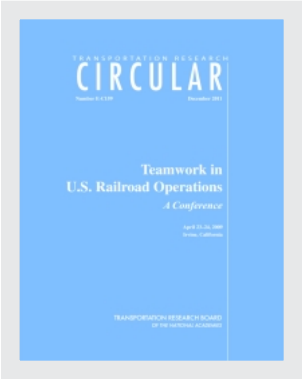

Teamwork in U.S. Railroad Operations: A Conference

DETAILS

0 pages | null | PAPERBACK
ISBN 978-0-309-43060-9 | DOI 10.17226/22833

AUTHORS

TRANSPORTATION RESEARCH
CIRCULAR

Number E-C159 December 2011

Teamwork in U.S. Railroad Operations

A Conference

April 23–24, 2009
Irvine, California

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TRANSPORTATION RESEARCH CIRCULAR E-C159

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Prepared for Railroad Operational Safety Committee by
Susan A. Ferguson, Ferguson International, LLC

December 2011

Transportation Research Board
500 Fifth Street, NW
Washington, DC 20001
www.TRB.org

TRANSPORTATION RESEARCH CIRCULAR E-C159
ISSN 0097-8515

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Glenda J. Beal, Production Editor; Jennifer Correro, Proofreader and Layout

Preface

This conference was part of the Railroad Operational Safety Committee's midyear meeting. Concerned with human performance and human factors research issues related to railroad operations, the committee draws upon the expertise of researchers and operating personnel to define, encourage, and disseminate results of research that will enhance the safety, performance, efficiency, and comfort of those involved in or using railroad and rail-related transportation systems.

ACKNOWLEDGMENTS

The success of this meeting is owed to the dedicated efforts and resources of a wide variety of people, all involved in the science of making railroad operations safer through a better understanding of the role of human factors. Key organizing functions of the meeting, and the people responsible for accomplishing them, are as follows:

- General coordination—Richard Pain, Stephen Popkin, Stephen Reinach, Heidi Howarth, Gina Melnik, Michelle Yeh, and Hadar Rosenhand
- Promoters—Gina Melnik, Jeffrey Moller, Richard Pain, Thomas Raslear, Stephen Reinach, and Thoams Streicher
- Subject matter expert—Fred Gamst
- Facilitators and liaisons—Judith Gertler, Curtis Morgan, and Joyce Ranney
- Notetakers—Lima Kopitch and Hadar Rosenhand
- Invited speakers—Elliot Entin, David Hofmann, and Eduardo Salas

Thanks also are extended to the panel members from the 88th Annual TRB Meeting on the topic "Understanding Teamwork in U.S. Railroad Operations." This panel was moderated by Edward Salas, and the panel members included Rick Inclima (Brotherhood of Maintenance of Way Employees Division), Thomas Pontolillo (Brotherhood of Locomotion Engineers and Trainmen), and Barry Wells (Norfolk Southern).

Thanks also go to committee members who offered comments after reviewing the papers and this circular.

The committee especially appreciates the support provided for this conference by the FRA and the Volpe National Transportation Systems Center. The committee also extends special thanks to Susan A. Ferguson, Ferguson International LLC, who prepared the overview and summary of the breakout sessions and compiled this report.

—Stephen J. Reinach, Chair; and Stephen M. Popkin, Vice-Chair
Railroad Operational Safety Committee

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Overview and Summary

SUSAN A. FERGUSON
Ferguson International, LLC

The Conference on Teamwork in U.S. Railroad Operations was held at the National Academies' Beckman Conference Center in Irvine, California, on April 23–24, 2009. The Conference was convened to explore the subject of how modern teaming strategies might assist in improving operational safety in the often dangerous environment of the U.S. railroad system. The goals were to better understand the challenges involved in improving teamwork, to look at various models that could help promote teamwork, and to examine new approaches that may be utilized. Three internationally recognized experts in the area of teamwork and industry and government stakeholders came together to discuss the issues surrounding teamwork and to discuss areas for improving safety in railroad operations. This Circular provides details of the information presented and the discussions among the participants.

The speakers presented the latest research and practices regarding team functioning and safety implications, and each presentation was followed by a question-and-answer session. The presentations addressed the general themes of teamwork effectiveness, teamwork communication, and leadership. Subsequent to these presentations, breakout discussions were held to further develop the themes as they might apply to railroad operations. Background papers were subsequently provided by the speakers to be included in this Circular. Summaries of the papers, along with the papers themselves, and the presentations are found in the body of this Circular. A detailed discussion of the breakout sessions is included later in the Circular. The Conference Agenda is available in Appendix A.

The views expressed in these summaries are those of individual speakers and discussants at the Conference and are not to be construed as consensus views or findings of the Conference participants.

INTRODUCTION

Teamwork is an essential requirement in the safe operation of railroads, not only for crews who are transporting passengers or freight, but also for crews performing equipment and line maintenance. Teamwork also is a necessity in the achievement of operational efficiency. Although there have been significant improvements in fostering teamwork within and between railroad crews, much remains to be done to match standards achieved in other industries.

BACKGROUND

The following section provides background information that was not included in the conference to aid readers understanding of the issues discussed. Crew resource management (CRM) techniques, initially developed by NASA and commercial airlines for cockpit crews, have brought about significant improvements in safety and operational efficiencies. Since then, CRM

training has evolved within commercial aviation to include not only pilots but the entire flight crew, air traffic controllers, and aircraft maintenance personnel.

A recent incident that demonstrated the benefit of CRM is the remarkable aircraft landing on the Hudson River in New York City in January 2009. In dramatic testimony before the NTSB in June 2009, US Airways Captain Chesley "Sully" Sullenberger described his actions and those of his copilot. After losing engine power after take-off because of flying through a flock of birds at 2,700 ft, the crew decided in a matter of seconds to ditch the plane in the river rather than try to return to the airport and risk a crash over the heavily populated city. Sullenberger specifically referenced the airline's emphasis on training pilots to work together as a team during moments of emergency as a key factor in the successful water landing of the aircraft.

Following the aviation industry example, groups including the military, commercial shipping, medical, nuclear power, and other industries have adopted the basic pillars of CRM to advance safety. In the railroad industry, significant steps are being taken among some railroad companies to adopt a "total safety culture," and good examples exist of management and labor working together to ensure the safety of railroad teams and those they transport (Ranney and Coplen, 2003). The railroad industry has a long way to go to mirror the progress seen in industries such as those cited above, as sectors of the railroad industry continue to operate with decades-old procedures and perspectives with respect to management and labor challenges.

In the Rail Safety Improvement Act of 2008, the U.S. Congress recognized that further improvements were necessary in railroad safety. Congress mandated that, in conjunction with existing voluntary and federally required efforts ongoing at the U.S. Department of Transportation and the FRA, a long-term strategy for improving railroad safety was needed. The strategy is intended to address the following goals:

1. Reduce the number and rates of accidents, incidents, injuries, and fatalities involving railroads including train collisions, derailments, and human factors.
2. Improve the consistency and effectiveness of enforcement and compliance programs.
3. Improve the identification of high-risk highway–rail grade crossings and strengthen enforcement and other methods to increase grade crossing safety.
4. Improve research efforts to enhance and promote railroad safety and performance.
5. Prevent railroad trespasser accidents, incidents, injuries, and fatalities.
6. Improve the safety of railroad bridges, tunnels, and related infrastructure to prevent accidents, incidents, injuries, and fatalities caused by catastrophic failures and other bridge and tunnel failures.

Additionally, Congress required that, beginning in 2009, the Secretary of Transportation provide an annual report to the Senate Committee on Commerce, Science, and Transportation and the House of Representatives Committee on Transportation and Infrastructure, on the FRA's progress towards achieving the goals of the railroad safety strategy. Clearly, improved teamwork to bring about a safe, efficient, and productive working environment and the eradication of unsafe practices are key components of achieving these strategic goals. However, achieving these goals represents a particular challenge because of the many different types of rail-related teams that have to work together to transport goods and personnel across widely spaced geographical terrain.

Morgan et al. (2006) studied a cross section of railroads within the United States and documented the common teams or crews that are present within the industry. They identified two

basic types of teams: elemental and interactive. In elemental teams, individuals in a fixed team work together as a unit in one geographical location, for example, a train and engine crew. Elemental crews can be sub-divided into teams responsible for transportation, including the movement of passengers and freight between destinations; engineering, including maintenance of tracks and signals; and mechanical, consisting of the upkeep of locomotives and cars.

The second type, interactive teams, is formed either when an individual interacts with an elemental team, or two or more teams work together (Morgan et al., 2006). Interactive teams typically are temporary teams brought together to accomplish a specific task, and may or may not be located in the same place. Examples of this are the train crew working with a dispatcher through whose area the train is passing, or a track maintenance crew who travels to various locations to make repairs. However, it is important that these temporary teams communicate and cooperate in much the same way as members of the elemental teams. That is, they need to develop interdependencies to ensure a coordinated approach to teamwork functioning, efficiency, and safety. Furthermore, better awareness and functioning within and between teams can help bring about improvements in operational effectiveness, magnifying the benefit to the railroad and the customer.

OVERVIEW OF PRESENTATIONS AND DISCUSSIONS

As noted above, three speakers presented the latest research and practices regarding team functioning and safety implications. The speakers made presentations that addressed the general themes of teamwork effectiveness, teamwork communications, and leadership. Following the conference speakers submitted background papers. A brief overview of each of the presentations/papers, reviewed by the respective authors, is provided below. The papers can be found following this overview and the presentations can be found in Appendix C.

Promoting Teamwork When Lives Depend on It: What Matters?

With increasing operational complexity and global competition, organizations more often are relying on teamwork to enable optimal performance in demanding environments. Teams are defined as a set of two or more individuals who interact and adapt to achieve shared and valued goals. Other features of a team include defined or specialized roles of their members, task relevant knowledge or expertise, shared common goals, interdependency, and the ability to adapt to changing conditions. A key goal for organizations is to build effective teams through training.

Because of the complexities that teams often have to deal with, team training is a necessary prerequisite to effective functioning. Several competencies are required. These include attitudes (what people feel), behaviors (what people do), and cognition or knowledge (what people think), otherwise known as the ABCs of teamwork. Within these areas many distinct components have been identified, some of which are more critical than others. Salas and his colleagues have identified five key components that include mutual performance monitoring, backup behavior, adaptability, team leadership, and team orientation. Team orientation addresses a person’s desire to work with others and is central to other components such as the desire to engage in mutual performance monitoring and backup behavior (when a team member recognizes that another member is in need of aid and offers assistance). Adaptability allows teams to cope with complex situations so they can quickly adapt to changing environments.

Finally, team leaders perform a variety of functions ranging from defining goals and creating a team climate as well as obtaining the necessary resources for the team to succeed.

How is a team of experts turned into an expert team? The answer to that question lies in what the most-effective teams do best. First, effective teams have a clear and common purpose as well as clear roles and responsibilities that allow them to understand how the team fits together. This knowledge enables the optimization of resources. They have strong leadership, which encompasses the ability to facilitate teamwork, cooperation, coordination, and set team and individual priorities. They also develop a strong sense of collective trust which is grounded not only in an understanding of their respective roles but also in the development of affective or emotional ties. This allows them to have faith in each other's intentions and limit conflict. Finally, they engage in a cycle of prebrief, performance, and debrief on a regular basis. During these sessions they can provide feedback on performance, identify lessons learned, and evaluate team effectiveness. Expert teams make fewer errors and thus have a higher probability of success.

There are several training interventions available to help develop expert teams. Team training involves the development of necessary competencies to enable the team members to coordinate and communicate effectively. Common team training strategies include individual task work training, which is focused on acquiring the necessary skills for the job; on-the-job training in which personnel can practice skills in the job setting; cross training in which the trainee learns about others roles within the team; team self-correction training that focuses on improving a team's debrief skills; team leader training; and goal-setting training. These training packages should not necessarily be seen as independent, but as part of a comprehensive training package. There is a wealth of research confirming the efficacy of these training techniques, suggesting that overall team training has positive effects on team outcomes such as cognitive, process, and performance outcomes. In addition, there is evidence that team training can improve productivity and financial performance.

Teams do not become expert without guidance. They must be trained according to the established scientific principles. But training alone is not enough. To facilitate its success, organizations must promote and reinforce teamwork behaviors. Long-term organizational commitment is crucial to demonstrating that teamwork training is not just a fad but is a central component of company policies and procedures. In other words, there needs to be a "culture of teamwork" embedded within the organization.

Enhancing Communication to Improve Team Performance with Applications to Train Crews

Work teams in diverse environments rely on effective communication to successfully do their jobs. Communication can be seen as the glue that allows them to coordinate their actions and act collectively to complete complex tasks. Analyses of the communication itself can provide a useful source of data for instructors, analysts, and researchers to gain a better understanding of how teams are functioning. Such analyses can provide insight into the health of the team and how well they function in the light of normal and evolving situations. Analyses of communications have been used successfully in many industries, such as the military, aviation, and medicine, to guide the development of training programs, inform the training process, and ultimately improve team functioning. Although teams within various industries may have different tasks, findings across the different domains provide a consistent picture because the

basic team processes are similar, allowing for lessons learned in one domain to be readily transferred to another.

Since communications are multifaceted, their measurement can be complex. This is especially true when communications are done manually and hand-coded. However, recent technological changes in communication media, e.g., e-mail, text, or Internet chat, as well as automatic voice recognition software, now allow automated methods of data collection and analysis. There are various levels of analysis. Coding at the semantic level of detail provides a more meaningful understanding of the nature of the communication but is both difficult and time-consuming. On the other hand, simple frequency counts do not provide a meaningful window into team processes. But recently developed methods allow the collection of an intermediate level of detail, gathering both semantic and quantitative aspects of the communications stream that can more readily be applied in the work setting (for further detail see the full paper by Entin et al. provided later in this E-Circular).

There are a few lessons learned from research into communication processes that can be adapted to the railroad industry. For example, it has been shown that highly functioning airline crews use periods of low workload, such as when the plane is flying on automatic pilot, to plan ahead so that if a difficult situation arose the explicit discussions become the basis for actions. In addition, the way in which communications are made also is important. The tone of the communication, whether from superiors or subordinates, can affect whether communications are heard and acted upon.

One key aspect of successful teams is the ability to adapt to changes in their environment without compromising performance. It has been shown that effective communications within a team are critical for facilitating the adaptive processes. Central to this process is a shared mental model of the task and its environment and the team member's tasks and abilities. The ability to recognize changes in one's environment and adopt adaptive strategies to deal with them can be successfully taught. One strategy is to train team members to anticipate other member's needs and push needed information before it is requested, moving communications from explicit to implicit. Another is to train team leaders to provide situational reports that will facilitate the maintenance of mental models, that is, keep everyone on the same page.

Even if training is provided to facilitate effective team performance, there still is a need to understand on an ongoing basis how communications are flowing. With current communication equipment this could be difficult, but with the introduction of modern technology—for example, digital e-mail, Internet chat, and automatic speech recognition software—automated data collection methods could be adopted.

Effective teams rely on effective communications and understanding those communications can aid in the safe and efficient operation of railroads. With advances in communication technologies, the task of collecting and analyzing such communications will become much easier. If internal and external communications were captured across a large number of railroad crews over an extended period of time a model could be developed that could predict and identify problems as they are emerging, enabling corrective actions to be taken.

Leadership's Role in Team Performance: Implications for Safety Culture

Effective leaders are the linchpin to ensure a team's success. According to Hofmann, "Leaders are those individuals who, after choosing a direction, are able to influence and motivate teams as well as put systems in place to achieve goals aligned to this direction." The central question is what kind of leader can achieve these aims.

There are three distinct categories of leaders: leader-based, relationship-based, and follower-based. All three of these approaches are usually necessary for effective leadership, but the relative emphasis placed on the three styles of leadership may vary. Leader-based leadership is based on charisma, energy, the vision and direction leaders cast for the team, and the way in which they reinforce this direction both through symbolic actions and aligned organizational systems. Such leaders communicate to the team that their work has meaning and that they are making a contribution to something more significant than the company's bottom line. Relationship-based leadership, as the title would suggest, is based on influencing team members through relationships, both economic relationships based on the work contract and socially based relationships where the leader views the team members as partners and assets in accomplishing team goals. Influence is based on trust, respect, and mutual obligation and reciprocation. Follower-based leadership establishes the long-term stability of the team by establishing a strong foundation in terms of skills and abilities as well as empowerment and ownership of the vision and goals of the team.

In order for safety to be a core value of the organization, leaders must value it. Leader-based leaders are especially influential in establishing safety as a priority within an organization, as they are the ones who establish long-term goals and priorities. These goals should be linked to underlying core values, such as safety, and systems and structures should be established to accomplish these goals. Relationship-based leaders are influential in engendering employee motivation and commitment to the established goals. There is need among employees to feel that they are a valued asset and that the leader cares about their well-being. Such positive relationships can make the difference in whether employees are inclined to view safety as discretionary or as part of their expected role. Thus, leader-based leaders set direction and relationship-based leaders create the motivation and commitment to follow through.

An unwavering commitment to safety should be evident at every level within the organization. Top-level management may set the priorities within the organization, but front-line managers have the day-to-day responsibility of implementing safety practices. Moreover, the communication of safety messages to those implementing those communications does not always have to flow down from the top but also can be effectively communicated by those who are directly impacted by their actions—for example, patients could deliver a message to doctors and their teams of the positive impact their work had on their own lives.

Effective communication of safety messages is important but employees still may not follow accepted protocol. In failing to follow protocol they may make errors, or they may commit intentional violations. Hofmann believes that violations rarely are made with the intent of harming the organization, but may result from a desire to achieve a positive outcome or goal. This may be more likely to occur during times of task overload or when under time constraints. There are ways to reduce both types of incidents. To reduce violations, organizations need to have in place a clear expectation that adhering to organizational policies and procedures is expected, rewarded, and supported. To reduce errors, the organization has to design the tasks and supporting systems in such a way that errors are prevented. On top of that, when such incidents

do occur, organizations need to respond appropriately. In the case of violations, there should be disciplinary policies in place that are followed through with. In the case of errors, there should be mechanisms in place to catch them, and procedures that can manage them to avoid negative outcomes at the time and in the future.

Effective leaders are a central component of well-functioning teams. They provide direction and motivation, and engender loyalty among team members to follow their established direction. Management and leaders at every level must demonstrate a commitment to safety both in their actions and reactions in order for safety to be considered a core value. Furthermore, steps should be taken to ensure that failures to follow protocol are addressed in a consistent manner, both in designing procedures to reduce potential errors and in having clear expectations that violations will not be tolerated.

SUMMARY OF BREAKOUT GROUP SESSIONS

Following the presentations, breakout groups were convened to discuss the implications of the presentations for improving railroad teamwork. Three breakout sessions were conducted to discuss each presentation: (*a*) how to improve team effectiveness, (*b*) enhancing communications, and (*c*) leadership's role in safety culture. Issues such as management and labor relations, voluntary reporting of operational errors, disciplinary actions, and building of trust between the stakeholders as they pertained to teamwork, were discussed at length. Below is an overview of the issues discussed without reference to the individual breakout sessions in which they were discussed. Some issues were discussed in more than one breakout session. A fuller discussion of the individual breakout sessions can be found later in the E-Circular (Detailed Summary of Breakout Group Sessions, page 52).

RANGE OF ISSUES

Conference participants raised a variety of issues in the discussions; points noted by individual participants include the following:

- Safety as a core value. For safety to become a central focus, not a temporary one in response to a particular incident, it was noted that safety needs to be a "core value." As other industries now are demonstrating, safety can contribute to the bottom line when the potential downsides of serious accidents are taken into account.
- A need for cultural change. It is often said that the railroad culture tends to be more conservative than other industries, with little change over many years. That being said, there are now a number of major railroads that are adopting safety strategies and are leading the way in this area.
- Top-down enforcement of safety. It was observed that effective leadership is critical at every level and safety needs to be seen as a priority enforced from the top of the management chain down through middle management structure and into the teams. While safety training is being adopted by more railroads, participants noted that more effective training practices need to become systemic in the industry.

- Discipline as an impediment to open communication. It was noted that voluntary reporting of operational errors, now increasingly adopted in other industries, needs to be more widely accepted by the railroads. Some participants observed that there continues to be a blame culture in the railroad industry that brings about unwillingness among crews to admit to errors. These errors, while not usually resulting in a catastrophe, can lead to complacency or the avoidance of necessary steps to engineer out the potential for errors. Furthermore, errors and violations may often be treated in the same way. A need was noted for an environment where crews can admit to errors without disciplinary procedures being taken. Company management and union officials would need to work more closely on this approach to establish a trusting environment.
- Management issues. There was a range of topics discussed within the category of management issues. Managers today have many more administrative responsibilities than in the past, leaving less time to get out into the field. Middle managers also may have gaps in their skills, capabilities, and experience. It was noted that the low ratio of supervisors to employees can be a problem, with employees lacking direct supervision. Management can be seen to be hands off with little vertical flow of information.
- Loss of party line. The move towards central control of communications, a provision of the Rail Safety Improvement Act of 2008, raises concerns that announcements will not be made over broadcast airwaves such that personnel may not be in a position to hear critical communications. It was noted that some means of communication between work crews need to be in place if individuals are to have adequate situational awareness. On the flip side, under the current system, there also is the potential for communications that are widely broadcast to be misunderstood, possibly leading to catastrophic results.
- Information overload and nonoptimal presentation. Concerns exist regarding the amount of information of which workers need to be aware, and the way in which it is organized, particularly with respect to rulebooks. There are multiple rulebooks in place as a result of the number of independent railroads that have operated over the decades. Some participants noted that this caused problems when trains move through different geographical areas, particularly when railroad companies have merged or have been acquired.

Following the discussion of problem areas, each breakout group discussed successful programs and practices that have been implemented within some railroads that are good candidates for adoption by the industry at large. Adoption of safety initiatives by local divisions may show improvements more quickly. It was noted that these improvements could then support wider implementation across the industry and could go a long way to improving the safety culture.

PROMISING PRACTICES AND LESSONS LEARNED

Examples cited by individual participants included the following:

- The adoption of a “total safety culture” such as that at Union Pacific (UP). Developed initially to counter drug and alcohol abuse in the industry, peer-to-peer programs such as this are seen by some railroads as key building blocks for a systemwide safety culture.

- Voluntary reporting via “hot lines” such as the Confidential Close Calls Reporting System (C3RS), in which near-miss accidents can be confidentially documented without penalizing the railroad workers who report them.
- Programs such as the Investigation of Safety-Related Occurrences Protocol (ISROP), a Canadian Pacific Railway (CPR) project, have led to increases in the amount of data collected and improvement in its quality, thereby resulting in a better understanding of the factors involved in unsafe practices.
- Watching for signs of team worker fatigue or careless behavior, and a “looking after my buddy” mentality.
- Improved leadership training and emphasis on teaming relationships between management and labor.
- Adoption of more formal pre and post-briefing of operations, much as is done in the aviation industry. In addition, regular conference calls on safety issues as they arise can help forestall risky situations and accidents.
- The stronger position being taken by workers on track safety issues, with the support of their first-line managers. There now is a growing acceptance that track workers deserve a safe working environment and that safe operational practices can lead to better overall railroad performance.
- Improved evaluation tools. Metrics that can assist in pointing out areas for improvement, as well as provide measurements of countermeasure effectiveness, could be helpful.

There is much to be gained from an improved safety culture in the railroads, as envisaged by industry leaders and Congress. The willingness of participants at this conference to discuss the issues, concerns, and lessons learned, is an important step in this process.

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Promoting Teamwork When Lives Depend on It
What Matters in the Railroad Industry?

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Organizations are increasingly structuring work around teams in order to deal with rising complexity and global competition. Rail teams are no exception. Railroad operations are an example of a complex sociotechnical system that is dependent on the work of multiple individuals separated by time and space. The system's performance is contingent on how coordinated the individuals on the teams are, how those individuals accept their goals (i.e., subset and overall goals), how they all use the unique type and amount of information that is available to them, and how they incorporate their perspective to accomplish the overall team goal.

The fact that every member of a team understands and accomplishes their individual task well does not mean that the team will perform successfully. Anecdotally, this can be best illustrated by the 2004 Olympics Men's U.S. basketball team. The team was comprised of professional basketball players who received many accolades during the regular National Basketball Association season. Moreover they were identified as all-stars, even by coach Larry Brown. He had stated prior to the Olympics that the team "wanted to go from an all-star team to a team." In other words, the coach wanted to take the team from a collection of good players of the sport to a cohesive and effective team. Nonetheless, the team was unable to win the gold medal at the Olympics and came close to losing to Lithuania in the bronze medal match.

In addition to athletic teams, rail teams have also exhibited subpar performance that has led to catastrophic outcomes. For example, in 1997 in Devine, Texas, UP Railroad freight trains 5981 North and 9186 had a head-on collision killing and injuring several people with damages exceeded $6 million. The National Transportation Safety Board (NTSB) investigated the accident and concluded that poor communication was the major contributing factor of this collision (NTSB, 1998). The dispatcher not only communicated inaccurate information, but the crew did not acknowledge and verify the accuracy of the message back to the dispatcher; thus, the breakdowns in communication between the dispatcher and the rail crews resulted in a head-on collision costing a significant amount of money as well as the lives of several individuals.

As illustrated in the previous two examples, a collection of experts does not create an expert team. Effective and high-performing teams must perform fluidly and do so with high reliability. In other words, they must repeatedly perform at high levels. When a team develops into an expert team the team is able to identify the task work requirements necessary for them to maintain high levels of performance. Moreover, they can also identify the necessary teamwork requirements.

In the past, one third of all railroad accidents were attributed to human factors; however, recently, in 2004, that statistic has increased to 40% (Sussman and Raslear, 2007). Some of the reported examples of causes of railway accidents are loss of alertness and cognitive speed, operator fatigue, improper signal detection, and communication error. However, the most-cited human factor cause of accidents is fatigue of the operators.

Research on the negative effects of fatigue has been prevalent. Fatigue is broadly defined as "any reduction in the capacity or motivation to perform, which may decrease efficiency, increase operational errors or accidents, or otherwise compromise the safety or health of workers or those who might depend on them" (Rosa, 2001, p. 513). One of the many sources of fatigue is work schedules (i.e., hours worked). There are concerns about how schedules that add on to the average demand of the 40-h/5-day week, whether by increasing hours, reducing opportunities for rest, and working at times of reduced capacity, impact a person's fatigue and then in turn impacts the ability of completing a job effectively. As reported by Sussman and Raslear (2007), an indicator of fatigue being a critical problem in the railroad industry is that more than 70% of railway employees get less than 6 h of sleep on workdays. That is considerably more than the average for U.S. adults (i.e., 39%).

Unexpected events and environmental stressors can significantly alter the workload a particular team experiences. Under conditions of operator fatigue, these events and stressors can result in catastrophic results. Each individual or team reacts differently to the levels and sources of workload presented during the completion of a task. Regardless of the sources of workload, proper training and preparation, the adoption of strategies appropriate for the situation, effective leadership, and effective teamwork can counteract some of the negative effects of workload (i.e., task demands, environmental stressors, and fatigue). Before we provide a brief overview of how rail crews function, it is important to understand the definition of a team as well as what is known as a multiteam systems.

TEAMS AND MULTITEAM SYSTEMS

For many years research has been conducted on teams (Levine and Moreland, 1990; West, 1996) some specifically examining the difference between groups and teams (Salas, Dickinson, Converse, and Tannenbaum, 1992). Several of the central points that Salas and colleagues highlight in their distinction between a team and a group is that task completion requires: (*a*) dynamic exchange of information, (*b*) coordination of such activities as active communication, situation monitoring, backup behaviors, etc., (*c*) adjustments to task demands, and (*d*) some structure to the members. In their examination of team training and teams, Salas and colleagues developed a definition of a team, which the literature has accepted. A team is a set of two or more individuals who interact and adapt to achieve shared and valued goals.

Other researchers have also examined other defining features of teams. Some of these include having sufficient levels of task interdependencies and task-relevant knowledge/expertise (Saavedra, Earley, and Van Dyne, 1993; Salas, Stagl, Burke, and Goodwin, 2007). Team members must have meaningful task interdependencies and task-relevant knowledge. In addition, team members must also tend to have defined/specialized roles, be arranged hierarchically, and have multiple sources of information (Salas and Cannon-Bowers, 2000). The underlying distinction between teams and groups is the issue of interdependency. We now look at the definition of multiteam systems, which is a specific type of team, and one that we believe best describes a rail team.

Since not all teams are the same, examination of different forms of teams is critical to better understand the functioning of all types of teams. Mathieu, Marks, and Zaccaro (2001) defined a form of a team, the multiteam system (MTS), as "two or more teams that interface directly and interdependently in response to environmental contingencies toward the

accomplishment of collective goals. MTS boundaries are defined by virtue of the fact that all teams within the system, while pursuing different proximal goals, share at least one common distal goal; and in so doing exhibit input, process, and outcome interdependence with at least one other team in the system" (p. 290). Teamwork is just as critical to the effectiveness of a MTS. Each component team must align their efforts with the other component team in the system (Ancona and Chong, 1999; Marks, DeChurch, Mathieu, Panzer, and Alonso, 2005) in order to accomplish their shared goal. To best illustrate how the science has informed the defining characteristics of a team, see Table 1 where general team characteristics that define a team as well as example citations that support the inclusion of the specific characteristic are listed.

