Overview of the Federal Railroad Administration's Human Factors Safety Research Program

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The Federal Railroad Administration (FRA) supports a program of research on human factors safety that focuses on three major programmatic areas of research -- *train operations systems*, *railroad operating practices* and *grade crossing safety*. This program of research supports the FRA's strategic goals of reducing the rate of rail-related deaths, injuries, and train accidents by understanding and eliminating the causes of human error, by fostering better practices through the development of model training curricula, and by anticipating the human factors safety consequences of new technology.

The human factors research program in *Train Operations Systems* conducts research projects in four major areas: *fatigue, new technology, training and selection*, and *organizational behavior and culture.*

Fatigue Research: Numerous laboratory and field studies have demonstrated that sleep deprivation and fatigue can negatively affect performance and operational safety, especially during night work. In 1997 the FRA published a study of workload, stress and fatigue that extended this conclusion to locomotive engineers[1]. Currently, sleep and fatigue research projects are in progress to evaluate strategies designed to mitigate the effects of fatigue and sleep deprivation. The *Napping Strategies* study is examining the performance and operational safety effects of on-duty naps of various durations in locomotive engineers. *Alertness Monitoring Devices* are being evaluated to determine their ability to predict a lack of alertness so that operating personnel can take measures to compensate (perhaps by taking a nap). The *Dispatcher Workload, Stress and Fatigue* project has developed methods for non-obtrusive measurements of workload, stress and fatigue. A study of shift schedule and other factors using these methods in freight and passenger-service dispatchers is almost complete.

New Technology Research: Advances in information technology will change communications, operations, and information use in the railroad industry, and the FRA is being proactive to ensure that the deployment of new technology enhances safety. Projects are being conducted on the use of *Digital Communications* to ensure that the increase in efficiency and precision over voice communications does not also create new opportunities for human error. Similarly, innovative *Information Displays* about train operations are under development to enhance the safety and efficiency of train movements. Because of the introduction of high-speed rail operations in the U.S., *High-Speed Simulations* continue to be studied in laboratory settings [2] and are proposed for Amtrak's high-speed simulator to explore human factors issues. Positive train control technology will eliminate the causes of many human factor accidents that currently occur in train operations. However, because the jobs of locomotive engineers and dispatchers will change, new human errors are likely to occur. A project to study *Human Factors Issues in Positive Train*

Control is being conducted to determine the sources of human error in these systems.

Training and Selection: Training and selection are essential elements of any human factors safety program. Two studies have recently been completed in this area. The *Non-Accident Releases of Hazmat: Training Issues* study [3] compared the reading level of instructional materials used to train employees who handle hazmat with the reading level of the employees. The study found that instructional materials often required a higher reading level than the employees possessed. The study suggests methods for evaluating the reading levels of instructional materials and employees and guidelines for the preparation, format, and organization of instruction for hazardous material loading/unloading training. The *Training of Railroad Dispatchers* study [4] developed training objectives for railroad dispatchers, syllabi for three types of training programs, and test designs for the three programs. Training objectives were developed from a comprehensive job analysis, and that information is being used in a study to develop guidelines and best practices for the *Selection of Railroad Dispatchers*.

Organizational Behavior & Culture Research: The FRA has recently begun an ambitious program of research in Organizational Behavior & Culture Research. Organizational culture consists of artifacts, values and assumptions. While the values and assumptions are difficult to observe because they are cognitive, the artifacts can be directly seen in written procedures and behaviors. Operating rules are one type of artifact of railroad organizational culture, as is compliance with those rules. The mis-alignment of aspects of an organizational culture, such as its artifacts and values, can adversely affect safety. For example, a recent study of *Compliance with Railroad Operating Rules* [5] found that senior management emphasized productivity over safety, and that this may have unintentionally encouraged operating rules violations. Studies of organizational behavior & culture have shown that the interactions between members of informal teams, such as train crews, are a major determinate of human error. A project on *train crew resource management* is being conducted to enhance safety through more effective «teaming». The Behavior-based Safety Process refers to the use of applied behavioral analysis methods to attain continuous improvements in safety in industrial settings. The *behavior-based safety* project is focusing these methods on a high risk railroad job to demonstrate the applicability of a promising safety enhancing tool within the railroad industry.

The Human Factors Research Program in *Operating Practices* conducts research projects in the following two major areas: *Job Analysis* and *Ergonomics*.

