel from elemental teams that interact on a regular basis rather than training only with members of the same elemental team. This combined training allows sharing of experience from one discipline to another, thereby increasing appreciation and understanding of the needs associated with each elemental team.

Table 23. Examples of Interactive Teams within the Rail Industry

Interactive Team	Team Function or Task/Relation to CRM Principles
Dispatcher Road Crew	The dispatcher and road crew must constantly communicate conditions, intentions, and other information to one another. They have a variety of communication methods (e.g., radio, signals). Determining what information to pass between elements within this interactive team requires knowledge of the needs and limitations of each position on the part of the other team member. Timeliness and completeness of information is also an issue.
Dispatcher Section Gang	The dispatcher and section gang must operate cooperatively in the use of track warrants so that necessary repairs, as well as continued rail operations, can take place. Coordination between the gang foreman and dispatcher on activating and vacating of track warrants is vital to ensure safety and not unnecessarily delay the progress of trains. The dispatcher must notify the gang of trains that must pass through the work area and their ETA.
Dispatcher Road Crew MOW Crews	The dispatcher, road crews, and MOW crews must often interact to maintain clear and unobstructed train passage. Information must pass between all the parties to prevent injury or accident.
Yardmaster Locomotive Repair Crew Car Repair Crew Hostler Crew Yard Crew Yard Clerk	This interactive team and subsets of its members must all coordinate movement of locomotives and cars within the yard to and from servicing or maintenance facilities. The hostler may move a locomotive out of the repair facility and put it in a location where it can be picked up by a yard crew, which then takes the locomotive to switch and gather bad order cars to move them to the repair-in-place tracks (RIP track) where the car repair crew repairs them. The yardmaster must organize and orchestrate such operations and keep everyone informed through a variety of written, telephonic, and electronic means.
Production Gang Dispatcher Road Crew(s)	A production gang must often work cooperatively with a dispatcher to allow windows of opportunity when he/she can clear the tracks during which trains can pass. The dispatcher must plan and line up the trains to take advantage of these pauses in the track work and sequence them properly to maximize traffic flow during that time. Road crews must be vigilant and responsive as they travel through areas where workers are present and speed restrictions may be in effect.

3.0 Current Rail CRM Programs

3.1 Site Visit Railroads

Task 3.0 of this project consisted of a survey of railroad companies to determine if CRM training is performed and the methods used. The survey pool consisted of the same railroads contacted during Task 2.0 and other Class I railroads. To accomplish this, the research team collected data on railroad safety training programs during the Task 2.0 site visits that took place between May 2002 and March 2003. The other Class I railroads were contacted by mail and followup phone calls to determine the status of any current CRM training programs or similar training efforts.

3.1.1 Railroads Visited during Task 2.0

BNSF
Date of visit: May 20-24, 2002
BNSF does not currently have a systemwide formal CRM training program for transportation or operating personnel. In March 2003, however, they initiated a CRM training program for operating crew employees in their southern California division. Additionally, BNSF has developed a CBT module for CRM that can be viewed by employees systemwide or assigned as remedial training. Other safety programs at BNSF also encompass various elements included in traditional CRM training programs, specifically the team building and situational awareness elements of CRM.

BNSF incorporates many of the traditional training methods for their labor forces, including video, lecture, simulation, and CBT. BNSF also has a formal training program for labor forces that is similar to military training courses in which general classroom instruction sessions are followed by intensive hands-on training conducted either on-the-job (i.e., OJT) or through the use of advanced simulation devices. As a part of the team building and situational awareness training, BNSF reinforces the students' learning with role-playing exercises where appropriate.

TTI's observations and review of BNSF's current training methods, including their indicated future emphasis on CBT training, indicates that BNSF can incorporate CRM training into their current training programs with little or no training method change. In response to the research team's request for information, members of the TTI team were invited to the BNSF training center at Johnson County Community College in Overland Park, KS, where the team reviewed their current CRM CBT curriculum and discussed the railroad's current efforts with CRM.