The rail team is viewed as an example of a MTS, composed of various component crews. Passenger road crews, freight road crews, and dispatch are examples of the component teams in the MTS. The team members interact interdependently with one another, and the teams also interact with other component teams in the system, to achieve a common distal goal. The specific responsibilities of these component teams are such that the passenger road crews and freight road crews are responsible for safely operating trains between destinations while complying with federal and company regulations (Morgan et al., 2006) and dispatch plans safe train movements from one location to another. Although the road crews and dispatch share the common distal goal of safe train travel between locations, the road crews and dispatch also possess conflicting proximal goals. The road crew's (specifically the locomotive engineer) immediate concern is to complete the run as quickly and safely as possibly. Conversely, the dispatcher's central proximal goal is to maximize throughput (Sussman and Raslear, 2007). Even though the locomotive engineer and dispatcher have conflicting proximal goals, both crews remain interdependent to achieve the common, overarching outcome of safe train travel.

Teams and multiteam systems, including rail crews, often face several challenges that impede their effectiveness such as severe time pressure, high stakes, information overload, ambiguous cues, severe consequences of error, distributed multi-operator environment, and harsh physical conditions. However, teams must overcome these obstacles and still perform to accomplish their goals. Thus, we will now detail some of the essential team competencies to achieve successful team performance.

TABLE 1 List of Defining Characteristics of Teams

Team Characteristics	Citation(s)
Two or more individuals	Salas, Dickinson, Converse, and Tannenbaum (1992)
Adapt to changing conditions	Burke, Stagl, Salas, Pierce, and Kendall (2006); Salas, Dickinson, Converse, and Tannenbaum (1992)
Shared, common goal	Salas, Dickinson, Converse, and Tannenbaum (1992)
Interdependent	Saavedra, Earley, and Van Dyne (1993)
Task-relevant knowledge or expertise/specialized roles	Salas and Cannon-Bowers (2000); Salas, Stagl, Burke, and Goodwin (2007)
Hierarchically organized	Salas and Cannon-Bowers (2000)
Multiple information sources	Salas and Cannon-Bowers (2000)
Requires coordination	Salas, Rosen, Burke, and Goodwin (2008)

ESSENTIAL TEAM COMPETENCIES

Operating as a team requires several competencies in order to achieve effective team performance. These competencies can be grouped into three categories: attitudes, behaviors, and cognition (i.e., knowledge), otherwise known as the ABCs of teamwork. Attitude competencies refer to what team members feel (Salas and Cannon-Bowers, 2000) and can more formally be defined as "an internal state that influences an individual's choice to act in a certain way under particular circumstances" (Cannon-Bowers, Tannenbaum, Salas, and Volpe, 1995, p. 352). Examples of attitude competencies include collective efficacy (i.e., the beliefs about the expected performance of the team for a particular task), team cohesion (i.e., team members maintaining united in pursuit of its goals and objectives despite difficulties and set-backs), mutual trust (i.e., expectancy of positive outcomes based on the expected actions of another party in an interaction based on uncertainty), and team orientation (i.e., the preference that individuals have to work in teams rather than alone).

Behavioral competencies refer to what team members do (Salas and Cannon-Bowers, 2000). Examples of behavioral competencies include mutual performance monitoring, backup behavior, team leadership, closed-loop communication, and conflict management. Since teams work interdependently it is common to have a scenario where several team members are engaging in different actions simultaneously in order to work towards the same goal, especially in rail crews where often these teams are distributed. Mutual performance monitoring refers to the fact that team members are aware of each other's work without it interrupting their own work (McIntyre and Salas, 1995). A potential result of mutual performance monitoring is that of back-up behaviors. Backup behaviors represent the ability of a team to reallocate resources and provide assistance to any individual member or team (Marks, Mathieu, and Zaccaro, 2001; Porter, Hollenbeck, Ilgen, Ellis, West, and Henry, 2003).

The team leader has a great impact on team performance (Stewart and Manz, 1995). A team leader who does not guide a team towards the accomplishment of the team's goal has not only failed his job, but also may be the reason for the team's ineffective performance. A team leader has the capability of facilitating the coordinating behaviors that a team needs, as well as providing direction for the collective action of the team (Gardner and Schermerhorn, 1992; Jacobs and Jaques, 1990; Zaccaro, Heinen, and Shuffler, 2009).

Closed-loop communication refers to the exchange of information between a sender and a receiver regardless of the medium (McIntyre and Salas, 1995). Examples of specific behaviors of closed-loop communication are that team members follow up to ensure the message was received and clarify with the sender of the message that the message received is the same as the intended message. Because conflict is central to organizational groups, conflict management is critical to the effectiveness of teams. Conflict management is the ability to deal with issues in work teams in order to manage the team's conflicts productively (Alper, Tjosvold, and Law, 2000).

Cognitive competencies address what team members think (Salas and Cannon-Bowers, 2000). Common cognitive competencies include the individual task proficiencies that each member brings to the team, team members' knowledge of their roles and team objectives, shared mental models (i.e., the degree of overlap between team members' knowledge), and transactive memory systems (i.e., knowing who knows what). Adapted from Salas and Cannon-Bowers (2000), Figure 1 is a visual representation of the components of team performance.

In an attempt to identify the most critical components of teamwork, Salas, Sims, and Burke (2005) proposed the Big 5 of teamwork. The goal of the Big 5 was to identity the five

most-important features of high-performing teams. The Big 5 consist of mutual performance monitoring, backup behavior, adaptability, team leadership, and team orientation. Mutual performance monitoring, backup behavior, adaptability, and team leadership reflect behavioral competencies, whereas team orientation reflects an attitudinal competency. Each of the components of the Big 5 will be defined in greater detail in the subsequent section.

Team orientation refers to a person's tendency to prefer working with others (Salas, Guthrie, Wilson-Donnelly, Priest, and Burke, 2005). A person high on team orientation tends to take into account other people's feelings and input. Team orientation has been found to be an important predictor of a person's desire to engage in mutual performance monitoring and back-up behavior.

Mutual performance monitoring refers to the ability to "keep track of fellow team members' work while carrying out their own…to ensure that everything is running as expected and…to ensure that they are following procedures correctly" (McIntyre and Salas, 1995, p. 23). Mutual performance monitoring is necessary in teams in order to prevent teams from making errors and enable teams to engage in backup behaviors.

Backup behavior occurs when a team member recognizes that another team member is in need of aid and offers assistance. Backup behavior requires team members to know enough about other team members' responsibilities to anticipate their needs. Marks, Mathieu, and Zaccaro (2001) identified three types of backup behavior: (1) providing feedback to improve performance, (2) assisting a teammate in performing a task, and (3) completing a task for a team member who is overloaded.

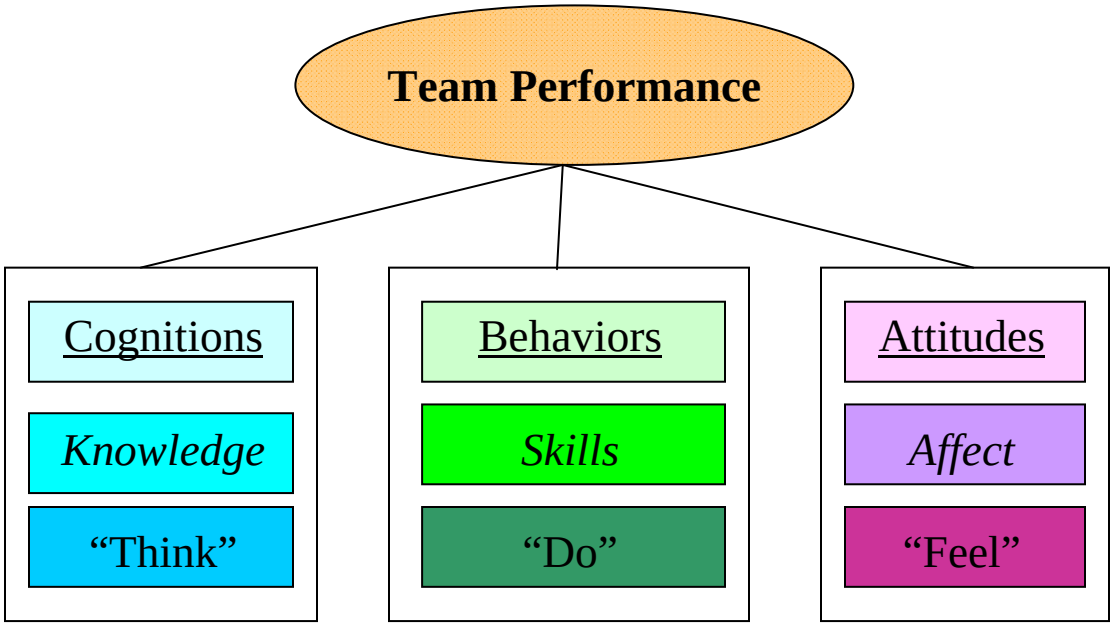

FIGURE 1 Components of team performance.
(Adapted from Salas and Cannon-Bowers, 2000.)

Adaptability has been defined as the ability to recognize that changes from a course of action are necessary and to readjust actions accordingly (Salas et al., 2005). Given that most teams are created to deal with complex situations, the ability of teams to adapt to changing situations is essential. Mutual performance monitoring and backup behavior has been identified as necessary components to adaptability (Salas et al., 2005). Additionally, team leadership has been proposed as a key driver of team adaptability (Kozlowski, Watola, Jensen, Kim, and Botero, 2008). Leaders perform a variety of functions in teams, ranging from defining goals and creating a team climate to obtaining necessary resources. Essentially the job of the leader is to address whatever issues or duties are not being handled by the team (McGrath, 1962). Figure 2 depicts a visual representation of the Big 5 of teamwork and Table 2 provides the definition of each of the five competencies.

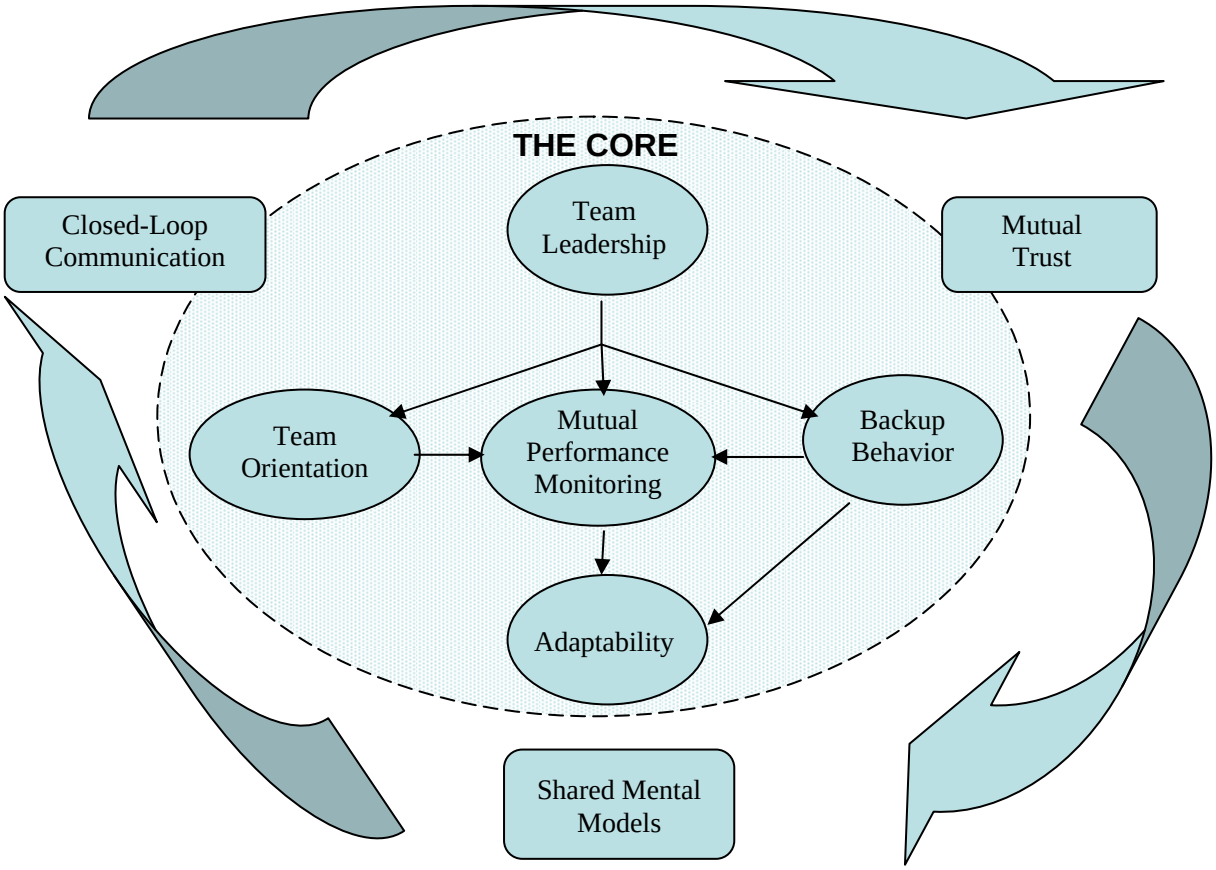

FIGURE 2 A visual representation of the relationships among the Big 5 team competencies. (Adapted from Salas, Sims, and Burke, 2005.)

TABLE 2 The Big 5 Competencies

Teamwork Competency	Definition	Citation
Mutual performance monitoring	The ability to "keep track of fellow team members' work while carrying out their own…to ensure that everything is running as expected and…to ensure that they are following procedures correctly."	McIntyre and Salas (1995, p. 23)
Backup behavior	The ability "to anticipate other team members' needs through accurate knowledge about their responsibilities. This includes the ability to shift workload among members to achieve balance during high periods of workload or pressure."	Salas, Sims, and Burke (2005, p. 560)
Adaptability	The ability to recognize that changes from a course of action are necessary and readjust actions accordingly.	Salas, Sims, and Burke (2005)
Team leadership	The ability "to direct and coordinate the activities of other team members, assess team performance, assign tasks, develop team knowledge, skills, and abilities, motivate team members, plan and organize, and establish a positive atmosphere."	Salas, Sims, and Burke (2005, p. 560)
Team orientation	A person's tendency to prefer working with others.	Salas, Guthrie, Wilson, Priest, and Burke (2005)

EXPERT TEAMS VERSUS NONEXPERT TEAMS

Before delving into a discussion of what expert teams do, we present an illustration of how a nonexpert team performs. In 1998, Norfolk Southern train 255L5, en route to Fort Wayne, Indiana, struck Conrail train TV 220, which was en route to Columbus, Ohio. Both of the locomotives derailed, five cars from the Norfolk Southern train derailed, and three cars from the Conrail train derailed. In addition, the Norfolk conductor was killed, and several other crew members sustained injuries. Investigative reports revealed that the probable cause of the accident was due to the "failure of the engineer and conductor of train 255L5 to comply with operating rules…and the failure of Norfolk Southern Corporation to ensure employees' compliance with operating rules" (NTSB, 1999, p. 2).

In addition, inadequate training, feedback, communication, and the crews' coordination breakdowns were other noteworthy factors contributing to the cause of this accident. Statements have indicated that all communication ceased immediately preceding the accident. In fact, a student engineer operated the train independently, receiving no guidance through supervisor role modeling or feedback prior to the collision. This incident is an exemplary prototype of a non-expert team because not only were they not trained adequately with effective feedback prior to the day of the accident, but also communication and coordination completely broke down between all team members directly before the incident.

Salas and colleagues (Salas, Rosen, Burke, and Goodwin, 2008; Salas, Rosen, Burke, Goodwin, and Fiore, 2006) have identified several factors that can distinguish expert teams from

nonexpert teams. First, expert teams have a clear and common purpose. Stemming from having clear expectations, team members have clear expectations regarding how each team member's role fits with the objectives of the team. Often a team's shared vision is shaped by strong leadership. It should be noted that leadership entails more than just technical skills. For example, skilled leaders facilitate teamwork, cooperation, and coordination, as well as set team and individual priorities. With a shared understanding of the team's purpose and individual members' roles, expert teams develop accurate shared mental models. An accurate shared mental model refers to degree of overlap and the accuracy between team member's knowledge structures regarding the team's task and members roles in accomplishing that task (Salas et al., 2005). Through having a shared mental model, expert team members can anticipate each other's actions and back each other up when needed, as well as coordinate without explicit and lengthy communication.

In addition to having a shared purpose and understanding of each member's role, expert teams develop affective or emotional ties with one another. Expert teams develop high levels of trust and have faith in each other's intentions. Trust enables expert teams to interpret mutual performance monitoring positively instead of viewing it as monitoring only those who do not do their job well (Salas et al., 2005). Expert teams also manage conflict well and capitalize on task-related conflict and disagreement to ensure optimal decisions. Additionally, expert teams are able to experience task conflict and prevent it from forming into relationship conflict in which members engage in interpersonal attacks. Expert teams also believe in the importance of the team and believe that the team can succeed. One advantage of expert teams forming affective ties is that they are better able to tolerate stress. In other words they are workload sponges, being able to adapt to the required workload.

The behaviors of expert teams can also be distinguished from nonexpert teams. For example, expert teams engage in a regular cycle of prebrief, performance, and debrief (Salas et al., 2006, 2008). Through engaging in this cycle of performance expert teams are able to establish, as well as revise goals and plans, and identify high and low priorities. Regular debriefings allow teams to receive and provide feedback, identify lessons learned, and evaluate whether the team is or is not effective both in performing the task and identifying the needs of team members. Routinely engaging in a prebrief–performance–debrief cycle enables team members to self correct and compensate for one another. The main advantage of developing expert teams is that they have higher levels of performance. For example, expert teams make better decisions and fewer errors, which in turn enable expert teams to have a higher probability of mission success.

Effective teams have great team leaders who focus on task-related behaviors as well as developing team members. Strong team leaders have good leadership skills and not only-just-competent technical skills. They provide situation updates and help the team to self-correct. Moreover, effective team leaders foster teamwork, coordination, cooperation, and lead team members who believe that they care about the team. Table 3 summarizes what is known about what expert teams do best, based on Salas, Rosen, Burke, Goodwin, and Fiore (2006).

TEAM TRAINING

Several team training interventions are available to help develop expert teams. Team training has been found to be an effective way to enable teams to perform well in demanding and complex

TABLE 3 Expert Team Performance Effective Processes and Outcomes (Adapted from Salas et al., 2006)

Expert teams	
Hold shared mental models.	They have members who anticipate each other. They can communicate without the need to communicate overtly.
Optimize resources by learning and adapting.	They compensate for each other. They reallocate functions.
Have clear roles and responsibilities.	They have members who understand each others' roles and how they fit together. They ensure team member roles are clear but not overly rigid.
Have a clear, valued, and shared vision.	They have a clear and common purpose.
Engage in a cycle or discipline of prebrief → performance → debrief.	They regularly provide feedback to each other, both individually and as a team. They establish and revise ream goals and plans. They have mechanisms for anticipating and reviewing issues and problems of members.
Have strong team leadership.	They are led by someone with good leadership skills and not just technical competence. They have team members who believe the leaders care about them. They provide situation updates.
Develop a strong sense of "collective," trust, team spirit, and confidence.	They manage conflict well; team members confront each other effectively. They strongly believe in the team's collective ability to succeed.
They develop collective efficacy.	Manage and optimize performance outcomes They make better decisions. They have a greater chance of mission success.
Cooperate and coordinate.	They ensure that, through staffing or development, the team possesses the right mix of competencies. They consciously integrate new team members. They distribute and assign work thoughtfully.

conditions. Team training can be defined as a set of tools and methods that in combination with required competencies and training objectives form an instructional strategy (Cannon-Bowers and Salas, 1998; Salas and Cannon-Bowers, 1997; Tannenbaum, Salas, and Cannon-Bowers, 1996). Common team training strategies include individual task work training, on-the-job training, cross training, team self-correction, team leader training, and goal setting training. The objective of team training is to develop the competencies that will enable team members to coordinate and communicate effectively (Salas and Priest, 2005).

Currently, there are several examples of types of team training being implemented in the U.S. and Canada railroad systems. For example, CSX Transportation, a corporation owning Class I Railroads, has mandated Safety Leadership Process Training, an instructional class that is designed to enhance the behavioral skills of rail supervisors and labor safety coordinators. Specifically, the leadership course focuses on developing effective communication and

assertiveness skills in rail leaders (Brown, 2007; Smith, 2003). Another example of team training being implemented in rail teams is CRM training. The Centre for Rail Training and Technology at the Southern Alberta Institute of Technology in Calgary, Canada, has instituted a classroom-based CRM course specifically designed for the rail industry (Morgan, Olson, Kyte, Roop, and Carlisle, 2006). The training begins by defining and describing the fundamental skills (i.e., situational awareness, communication, and teamwork) for rail teams as well as introducing issues pertaining to human factors (e.g., information processing and human error). Furthermore, the training provides demonstrations and simulated scenarios which exhibit the essential CRM principles. Now that a few examples of existing team training have been discussed, the following section will elaborate on several general types of team training interventions as well as tips for insuring their successful implementation.

The most basic level of training is individual task work training. Individual task work training is focused on training team members on the skills needed to perform their individual jobs. The basic premise behind individual task work training is to ensure that team members know their job and how their job is related to other team members' jobs. If team members' have sufficient knowledge and skills related to their individual jobs, it may be beneficial to skip task work training and focus on more team-based training interventions, that is, those interventions that address the Big 5 competencies of teamwork.

A common team training intervention is on-the-job training. With on-the-job training, team members practice team skills in actual job settings. When utilizing on-the- job training, it is important for trainers to highlight task interdependencies, identity coordination demands, and provide detailed feedback. On-the-job training is typically combined with other training techniques discussed below.

Cross training is another common training intervention. Cross training typically involves training individuals on the tasks that all other team members perform. Common cross training interventions involve team members shadowing other team members as they perform their job or receiving information regarding the role and duties of other team members. The objective of cross training is to improve team members' understanding and knowledge structures regarding each team members' role within the team (Sims, Salas, and Burke, 2005). Cross training has been found to improve coordination, decrease process loss, facilitate the development of shared mental models, and improve team performance (Salas, Cannon-Bowers, and Johnston, 1997; Volpe, Cannon-Bowers, Salas, and Spector, 1996).

Team self-correction training focuses on improving a team's debrief cycle. Self-correction training teaches members to review events, correct errors, discuss strategies, and plan for future events. Through self-correction training, teams learn how to identify and correct mistakes without external intervention. The rationale behind self-correction training is that teams who are able to self-correct are able to minimize the cost and damage done by errors that go undetected.

Team leadership training is focused on improving the leadership skills of team leaders. Specifically team leaders are trained on how to specify expectations, clarify roles, and provide updates to team members. Team members are also taught how to provide effective feedback to team members such as providing behavior-oriented feedback instead of person-oriented feedback, as well as expressing satisfaction when improvements occur.

Lastly, goal setting and performance management training can be considered a supplement to team leadership training. Trainees learn how to set effective goals for both individuals and teams. Specifically, trainees learn how to create hard, challenging, and attainable

goals. Trainees also learn about the importance of setting individual or team goals and how individual and team goals may conflict with one another. Additionally, trainees learn the importance of providing behavior-oriented feedback in maintaining goal-directed behavior. Lastly, trainees learn to identify when certain goals such as performance or learning goals are appropriate for accomplishing certain objectives.

In reviewing the various team training strategies that are available, it should be noted that these training interventions do not exist in a vacuum from one another. Each of the training strategies can be integrated into a comprehensive training intervention. For example, team leaders can receive a combination of leadership and goal setting training. Team members can be given individual task work training, on-the-job training, cross training, and self-correction training. By utilizing these and other team training strategies that are available, organizations are more likely to facilitate the development of expert teams.

WHAT IS THE EVIDENCE?

To determine which of these training techniques is successful, researchers have conducted studies examining the relationship between training and performance. For example, in 1998 Cannon-Bowers and Salas found evidence that training resulted in enhanced outcomes. Specifically, their study suggested that training improved mission performance by 45%, communication efficiency by 25%, tactical decision making by 33%, as well as a 10% to 34% improvement in team coordination. To further investigate training on team performance, Salas et al. (1999) conducted a study within the aviation environment. Their results indicated that training resulted in 6% to 20% improvement in teamwork behaviors (e.g., communication, leadership, and adaptability).

To provide a comprehensive picture to thoroughly understand the impact of team training on team performance, Salas, Diazgranados, Klein, Burke, Stagl, Goodwin, and associates (2008) conducted a meta-analysis on all types of team training. The results of their meta-analytic investigation indicated that overall team training had a moderate, positive effect on team functioning ($\rho = .34$) with team training accounting for approximately 20% of the team performance variance. Additionally, Salas et al. investigated the effects of training content (i.e., did training focus on task work, teamwork, or the combination), team membership stability (i.e., were teams intact or ad hoc), and team size (i.e., were teams small, medium, or large) on cognitive, affective, process, and performance outcomes. The meta-analytic results suggested that team training has the strongest impact on cognitive outcomes ($\rho = .42$) followed by process outcomes ($\rho = .44$) then performance outcomes ($\rho = .39$) with affective outcomes having the weakest relationship ($\rho = .35$). For more information on the detailed results for each of the outcomes see Table 4.

In addition to the benefits of team training on team performance outcomes, there is also support that team training impacts other key organizational factors. For instance, there is evidence that team training can improve productivity (Cohen and Ledford, 1994). Similarly, Pasmore et. al (1982) reported that 89% of studies using self-managing teams asserted an increase in productivity. Furthermore, team training has also been shown to improve quality (Applebaum and Batt, 1994), safety (Goodman et al., 1988; Trist et al., 1977), job satisfaction (Cordery, Mueller, and Smith, 1991), and organizational commitment (Kirkman and Rosen, 1999). In addition, team

TABLE 4 Detailed Results of Team Training Meta-Analysis (Adapted from Salas et al., 2008)

Outcome Type	N	K	r	CI, 10%	CI, 90%	ρ	SD ρ	10% CV	90% CV	% Var. Accounted for by Artifact
Cognitive	554	12	.38	.30	.46	.42	.19	.18	.67	34.87
Affective	465	16	.32	.26	.37	.35	.00	.35	.35	100.00
Process	607	25	.39	.34	.44	.44	.00	.44	.44	100.00
Performance	1024	40	.33	.29	.37	.39	.09	.27	.50	86.63
All Outcomes	1563	52	.34	.31	.37	.34	.00	.34	.34	100.00

training also significantly impacts financial performance. For example, DeVaro (2006) found an 8.7% increase in the probability of having financial performance considerably better than the industry average. The good news is that team training does work and the railroad industry can take advantage of these interventions to improve team functioning of rail crews.

WHAT THE RAILROAD INDUSTRY MUST DO TO ENSURE SUCCESS

Although there is evidence to suggest that team training can enhance team performance, it has to be developed and executed appropriately. Thus, there are a variety of components to consider ensuring that team training is successful. First and foremost, designers should develop training based upon the science of team performance and training (see Salas and Cannon-Bowers, 2001). Effective training that is grounded in scientific principles creates a learning environment that will motivate and immerse the trainee in acquiring knowledge, skills, and abilities (KSAs). Therefore, when developing training, it is essential to consider individual factors (e.g., cognitive ability, self efficacy, and motivation). As an example, it is important to consider a trainee's motivation level because it can influence the ability to acquire, retain, and apply trained skills. In other words, unmotivated trainees may experience learning deficits; thus, training is most effective when it fosters a learning climate that is designed enhance the motivation of trainees (Quinones, 1995; 1997).

In addition to individual factors, successful team training also considers the contextual and environmental factors to prepare the organization accordingly. Goldstein and Ford (2002) proposed that some aspects of the organization to consider include "an examination of organizational goals, resources of the organization, transfer climate for training, and internal and external constraints present in the environment" (p. 41). If done appropriately, the efforts made before implementing training will positively impact learning and performance. Thus, trainees should be prepared prior to training by receiving preparatory information about the training (e.g., brochures and pamphlets) or advanced organizers to manage the information (Cannon-Bowers, Burns, Salas, and Pruitt, 1998). The advantages of establishing appropriate the prepractice conditions is that not only will it benefit trainees by optimizing learning, but it is also a cost effective way to facilitate the success of the training system.

All effective team training is designed to include a set of teamwork related competencies. To determine what teamwork competencies are necessary, organizations should conduct a task analysis (Goldstein and Ford, 2002). A task analysis uncovers all of the required KSAs necessary for performance by analyzing all of the components inherent in the task. Thus, a task analysis

establishes the foundation for designing team training since it provides both trainers and trainees with the learning outcomes and training objectives.

Organizations must promote and reinforce teamwork behaviors to facilitate the success of team training. When supervisors provide positive reinforcement, it encourages trainees to use their trained skills on the job (Rouiller and Goldstein, 1993). For instance, supervisors can role model behavior or employees can receive verbal praise when they exhibit desired behavior. Positive reinforcement when applied appropriately (i.e., immediately following behavior) will foster on the job transfer (McConnell, 2005). Role modeling behavior and providing reinforcements sends out a positive message to trainees, which is vital for the success of training.

