Research Results

Human Factors Root Cause Analysis
Of Accidents/Incidents Involving
Remote Control Locomotive Operations

SUMMARY

The Federal Railroad Administration (FRA) Office of Research and Development sponsored a project to learn more about human factors root cause analysis (RCA) of six train accidents/incidents - collisions, derailments, and employee injuries - involving remote control locomotive (RCL) operations in U.S. railroad switching yards. Descriptive data from participating railroads were collected on all FRA reportable RCL accidents/incidents from May to October 2004. RCA were performed on six RCL accidents/incidents (case studies) to examine factors that contributed to each accident/incident. RCA data collection and analysis tools were developed based on a modified version of the Human Factors Analysis and Classification System (HFACS-RR) to provide a theoretical foundation to the RCA. A total of 67 RCL accidents/incidents were reported by participating railroads: 29 collisions, 25 derailments, and 13 employee injuries. RCA were conducted on three collisions, two derailments and one injury. A total of 36 probable contributing factors were identified among the six case studies, and 33 of these were concentrated among six HFACS-RR categories: the technological environment (8), skill-based errors (7), the organizational process (6), inadequate supervision (5), decision errors (4), and resource management (3). Based on an analysis of all of the contributing factors, several key safety issues emerged: loss of remote control operator (RCO – Figure 1) situation awareness, insufficient training, inadequate staffing and pairing of inexperienced crewmembers, and inadequate practices and procedures governing RCL operations and the use of RCL technology, including pullback protection.

Figure 1. RCO making coupling

BACKGROUND

In an effort to reduce operating costs and increase efficiency, Class I freight railroads in the U.S. have begun to implement remote control locomotive (RCL) operations in and around railroad yards. U.S. railroads are permitted to use RCL operations as long as they follow all relevant FRA safety regulations. RCL operations consist of three components:

1) The locomotive (the RCL),
2) An onboard control computer (OCC) that interfaces with the locomotive's controls (and usually mounted somewhere inside or on the RCL), and
3) A portable remote control device (RCD; also frequently referred to as a "belt pack," "operator control unit," or simply "the box."). A remote control operator (RCO) wears the RCD, usually by means of a vest.

Although the technology has been around for decades, the safety implications of using these devices in the U.S. railroad industry, and of reducing crew size in switching operations, have not been clearly discerned and are not fully known. The FRA has begun to collect RCL operation-related train accident/incident data. However, due to the recent implementation of RCL operations on a large scale in the U.S. (beginning in early 2002), and the more recent FRA requirement (effective May 01, 2003) to report the involvement of RCLs and RCOs in train accidents/incidents, this data collection process will require several years before adequate data are available to analyze.

To better understand the safety implications of RCL operations, the FRA Office of Research and Development Human Factors Program and FRA Office of Safety initiated a multi-study program of research into RCL operations in early 2002, just as RCL operations began on a large scale in the U.S. The FRA sponsored three separate studies: a comparative risk assessment of RCL and conventional yard switching operations; focus groups with RCOs to identify safety issues and best practices; and a root cause analysis (RCA) of RCL-involved train accidents/incidents that occur in railroad yards. This report describes the results of the RCA of six RCL-involved accidents/incidents that occurred between May 01 and October 31, 2004.

OBJECTIVES

The specific objectives of this research project were to:
*   Understand the circumstances that contribute to RCL-involved accidents/incidents in railroad yards.
*   Identify individual, organizational, technological and situational factors that contribute to RCL operations safety.
*   Determine the applicability and validity of selected human error taxonomy to railroad operations.

METHODS

Between 01 May and 31 October 2004, participating railroads were asked to notify researchers within 24 hours, or the next business day, of the occurrence of all FRA-reportable collisions, derailments and employee injuries that involved the movement of on-track equipment and that involved RCL yard operations. Selection criteria and guidelines were established to aid in identifying six accidents/incidents to examine in greater detail. During this six-month data collection period, six of these accidents/incidents - three collisions, two derailments and one employee injury - were examined in greater detail using RCA methods and paper-based tools developed for this study and based on application of a modified version of the Human Factors Analysis and Classification System (HFACS-RR).

RCA is a method of accident/incident investigation (i.e., data collection) and analysis that enables investigators or researchers to identify individual, organizational, technological and situational factors that contributed to an accident/incident. A guiding principle behind RCA is that accidents/incidents are not solely caused by *one* event; rather, *multiple* factors play a role in every accident/incident. RCA is a process used to methodically and objectively shed light on these contributing factors, many of which are otherwise difficult to find.

The use of a theoretically driven RCA approach, based on a modified version of HFACS, ensures that the causal factors identified during an investigation go beyond "what" happened to "why" an error occurred. Researchers used the RCA philosophy combined with the HFACS-RR structure to guide data collection and analysis for the six RCL accidents/incidents. A number of data collection tools were developed,