BNSF officials have shown a strong desire to improve their CRM training and expand it to include those teams outside the train operating crews. BNSF is working with the FRA Office of Safety and this research team to implement a limited pilot CRM training program at a terminal location in Fort Worth, TX. As noted above, BNSF has also recently begun a large CRM training effort in one of its regions.

CSXT
Date of visit: February 17-20, 2003
CSXT does not currently have a system-wide formal CRM training program for transportation or operating personnel. CSXT incorporates many of the traditional training methods for their labor forces, including video, classroom, simulation, and CBT. CSXT has self-paced training available for all employees with specific courses on teams and team leadership through their Employee Development Program. The self-paced learning material is presented in book, audiotape, and CBT formats. CSXT also uses formal training for scheduled employees that is similar to military training courses with instruction sessions followed by intensive hands-on training. TTI expects CSXT could readily incorporate CRM training into their current training programs with little or no training method change.

CSXT management has recently begun several new efforts to focus on safety at their railroad. Many of these programs are related to training in selected CRM principles and incorporate many of the characteristics of CRM without assigning the formal name of CRM. The most prominent program underway at CSXT of this type is the CSXT Safety Leadership Process training program that was observed and evaluated during the TTI team's site visit to the Jacksonville terminal area. One member of the research team attended a day-long *CSX Safety Leadership Process* class, spoke with the instructors, and reviewed the student handout materials.

CSXT management and the DuPont Corporation's safety division initially developed this training program. Since that time, CSXT has internalized the program and developed initial classroom instruction for all employees that emphasizes the communications and situational awareness skills often contained in CRM training programs. One member of management and one labor safety representative who have been trained specifically in this subject area facilitate the class. This training was to be completed by every employee in the Jacksonville Division by March 31, 2003. This existing training program could likely be expanded to include additional elements of CRM training.

Chicago Metra
Date of visit: January 21-24, 2003
Metra is a commuter railroad serving Chicago and its suburbs. Its trains run according to strictly scheduled operating plans to bring commuters to and from the downtown Chicago metropolitan area. The morning and evening rush hours allow little time for training and maintenance during those hours. The operational slow-down for several hours during mid-day is used for routine maintenance functions and is the time during which many training activities take place. Over a set period of days, all of the rolling stock on a particular commuter line will cycle through the line's maintenance facility during these mid-day hours.

Many of the lines that Metra operates were once operated by freight railroads and have since been taken over by the public agency. Subsequently, the majority of the operating employees are trained (qualified) railroad personnel that were retained and have continued to operate trains over the same line as when they were employees of the freight railroads. In fact, several of Metra's commuter routes use the track of a major freight railroad. On these routes, Metra owns the passenger equipment, but freight railroad employees trained as passenger train operating crews

operate it. As retirement and attrition have taken place, new hires have been trained and/or promoted through the traditional apprenticeship method.

CRM is not currently a part of the Metra training program. In spite of this, Metra does incorporate different elements of CRM in its roadway worker and operating rules safety training and testing program. Although no CRM training program presently exists, CRM could be incorporated into the existing training and testing program over an extended period of time.

MRL
Date of visit: October 26-30, 2002
MRL is a relatively new railroad company, yet the physical property and its employees generally represent an existing railroad labor contingent from the BN's former Northern Pacific Railroad, from which MRL was created in 1987. Most new engineers hired by MRL have been previously trained and qualified at other railroad companies. Furthermore, MRL is somewhat unique because it operates trains with crews of two qualified locomotive engineers rather than an engineer and a conductor.