To sustain prosperous team training, organizations must maintain a commitment, showing employees that training is not simply a fad or trend that will disappear but rather an important, long-term component embedded within the organization. Organizations can demonstrate this commitment by recruiting “champions” who can serve as the driving force behind the training by motivating trainees to apply the learned skills and exhibit teamwork behaviors. In addition, organizations can also demonstrate their commitment by establishing policies and procedures that encourage trainees to participate in training.

Equally important to the training, but often neglected, is the evaluation process. All training should incorporate metrics to ensure that it is accomplishing the designated objectives. The most meaningful way to assess effectiveness is to evaluate training on four levels—trainee reactions (i.e., did trainees like the training?), learning (i.e., did trainees learn the trained concepts?), behaviors (i.e., are the trainees exhibiting the behaviors on the job?), and results (i.e., are there organizational changes?) (Kirkpatrick, 1976). Although most training is typically evaluated on one or two levels (i.e., reactions and learning), it is beneficial to assess training on all four levels. For example, trainees can learn the material, but still not apply the trained behaviors in the work environment. Thus, a complete and thorough evaluation guarantees that vital information is not overlooked. For a summary of these recommendations see Table 5.

CONCLUSION

As technology evolves and tasks become increasingly complex, teams become a fundamental component to organizations including the railroad industry. Effective teamwork has demonstrated improvements in several outcomes including productivity (Cohen and Ledford, 1994), satisfaction (Cordery et al., 1991), and performance (Salas et al., 2008). Additionally, teamwork, when executed efficiently, is also a viable process to enhancing safety. Since safety is

TABLE 5 What the Railroad Industry Must Do to Ensure Success

1.	Training developers and designers should create training based on the science of team performance and training.
2.	Consider the contextual and environmental factors to prepare the organization accordingly.
3.	Design team training to include a set of teamwork-related competencies.
4.	Promote and reinforce teamwork behaviors to facilitate the success of team training.
5.	Maintain a commitment, showing employees that training is not simply a fad or trend that will disappear but rather an important, long-term component embedded within the organization.
6.	Design, implement, evaluate, REDESIGN, and REEVALUATE.

such a critical element within the railroad industry, team training and team performance are paramount for success and efficiency. However, teams do not become experts without guidance; therefore, they must be trained accordingly. To facilitate the success of team training, designers should adhere to the science of learning, training, and performance. Thus, it is imperative that a needs analysis is conducted and the organization is prepared prior to implementing team training. Identifying the components inherent in performance as well as the organizational constraints a priori will ease the training design and development process and ensure that the training objectives are met.

All of the elements embedded within teamwork are best accomplished by collaborative efforts, and training is most effective when the expertise of multiple industries is combined. Thus, the findings from other industries (e.g., aviation, military, and health care) should be leveraged to facilitate the development of team training. Additionally, training can benefit when practitioners with domain expertise work with scientists who possess training, learning, and instructional design expertise.

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Enhancing Communication to Improve Team Performance with Applications to Train Crews

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Success on an athletic field, in an operating room, or inside an airplane cockpit often depends on how information is passed from person to person, actions are coordinated, attention is directed to an outside object or event, or ideas are collectively generated. Communication—the process of human-to-human information exchange and transfer through a medium (e.g., face-to-face conversation, e-mail, hand signals)—is the glue that allows teams in diverse work environments to coordinate their actions and act collectively to complete complex tasks. And, increasingly, it is a source of data to be used to help instructors, analysts, and researchers to investigate and understand how a work team is performing. In this section, some current research that seeks to harness communication data and explore the relevance to the railroad industry is described.

INTRODUCTION AND MOTIVATION

Defining Communication

Operating a train is a complex task. A distributed team consisting of a conductor, engineer, and other trained staff must coordinate internally to assure that the train is operating in full working order. Simultaneously, they must monitor and communicate with external actors (e.g., dispatchers, other train conductors, service personnel) to develop clear understandings of current and evolving external situations (Roth and Multer, 2009). Failure to develop this understanding or situational awareness (Endsley, 1995) can lead to catastrophic failure, as has happened in aviation (Phelps, 1985), medicine (Leonard et al., 2004), or for example the September 13, 2008, train crash in Los Angeles that killed 25 (Steinhauer and Cieply, 2008). In the latter event it was quickly determined that the Metrolink train engineer ran a red signal, but frequently transportation accident investigations involve analysis of communications among members of the operations crew to shed light on causation. In aviation, this involves recorded exchanges of the pilots with the air traffic controllers and recording of flight crew conversations obtained from the "black box" aboard all commercial air planes. Similar analyses would be possible in the railroad industry if appropriate steps were taken to record and preserve crew conversations.

Experts are often able to listen to communications and detect when the performance is not going well. For example, a soccer coach understands the state of his team in part by watching their performance on the field, and in part by listening to how much or how little they are talking to each other and what they are talking about. An experienced train engineer "listening in" on communications directed at others may be able to say if there is a potential problem down the line (Roth and Multer, 2009, p. 27).

In some respects, linguistic communications can provide a window into the health of the team. This is as true within a large corporation of 20,000 employees as it is for a commercial airline crew. Even a naïve observer could gain insight into the dynamics of an organization by analyzing linguistic communications. Like the soccer coach, the observer could over time (or based on their conception of team interaction) begin to correlate objective measures of team performance with patterns in communication that convey something about the dynamics of interaction. These patterns could be as simple as the volume of communication or as complicated as a detailed decomposition of information flow among team members over time. These indicators could include identification of communication patterns typical of normal operation, and an understanding of the implications of deviations from those patterns. This section describes recent research into analyzing communications in these ways for the purposes of training and assessing teams, with implications for the railroad industry.

Can Learning from Other Domains Be Applied to Railroad Teams?

The research described in the sections that follow draw primarily from military teams and commercial airline crews. This sample, however, is quite diverse. The military teams were drawn from several services, working in different domains, and engaged in many different tasks. Thus, we believe that the teams comprising the observational units for the discussed research are a reasonably representative sample. Moreover, the teams in the research sample share the same defining features of a team delineated by Salas et al. (1992) as the various teams found in the railroad domain. In addition, findings across the different domains give a consistent picture. Although military teams and railroad teams many engage in different types of tasks, the basic processes within teams—coordination, communication, and situation assessment—are similar. Thus, we argue that research dealing with team communication dynamics derived from samples of military teams and commercial airline crews is applicable to railroad teams as well.

MEASURING COMMUNICATION IN TEAMS

To use communications to assess team performance, those communications must first be measured in some manner. Traditionally, this has been done manually—listening to the team, or recordings of the team and then hand coding the utterances. Recent technological gains allow for automated methods, both to capture communications—e.g., in the digital forms of email and Internet chat, or the conversion of voice communications with automatic speech recognition software—and for analyzing those communications with a range of statistical methods.

Manual Real-Time Coding of Team Communications

When communications among team members are analyzed at a detailed semantic level, it is both difficult and time-consuming to develop meaningful, quantitatively based measures to describe the nature of the communications (see Krippendorff, 2004, for examples). At the opposite end of the continuum, simple frequency counts of utterances, though straightforward, do not provide a complete window into team processes. Entin and Serfaty (1999) discuss an approach that permits verbal communications among the members of a team to be captured by observers at an intermediate level of detail that incorporates both semantic and quantitative aspects of the

communication stream. This approach was developed from the semantically rich but time-intensive procedure used by Orasanu (1990). A trained observer, using a handheld tablet or laptop computer running specifically designed software, codes the sender, the recipient, the time, and the type of the verbal communications among the team members. In this approach, types of communications are divided into three basic categories: transfers, requests, and acknowledgments. Both transfers and requests are, in turn, subclassified as to concerning information, action, or coordination. This procedure has proved to be a useful and sensitive means to capture and code communications and help explain team behavior (Entin, 1999; Entin and Serfaty, 1999; Diedrich et al., 2003).

The coded communications are available in matrix format and as a time-stamped list of categories used. Thus, processing routines can derive a number of different communication measures that reflect the quantity, directionality, timing, and type of communications that occur. One particularly useful class of measures is the "anticipation ratio." The overall anticipation ratio is the ratio of all transfers to all requests. In this context, ratios larger than 1.0 are assumed to indicate that team members are anticipating the needs and requirements of other team members and "pushing" them required information before they request it (Entin and Serfaty, 1999). Ratios less than 1.0 are assumed to indicate that little anticipation of needs is occurring and team members must request (pull) what is required from others. Anticipation ratios have been found to co-vary with a team's performance level (Entin and Serfaty, 1999).

Automated Methods of Communication Analysis

Although informative, manual analysis of the communications data is costly for research in terms of time and money spent and in operational settings it is nearly impossible. Recently, a number of groups have been developing techniques to automate the processing of communications for performance measurement. The two most common methods of automatic analysis are to examine the communication flow (who talks to whom when) and the communication content (what was said).

Flow analyses explicitly ignore the content of the communications and determine just who is talking to whom in what order (without concern for what they are saying). A variety of statistical measures can be obtained from such data. For example, Kiekel et al. (2002, 2004) created a measure which detects "chains" of communications: stable sequences of speakers such as ABAB in which A speaks, B speaks, A speaks, B speaks, etc. A measure of how many stable communication patterns a team exhibited was based on the relative amount of time each team member spoke. If in every minute of an experiment, A speaks 20% of the time, B speaks 70%, and C speaks 10%, then there is just one typical pattern for this team. If however, there are times when A speaks 70%, and other times when C speaks 70%, then there are multiple stable communication patterns. Another speech pattern examined by these researchers was "dominance" of one speaker over another. This speech pattern is predicated on whether the utterance by one speaker predicts the initiation of speaking by another speaker—e.g., if when A speaks, B always follows, but not vice versa, then A dominates B, or B is reactive to A.

If the contents of communications are examined, then statistical techniques can also be used to automatically label the type of statements as described above, with nearly as much reliability as human coders (Stolcke, 2000). There are also methods to look at the meaning or semantics of the statements using statistical methods. For example, latent semantic analysis (LSA) (Landauer and Dumais, 1997) is a technique from computational linguistics which can

measure the semantic similarity between units of text—beyond just the surface similarity of the words in the two texts. It does this by training on a large corpus of domain-relevant documents, and creating a "semantic space" based on the co-occurrence of words. New documents can then be placed in this space and their similarity measured by the distance in that space. If some documents, such as transcripts from previous exercises, have been graded, then a new document, or ongoing communication, can be given a grade based on the closest graded documents. This same basic technique is used today to automatically grade student essays (Landauer et al., 2001).

LESSONS LEARNED FROM COMMUNICATIONS RESEARCH

Measuring and Interpreting Communication in Small Highly Trained Teams

Orasanu (1990) analyzed the cognitive functions of pilot communications in commercial cockpits. Airline crews represent a small team of highly trained individuals charged with a single primary mission: to fly an aircraft safely from one location to another. Expected changes like heavy traffic or predicted inclement weather or sudden unexpected changes like system failure or bird strikes can make this a daunting task even when supported by a myriad of automated tools. Orasanu (1990) found that what captains and first officers talked about, and how communication flowed between the captains and the first officers, significantly affected how they dealt with both expected and unexpected changes in the environment. Highly performing crews tend to use periods of low workload when automation was doing most of the flying to discuss contingencies, plan ahead, and play "what if" games. Then, if some difficult situation arose, these explicit discussions became the bases for actions. Other analyses indicated that better-performing crews' communications included explicit definitions of the problem, articulated plans, strategies for coping with the problem, more relevant information, rationales for actions, and allocation and coordination of responsibility for the crew. In short, better-performing crews stayed focused on the problem in both speech and deed.

Not only what you say, but how you say it makes a difference as well. How captains address the flight crew and how first officers address captains was researched by Fischer and Orasanu (1997). Their findings show that captains tended to give more direct commands or suggest an action as in "let's do this." First officers, on the other hand, exhibiting the effects of norms and hierarchy tended to be more indirect, eschewing explicit statements or orders of what to do in favor of using "hints" in the form of problem statements. Thus, to alert the captain to some situation or offer a correction, the first officer may issue a statement indicating a specific problem or goal, e.g., "captain we are 15 knots too slow." Another strategy was to use a permission-seeking question leaving the final decision to the captain, e.g., "Do you want me to ask ATC (air traffic control) if they still want us on this heading?" By not phrasing a statement that might challenge the captain's authority, first officers maintain social harmony in the cockpit and thus do not create any unwarranted annoyance that could compromise safe operation of the aircraft.

APPLICATIONS FOR RAILROAD TEAMS

There are several direct applications. First, instruct or encourage railroad teams to use periods of low workload/activity to discuss contingencies and carry on "what if" exchanges concerning

future possible situations. Such discussions can become the basis for actions required in the future, particularly if future situations depart from the nominal. Second, during problem situations, strongly encourage or instruct railroad team members to stay focused on the problem and use communications that precisely define the problem, articulate plans, draw in relevant information, and stress coordination activities. Last, team members can be advised that maintaining some level of social tranquility within a team may facilitate work effectiveness.

Take, for example, the "run-away" event that took place on March 10, 2004, in New York. The crew had been charged to deliver a locomotive in need of repair and service from Morris Park, New York (Long Island Railroad), to the New York and Atlantic Railway yard in Fresh Pond. The locomotive in need of service was moved "dead in tow" (unpowered) in the middle of a group of three locomotives. It took over 2 h to move the three-locomotive train to the Fresh Pond yard at which time it became necessary to separate one of the end locomotives from the train. That locomotive was left unattended on a 1% grade with only the air brakes engaged. Apparently, the air pressure went to zero and the locomotive rolled over 2 mi striking several vehicles along the way, causing considerable property damage and human injury. The crew knew they would have to decouple the three locomotive trains when they reached the Fresh Pond yard so they could connect the locomotive in need of service to the end of another train. If the train crew had used the low workload period during transit to discuss the steps required to carry out this task the crew would realize a locomotive would be left separated from the train unattended and probably would have discussed the rules to properly handle the unattended locomotive, e.g., securing the hand brakes and chocking a wheel. Or discussed in a "what if" manner what might happen if the locomotive was secured with just the air brakes and if the air pressure were to fail. If such preplanning discussions had occurred it is likely the accident would not have occurred.

Communication in Teams and Adapting to Change

Frequently teams, whether railroad work teams, military teams, or surgical teams, must adapt to changes in their environment. It has been observed that competent teams are adept at sensing changes in their environment and altering their strategies to accommodate these changes without compromising performance (LaPorte and Consolini, 1988; Entin and Serfaty, 1999). In fact, teams that can adapt to internal changes or changes in their environment have a much better chance at performing required tasks and achieving their goals. Diedrich et al. (2003) and Entin, Diedrich, and Rubineau (2003), moreover, observed that effective communications within a team are critical for facilitating the adaptive process, whereas ineffective communications stymie the adaptive process.

Researchers focus on communications because they universally hold that communications are a primary process used to indicate the need for change. Teams (and organizations) typically coordinate the reallocation of assets, the redistribution of workload, and joint processing of tasks via voice communication (Orasanu, 1990; Entin and Serfaty, 1999; Entin, 1999). Moreover, the major conduit for the sharing of information is typically by voice communication. Thus, it was expected and found that the pattern of communications differs between situations where a team's strategies and organizational structure are adequate for the required tasks and where they are not (Diedrich et al., 2003; Entin, Diedrich, and Rubineau, 2003). Entin et al. (2003) found that communication volume increased markedly in conditions where a team's current strategies were failing.

To elaborate, investigating two ubiquitous organizational structures frequently assumed by work teams, commonly referred to as "functional" and "divisional," Entin et al. (2003) explored the pattern of communications' within teams when the organizational structure became inappropriate due to alterations in the environment. In a functional organizational structure each member of the team specializes in one type of task or one aspect of a task such as welding or electrical work. In contrast, in a divisional organizational structure, each member of the team is a generalist and has a modicum of capability doing several different tasks, e.g., some welding, some electrical, and some carpentry.

Striking differences in communication patterns were observed between the two different organizational structures and when the functional or divisional organizational structure changed from being appropriate to address the required tasks to inappropriate because changes in the environment changed the required tasks. Teams using the divisional structure reacted by talking more when they went from appropriate to inappropriate situations. In contrast, when teams using the functional structure went from appropriate to inappropriate situations they reacted by making substantial changes in what they talked about. These results suggest that the context of being in a particular organization given a particular set of tasks influences how teams react when trying to cope with an inappropriate structure. Further analyses showed that the increase in communications in the divisional structure teams consisted mostly of information requests and transfers, whereas team members under the functional structure talked more about coordination, task requirements, and asset allocation/reallocation. It appeared that teams using the functional structure were making more of a concerted effort to adapt to the changes in the situation than those using the divisional structure.

Implications for Railroad Teams

It behooves supervisors, foreman, or team leaders of any type of railroad team to be cognizant of the team's organizational structure and how well that structure matches the demands of the tasks to be accomplished. It is also to supervisors', foremen's, or team leaders' advantage to monitor a team's communication patterns for signs of incongruence between the team's structure and the tasks to be performed. Early detection that unexpected environmental changes have made the current team's structure and strategies inappropriate can minimize wasted effort and performance loss. Moreover, steps can be taken by team leaders to facilitate communication patterns that address the adaptation process. In the next section we discuss how teams were trained to detect environmentally induced stressors and behaviors to cope and/or adapt to them.

Training Teams How to Coordinate and Communicate Better to Maintain and Enhance Performance

Teams that perform well when the organizational structure has become inappropriate and in high stress conditions employ different strategies than teams that perform poorly under such conditions (LaPorte and Consolini, 1988). LaPorte and Consolini identified three characteristics of highly performing teams: the team structure is adaptive to changes in the task environment; the team maintains open and flexible communication lines; and team members are extremely sensitive to other members' workload and performance in high-tempo situations. Entin and Serfaty (1999) argue that high-performing teams possess the ability not only to adapt their strategies, but even to dynamically adjust their team structure in order to maintain their

performance in the presence of incongruence between team structure, task set, and escalating workload. They go on to say that an important mechanism that highly performing teams use in the adaptation process is to develop a shared mental model of the task environment and the task itself and a mutual mental model of interacting team members' tasks and abilities. Such models are used to generate expectations about how other team members will behave; there is evidence to show that high-performing teams make use of such models, when timely, error-free, and unambiguous information is at a premium, to anticipate both the developments of the situation and the needs of the other team members (Serfaty et al., 1993; Entin et al., 1993; Entin and Serfaty, 1999). It appears that this strategy of anticipating changes in the situation and in the needs of other team members contributes significantly to the team's high performance under trying conditions.

To provide empirical substantiation to the above arguments, Entin and Serfaty (1999) observed teams that were trained to identify signs that changes in the environment were increasing workload, compromising team strategies, and increasing workload induced stress. These teams were also trained in a set of adaptive strategies including communication structuring strategies to accommodate to these changes. Results clearly demonstrated that teams can be trained to recognize the signs of failing team strategies and increasing workload and then use adaptive strategies to mitigate some of their debilitating effects. The finding that appropriate training can significantly improve both teamwork skills and task performance supports the assertion that the dual concepts of shared mental models and adaptive coordination are a productive approach for understanding and developing effective teamwork.

Two important contributors to successful team training were specific communication strategies. First, team members were trained to anticipate other team members' needs and to push needed information before it had to be requested. Training allowed the pushing of anticipated needs to outstrip requests by a factor of three to one, thus reducing team overhead and facilitating performance. This anticipatory strategy implies a shift away from explicit communication and toward implicit communication. To shift from explicit to implicit communication, team members must rely on mental models of the other team members, developed earlier, to anticipate their needs. There are also some indications that implicit modes of communication are more resilient to disruptions and thus conducive in periods of confusion, as when a team is adapting to environmental changes (see Cannon-Bowers, Salas, and Converse, 1991). Second, team leaders were instructed to give periodic situational reports to all team members. Team members were taught that the situational reports contained a digested summary of the situation as perceived by the team leader based on reports supplied by team members and other external sources. As predicted, situational reports facilitated the maintenance of mutual mental models among all the team members. In other words it helped unify the team's situational picture, i.e., "keep everybody on the same page." Additionally, the situational briefs gave team members a special insight into the team leader's mental model of the situation. Thus, team members could use the perspective and priorities contained in the leader's situational brief to prioritize what goals to strive toward to achieve the leader's, and presumably the team's, overall concept.

Applications to Railroad Teams

The first critical lesson is that strategies used by high-performing teams can be successfully taught, be it to naval or railroad teams, and that a team's performance and adaptive skills can thereby be enhanced. Using standard training procedures railroad team members could be trained to be proactive and preempt the needs of other team members before they make requests, particularly during times of high activity and turmoil. That is, instruct railroad team members to use their developed mental models of others and the situation to shift from an explicit to a more implicit mode of communication and coordination. Such strategies reduce a team's overhead and have proven robust in chaotic conditions. An experienced engineer was watching a crew line up cars in a switching yard. Drawing on his experience and mental model of the situation he realized that one of the cars would be too long to safely negotiate a curve that would be encountered. He called a member of the crew and inquired what their intentions were and at the same time noted that one of the cars they were working was too long to make a necessary curve. The crew took this information under advisement and altered the way they handled the extra long car. Thus, the monitoring and backup behavior of an experience engineer averted a possible mishap.

In another application, supervisors, foremen, or team leaders could be trained to provide brief periodic situational reports to refresh everyone's mental model of the situation and to keep team members focused and striving to reach appropriate goals—another proven strategy to maintain team performance in highly dynamic challenging situations.

PREDICTING PERFORMANCE WITH AUTOMATED MEASURES

While instruction and supervisor monitoring could lead to better communications in railroad teams, there is still a need to be able to monitor communications on a large scale and to detect automatically if there are breakdowns in those communications. To this end, recent work has been investigating the use of automated communications measures to predict performance.

Kiekel et al. (2002, 2004) found that just by looking at the sequence of speakers, one can predict the performance of small teams in a military domain. In this study, they had teams of people control a simulated unmanned air vehicle. These teams consisted of three interdependent roles: a route planner, a pilot, and a photographer. The teams communicated over headsets using a push-to-talk system that directed communications to one of the other team members. Each team conducted seven "missions" and in Kiekel et al. (2004), the sixth mission would always contain a communications "glitch" whereby the planner could not speak directly to the pilot. They also tested teams being either in the same room (and thus capable of overhearing communications) or in separate rooms. In this simulated context, Kiekel et al. were able to record every time one of the team members pushed to talk, thus capturing data on who spoke to whom, when, and for how long. Performance on the task itself was a combined measure of the number of suitable photos taken, the time spent to complete the mission, and the amount of fuel and film used.

Kiekel et al. found that automated flow measures based on chain extraction, communication patterns, and dominance could be used to predict performance. For example, the maximum chain length and the number of communication patterns were both significantly correlated to performance.

The content of the communications in these experiments was also analyzed using latent semantic analysis by Foltz et al. (2006). Transcripts from ungraded teams were compared to

transcripts of manually-graded teams and a similarity measure derived using LSA. Transcripts with higher similarity scores were weighted more than transcripts with lower similarity scores. The scores estimated in this manner were found to be significantly correlated with the actual performance scores.

Implications for the Railroad Industry

The current radio communications technologies used by the railroad industry make automated communications analysis difficult. However, as modern technology such as cell phones and computer communications get rolled out, the potential to use this information for performance assessment could become critical to avoiding mistakes. Flow analyses would be the easiest to implement and could provide a quick view on the how communications are flowing within a train, between trains, between trains and dispatchers, or within a yard. The statistical techniques used for the content analysis are actually quite robust to automated speech recognition issues, so these techniques could be applied to understand and assess performance.

ONGOING COMMUNICATION RESEARCH

Our recent work (Salter et al., forthcoming) is investigating how communications within a team changes over the course of training. This work is analyzing communications in simulations of the U.S. Air Force's Air and Space Operations Center (AOC) where dozens of operators control the air space, as well as find, track, and prosecute dynamic targets. At any given time, half a dozen targets may be active and being discussed at once by and across different teams within the AOC. Their primary mode of communication is Internet Relay Chat real-time text messaging. Because of the complexity of the data, tools to visualize both the raw data and the analyses have been developed.

Figure 3 shows the graphical user interface used for development (with fake data randomly generated by the authors). This tool centralizes the chat data itself along with various analyses applied to those data. It makes it possible to filter messages by various criteria, display on a timeline results filtered by any two criteria, and link to the location in the chat stream of messages of interest, among other functions. For example, we might want to see just those communications between two people in a particular chat room when they are talking about a particular topic and the rate of messages is abnormally high.

Another way to examine these interactions is to use measures derived from social network and dynamic network analyses (Carley, 2007). These analyses provide insight into communications transactions and interactions over time. In particular, we are exploring communications centrality as a method to determine who the most influential individuals are and how well this corresponds to the established hierarchy. When combined with the other analyses, we can also track the sources and sinks of commands, acknowledgements, questions, answers, etc. The network tool shown in Figure 4 allows one to see the communications network as a whole and as it evolves over time. Additionally, any of the analyses performed on the communications data can also be used to filter and weight the edges between vertices.

The graph in Figure 4 shows sender sequences. An arrow from A to B indicates that a message from A was followed by a message from B within the same chat room. The thickness of the arrow indicates the percent of messages from A that were followed by messages from B; when these are about the same size this suggests the two tend to have conversations. The length

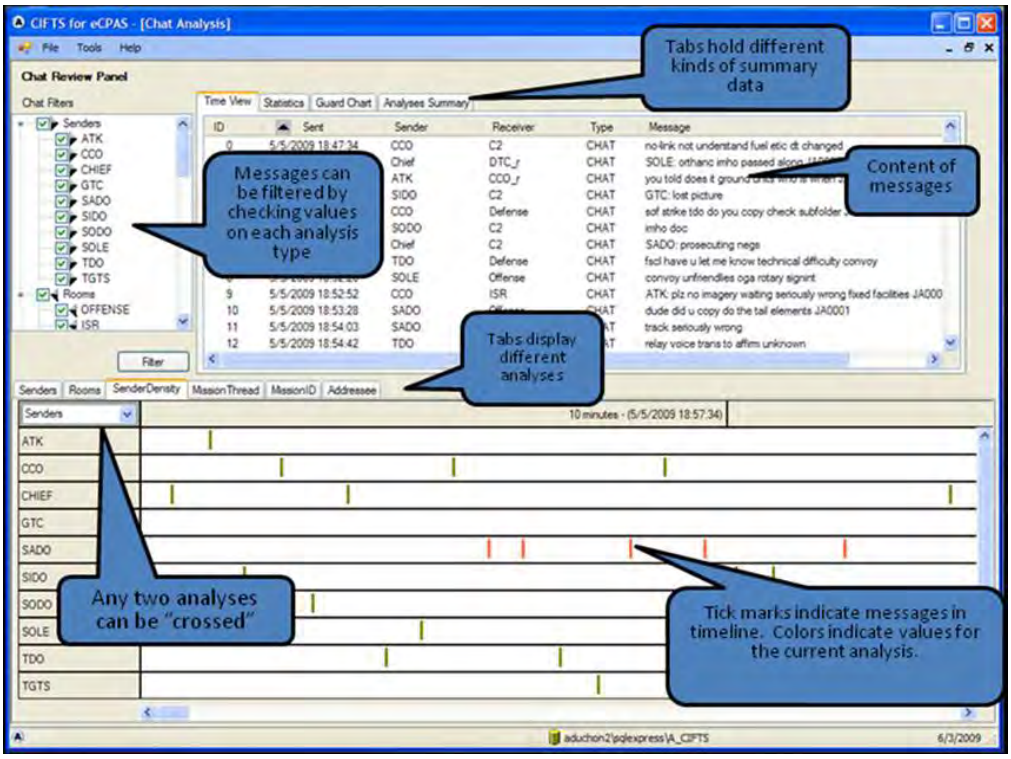

FIGURE 3 Aptima's communications timeline tool.