Job Analysis: Many injuries to on-duty railroad employees occur in yard, terminal and maintenance-of-way operations. Anecdotal evidence indicates that there are several reasons for many of these injuries: (1) employee complacency leading to inattention to safety considerations while performing familiar tasks; (2) inadequate supervision; (3) inadequate training; and, (4) inadequate safeguards in procedures and equipment. Job analysis research is conducted to identify practices and conditions that contribute to employee injuries so that remedial actions can be suggested. A project on *Yard & Terminal Safety* will be completed soon and is expected to indicate that many yard & terminal injuries have an ergonomic basis. A similar project on

Maintenance-Of-Way (MOW) Safety will begin soon.

Ergonomics: Working conditions and safety in the locomotive cab are a critical aspect of current railroad operating practices. To assist railroads in evaluating the adequacy of working conditions and safety in locomotive cabs the FRA has published *Human Factors Guidelines for Locomotive Cabs* [6]. This is an on-going effort, and work continues to examine the effects of temperature and vibration on operating performance. The results of the yard & terminal safety project appear to indicate that a majority of yard & terminal injuries are caused by slips, trips and sprains. Many of these kinds of injuries have an ergonomic basis and will be addressed in the *Ergonomics of Yard & Terminal Injuries* project. Information about at-risk jobs, locations, etc. will be used to suggest how the application of ergonomic principles can be used to reduce injuries.

Human Factors Research Program in *Grade Crossing Safety* takes a human-centered systems approach to the prevention of crashes at grade crossings. From this point of view, the motorist must detect and recognize trains in or near the intersection and decide whether he/she must stop or continue. A signal detection analysis of grade crossing accidents [7] has indicated that there are two independent factors which affect the motorist' decision: ability to detect/recognize the train and willingness to stop. Ability to detect/recognize the train is largely determined by characteristics of the train, such as the train horn, auxiliary lights, reflectorization, etc. However, characteristics of the background, such as visual clutter, lighting, etc., are also important. Willingness to stop is mainly influenced by motivation and expectation. Photo enforcement increases 'willingness to stop' because of fines imposed for violations (motivation). 'Willingness to stop' varies with grade crossing devices because there is a higher expectation of a train at active crossings (e.g., flashing lights) than at passive crossings. The human factors grade crossing safety research program has projects that address *train detection/recognition* and *willingness to stop.*

Train Detection and Recognition: Research to enhance train detection and recognition includes projects on the *Acoustic Characteristics of Train Horns* [8,9]. The use of train horns at grade crossings is known to reduce accidents by approximately one-third, but the use of horns also is a source of community annoyance. A possible solution is to place the horn at the wayside, directed at the highway rather than the community and with a lower sound level [10]. Current research is being conducted to determine the optimal acoustic characteristics of train horns so that the horn has maximal effectiveness for the motorist while minimizing community annoyance. While the train horn is probably important for localization (where to look), ultimately, train detection/recognition depends on train conspicuity. Research on *Train Conspicuity* suggested the current use of auxiliary lights on the front of locomotives to form a triangular light pattern to improve train visibility [11]. Freight cars at grade crossings are often difficult to see, and many crashes occur in which the motor vehicle strikes the train after the lead locomotive. Research suggests that *Freight Car Reflectorization* [12] will enhance the visibility of freight cars and reduce the occurrence of these crashes.

Willingness to Stop: Much less is known about the factors that influence a motorist's willingness

to stop because there has been little research on motorist motivation and expectation. Knowledge of the consequences of not stopping at grade crossings goes to motivational factors, and driver education programs are crucial for conveying information about the dangers of grade crossings and the proper actions to take at various kinds of grade crossings. However, the effectiveness of most programs has never been formally evaluated. The *Driver Education Evaluation* project is being conducted to consolidate information on available programs and to evaluate their effectiveness. Although much is known about **what** happened at grade crossing crashes, there is little known about **why** the crashes occur. The *Accident Causation* and *Motorist Behavior* projects will focus on why crashes occur with particular attention to the influence of motivation and expectation on motorist behavior.

The FRA's research program in Human Factors is focused on the aggressive application of knowledge about human behavior and physiology to reducing the rate of rail-related deaths, injuries, and train accidents. The program's goal is to establish the U.S. railroad industry as the safest mode of transportation in the U.S. through the application of human factors principles.

Additional information can be obtained from:

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