MRL does not have an ongoing CRM training program for their train crews. MRL, however, did conduct a one-time CRM training program for their locomotive engineers in approximately 1998 or 1999 as part of its engineer re-certification training program. MRL management and safety officials support CRM and its concepts. Due to the railroad company's small size, low hiring frequency, limited formal training program, and their high crew workload at the present time, however, it would be quite difficult for MRL to effectively incorporate a formal CRM training program. Expanding CRM to incorporate other crews at such a small railroad would also be difficult due to limited staff and training facilities. It is likely that certain aspects of CRM training programs would need to be tailored specifically for regional and shortline railroads, taking into account their more limited training capacity in personnel time and training facilities.

Amtrak
Date of visit: March 24-26, 2003
Amtrak has a formal CRM training program for its locomotive engineers. The program is based upon the materials supplied and developed by AAR in conjunction with NS. The basic AAR CRM program resulted from a NTSB recommendation that all U.S. railroads should conduct CRM training for operating (transportation) personnel. Amtrak supplied specific video clips and logo materials for inclusion in the materials presented to engineers to enhance identification with actual Amtrak activity. The training program was first presented to a class of new hire student engineers in 2000.

The existing training video and materials, as supplied to Amtrak, are structured to be presented in a single training cycle. Amtrak's engineer training personnel, however, have modified the delivery schedule of the program and present it in four segments over a 4 to 6 week period to newly hired engineers. Amtrak's engineer training officers are convinced that CRM training needs to be periodic, allowing for reinforcement of the concepts, rather than a single session where the student may see the concept as a one-time introduction and fail to grasp the continuous applicability of CRM to his or her personal and working life. Annual engineer refresher training on CRM is a 1 to 2 hour session in which CRM is included along with other training topics.

Amtrak uses the traditional railroad training means of OJT (i.e., helper-apprentice qualification) and other training methods, including classroom lectures, video, overhead or electronic slide presentations, and CBT. The existing facilities and training capabilities of Amtrak make it possible that an expansion of CRM training to other crafts and teams could be developed over time.

3.1.2 Other Class I Railroads

NS
Norfolk Southern (NS) supplied the research team with a letter response in which they stated that they were currently using the AAR-CRM training program developed jointly by NS and AAR in 2000. In this letter they state:

> At NS, CRM is included in the training provided to employees in our Accelerated Conductor Training program and to new dispatchers. The concepts are reviewed annually in book of rules classes and are included in numerous training initiatives involving train, engine and dispatcher personnel. Our approach to CRM is that it is an on-going process that positively influences safety of operations in the railroad industry (C.J. Wehrmeister, personal communication, October 3, 2002).

Additionally, they state:

> The AAR-CRM training program provides the railroad industry with a comprehensive and high quality product that contributes to our efforts of achieving continuous improvement in safety of operations (C.J. Wehrmeister, personal communication, October 3, 2002).

CP
CP has a rather well advanced and implemented CRM program in comparison to most other North American railroads. In responding to the research team's request for information, CP outlined in detail the extent of their efforts with CRM on different divisions of their rail system. CP's implementation of CRM began with their Canadian territories in 2001 with a 4-hour training program, including elements of both CRM and the FRA's Switching Operations Fatalities Analysis (SOFA) principles. Within Canada, their program has advanced after several years, from classroom instruction to its present form in which "an Instructor/Coach will be riding with each running trades employee and will observe their performance. The coach will provide feedback on their performance and pay particular attention to the way the train and yard crews apply the CRM principles on the job" (Paul Wajda, personal e-mail communication, April 3, 2003).

Similarly, CP initiated CRM training in the United States during 2001 by conducting a 2-day CRM/SOFA training program for all running trades employees in its Chicago and Saint Paul service areas. A 4-hour training session on CRM was provided to the CP employees in its Northeastern Service Area (the former Delaware and Hudson). Both areas responded positively to the training. CP reports that employees primarily expressed interest in the SOFA and

situational awareness topics. In 2002, CP embedded elements of CRM into its annual recertification programs. Specifically, communication and situational awareness factors were incorporated into the trip simulation portion of the training. Additionally, CP states that all new-hire conductors in Canada and the United States receive the 2-day CRM program (Paul Wajda, personal e-mail communication, April 3, 2003).