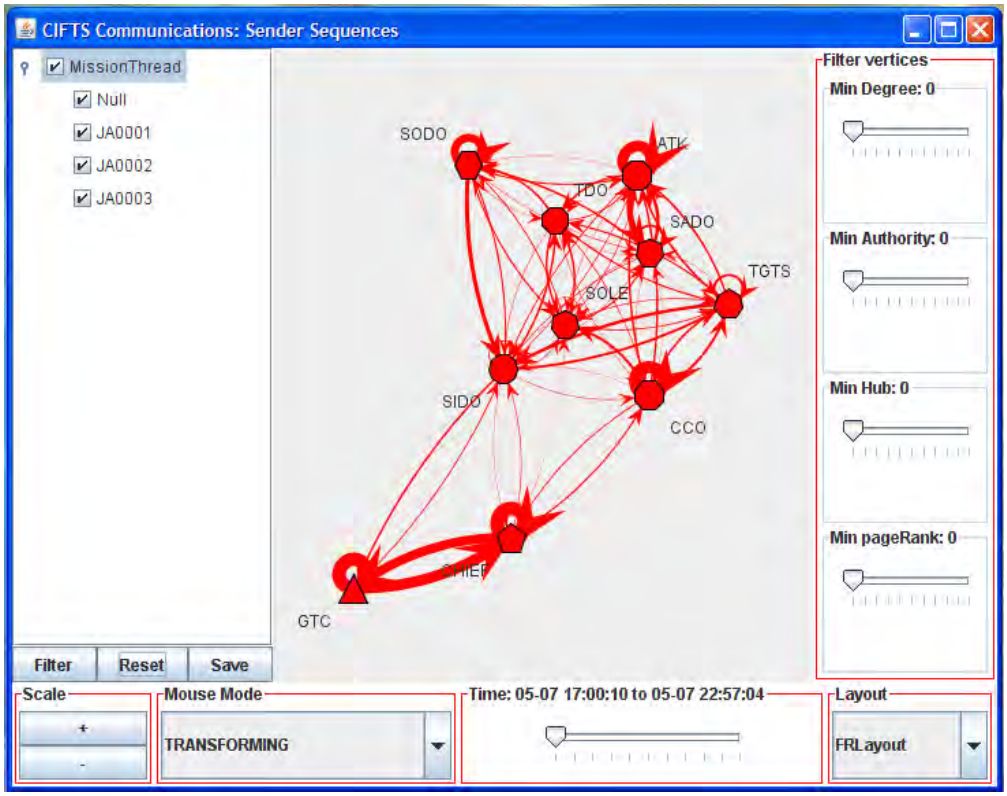

FIGURE 4 Aptima's communications network tool.

of the line indicates the time interval between messages, thus when many senders are packed close together they have very dense communications between them. The size of the vertex indicates the percent of all messages that this participant sent. In general, the layout algorithms result in minimizing line crossings, which has the effect that participants who communicate with more other participants tend to be closer to the middle of the graph. These graphs can be used for quickly understanding the flow of communications and determining what information should be extracted for further analysis and presentation.

In addition to the visualizations of these data, we are also looking at more aggregate communications behavior. For example, one might suspect that teams that don't use the same words to describe the same thing might not understand each other (e.g., even in English, Americans say "elevator," British say "lift"). In the military, teams are often composed of people from around the country, with a variety of backgrounds, and, in our data at least, different experience levels with Internet chat.

Therefore we investigated the vocabulary that the participants used over the course of a week of training. Most of the participants had never worked together before and varied considerably in the amount of experience they had. Thus, regional and experiential differences might cause misunderstandings due to different words being used for the same idea. We measured the size of each participant's vocabulary by using a dictionary of terms common to the AOC to pull out multiword terms and expressions (such as "latitude and longitude"). For each participant we then looked at the percent of their terms that were also used by the other participants. We would not expect everyone to use the exact same words—the requirements of their different roles and information they provide are different by design. However, to communicate effectively with each other, some shared vocabulary is clearly required. We found that the average percent of shared vocabulary between participants increased steadily over the first three exercise periods and then leveled off. This vocabulary convergence may indicate that only a few sessions together are required for these kinds of teams to learn to "speak the same language."

Implications for the Railroad Industry

The visualization of communications could be quite revealing for administrators to understand how information flows through a rail yard, a metro system, a specific geographic region, or even across the country. Automated monitoring of vocabulary of teams could be an indicator of future communications breakdowns due to differences in terms and dialects.

CONCLUDING REMARKS: COMMUNICATION ANALYSIS FOR TRAIN CREWS

Work teams in diverse environments rely on effective communication in order to successfully do their jobs, whether that job includes flying a plane, scoring more points than an opponent, or moving a train through a yard. In this article, we described ways in which analysis of the communication that naturally arises during normal work activities can be used to improve training or operational efficiency.

The current applications for the analyses described in this article rely heavily on technologies in which communication is naturally captured. For example, it is relatively easy to save and analyze e-mail or text chat because they are already in a form that is easy to archive. In

contrast, communication that occurs in face-to-face, by telephone, or in radio environments is more difficult to capture, transcribe, and analyze. However, over the next decade, the use of digital radio (that improves the sound quality), improved automatic speech recognition software (that transcribes what is being said), and speaker recognition systems (that can identify who is talking) will make possible far greater use of automated communications assessment tools.

Throughout this section, we have described ways in which the analysis of communications might be applicable to the railroad industry. Looking over several techniques, other potential applications come to mind. Consider the impact of new technology, such as a new positive train control (PTC) system. Once the system is installed and crews become familiar with it, how might one assess the effects of the new system on team performance? If analysts are able to capture communication of train crews before, during, and after the introduction of the technology, the manual and automated techniques described here would allow them to systematically assess the effects of that technology on specific coordinative processes. The results of studies like this could have wide implications throughout an industry undergoing dramatic transformation.

If internal and external communication were being captured across a large number of train crews over a long period of time—along with other important information (e.g., time per travel leg, track conditions, problems or irregularities)—a model could be developed that could help predict and identify problems as they are emerging, enabling corrective action to be taken earlier in the process. This is possible by looking at historical correlations between patterns of communication captured automatically with indicators of problems, and looking for those same patterns in real time. The implementation of such a system could greatly increase safety and efficiency.

The railroad industry is in a period of historic transformation, perhaps as significant as those of the 1860s and 1920s. It faces new challenges and opportunities and is being swept by a wave of new technologies and business models. Energy consumption seems to be shifting from a periodic to a permanent national policy concern, creating unprecedented opportunities in freight, long-haul passenger travel, and commuter rail. Investment requirements, however, to upgrade roadbed and equipment are very high and aspects of the cost structure in the industry, primarily those associated with labor, present further barriers. At the same time, new automation technologies offer the promise of reducing staffing requirements while also potentially enhancing safety even at the increased speeds that upgraded roadbed and equipment will make possible. Those technologies place new demands on train crews in terms of tasks to be performed, skills required, and the size and mix of both onboard and distributed teams.

Making the most of new technologies to improve efficiency while maintaining safe and augment effectiveness will always present challenges, but we are convinced that prudent application of team science in general and of communications analysis in particular can both facilitate their achievement and enhance their utility. We hope that this article has suggested some of the ways in which team science and communications analysis can contribute to the creation of a railroad industry that can grow and prosper in the 21st century.

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Leadership's Role in Team Performance
Implications for Safety Culture

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Virtually all organizations accomplish at least some of their work through the use of teams (Kozlowski and Bell, 2003). In fact, in a recent survey, 91% of managers polled agreed that "teams are central to organizational success" (Martin and Bal, 2006). Within the railroad industry teams have been one of the focal points for improving safety through the introduction of interventions such as CRM (Morgon, Olson, Kyte, and Roop, 2007), behavioral-based safety, and labor–management root cause analysis. With the increasing use of teams, there has been a corresponding increase in research investigating team effectiveness (Kozlowski and Bell, 2003). Although lagging in research on team effectiveness, there have also been investigations into the leaders' role in ensuring team success (Manz and Sims, 1987; Morgeson, DeRue, and Karam, in press). Although questions sometimes arise regarding what the leader's role is in respect to team leadership—particularly as teams become increasingly self-directed and autonomous—in all team situations there is a role for leaders and leadership. Although this role may change depending on the type of team managed, there are number of critical leadership functions that need to occur (Morgeson et al., in press).

The purpose of this paper is to describe several of the key aspects of leadership as they relate to team effectiveness and, in the process, describe how effective leadership is necessary to support team-based safety initiatives that are of interest to the railroad industry such as CRM, behavioral safety, close call reporting, and other similar programs. The particular focus here is on leaderships' role in creating a positive safety culture that supports and provides the foundation for the effectiveness of safety interventions. Although the focus is on safety culture (and climate), the leadership principles described below apply to other domains as well.

THREE COMPONENTS OF LEADERSHIP

Leadership has been defined in many different ways (Yukl and Van Fleet, 1992). For the purposes of this discussion:

> Leaders are those individuals who, after choosing a direction, are able to influence and motivate teams as well as put systems in place to achieve goals aligned with this direction.

It is important to highlight several important aspects of this definition of leadership. First, leaders are individuals who have a clear direction for the team they are leading. As we will see below, they are not the only ones who have responsibility for communicating this direction but, nevertheless, leaders are individuals who have a vision for the team in terms of an ultimate goal or destination. Second, leaders are individuals who motivate and influence. These two terms are chosen purposefully and are not interchangeable. Motivation has to do with setting clear goals,

having clear expectations, defining clear roles and responsibilities, and aligning reward systems to encourage appropriate behavior. Motivation, therefore, can flow from a formal position of authority and control over resources. Influence, on the other hand, conveys a connection with employees on a deeper, more substantive level. Leaders influence employees when they communicate a direction and vision that links to their core values and arouses emotional connections. Influence can also emerge out of interpersonal treatment. Influence, therefore, comes from who the leader is—their integrity and their ability to communicate a deeper meaning in the team's work.

The third aspect of this definition to highlight is that leaders also have the responsibility of putting in place systems to achieve the goals and direction of the team. These systems could entail the clear roles and responsibilities noted above, but they may also involve information systems such that individuals have the appropriate information available to make well-informed decisions. Other systems would include project execution frameworks, human resource management policies, the team structure of roles and responsibilities, selection and promotion processes and the like. All of these systems need to be aligned with the overall direction and goal of the team. Nadler and Tushman (1980) provide a framework for diagnosing and evaluating the congruence of various team and organizational systems that highlights the congruent and mutually reinforcing aspects of these various systems.

When applied to the railroad industry, this view of leadership suggests that it is not sufficient for management to simply espouse using teams to achieve safety goals and objectives. Instead, railroad industry leaders need to think holistically and systematically about establishing within their organization both a formal and an informal system that supports these teams as they seek to improve safety and signals to them that safety is critically important to the organization. This would involve thinking about how to effectively communicate and espouse the value of safety, how to motivate compliance with accepted safety protocol, and how to provide the resources (budget, people, etc.) required to ensure these team-based initiatives are implemented successfully. Leaders must also recognize how their symbolic actions can create a culture and climate that either reinforces the value of safety or undercuts their espoused value for safety.

Although the above definition of leadership describes what leaders need to achieve (direction, motivation, influence, systems), it does not elaborate on how leaders achieve these ends. For the purposes of our discussion, we will categorize leader activities into three broad dimensions: leader-based, relationship-based, and follower-based. For any given team leadership position, all three of these components are necessary, although the amount of time spent in each of the three categories may vary.

From a leadership theory standpoint, leader-based leadership is most closely aligned with research and theory investigating transformational leadership (Bass, 1985; Yukl and Van Fleet, 1992). Influence from leader-based leadership flows from the charisma of the leader, their ideas, the direction and vision they cast for the team, and how they reinforce this direction through both symbolic actions and aligned organizational systems.

As noted above, the first necessary component of leadership is having a direction and communicating this direction to the team. This direction could involve the articulation of a desired future state, a long-term goal, a yardstick for measuring progress, and/or something that the team wants to become known for or become (e.g., the best at customer service in the organization). The most critical aspect of this direction is that it extends beyond simple operational metrics (e.g., reduce costs 5% over the next 6 months) to communicate some higher level conceptualization of what the team is doing and how it contributes something meaningful

to the organization, customers, or larger society. One of the key aspects of the research on transformational leadership is that leaders communicate the direction of the team in such a way as to convey to the team members that their work has meaning and that they are making a compelling contribution to something larger than reducing costs or hitting a particularly efficiency metric (Bass, 1985; Frese, Beimel, and Schoenborn, 2003; Rafferty and Griffin, 2004).

Within the rail industry, there are several avenues through which this could be accomplished. From a broad industry perspective, leaders could emphasize the fuel efficiency of rail transportation and how that links to providing lower-cost products to consumers as well as a more "green" transportation system. With respect to safety, leaders could link safety into the protection of, or caring for, the health and well-being of employees. It is important, however, to remember that the espoused and enacted values must be aligned at a systems level. So leaders need to ensure that if they link their safety message to the health and well-being of employees that there are no other systems in place (e.g., poor ergonomic job design) that undercut this espoused value.

Leaders can also influence others through relationships (relationship-based leadership). Broadly speaking, relationships between leaders and team members can range from economic-based exchanges—where the leader hires the team member to do a piece of work and then pays them—to richer, mutual investment, and social-based exchanges where the leader views team members as partners and assets in accomplishing the goals of the team. From a theoretical perspective, this approach to leadership is connected with research on leader–member exchanges (LMX). Developed by Dansereau, Graen, and Haga (1975), hundreds of conducted studies have been recently meta-analytically summarized by Gerstner and Day (1997). There is considerable evidence that a social-based, mutual investment leader relationship is related to a host of positive affective and behavioral outcomes.

Recently in the railroad industry there have been increased emphasis by some railroads on approaches to leadership that move the leader–worker relationship more towards a social-based, mutual investment model. For example, focusing on coaching rather than disciplining employees involved in incidents and the FRA's close call reporting system C3RS, which grants immunity from discipline for an employee who calls in a close call, both signal a constructive, mutual problem-solving approach to accidents and incidents. By approach these situations with a mindset of trying to understand the employee's perspective, the situation they faced, the actions that occurred, and working with them to jointly affect change sends a strong signal that the relationship between leaders and employees is an ongoing, reciprocal relationship where each side seeks to understand the other and work jointly and cooperatively to identify effect solutions.

Although the example above focused on leaders and subordinates or workers broadly defined, it is important to point out that relationship-based leadership not only occurs at the broader system level (i.e., what message does the accident investigation system send to employees regarding their relationship with management?), it is also enacted day-to-day on the front lines of the organization between team leaders and their employees. Here, relationship-based leadership takes on a much more interpersonal-based focus. Leaders creating social-based exchanges will know their employees well (e.g., what they value, family struggles they may be facing) and engage with them positively from an interpersonal perspective (e.g., seek their input on decisions that impact them). Leaders creating more economic-based exchanges will be more autocratic and one-way in their direction giving and show little interest in their employees as people. Across industries—and applicable to the rail industry as described below—research has shown that richer, social, and mutual investment type of relationships on the front lines of

organizations leads to much more motivated and proactive employees who are much more willing to make positive contributions to the success of both their leader and the broader organization (Gerstner and Day, 1997).

Finally, it is important to point out that team leaders in the railroad industry must also develop effective relationships with laterally organized peers and their supervisor. Relationships with lateral peers are necessary to secure resources and cooperation from other teams on whom the leader's team depends. Take, for instance, the results of a root cause investigation that identifies a transportation problem that also involves both track engineering and train scheduling. The cooperation of all three of these departments will be needed to successfully design and implement a solution. The process of designing and implementing this change will be exponentially easier if the leaders of these three groups have already laid the relationship groundwork and established mutually beneficial, cooperative relationships with each other prior to the root cause analysis. The establishment of these relationships rests not only with these leaders, who need to proactively reach out to each other in an effort to learn the key demands and goals of one another, but also with senior leadership who need to encourage middle-level managers to think in the general interest of the carrier location or region and not focus exclusively on their more narrow domain of responsibility.

Although not the primary focus of this paper, follower-based leadership captures the leaders' influence on the skill development and empowerment of team members (Mathieu, Gilson, and Ruddy, 2006; Spreitzer, 1995). This aspect of leadership establishes the long-term sustainability of the team by building a strong foundation in terms of skills and abilities as well as empowerment and ownership of the vision and goal of the team.

LEADERSHIP AND SAFETY

Leaders Must Value Safety

There is much research in the safety domain that consistently supports the relationship between leadership within the organization and safety (Barling, Loughlin, and Kelloway, 2002; Gonzalez-Roma, Peiro, and Tordera, 2002; Hofmann and Morgeson, 1999; Hofmann, Morgeson, and Gerras, 2003; Kozlowski and Doherty, 1989; Zohar, 2002; Zohar and Luria, 2004; Zohar and Tenne-Gazit, 2008). This relationship can be explained as a social learning process in which group members repeatedly observe and exchange information with their leader as a means for interpreting the organizational environment (Dragoni, 2005). In addition, supervisory practices are relatively easy to observe due to their proximity and availability, and they routinely inform group members regarding relative priorities as well as behavior that is valued and supported by both the leader and the organization at large (Zohar and Hofmann, in press; Zohar and Luria, 2004).

Leader-based leadership, in particular, is likely to be quite influential in establishing safety as a priority within the organization (Bass, 1985; Yukl, 2006). This type of leadership establishes clear long-term goals and priorities and often links these goals to underlying core values. In addition, leaders who base their prioritization of safety on underlying core values should exhibit increased consistency across situations which will help further reinforce an unwavering commitment to safety.

Leader-based leadership, therefore, will directly influence the emphasis on safety through the articulation of long-term, safety-related goals and objectives and by putting in place the systems and structures to accomplish these goals. With respect to safety, it is important for the prioritization of safety to extend to all organizational levels. Zohar and Luria (2005) investigated the way in which the prioritization of safety can cascade throughout the organization. Although top management sets the overall emphasis on safety within the organization, front-line supervisors still have day-to-day discretion in the implementation of the practices and systems that support safety. Zohar and Luria (2005) found that the influence of top management's emphasis on safety was mediated by the extent to which local, more proximal supervisors reinforced the importance of safety. In addition, as top management's commitment to safety increased, the degree of variability across front-line supervisors was reduced. In other words, if top management was both highly committed to safety and they were uniform in this commitment, then front-line supervisors had higher commitment to safety, and there was more consistency across supervisors in their commitment to safety.

One way that railroads can get greater alignment is by ensuring that the leaders' espoused values surrounding safety are reinforced through the front-line policies and practices (Zohar and Hofmann, in press). Providing sufficient resources for safety programs would be one way to ensure a consistent alignment between espoused and enacted values around safety. Another example is to think about what leaders within the organization pay attention to. For example, one railroad senior manager implemented a safety-oriented root cause continuous improvement problem-solving protocol, which used joint labor-management teams for the analysis. For the first couple of years, he personally reviewed all written investigations that used the tool. By personally reviewing them and requiring that they be resubmitted when they weren't complete he was able to coach his organization (managers and workers alike) in how to identify systemic contributing causes. In addition, he insisted that all investigations include in their list of contributing factors at least one way in which management was contributing to the problem which, by the way, helped to reinforce a more cooperative, mutual problem-solving approach since both workers and employees were assumed to have contributed to the event (i.e., relationship-based leadership). He also required a spreadsheet to be kept on the corrective actions that he routinely followed-up on. All of these actions, taken together, helped align espoused values with enacted practices through the use of broader organizational systems and the signals they send.

Leaders Do Not Need to Be the Only Communicators

Organizational leaders, however, do not need to be the only people communicating that safety is important. Specifically, when considering leaders' communication regarding the importance of safety, two questions emerge. The first question is whether leaders are the right source for the message, and the second question is what the message should be. With respect to the first question, Grant, Campbell, Chen, Cottone, Lapedis, and Lee (2007) recently reported the results of three field experiments where they showed that connecting employees with the beneficiaries of their job can increase both effort and performance over time. But, in follow-up research, Grant and Hofmann (2009) found that messages delivered by the direct beneficiary were more impactful on employee effort and performance than more general inspirational appeals. This occurred even in situations when the leader was perceived as a better communicator and when they delivered the same message. In contrast to the leadership literature that emphasizes the role

of the leader in communicating meaning and purpose to employees, Grant and Hofmann (2009) concluded that "leaders may benefit from deferring these communications to the direct beneficiaries of employees' efforts, who can attest firsthand to its importance. Our findings invite consideration of the possibility that leaders may not be the optimal source of inspirational appeals."

It is important to point out that all of the work by Grant and colleagues in this area has focused on communicating positive messages, that is, the benefits of one's work. An open question is whether this is the right message for improving employees' motivation surrounding safety performance. Within the health-related behavioral marketing literature, there is considerable evidence suggesting that negative messages may be more effective (e.g., Meyerowitz and Chaiken, 1987), but these results may depend on the relative depth of processing the message (Maheswaran and Meyers-Levy, 1990). Another possibility is to provide messages that contain both positive and negative appeals (Treiber, 1986).

Coupling these two questions together suggests some implications for future research with respect to safety performance in the rail industry. One important question is how the leader should go about communicating to the team (or organization) that safety issues are an important and critical aspect of organizational functioning. Perhaps the way to communicate this message would be for the leader to discuss the importance of performing safely to the team, and then bring in individuals (after granting them immunity from discipline) who have been directly impacted by safety issues or problems being examined by the team to discuss the ramifications of these problems for them personally as well as others who were harmed. For example, if management is trying to create a culture where employees actively look out for one another's safety in the locomotive maintenance shop, then employees from this area could "tell their story" in an effort to reinforce that this is not just a "management" value, but it is one that needs to permeate throughout the organization. This could be, for example, an employee who was injured in some serious way. With respect to the content of the communication, it seems two messages need to be delivered (Treiber, 1986): one message containing a positive appeal (e.g., communicating the positive effects of being vigilant regarding safety issues, speaking up when problems were noticed, implementing a positive response, and preventing significant losses to the team), and one message containing a negative appeal (e.g., communicating the safety issues that were not effectively managed). Although there may still be remaining unanswered questions, the overall point is that leaders may be able to effectively "outsource" some of the "inspiration" designed to communicate the importance of safety.

Teams Must Also Take Ownership of Safety

In addition to leaders at all levels of the organization needing to establish a clear message regarding the importance of safety, leaders must also engage in relationship-based leadership in order to influence employee commitment to this direction. As noted above, relationship-based leadership most closely resembles the LMX theory of leadership. With respect to safety, Hofmann, Morgeson, and Gerras (2003) were interested in how employees view their work role with respect to safety. The overarching question was when will employees view extra-role, discretionary safety-related behavior (i.e., safety citizenship behavior) as part of their formal job duties or "part of their expected role." Again, adopting a social exchange theoretical foundation and drawing upon previous LMX research, they hypothesized that employees would reciprocate high-quality LMX relationships with safety-oriented citizenship behaviors only when the

leaders' behavior engendered a climate within the group that highly valued safety. The authors found support for the interaction. Under positive safety climates, there was a significant positive relationship between LMX and subordinate role definitions; that is, employees were more likely to view safety citizenship behaviors as in-role when there was a positive safety climate and high-quality LMX relationships. Alternatively, under poor safety climates, the relationship between LMX and safety role definitions was insignificant. In other words, when the surrounding context did not signal a strong commitment to safety, employees did not reciprocate high-quality LMX relationships by expanding their safety-related role definitions, nor did they engage in these behaviors more frequently. Thus, leaders' setting the overall direction in terms of the importance of safety is not enough. They must also engage in relationship-based leadership in order to create the motivation and commitment to this direction such that employees are willing to going above and beyond the call of duty to ensure safety performance.

As noted above, this type of relationship-based leadership related to safety can be communicated both through the broader systems of the organization (e.g., joint labor–management root cause analysis teams) as well as through the relationships that supervisors have with their front-line employees. For railroad leaders, it is not enough to just have team-based safety programs. They must reinforce a positive, constructive approach to safety issues through other ways as well. This could be through walking the yard and soliciting concerns, quickly addressing hot-line safety calls, having teams present their analysis and corrective actions at briefings and meetings, and having managers and workers work together to help resolve a safety issue (e.g., working jointly on a rules revisions; Ranney and Nelson, 2003). For example, say that a root cause analysis suggested that there was a tripping hazard caused by the debris in the yard. One solution might be for the organization to schedule a paid clean-up day where BOTH labor and management spend part of the day cleaning up the yard.

More Comprehensive View of Safety and Risk Management

Although clearly communicating a commitment to safety is important, safety problems can arise from things other than employees not following accepted safety protocol. Reason (1990), for example, drew a distinction between violations and errors. Violations represent intentional deviations from acceptable and necessary practices (Reason, 1990). Violations may occur for any number of reasons, some of which include perceptions of role overload, time pressure, or other strategic objectives being given higher priority (Hofmann and Stetzer, 1996; Reason, 1990; Zohar, 2003). For example, Zohar (2003) recently discussed the relative priority of safety versus other demands such as productivity. As certain demands for productivity increase, the social context may reinforce engaging in safety violations (e.g., safety shortcuts) in order to meet these demands. Related to this line of reasoning, Hofmann and Stetzer (1996) investigated the relationship between factors describing the social context (e.g., role overload, group process) and the degree to which employees engage in minor unsafe behavior. They found, among other things, that when employees perceived time pressure and significant role overload, they were more likely to engage in minor safety shortcuts. These shortcuts were associated with the occurrence of more significant accidents within the work teams (i.e., recordable accidents as defined by the Occupational Safety and Health Administration).

In terms of the motivation for committing these violations, I believe that individuals rarely engage in behavior designed to purposely damage the organization, other workers, or themselves (although see Griffin, O'Leary-Kelly, and Pritchard, 2004; Skarlicki and Folger,

1997). Thus, their behavior is motivated, most often, by a desire to accomplish some positive organizational outcome. Furthermore, given that negative consequences (i.e., injuries or damage to the organization) rarely occur following these violations, employees likely perceive little "cost" to these behaviors. An employee might think, for example, that enacting safety shortcuts will enable them to accomplish some organizational goal (e.g., increased production) with very little increased risk (i.e., little increased risk of injury). Reinforcing these thoughts about the small degree of risk associated with these behaviors may be an organizational context that highly rewards and values production with safety receiving a lower strategic priority (Zohar, 2003). Thus, for our purposes we will assume that routine violations have the following defining characteristics: (*a*) they are designed to accomplish some positive and desired goal, but where the behaviors enacted to accomplish this goal represent a deviation from accepted policies and procedures; and (*b*) there is an assumption by the actor that there is relatively low risk of injury or damage to themselves, others, or the organization.

Violations, however, are not the only way in which safety and risk problems can come about. Whenever individuals are involved, there will be errors. Reason (1990) defined error as "a generic term to encompass occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency" (p. 9). Based on this definition, the necessary conditions for concluding that a given failure emerges from an "error" are: (*a*) there is a plan in place and (*b*) this plan does not achieve its intended outcome. Within these necessary conditions, one can further think of errors as occurring because the chosen plan was not executed properly (i.e., execution failures) or because the wrong plan was chosen and executed (i.e., planning failures; Reason, 1990). The overriding theme of errors, therefore, is that individuals are trying to do the right thing, but they are unsuccessful due to a mistakenly faulty plan or a miscue in the execution of the correct plan. Errors are cited quite frequently as underlying causes to railway accidents and incidents (Baysari, McIntosh, and Wilson, 2008; Edkins and Pollock, 1997).

Looking across the distinctions between errors and violations and how organizations attempt to cope with these types of failures, two underlying dimensions seem to emerge. The first dimension focuses on the intentionality of the actor's behavior to achieve the desired outcome. Specifically, was the actor trying to accomplish some expected and desired outcome (e.g., such as increasing productivity or lifting a patient out of bed) through a generally accepted process or through a deviation from this accepted protocol (i.e., correct versus incorrect intentions regarding the behavior)? While this first dimension involves an assessment of the actor's behaviors used to accomplish some desired or expected outcome, the second dimension focuses on the different orientations to safety and errors that organizations can adopt. Specifically, this dimension describes orientations that are either prevention or management focused. The distinction here is that systems focused on prevention attempt to stop or encourage behavior prior to action, whereas systems focused on management attempt to facilitate the recovery and learning from behavior that has already been performed. Thus, in order for a team to establish an integrative risk management system each of the following activities are necessary:

- Proactively seek to reduce violations. This is where things like safety climate and culture come into play. The goal of creating a strong safety culture is to clearly communicate to employees through multiple ways that following organizational policies and procedures is expected, valued, rewarded, and supported.

- Proactively seek to reduce errors. The organization seeks to design the job and the supporting systems in such a way that errors are prevented. This is really the focus of systems engineering: designing the system so that doing the wrong thing erroneously is difficult or impossible to do. Say, for example, in a survey you ask people to rank several different items and the sum must equal 100. In this case, you could program the software so that if an individual's ranks did not sum to 100, then he will not be allowed to proceed to the next part of the survey. This is proactive error prevention—making the system so that it prevents errors.
- Effectively respond following errors. The focus here is on building a culture where errors are caught and managed before negative consequences accrue. This involves creating cultures where individuals are monitoring each others' work, where individuals feel safe in asking for help if things don't "look right," and where multiple people review products, output, etc.
- Effectively respond following violations. In this case, an individual has knowingly violated an organizational policy. This is where progressive discipline from a human resource management perspective can come into play. The organization needs to see that ramifications do happen when accepted practices are violated. Of course, these ramifications need to be justly and fairly carried out.

This approach to managing human failures within organizations suggests that organizations should approach safety in light of both the contributing type of individual behavior as well as the larger system within which they are imbedded. Clearly specifying these underlying distinctions, and perhaps revising our evaluation of organizational systems related to safety to include the approach to errors, system design, and human resource management policies and practices. This comprehensive approach should enable researchers to better develop a comprehensive understanding of human failure in organizations and how to successfully manage and prevent it.

Throughout this paper, there has been an underlying focus on how leaders in general, and team leaders in particular, are responsible for aligning multiple organizational systems to communicate a consistent message surrounding safety in terms of both espoused and enacted values. The focus of the first part of the article was on leaderships' role in helping to create a safety culture throughout the entire organization. The broader view of safety just discussed takes this systematic view of organizations one step further suggesting that how the organization approaches errors, how they design their organization from a systems engineering perspective, and how their human resource management policies and practices may all play an interconnected and interdependent role in creating a safe organization. With respect to the rail industry, this suggests that many different areas within the organization will need to come together to plan and implement a comprehensive approach to safety in order to significantly improve safety performance.