including interview questionnaires, a checklist of items to request from the railroad, and a series of decision trees designed around HFACS-RR. The HFACS-RR taxonomy identifies five major categories of contributing factors (Figure 2), and for each category, additional factors. Figure 2 presents the five HFACS-RR categories according to their flow of influence. Influence flows from the outer categories toward the inner categories.
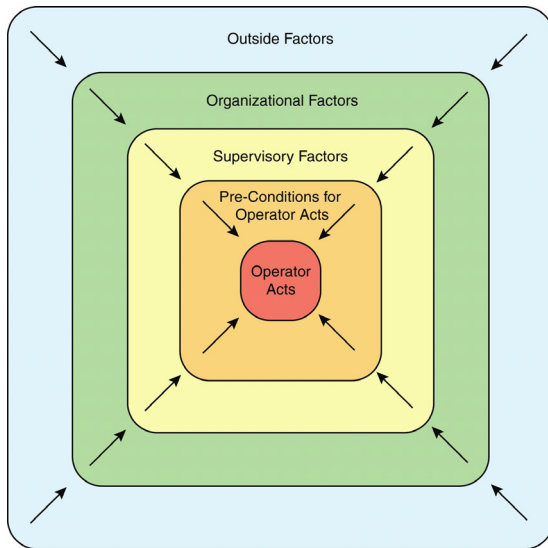

Figure 2. HFACS-RR diagram depicting concentric influence of categories

When an accident/incident was selected for RCA, researchers worked with the participating railroad point-of-contact to arrange to travel to the accident/incident site as soon as possible, generally within 1-2 d of notification. Separately, the point-of-contact from the union that represented the crewmembers involved in the accident/incident was contacted to help begin to arrange interviews with the crewmembers. Interviews were conducted privately with crewmembers; railroad officers were not present. Researchers spent 2-3 d on-site collecting interview data and railroad-provided records, logs, and reports for each RCL accident/incident. Accident/incident data were de-identified to protect the identities of the individuals and railroads that participated.

RESULTS

A total of 67 RCL accidents/incidents were reported by participating railroads from May 01 to October 31, 2004. Of the 67 accidents/incidents, there were 29 collisions, 25 derailments, and 13 employee injuries not associated with a reportable collision or derailment. Analysis of all 67 accidents/incidents by time-of-day reveals that almost half of the 67 accidents/incidents (30) occurred between midnight and 8 a.m. (see Figure 3). The greatest number of accidents/incidents reported in any one month (16) occurred in August.
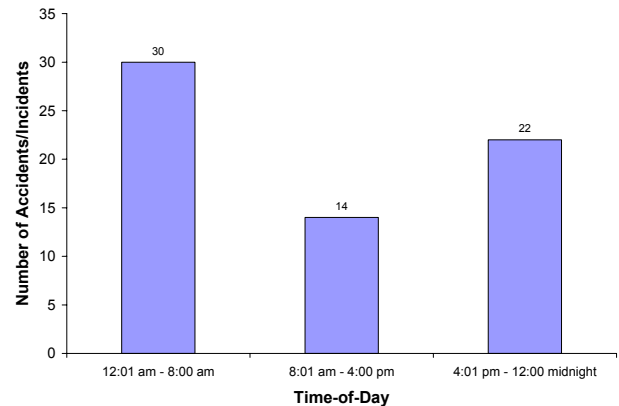

Figure 3. RCL accidents/incidents by time-of-day

A total of 36 probable contributing factors were identified among the six accidents/incidents. Key themes that emerged from the RCL accident/incident RCA are:

- Six HFACS-RR categories (26 percent) were associated with 92 percent of probable contributing factors. They were: 1) the technological environment, 2) skill-based errors; 3) organizational process; 4) inadequate supervision; 5) decision errors; and 6) resource management.
- Eight probable contributing factors were associated with the technological environment. Four of the eight contributing factors were related to one or more RCO's control of a movement from a physical location away from the RCL and/or cut of cars. Three contributing factors (all were associated with one accident/incident) focused on the failure of the pullback protection system technology as part of the overall RCL system. And one contributing factor was associated with the physical characteristics of the RCD itself.

- Seven skill-based errors were identified among the 36 probable contributing factors; a majority of these were attention failures by the RCO facilitated by the use of RCL technology.
- Organizational process was identified six times among the 36 probable contributing factors, and all six were related to inadequate practices and procedures governing RCL operations and the use of the RCL technology, including the pullback protection system. Inadequate supervision was identified five times among the 36 probable contributing factors; four of the five were related to some aspect of RCO training.
- Four decision errors were identified among the 36 probable contributing factors; half related to decisions made with regard to controlling a cut of cars.
- Three probable contributing factors were associated with resource management issues. One was related to staffing while the other two were equipment-related.
- Analysis of operator work schedule history and sleep habits information suggests that, in two of the accidents/incidents, an RCO may have been operating with compromised alertness.

CONCLUSIONS

Based on analysis of the probable contributing factors for the six RCL accidents/incidents, four critical safety issues were identified:

- *Loss of RCO situation awareness*. Loss of RCO situation awareness was identified as a factor in five of the six RCL accidents/incidents analyzed.
- *Insufficient RCO training*. Insufficient training was directly implicated as a contributing factor among the RCL accidents/incidents. Improved training may also be able to mitigate some of the skill-based and decision errors that were identified.
- *Inadequate staffing and pairing of inexperienced crewmembers*. Though these factors were identified as contributing to only one of the six RCL accidents/incidents analyzed in the study, given the current industry shortage of switchmen and engineers, these may be significant safety issues in the future, especially when combined with insufficient training.

- *Inadequate practices and procedures governing RCL operations and the use of the RCL technology, including the pullback protection system*. Inadequate practices and procedures were identified as contributing factors in several RCL accidents/incidents. Given that operating rules and practices govern most of railroading, inadequate practices and procedures can have significant consequences.

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