KCS

KCS does not currently provide a CRM training program. It has shown great interest in CRM principles, however, and has taken several steps toward participating in a broad CRM training program. Members of the research team have met with KCS officials and briefed them on this project. In conducting these meetings, researchers found that KCS had reviewed the AAR CRM training program materials and had attended CP's CRM training to assess its applicability to KCS. It is their feeling that the existing CRM training programs would need to be modified to meet the needs of their railroad. FRA's Office of Safety has responded to KCS's strong interest and asked that TTI include KCS's input as part of its development of a pilot CRM training program that is ongoing with BNSF as an extension to the project described in this report.

UP

UP supplied the research team with a copy of the CRM program material that they present to their employees. The material is the standard AAR developed CRM training program. Based upon the material provided and subsequent inquiries to UP, it is the research team's understanding that this CRM course is used by UP to train all train and engine service employees. It is provided on a one-time basis with no formal ongoing refresher courses. UP instead provides for followup consultations and in-cab CRM technique implementation through at least semi-annual one-on-one sessions with supervisory train and engine personnel. UP indicates the one-on-one sessions between the employee and the supervisor provide a more effective means of reinforcing the formal CRM training than merely providing further classroom instruction sessions of CRM on a repetitive basis (i.e., every 2 years).

Under UP's Total Safety Culture approach to operations, field managers present structured or pre-prepared subjects to train service employees as part of the ongoing schedule of regular safety meetings. UP's Training Department has prepared several topical modules for field managers to present at the train service safety meetings that address cab communications, conflict resolution, and situational awareness. These pre-prepared topics are designed for focused application of the subject matter versus a broad-brush discussion of the theory.

CRM principles are generally applied throughout UP's scheduled crafts training materials. It is not UP's practice, however, to formalize the material presentation into a specific course of presentation directed to CRM. The principles are a general subset of the Total Safety Culture climate at UP and are most identifiable in the Mechanical Department training at this time according to UP. UP does emphasize that the cultural awareness and application of CRM principles are gradually being absorbed into the Engineering and Transportation Department's training programs as well. The focus is on topical presentation of each principle as it can be applied to the different department's functions and situations.

CN

CN employs the standard AAR CRM training program as the basis for a train and engineman CRM training program. TTI was supplied with a complete copy of the CN program, including the course leader guidebook, computer presentation, student worksheets, and video. The program is used in Canada and the United States on CN system roads, including the Illinois Central (IC) portion of the company. A substantial amount of leeway is allowed for presentation of this program to CN-IC crews. It is arranged in a manner allowing the program to be presented in either one continuous session or in several segments, as time allows at the location of instruction.

Currently, the CRM program is presented as part of the CN new hires program and in rules training, which occurs on a biennial or quadrennial basis. CN is presently reevaluating its CRM training program for possible improvements. Part of this process is centered on formalizing its presentation of CRM skills as a distinct training element. The current system allows supervisors to incorporate CRM concepts into regular, ongoing briefings, but employees often answer no when asked if they have received CRM training by NTSB during accident investigations. When employee training records are checked, it has been documented that they have actually undergone CRM training. When asked again, the employees are able to explain concepts of CRM and remember undergoing that training, but fail to identify it with CRM. CN is also open to using CRM in its other crafts (i.e., MOW, mechanical, etc.), but efforts to date have focused mainly on training road crews.

3.2 Conclusions

Based upon the findings observed or determined during the site visits made for this project, it is apparent that none of the U.S. Class I railroads currently have a comprehensive formal CRM training or awareness program that covers all employee crafts. Those railroads that have active formal CRM training programs, with the sole exception of NS, restrict CRM training to train and engine service employees. NS also includes dispatchers in their CRM training courses, including regular annual classroom refresher training.