SUMMARY

Leaders at all levels within organizations need to recognize that it takes complementary and mutually reinforcing organizational systems to create a positive safety culture and to provide the necessary organizational support to ensure the success of team-based safety interventions. They cannot simply identify an intervention—such as behavioral safety—and assume that the implementation will be successful without building the necessary supporting structure (Hofmann

and Stetzer, 1999). This would involve things like ensuring leaders at all levels, particularly those team leaders on the front line of the organization, reinforce the value of safety and help support the teams and their activities. Other supporting structures—for example, aligning incentives, ensuring all the required information is readily available, making sure that the intervention is consistent with the way the job is designed, developing appropriate metrics to evaluate both implementation progress and the ultimate effectiveness of the project, etc.—all need to signal that safety is important and that this intervention is valued and supported at all levels of the organization.

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Detailed Summary of Breakout Group Discussions

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Three breakout group discussions followed the presentations from the guest speakers. After a brief recap of the main points of the presentations, the breakout session moderators followed the agenda below to facilitate discussions:

1. Introduction of breakout participants, and setting of objectives;
2. General discussion of the papers presented by the speakers, specific to the breakout session group;
3. Documenting the issues and concerns, i.e., recognition of issues within your organization, and plans within the organization for addressing these issues;
4. Identify promising practices for potential wider adoption, including approaches already tried and degree of success;
5. Identify the next steps; and
6. Finalize the group's report-out briefing.

On day two of the conference, the key issues emerging from the three breakout discussions were reported, each followed by a question-and-answer session. A summary of the three breakout sessions follow each consisting of the range of issues, promising practices, lessons learned, and takeaways. The views expressed in these summaries are those of individual speakers and discussants at the Conference and are not to be construed as consensus views or findings of the conference participants.

TEAM EFFECTIVENESS BREAKOUT SESSION

Range of Issues

- A need for cultural change. Many participants observed that there is a need for an overall change in railroad safety culture, which tends to be very conservative and has not changed significantly during many decades of operation. That being said, a number of major railroads now are adopting safety strategies, and these should be seen as leading the way in this area. If safety becomes a core value adopted by railroad companies, there is less likelihood it will be a secondary consideration to the bottom line. Adopting safety as a core value means that safety is taken into consideration in all facets of railroad operations and not just in response to any specific incident.
- Resistance to change. In the railroad industry, as in many other industries, it was noted that there continues to be a general resistance to change if there is no demonstrable benefit to the business case. Instituting change can involve monetary costs which may, on the face of it, be difficult to justify. However, as other industries have found, safety also can provide financial

benefits in the longer term. There is more realization of the potential costs due to litigation arising from errors and accidents, and hospitals in particular now are using teaming as an effective way to reduce the occurrences of such events.

- Top-down enforcement. The point was made that safety needs to be seen as a priority enforced from the top of the management chain, down through middle management structure, and into the teams. The message and the importance of this flow down can become lost in middle management without continued oversight and attention from above. Furthermore, a relatively short leadership rotation period does not help in providing a continued emphasis on safety and the enforcement of the cultural changes necessary to maintain it.
- A culture of blame and discipline. There was considerable discussion about a blame culture existing in the industry. “Discipline is a codeword for punishment.” This brings about an unwillingness by crews to admit to errors that, while not resulting in a catastrophe in any one instance (e.g., close calls), can lead to complacency or the avoidance of necessary steps to engineer out the potential for errors. Often errors and violations are treated in the same way. As the airline industry has championed over the years, there is a need for an environment where crews can admit to errors without disciplinary procedures being taken by management. Only if company management and union officials work more closely on this aspect, participants observed, will a trusting environment be established.
- Management oversight. Often in the railroad industry, crews operate without direct management supervision, especially when operating over a wide geographical area on track maintenance activities. Crews who form these teams can often be made up of individuals who prefer to operate on their own in a loose grouping. This can make it difficult to oversee their performance, ensure their safety, and bring about a unified approach to problem solving.

Promising Practices

There are a number of pilot programs within the railroad industry that are now being expanded more widely and can be developed and promulgated further. One key is first to demonstrate success within a pilot program. Below are examples raised at the session:

- The Total Safety Culture adopted by UP. A central feature of this program is Operation Red Block, which was adopted within UP in 1983 with the United Transportation Union and the Brotherhood of Locomotive Engineers. Operation Red Block is based on the idea that employees have the right to a drug- and alcohol-free work environment. Peer-to-peer programs of this nature can be expanded beyond a drug and alcohol basis to include operations safety for work crews.
- The ISROP as introduced by CPR in 2002. CPR developed ISROP to standardize procedures, increase the amount of data collected and its quality, and thereby better understand the factors involved in unsafe practices. Improvements have been seen across the board through corrective actions undertaken.
- C3RS is a partnership between the railroads, labor, and the FRA. This system enables confidential reporting of safety hazards, without the threat of disciplinary action on the individual. Based on the hazards identified, measures can be taken proactively to reduce risks before accidents occur.

Additional potential areas for improvement:

- Training work crews to spot signs of fatigue among their crew members.
- Develop a “look after my buddy” mentality.
- Flow down of successful programs and practices from large railroad companies to smaller ones.

Lessons Learned

- Prebriefing and debriefing of operations, both of the team and the individual, can be a powerful approach to ensuring safety. This is used extensively in the aviation business and the military, and also is showing positive results in the medical world, especially in the operating theater. Key to its success is that the briefing has to be immediate and systematic.
- Operation Red Block Program, as described above, could be a model for other companies as a way in which a companywide safety culture may be adopted.
- Introduction of safety initiatives in a railroad by division can show improvements more quickly than systemwide programs.
- Results of pilot studies, while providing indications of progress, may not easily be extrapolated to wider implementation throughout the industry.
- Railroad companies are developing programs for their organization from within, with beneficial input and involvement from labor.
- Improved evaluation tools would allow the overall effects of safety actions to be estimated. In particular, participants cited the need for additional measures of success, other than number of accidents. One example would be to look not just at accident rates but also to consider measures of length of time between them.

Takeaways

The following approaches to improving safety were identified as takeaways from this breakout session:

- Safety could become a core value within the railroad company, not a secondary issue after business considerations.
- A systemwide approach to command and control for safety could be adopted throughout the railroad industry, along with crew resource management.
- Middle management is often cited as a barrier to the top-down adoption of safety planning approaches. This could be addressed through the adoption of training programs for middle managers that are related specifically to teaming concerns and safety.
- The C3RS approach could be expanded to include all railroad companies, with hotlines available for employees to voluntarily report where a close call may have led to an incident or accident.
- Fatigue management has moved forward significantly in some railroad companies, but more work can be done to expand this important tool.
- It could be helpful to identify influencers and informal leaders who “get the message,” and who can successfully influence their coworkers to adopt safe working techniques.

- Participants discussed the usefulness of a white paper that would create a mental model or teamwork schema of the kinds of operations and communications within different types of teams throughout the industry. This could provide a good starting point.
- Salas summarized the way in which he would approach the question of how to instill safety as a core value. Starting with an organizational needs analysis to get back to basics, and an understanding of the available data, try to understand some of the barriers and ways to facilitate the process. There also needs to be a better understanding of whether the industry is ready to embrace the concept. A compelling business case could be made as to why the adoption of safety as a core value is the right thing to do.

TEAM COMMUNICATION BREAKOUT SESSION

A number of issues discussed in the communications breakout session were similar to those discussed in the effectiveness breakout session. Nevertheless, they are included here so as to reflect all the issues discussed.

Range of Issues

- Loss of party line. Currently, a crew may have one radio channel assigned to them, but still have the opportunity to listen in to communications to other crews. This wider communication allows for shared mental models and, importantly, wider situational awareness among the crews. The Rail Safety Improvement Act of 2008 mandates that all Class I railroads, and those providing regularly scheduled intercity or commuter rail passenger service, implement PTC by 2015. This requires centralized command and control of rail traffic. However, central control of communications raises concerns that announcements will not be made over broadcast airwaves such that personnel may not be in a position to hear critical communications. Such communications may have alerted them to potentially dangerous situations, for example, knowledge of a train's locations. However, there also is the potential for communications that are widely broadcast being misunderstood, with catastrophic results. One potential solution, with increasingly sophisticated digital radios now becoming available, is that additional information will be available to the operator, including from whom the communication originated, where the message is coming from, and for whom it is intended, etc.
- Discipline as an impediment to open communication. Trying to get to the root cause of certain incidents can be difficult because the personnel with the best knowledge may be reticent to say or sign their name to anything that could end up with a disciplinary action. Consequently, there may be potentially important incidents or situations that arise with implications for safety of which management is unaware.
- Switching Operations Fatality Analysis (SOFA). The SOFA data collection program was begun in 1998 to better understand fatalities that were occurring during switching of trains. Measures have been adopted by railroads, although there is not a clear appreciation of what these are. Moreover, in the past couple of years there has been an increase in the number of switching-related fatalities. The SOFA working group is being reconvened to look at whether implementation guidelines still are being followed, to gauge the breadth of utilization of the recommendations, and how to get the message out to the industry effectively. One question that will need to be addressed is whether the increase in switching fatalities represents the same

causation patterns, or whether new patterns exist. One participant pointed out that switching operations have changed substantially since the SOFA report was completed.

- Information overload/nonoptimal presentation. Issues exist around the amount of information workers need to be aware of, and the way it is organized, particularly with respect to rulebooks. There are multiple rulebooks among the multiple railroads, many of which have conflicting information. Furthermore, this problem has been exacerbated with railroad mergers that have taken place over the years, increasing the opportunity for errors. There was a general discussion about homogenizing rules, at the same time recognizing that there were significant differences in philosophy among railroads, particularly between railroads that operate in the east versus the west. Rulebooks within the European Community now have been integrated across multiple railroads within different countries. This could provide a model for integration within the United States.
- Signal uniformity. Signals can differ across railroads and within a given territory. Unless the crew is paying specific attention and is conscious of the different configurations between territories, there is potential for confusion and accidents.

Promising Practices

There are initiatives in place that are showing promise in improving communications, as outlined below:

- Peer-to-peer monitoring programs have been shown to improve behavior-based safety at UP, and other railroads are considering this approach.
- As detailed in the Team Effectiveness Breakout Session report, a total safety culture, as developed at UP shows promise. However, implementation on a larger scale is necessary if the industry is to benefit measurably.
- Team-based training is being discussed as a moniker for training programs. Using this title rather than CRM may provide a clearer indication as to the purpose of the training.
- The close calls program, described above, is still in the pilot phase, but is considered promising. This program makes it possible for individuals to talk about unsafe conditions and report them. However, some efforts to implement this approach have failed over the issue of discipline.

Lessons Learned

- Many participants noted the importance of local union leadership buy in to the safety culture.
- It was also observed that those involved need to be those who are directly impacted and involved in the implementation of a safety program. The design of the program is often best left to the individuals who are going to work with it on a day-to-day basis.
- Program implementation is a partnership, and potentially much more involved than may be anticipated at the outset. Hence the importance of having leadership that is supportive of the process, and being seen to be so.
- Many participants emphasized that regular evaluation of any changes made to procedures is necessary for sustainability.

- There was a detailed discussion on the issue of multiple rulebooks. The multiple rulebook issue is a major concern. Outlined below are the various issues that were raised:
  - With each railroad having a stake in any proposed changes to the rules, homogenization of the various rules can be very hard to achieve. A problem that consistently occurred was that the clearer and simpler a rule was, the more the railroads said it was too restrictive. In reality, it was noted, to have an effective rule, everyone's procedure is going to have to be the same. One approach is first to work with the railroads that have the most problems and then work to homogenize those rules first. Other problem areas can be addressed subsequently.
  - In addition to various rulebooks, industry is taking full advantage of modern digital technologies and providing rulebooks in electronic format. One of the downsides of using such a format is that new employees may have no one with whom they can discuss how specific rules are implemented.
  - Proliferation of different rules tends to reinforce a blame-based system. ("When there are so many rules, you can always blame an individual.") There is anecdotal evidence that when labor and management coordinate on safety rules, it can reduce liability in court cases because the rules were clear. Also, it was much more difficult to shift the blame to another party because it was a joint effort.
  - As a result of mergers among railroad companies, rulebooks have been consolidated and progress has been made. However, there is still a major difference in philosophy between railroads that operate in the eastern areas of the United States versus the west. Participants noted that consolidation is not going to happen quickly, but there is no question that it is occurring.
  - The potential impact on communications to and between workers was again discussed, particularly with regard to the Rail Safety Improvement Act and the use of digital communication devices. The importance of shared communication is understood, but there have been catastrophic accidents where transmissions had been misunderstood. With the future demise of party line (see above), there will likely be more importance placed on precise communication. Participants noted that in instances where adjacent track work is going on, this will be especially critical. There is a lot of work to be done on handheld communication units, units on trucks, and what types of information should be displayed.
  - The European Union (EU) has had similar problems due to multiple rulebooks among the different countries operating on the same railroads. The EU is integrating these rulebooks, so it might be worthwhile to begin a dialogue with the EU to understand the process and lessons learned.

TEAM LEADERSHIP BREAKOUT SESSION

Range of Issues

- Issues with management. There were a range of topics discussed within the category of management issues. Managers today have many more administrative responsibilities than in the past, leaving less time to get out into the field. Middle managers also may have gaps in their skills, capabilities, and experience. It was noted that the low ratio of supervisors to employees

can be a problem, with employees lacking direct supervision. Management can be seen to be hands off, with little vertical flow of information.

- Generational issues. The new generation of employees is seen as having different priorities with respect to the work–life balance. It is felt that they give more priority to life outside of work than do the older, more established workforce. This may require a different type of employment contract in order to recruit them into the industry—one that recognizes their priorities outside of the workplace.
- Safety not at the forefront. NTSB is not investigating all accidents, as they have in the past, due to low manpower or other issues. Safety might not be at the forefront of the minds of senior management, and there are incentives to put productivity (i.e., bottom line and profit) ahead of safety for workers. As noted above, because of hands-off management approaches there may be limited opportunities to reinforce the safety message.
- Inconsistent communication. Problems were noted with enforcing safety attitudes with front-line managers.
- Informal leaders. There are individuals within the railroad industry who are not located on any leadership flowcharts but who can be very influential. It would be useful to identify who they are and their roles, but it can be difficult to figure out who those people are, and how best to use them.

Promising Practices

Attendees from the railroad industry and labor unions identified promising practices within their companies that were not tied to the pilot programs identified above.

- It was observed that workers are taking a stance for safety. They are refusing to engage in unsafe behavior, and are being supported by their first line managers.
- FRA inspectors can encourage managers to be consistent in their communication about safety.
- Some reported that there are more daily conference calls on safety-related occurrences. Topics of the discussions may include injuries that have occurred, how to prevent them in the future, and implementation of potential corrective actions. Other examples include evaluations of problematic train handling issues and how to correct them.
- Managers model safety behavior in order for their employees to engage in safe behavior.

Lessons Learned

- Including managers in training can help them to better perform their roles. When pilot programs are instituted, train managers as well as workers to ensure a successful outcome. In some railroads, managers are being included in the team; they receive training about their role and how to support others.
- Managers cannot be disciplinarians one day, and provide developmental guidance the next. For consistency they cannot go back and forth; participants noted that they need to choose one style.
- In the military, safety data goes all the way up through the chain of command. Within some companies it may be getting filtered out, going only to the safety department. Tracking

how far up in the organization the safety data is promulgated, and how frequently, can provide an indication of the success of the effort to make safety a priority.

- Metrics are important, not only to measure operational performance, but also to recognize and reward teams and individuals. There are many forms of data metrics. The key is to know what data are available, and whether the data are meaningful and relevant.

Takeaways

- Many participants cited the fact that the railroad industry is talking about leadership and generational differences as a good sign. The industry is acknowledging that there are problems and talking about possible solutions.
- Effective leadership was seen as critical at every level—managers who believe in what they are doing and foster the message throughout the workforce.
- Making safety a core value, not just a goal, was seen as critical by many participants. In today's military, safety is on a par with mission performance. With rail operator's lives at stake, safety needs to be a priority. But a more constructive safety culture, with everyone pulling together towards one goal, can also sustain the day-to-day operations more efficiently.
- Owning up to errors remains a challenge in the railroad industry.
- Good leaders have a charisma that positively influences the workforce. However, it is possible to outsource charisma, having someone other than the leader talk about the value of safety, and still be effective. The communication of safety messages does not always have to flow down from the top but also can be effectively communicated by those who are directly impacted by their actions—for example, patients could deliver a message to doctors and their teams of the positive impact their work had on their own lives.
- The workforce could benefit from hearing from top management that there is a commitment to the safety culture, but also from their peers to whom they can relate more closely and people whom they respect.
- A gap in leadership training and development was identified. In the highway safety arena, some states have highway safety committees with representatives from many different organizations and agencies. Standardized materials have been developed for use by the states which puts all the basic information in one place, which can then be tailored for individual users. Also, some airlines and health care providers are using this approach. A challenge may be to find a railroad which will volunteer to pilot such an approach, although a smaller railroad may be a good starting point.

APPENDIX A

Conference Agenda

Conference on Teamwork in U.S. Railroad Operations
Beckman Center
Irvine, California
April 23–24, 2009

THURSDAY, APRIL 23, 2009

7:30 a.m.	Breakfast at Beckman Center
8:00 a.m.	Introduction and agenda
8:20 a.m.	Speaker 1: Eduardo Salas
9:20 a.m.	Speaker 2: Elliot Entin
10:20 a.m.	Break
10:35 a.m.	Speaker 3: David Hofmann
11:35 a.m.	Audience discussion
11:55 a.m.	Instructions for breakout sessions
12:00 p.m.	Lunch at Beckman Center
1:30 p.m.	Concurrent breakout sessions
3:30 p.m.	Break
3:45 p.m.	Breakout sessions resume
5:30 p.m.	Adjourn

FRIDAY, APRIL 24, 2009

8:00 a.m.	Breakfast at Beckman Center
8:30 a.m.	Agenda review
8:40 a.m.	Breakout Session 1 report out; Q and A
9:30 a.m.	Breakout Session 2 report out; Q and A
10:10 a.m.	Break
10:20 a.m.	Breakout Session 3 report out; Q and A
11:25 a.m.	Discuss next steps; concluding remarks

APPENDIX B

Conference Participants

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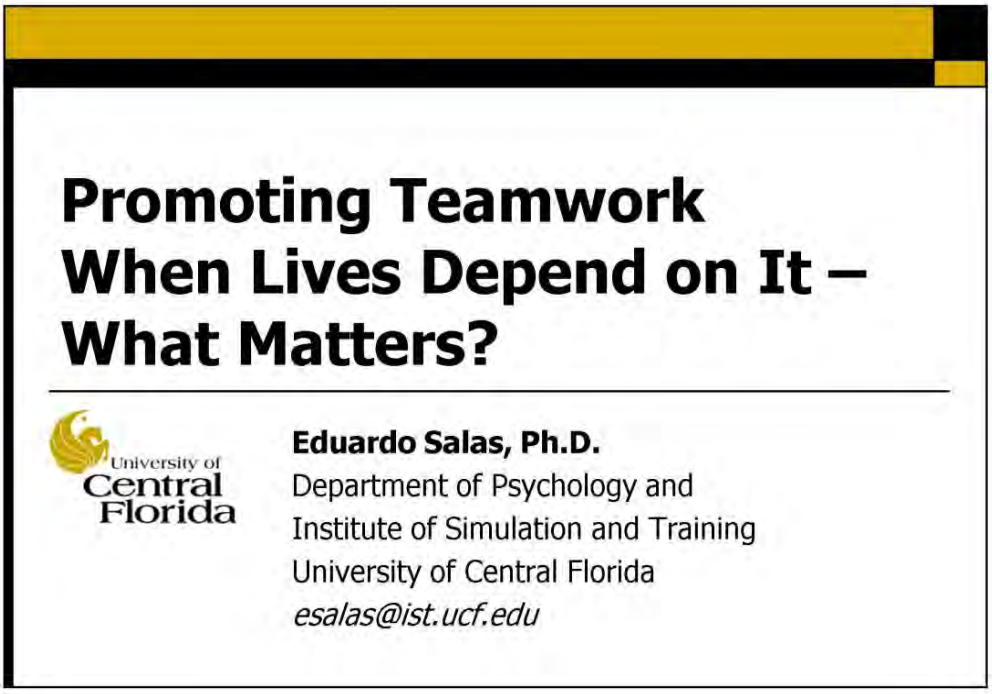
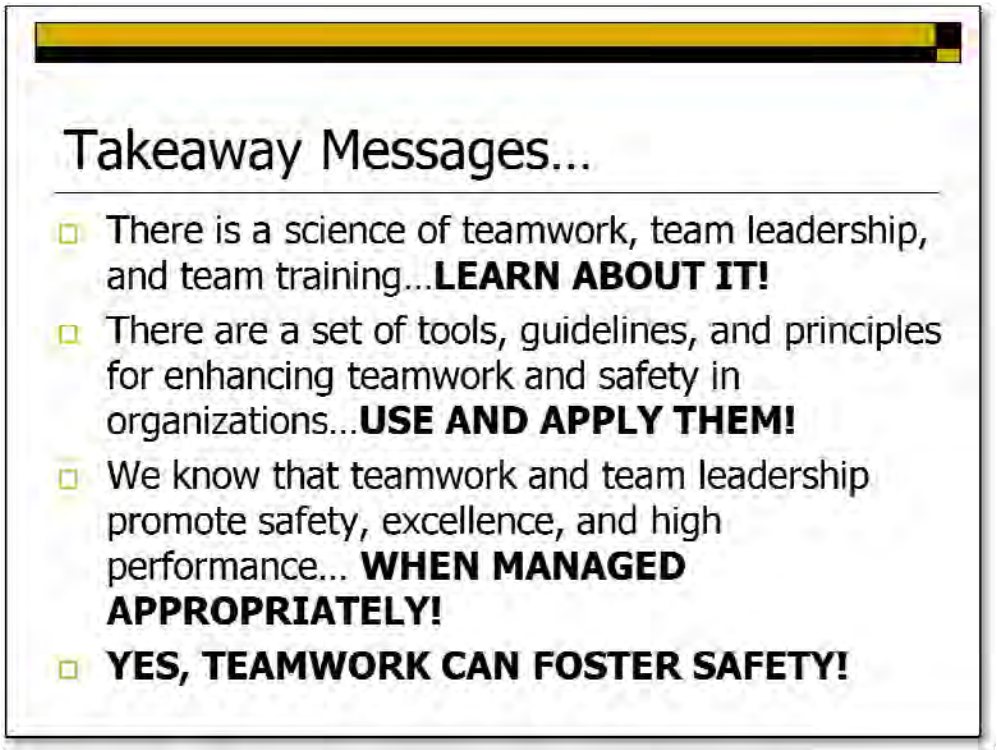
APPENDIX C

Guest Speaker PowerPoint Presentations



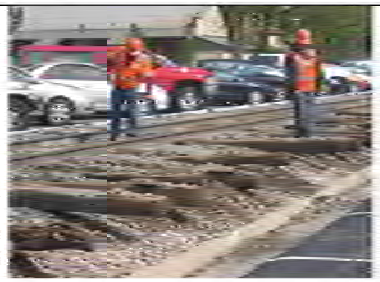


Outline of Presentation

I. What is the State of the Science?
II. What do High Reliability Teams do well?
III. What does it take to promote teamwork?
   - Tips
IV. What is the evidence?
V. What must the railroad industry do to ensure success?
   - What matters!
VI. Concluding remarks

Who Cares About Teamwork?



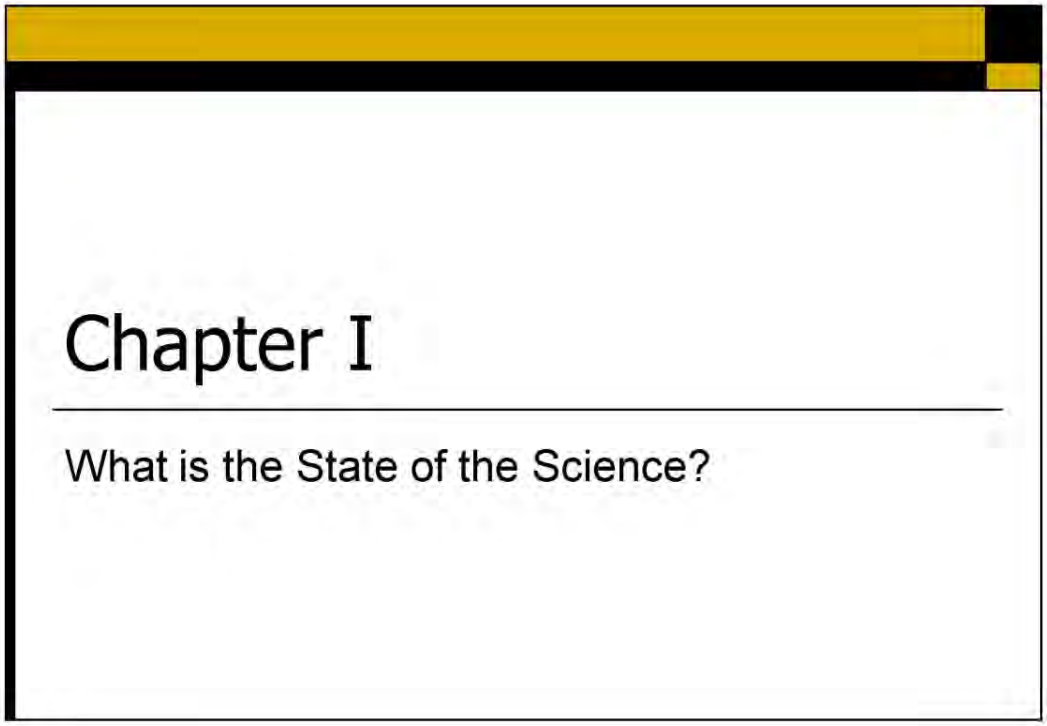


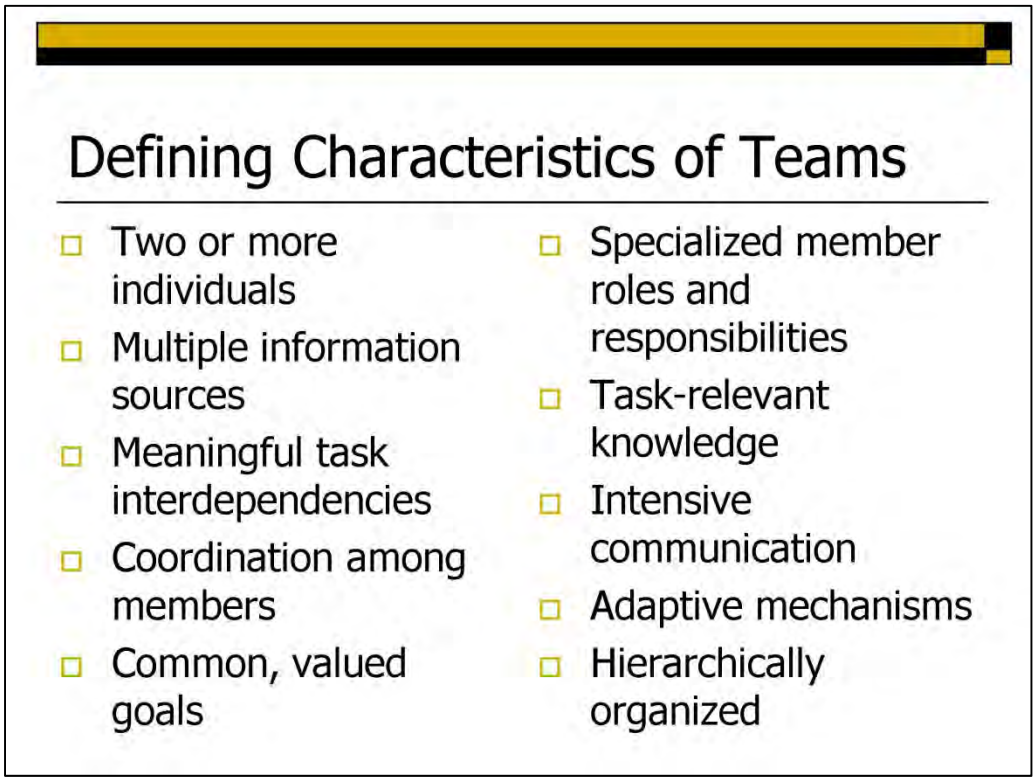
Why Research Continues?

- 1980 Olympic Team
  - Rookie team.
  - Highly motivated, well coached.
  - Worked together to win a gold medal.
- 2004 Olympic Team
  - Talented athletes.
  - Didn't work as a team on the court.
  - "Superstars" do not make a team.

Why Research Continues?

- The Bay of Pigs, 1962
  - Talented, intelligent policy team.
  - Group think led to unworkable plan and disastrous results.
- USS Vincennes shoots down Iranian airliner, 1988
  - Well-trained team.
  - Lack of understanding regarding information and perspectives resulted in catastrophic consequences.





Defining Characteristics of the Environment

- Complex, Multicomponent Decisions
- Rapidly Evolving Ambiguous Situations
- Information Overload
- Severe Time Pressure
- Severe Consequences of Error
- Adverse Physical Conditions
- Performance/Command Pressure
- Distributed Multioperator Problems

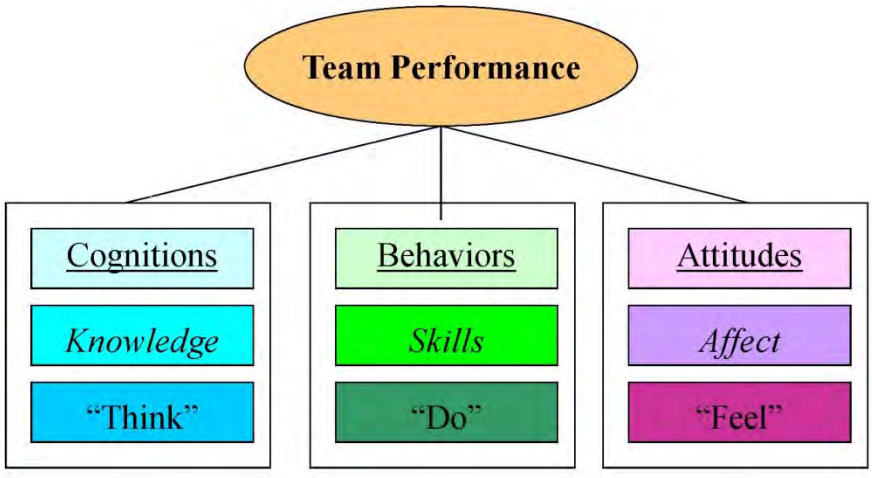
What is the State of the Science?

How Do We Turn a Team of Experts into an Expert Team?

What is the State of the Science?

- Theoretically driven
  - "Nothing more practical than a good theory."
- Studying real teams; performing real tasks
  - "Teams in the Wild"
  - Simulations
- Experts as participants
- Hundreds of teams!

What Comprises Team Performance?



What Are the Required Teamwork Competencies?

- Knowledge requirements in teams:
  - Cue/strategy associations—shared mental models
  - Knowledge of how to get knowledge
  - Teammate characteristics; familiarity
  - Knowledge of team mission, objectives, norms, resources
  - Roles and responsibilities
  - Individual task proficiency; taskwork

What Are the Required Teamwork Competencies?

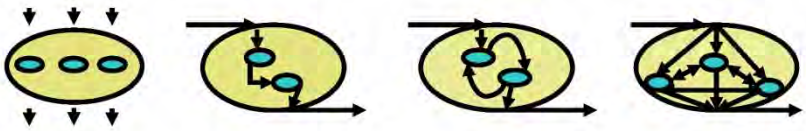
- Skill requirements in teams:
  - Mutual performance monitoring and adaptability
  - Supporting/back-up behavior
  - Team leadership
  - Task-related assertiveness
  - Conflict resolution
  - Closed-loop communication

What Are the Required Teamwork Competencies?

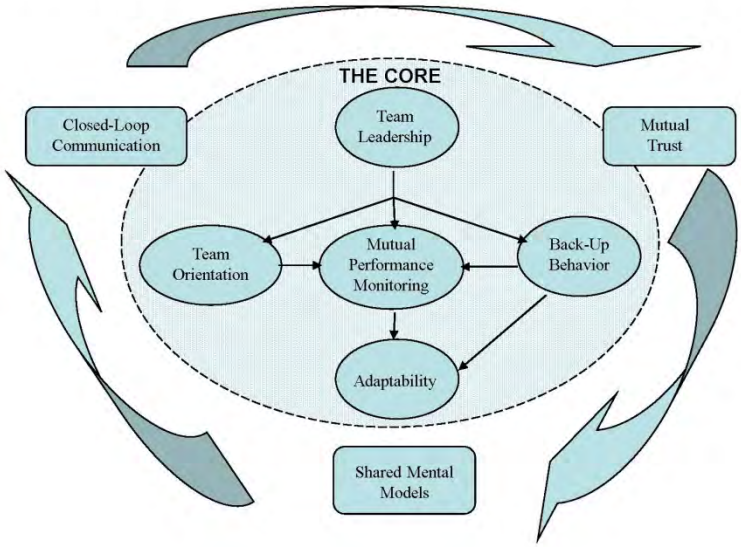
- Attitude requirements in teams:
  - Collective efficacy
  - Shared vision
  - Team cohesion
  - Mutual trust
  - Collective/team orientation
  - Value of teamwork

What is Teamwork?

- It is a set of interrelated actions, events, and behaviors taken to accomplish a team goal.
- It is about…
  - Task work knowledge (i.e., own task).
  - Teamwork knowledge (i.e., how to work together).
  - Building and maintaining both.
- Different forms…



The "Big 5" Teamwork Dimensions



The "Big 5" Teamwork Dimensions

- Mutual Performance Monitoring
  - Observe and keep track of teammates' communications and performance.
  - Recognize when a team member makes a mistake.
  - Recognize when a team member performs exceptionally well.
- Back-up/Situation Assessment/Supportive Behavior
  - Step in and help other teammates.
  - Make sure teammates are aware of what you did.
  - Ask for help when needed.

The "Big 5" Teamwork Dimensions

- Adaptability
  - Recognize changes in the environment.
  - Change functions.
  - Shift strategies when appropriate.
  - Alter behavior to demands.

The "Big 5" Teamwork Dimensions

- Team Leadership
  - Determine task to be assigned.
  - Set expectations for task.
  - Focus team attention on task and provide situation updates.
  - Encourage all members to contribute.
  - Set climate for collaboration.
- Team Orientation
  - Consider teammate input.
  - Accept feedback and assistance.
  - Be willing to observe teammates.

Chapter II

What do High Reliability Teams do well?

What Effective Teams Do Best!

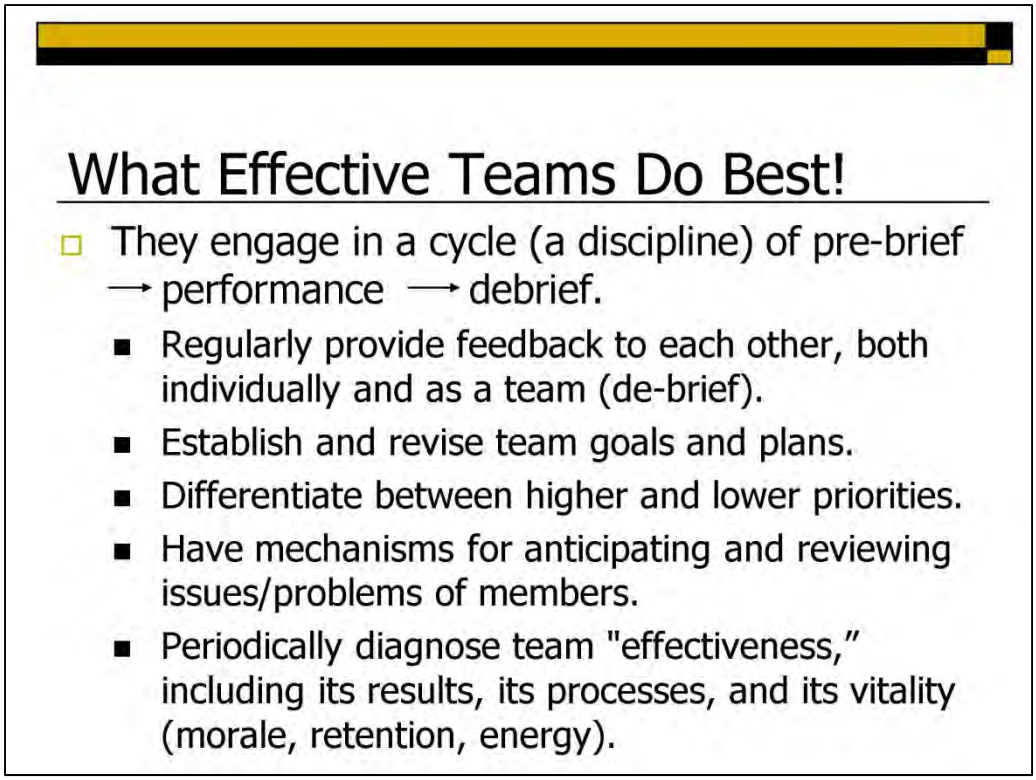
- They hold shared mental models.
  - Have members who anticipate each other.
  - Can coordinate without the need to communicate overtly.
- They optimize resources.
  - Are self correcting.
  - Compensate for each other.
  - Reallocate functions.

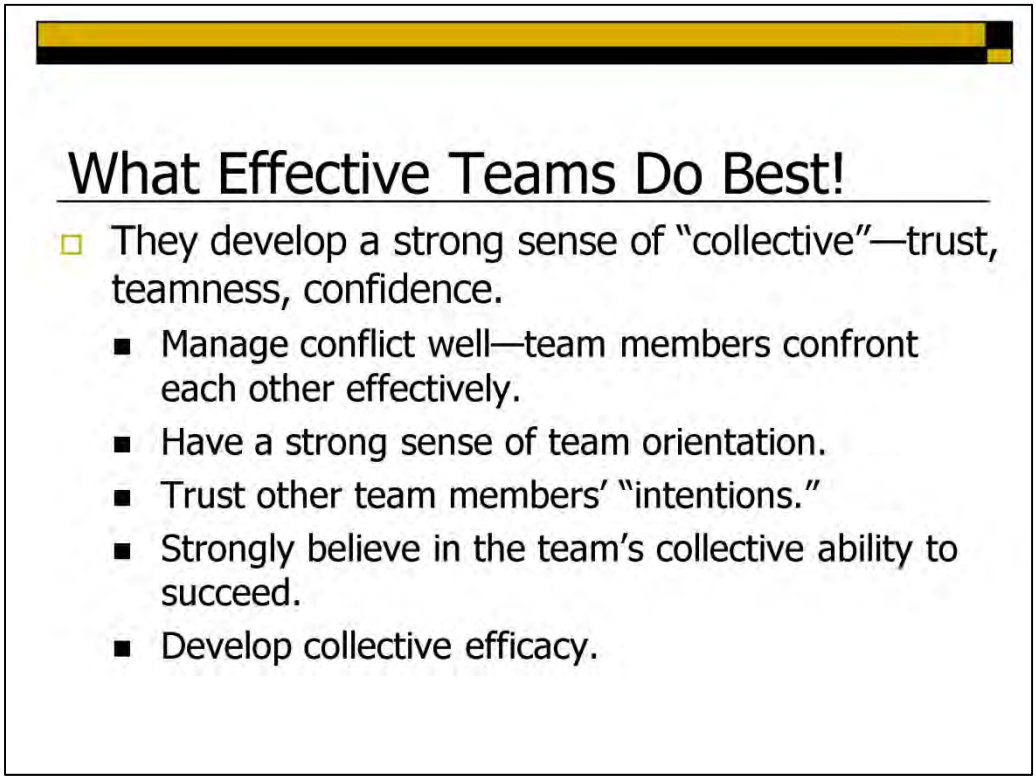
What Effective Teams Do Best!

- They have clear roles and responsibilities.
  - Manage expectations.
  - Have members who understand each others' roles and how they fit together.
  - Ensure team member roles are clear but not overly rigid.
- They have a clear, valued, and shared vision.
  - Have a clear common purpose.

What Effective Teams Do Best!

- They have strong team leadership.
  - Are led by someone with good leadership skills and not just technical competence.
  - Have team members who believe the leaders care about them.
  - Provide situation updates.
  - Foster teamwork, coordination, and cooperation.
  - Self-correct first.



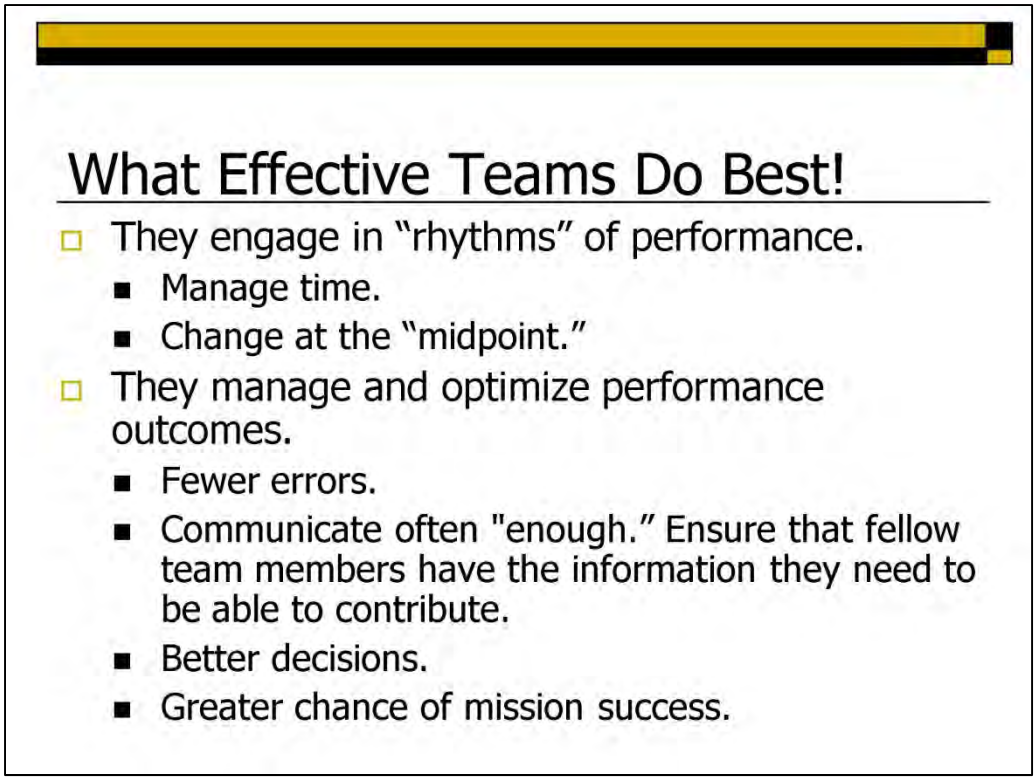


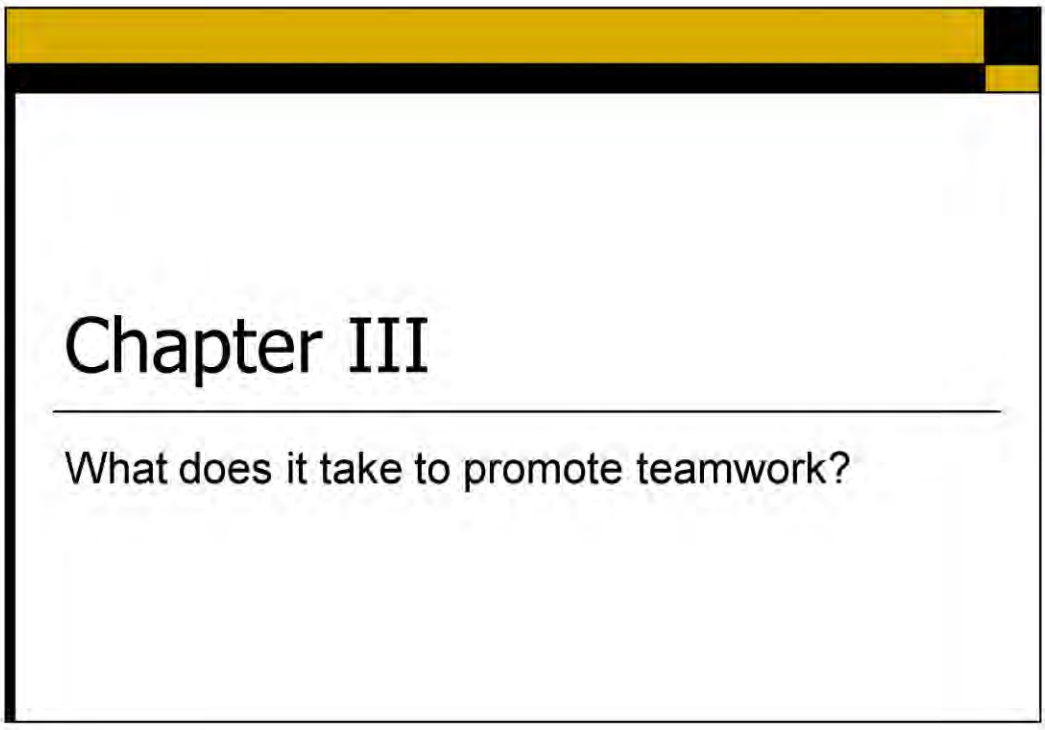
What Effective Teams Do Best!

- They are "workload sponges."
  - Tolerate stress better.
- They have good team leaders.
  - Focus on task-related behaviors.
  - Focus on developing team members.

What Effective Teams Do Best!

- They set expectations well (and are managed).
  - Provide foundation and markers for individual/team self-correction.
  - Increase shared understanding.
  - Increase satisfaction.
- They have teammates that trust each other.
  - Ease conflict resolution.
  - Foster continuous learning/adaptation.
  - Develop "psychological safety."



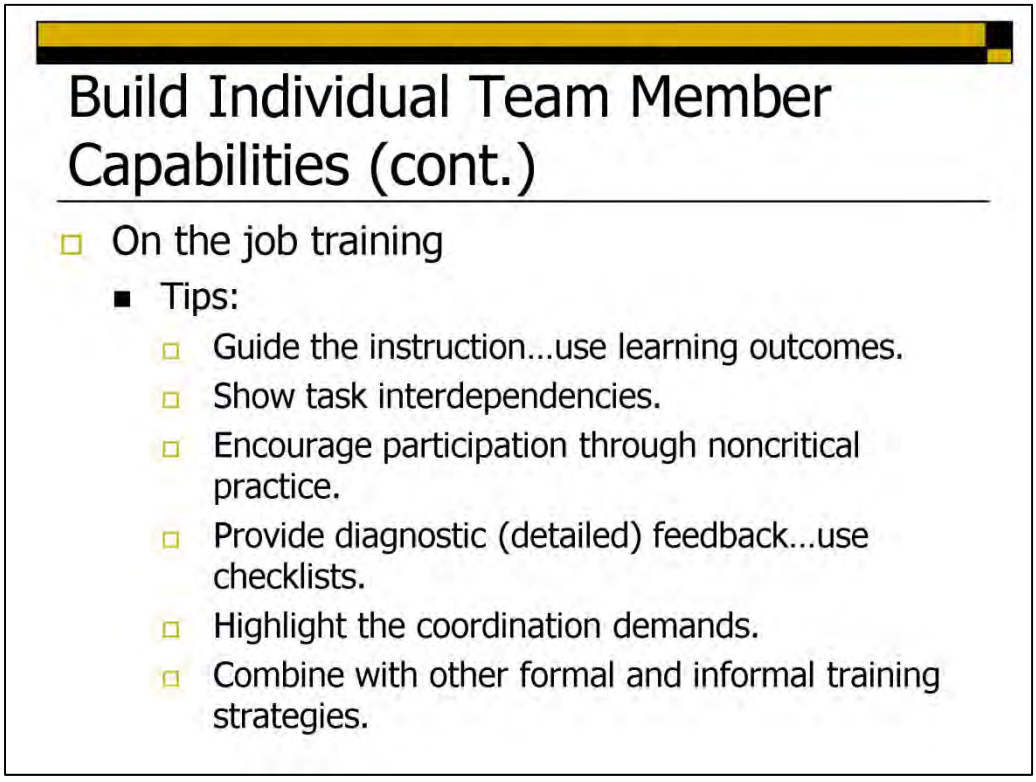


What does it take?

- Build individual team member capabilities.
- Build teamwork competencies (KSAs).
- Create a "culture of teamwork."

Build Individual Team Member Capabilities

- Individual taskwork training
  - Tips:
    - Ensure team members know their job.
    - Provide detailed, timely, and diagnostic feedback.
    - Ensure members know how their jobs intersect with team members.



Build Individual Team Member Capabilities (cont.)

- Coaching/mentoring
  - Tips:
    - Focus on team effort (motivation).
    - Help develop performance strategies.
    - Increase knowledge and skill competencies.
    - Coaching functions will vary through the team task/cycle.
    - Address team processes (moment-to-moment behaviors and actions).

Build Individual Team Member Capabilities (cont.)

- Team leader training
  - Tips:
    - Train team leaders to…
      - Set expectations.
      - Clarify roles.
      - Provide situation updates.
    - Team leaders must…
      - Initiate self-correction.
      - Solicit ideas and observations from team members.
      - Seek out opportunities to reinforce effective teamwork.
      - Request/accept feedback on own performance.

Build Individual Team Member Capabilities (cont.)

- Team leader training
  - Tips (cont):
    - Team leaders must…
      - Provide behavior-oriented rather than person-oriented feedback.
      - Provide specific solution-oriented feedback.
      - Re-state others' feedback to make it constructive.
      - Voice satisfaction when improvements are noted.

Build Teamwork Competencies: Team Training Strategies

- Team training ≠ team building
  - Team training = skill based
  - Team building = role clarification
- Strategies
  - Cross-training (e.g., positional rotation, position clarification training)
  - Team self-correction
  - Scenario-based training
  - Skill/behavior-based team training
  - Team coordination training/CRM
  - Meta-cognition training

Build Teamwork Competencies: Team Training Strategies

- Team training (cont.)
  - Tips:
    - Team training should…
      - Focus on teamwork, not task work.
      - Be based on competency requirements.
      - Be more then just "feel good."
      - Include a context to practice, assist, diagnose, and learn.
      - Be realistic, sub-relevant.
      - Focus on team-based learning outcomes.
      - Be ongoing.

Build Teamwork Competencies: Team Training Strategies

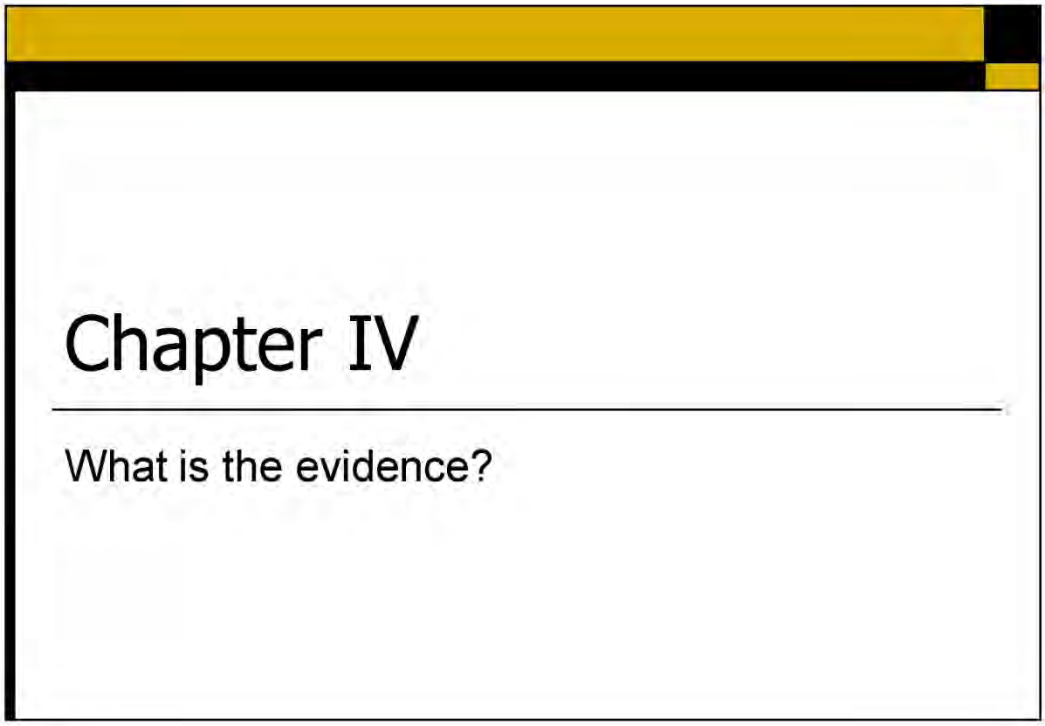
- Cross Training
  - Promotes shared mental models.
  - Allows trainees to experience coworkers' jobs.
  - Makes trainees aware of needed information.
  - Strategies:
    - Job shadowing.
    - Giving team members information about their teammates role/position.

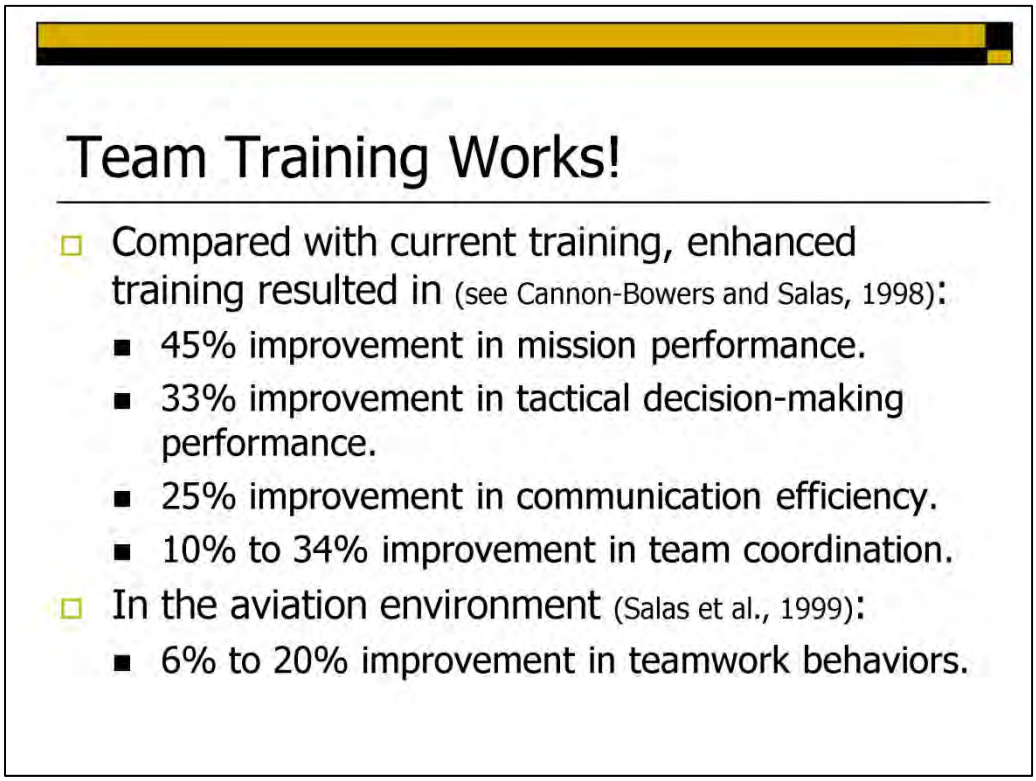
Build Teamwork Competencies: Team Training Strategies

- Team Self Correction
  - "Replay at the bar."
  - Leaders facilitate team critique.
  - Team is questioned regarding specific behaviors linked to key events.
  - Behavioral goals are set.

Creating a Culture of Teamwork

- Teams are embedded in organizations.
- Tips:
  - Establish a culture to foster teamwork.
    - Send right signals.
    - Must come from the top.
  - Measure and reinforce teamwork behaviors.
    - You get what you ask for.
  - Prepare people through team training
    - Evaluate at multiple levels.
  - Foster continuous learning.
    - Promote error checking.
    - Learn from mistakes.