Many CRM principles and skills are taught to the broad employee base throughout the rail industry but not through any formal training that is called CRM. 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 throughout many different training courses. The idea of teamwork within a CRM framework, however, is not necessarily taught. Situational awareness is another principle of CRM that may be taught industry-wide but not in the context of CRM and its other precepts.

The training systems and support network of educational materials and methods available throughout U.S. Class I railroads and their training departments is capable of implementing CRM more fully through improved and formalized training courses using existing methods. The same capacity to quickly implement CRM is not apparent in the shortline and regional railroad segment of the industry. Commuter railroads may also have difficulty in fully implementing CRM in the short term due to limited training opportunities related to their more dynamic operational schedule. In order for the railroad industry to expand its use of CRM training

beyond the operational crews, as the airline industry and others have, labor and management must recognize that important safety benefits that flow from CRM training can also bring economic benefits to the industry, as a whole. as a byproduct of lower accident rates. Federal support of CRM training is also essential if it is to be fully implemented through all crafts at the railroad.

4.0 Mapping Observed Railroad Teams to Appropriate Training Methods

4.1 Matching Training Methodology with Railroad Teams

Up to this point in this report, the different methods for delivery of a CRM training and the types of team members who would receive CRM training have been reviewed. In order to maximize the effectiveness of CRM, it is necessary to properly match the teams to a specific training method or group of methods. Making this decision should require a team of employees from the railroad who have a thorough understanding of both the jobs and teams involved, as well as experts in the field of learning and training (who are not necessarily employees of a railroad). Often a combination of training methodologies will provide the best coverage of CRM skill sets. For example, a CRM training program might begin with a 1-day lecture and group discussion on the basics of CRM followed by work and evaluation in a simulator. To guide in the decision of what training methods should be implemented in a training program, Haccoun and Saks (1998) recommend using what they call a training analysis grid (TAG). Modified below to fit CRM training specifically, the TAG would have a list of CRM competencies as row headings with training modalities/activities as different column headings as shown in Table 24. A trainer could then ensure that each of the components of CRM was getting coverage across the training activities.

Table 24. Example of CRM-Based Training Analysis Grid

Desired CRM Competencies	Lecture	Simulator	Group Discussion	Case Study	Interactive Video	Interactive Training
Communication	X	X	X			X
Assertiveness	X	X	X			
Crewmember Proficiency	X	X		X	X	X
Team Work	X	X	X			X
Situational Awareness	X	X	X	X	X	X
Crew Coordination	X	X			X	X
Active Practice and Feedback		X			X	X

It is also important to supplement less traditional training methodologies with those that have been commonly accepted and time-tested in the industry of choice. For example, the U.S. Minerals Management Service, which regulates the training practices of oil and gas drilling operations, allows for alternative training methods, such as computer-based learning and videos, but recommends that these methodologies be reinforced with demonstrations and hands-on training (Federal Register, 2000).

4.1.1 Effectiveness of CRM Training Methods for Different Types of Teams

One of the benefits of CRM training has been its applicability to training at the team rather than simply individual level (Seamster and Kaempf, 2001). CRM has been found to be effective for crews or other teams that, at least on certain occasions, must make decisions quickly (Koenig, 1997). Seamster and Kaempf (2001) suggest that resource management skills will be well suited to teams, which perform "complex, time-constrained, and critical tasks." Examples of such teams would include surgical teams, nuclear power plant teams, cockpit crews, and tank crews. CRM has also been used effectively in teams where assertive behavior can help a team to "pool [their] ideas, observations, and concerns to reach decisions that have far-reaching financial implications for their organizations" (Jentsch and Smith-Jentsch, 2001).

4.2 Elemental Teams

Table 25 includes the recommended training methods for elemental teams. The table lists possible training methods for each team based upon those identified and in use in other industries for similar teams. The listings of training methods are in order of desirability; however, not all railroad companies will have the resources to apply certain methods. For example, not all railroads will have a locomotive simulator available to practice CRM skills in such cases; the railroad should look for other methods in the list, such as OJT, as a method to teach and reinforce CRM. Likewise, CBT may not be available, but film or video might be. Training departments at railroads should have the flexibility to choose the best method for their situation. That being said, almost all existing CRM training programs begin with an instructor/facilitator-led classroom instruction period during which basic CRM principles are presented and practiced.