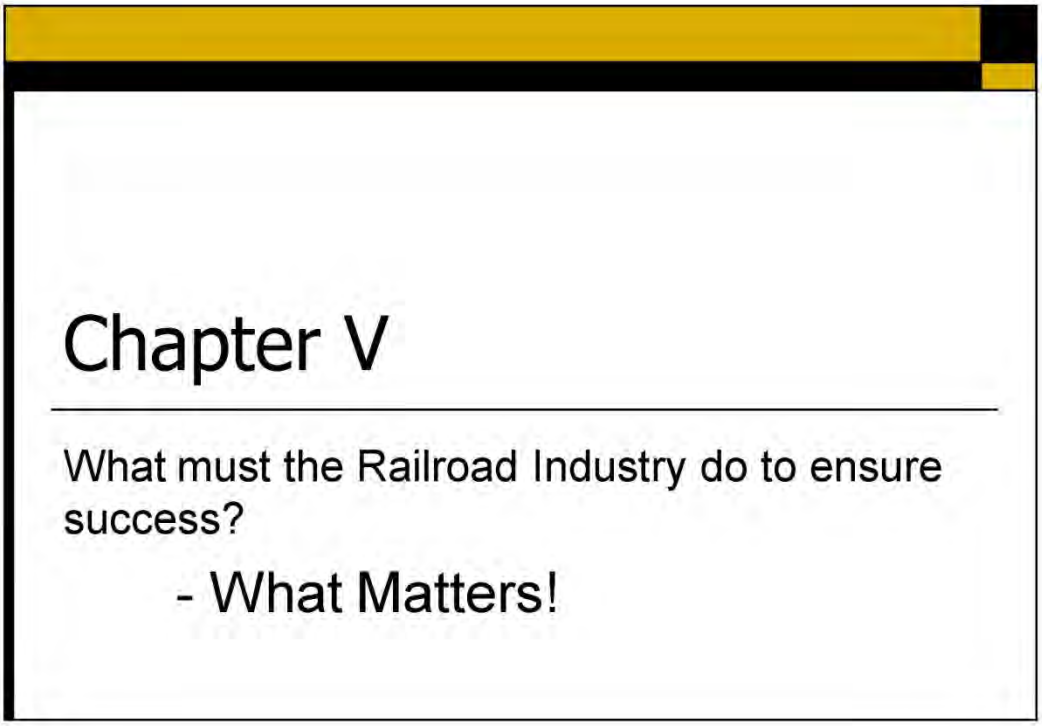
Team Training Meta-Analysis

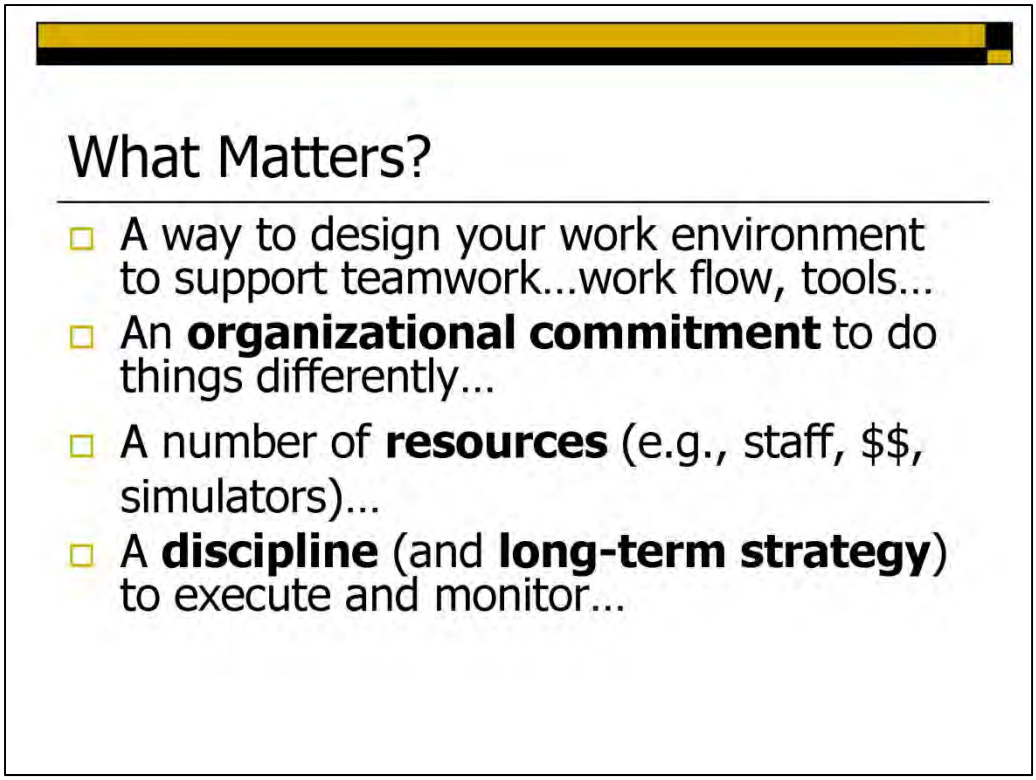
Salas, DiazGranados, Klein, Burke, Stagl, Goodwin, and Halpin (2008)

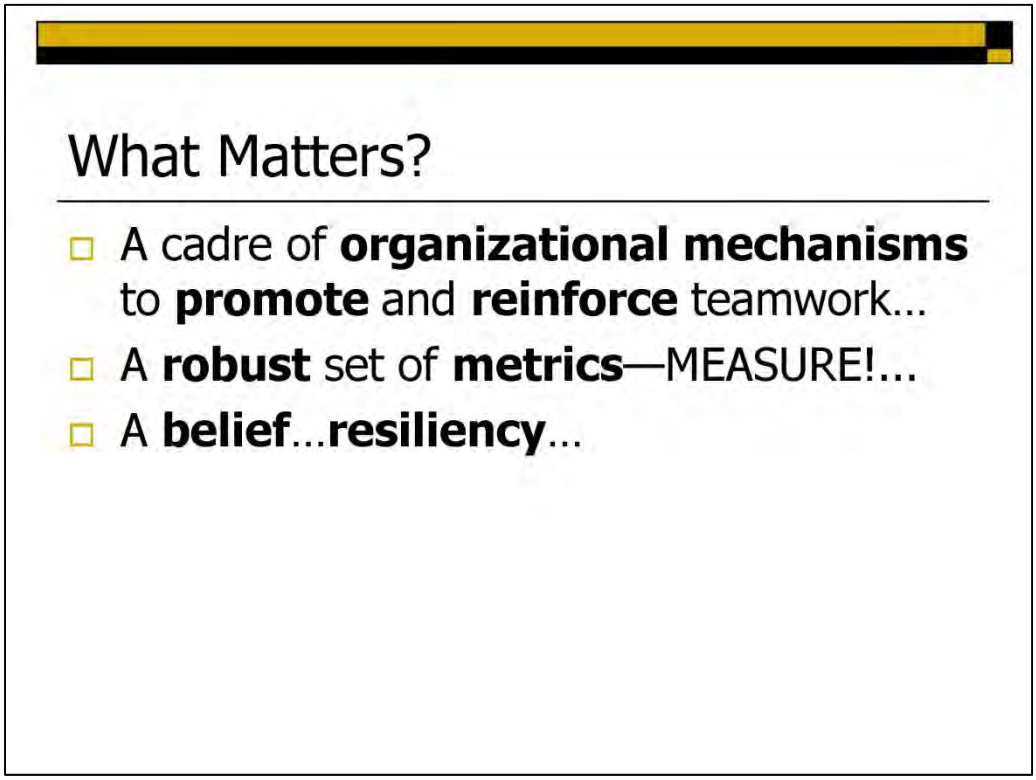
- Overall, team training was shown to have a **moderate, positive effect** on team functioning ($\rho = .34$)
- Four outcomes investigated:
  - Cognitive outcomes ($\rho = .42$)
  - Affective outcomes ($\rho = .35$)
  - Process outcomes ($\rho = .44$)
  - Performance outcomes ($\rho = .39$)
- Team training accounts for about **20%** of the team performance variance.

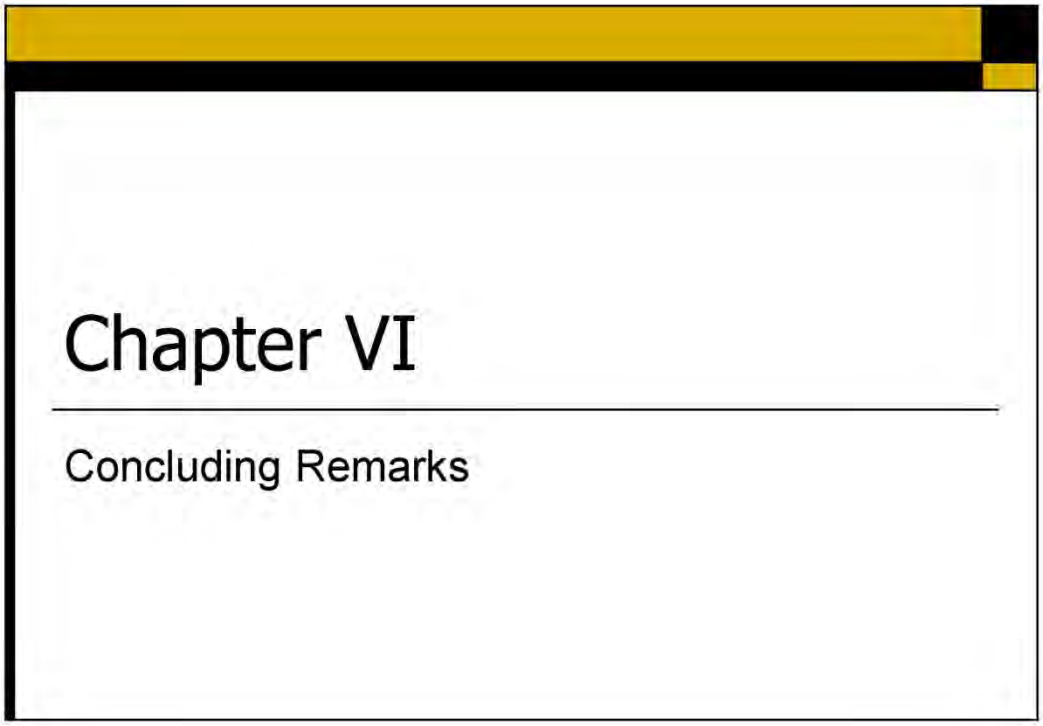
Team-Based Organizations Show...

- High levels of productivity (e.g., Cohen and Ledford, 1994).
  - 89% of studies using self-managing teams report increased productivity (Pasmore et al., 1982).
- Quality (e.g., Applebaum and Batt, 1994).
- Safety (e.g., Goodman et al., 1988; Trist et al., 1977).
- Job satisfaction (e.g., Cordery, Mueller, and Smith, 1991).
- Organizational commitment (e.g., Kirkman and Rosen, 1999).
- Financial performance.
  - 8.7% increase in the probability of having financial performance considerably better than the industry average (DeVaro, 2004).









Conclusions

- Teamwork is a viable process to enhance safety…Can save lives!
- "Do your homework"…
  - Needs analysis; organizational readiness…
- "Don't try this at home"…
  - Create partnerships
- Use the science.
- Apply the tips, tools, and strategies presented.
- Take action!

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Talk the Talk and Walk the Walk: Enhancing Communication to Improve Team Performance

Elliot E. Entin
(with help from Shawn Weil, Andrew Duchon, and Others)

Conference on Teamwork in U.S. Railroad Operations

April 23, 2009

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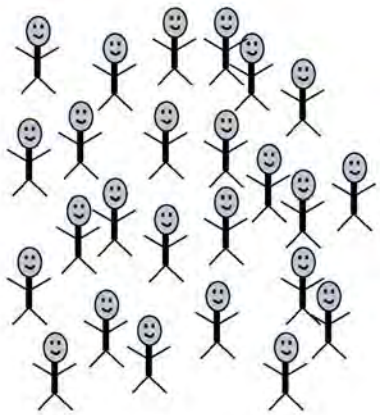
Problem

- Communication is a fundamental aspect of human interaction
- Dyads, teams, and large organizations
- Interwoven with their work
- Media: E-mail, text chat, telephone, IM, social media (e.g., Facebook), telephone, transcribed speech



*What can **analysis of communication** tell us about **team performance**?*

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Question

- Are the findings we have gleaned from a myriad of military teams, ER teams, surgical teams, anesthesia teams, EMTs, etc., applicable to various railroad teams and crews?
  - We argue YES!
- Teams from all domains appear to share common dynamics:
  - Task work,
  - Teamwork, and
  - Communications.
- Thus we offer our research and lessons learned with "wild abandon."

 3

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Talk Types

- Comms modalities we can potentially capture:
  - Voice based (e.g., face-to-face, radio, VoIP, telephone);
  - Text based (e.g., e-mail, SMS, IM, chat, letters, faxes); and
  - Social media (e.g., Facebook, MySpace, Physical interaction).
- Language use can reflect what is going on:
  - Non-verbal communications,
  - Preexisting common ground,
  - Emerging common ground, and
  - The context of the communication.

- Language can potentially allow us to *approximately* know what is going on.
  - Research linking communication and performance is ongoing.

 4

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What's in Talk? What Can We Learn?

- Team readiness
- Situational awareness
- Affective state
- Level of expertise
- Potential for team failure
- Group cohesion
- Interaction efficiency
- Communications (protocol adherence)
- Individual differences
- Likely decision-making paths

*What **methods** exist, and which should be used for what?*

 5

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Talk – Measure by Measure *Multiple Flavors*

- **Interaction**
  - Who was communicating.
  - To whom were they communicating.
  - What tools did they use.
  - What was going on while they were communicating.
  - → Social Network Analysis; Dynamic SNA; Transaction Analysis
- **Temporal**
  - When did they say it.
  - How long was the message.
  - In what order did they say it.
  - In what order was it read/heard.
  - → FLOW Analysis; Turn-Taking
- **Content**
  - What was said.
  - What was said around the things that were said.
  - To which categories/bins do those communicative bits belong?
  - → Utterance Classification; Linguistic Inquiry and Word Count; Application of (LSA, pLSA, LDA); Network Text Analysis; Conversation Analysis

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Talk Assessment: Interaction and Temporal

- **Social Network Analysis** refers to a class of analysis in which actors/agents are represented as nodes and interactions/transactions are represented as connections (arcs) between those nodes. This representation enables a host of potentially useful analyses (e.g., density, centrality, path length).
- **FLOW Analysis** focuses specifically on temporal patterns of interaction in communication. In what order are team members speaking? Is that consistent or inconsistent with (1) what they've done in the past or (2) some expected pattern?

 7

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Classification of Talk Manual (or Grunt) Mode

- Various protocols exit to code and analyze communication manually.
  - Procedures are often difficult and time consuming.
    - Counts of utterances, though straightforward, do not provide a meaningful window into team processes.
    - At a detailed semantic level, it can take months to code.
    - Procedure adopted by Orasanu when analyzing communications in cockpits.
- Intermediate level—practical compromise.
  - Our protocol adapted from Orasanu.
  - Adopted small finite number of categories.
  - Captured speaker and recipient.
  - Performed real-time or from recordings.

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Categorizing Talk

Two primary axes: Request and Transfers, Information and Action

- Information requests.
- Information request about a task.
- Information request about a resource.
- Action and task request.
- Resource utilization request.
- Coordination request.

- Information transfers.
- Information transfers about a task.
- Information transfer about a resource.
- Action and task transfers.
- Resource utilization transfers.
- Coordination transfers.
- Acknowledgements.

Adapted from Orasanu et al.

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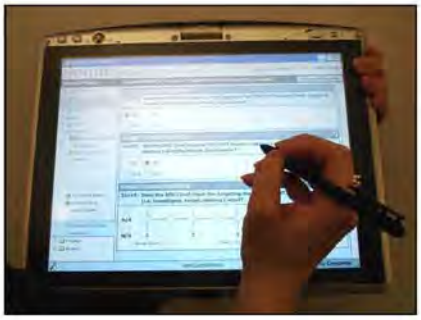
"Faster Than a Speeding Bullet" Coding Talk in Real Time



- **Coding done at an intermediate level of detail**
  - Incorporates both semantic and quantitative aspects of the communication stream.
- Computer-Assisted Coding:
  - Touch sensitive tablet.
  - Specifically designed software.
  - Two interfaces.
  - Application produces two output files.
- Training:
  - 25 to 40 h to become proficient.
- **Adequate procedure, but still time consuming and complex**

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How Else Can We Do It? Talk Assessment (1)

Other than utterance classification:

- **Linguistic Inquiry and Word Count** (LIWC) looks at the occurrence of linguistic features and constructs and correlates them with other measures of team performance.
- **Conversation/Discourse Analysis** requires researchers to annotate text with predefined meta-information based on linguistic or discourse markers.

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Talk Assessment (2)

- **Latent Semantic Analysis** (LSA) is a fully automatic mathematical/statistical technique to extract and infer meaning and relations.
- **Probabilistic Latent Semantic Analysis** (PLSA) is an unsupervised machine-learning technique that identifies and distinguishes between a variety of contexts for word usage without recourse to a dictionary, thesaurus, or a predefined taxonomy of concepts.
- **Network Text Analysis** (NTA) borrows concepts and measures from Social Network Analysis (graph theory) to represent "mental models."

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Approach Must Fit the Situation and Goals

- These approaches have different strengths and weaknesses:
  - Automation transparency,
  - Manual manipulation,
  - Level of abstraction,
  - Granular linguistic unit,
  - Validation and verification, and
  - Integration with other forms of data.
- Need lots of research and theory development.

*How are we applying these **methods**?*

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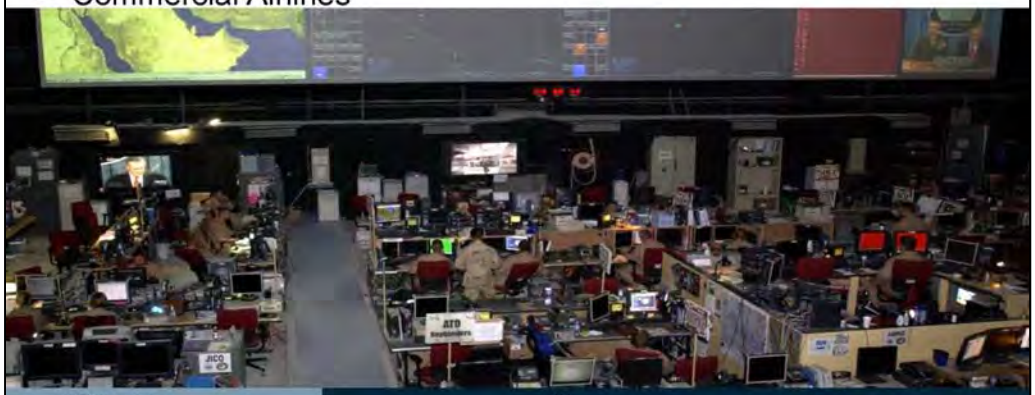
Source of Research (i.e., Who Have We Pestered)

- Navy C2 (A2C2)
- Corporate E-mail (IMAGES)
- Corporate and Emergency Ops (CARTOS)
- Commercial Airlines
- AF C2 (CIFTS)
- AF F-16 and AWACS (WCAS)
- Army platoon ops (AutoCAS)
- Medical teams



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Talk at 35,000 ft

- Orasanu observed comms in commercial airline cockpits:
  - When, how, and what differentiated high from low-performing crews.
- High-performing crews used low workload periods to discuss "what ifs" and planned.
- More effective crews verbalized concerns with the constraints, gathered more info about multiple options, and took longer to make their decisions.
  - Discussions emphasized assessing potential solutions.
- Effective captains' (i.e., crews made few errors) talk distinguished by high levels of planning and strategizing, gathered info, predicting/alerting, and explaining—especially in emergencies.

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Status and Etiquette at 35,000 ft

- Orasanu and Fischer conducted simulations and researched the accident literature.
  - Analyzed comms: status makes a difference.
- Captains gave direct commands (more often) or made suggestions ("lets do this").
  - Rate less effective, but used most.
- First Officers were less direct.
  - Most frequently used hints to alert the captain to a problem/goal.
  - Or used permission-seeking questions.
  - Or used a confirmation-seeking question.
- Strong versus weak hints.

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What We Know

- In low workload periods discuss "what ifs" and plan.
- Subordinates don't have to be direct to be heard.
  - Use strong versus weak hints.
  - Use permission statements.
- High status team leaders claim they are not into commands, but use them a majority of the time—"it's a force of nature."
- Team leaders, particularly under high workload or emergency situations, need to communicate plans, strategies, direct info gathering, and predict, alert, and explain.

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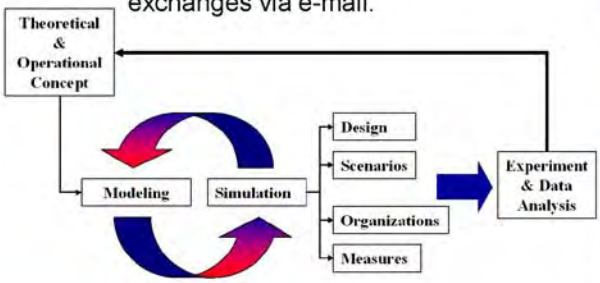
A2C2
Adaptive Architectures for Command and Control

- Model-based experimentation.
- Taxonomic classificatio.n
- Communications Patterns.
  - Ratio of info and action transfers and requests; anticipation ratio.
  - Within versus between groups communications.
  - Number and types of information exchanges via e-mail.



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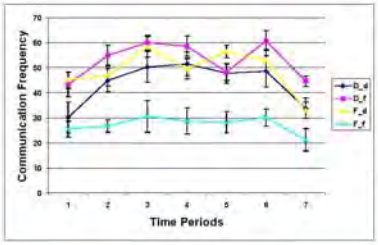
Talk in Organization Adaptation

Organization  Mission vs. Organization  Mission

- Simulator-based experiment.
- Observed adaptation to misalignment between organizational structure and mission (tasks to be performed).
  - Communication is an important key to coordination and adaptive strategies.



- Incongruence significantly influence performance and communication.
  - How much they talked.
  - The pattern of communication (to whom).
  - The content of communication (about what).
- As communication volume went up performance dipped.

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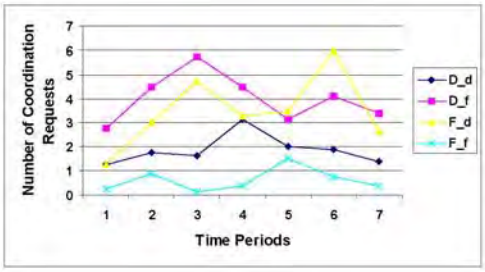
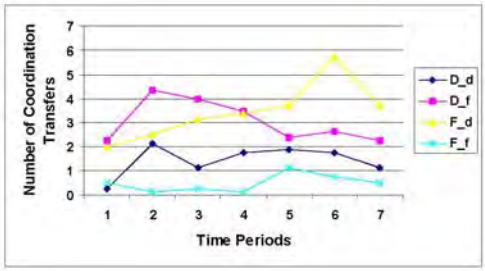
Differences in Talk Type

- Communication is critical to attempts to adapt and coordinate.
  - Coordination talk went up, appeared early, and persisted.





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What We Know

- Facilitate communication:
  - Adaptation and coordination are accomplished via communication.
- Increases in communication, particularly in coordination utterances, can be used as an early warning that the team structure doesn't match the tasks to be done.
  - Pattern of communication also changes.

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Talk to Build Better Teams

- Team Adaptation and Coordination:
  - Teams can adapt to changes in the internal or external environment.
  - During high workload/time pressure high-performing teams switch from explicit to implicit coordination:
    - This requires the use of shared or mutual mental models.
  - Such a shift reduces communication and coordination overhead.
- We effectively trained Navy teams to do just that (TACT).
  - A main focus was on team communication.

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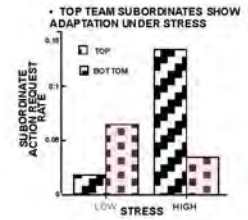
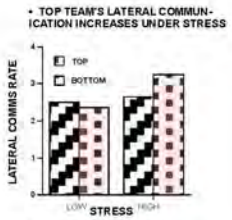
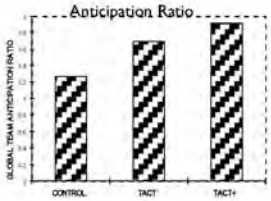
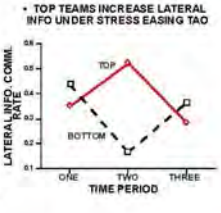
Talk Training Worked









- Training produced significant outcomes:
  - Explicit versus implicit comms.
  - Anticipation ratio, members pushed rather than needed to pull needed information.
  - TAOs (leaders) provided periodic situational updates to team:
    - Maintained shared mental model.

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What We Know

- Teams can be trained to more be effective in high workload/high-pressure (e.g., emergency) situations:
  - Learn to reduce teamwork and communication overhead.
  - Learn to shift from explicit to implicit communication:
    - Push rather than pull information.
  - Learn to maintain shared or mutual mental models.

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Railroad Example

- A yard crew is backing up a train.
- Brakeman is on the ground communicating via radio with the engineer.
- Engineer doesn't "hear" the switchman tell him that he has passed the switch.
- Crashes into another cut of cars.
- From what we know, how could this be avoided?

Thanks to Judith Gertler

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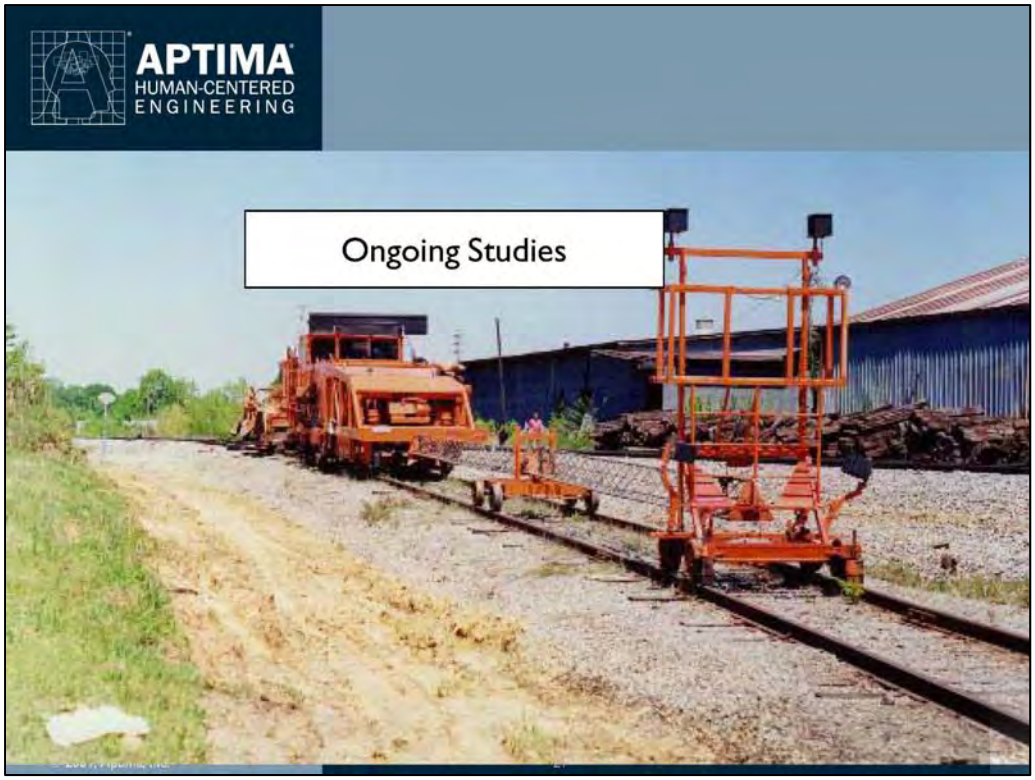

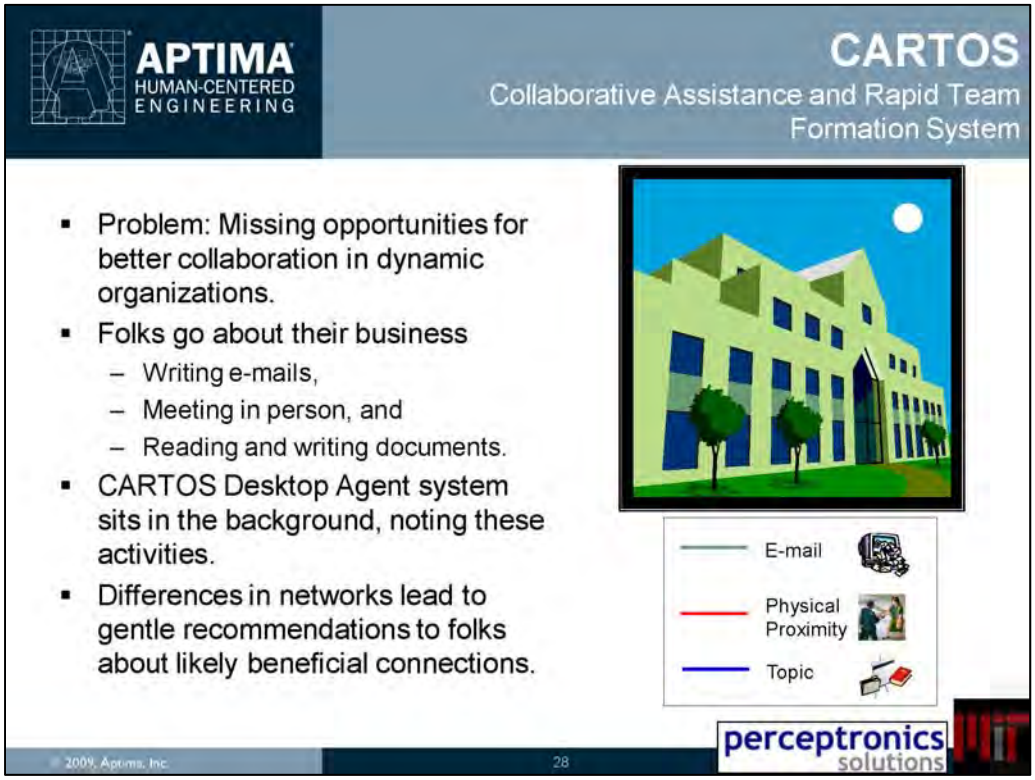

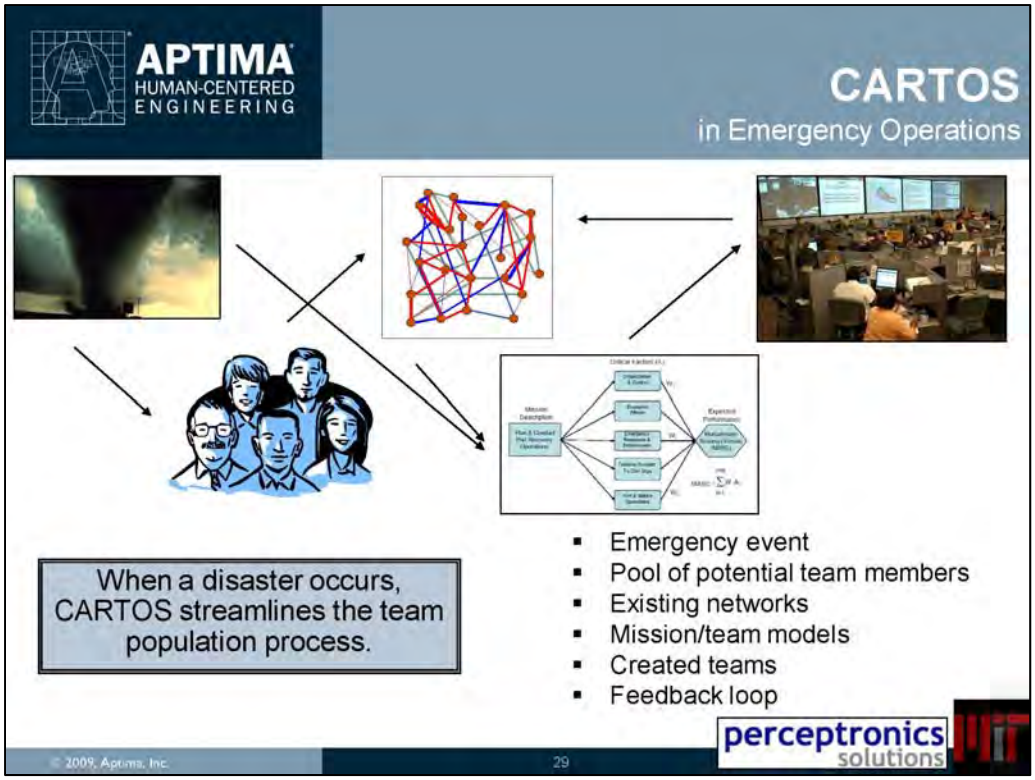

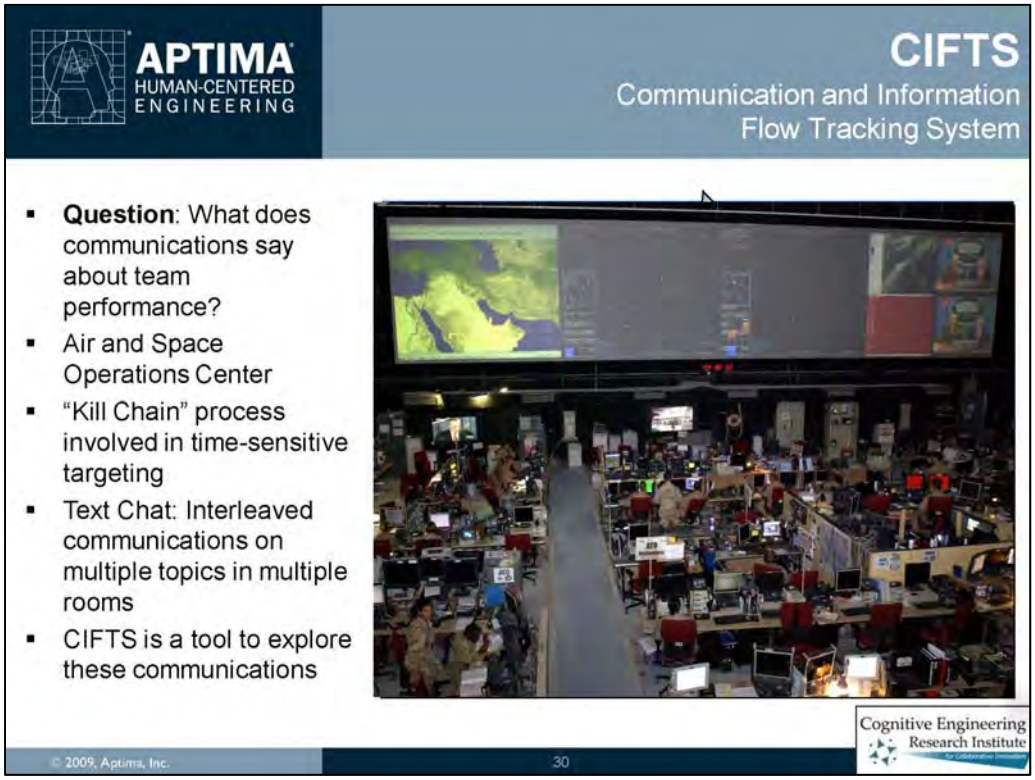

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Conclusions

- Don't pull on Superman's cape.
  - Subordinates can make themselves heard without being confrontational.
- Don't spit into the wind.
  - Use periods of low workload to strategize and plan for possible futures.
- And don't mess around with Slim.
  - Teams can be trained to better manage their coordination and communication overhead and to exhibit better teamwork skills

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Backup Slides

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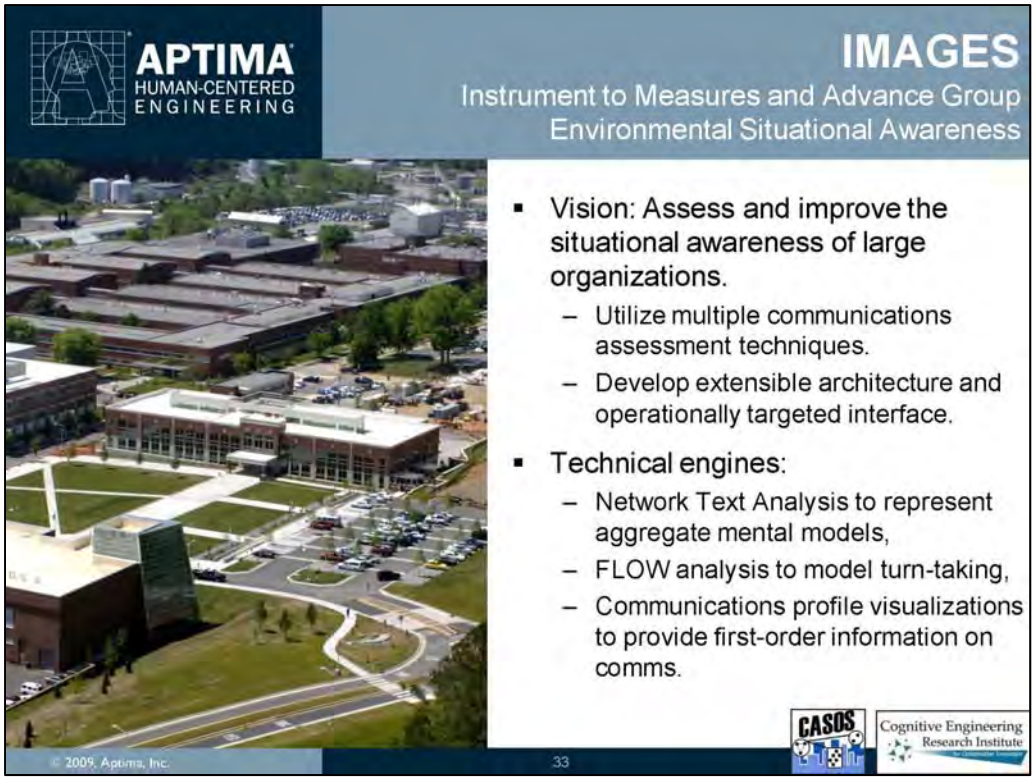

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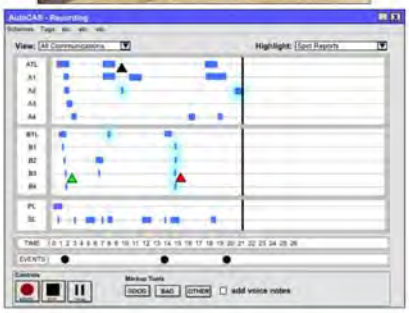
AutoCAS
Automated Communications Analysis System

- MOUT Communication Skills
  - Capturing communication data +
  - Measuring communication performance +
  - Diagnosing communication strengths and deficiencies +
  - Automating real time and AAR feedback
- Original Vision
  - Synthetic task environment
  - Automated speech recognition
  - Automated utterance classification
  - Communications process measures
  - After action review
- Low-Hanging Fruit = Successful



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Leadership's Role in Team Performance: Implications for Safety Culture

David A. Hofmann

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TRB TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES

Session Objectives

- Provide a generalized model of leadership.
- Describe how this model relates to team performance.
- Draw implications for safety culture.
- Conclude with some broader thoughts about an integrated safety management system.

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Defining Leadership

Leaders are those individuals who, after choosing a direction, are able to influence and motivate teams as well as put systems in place to achieve goals aligned with this direction.

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Three Components of Leadership

- Leader-based
  - Establishes direction.
- Relationship-based
  - Ensures alignment, resources, loyalty/commitment.
- Follower-based
  - Builds/develops skills.
- Today's focus:
  - How leader- and relationship-based leadership establish the context for team performance.

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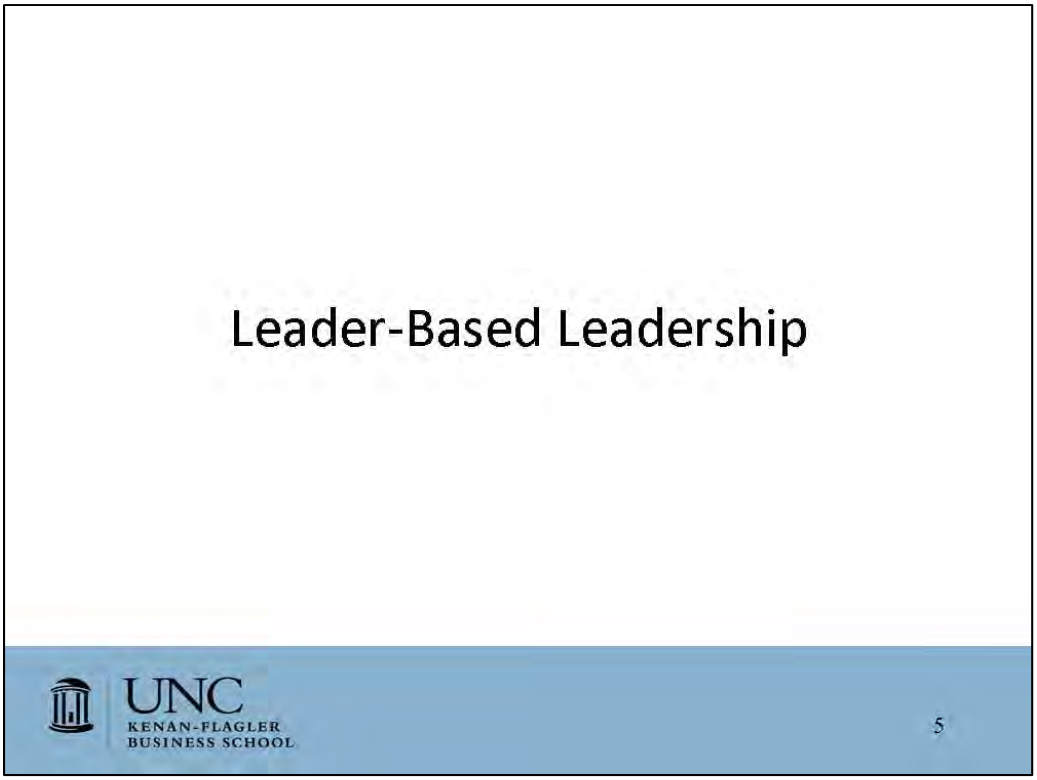

Vision/Goal

- It can be any of the following:
  - Articulation of desired future,
  - Long-term goal,
  - Yardstick for measuring progress, and
  - What you want to become/known for.
- Most critical component:
  - Communicates that their work
    - Makes a *compelling contribution,*
    - Impacts others in a meaningful way, and
    - Resonates with their core values.

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Vision / Goal

A clear vision is the first step; you also must reinforce that vision through the use of symbols.

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Symbols in Leadership

- Communicate messages that cannot be communicated in words.
- May either reinforce or detract from values and vision.
- Are often perceived even when not intended.

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Symbolic Behavior

- Common symbols:
  - Awards/recognition
    - Formal—what are the criteria and
    - Informal—what you call out, appreciate, punish, ignore;
  - Presence or absence at meetings;
  - Where meetings are held and physical layout;
  - Decisions and the criteria used to make them.
- Virtually all of your non-verbal and verbal behavior
  - Communicated what you value, expect, reward, and support.
  - Monitor and use strategically.

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Aligning Supporting Systems

- What do the supporting systems communicate about what is expected, valued, rewarded, and supported?
- Systems such as
  - Information,
  - Metrics of performance,
  - Criteria used to assess team performance, and
  - Informal feedback.

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Leader-Based Leadership

- Do you have a clear vision/goal?
- Have you clearly communicated it?
- Does your behavior reinforce this vision?
- What do the supporting systems communicate to your teams?

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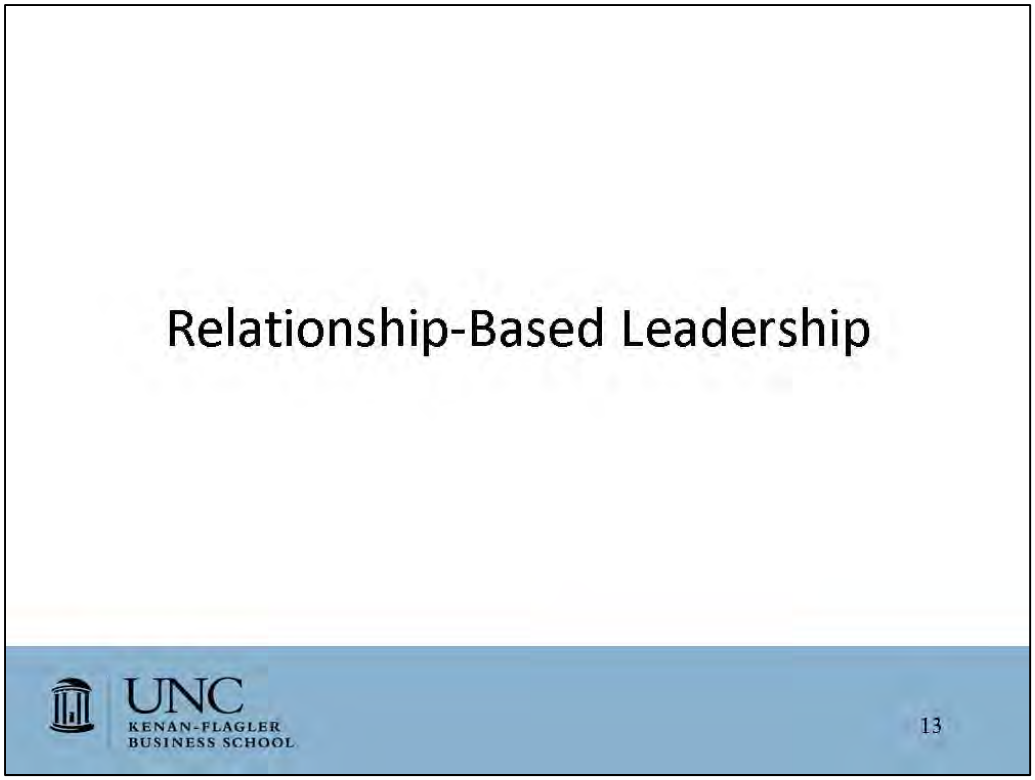

Relationship-Based Leadership

- You must build effective relationships in all directions:
  - Upward with your boss:
    - Ensures alignment of the team with organizational goals.
  - Outward with your peers:
    - Secures resources for your team.
  - Downward within your team:
    - Builds loyalty and commitment and
    - Ensures commitment to your goals and objectives.
- We have to think creatively about our currencies.

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Relationships and Influence

- Law of reciprocity:
  - Cross cultural.
  - People expect actions will be paid back in some form or fashion.
- Basis of influence:
  - Understand their world (demands, constraints, pressures, etc.).
  - Mutually satisfactory exchanges:
    - What resources would they value?
  - You must be offering something that someone else needs/wants in order to influence them.
  - It must be a win–win … what's in it for them?

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What Is In It for Them?

Appealing purpose	Vision, to be part of a winner, excitement, moral/ethical imperative
Task facilitation	Resources, assistance, cooperation, information
Position enhancement	Advancement, recognition, visibility, reputation, importance/becoming insider, networks/contacts
Our relationship	Maintaining friendship and loyalty, gratitude, subsequent reciprocation
Personal development	Challenging/learning, ownership/involvement

Cohen, A.R., and D.L. Bradford. Influence Without Authority: The Use of Alliances, Reciprocity, and Exchange to Accomplish Work. *Organizational Dynamics*, Vol. 17, 1989, pp. 5–17.

At Every Level in the Organization

- Every leader, at every level
  - Communicates a compelling goal/vision,
  - Develop relationships in all directions
    - Ensure alignment, secure resources and support, gain loyalty, and
  - Build skills and capabilities of subordinates.
- As an application of this model, let's look at how it impacts safety culture.

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Leadership and Safety: Overview

- Leaders must value safety:
  - Words,
  - Actions or symbols, and
  - But, should the message just come from you?
- But, we want teams to "own" their safety and the safety of others
  - Vision alone will not do it.
  - Also need mutual investment model (relationships).

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Leaders Must Value Safety

- Top management must signal clear commitment to safety and establish it as a priority.
  - React quickly to problems.
  - Provide resources (equipment, training).
  - Accountability of managers for safety.
  - Listen and act upon worker ideas for improvement.
- Question
  - Should they be the ones to deliver the entire message?

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Leaders Must Value Safety

- Maybe it should not always be the leader
  - Connecting people to beneficiaries can be powerful motivator (Grant et al., 2007)
  - Comparison of appeals from leaders versus beneficiaries (Grant and Hofmann, 2009)
    - Beneficiaries had larger effect on effort and performance
    - Even when leader was better communicator
    - And, when they delivered the same message
- Implications
  - Think creatively how to get those impacted by safety to help communicate the message

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Leaders Must Value Safety

- If top management communicates commitment to safety (Zohar and Luria, 2005):
  - Reduces variance in team safety climate;
  - Raises level of team safety climate;
  - Creates a strong situation which limits discretion; and
  - Impacts front-line safety.

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Team Ownership of Safety

- Wouldn't it be nice if teams thought
  - Helping others learn about safety protocol;
  - Expressing opinions and ideas surrounding safety;
  - Being a steward over others' safety;
  - Explaining to others why safety violations are not acceptable;
  - Keeping in formed about safety issues; and
  - Trying to improve the safety performance of the organization

Was …

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Part of Their Job…

So How Do You Get There…

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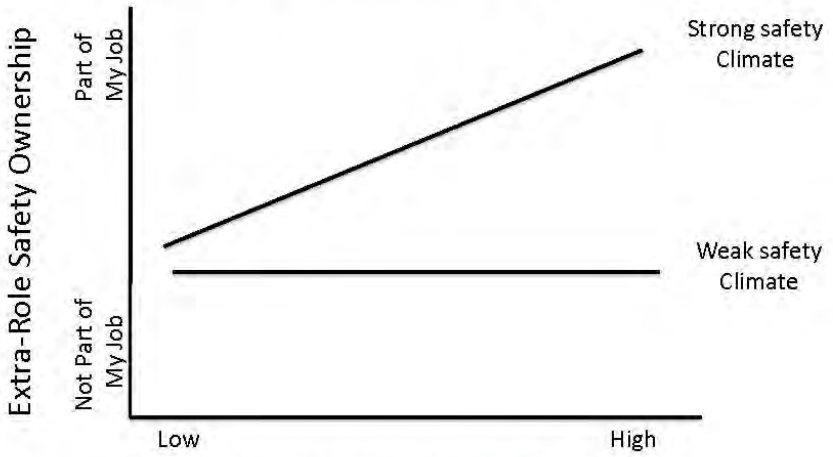
Team Ownership of Safety



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Practical Takeaway

- Leaders at all levels need to communicate that safety is important.
  - Top:
    - Resources, training, status of safety organization and
    - Symbolic behavior, "out"-sourcing the "in"-spiration.
  - Middle and front line:
    - Importance of following protocol,
    - Good rules and rule revision (Ranney and Nelson, 2004), and
    - Monitoring symbolic behavior.
  - Within teams.

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Practical Takeaways

- Relationship with team leaders and members are critical.
  - How decisions are made.
  - Support that teams perceive.
  - Interpersonal relationships that communicate concern, value, respect.
- This is the only way you get the loyalty and motivation to pursue direction set by the broader strategic climate/culture.

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But Wait, There is More

- Following safety protocol is not the only way to ensure safety.
- What about the concept of errors?
  - How do you think about errors?
  - Prevention versus management.
- What happens if someone makes an honest mistake?
  - How is it viewed?
  - What happens to them?

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Integrated Safety Systems

- Clarifying definitions:
  - Errors and violations clearly different,
  - Errors are unintentional deviations, and
  - Violations are intentional.
- In order to really impact safety, teams need to think about a more comprehensive system.

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Integrative Safety Systems

- Two dimensions:
  - Prevention versus management and
  - Errors versus violations.
- Results in four integrative and interdependent safety management systems.

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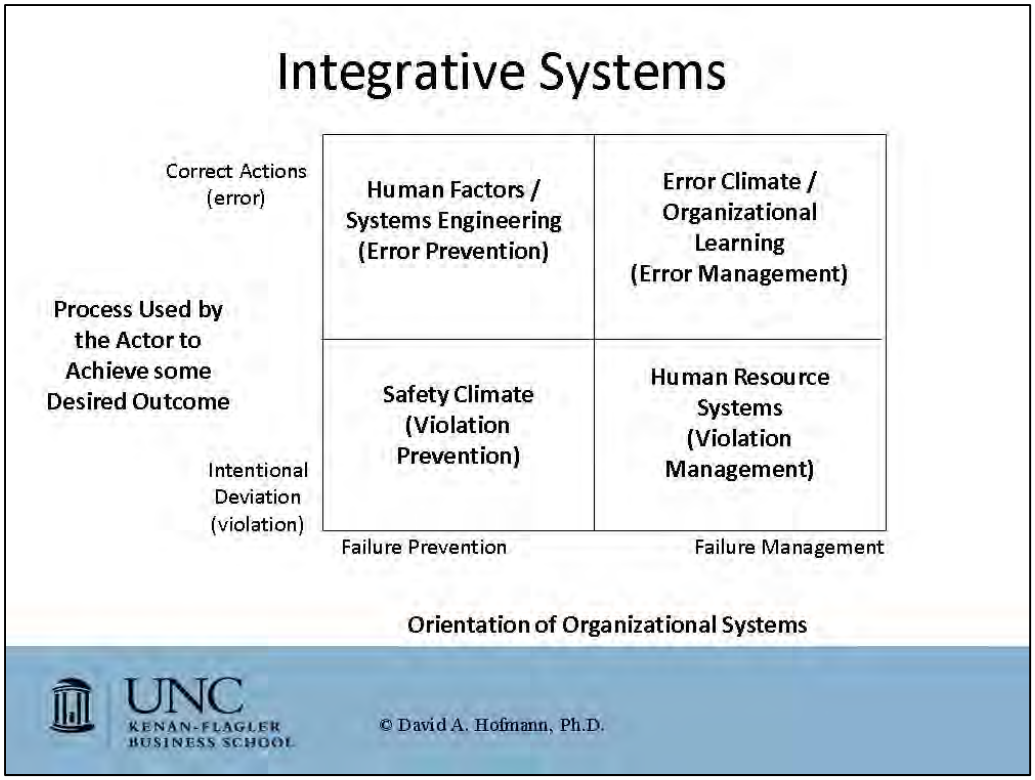

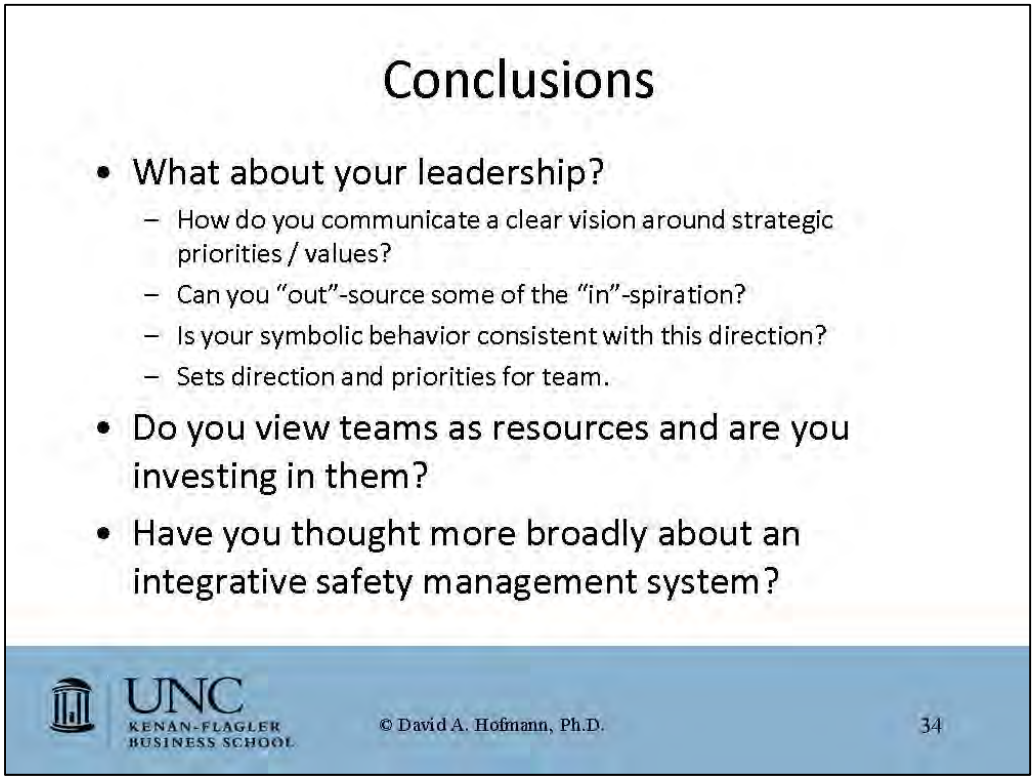

Decisions

- People evaluate decisions based on two primary criteria:
  - Outcomes and
  - Process.

Outcomes

- Fairness of outcomes
  - Typically involves comparison to a referent other.
  - How do my outcomes and inputs compare to my referent others (equity)?
- Reactions to inequity:
  - Alter inputs,
  - Alter outcomes,
  - Cognitive distort,
  - Leave/withdrawal, and
  - Select new comparison.

Process

- Perceptions regarding the fairness of the procedures used in making decisions.
- Perceived more fair if
  - Consistency; no personal bias; accurate information.
  - Keeps interests of individuals in mind.
  - Modifiable outcome (balance consistency with flexibility).
- Related to
  - Organizational commitment, extra-role behavior, violence, retaliation.
- Reactions to outcomes depend on procedure.

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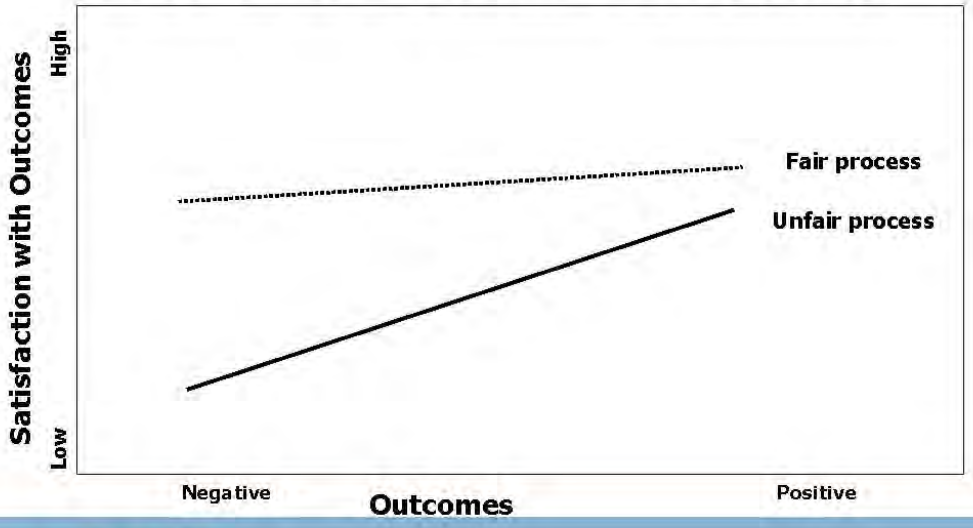
Process and Outcomes Interaction



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