Table 25. Recommended Training Methods for Elemental Teams

Elemental Team	RECOMMENDED TRAINING METHODS		
	Cognitive/Knowledge	Behavioral	Recurrent
Freight Road Crew	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Locomotive Simulator • OJT	• Locomotive Simulator • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Passenger Road Crew	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Locomotive Simulator • OJT	• Locomotive Simulator • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Track Inspector	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • OJT	• OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Yard Crew (Remote Control)	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Hands-on Training Simulator • OJT	• Hands-on Training Simulator • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction

Elemental Team	RECOMMENDED TRAINING METHODS		
	Cognitive/Knowledge	**Behavioral**	**Recurrent**
Yard Crew (Conventional)	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Locomotive Simulator • OJT	• Locomotive Simulator • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Dispatch Crew	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Dispatch Training Simulator • OJT	• Dispatch Training Simulator • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • Computer-based training CBT • Film or Video Instruction
Intermodal Load and Unload Crew	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Intermodal Load and Unload Simulation • Classroom Instruction (Role-Play) • OJT	• Simulation • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Section Gang	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Hands-on Rail Simulation • OJT	• Hands-on Rail Simulation • OJT • Role-Play/ Scenarios • FICBT • Classroom Instruction • CBT • Film or Video Instruction

Elemental Team	RECOMMENDED TRAINING METHODS		
	Cognitive/Knowledge	**Behavioral**	**Recurrent**
Production Gang	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • OJT	• OJT • Classroom Instruction • FICBT • Role-Play/ Scenarios • CBT • Film or Video Instruction
Structures (BandB)	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • OJT	• OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Electrical Bonding Crew	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Electrical Bonding Simulation • OJT	• Electrical Bonding Simulation • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Catenary Maintenance Crew	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Catenary Simulation • OJT	• Catenary Simulation • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction

Elemental Team	RECOMMENDED TRAINING METHODS		
	Cognitive/Knowledge	**Behavioral**	**Recurrent**
Signal Gang	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • OJT	• OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Signal Maintainer	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Simulation • OJT	• Simulation • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Hostler Crew	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Locomotive Simulator • OJT	• Locomotive Simulator • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Locomotive Repair Shop Crew	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Hands-on Simulation • OJT	• Hands-on Simulation • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction

Elemental Team	RECOMMENDED TRAINING METHODS		
	Cognitive/Knowledge	**Behavioral**	**Recurrent**
Locomotive Service Crew	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Hands-on Simulation • OJT	• Hands-on Simulation • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Inbound-Outbound Train Inspection Team	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • Train Inspection Simulations • OJT	• Train Inspection Simulations • OJT • FICBT • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction
Car Repair Shop Crews	• Classroom Instruction • FICBT • CBT • Film or Video Instruction	• Classroom Instruction (Role-Play) • OJT	• Car repair simulation • OJT • FICBT Systems • Classroom Instruction • Role-Play/ Scenarios • CBT • Film or Video Instruction

4.3 Interactive Teams

While each of the above training methods is available for specialized training to the elemental teams, the preferred method of presenting CRM training is through the use of a combined training forum in which members of several closely related elemental teams are trained simultaneously. As mentioned in Chapter 2, this type of combined training allows sharing of experience from one discipline to another, thereby increasing the appreciation that CRM skills can be applied throughout all aspects of the rail industry and are not limited to only those internal to each elemental team.

4.4 Use of Combined Team Classroom Instruction

Of the training methods discovered during this project, perhaps the most promising is the use of classroom instruction to train a variety of employees, representing several elemental teams, that have been grouped according to similar job functions. This model has been used at Maersk Shipping and the U.S. Navy for their initial CRM training programs. As an example, this report has grouped the identified elemental teams into three groups—transportation, engineering, and mechanical—as shown in Chapter 2. Each of these areas could become a training group under which individual tracks of training materials could be developed. Films or videos and incidents/scenarios related directly to the daily activities of those in that particular training group could then be selected and tailored to their specific needs. Selecting such examples and balancing the content across all of the participants in each training group would ensure that the trainees remain engaged and attentive. This specialization of the training program allows for trainees to more readily accept the CRM concepts and put them into practice. Training in this manner allows for the different railroad crafts to interact and share insights or work procedural knowledge that could be useful in fostering better teamwork and improved safety. Once the initial awareness training phase is complete, practice and feedback could take place on an even more specialized, elemental team basis, as well using the methods described above.

4.5 Gaps in Training Methods

One task that was specifically assigned as part of this study was the identification of any gaps in available training methods for CRM in the railroad environment. Based upon the literature review and survey of railroad teams, a shortage of training methods does not appear to exist; a problem does exist with the general availability of certain training resources. This lack of available resources is due to several factors, including geographic proximity of some railroad crew locations to designated railroad training centers, the funding levels dedicated by Class I railroads for training compared to that which can be dedicated by smaller rail companies, and the costs associated with purchase and maintenance of advanced simulation/CBT devices (or rental/travel/lost work time costs necessary to gain access to such devices).

Current CRM programs in the rail environment such as that produced by AAR are a positive first-step towards training railroad personnel. The lack of emphasis on non-operating crafts in the examples and application of CRM in such programs, however, limits its effectiveness in moving CRM principles into other crafts. Just as the airline industry first applied CRM in the cockpit and later applied it to other areas, the railroad industry too needs to seek such a change in the focus of its CRM programs. Creative use of the available training methods such as those outlined in this report will ease this transition.

4.6 Conclusions

CRM training could be much more widely applied within the rail industry to address human factors error and prevent accidents before they take place. Many different training methods exist, which can be used to train the varied elemental and interactive teams identified in this report. While not all of the methods can be applied at every railroad or in every circumstance, ample methodological options exist for improvement in both cognitive and behavioral training in CRM available to every railroad company. At the present time, organization and dedication of

training resources to the issues of CRM need improvement. In order for this or any training program of this sort to fully succeed, the support of the railroad industry as a whole—labor and management—as well as that of the government must be directed at these issues. Without such support, CRM will not be able to meet its full potential.

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Acronyms

AAR	Association of American Railroads
ACRM	Anesthesia Crisis Resource Management
ACT	Naval Aircrew Coordination Training
Amtrak	National Rail Passenger Corporation
ASLRRA	American Short Line and Regional Railroad Association
BNSF	Burlington Northern Santa Fe
BRM	Bridge Resource Management
CBT	computer-based training
CN	Canadian National
CP	Canadian Pacific
CRM	crew resource management
CRTT	Centre for Rail Training and Technology
DVD	digital video discs
FAA	Federal Aviation Administration
FATS	Fire Arms Training Simulator
FICBT	fully integrated computer-based training
FRA	Federal Railroad Administration
GAO	U.S. General Accounting Office
IC	Illinois Central
ITS	intelligent transportation systems
KCS	Kansas City Southern
LOFT	Line-Oriented Flight Training
LOSA	Line Operations Safety Audit
MOW	maintenance-of-way
MRL	Montana Rail Link
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
NS	Norfolk Southern
NYPD	New York Police Department
OBS	on-board service
OJT	on-the-job-training
RC	remote control
RIP	repair-in-place
SA	situational awareness
SAIT	Southern Alberta Institute of Technology
SOFA	Switching Operations Fatalities Analysis
SP	Southern Pacific
STCW	Standards, Training, Certification and Watchkeeping for Seafarers
TAG	Training Analysis Grid
TTI	Texas Transportation Institute
UP	Union Pacific